MONTANA CLIMATE CHANGE ACTION PLAN

Recommendations Possibly Needing Legislation
Presented to EQC January 14, 2008

Recommendation, Goal/Timing	Reductions/Costs*	Possible Legislative Action
RCII-1 **Demand Side Management Programs, Efficiency Funds and Requirements** • Each utility to meet 20% of its load from renewable resources by 2020 increasing to 25% by 2025. • Each utility to capture 100% of its cost effective energy by 2025.	**6.6/ -$21**	• Expand RPS beyond 2015 and to include electric co-operatives. • Create an efficiency portfolio standard requiring utilities to achieve 100% of cost-effective conservation by 2025. • Expand USB program to increase requirements for natural gas. • Establish a statewide non-provider supplier of services under USB. • Create non-profit provider of energy efficiency services.
RCII-2 **Market Transformation and Technology Development Programs** • By 2009 put in place mechanism to allow broader coverage of market transformation efforts to all geographical areas.	**1.9/ -$23**	• Legislation for incentives for energy efficient appliances or equipment. • Resources needed to expand education.
RCII-3 **State Level Appliance Efficiency Standards and State Support for Improved Federal Standards** • Review standards and report to Governor by 2008, with adoption of changes in standards by 2009.	**1.5/ -$36**	• Set appliance efficiency standards
RCII-4 **Building Energy Codes** • Improve building codes to reduce the amount of fossil energy input needed to operate buildings.	**1.6/ -$10**	• Statewide building permit program with inspections and enforcement.

*Total GHG Reductions ($MMtCO_2e$) 2007-2020/Cost Effectiveness ($/ton$CO_2$e)

Recommendation, Goal/Timing	Reductions/Costs*	Possible Legislative Action
RCII-5 **"Beyond Code" Building Design Incentives and Mandatory Programs** • Reduce energy use 20% in existing buildings and 50% in new buildings by 2020 with up to 10% of the targeted reduction available from renewable energy generation. • Improve 25% of the residential and commercial space by 2020.	**3.4/ -$5**	• Improve incentives for energy efficiency in commercial buildings. • Possible impact fees or fast-track permitting for codes. Would require local government agreement.
RCII-6 **Consumer Education Programs** • Educate consumers and children so they can make informed choices to reduce energy use, improve efficiency, and reduce environmental consequences of their actions. • Educate professionals working in energy efficiency so they can better inform consumers and make wise decisions.	**Not quantified**	• Legislation could define role and responsibility with resources to accomplish work.
RCII-7 **Support for Implementation of Clean Combined Heat and Power** See ES-4	**Not quantified**	
RCII-8 **Support for Renewable Energy Applications** See ES-4	**Not quantified**	
RCII-9 **Carbon Tax** • No goals identified	**Not quantified**	• None at this time. May be needed to join or follow national efforts in the future.
RCII-10 **Industrial Energy Audits and Recommended Measure Implementation** • Reduce industrial energy use by 10% by 2020.	**3.6/ -$26**	• Possible tax incentives for industrial energy-efficiency improvements, evaluate what currently exists.

*Total GHG Reductions ($MMtCO_2e$) 2007-2020/Cost Effectiveness ($/ton$CO_2e$)

Recommendation, Goal/Timing	Reductions/Costs*	Possible Legislative Action
RCII-11 **Low Income and Rental Housing Energy Efficiency Programs** • Increase energy efficiency by 30% in 50% of low income units by 2015.	**4.7/ -$9**	• Incentives for landlords to improve rental property. • Replace inefficient manufactured housing that cannot be weatherized.
RCII-12 **State Lead by Example** • Reduce per unit use of electricity and natural gas by 20% in existing buildings and 40% in new buildings by 2020. • Purchase 25% of power from renewable energy that is not included in an RPS or generate the power by 2025. • Implement purchasing programs to require the purchase of energy efficient goods and services.	**2.0/ -$6**	• Require new state buildings to be built to high energy-efficiency standards. • Renovate existing state buildings through the State Buildings Energy Program at a much faster rate. • Purchase a certain percentage of energy for state government use from green power. • Require carbon neutral bonding for state bonds.
RCII-13 **Metering Technologies w/Opportunity for Load Management and Choice** • Develop a pilot program of installing smart meters for residential and non-residential buildings starting in 2009, targeting 10% of homes by 2011 and an additional 30% by 2020.	**0.9/ -$12**	
ES-1 **Environmental Portfolio Standard (Renewables and Energy Efficiency)** • Extend RPS so that each investor owned utility and public utility including member-owned electric co-operatives must meet 20% of its load with renewable energy by 2020 and 25% by 2025. • Each utility must implement a plan to obtain 100% of achievable cost-effective energy conservation by 2025.	**10.9/ -$15** 10.9 total 5.4 from conservation 5.5 from expanded renewable portfolio standard/ -$15 for conservation and $10 for expanded RPS	• Expand RPS beyond 2015 and include electric co-operatives. • Create an efficiency portfolio standard requiring utilities to achieve 100% of cost-effective conservation by 2025 and to require plans.

*Total GHG Reductions (MMtCO_2e) 2007-2020/Cost Effectiveness ($/ton$CO_2$e)

Recommendation, Goal/Timing	Reductions/Costs*	Possible Legislative Action
• By 2010 each utility must identify its achievable cost-effective energy conservation for the next 10 years.		
ES-2 **Renewable Energy Incentives (Biomass, Wind, Solar, Geothermal)** • Same as ES-1.	Not quantified separately. See ES-1	• Provide research and development funds for new technologies such as compressed air storage. • Overcome barriers to increased penetration of renewable resources, particularly the ability to integrate wind into the grid. • Possible legislation to establish a comprehensive wind program including monitoring, planning, incentives, and appropriate development of transmission and towers. • Possible legislation on carbon markets including allowances and/or offsets (likely not in 2009, may follow national effort).
ES-3 **Research and Development (R&D), including R&D for Energy Storage and Advanced Fossil Fuel Technologies** • Target R&D funding to a specific technology with a mission to build an industry around that technology or help deploy it. No specific goal identified.	Not quantified separately.	• Provide research and development funds for new technologies such as compressed air and other storage technologies and carbon sequestration.
ES-4 **Incentives and Barrier Removal (including Interconnection Rules and Net Metering Arrangements) for Combined Heat and Power (CHP) and Clean Distributed Generation (DG)** • Provide 470 MW of CHP, 4.5 MW of solar PV, and 30 MW of small wind by 2020.	5.8 total .8 from distributed renewable generation 5.0 from CHP/ $21 for distributed renewable generation and $16 for CHP	• Provide incentives for CHP. • Maintain Universal Systems Benefits (USB) program for small scale and community renewables (ETIC looking at USB extension).

*Total GHG Reductions (MMtCO_2e) 2007-2020/Cost Effectiveness ($/ton$CO_2$e)

Recommendation, Goal/Timing	Reductions/Costs*	Possible Legislative Action
ES-5 **Incentives for Advanced Fossil Fuel Generation and Carbon Capture and Storage or Reuse (CCSR), including Combined Hydrogen and Electricity Production with Carbon Sequestration** • Recommended goal of 0.5 tCO_2/MWh or 1100 lbs/MWh decreasing commensurate with best available control technology.	4.5 assuming reference case of small growth. 24.4 assuming high fossil fuel growth/ $30 for both cases.	• Legislation needed to require technology/fuel neutral emissions and provide DEQ authority to write rules requiring CO2 plans and enable eminent domain for CO2 pipelines.
ES-6 **Efficiency Improvements and Repowering of Existing Plants** • Improve generation efficiency at power stations through improvements at existing power plants. No numerical goals identified.	Not quantified	• Possible legislation to provide incentives for repowering power plants.
ES-7 **Demand-Side Management** • Completed as Residential, Commercial, Industrial and Institutional (RCII) recommendations.	Not quantified under Energy Supply. Major component of RCII.	See RCII.
ES-8/9 **Market Based Mechanisms to Establish a Price Signal for GHG Emissions (GHG Cap-and-Trade or Tax)** • Recognize importance of market price signals through carbon tax or cap and trade. No goals set.	Not quantified	• None. Legislation most likely to occur at a national level.
ES-10 **Generation Performance Standards or GHG Mitigation Requirements for New (and/or existing) Generation Facilities, with/without GHG Offsets** • By 2010 establish a GHG standard that is equal to or less than a new combined-cycle natural gas power plant for all new long-term financial commitments to baseload electric generation by load serving utilities. Applies to both in-state and	**4.7/ $13**	• Establish a GHG standard that is equal to or less than a new combined-cycle natural gas power plant for all new long-term financial commitments to base load electric generation.

*Total GHG Reductions ($MMtCO_2e$) 2007-2020/Cost Effectiveness ($/ton$CO_2e$)

Recommendation, Goal/Timing	Reductions/Costs*	Possible Legislative Action
imported electricity.		
ES-11 **Methane and CO_2 Reduction in Oil and Gas Operations, including Fuel Use and Emissions Reduction in Venting and Flaring** • Reduce methane emissions by 30% below business as usual based on the analysis of cost-effective, achievable reductions.	3.9 assuming reference case of small growth 6.6 assuming high fossil fuel growth/ Likely a net benefit for both scenarios	• Possible legislation for incentives, especially for small companies to reduce emissions.
ES-12 **GHG Reduction in Refinery Operations, including in Future Coal-to-Liquids Refineries** • Produce CTL fuels with a life cycle GHG emissions at least 20-30% below petroleum based fuels.	35 CTL under high fossil fuel growth 1.5 petroleum refining under reference case 2.2 petroleum refining under high fossil fuel growth/ cost not estimated for any scenario	• Legislation needed for performance standards for CTL.
ES-13 **CO_2 Capture and Storage or Reuse (CCSR) in O&G Operations, including Refineries and Coal-to-Liquids Operations** • Captured in ES-5 and ES-12.	None	
TLU-1 **Light Duty Vehicle Clean Car Standards** • Go beyond federal emissions standards for cars and light trucks.	**4.92/ -$100**	• Adopt California standards with provision that when California adopts, Montana will follow.
TLU-2 **Fuel Efficient Replacement Tires Program** • Establish voluntary energy efficiency standards that achieve an average 4.5% gain in fuel economy by 2009. • Replace a proportion of tires on state-owned vehicles with low rolling resistance tires by 2011.	**0.14/ -$90**	• Set low rolling resistance tire standards and mandatory labeling. Need readily available all-season tires for replacement tires which are not yet available, so legislation in future sessions.

*Total GHG Reductions ($MMtCO_2e$) 2007-2020/Cost Effectiveness ($/ton$CO_2e$)

Recommendation, Goal/Timing	Reductions/Costs*	Possible Legislative Action
• Legislatively set LRR standards with mandatory manufacturers rating when all season/all weather LRR tires are available.		
TLU-3 **Consumer Information on Vehicle Miles Per Gallon (MPG)** • Greatly increase the awareness of consumer information on MPG to result in greater fuel efficiency across the state beginning in 2008.	Included in TLU-1 and TLU-2.	
TLU-4 **Financial and Market Incentives for Low GHG Vehicle Ownership and Use** • By 2010 prepare a detailed analysis of feebates, excise taxes and labeling to determine which option or combination of options would create the best incentives for purchase and operation of vehicles that emit lower levels of GHG.	Included in TLU-1.	• Legislation would be needed for fees or rebates, excise taxes and consumer labeling, if identified as feasible through the analysis.
TLU-5 **Growth and Development Bundle** • Implement a package of policies and incentives that will significantly reduce urban VMT below the 2020 baseline, preferable in the higher end of a range of 3% to 11%.	**0.77/ <$0**	• Legislation could be needed to assist local governments' direct growth, provide market incentives for smart growth principles, or provide alternative sources of revenue to reduce reliance on property taxes. • Establish a state-level Community Technical Assistance Program on smart growth. • Directed growth policies or requirements on where to locate state buildings, schools. • Local government policies to encourage smart growth for infill development, transit, local option fuel taxes, developer impact fees.

*Total GHG Reductions (MMtCO_2e) 2007-2020/Cost Effectiveness ($/ton$CO_2$e)

Recommendation, Goal/Timing	Reductions/Costs*	Possible Legislative Action
		- Legislation needed to strengthen current access management programs.
TLU-6 **Low Carbon Fuels** - Create a Low Carbon Fuel Target for transportation fuels sold in Montana and reduce carbon intensity of Montana's passenger vehicle fuels sold in Montana by at least 10% by 2020.	**0.39/ Cost not available**	- Carbon fuel accounting to measure net carbon emission per unit of energy delivered. - Set a low carbon fuel standard. - Provide trading system for low carbon fuel credits. - Develop incentives for low carbon fuels to be distributed and sold. - Tax on high carbon fuels. - Require low carbon fuels in state fleet vehicles and state contracts. - Set voluntary or mandatory goals.
TLU-7 **Heavy-Duty Vehicle Emissions Standards and Retrofit Incentives** - Encourage the retrofit of on-road heavy-duty diesel vehicles 2006 or earlier. - Retrofit 50% of pre 2007 heavy duty diesel engines. - Lead by example by initiating a retrofit program for state-owned and state-leased fleet or 80% of pre 2007 vehicles.	**0.16/ $79**	- Tax credits for diesel engine retrofits.
TLU-8 **Heavy-Duty Vehicle and Locomotive Idle Reduction** - Reduce fuel consumption from vehicles idling at rest areas and truck stops 40% by 2010 and 85% by 2020. - Require that 85% of school transportation to have anti-idling policies or in-house electrification.	**0.13/ -$44**	- Incentive or financing program for truck stop electrification

*Total GHG Reductions ($MMtCO_2e$) 2007-2020/Cost Effectiveness ($\$/tonCO_2e$)

Recommendation, Goal/Timing	Reductions/Costs*	Possible Legislative Action
- Reduce locomotive idling at rail yards by 50%.		
TLU-9 **Procurement of Efficient Fleet Vehicles** - Goal of 70% all heavy duty vehicles and 90% of all light duty vehicles in state fleet to be energy efficient.	Included in TLU-1, TLU-6, TLU-7, TLU-8, and TLU-11.	
TLU-10 **Transportation System Management** - Promote the development of efficiencies in Montana's transportation system to achieve fuel savings and improved safety.	Not quantified	- Legislation needed to strengthen current access management programs.
TLU-11 **Intermodal Freight Transportation** - Target 1 intermodal unit train to Seattle by 2010 and 4 intermodal trains by 2020.	**0.59/ cost not available**	
TLU-12 **Off-Road Engines and Vehicles GHG Emissions Reductions** - Adopt CO2 emissions standards for off-road equipment within 2 years of another state or municipality establishing such standards. - Lead by example by initiating retrofit program for 40% of state owned off road vehicles by 2010.		- Adopt CO2 emissions standards for off road equipment if other states take the lead. - Tax incentives for retrofits.
TLU-13 **Reduced GHG Emissions from Aviation** - Seek development of federal policies to reduce GHG emissions from aviation.	Not quantified	
AFW-1 **Agricultural Soil Carbon Management – Conservation/No-Till** **Agricultural Soil Carbon Management – Organic Farming** - Increase cropland managed using	3.7/ $0	- Possible legislation to expand programs.

*Total GHG Reductions ($MMtCO_2e$) 2007-2020/Cost Effectiveness ($\$/tonCO_2e$)

Recommendation, Goal/Timing	Reductions/Costs*	Possible Legislative Action
BMPs by 20% by 2012 and 50% by 2020. - Increase organic farm acreage 15% above projected levels in 2015 and 50% above 2025 levels.		
AFW-2 **Biodiesel Production (Incentives for Feedstocks and Production Plants)** - Produce sufficient biodiesel from Montana feedstocks to meet 2% of 2010 total diesel needs, 10% of 2015 needs and 20% of 2020 needs.	**0.9/ $14**	- Possible changes to incentives.
AFW-3 **Ethanol Production** - Produce 50 mgy starch based and 2 mgy cellulosic ethanol by 2010; 110 mgy starch based and 25 mgy cellulosic by 2015; 250 mgy starch based and 50 mgy cellulosic by 2020.	**2.2/ $4**	- Possible changes to incentives. - Review incentives for biodiesel.
AFW-4 **Incentives for Enhancing GHG Benefits of Conservation Provisions of Farm Bill Programs** - Retain land that is being retired from CRP in some type of management program that protects the soil carbon.	**15/ $12**	- Review incentives for ethanol. - Possibly concentrate on infrastructure development.
AFW-5 **Preserve Open Space and Working Lands: Forests and Agriculture** - By 2020, reduce the rate that forest and agricultural lands are converted to developed use by 50% from current levels achieving the first 25% by 2015.	**Agr: 0.12/ $32** **Forests: 0.9/ $3**	- Create a state-level program to conserve working lands.
AFW-6 Dropped from Consideration		
AFW-7 **Expanded Use of Biomass Feedstocks for Energy Use** - Increase the useage of woody biomass residue for renewable	**1.1/ -$23**	- Legislation to lower the threshold for MT renewable energy tax credit.

*Total GHG Reductions (MMtCO$_2$e) 2007-2020/Cost Effectiveness ($/tonCO$_2$e)

Recommendation, Goal/Timing	Reductions/Costs*	Possible Legislative Action
electricity, heat and steam generation to 450,000 tons/year by 2020.and agricultural biomass to 540,000 tons annually by 2020.		
AFW-8 **Afforestation/Reforestation Programs – Restocking** • Ensure restocking on 20% of accessible forest lands impacted by wildfire since 2000. • For future fires, re-stock 30% within 5 years. • Plant 42,250 new per year in urban areas.	**Restocking: 3.4/ $12** **Urban Trees: 0.04/ -$3**	
AFW-9 **Improved Management and Restoration of Existing Stands** • Increase forest productivity by 20% by 2020 on 700,000 acres of private and state land.	**1.3/ $119**	
AFW-10 **Expanded Use of Wood Products for Building Materials** • Expand the use of wood products by 5% over 2007 levels by 2020. • Increase usage of wood products by 2% by 2010.	**Not quantified**	
AFW-11 **Programs to Promote Local Food and Fiber** • 20% of food consumed in Montana to be grown and processed in MT by 2010; 30% by 2020.	**0.12/ $5**	
AFW-12 **Enhanced Solid Waste Recovery and Recycling** • Increase Montana solid waste recycling rates to 17% by 2008; 22% by 2011; 25% by 2015 and 28% by 2020.	**3.3/ $17**	• Possible legislation to assist small businesses, and development of local markets. • Possible assistance to waste to energy sewage treatment plan upgrades.

*Total GHG Reductions ($MMtCO_2e$) 2007-2020/Cost Effectiveness ($\$/tonCO_2e$)

Recommendation, Goal/Timing	Reductions/Costs*	Possible Legislative Action
		- Legislation to extend the tax incentives for recycling that are due to expire in 2009.
CC-1 **GHG Inventories and Forecasts** - Develop complete inventory of emissions sources and sinks on continuing basis with forecasts as soon a possible.	Not quantified	
CC-2 **State GHG Reporting** - Implement a GHG reporting program as soon as possible preferably by 2008.	Not quantified	
CC-3 **State GHG Registry** - Establish a climate registry in participation with other states and assist in key registry design characteristics.	Not quantified	- Possible legislation to participate in emissions trading program in the future.
CC-4 **State Climate Public Education and Outreach** - Shift in public consciousness to commitment to choices that enhance personal community and statewide health and contribute to productive, thriving natural systems.	Not quantified	- Need resources to complete these tasks.
CC-6 **Options for State GHG Goals or Targets** - Reduce green house gas emissions to 1990 levels by 2020, for both consumption-based and production-based emissions, and further to reduce emissions 80% below 1990 levels by 2050.	Not quantified	- Legislation could formally set the goals recommended in the Plan.
CC-7 **The State's Own GHG Emissions** - See individual action below.	Not quantified	

*Total GHG Reductions ($MMtCO_2e$) 2007-2020/Cost Effectiveness ($/ton$CO_2e$)

Recommendation, Goal/Timing	Reductions/Costs*	Possible Legislative Action
CC-7.1 **Establish a Target for Reducing the State's Own GHG Emissions** • Reduce GHG emissions from Montana State Government to 1990 levels by 2018 and 5% below 1990 levels by 2020.	Not quantified	• Resources will be requested to meet the goals for state building energy efficiency.
CC-7.2 **Climate-Neutral Bonding** • See RCII-12	Not quantified	See RCII-12
CC-7.3 **Require Evaluation of GHG Emissions in Environmental Studies** • Make informed decisions encouraging development that produces the least GHG emissions.	Not quantified	
CC-7.4 **Join WCI and Consider Joining Chicago Climate Exchange** • Join Western Climate Initiative (WCI) and consider joining the Chicago Climate Exchange (CCX).	Not quantified	

*Total GHG Reductions (MMtCO$_2$e) 2007-2020/Cost Effectiveness (\$/tonCO$_2$e)

Montana Climate Change Action Plan

Final Report of the Governor's Climate Change Advisory Committee

November 2007

Photo Credit

Cover photo of Piegan Glacier, Glacier National Park, Montana. Park scientists are still debating whether Piegan Glacier, on the slopes of Piegan Mountain, is really still a glacier. Credit: U.S. National Park Service, August 2001.

Table of Contents

Appendixes

Acknowledgments

The Montana Climate Change Advisory Committee (CCAC) gratefully acknowledges the individuals and organizations who contributed significantly to the successful completion of the CCAC process and the publication of this Final Report.

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The CCAC also recognizes the many individuals who participated in the sector-based Technical Work Groups, all of whom are listed in Appendix C.

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Members of the Montana
Climate Change Advisory Committee

Peggy Beltrone, Cascade County Commissioner
Robert Boettcher, Organic Farmer
Mark Brandt, Teamsters Local #2
Buck Buchanan, Teacher
Sue Dickenson, Representative, House District 25
Mary Fitzpatrick, Self-Employed
Gloria Flora, Sustainable Obtainable Solutions
Tim Gregori, Southern Montana Electric
Patrick Judge, Montana Environmental Information Center
Mark Lambrecht, PPL Montana
Steve Loken, Center for Resource Building Technology
Charles McGraw, Natural Resources Defense Council
Shane Mogensen, Nance Petroleum
Gary Perry, Senator, Senate District 35
Trudi Peterson, Sustainable Cattle Rancher
Bob Raney, Public Service Commission Member
Dave Ryan, National Center for Appropriate Technology
William Walks Along, Northern Cheyenne

Members of the Scientific Advisory Panel

Susan Capalbo, Big Sky Carbon Sequestration Partnership, Montana State University
Ted Dodge, National Carbon Offset Coalition
Dan Fagre, Global Change Research Program, U.S. Geological Survey
David McGinnis, Grants and Sponsored Programs Office, Montana State University
Don Potts, College of Forestry and Conservation, University of Montana
Steve Running, Numerical Terradynamics Simulation Group, College of Forestry and Conservation, University of Montana

Acronyms

ACEEE	American Council for an Energy-Efficient Economy
AEO2006	Annual Energy Outlook 2006 [US DOE Energy Information Administration]
AERLP	Alternative Energy Revolving Loan Program
AERO	Alternative Energy Resources Organization
AFW	Agriculture, Forestry, and Waste Management [TWG]
API	American Petroleum Institute
ARM	Annotated Rules of Montana
ASAP	Appliance Standards Awareness Project
BACT	best available control technology
BAU	business as usual
BC	black carbon
BCAP	Building Code Assistance Project
BEF	Bonneville Environmental Foundation
BLM	Bureau of Land Management
BMP	best management practices
BNSF	Burlington Northern Santa Fe [railroad]
BPA	Bonneville Power Administration
BSCSP	Big Sky Carbon Sequestration Partnership
BTL	biomass-to-liquids
CAFE	corporate automobile fuel economy [standards]
CAIT	Climate Analysis Indicators Tool
CC	Cross-Cutting Issues [TWG]
CCAC	Climate Change Advisory Committee
CCS	carbon capture and sequestration [or storage]
CCS	Center for Climate Strategies
CCSR	carbon capture and sequestration [storage] or reuse
CCX	Chicago Climate Exchange
CDEAC	Clean and Diversified Energy Advisory Committee
CDEI	Clean and Diversified Energy Initiative
CE	cost-effectiveness
CFC	chlorofluorocarbon
CFL	compact fluorescent lamp
CH_4	methane
CHP	combined heat and power
CMAQ	Congestion Mitigation and Air Quality Improvement [Program]
CO_2	carbon dioxide

CO_2e	carbon dioxide equivalent
CORRIM	Consortium for Research on Renewable Industrial Materials
CPUC	California Public Utilities Commission
CRP	Conservation Reserve Program
CSP	Conservation Security Program
CTL	coal-to-liquids
DERA	Diesel Emissions Reduction Act
DG	[clean] distributed generation
DMV	Department of Motor Vehicles
DNRC	[MT] Department of Natural Resources and Conservation
DOA	[MT] Department of Administration
DOC	diesel oxidation catalyst
DOJ	[MT] Department of Justice
DPF	diesel particulate filter
DSM	demand-side management
EA	environmental assessments
ECBM	enhanced coal bed methane
EE	energy efficiency
EIA	Energy Information Administration [US DOE]
EIIP	Emissions Inventory Improvement Project [US EPA]
EIS	environmental impact statement
EOR	enhanced oil recovery
EPS	environmental portfolio standard
EQIP	Environmental Quality Incentives Program
ERS	Economic Research Service
ES	Energy Supply [TWG]
EtOH	ethyl alcohol
EU	European Union
FAQ	frequently asked questions
FBC	fluidized bed combustion
fc	foot-candles
FIA	Forest Inventory Analysis [USFS]
FTE	full-time equivalent
FWP	[MT] Department of Fish, Wildlife and Parks
GHG	greenhouse gas
GPS	generation performance standard
GSP	gross state product
GTR	[USFS] General Technical Report

GVW	gross vehicle weight
GWh	gigawatt-hours (1 million kilowatt-hours)
GWP	global warming potential
HB	House Bill
HDPE	high density polyethylene
HDV	heavy-duty vehicle
HFC	hydrofluorocarbon
HID	high intensity discharge
HPMS	highway performance monitoring system
HVAC	heating, ventilation, and air conditioning
HWP	harvested wood products
I&F	Inventory and Forecast
IECC	International Energy Conservation Codes
IGCC	integrated gasification combined cycle
IOU	investor-owned utility
IPCC	Intergovernmental Panel on Climate Change
IPP	independent power producer
IRP	Integrated Resource Plan
kWh	kilowatt-hour
LCF	low carbon fuel
LCFS	Low Carbon Fuel Standard
LDV	light-duty vehicle
LED	light-emitting diode
LEED	Leadership in Energy and Environmental Design
LFGTE	landfill gas to energy
LMOP	Landfill Methane Outreach Program
LNG	liquefied natural gas
LPG	liquefied petroleum gas
LRES	Land Resource and Environmental Sciences
LRR	low rolling resistance
LSE	load-serving entity
m^3/ha/yr	cubic meters per hectare per year
MACo	Montana Association of Counties
MCA	Montana Code Annotated
MDEQ	Montana Department of Environmental Quality
MDOA	Montana Department of Agriculture
MDT	Montana Department of Transportation
MDU	Montana–Dakota Utilities Company

MECA	Montana Electric Cooperatives Association
MEEC	Montana Energy Education Council
MEIC	Montana Environmental Information Center
MG	million gallons
MGY	million gallons per year
MMBtu	one million (a thousand thousand) British thermal units
MMES	Montana Manufacturing Extension Service
MMt	million metric tons
$MMtCO_2e$	million metric tons of carbon dioxide equivalent
MOU	Memorandum of Understanding
MPG	miles per gallon
MRL	Montana Rail Link
MSU	Montana State University
Mt	metric ton (equivalent to 1.102 short tons)
MW	megawatt
MWh	megawatt-hours (1 thousand kilowatt-hours)
MY	model year [cars]
N_2O	nitrous oxide
NAS	National Academy of Sciences
NASS	National Agricultural Statistics Service
NCAT	National Center for Appropriate Technology
NCDC	National Clean Diesel Campaign
NCOC	National Carbon Offset Coalition
NCSU	North Carolina State University
NEEA	Northwest Energy Efficiency Alliance
NEV	neighborhood electric vehicles
NGCC	natural gas combined cycle
NO_x	nitrogen oxides
NPV	net present value
NRC	National Research Council
NRCS	Natural Resources Conservation Service [USDA]
NREL	National Renewable Energy Laboratory
NWE	NorthWestern Energy
NWPPC	Northwest Power Planning Council
O&M	operation and maintenance
ODS	ozone-depleting substance
OPS	U.S. Office of Pipeline Safety
ORNL	Oak Ridge National Laboratory [US DOE]

PC	pulverized coal
PET	polyethylene terephthalate
PFC	perfluorocarbon
PIRG	Public Interest Research Group
PM	particulate matter
PPL	PPL Montana [power company]
PRC	Public Regulatory Commission
PRO	partnership reduction opportunities
PSC	[MT] Public Service Commission
PSW	Pacific Southwest Research Station [USFS]
PTC	[federal] Production Tax Credit
PURPA	Public Utility Regulatory Policy Act
PV	photovoltaics
QF	qualifying facilities
R&D	research and development
RCI	Residential, Commercial, and Industrial
RCII	Residential, Commercial, Institutional, and Industrial [TWG]
RCW	Revised Code of Washington
REC	renewable-energy credits
RGGI	Regional Greenhouse Gas Initiative
RNP	Required Navigation Performance [aircraft]
RPS	renewable portfolio standard
RVSM	Reduced Vertical Separation Minimums [aircraft]
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
SAGE	System for Assessing Aviation’s Global Emissions
SED	state energy data
SF_6	sulfur hexafluoride
SO_x	sulfur oxides
SUV	sport utility vehicle
SWEEP	Southwest Energy Efficiency Project
TCRP	Transit Cooperative Research Program [Transportation Research Board]
TEU	trailer equivalent units
TLU	Transportation and Land Use [TWG]
TOD	transit-oriented development
TSE	truck stop electrification
TWG	Technical Work Group
TWh	terawatt-hours

U&CF	Urban & Community Forestry [USFS program]
UM	University of Montana
UNFCCC	United Nations Framework Convention on Climate Change
US DOE	U.S. Department of Energy
US EPA	U.S. Environmental Protection Agency
USB	Universal System Benefits
USBP	Universal System Benefits Program
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
VALE	Voluntary Airport Low Emissions
VMT	vehicle miles traveled
WARM	WAste Reduction Model
WCI	Western Climate Initiative
WECC	Western Electric Coordinating Council
WGA	Western Governors' Association
WIRED	Work Force Innovation and Rural Economic Development
WREGIS	Western Renewable Energy Generation Information System
WW	wastewater
ZERT	Zero Emission Research and Technology [Center]

Executive Summary

Background

Recognizing the profound consequences that global warming could have on the economy, environment, and quality of life in Montana, Governor Brian Schweitzer issued a letter on December 13, 2005, directing the Montana Department of Environmental Quality (MDEQ) to establish a Climate Change Advisory Committee (CCAC). Under this initiative, the CCAC evaluated state-level greenhouse gas (GHG) reduction opportunities in various sectors of Montana's economy while taking into consideration the Governor's charge to develop policy recommendations that would "save money, conserve energy, and bolster the Montana economy."

The Climate Change Advisory Committee

MDEQ Director Richard Opper appointed a broad-based group of 18 Montana citizens to the CCAC. The CCAC was supported by a panel of scientific experts, public and private sector technical and policy specialists, and staff from MDEQ. These individuals evaluated options and made recommendations on existing programs in Montana, policies to reduce GHG emissions, and the potential cost of those policies. The CCAC met six times from July 2006 through July 2007 to evaluate the recommendations from technical work groups (TWGs) representing four sectors of Montana's economy:

1. Energy Supply (ES)
2. Residential, Commercial, Institutional, and Industrial (RCII)
3. Transportation and Land Use (TLU)
4. Agricultural, Forestry, and Waste Management (AFW)

A fifth TWG, Cross-Cutting Issues (CC), developed strategies that cut across many sectors of Montana's economy and evaluated the issues of inventorying, forecasting, reporting, and registering Montana's GHG emissions.

The CCAC followed a process designed and implemented by the nonprofit Center for Climate Strategies (CCS). Staff from the CCS provided facilitation services and technical expertise to the CCAC as it formulated its recommendations. The MDEQ provided coordination and oversight to the process.

Inventory of Montana's Greenhouse Gas Emissions

Montana's GHG emissions were last inventoried in 1990. The inventory was updated to the present, and a forecast was made of expected GHG emissions through 2020. The inventory shows that Montana's electricity generation, heating needs, commerce, agricultural practices, and transportation needs accounted for 0.6% of the GHG emissions in the United States in 2005. The state's forests, cropland, and rangeland provide a vast terrestrial carbon sink that helps balance the state's emissions. A 14% increase in GHG emissions from 1990 to 2005 moved Montana from a net carbon sink to a net carbon emitter, and the state now averages net emissions of approximately 12 million metric tons of carbon dioxide equivalents ($MMtCO_2e$) per year.

Montana also has a higher rate of GHG emissions per capita—nearly double the national average. The reasons for this are varied but include the state's large fossil fuel production industry, substantial agricultural industry, large distances for transportation, cooler climate, and low population base.

Climate Change Advisory Committee Recommendations

The CCAC agreed upon 54 policy recommendations that are designed to help reduce Montana's emissions of GHGs to 1990 levels by the year 2020. Some of the recommendations can be implemented immediately, and some will require the support of the Montana State Legislature. Some will cost money to implement, and many will save money by reducing energy needs and costs. Others will require technological advances to fully implement. Most of these recommendations will have additional benefits beyond reducing GHG emissions, including reduced reliance on imported fossil fuels, reduction in air pollution, increased opportunity for Montana agriculture to provide renewable fuels, healthier forests, and the opportunity for Montana to be a leader in developing new technologies to produce cleaner burning fuels while sequestering GHGs.

The CCAC advised that the overall results of its recommended policy options be compared using two GHG emissions calculation approaches to identify which long-term emissions reduction goals could be met. The first is a "consumption-based" approach based on a projection of the amount of energy consumed by Montana residents, businesses, industries, and institutions. This includes emissions that result from all electricity, natural gas, and transportation fuel use in Montana as well as emissions from all non-energy sectors of the economy (e.g., agricultural and industrial processes). This approach shows how the actions of Montanans can affect the amount of GHGs emitted for the energy needed in-state. The second approach is "production-based." It includes everything in the consumption-based calculation plus GHG emissions from electricity produced in Montana for export to other states. The difference in emissions is significant, because Montana exports, on average, more than 40% of the electricity it produces each year. More information on these approaches can be found in Chapter 4 and Appendix G. In this document, unless otherwise noted, all GHG emission reductions are reported in terms of $MMtCO_2e$, costs reflect net present values (NPVs), and cost-effectiveness (cost-per-ton) is reported as $\$/MtCO_2e$ reduced or removed.

Figure EX-1 shows the projected growth in Montana's GHG emissions under a no-action scenario (business as usual) for the energy that is consumed in Montana only (i.e., calculating GHG emissions using the consumption-based approach). It also shows the projected emissions if all of the CCAC's recommendations are implemented as well as the CCAC's recommended GHG emission target for Montana in 2020. Figure EX-1 indicates that the CCAC's goal of reducing GHG emissions to 1990 levels by the year 2020 can be met and exceeded if all recommendations are implemented.

Figure EX-1. Reference case Montana consumption-based gross GHG emissions

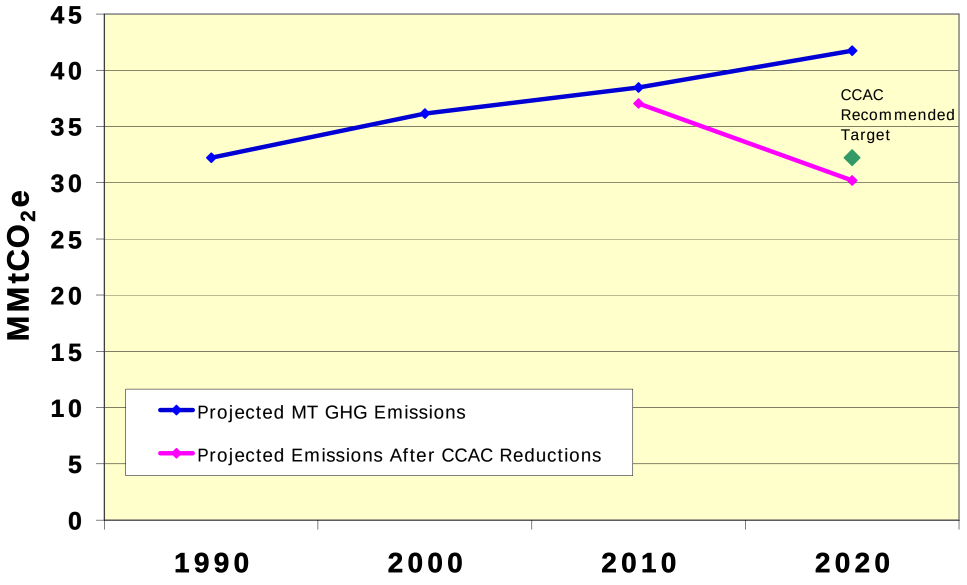
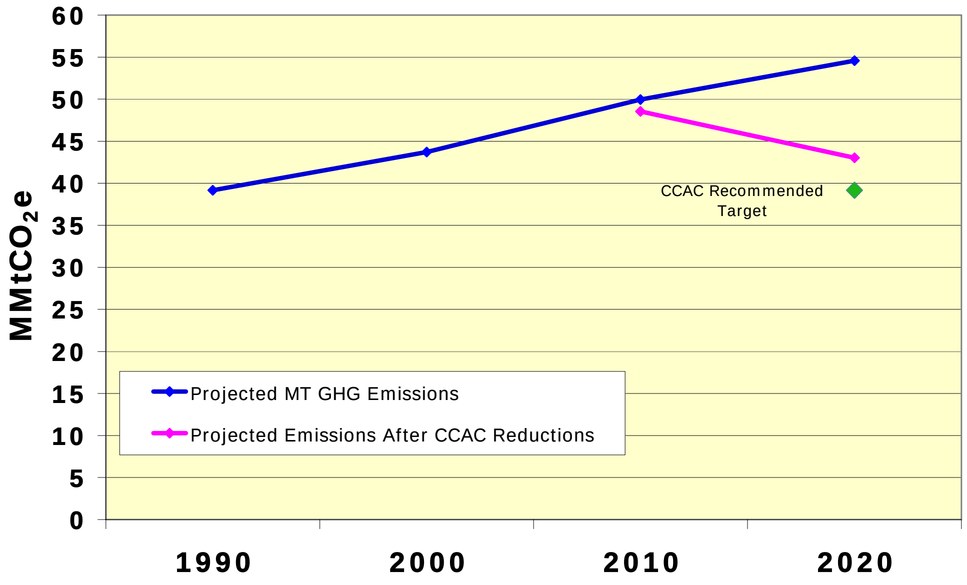


Figure EX-2 shows the projected growth in Montana’s GHG emissions under a no-action scenario (business as usual) for both the energy that is consumed in Montana and the electricity that is produced and exported from Montana (i.e., calculating GHG emissions using the production-based approach). As in Figure EX-1, this graph shows the projected GHG emissions if all the CCAC’s recommendations are implemented as well as the CCAC’s recommended GHG emissions target for Montana in 2020. Figure EX-2 indicates that the CCAC’s goal of reducing emissions to 1990 levels by the year 2020 will not be fully met under the production-based approach. This is because the 54 recommended policy options do not significantly reduce emissions from the electricity that is currently produced in Montana and exported out of state.

Figure EX-2. Reference case Montana production-based gross GHG emissions



Under the consumption-based approach with the GHG reductions from the policy options, the four sectors of Montana's economy (as defined in the CCAC process) would provide the following reductions as shown in Figure EX-3:

- 29.0% of the reductions (18.4 $MMtCO_2e$) would come from the RCII sector,
- 34.5% (21.9 $MMtCO_2e$) would come from the ES sector,
- 9.6% (6.1 $MMtCO_2e$) would come from the TLU sector, and
- 26.9% (17.1 $MMtCO_2e$) would come from the AFW sector.

Figure EX-3. Sector shares of recommended GHG reductions

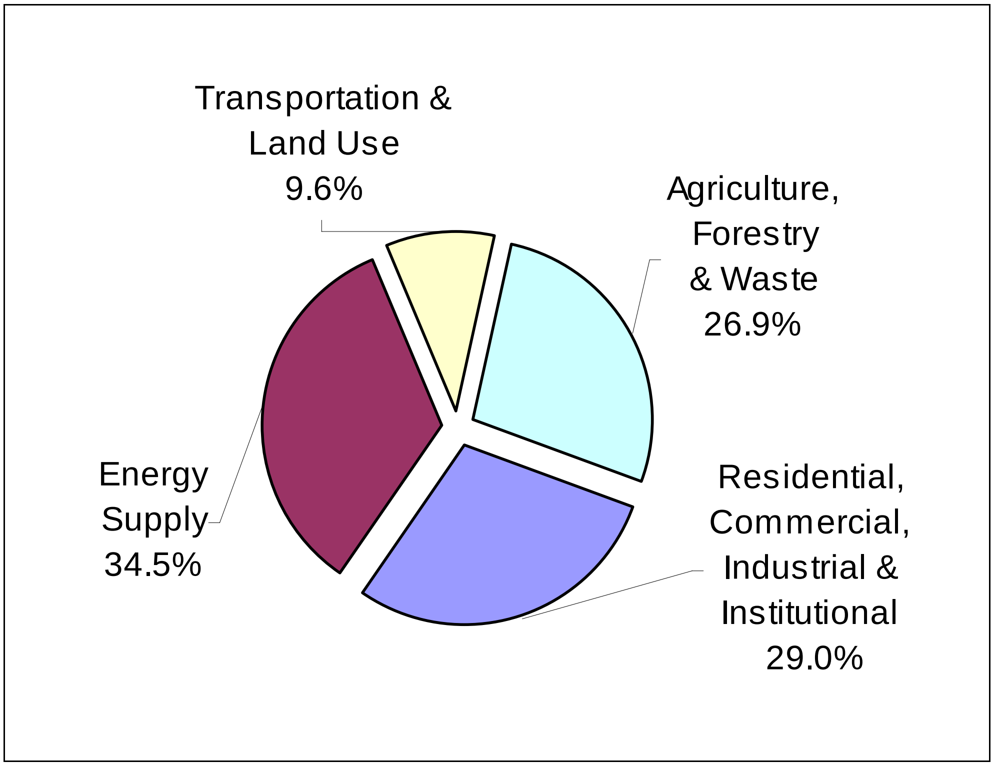
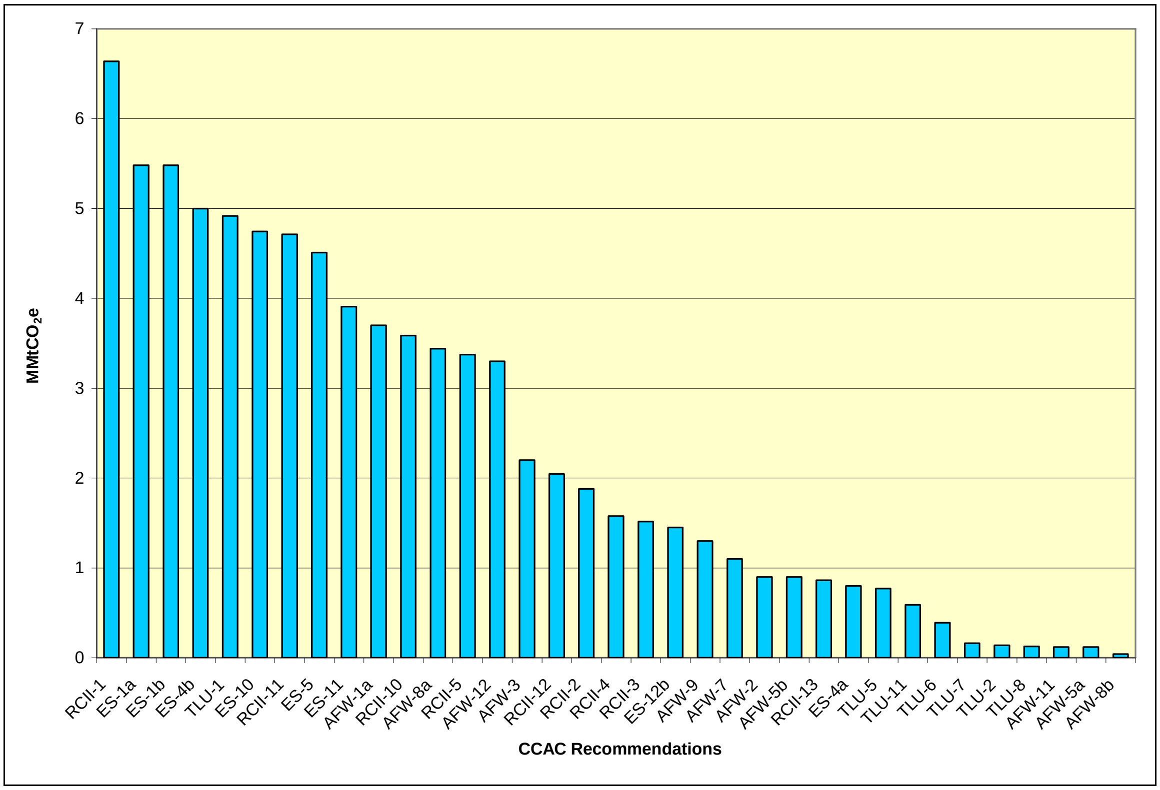


Figure EX-4 illustrates the range of GHG emission reductions that would result from implementing the individual recommendations of the CCAC as listed in Table EX-1. It is important to note that in Figure EX-4, each policy recommendation is illustrated as though it were a stand-alone option. Individual policy recommendations sometimes address the same GHG emissions, however, so the results of Figure EX-4 cannot be summed to produce total GHG emission reductions. Such overlaps have been accounted for in cumulative assessments of the CCAC's recommendations (e.g., in Figures EX-1 through EX-3).

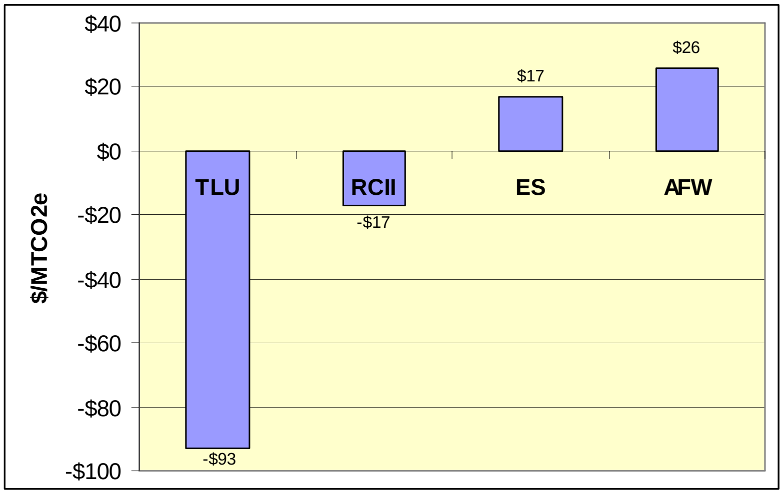
Figure EX-4. Policy recommendations ranked by GHG emission reductions



Costs of Implementation

There is considerable variation in the net costs or benefits of implementing the CCAC's recommendations as shown in Figure EX-5.

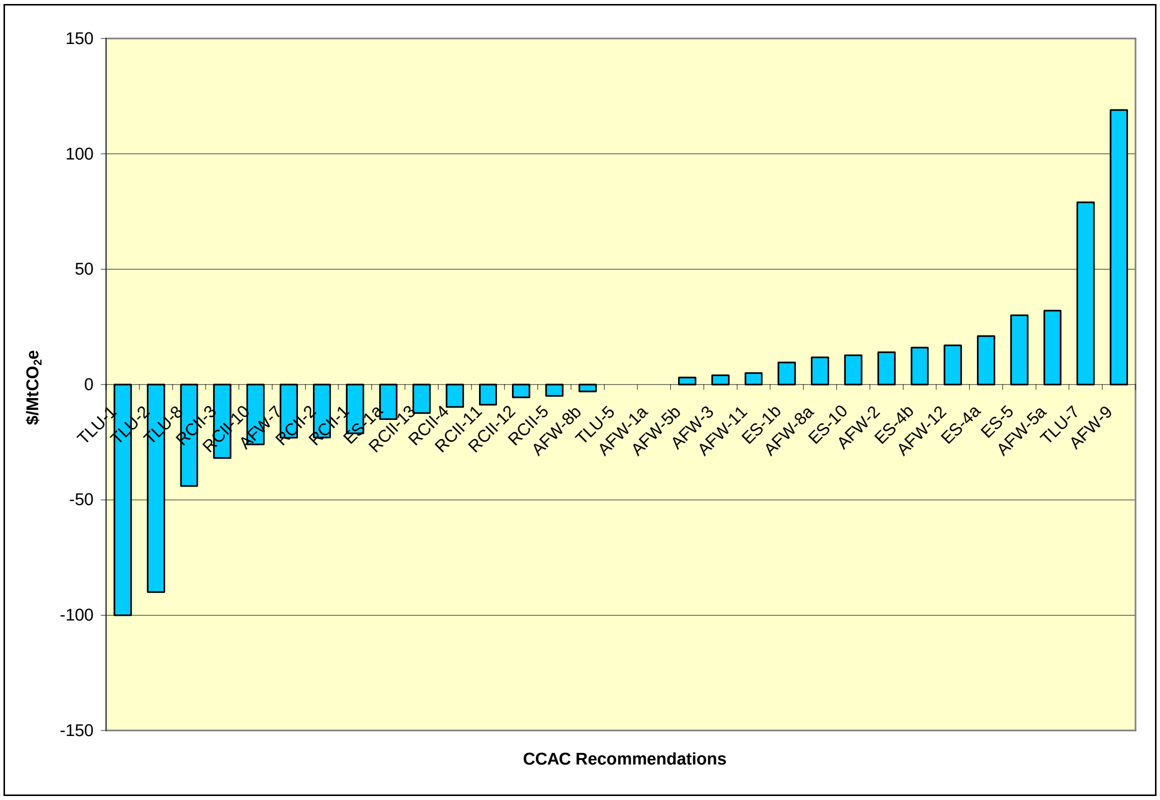
Figure EX-5. Overall cost-per-ton-reduced by sector



As Figure EX-5 illustrates, there are net costs to reducing a ton of carbon emissions from the ES and the AFW sectors. Conversely, there are net economic benefits to reducing emissions from the TLU and the RCII sectors. Most of the savings for these latter two sectors comes from reduced energy costs due to more efficient energy usage. Cumulatively, there is a slight economic benefit from implementing all of the CCAC’s recommendations.

Figure EX-6 provides a ranking of individual policy recommendations based on their respective costs per $MtCO_2e$.

Figure EX-6. Policy recommendations ranked by cost-per-ton reduced



List of Recommendations

Table EX-1 lists all of the CCAC’s individual policy recommendations. The recommendations are grouped by sector, and the table provides information on the amount of GHG reduction each recommendation would provide over the period 2007–2020 and their respective net costs or benefits on a cost-effectiveness (i.e., cost-per-ton-reduced) basis. Some recommendations are not quantified but are important to the success of the overall effort to reduce GHG emissions. For example, consumer education is not quantified by itself but is important to many of the policy recommendations.

Table EX-1. Policy options recommended by the CCAC

	Policy Option		GHG Reductions ($MMtCO_2e$) Total 2007–2020	Cost Effectiveness ($\$/tCO_2e$)
	RESIDENTIAL, COMMERCIAL, INSTITUTIONAL, AND INDUSTRIAL			
RCII-1	Demand-Side Management Programs, Efficiency Funds and Requirements (and Financial Incentives)		6.6	–$21
RCII-2	Market Transformation and Technology Development Programs		1.9	–$23
RCII-3	State-Level Appliance Efficiency Standards and State Support for Improved Federal Standards		1.5	–$36
RCII-4	Building Energy Codes		1.6	–$10
RCII-5	“Beyond Code” Building Design Incentives and Mandatory Programs		3.4	–$5
RCII-6	Consumer Education Programs		*Not quantified*	
RCII-10	Industrial Energy Audits and Recommended Measure Implementation		3.6	–$26
RCII-11	Low-Income and Rental Housing Energy Efficiency Programs		4.7	–$9
RCII-12	State Lead by Example		2.0	–$6
RCII-13	Metering Technologies With Opportunity for Load Management and Choice		0.9	–$12
	Sector Total After Adjusting for Overlaps		**18.4**	**–$17**
	Reductions From Recent Actions			
RCII-1	Expand Energy Efficiency Funds		6.5	
RCII-11	Low-Income Energy Efficiency Programs		0.4	
	Sector Total Plus Recent Actions		**25.3**	
	ENERGY SUPPLY			
ES-1	Environmental Portfolio Standard (Renewables and Energy Efficiency)	Efficiency / Conservation	5.4	–$15
		Renewable Energy	5.5	$10
ES-2	Renewable Energy Incentives (Biomass, Wind, Solar, Geothermal)		*Not quantified separately (see ES-1 and ES-4)*	
ES-3	Research and Development (R&D), Including R&D for Energy Storage and Advanced Fossil Fuel Technologies		*Not quantified*	
ES-4	Incentives and Barrier Removal (Including Interconnection Rules and Net Metering Arrangements) for Combined Heat and Power (CHP) and Clean Distributed Generation (DG)	Distributed Renewables	0.8	$21
		Combined Heat and Power	5.0	$16
ES-5	Incentives for Advanced Fossil Fuel Generation and Carbon Capture and Storage (CCS), Including Combined Hydrogen and Electricity Production with Carbon Sequestration	Reference Case	4.5	$30
		High Fossil Fuel Scenario	24.4	$30
ES-6	Efficiency Improvements and Repowering of Existing Plants		*Not quantified*	
ES-7	Demand-Side Management		*Not quantified separately (see ES-1 and RCII-1)*	
ES-8/9	Market-Based Mechanisms to Establish a Price Signal for GHG Emissions (GHG Cap-and-Trade or Tax)		*Not quantified*	

ES-10	Generation Performance Standards or GHG Mitigation Requirements for New (and/or Existing) Generation Facilities, With/Without GHG Offsets		4.7	$13
ES-11	Methane and CO_2 Reduction in Oil and Gas Operations, Including Fuel Use and Emissions Reduction in Venting and Flaring	Reference Case	3.9	*Likely net benefit*
		High Fossil Fuel Case	6.6	*Likely net benefit*
ES-12	GHG Reduction in Refinery Operations, Including in Future Coal-to-Liquids Refineries	Coal-to-Liquids High Fossil Fuel Case	35	*Not estimated*
		Petroleum Refining – Reference Case	1.5	*Not estimated*
		Petroleum Refining – High Fossil Fuel Case	2.2	*Not estimated*
	Sector Total After Adjusting for Overlaps (Among ES Options and After Demand Reductions From RCI Options)	**Reference Case**	**21.9**	**$17**
		High Fossil Fuel Case	**79.4**	**$24**
	TRANSPORTATION AND LAND USE			
TLU-1	Light-Duty Vehicle Clean Car Standards		4.92	–$100
TLU-2	Fuel Efficient Replacement Tires Program		0.14	–$90
TLU-3	Consumer Information on Vehicle Miles Per Gallon		*Included in TLU-1 and TLU-2*	
TLU-4	Financial and Market Incentives for Low GHG Vehicle Ownership and Use		*Included in TLU-1*	
TLU-5	Growth and Development Bundle		0.77	<$0
TLU-6	Low-Carbon Fuels		0.39	N/A
TLU-7	Heavy-Duty Vehicle Emissions Standards and Retrofit Incentives		0.16	$79
TLU-8	Heavy-Duty Vehicle and Locomotive Idle Reduction		0.13	–$44
TLU-9	Procurement of Efficient Fleet Vehicles		*Included in TLU-1, TLU-6 through TLU-8, and TLU-11*	
TLU-10	Transportation System Management		*Not quantified*	
TLU-11	Intermodal Freight Transportation		0.59	N/A
TLU-12	Off-Road Engines and Vehicles GHG Emissions Reductions		*Not quantified*	
TLU-13	Reduced GHG Emissions From Aviation		*Not quantified*	
	Sector Total After Adjusting for Overlaps		**6.1**	**–$93**
	AGRICULTURE, FORESTRY, AND WASTE MANAGEMENT			
AFW-1	Agricultural Soil Carbon Management – Conservation/No-Till		3.7	$0
	Agricultural Soil Carbon Management – Organic Farming		*Not quantified*	
AFW-2	Biodiesel Production (Incentives for Feedstocks and Production Plants)		0.9	$14
AFW-3	Ethanol Production		2.2	$4
AFW-4*	Incentives for Enhancing GHG Benefits of Conservation Provisions of Farm Bill Programs		15	$12
AFW-5	Preserve Open Space and Working Lands – Agriculture		0.12	$32
	Preserve Open Space and Working Lands – Forests		0.9	$3
AFW-7	Expanded Use of Biomass Feedstocks for Energy Use		1.1	–$23
AFW-8	Afforestation/Reforestation Programs – Restocking		3.4	$12
	Afforestation/Reforestation Programs – Urban Trees		0.04	–$3
AFW-9	Improved Management and Restoration of Existing Stands		1.3	$119
AFW-10	Expanded Use of Wood Products for Building Materials		*Not quantified*	
AFW-11	Programs to Promote Local Food and Fiber		0.12	$5

AFW-12	Enhanced Solid Waste Recovery and Recycling	3.3	$17
	Reductions From Recent Actions	**0**	**$0**
	Sector Total Plus Recent Actions	**17**	**$26**
	CROSS CUTTING ISSUES		
CC-1	GHG Inventories and Forecasts	*Not quantified*	
CC-2	State GHG Reporting	*Not quantified*	
CC-3	State GHG Registry	*Not quantified*	
CC-4	State Climate Public Education and Outreach	*Not quantified*	
CC-6	Options for State GHG Goals or Targets	*Not quantified*	
CC-7	The State's Own GHG Emissions	*Not quantified*	

N/A = not applicable

* AFW-4 reductions were left out of the totals because they were not counted in the inventory.

Chapter 1
Background and Overview

The Governor's Initiative

Concerned about the profound implications that global warming could have on the economy, environment, and quality of life in Montana, Governor Brian Schweitzer on December 13, 2005, directed the Montana Department of Environment Quality (MDEQ) to establish a Climate Change Advisory Committee (CCAC).[1] The Governor asked the CCAC to "prepare a Climate Change Action Plan that includes recommendations for reducing greenhouse gas emissions in Montana and conserving energy in various sectors of our economy." Under this initiative, the CCAC took on the responsibility of identifying greenhouse gas (GHG) reduction opportunities in all economic sectors in Montana while at the same time seeking to save money, conserve energy, and bolster the Montana economy.

Governor Schweitzer noted the scientific consensus on this issue as embodied by reports issued by the Intergovernmental Panel on Climate Change (IPCC) and the National Academy of Sciences. Climate models indicate that global average temperatures could rise from 3 to 10 degrees Fahrenheit by the end of this century. The IPCC predicts that such a warming will result in rising sea levels, increased rainfall rates, heavy precipitation events (especially over the higher latitudes), and higher evaporation rates that would accelerate the drying of soils following rain events. Other studies of the effects of climate change on the Rocky Mountain West cite the potential for prolonged drought, earlier snowmelt, reduced snow pack, more severe forest fires, and other harmful effects.[2]

The CCAC presents this report covering:

- An inventory of historical, current, and forecasted GHG emissions in Montana,
- A description and analysis of existing policies and programs that currently reduce GHG emissions in Montana,
- Long-term GHG emission reduction goals for Montana and recommended policies to achieve these goals,
- Recommended mechanisms for implementing these goals and policies across all sectors of Montana's economy,
- Estimated GHG emissions reductions from the recommended policies, expressed in tons of carbon dioxide equivalents (tCO_2e),
- Consideration of the costs and benefits of the recommendations, and
- Challenges inherent in each recommendation as well as feasibility issues.

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[1] Appendix A is a copy of the Governor's letter.

[2] Agency Technical Work Group, State of New Mexico, Potential Effects of Climate Change on New Mexico, December 30, 2005. http://www.nmenv.state.nm.us/aqb/cc/Potential_Effects_Climate_Change_NM.pdf

The report is organized into six areas:

1. Inventory and Projections;
2. Residential, Commercial, Institutional, and Industrial;
3. Energy Supply;
4. Transportation and Land Use;
5. Agriculture, Forestry, and Waste Management; and
6. Cross-Cutting Issues.

The inventory and projections provide a forecast of Montana's GHG emissions under current practices. Goals and recommended policies in many sectors include assumptions, methods, and data used to quantify emissions reductions.

Greenhouse Gas Reduction Policies Already in Place

Currently in Montana there are a number of policies and programs designed to conserve energy, encourage the use of renewable energy, support replanting and growth of forests, and protect agricultural and range lands. These programs and policies include tax incentives and financing mechanisms for conservation and renewable energy, a renewable portfolio standard, and the opportunity for consumers to purchase "green power" from utility companies. Governor Schweitzer was the first governor in the nation to sign on to the 25 × 25 Initiative recommending that 25% of the nation's energy should come from renewable resources by 2025. The 2007 Montana Legislature also endorsed this policy. Montana participated in the Western Governors' Association Clean and Diversified Energy Initiative and is a member of *The Climate Registry*, a group of 39 states and 3 Canadian provinces working to track and reduce GHG emissions.

The CCAC Process

The CCAC was selected to represent a broad base of Montana citizens with diverse expertise and perspectives on climate change and GHG emissions. MDEQ Director Richard Opper appointed 18 stakeholders representing a broad range of backgrounds and interests. Montana's CCAC held its first meeting on July 13, 2006, followed by more than a year of intensive fact finding and consensus building. The CCAC met six times from July 2006 to July 2007.

A Scientific Advisory Panel drawn from agencies and Montana universities assisted the group. This panel included representatives from the Big Sky Carbon Sequestration Partnership, National Carbon Offset Coalition, United States Geological Survey, Montana State University, and The University of Montana. The representative from the University of Montana is also a member of the IPCC. The IPCC was recently awarded the 2007 Nobel Peace Prize.

Additional technical and policy expertise was provided by members of the public and private sectors who joined CCAC and Scientific Advisory Panel members on five Technical Work Groups (TWGs). The work groups developed initial recommendations and completed further analysis of options in five areas: Energy Supply (ES); Residential, Commercial, Institutional, and Industrial (RCII); Transportation and Land Use (TLU); Agriculture, Forestry, and Waste

Management (AFW); and Cross-Cutting Issues (CC). These five TWGs met more than 60 times via teleconference, beginning in August 2006 and concluding in September 2007.

The MDEQ organized the process and provided technical expertise to the sector-based TWGs. The CCAC followed a consensus-building process designed and implemented by the nonprofit Center for Climate Strategies (CCS). The CCS applied a design similar to those used in other successful state climate planning initiatives (i.e., Arizona and New Mexico). The CCS provided both facilitation services and technical analysis on emission reductions and costs to the CCAC in formulating its recommendations.

During the course of the process, the CCAC prepared a reference case inventory and projections of future Montana GHG emissions and then evaluated specific mitigation options to reduce GHG emissions including benefits, costs, and feasibility issues associated with the various options. The CCAC process sought but did not mandate consensus, and it explicitly documented the level of CCAC support for individual policy recommendations and key findings established through a voting process, including barriers to consensus where they existed.

The recommendations adopted by the CCAC and presented in this report underwent two levels of screening by the CCAC. First, a potential policy option being considered by a TWG was not accepted as a priority for analysis and developed for full analysis unless it had a super-majority of support from CCAC members (with a *super-majority* defined as five or fewer “no” votes or objections). Second, after the analyses were conducted, only policy options that received at least majority support from CCAC members were adopted as recommendations by the CCAC and included in this report. In total, of the 54 policy recommendations adopted by the CCAC, all received unanimous consent except for one, and that one had only one dissenting member for a portion of the recommendation.

Analysis of Options

With CCS providing facilitation and technical analysis, the TWGs prepared policy options for CCAC consideration using a “policy template” conveying the following key information:

- Policy description,
- Policy design (goals, timing, parties involved),
- Implementation mechanisms,
- Related policies/programs in place,
- Estimated GHG reductions and costs,
- Key uncertainties,
- Contributing issues,
- Feasibility issues,
- Status of group approval,
- Level of group support, and
- Barriers to consensus.

Over the course of its deliberations, the CCAC modified and embraced various policy options. The final versions, conforming to the original policy templates, appear in Appendixes F through J and constitute the most detailed record of decisions of the CCAC. Appendix E presents a description of the methods used for quantification of policy options. Three key methods are summarized here:

- **Estimates of GHG Reductions.** Using the projection of future GHG emissions (see below) as a starting point, analysis of the impact of policy recommendations produced estimates of the GHG reductions attributable to each option in the years 2010 and 2020, and cumulative over the time period 2007–2020. Many reductions occurred as a result of the quantity or type of fossil fuel combusted; others occurred as a result of methane, or carbon dioxide (CO_2) sequestered. Among the many assumptions involved in this task was selection of the appropriate GHG accounting framework, particularly the choice between a "production-based" approach vs. a "consumption-based" approach to calculating GHG emissions from certain sectors of the economy.[3]

  The consumption-based approach is based on estimates of the amount of energy consumed by Montana residents, businesses, industry, and institutions. This includes emissions that result from all of the electricity, natural gas, and transportation fuel use in Montana, plus direct emissions from all non-energy sectors of the economy (e.g., agriculture and industrial processes). The consumption-based approach does not include emissions associated with electricity generated in Montana for use in other states.

  The production-based approach includes everything in the consumption-based scenario plus those emissions associated with electricity that is produced in Montana for export to other states. This difference is significant, because Montana exports more than 40% of the electricity it produces on average each year. The CCAC looked at both the consumption-based and production-based approaches. The recommended policy options are identical under both approaches; however, the impact is different because projected GHG emissions are greater under the production-based approach.

  There are advantages and disadvantages to utilizing either approach as a framework for decision making. This report does not endorse one approach over the other but presents both sets of values for electricity in the energy supply sector. For all other sectors, the report applies the consumption-based approach only. The consumption and production-based approaches, along with other GHG estimation issues (e.g., analysis of overlapping or interacting policy impacts), are discussed below and in detail in Chapter 2, Appendix D (GHG Emissions Inventory and Reference Case Projections), and Appendix E (Methods for Quantification). In addition, the application of the consumption-based approach for the electricity sector receives additional treatment in Chapter 4 and Appendix G (Energy Supply).

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[3] In brief, a production-based approach estimates GHG emissions associated with goods and services produced within the state, and a consumption-based approach estimates GHG emissions associated with goods and services consumed within the state. In some sectors of the economy, these two approaches may not result in significantly different numbers; however, the power sector is notable in that it is responsible for large quantities of GHG emissions, and states often produce far more or far less electricity than they consume (with the remainder attributable to power exports or imports). Montana is an example of a high production energy exporting state.

- **Estimates of Cost.** CCS and the TWGs produced estimates of the cost of various policy options, both in terms of a net present value (NPV) from 2007 to 2020 and a dollars-per-ton-reduction cost (i.e., cost-effectiveness).[4] The costing approach used was similar to a conventional cost-benefit framework but had some important differences:
    - *Benefits vs. Costs*—The principal benefit of the CCAC options is reduced GHG emissions, and this benefit was quantified simply as tons of emissions reduced. Many options resulted in easily monetized economic benefits such as fuel savings and electricity savings. In such cases, monetized benefits were subtracted from monetized costs resulting in lower costs and even cost savings for some recommendations. There was no attempt to quantify or monetize other possible benefits associated with policy options such as health benefits from less air pollution.
    - *Direct vs. Indirect Effects*—Cost estimates were primarily based on "direct effects," i.e., those borne by the entities implementing the options.[5] Implementing entities could be individuals, companies, and/or government agencies. In contrast, conventional cost-benefit analysis takes the "societal perspective" and tallies every conceivable impact on every entity in society and quantifies these wherever possible.
    - *Montana vs. National/Global Perspective*—Costs estimates were based on implementing entities in Montana, not on a broader societal perspective (national or global). One implication of this is that national taxes or subsidies that affect actions in Montana were not part of the analysis.
    - *Discounted and "Levelized" Costs*— The NPVs of costs were calculated by applying a real discount rate of 5%. Dollars-per-ton estimates were derived as a levelized cost per ton (i.e., by dividing the present value cost by the cumulative GHG reduction measured in tons). As was the case with GHG reductions, the period 2007–2020 was analyzed.

Montana GHG Emissions Inventory and Reference Case Projections

In cooperation with MDEQ, CCS prepared a draft document, titled *Montana GHG Emissions Inventory and Reference Case Projections, 1990–2020* (hereafter *Inventory and Projections*). The projection of future emissions aimed to capture as accurately as possible the trajectory of emissions, given policies currently in place as of 2007 and recognizing the likely increase in fossil fuel production that will occur in Montana. The draft *Inventory and Projections* was presented to the CCAC at its first meeting and approved by unanimous consent at the CCAC's third meeting following technical review and revision.[6] The *Inventory and Projections* included detailed coverage of all economic sectors and GHGs in Montana, including future emissions trends and assessment issues related to energy and economic and population growth. The assessment provided discrete perspectives on total state emissions in two key areas:

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[4] The analysis addressed cost and did not attempt to estimate specific price changes or utility rate changes that might result from implementation of a policy option.

[5] "Indirect effects" were defined as those borne by entities other than those implementing the option. These indirect effects were quantified on a case-by-case basis depending on magnitude, importance, need and availability of data.

[6] With final technical corrections performed for this final CCAC report. The final *Montana GHG Emissions Inventory and Reference Case Projections, 1990–2020* report is available on the web at: www.mtclimatechange.us/CCAC.cfm.

1. The distinction between *gross* emissions (leaving aside carbon sinks such as forests and cropland) or *net* emissions (in which lowered emissions due to carbon sinks are subtracted from gross emissions).
2. The differences between production-based and consumption-based accounting (see earlier discussion).

These two key factors resulted in the following perspectives for measuring Montana GHG emissions:

- Gross GHG emissions using the production-based approach in all sectors,
- Net GHG emissions (including carbon sinks) using the production-based approach in all sectors,
- An alternative using an expected higher rate of in-state fossil fuel production in the future,
- Gross GHG emissions using the consumption-based approach in the electricity sector, and
- Net GHG emissions using the consumption-based approach in the electricity sector.

After considering the relative merits of these perspectives, the CCAC decided that net emissions in all sectors using the consumption-based approach would be the basis for the report except in the electricity sector where both the consumption-based and production-based approaches needed to be considered. A detailed discussion of the issues involved appears in Chapter 2 and the final report is referenced Appendix D and available on the web at: www.mtclimatechange.us/CCAC.cfm.

The *Inventory and Projections* revealed substantial emissions growth rates and related policy challenges. Figure 1-1 shows the reference projections for Montana's gross GHG emissions (not counting sequestration) steadily climbing to 42 million metric tons of carbon dioxide equivalents ($MMtCO_2e$)[7] by 2020, 30% above 1990 levels. Most of this growth in emissions is projected to come from the transportation sector. Accounting for carbon sequestration or carbon sinks, Montana's forests and soil would decrease the gross estimates by about 25.4 $MMtCO_2e$ annually, resulting in net emissions of about 16.3 $MMtCO_2e$ in 2020. Figure 1-1 also illustrates the breakdown of forecasted GHG emissions by sector.

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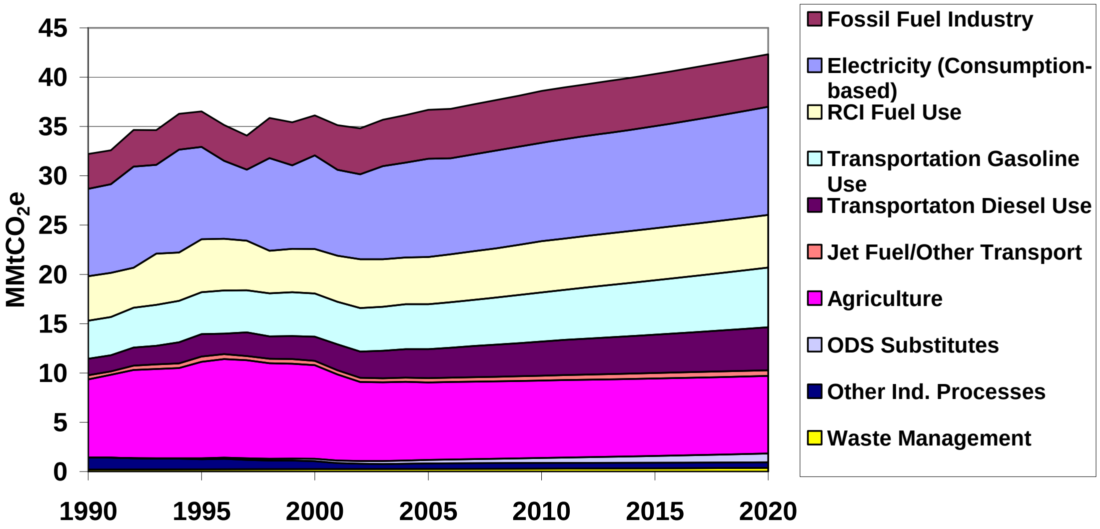
[7] Carbon dioxide equivalency is a method used to compare the emissions from various GHGs based upon their global warming potential (GWP) and their comparative ability to trap radiation and increase warming. It is commonly expressed as million metric tons of carbon dioxide equivalents ($MMtCO_2e$). For example, the GWP for methane is 24.5, meaning that emissions of one million metric tons of methane is equivalent to emissions of 24.5 million metric tons of carbon dioxide.

Figure 1-1. Gross GHG emissions by sector, 1990–2020: historical and projected (consumption-based approach)



The inventory and projection of Montana's GHG emissions provided several critical findings:

- The electricity and transportation sectors are two of the sectors with the largest emissions (26% and 20%, respectively) and are expected to continue to grow.
- Agriculture, with 26% of Montana's gross GHG emissions, is the second largest GHG source (after electricity) and is expected to remain reasonably constant over time.
- Montana has a significant fossil fuel production sector that produces natural gas (by both conventional production and coal bed methane extraction), oil, and coal for export out-of - state. In 2000, the fossil fuel industries' emissions accounted for 11% of gross GHG emissions.

While Montana's emissions growth rate presents challenges, it also provides major opportunities. Key choices on technologies and infrastructure can have a significant impact on emissions growth. The CCAC's recommendations document the opportunities for the state to reduce its GHG emissions while continuing strong economic growth by being more energy efficient, using more renewable energy sources, and increasing the use of cleaner transportation modes, technologies, and fuels. New approaches to sequestering the carbon from fossil fuel extraction and processing can offset growth in emissions from the energy supply sector. The inventory and reference case projections are discussed in more detail in Chapter 2; the full study, provided as a companion document to this report, is referenced in Appendix D.

Overview of CCAC Policy Recommendations

The CCAC is making 54 policy recommendations to the Governor to help reduce the state's GHG emissions. If implemented, the recommendations are projected to reduce the state's GHG emissions by 11.5 MMtCO$_2$e by 2020 below what emissions would be in 2020 without the recommendations. Figure 1-2 illustrates the level of reductions that these recommendations would achieve compared with the projected growth in Montana's GHG emissions (the "reference case" forecast of emissions) using a consumption-based approach. Table 1-1 provides the numeric estimates underlying Figure 1-2. Figure 1-3 and Table 1-2 illustrate the level of reductions these recommendations would achieve compared with the projected growth in Montana's GHG emissions using a production-based approach. The CCAC recommendations reach and exceed their reduction target for the consumption-based case but fall short for the production-based case. This is largely because the 54 recommended policy options do not significantly reduce emissions from the electricity that is currently produced in Montana and exported out of state.

Figure 1-2. Reference case Montana gross GHG emissions (consumption basis)

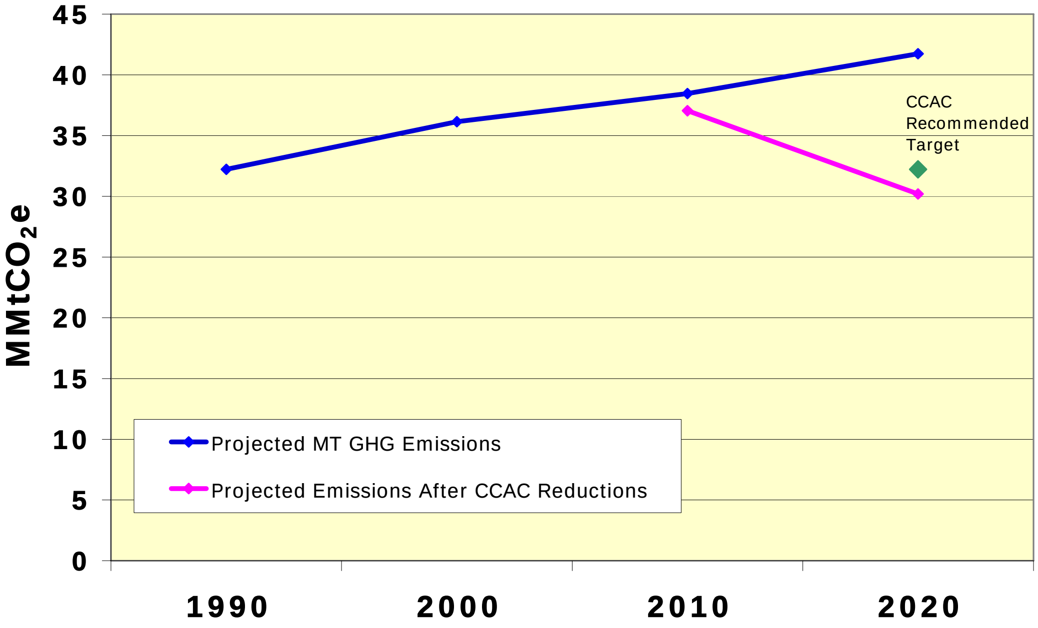


Table 1-1. Annual gross emissions (consumption basis): reference case projections and CCAC recommendations

Annual Gross Emissions–Consumption Basis ($MMtCO_2e$)	1990	2000	2010	2020
Reference Case Projections	32.2	36.1	38.5	41.7
CCAC Recommended Target*				32.2
GHG Reductions From CCAC Recommendations			–1.4	–11.5
Annual Emissions With CCAC Recommendations			37.1	30.2

* This target aims to reduce Montana GHG emissions to 1990 levels by 2020.

Figure 1-3. Reference case Montana gross GHG emissions (production basis)

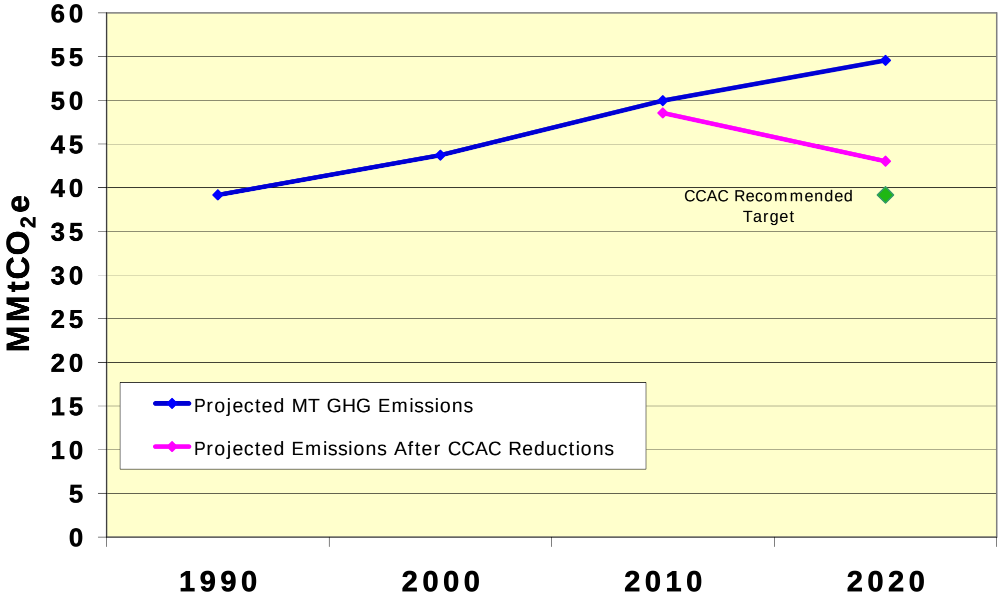


Table 1-2. Annual gross emissions (production basis): reference case projections and CCAC recommendations

Annual Gross Emissions–Production Basis ($MMtCO_2e$)	1990	2000	2010	2020
Reference Case Projections	39.2	43.7	50.0	54.6
CCAC Recommended Target*				39.2
GHG Reductions From CCAC Recommendations			–1.4	–11.5
Annual Emissions With CCAC Recommendations			48.6	43.0

* This target aims to reduce Montana GHG emissions to 1990 levels by 2020.

The CCAC recommends that Montana establish a statewide, economy-wide GHG reduction goal to reduce gross GHG emissions to 1990 levels by 2020, for both consumption-based and production-based emissions, and to further reduce emissions to 80% below 1990 levels by 2050. In lieu of establishing a specific target sooner than 2020, the CCAC also strongly recommends early and aggressive implementation of its comprehensive recommendations, along with a corresponding set of incentives to promote early adoption of needed changes. These goals are consistent with the levels and framework of goals set by other states, including those in the West, that are implementing GHG reduction strategies.

Table 1-3. Comparison of state GHG reduction goals and timelines

State	GHG Reduction Goals and Timelines
AZ	2000 levels by 2020; 50% below 2000 levels by 2040
CA	2000 levels by 2010; 10% below by 2020; 80% below by 2050
CT	1990 levels by 2010; 10% below by 2020; 75% below by 2050
MA	1990 levels by 2010; 10% below by 2020; 75% below by 2050
ME	1990 levels by 2010; 10% below by 2020; 75% below by 2050
MT	**1990 levels by 2020, 80% below by 2050**
NJ	5% below 1990 levels by 2005
NM	2000 levels by 2012; 10% below by 2020; 75% below 2050
NY	5% below 1990 levels by 2010
OR	1990 levels by 2010; 10% below by 2020; 75% by 2100
RI	1990 levels by 2010; 10% below by 2020; 75% by 2050
VT	25% below 1990 levels by 2012; 50% below 2028; 75% below by 2050
WA (Puget Sound)	1990 levels by 2010; 10% below by 2020; 75% by 2100

For Montana, as for any state, meeting a near-term reduction goal will require prompt and energetic implementation of the required GHG reduction policies by state government and all stakeholders. Meeting longer-term goals will require a consistent commitment by successive governors and legislatures, aided by an equal commitment by those same stakeholders.

The CCAC's recommendations are summarized in the Executive Summary, along with rankings of the options in terms of total GHG reductions and cost (or cost savings). Chapters 3 through 7 and the Appendixes provide detailed descriptions and analysis of GHG reductions, costs, additional impacts, and feasibility for individual options developed by the five TWGs:

- Residential, Commercial, Institutional, and Industrial (RCII);
- Energy Supply (ES);
- Transportation and Land Use (TLU);
- Agriculture, Forestry, and Waste Management (AFW); and
- Cross-Cutting Issues (CC).

Although not prepared in coordination with other state and regional actions, the recommendations adopted by the CCAC are consistent with and supportive of resolutions adopted by the Western Governors' Association (WGA), including those adopted at its June 2006 annual meeting in Sedona, Arizona, pertaining to "Regional and National Policies Regarding Global Climate Change,"[8] "Clean and Diversified Energy for the West,"[9] and "Transportation Fuels for the Future,"[10] as well as the recommendations of the WGA's Clean and Diversified Energy Advisory Committee.[11]

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[8] Resolution 06-3 http://www.westgov.org/wga/policy/06/climate-change.pdf

[9] Resolution 06-10 http://www.westgov.org/wga/policy/06/clean-energy.pdf

[10] Resolution 06-20 http://www.westgov.org/wga/policy/06/futurefuels.pdf

[11] http://www.westgov.org/wga/meetings/am2006/CDEAC06.pdf

The CCAC's recommendations also complement other efforts underway in Montana, outlined at the beginning of this chapter. This underscores the potential co-benefits of the CCAC's recommended policy options.

Chapter 2
Inventory and Projections of GHG Emissions

Introduction

This chapter presents a summary of the full study, *Montana Greenhouse Gas Inventory and Reference Case Projections 1990–2020* (hereafter, the *Inventory and Projections*, Appendix D to this report) and includes the emission estimates (historical and projected) along with key methodological issues and uncertainties. These estimates are intended to help the state and stakeholders understand past, current, and possible future greenhouse gas (GHG) emissions in Montana and thereby inform the policymaking process.

Historical GHG emissions estimates (1990 through 2005)[1] were developed using a set of generally accepted principles and guidelines for state GHG emissions inventories, relying to the extent possible on Montana-specific data and inputs. The reference case projections (2006–2020) are based on a compilation of various existing Montana and regional projections of electricity generation, fuel use, and other GHG-emitting activities, along with a set of simple, transparent assumptions described later in this chapter. Developing a "reference case" projection for the most likely development of Montana's electricity and fossil fuel production sectors is particularly challenging, given the many factors impacting energy production-related emissions. The principal uncertainty of interest is on the high side, given the many plans and initiatives to increase coal utilization locally and nationally. As a result, an alternative scenario of future energy supply development—the high fossil fuel production scenario—is also included.

Inventory and Projections covers the six types of gases included in the U.S. Greenhouse Gas Inventory: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Emissions of these GHGs are presented using a common metric, CO_2 equivalents (CO_2e), which indicates the relative contribution of each gas, per unit mass, to global average radiative forcing on a global warming potential- (GWP-) weighted basis.

It is important to note that the preliminary emissions estimates reflect the *GHG emissions associated with the electricity sources used to meet Montana's demands,* corresponding to a consumption-based approach to emissions accounting. Another way to look at electricity emissions is to consider the GHG emissions produced by electricity generation facilities in the state. For many years, Montana power plants have tended to produce considerably more electricity than is consumed in the state—emissions associated with exported electricity are excluded from the consumption-based emissions. This report covers both methods of accounting for emissions, but for consistency, all total results are reported as *consumption-based.*

Montana GHG Emissions: Sources and Trends

Table 2-1 provides a summary of GHG emissions estimated for Montana by sector for the years 1990, 2000, 2005, 2010, and 2020. As shown in this table, Montana is estimated to be a net

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[1] The last year of available historical data varies by sector from 2000 to 2005.

source of GHG emissions, but with significant sinks of GHG emissions due to the forestry sector and agricultural soils. We note that there are significant uncertainties associated with estimating forest carbon sinks. In the sections below, we discuss GHG emission sources (positive, or *gross*, emissions) and sinks (negative emissions) separately in order to clearly identify trends, projections, and uncertainties.

The next section of the report provides a summary of the historical emissions (1990 through 2005) followed by a summary of the forecasted reference case projection year emissions (2006 through 2020), key uncertainties, and next steps. We also provide an overview of the general methodology, principles, and guidelines followed for preparing the inventory.

Table 2-1. Montana historical and reference case GHG emissions, consumption-based by sector*

$MMtCO_2e$	1990	2000	2005	2010	2020
Energy	**22.9**	**25.3**	**27.7**	**29.2**	**32.0**
Electricity use	8.9	9.5	10.0	10.0	11.0
Transportation fuel use	5.9	7.3	8.0	8.8	10.4
Fossil fuel industry	3.5	4.1	5.0	5.2	5.3
Residential/commercial/other industrial fuel use	4.5	4.5	4.8	5.2	5.3
Other	**9.3**	**10.9**	**9.1**	**9.3**	**9.8**
Industrial processes	1.2	1.0	0.9	1.1	1.5
Agriculture	7.9	9.5	7.9	7.9	7.9
Waste management	0.2	0.2	0.3	0.3	0.4
Gross emissions	**32.2**	**36.1**	**36.8**	**38.5**	**41.7**
Change relative to 1990		*12%*	*14%*	*19%*	*30%*
Change relative to 2000			*2%*	*6%*	*15%*
Forestry	**–23.1**	**–23.1**	**–23.1**	**–23.1**	**–23.1**
Agricultural soils sink	**–2.3**	**–2.3**	**–2.3**	**–2.3**	**–2.3**
Net emissions (including sinks)	**6.8**	**10.7**	**11.4**	**13.1**	**16.3**
Change relative to 1990		*57%*	*67%*	*92%*	*139%*
Change relative to 2000			*7%*	*22%*	*52%*
Per capita gross emissions	**40.3**	**40.1**	**39.4**	**39.7**	**40.8**
Per capita net emissions	**8.5**	**11.9**	**12.2**	**13.5**	**15.9**

*Totals may not equal exact sum of subtotals shown in this table due to independent rounding.
$MMtCO_2e$ = million metric tons carbon dioxide equivalent

Historical Emissions

Overview

Preliminary analyses suggest that in 2005, activities in Montana accounted for approximately 37 million metric tons (MMt) of CO_2e gross emissions, an amount equal to 0.6% of total U.S. GHG emissions.[2] Montana's gross GHG emissions are rising at about the same rate as those of

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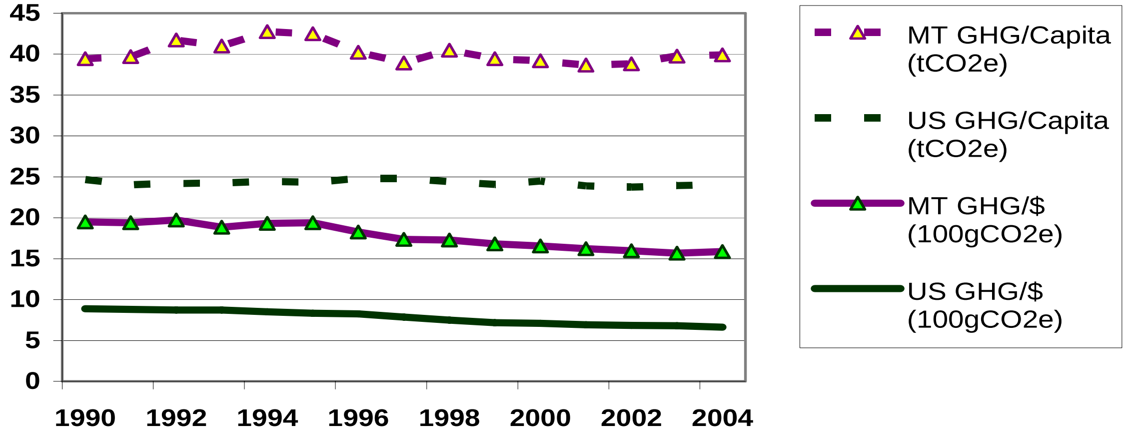
[2] United States emissions estimates are drawn from US EPA 2006. *Inventory of US Greenhouse Gas Emissions and Sinks:1990–2004*.

the nation as a whole.[3] Montana's gross GHG emissions were up 11% from 1990 to 2004, while national emissions rose by 15% during this period.

Although Montana's GHG emissions are low on an absolute scale compared with the total national output on a per capita basis during the period from 1990 to 2004, Montanans emit about 40 $MtCO_2e$, much higher than the national average of 25 $MtCO_2e$ over this same time period. The reasons for the higher per capita intensity in Montana are varied, but they include the state's strong fossil fuel production industry, large agricultural industry, large distances for transportation, and low population base. Figure 2-1 illustrates the state's emissions per capita and per unit of economic output. It also shows that, like the nation as a whole, per capita emissions have remained fairly flat, while economic growth exceeded emissions growth throughout the 1990–2004 period. From 1990 to 2004, emissions per unit of gross product dropped by 25% nationally and by 18% in Montana.

Figure 2-1. Montana and U.S. gross GHG emissions, per capita and per unit gross product



tCO_2e = tons carbon dioxide equivalent gCO_2e = grams carbon dioxide equivalent

Electricity use, agriculture, and transportation are the state's principal GHG emissions sources. Together, the combustion of fossil fuels for electricity generation used in-state and in the transportation sector account for about 46% of Montana's gross GHG emissions, as shown in Figure 2-2. The relative contribution of agricultural emissions (methane and N_2O emissions from manure management, fertilizer use, and livestock) is much higher in Montana (26%) than in the nation as a whole (7%). This is a result of more agricultural activity per capita in Montana compared with that in the United States as a whole. The state also has higher levels of emissions (methane) from the fossil fuels industry—natural gas, oil products, and coal—than the national average (11% of the state's emissions). The remaining use of fossil fuels in the residential,

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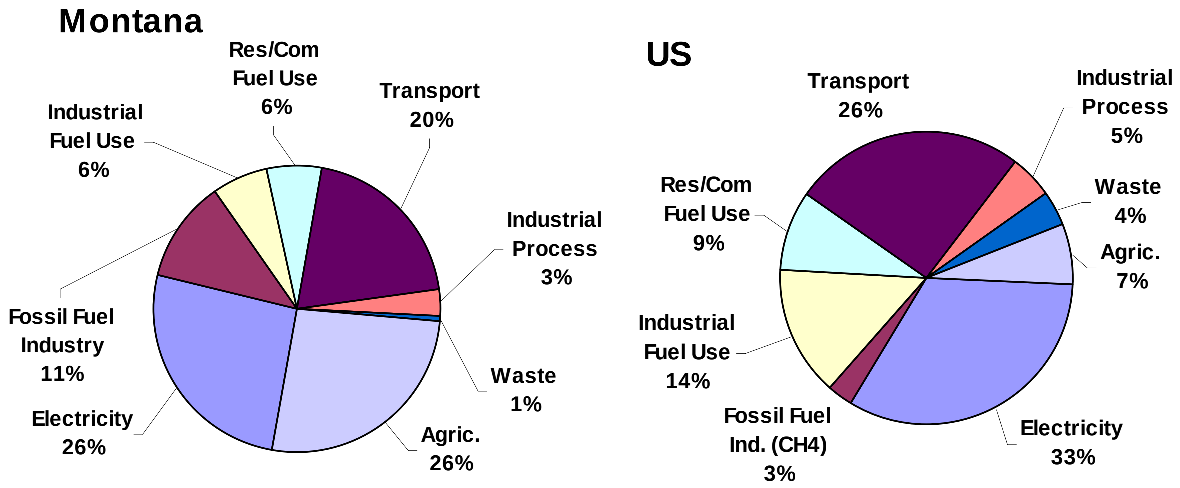
[3] *Gross* emissions estimates include only those sources with positive emissions. Carbon sequestration in soils and vegetation is included in *net* emissions estimates. All emissions reported in this section for Montana reflect consumption-based accounting (excluding emissions from electricity exports). On a national basis, little difference exists between *production-based* and *consumption-based* accounting for GHG emissions because net electricity imports are less than 1% of national electricity generation.

commercial, institutional, and industrial (RCII) sectors constitutes another 12% of state emissions.

Figure 2-2. Gross GHG emissions by sector, 2000, Montana and US



Industrial process emissions comprised only about 3% of state GHG emissions in 2000, but these emissions are expected to rise in the future due to the increasing use of HFCs as substitutes for ozone-depleting chlorofluorocarbons.[4] Other industrial process emissions result from CO_2 released during aluminum and cement production and soda ash, limestone, and dolomite use. Landfills and wastewater management facilities produce CH_4 and N_2O emissions accounting for the remaining 1% of the state's emissions in 2000.

Based on data from 1989 to 2004, Montana's forests are estimated to be net sinks, accounting for –23.1 $MMtCO_2$ of GHG emissions (the negative value indicates a net sequestration of carbon dioxide from the atmosphere). Also, agricultural soils are estimated to sequester an additional 2.3 $MMtCO_2$. With these GHG sinks, Montana's net emissions were 6.8 $MMtCO_2$ in 1990. Because of a lack of information for estimating future trends, these sinks were estimated to remain constant throughout the forecast period from 2005 through 2020. Thus, with the increase in GHG emission sources, by 2020, the net emissions in Montana are estimated to increase to about 16.3 $MMtCO_2e$/year.

The Center for Climate Strategies (CCS) also prepared emission estimates for black carbon (BC), which is an aerosol species (component of particulate matter) that has positive climate forcing potential. The 2002 estimates for BC were 2.6 $MMtCO_2e$ across all source sectors. This is about 7% of the total emissions for the six GHGs shown in Table 2-1 during this period. Important sources of BC are diesel combustion, non-road engines (31%), rail (29%), and on-road vehicles (24%). An assessment of these sources using available data for a 2018 projection from the Western Regional Air Partnership showed a decrease in the on-road and non-road diesel sectors because of the new federal engine and fuel standards for particulate matter. Rail emissions rose

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[4] Chlorofluorocarbons (CFCs) are also potent GHGs; however, they are not included in GHG estimates because of concerns related to implementation of the Montreal Protocol. See Appendix J.

only slightly. Overall, future BC emissions are expected to drop as a result of the new federal standards.

A Closer Look at the Three Major Sources: Electricity, Agriculture, and Transportation

As shown in Figure 2-2, the electricity, agriculture, and transportation sectors are the largest contributors to Montana's gross consumption-based emissions. These sectors accounted for 26%, 26%, and 20%, respectively, of total GHG emissions in 2000.

It is important to note that the electricity emissions estimates reflect the *GHG emissions associated with the electricity sources used to meet Montana demands,* corresponding to a consumption-based approach to emissions accounting. Another way to look at electricity emissions is to consider the GHG emissions produced by electricity generation facilities in the state. For many years, Montana power plants produced almost twice the electricity that was consumed in the state. In the year 2000, for example, Montana exported 41% of the electricity produced in the state. As a result, in 2000, emissions associated with electricity consumption (9.5 MMtCO$_2$e) were much lower than those associated with electricity production (17.1 MMtCO$_2$e).[5]

While we estimate both the emissions from electricity production and consumption, unless otherwise indicated, tables, figures, and totals in this report reflect electricity consumption emissions. The consumption-based approach can better reflect the emissions (and emissions reductions) associated with activities occurring in the state, particularly with respect to electricity use (and efficiency improvements), and is particularly useful for policy making. Under this approach, emissions associated with electricity exported to other states would need to be covered in those states' accounts in order to avoid double counting or exclusions. (Indeed, Arizona, California, Oregon, New Mexico, and Washington are currently considering such an approach.)

Emissions from agricultural sources (CH_4 and N_2O emissions from enteric fermentation, manure management, agricultural soils and crop residue burning) ranged from about 8 to 10 MMtCO$_2$e during the period 1990 to 2005. Total GHG emissions increased from 8 MMtCO$_2$e in 1990 to a high of 10 MMtCO$_2$e in 1996 before dropping back to 8 MMtCO$_2$e in 2002 and remaining at this level. Except for emissions from agricultural soils, emissions in each subsector were fairly static. For agricultural soils, emissions grew through the mid-1990s but then began to fall during the late 1990s. Emissions from agricultural soils are N_2O emissions from the use of synthetic fertilizers, crop residue, nitrogen fixing crops, and manure application. Manure application is the largest contributor to the emissions from agricultural soils.

Like electricity emissions, GHG emissions from transportation fuel use have risen steadily since 1990 at an average rate of slightly over 2% annually. Gasoline-powered vehicles account for about 54% of transportation GHG emissions in 2005. Diesel consumption accounts for another 39%, air travel for roughly 6%, and the remainder of transportation emissions come from natural gas and liquefied petroleum gas (LPG) vehicles and lubricants. As the result of Montana's

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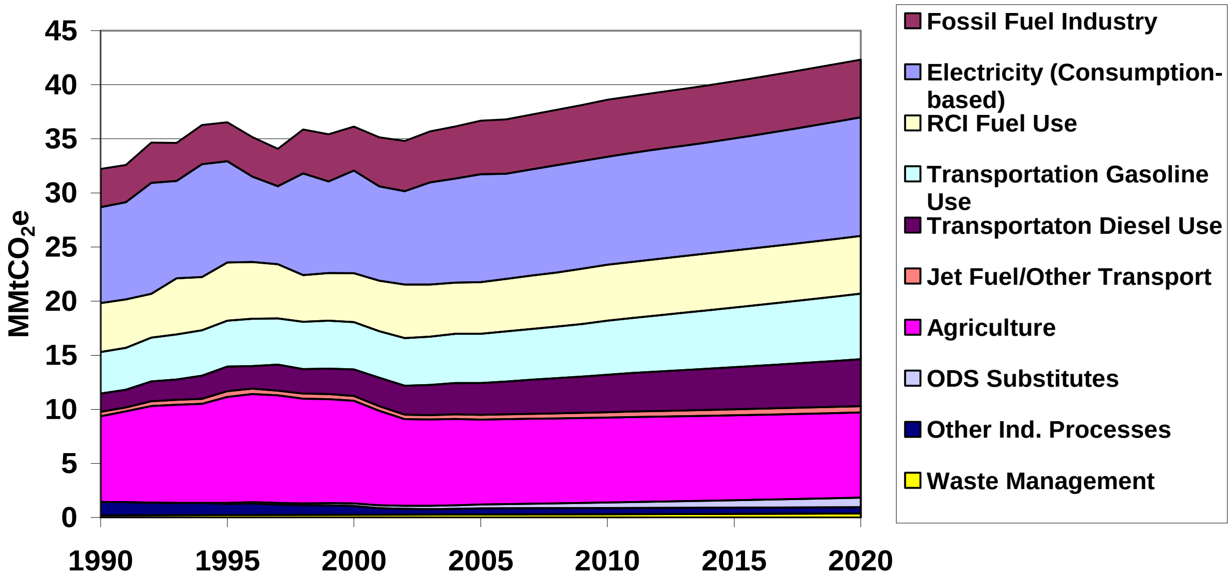
[5] Estimating the emissions associated with electricity use requires an understanding of the electricity sources (both in-state and out-of-state) used by utilities to meet consumer demand. The current estimate reflects some very simple assumptions described in Appendix A of *Inventory and Projections*.

population and economic expansion and an increase in miles traveled during the 1990s, gasoline use has grown at rate of 0.9% annually from 1990 to 2005. Meanwhile, over the same period, on-road diesel fuel use has risen 4% annually, suggesting an even more rapid growth in freight movement within the State.

Reference Case Projections

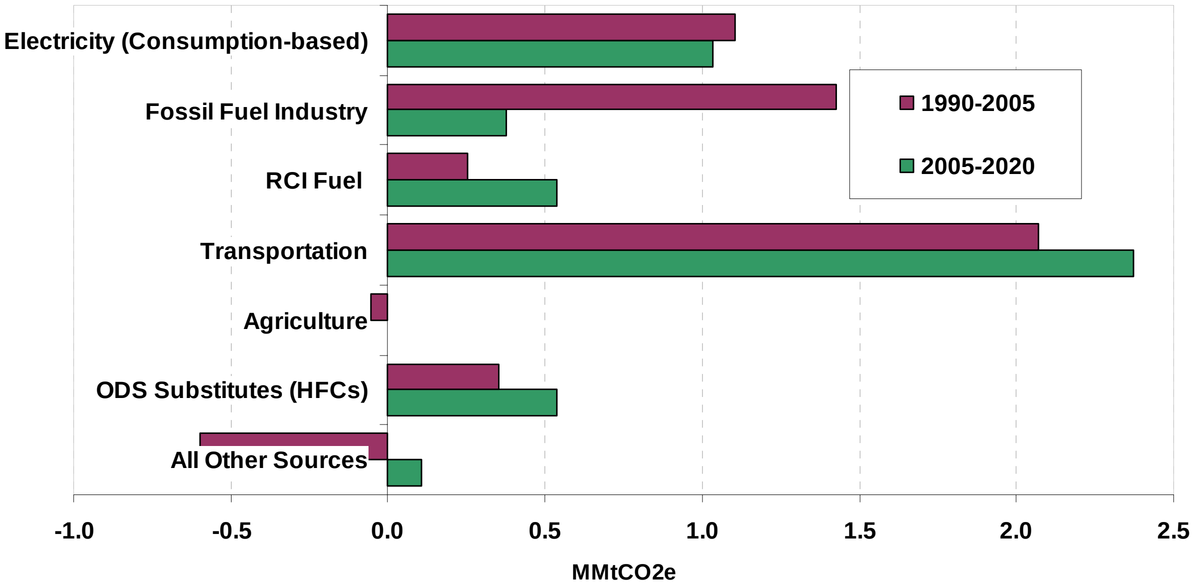
Relying on a variety of sources for projections of electricity and fuel use, as noted below and in *Inventory and Projections*, we developed a simple reference case projection of GHG emissions through 2020. As illustrated in Figure 2-3 and shown numerically in Table 2-1 under the reference case projections, Montana gross GHG emissions continue to grow steadily, climbing to 42 MMtCO$_2$e by 2020, 30% above 1990 levels. Transportation is projected to be the largest contributor to future emissions growth, followed by the electricity sector, as shown in Figure 2-4. Other major sources of emissions growth include the fossil fuel industry and RCII fuel use. The decrease in GHG emissions from *All Other Sources* in Figure 2-4 is driven by the drop in aluminum production from 1990 to 2005.

Figure 2-3. Montana gross GHG emissions by sector, 1990–2020: historical and projected under reference case assumptions



*RCI = direct fuel use in residential, commercial, and industrial sectors (excluding the fossil fuel production industry); ODS = ozone-depleting substance. Other Ind. Processes includes process-related GHG emissions from aluminum production, cement production, and soda ash, limestone, and dolomite use.

Figure 2-4. Sector contributions to emissions growth in Montana, 1990–2020: historic and reference case projections



*RCI = direct fuel use in residential, commercial, and industrial sectors (excluding the fossil fuel production industry); ODS = ozone-depleting substance; HFC = hydrofluorocarbon.

High Fossil Fuel Production Scenario

Given the many factors impacting energy production-related emissions and a diversity of assumptions by stakeholders within the energy sector, developing a "reference case" projection for the most likely development of Montana's electricity and fossil fuel production sectors is particularly challenging. The principal uncertainty of interest is on the high side, given the many plans and initiatives to increase coal utilization locally and nationally. As a result, we explore an alternative scenario of future energy supply development—the high fossil fuel production scenario. The high fossil fuel scenario assumes that

- Additional new transmission lines will be built to export power from Montana. The total additional transmission lines in this case would have a capacity of 2,500 additional MW over the reference case addition of 500 MW, or 3,000 total additional MW capacity, relative to current levels. The new power plants built in Montana to use the capacity of the additional transmission lines are assumed to be a mix of 67% fluidized bed coal and 33% wind.
- Total natural gas production triples between 2005 and 2010 and increases an additional 74% above 2010 levels by 2020. Much of this increase is driven by increased coal bed methane development. To support this production, the scenario assumes two new natural gas transmission lines cross the state.
- Montana refining capacity increases, through both expansion of existing refineries and the addition of a new refinery, for refining of Athabasca crude from Alberta's oil sands.
- Two commercial coal-to-liquids plants are assumed to begin operation in Montana, and coal mining increases modestly to support these plants.

The above assumptions reflect the high end of estimates for future fossil fuel development, under favorable conditions.

Table 2-2 presents a summary of GHG emissions from the electricity sector in Montana on a production basis for both the reference case and the high fossil fuel scenario and on a consumption basis, which has the same estimated emissions for each case. Though the GHG emissions are significantly different from each other, each set of estimates is valid depending on circumstances. The difference between the emissions in the reference case and the high fossil fuel scenario estimates reflects the uncertainty in future energy development in Montana. The consumption-based emissions represent a focus on the emissions associated with electricity consumption in Montana. This focus is important when evaluating the effects of actions directed at in-state electricity conservation.

Table 2-2. Summary GHG emissions for Montana electric sector

(MMtCO$_2$e)	**1990**	**2000**	**2005**	**2010**	**2020**
Production-based					
Reference case	15.8	17.1	19.3	21.5	23.8
High fossil fuel scenario	15.8	17.1	19.3	21.5	34.2
Consumption-based	**8.9**	**9.5**	**10.0**	**10.0**	**11.0**

Note: Consumption-based emissions are the same for both the reference case and the high fossil fuel scenario because electricity consumption in Montana is the same for both cases.

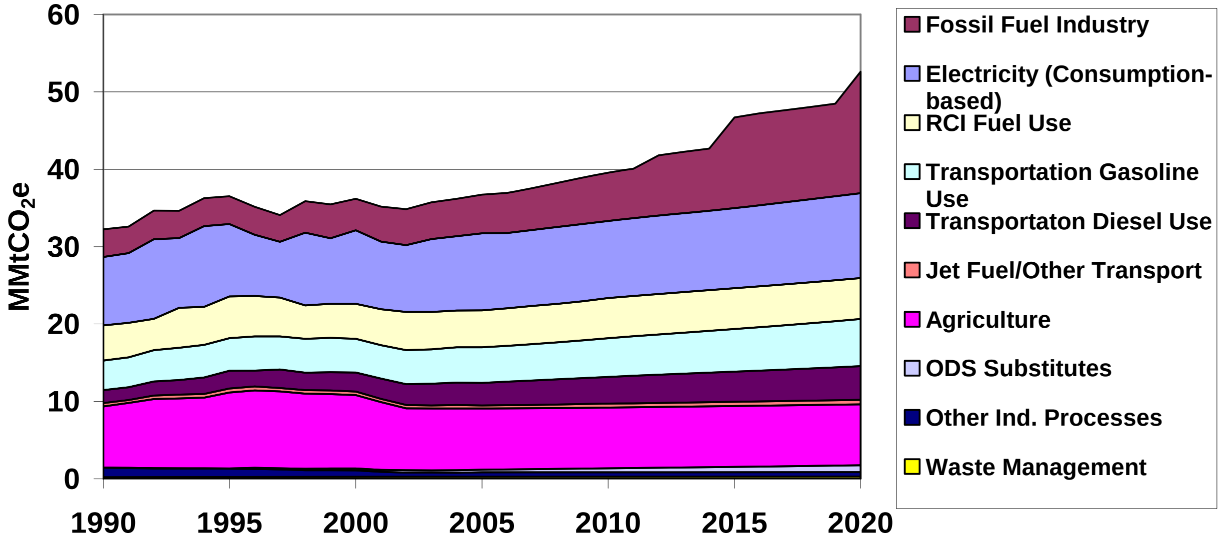
Table 2-3 presents a summary of GHG emissions from the Montana fossil fuel sector for both the reference case and the high fossil fuel scenario. The projected growth between 2005 and 2020 is only 7% in the reference case and 216% in the high fossil fuel case, in which a number of unconventional technologies are assumed to reach commercial scale production. Under the high fossil fuel scenario, GHG emissions in 2020 are 10 MMtCO$_2$e higher than in the reference case, adding approximately 19% to the state's production-based emissions in that year.

Table 2-3. Comparison of total fossil fuel industry GHG emissions for reference and high fossil fuel scenario

(MMtCO$_2$e)	**1990**	**2000**	**2005**	**2010**	**2015**	**2020**
Fossil fuel industry						
Reference case	**3.5**	**4.1**	**5.0**	**5.2**	**5.3**	**5.3**
Natural gas industry	1.4	1.7	2.0	2.3	2.3	2.4
Oil industry	2.0	2.2	2.7	2.8	2.8	2.8
Coal mining	0.2	0.2	0.2	0.2	0.2	0.2
Coal-to-liquids	0.0	0.0	0.0	0.0	0.0	0.0
High fossil fuel scenario	**3.5**	**4.1**	**5.0**	**6.2**	**11.7**	**15.7**
Natural gas industry	1.4	1.7	2.1	2.9	3.4	3.6
Oil industry	2.0	2.2	2.7	3.1	4.4	4.4
Coal mining	0.2	0.2	0.2	0.2	0.2	0.3
Coal-to-liquids	0.0	0.0	0.0	0.0	3.7	7.3

Figure 2-5 illustrates the Montana gross GHG emissions under the high fossil fuel scenario assumptions. In this case, gross GHG emissions are projected to grow to 52 MMtCO$_2$e by 2020, 61% above 1990 levels.

Figure 2-5. Montana gross GHG emissions by sector, 1990–2020: historical and projected under high fossil fuel scenario assumptions



RCI = residential, commercial, and industrial; ODS = ozone-depleting substance.

Key Uncertainties

Some data uncertainties exist in this inventory, and particularly in the reference case projections. Potential improvements to this work include developing a better understanding of the electricity generation sources currently used to meet Montana loads (in collaboration with state utilities), and review and revision of key drivers such as the electricity and transportation fuel use growth rates that will be major determinants of Montana's future GHG emissions (See Table 2-4). These growth rates are driven by uncertain economic, demographic, and land use trends (including growth patterns and transportation system impacts), all of which could be refined further.

Perhaps the variable with the most important implications for GHG emissions is the type and number of power plants built in Montana between now and 2020. The assumptions related to vehicle miles traveled (VMT) and air travel growth also have large impacts on the GHG emission growth in the state. Finally, uncertainty remains on estimates for historic GHG sinks from forestry and agriculture, and projections for these emissions will greatly impact the net GHG emissions attributed to Montana.

Table 2-4. Key annual growth rates for Montana, historical and projected

	1990–2005	2005–2020	Sources
Population	1.0%	0.6%	U.S. Bureau of Census
Employment			Montana Department of Labor Web site, based on analysis by the US Bureau of Labor and Statistics
Goods	2.5%	0.9%	
Services	2.3%	1.7%	
Electricity sales	0.0%	1.6%	EIA (USDA's Energy Information Administration) data for 1990–2004 (0% growth is a mix of increased residential and commercial electricity sales countered by a large decrease in industrial sales), projections based on plans from Montana utilities (all sectors projected to have increased sales)
Vehicle miles traveled	1.7%	1.9%	Federal Highway Administration, Highway Statistics; projections from Montana Department of Transportation

* Population and employment projections for Montana were used together with US DOE's Annual Energy Outlook 2006 projections of changes in fuel use on a per capita and per employee basis, as relevant for each sector. For instance, growth in Montana's residential natural gas use is calculated as the Montana population growth times the change in per capita natural gas use for the Mountain region. Montana population growth is also used as the driver of growth in cement production, soda ash consumption, and dolomite and limestone use.

Chapter 3
Residential, Commercial, Institutional, and Industrial Sectors

Overview of Sectoral Greenhouse Gas Emissions

The residential, commercial, institutional, and industrial (RCII) sectors were directly responsible for just over 15% of Montana's gross greenhouse gas (GHG) emissions as of 2005—a total of 5.7 MMtCO$_2$e (million metric tons of CO$_2$ equivalent). Direct emissions from these sectors result principally from the on-site combustion of natural gas, oil, coal, and wood, as well as the release of CO$_2$ and fluorinated gases (hydrofluorocarbons, or HFCs, and perfluorocarbons, or PFCs) during industrial processing (largely cement and, to a significantly lesser extent, the aluminum industry), the leakage of HFCs from refrigeration and related equipment, and to a smaller, and recently declining degree, from the use of sulfur hexafluoride (SF$_6$) in the utility industry.[1]

In addition to direct emissions from combustion of fuels and industrial processes in the RCII sectors, nearly all of the electricity sold in the Montana is consumed as the result of residential, commercial, institutional, and industrial activity. If the emissions associated with producing the electricity consumed in Montana are considered, RCII activities are associated with about 43% (15.7 MMtCO$_2$e) of the state's gross GHG emissions.[2] Montana's future GHG emissions therefore will depend significantly on future trends in the consumption of electricity and other fuels in the RCII sectors.

Historical and projected GHG emissions for the RCII sectors by fuel and source are provided in Figure 3-1 for the Reference Case forecast scenario. This figure illustrates the large fraction of RCII emissions (just under two-thirds) associated with electricity use. RCII emissions associated with electricity and natural gas use are expected to rise by about 11% between 2005 and 2020, and are projected to account for a quarter of the state's growth in gross GHG emissions during this period. Projected growth in industrial process emissions (essentially all from assumed growth in the use of HFC refrigerants) accounts for roughly another tenth of statewide growth in gross emissions through 2020.

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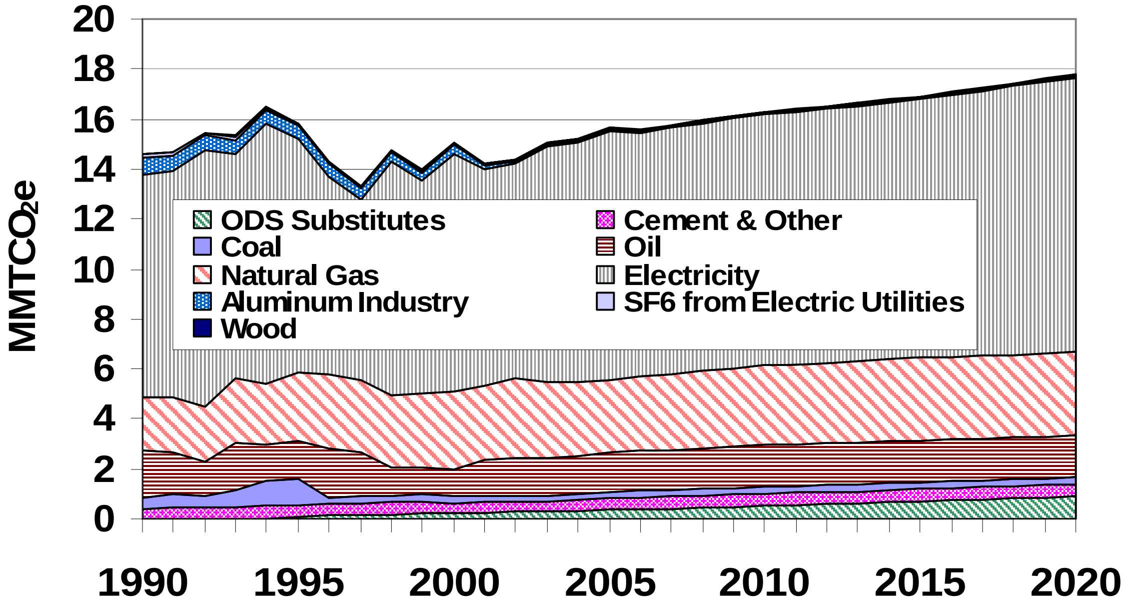
[1] RCII direct fuel use accounted for 4.8 MMtCO$_2$e in GHG emissions in 2005, and industrial process emissions, largely from cement production and the use of substitutes (such as HFCs) for ozone depleting substances (ODSs) accounted for 0.9 MMtCO$_2$e.

[2] Gross emissions here denote GHG emissions from activities in Montana, adjusted for exports of electricity, oil, and gas, but not including consideration of estimated "sinks" of GHGs in the forestry and land-use sectors.

Figure 3-1: Historical and projected residential, commercial, institutional, and industrial GHG emissions in Montana, 1990 to 2020



ODS = ozone-depleting substance.

Overall GHG emissions associated with industrial energy use in Montana were nearly twice as high as those in the residential sector in 1990, with commercial/institutional emissions about 20% lower than residential emissions. Due to a significant decline in industrial energy use and non-CO$_2$ emissions between 1995 and 2002, and gradually increasing emissions in the other sectors, industrial-sector emissions from energy use were only about 35% higher than residential sector emissions by 2005 and were about 39% of total RCII emissions. Industrial emissions from energy use are projected to grow, on average, at just below the rate of overall RCII emissions through 2020, constituting just over 38% of RCII emissions by 2020. As a result of the combination of slowing population growth and increasing commercial/institutional sector activity over the coming decades, commercial/institutional sector emissions are projected to grow somewhat faster than emissions from the residential sector so that by 2020, residential sector emissions are less than commercial/institutional sector emissions (at 26% and 27.5% of total RCII emissions, respectively). Manufacturing activity is expected to continue to grow at a rate of about 0.9% per year after 2005, though this growth is offset for all fuels except electricity by continuing declines in overall energy intensity due to energy efficiency gains and structural shifts to less energy-intensive industries.[3] Figure 3-2 shows RCII emissions by sector and source from 1990 through 2020.

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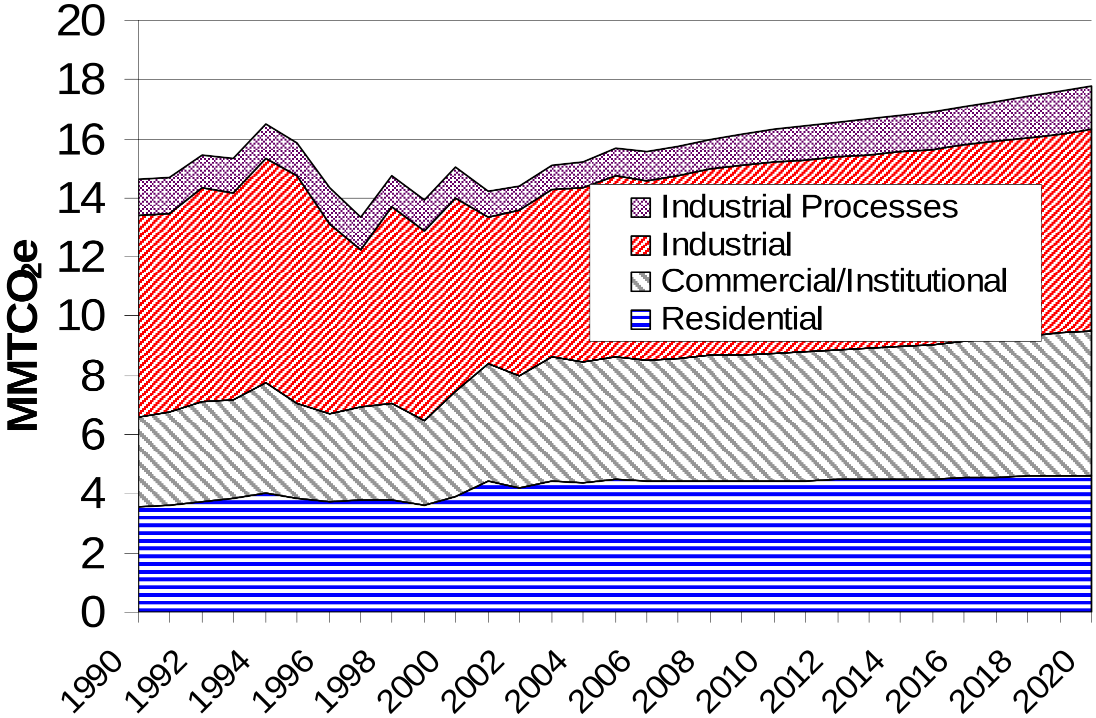
[3] Projections of manufacturing and nonmanufacturing activity (employment growth) are based on estimates from the Montana Department of Labor. Declines in energy intensity are based on projections by the U.S. Department of Energy (Annual Energy Outlook 2005).

Figure 3-2. 1990–2020 GHG emissions by source



Key Challenges and Opportunities

The principal means of reducing RCII sector GHG emissions include improving energy efficiency; substituting electricity, natural gas, and (in more limited instances) other fossil fuels with lower-emission energy resources (such as solar water heating and biofuels); reducing industrial process emissions; and promoting consumer-sited electricity generation using renewable fuels and combined heat and power systems. A universal systems benefits (USB) charge for some of the state's electric and gas utilities has been in place since 1997 and collected since 1999. It has provided funding for significant energy efficiency programs, but many opportunities remain to reduce emissions through programs and initiatives to improve the efficiency of buildings, appliances, and industrial practices. Though overall population growth in the state is projected to be modest, the strong growth of a number of Montana's communities places pressure on communities and businesses to make swift decisions before lower efficiency building energy performance becomes "locked in." Another challenge before the state is the desire to ensure that low-income residents are able to reap the benefits of—and not be adversely affected by—efforts to increase the efficiency of energy use and reduce emissions.

A number of ongoing and recently enacted Montana programs and initiatives have already taken important steps in providing the means to reduced RCII emissions. The USB charge noted above remains in effect for investor-owned electric and gas utilities, though some USB funds are currently used for purposes other than supporting energy efficiency or renewable energy programs. Additional energy efficiency programs have been provided to customers of cooperative utilities through the costs of power purchases from the Bonneville Power Administration. Tax credit programs are available to help fund consumers' investments in energy efficiency and renewable energy systems, and low-income weatherization programs have been operated for a number of years by state agencies and other service providers. Technical assistance services for energy efficiency and renewable energy have been provided by the Montana Department of Environmental Quality (DEQ) and others. A number of Montana organizations provide education on energy and environmental topics. The Montana State Buildings Energy Program provides funding for energy efficiency improvements in state buildings. While an indication of the growing momentum for improving efficiency and reducing GHG emissions, these actions only begin to tap the overall potential of the state to slow its growth of energy use and GHG emissions in the RCII sectors.

Overview of Policy Recommendations and Estimated Impacts

The Montana Climate Change Advisory Committee (CCAC) recommends a set of 13 policy options for the residential, commercial, institutional, and industrial sectors that offer the potential for major economic benefits and significant GHG emissions savings. Of these 13 options, 3 (RCII-7 through RCII-9) span both the RCII and Energy Supply (ES) sectors; those options are discussed in more detail in Chapter 5. As summarized in Figure 3-3, these RCII policy recommendations—not including those shared with ES—could lead to emissions savings from reference case projections by just under 3 MMtCO$_2$e per year by 2020 and provide cumulative savings of over 18 MMtCO$_2$e from 2007 through 2020.[4] These RCII policy options could result in an estimated net cost *savings* of more than $300 million through the year 2020 on a net present value (NPV) basis.[5] Most emissions savings from the RCII options are in the form of reduced carbon dioxide emissions, with relatively minor reductions of emissions of other GHGs (principally methane and nitrous oxide) produced via leakage and/or combustion of fuels.

The estimated impacts of the RCII policies recommended by the CCAC are shown in Figure 3-3. Figure 3-4 shows the results of several policies that have been recently implemented in Montana. These savings are not accounted for in the reference inventory and forecast, but they do contribute to overall emissions reduction along with savings from the CCAC-recommended measures. The combination of savings from recent actions and from CCAC policies is, in the RCII sectors, estimated to be significantly greater than the projected reference case growth in emissions from 2007 through 2020 and, as shown by the trend in the dark area in Figure 3-3, actually reduces RCII emissions below estimated 1990 emissions levels.[6]

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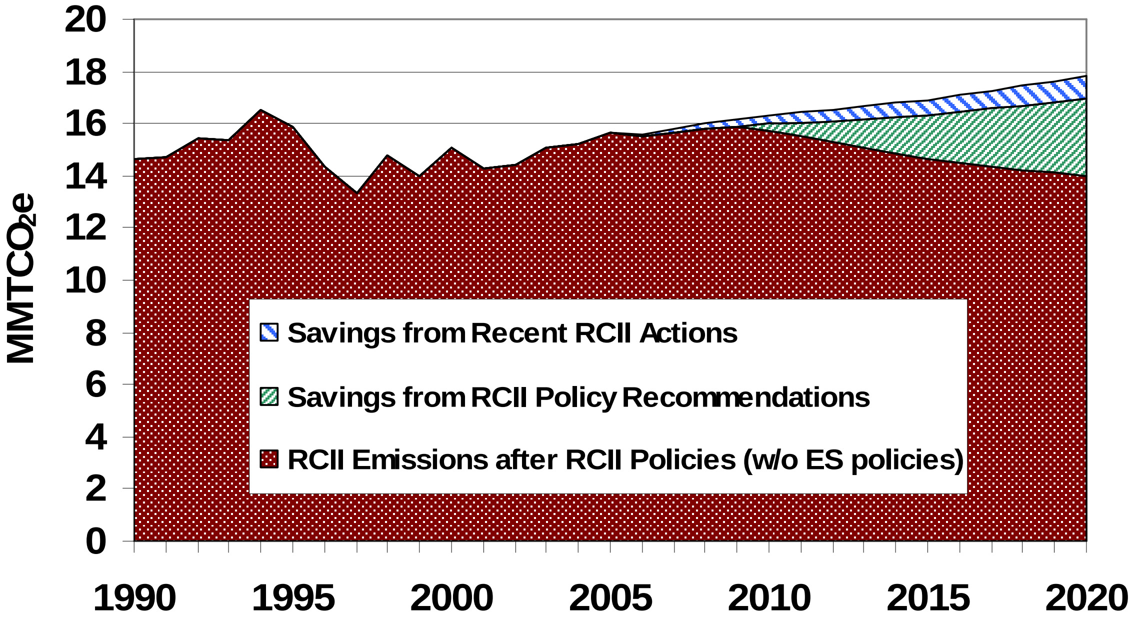
[4] Note that these figures do not include additional emission savings from recent actions not included in the reference case forecast; see below for a summary of savings from these recent actions. Note also that the emissions savings and costs of option RCII-6 were not quantified, because this education option is designed to support other policies and thus has largely indirect impacts on GHG emissions. See Appendix F for more detailed information. Of the total 18 MMtCO$_2$e in cumulative emissions savings from the RCII policies, about 15 MMtCO$_2$e are from reduced electricity consumption, with the remaining 3 MMtCO$_2$e from reduction in on-site use of fossil fuels.

[5] The net cost savings are based on fuel expenditures, operations, maintenance, and administrative costs, and on amortized, incremental equipment costs. All NPV values shown here are calculated using a 5% per year real discount rate.

[6] Note, however, that Montana RCII emissions grew relatively little, in aggregate, between 1990 and 2003, due primarily to a reduction in output of key industrial sectors.

Figure 3-3. Impact of policy recommendations on RCII emissions



The CCAC policy recommendations described briefly here, and in more detail in Appendix F, not only result in significant emissions and costs savings but also offer a host of additional benefits. These benefits include, but are by no means limited to, reduction in spending on energy by homeowners and businesses, contributions to local economic development, reduced local and regional air pollution and related human health impacts, improvements in business efficiency and productivity, electricity system generation, transmission and distribution benefits, reduction in water use and in related water supply impacts, and improvements in comfort, convenience and indoor air quality as a result of building improvement measures.

In order for the RCII policy options recommended by the CCAC to yield the levels of savings described here, the options must be implemented in a timely, aggressive, and thorough manner. This means, for example, not only putting the policies themselves in place, but also attending to the development of supporting policies that are needed to help make the recommended options effective. Many of these supporting policies are part of the package of RCII options and many are included among the policies recommended as “cross-cutting” policies (see Chapter 7). Elements of some ES policies (for example, those related to utility rates and cost recovery) and those from other groups may also bear upon the ultimate effectiveness of RCII options. For example, improved building codes and “beyond-code” building improvements (RCII-4 and RCII-5) will not be optimally effective without training contractors, builders, architects, financial institutions, building inspectors and others in the methods and benefits of efficient building design (as recommended in RCII-6). Regulatory policies that provide better incentives and lower disincentives for the adoption of consumer-sited combined heat and power and renewable electricity generation, as included in ES options, are also among the supporting policies crucial to the success of the shared ES/RCII options. Some of these policies are already in the formative stages (or beyond) in Montana. The CCAC’s work indicates that there are considerable benefits to both the environment and to consumers from adoption of the policy options offered. Careful, comprehensive, and detailed planning and implementation, as well as consistent support, of these policies will be required if these benefits are to be achieved.

Table 3-1. CCAC-recommended policy options and results for the residential, commercial, institutional, and industrial sectors

	Policy Option	**GHG Reductions (MMtCO$_2$e)**			**Net Present Value 2007–2020 (Million $)**	**Cost-Effective-ness ($/tCO$_2$e)**	**Level of Support**
		2010	**2020**	**Total 2007–2020**			
	Residential, Commercial, Institutional, and Industrial						
RCII-1	Demand-Side Management Programs, Efficiency Funds and Requirements (and Financial Incentives)	0.04	1.15	6.6	–$141	–$21	UC
RCII-2	Market Transformation and Technology Development Programs	0.03	0.30	1.9	–$43	–$23	UC
RCII-3	State-Level Appliance Efficiency Standards and State Support for Improved Federal Standards	0.05	0.20	1.5	–$55	–$36	UC
RCII-4	Building Energy Codes	0.03	0.25	1.6	–$15	–$10	UC
RCII-5	"Beyond Code" Building Design Incentives and Mandatory Programs	0.07	0.52	3.4	–$17	–$5	UC
RCII-6	Consumer Education Programs	*Not quantified*					UC
RCII-7	Support for Implementation of Clean Combined Heat and Power	*Quantified in Coordination with the Energy Supply TWG (as a part of ES-4)*					UC
RCII-8	Support for Renewable Energy Applications	*Quantified in Coordination with the Energy Supply TWG (as a part of ES-4)*					UC
RCII-9	Carbon Tax	*Not Quantified; Considered in Coordination with the Energy Supply TWG (as ES-8/9)*					UC
RCII-10	Industrial Energy Audits and Recommended Measure Implementation	0.07	0.56	3.6	–$93	–$26	UC
RCII-11	Low-Income and Rental Housing Energy Efficiency Programs	0.05	0.75	4.7	–$41	–$9	UC
RCII-12	State Lead by Example	0.03	0.33	2.0	–$11	–$6	UC
RCII-13	Metering Technologies With Opportunity for Load Management and Choice	0.02	0.12	0.9	–$11	–$12	UC
	Sector Total After Adjusting For Overlaps	0.28	2.95	18.4	–$304	–$17	N/A
	Reductions From Recent Policy Actions (see table below)	**0.32**	**0.84**	**6.9**	N/A	N/A	N/A
	Sector Total Plus Recent Policy Actions	0.59	3.79	25.3	N/A	N/A	N/A

Table 3-2: Emissions reductions associated with recently enacted policies (not included in baseline projections) related to RCII policy options

	Policy Option	Estimated 2010 GHG Reduction ($MMtCO_2e$)	Estimated 2020 GHG Reduction ($MMtCO_2e$)	Cumulative 2007–2020 GHG Reduction ($MMtCO_2e$)
RCII-1	Expand Energy Efficiency Funds	0.30	0.79	6.5
RCII-11	Low-Income Energy Efficiency Programs	0.02	0.05	0.4

Residential, Commercial, Institutional, and Industrial (RCII) Policy Descriptions

Policy options suggested by the CCAC for residential, commercial, institutional, and industrial sectors include those that address emissions reduction opportunities related to improving energy use efficiency, that support energy-efficiency efforts with education and new electricity metering strategies and, in coordination with options in the energy supply sector, promote using lower GHG energy sources for customer-sited generation.

RCII-1 Demand-Side Management Programs, Efficiency Funds and Requirements (and Financial Incentives)

The CCAC recommends that Montana increase the efficiency of electricity and natural gas use through demand-side management (DSM) programs, funds, and/or requirements. This option focuses on what are typically termed DSM activities—programs, usually delivered by utilities or government-designated agencies, designed to reduce energy consumption and/or change the timing of energy use. Examples of DSM programs include technical assistance for and implementation of energy efficiency and renewable energy measures, electrical and natural gas demand response, alternative rate schedules, and research activities. Note that the activities described for this option may also support implementation of other options recommended by the CCAC, such as RCII-11 and RCII-12.

This policy design is focused on increasing energy-efficiency programs offered through investor-owned and cooperative utilities and is linked with the energy-efficiency element of Energy Supply option ES-1, “Environmental Portfolio Standard.” RCII-1 and ES-1 require that each utility implement a plan to obtain 100% of the achievable cost-effective energy efficiency in its service territory by 2025. Intermediate steps for each utility include identifying, by 2010, the achievable cost-effective energy efficiency (or energy conservation) in its service territory for the subsequent 10 years and updating its energy-efficiency assessment and plan regularly, possibly every 2 years. Implementation of energy-efficiency programs under this option could be through an independent, nonprofit, statewide provider of energy-efficiency services to support, in particular, the provision of energy-efficiency/conservation programs in the service territories of smaller utilities, including cooperatives, with other utilities providing their own efficiency programs as appropriate. Revolving loan programs and new or expanded state tax credits to fund energy-efficiency/conservation investments are potentially key implementation elements for this policy, as are expanded information and education for consumers and energy-efficiency service providers.

RCII-2 Market Transformation and Technology Development Programs

Market transformation programs focus on voluntary efforts implemented by non-utility organizations to encourage greater uptake by consumers (residential, commercial, institutional, and industrial, as well as the professionals that service energy-using equipment) of cost-effective energy-efficiency practices. Market transformation also seeks to ensure sufficient supplies of technologies and practitioners to meet the subsequent increased demand for energy efficiency. The goal of a market transformation and technology development program is to put energy-efficiency technologies and practices into a position where they will be demanded by the public, chosen by builders and manufacturers, and provided by retailers and contractors. Methods of transformation can be different for each technology or practice, but often revolve around public and private review of quality and effectiveness, including partnerships between government agencies, retailers, manufacturers, and nongovernmental agencies. Market transformation programs can be statewide or regional.

Recognizing that Montana constitutes a limited market, by itself, for energy-efficient products, the CCAC recommends that Montana focus its efforts on joining, supporting, or increasing its participation in regional market transformation alliances that develop and implement technologies for reduction of energy use and GHG emissions. Market transformation and technology development efforts should stress addressing technologies of particular significance to Montana. One example is the testing and monitoring of residential and commercial high-efficiency structures to determine their performance under Montana conditions and to identify barriers to implementation of energy-efficient building practices.

RCII-3 State-Level Appliance Efficiency Standards and State Support for Improved Federal Standards

Appliance efficiency standards reduce the market cost of energy-efficiency improvements by incorporating technological advances into base appliance models, thereby creating economies of scale. In recognition of the fact that Montana represents, on its own, a relatively limited market for appliances and equipment, the CCAC recommends that the state work with other states and with regional entities, as applicable, to review federal appliance standards; work with federal agencies and others toward raising federal appliance and equipment energy-efficiency standards where applicable; and to implement, in concert with other states, higher-than-federal energy-efficiency standards for appliances where technological advances allow. It is anticipated that the process of setting higher energy-efficiency standards in Montana, in concert with other states, will encourage higher federal standards and higher-volume manufacturing of higher-efficiency appliances and equipment, resulting in wider distribution and likely lower prices for these devices.

RCII-4 Building Energy Codes

Building energy codes specify minimum energy-efficiency requirements for new buildings or for existing buildings undergoing a major renovation. Given the long lifetime of most buildings, amending state and/or local building codes to include minimum energy-efficiency requirements and periodically updating energy-efficiency codes could provide long-term GHG savings. The CCAC recommends that the energy-efficiency–related elements of building codes in Montana be improved to reduce the amount of fossil energy input needed for operating buildings in the state. Key elements of a policy to enhance Montana's building energy codes, and their effectiveness, include

- Undertaking a comprehensive review of existing building codes in Montana to determine where increased energy efficiency can be achieved;
- Increasing standards so that the minimum performance of new and substantially renovated buildings, both commercial and residential, is at least 15% higher by 2010 than that required by today's building codes (International Energy Conservation Codes [IECC] 2003), and 30% higher by 2020;
- Encouraging and working toward achieving the goal of "carbon-neutral" status for new buildings;
- Encouraging the use of recycled and local building materials;
- Expressing energy-efficiency standards on a per-unit-floor-space basis for commercial buildings and on a per-dwelling-unit basis for residential buildings;
- Periodically and regularly reviewing building codes, including energy-efficiency requirements of building codes, to ensure that they stay up-to-date;
- Offering, and requiring as appropriate, education to equip building code officials, builders, designers, and others to effectively implement building energy code improvements; and
- Exploring new mechanisms, such as working with financial institutions and the use of spot checks, to improve code implementation in rural areas.

RCII-5 "Beyond Code" Building Design Incentives and Mandatory Programs

The CCAC recommends that incentives and targets be provided to induce the owners and developers of new and existing buildings to improve the efficiency with which energy and other resources are used in those buildings, along with provisions for raising targets periodically and providing resources to help achieve the desired building performance. This policy includes elements to encourage improving and reviewing energy use goals over time and using flexibility in contracting arrangements to encourage integrated energy- and resource-efficient design and construction. The goals of this option are to induce one-quarter of new and existing homes and commercial/institutional buildings in Montana to reduce per-unit-floor-area consumption of grid electricity and natural gas by 20% by 2020 in existing buildings and by 50% in new buildings by 2020. A combination of financial incentives and regulatory policies—including, for example, fee adjustments, that is, adjustment of "impact fees" or "connection fees," permitting advantages (expedited review processing of applications), rewards programs for “beyond code” energy-efficiency/emissions reduction improvements, property tax adjustment, and increased tax incentives for energy-efficiency improvements and installation of renewable energy systems.

RCII-6 Consumer Education Programs

Noting that public education and outreach and training people to implement GHG emissions reduction strategies will be the foundation for the long-term success of all of the mitigation actions proposed by the CCAC, as well as those that may evolve in the future. The CCAC recommends the implementation of a package of consumer, primary/secondary school, and professional education initiatives, including

- Providing consumer education, through public broadcasting and other delivery systems, related to energy efficiency and the environmental consequences of energy and other choices;
- Directing the Office of Public Instruction and others to develop and implement curricula for primary and (particularly) secondary schools that teach students to evaluate the implications of consumption choices;
- Implementing and enhancing professional education and certification programs for teachers and for those involved in providing products and services related to energy use and GHG emissions to build the statewide pool of individuals trained to support RCII and other policy options;
- Educating businesses and retailers about the GHG emissions associated with products and supply chains and exploring regional efforts to rate the GHG emissions of products; and
- Discouraging use of excessive lighting in outdoor RCII applications, including yard lights and unneeded street lights, and use of lighting control systems when applicable.

The goals of the CCAC-recommended initiatives are to educate consumers, businesses, retailers, and children so they can make informed choices to reduce energy use, improve efficiency, and reduce environmental consequences of their actions, and to educate professionals working in energy efficiency so they can better inform consumers and make wise decisions.

RCII-7 Support for Implementation of Clean Combined Heat and Power

Distributed generation with clean combined heat and power (CHP) systems reduces fossil fuel use and GHG emissions both through the improved efficiency of the CHP systems, relative to separate heat and power technologies and by avoiding transmission and distribution losses associated with central power stations that are located far away from where the electricity is used. The CCAC recommends that implementation of these systems by residential, commercial, institutional, and industrial energy consumers be encouraged through a combination of regulatory changes and incentive programs. Further details on this recommended policy are provided in Chapter 5 as a part of ES-4, “Incentives and Barrier Removal (Including Interconnection Rules and Net Metering Arrangements) for Combined Heat and Power (CHP) and Clean Distributed Generation (DG)” and in Appendix G.

RCII-8 Support for Renewable Energy Applications

Distributed electricity generation sited at residences, commercial, industrial, and institutional facilities and powered by renewable energy sources (typically solar but also wind and hydro) displaces fossil-fueled generation and avoids electricity transmission and distribution losses, thus reducing GHG emissions. The CCAC recommends that regulatory changes and incentives be provided to encourage implementation of distributed (consumer-sited) renewable electricity generation; to encourage consumers to switch from using fossil fuels to using renewable fuels in applications such as water, process, and space heating; and to supply new energy services using fuels that produce low or no GHG emissions. Increasing the use of renewable energy applications in homes, businesses, and institutions in Montana can be achieved through a combination of regulatory changes and incentives. Further details on this recommended policy are provided in Chapter 5 as part of ES-4, “Incentives and Barrier Removal (Including Interconnection Rules and Net Metering Arrangements) for Combined Heat and Power (CHP) and Clean Distributed Generation (DG)” and in Appendix G.

RCII-9 Carbon Tax

A CO_2 tax would be a tax on each ton of CO_2 or CO_2-equivalent emitted from an emissions source covered by the tax. A CO_2 tax could be imposed upstream of final consumption based on the carbon content of fuels (for example, on fossil fuel suppliers) or at the point of combustion and emission (typically large point sources such as power plants or refineries). Taxed entities would pass some or all of the cost on to consumers, change production to lower emissions, or a combination of the two. As the suppliers respond to the tax, consumers would see the implicit cost of CO_2 emissions in products and services and would adjust their behavior to purchasing substitute goods and services that result in lower CO_2 emissions, thus allowing a market response to reduce emissions. CO_2 tax revenue could be used in a variety of ways, including for assisting households and businesses in reducing carbon emissions. Recognizing that a CO_2 tax is best implemented on a national level, the CCAC recommends that the state should investigate and advocate for a national GHG cap-and-trade or tax system, and should participate fully in the Western Regional Climate Action Initiative, which will consider development of regional market-based mechanisms for GHG emissions reduction.

The CO_2 tax option was considered by the CCAC as part of the overall ES-8/9 option “Market-Based Mechanisms to Establish a Price Signal for GHG Emissions (GHG Cap-and-Trade or Tax).” Further details of this recommended policy are provided in Chapter 5 and Appendix G.

RCII-10 Industrial Energy Audits and Recommended Measure Implementation

The CCAC recommends providing industrial-sector energy technical assistance (energy audits) to identify and recommend options for reducing fossil energy and electricity use and for reducing emissions of GHGs not related directly to electricity or fuels use. For example, an agency could hire experts who will visit industrial sites to assess current practices and equipment and provide recommendations for reducing GHG emissions and could be set up or housed in an existing post-secondary institution. A combination of incentives—for example, a program of low- or no-interest loans designed to encourage industrial customers to take up energy-efficiency measures that reduce both electricity and natural gas consumption—plus expertise and information to implement recommended options are included in the policy to encourage the operators of industrial-sector facilities to follow up on audit recommendations.

RCII-11 Low-Income and Rental Housing Energy Efficiency Programs

Though residential-sector energy-efficiency improvements are a key goal of several RCII policies recommended by the CCAC, low-income and rental consumers are frequently unable to participate in energy-efficiency programs because they lack funds to pay for improvements or, in the case of renters, are unable either to make changes to their residences or to fully benefit from any cost savings. In recognition of this barrier, and building on existing (and popular) Montana programs, the CCAC recommends the implementation of programs specifically targeted to the needs of low-income residents for services such as home weatherization, updating or repairing inefficient appliances, and providing funds for renewable energy systems. These programs could be designed to offer low-income residents energy-efficiency services with a minimum of up-front costs and should be marketed through an aggressive campaign of outreach to low-income households and communities, including communities with a high incidence of rental housing. A key goal of this policy is to substantially upgrade the efficiency of the majority of homes occupied by low-income Montana residents and a majority of rental homes by 2020.

RCII-12 State Lead by Example

The CCAC recommends that Montana state government provide leadership by moving the state toward a stock of buildings that has much higher energy efficiency and by improving efficiency in the operations of state buildings. This policy provides energy-efficiency and renewable energy targets that are much higher than code standards for new state-funded buildings and recommends their application to state-leased buildings and to other government buildings (e.g., county and municipal government buildings and schools). The policy also includes elements to encourage the improvement and review of efficiency goals over time and to encourage flexibility in contracting arrangements to facilitate integrated energy-efficient design and construction. Goals and targets are also provided for upgrading energy efficiency in existing state government facilities and for considering the overall environmental impacts of state operations (including increased waste reduction and recycling and purchasing of Energy Star–certified appliances and equipment or appliances and equipment with higher-than-standard energy efficiency). One suggested mechanism for this policy is climate neutral bonding, meaning that there is no net increase in GHG emissions within the bond-issuing agency's geographical jurisdiction after a project becomes operational.

RCII-13 Metering Technologies With Opportunity for Load Management and Choice

Providing Montana energy consumers with price and other information via metering that allows them to more clearly identify the outcomes of their choices is a potentially useful tool in improving energy efficiency, reducing GHG emissions, and saving consumers money. The CCAC recommends that Montana utilities implement systems for metering electricity demand

and consumption, building on successful initiatives in other jurisdictions, which reflect the real-time cost and GHG emissions implications of the resources that must be used to provide power. At the same time, rate structures should be implemented that allow utilities and consumers to take advantage of the information provided by the metering systems to lower emissions and costs. Doing so will provide consumers with incentives to manage their energy consumption so as to reduce both costs and GHG emissions. This policy option recommends the implementation of a pilot program of installation of “smart meters” at approximately 45,000 residential and some nonresidential customers’ sites, followed by a program resulting in the installation of smart meters for an additional 30% of residences by 2020.

Chapter 4
Energy Supply

Overview of GHG Emissions

Greenhouse gas (GHG) emissions from the energy supply (ES) sector in Montana include emissions from electricity generation and the fossil fuel industry (i.e., oil, natural gas, and coal production) and comprise a significant portion of the state's overall GHG emissions. In 2005, emissions associated with energy supply were approximately 24 million metric tons of carbon dioxide equivalents (MMtCO$_2$e) on a production basis and 15 MMtCO$_2$e if only the emissions associated with electricity consumed in-state are accounted for (consumption basis).[1] Fossil fuel production accounted for about 5 MMtCO$_2$e of these emissions, with electricity production accounting for the remainder.

By 2020, energy supply emissions under the reference case are projected to increase from 1990 levels by approximately 32% on a consumption basis, with the majority of the increase from electricity generation. Emissions reflecting energy produced in Montana (including electricity exported to other states) are anticipated to rise approximately 51% over 1990 levels by 2020, as the increase in electricity generation is projected to outpace electricity consumption in the state. Figure 4-1 depicts the historical and projected growth in electricity emissions for in-state use, for net electricity exports, and for fossil fuel production.

Given the many factors impacting energy production–related emissions and a diversity of assumptions by stakeholders within the energy sector—developing a “reference case” projection for the most likely development of Montana's electricity and fossil fuel production sectors is particularly challenging. The principal uncertainty of interest is on the high side, given the many plans and initiatives to increase coal utilization locally and nationally. As a result, an alternative scenario of future energy supply development was created—the high fossil fuel production scenario. The high fossil fuel production scenario assumes more rapid development of transmission lines for electricity exports and increased fossil fuel production, including the start-up of two commercial plants to produce liquid fossil fuels from coal. Under the high fossil fuel production scenario, production basis GHG emissions are projected to more than double compared with 1990 levels. The emission increase is split evenly between electricity generation (including exports) and fossil fuel production, as illustrated in Figure 4-2.

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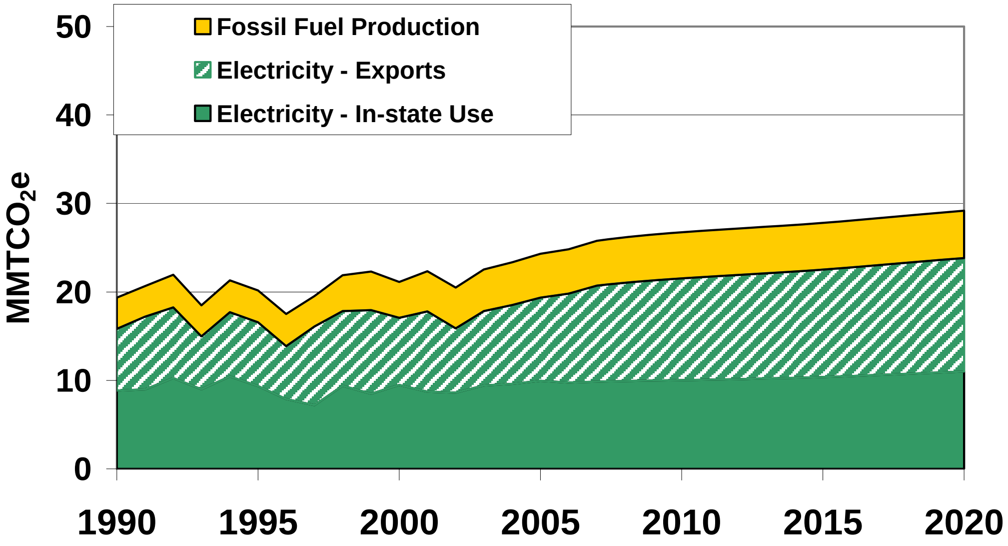
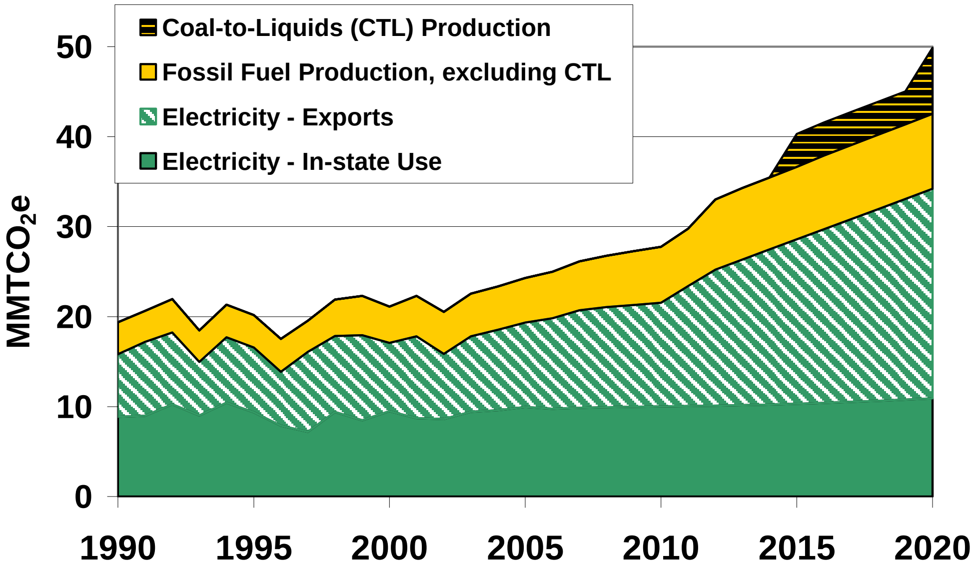
[1] Reporting emissions from a state's electricity sector is not unambiguous, especially for states with large amounts of electricity imports or exports. For many years, Montana power plants have produced almost twice the electricity that is consumed in the state. In general, the emission reporting for Montana used here reflects the *GHG emissions associated with the electricity sources used to meet Montana demands*, corresponding to a consumption-based approach to emissions accounting. This accounting method can better reflect the benefit of actions that reduce electricity consumption or affect the sources of electricity used to meet in-state demands. The *GHG emissions produced by all electricity generation facilities in the state* are reported separately. This production-based accounting can better reflect the effect of actions that impact all electricity generation, regardless of whether the electricity generated is for in-state or out-of-state consumption.

Figure 4-1. Historical and projected GHG emissions from the energy supply sector, Montana, 1990 to 2020, reference case



Note: The reference case assumes that commercial coal-to-liquids (CTL) production will not begin before 2020.

Figure 4-2. Historical and projected GHG emissions from the energy supply sector, Montana, 1990 to 2020, high fossil fuel production case



Key Challenges and Opportunities

Two major challenges in addressing GHG emissions from Montana’s energy supply sector are the uncertainty in future amounts of electricity and fossil fuel production within the state and the uncertainty of future costs and commercial readiness of lower GHG emission technologies. The uncertainty in future production is driven by factors such as the resource availability of conventional and unconventional natural gas, the nature of export markets plus cost and timing of transmission infrastructure needed to transport Montana's products, and policies enacted in other jurisdictions that seek to reduce GHG emissions associated with energy production (such as limits that California, Washington, and Oregon have implemented or discussed that limit GHG emissions for both electricity and transportation fuels). The differences in total emissions between Figures 4-1 and 4-2 indicate the potential range for Montana's future emissions based on uncertainty in production. The uncertainty in future costs and commercial readiness of energy production technologies overlaps strongly with the uncertainty in future production. This uncertainty is most obvious in the case of coal-to-liquids (CTL) production. Proponents are pursuing a CTL plant in Montana, though decisions on permits and timing for such a plant are not final. As noted in Figure 4-2, the GHG emissions associated with two commercial CTL plants in Montana are the same order of magnitude as GHG emissions associated with all of Montana's electricity sales. If these plants are built, Montana will have both greater growth in GHG emissions and different opportunities to install new technologies for GHG emission control.

Fortunately, there are significant opportunities to reduce GHG emissions growth attributable to energy production and supply. The GHG emissions of electricity generation can be addressed through: greater use of renewable energy; recapture of waste energy through combined heat and power; carbon capture and storage; and other technologies. For example, Montana has some of the nation's best wind locations, yet the remoteness and the intermittency of wind resources will require careful planning to enable their development. Electricity and fuel production facilities in Montana could be pioneers in the commercial use of carbon capture and storage, as well as in the substitution of biomass for coal (co-firing). Where actions are both technically and economically feasible, the producers and processors of natural gas can benefit from actions that reduce methane venting and leakage as well as on-site fuel use, which could also enable more natural gas to come to the market, producing a genuine win-win situation. In addition, there are significant opportunities to reduce GHG emissions through policies that result in both energy and cost savings, as the Climate Change Advisory Committee (CCAC) has identified for the residential, commercial, institutional, and industrial sectors in Chapter 3.

Overview of Policy Recommendations and Estimated Impacts

The CCAC recommends a set of 13 policy options for the energy supply sector as listed in Table 4-1, along with their projected emissions savings and costs (or cost savings). These recommendations can be grouped into those affecting electricity supply (ES-1, ES-2, ES-4 through ES-7, and ES-10), those affecting fossil fuel production (ES-11 and ES-12), and those with overarching impacts (ES-3, ES-8, and ES-9, which are not quantified).

Table 4-1. CCAC-recommended policy options and results for the energy supply sector

	Policy Option	**GHG Reductions (MMtCO$_2$e)**			**Net Present Value 2007–2020 (Million $)**	**Cost-Effective-ness ($/tCO$_2$e)**	**Level of Support**
		2012	**2020**	**Total 2007–2020**			
	Energy Supply						
ES-1	Environmental Portfolio Standard (Renewables and Energy Efficiency)						UC
	Efficiency/Conservation	0.03	0.92	5.4	–$79	–$15	UC
	Renewable Energy	0.0	1.6	5.5	$53	$10	UC
ES-2	Renewable Energy Incentives and Barrier Removal	*Not quantified separately (see ES-1 and ES-4)*					UC
ES-3	Research and Development (R&D), Including R&D for Energy Storage and Advanced Fossil Fuel Technologies	*Not quantified*					UC
ES-4	Incentives and Barrier Removal for Combined Heat and Power (CHP) and Clean Distributed Generation (DG)						UC
	Distributed Renewables	0.03	0.10	0.8	$16	$21	UC
	Combined Heat and Power	0.2	0.7	5.0	$81	$16	UC
ES-5	Incentives for Advanced Fossil Fuel Generation and Carbon Capture and Storage or Reuse (CCSR)						UC
	Reference Case	0	1.0	4.5	$135	$30	UC
	High Fossil Fuel Scenario	0	5.2	24.4	$733	$30	UC
ES-6	Efficiency Improvements and Repowering of Existing Plants	*Not quantified*					UC
ES-7	Demand-Side Management	*Not quantified separately (see ES-1 and RCII-1)*					UC
ES-8/9	Market-Based Mechanisms to Establish a Price Signal for GHG Emissions (GHG Cap-and-Trade or Tax)	*Not quantified*					UC
ES-10	Generation Performance Standards or GHG Mitigation Requirements for New (and/or Existing) Generation Facilities, With/Without GHG Offsets	0.1	0.8	4.7	$60	$13	UC
ES-11	Methane and CO$_2$ Reduction in Oil and Gas Operations, Including Fuel Use and Emissions Reduction in Venting and Flaring						UC
	Reference Case	0.1	0.5	3.9	*Not estimated*	*Likely net benefit*	UC
	High Fossil Fuel Case	0.3	0.8	6.6			UC
ES-12	GHG Reduction in Refinery Operations, Including in Future Coal-to-Liquids Refineries						UC
	Coal-to-Liquids – High Fossil Fuel Case	0	9.9	35	*Not estimated*	*Not estimated*	UC
	Petroleum Refining - Reference Case	0.02	0.24	1.5	*Not estimated*	*Not estimated*	UC
	Petroleum Refining - High Fossil Fuel Case	0.03	0.38	2.2	Not estimated	Not estimated	UC

	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2007–2020 (Million $)	Cost-Effective-ness ($\$/tCO_2e$)	Level of Support
		2012	2020	Total 2007–2020			
ES-13	CO_2 Capture and Storage or Reuse (CCSR) in Oil & Gas Operations, Including Refineries and Coal-to-Liquids Operations	*Incorporated in ES-5 and ES-12*					UC
	Sector Total After Adjusting for Overlaps (Among ES Options and After Demand Reductions From RCI Options)						
	Reference Case	**0.4**	**4.2**	**21.9**	**$272**	**$17**	
	High Fossil Fuel Case	**0.4**	**18.7**	**79.4**	**$870**	**$24**	

UC – Unanimous Consent

The electricity supply recommendations include efforts to increase the supply of renewable energy (ES-1 and ES-2), decrease the emission intensity of fossil-fuel–generated electricity (ES-5), reduce the average emissions of new utility resource acquisitions (ES-10), increase distributed generation (ES-4), and reduce demand. When taken together in a combined scenario that assumes all of the CCAC's recommendations are fully implemented, these electricity supply recommendations could result in cumulative GHG emissions reductions of about 16 $MMtCO_2e$ through 2020 at a cumulative net present value (NPV) cost of about $270 million.[2,3,4]

Recommendations to reduce emissions from oil and gas operations, oil refineries, and CTL facilities (ES-11 through ES-13) could yield another 5 $MMtCO_2e$ in cumulative emissions savings through 2020; there was insufficient information to estimate their cost impacts. Taken together, the energy supply recommendations could lead to cumulative reductions of almost 22 $MMtCO_2e$ from 2007 through 2020 and reductions of about 4.2 $MMtCO_2e$ per year by 2020. These results are shown in Figure 4-3.

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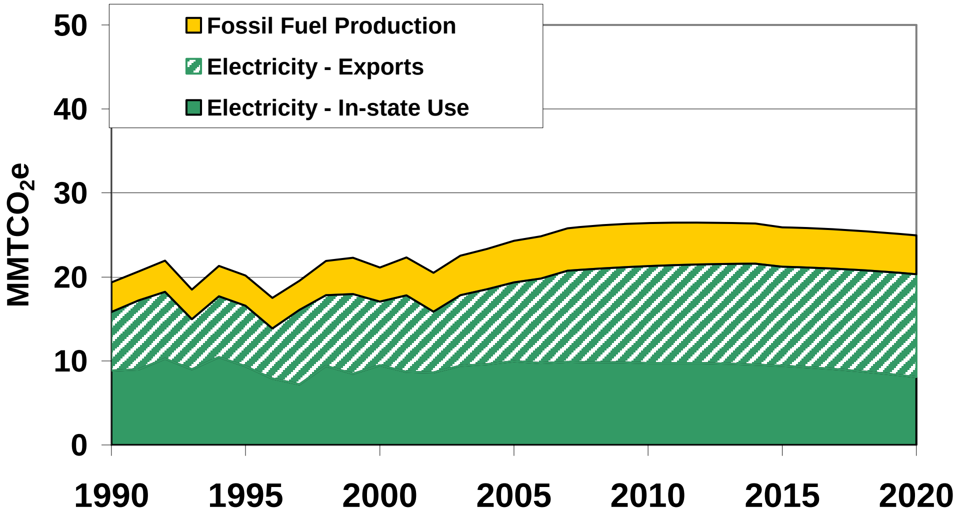
[2] A glance at the numbers in Table 4-1 suggests that if simply added together, cumulative emission reductions of these policies under the reference case could exceed 30 $MMtCO_2e$ in 2020, assuming all options are implemented in isolation from each other. However, these options are *not* additive. In fact, they tend to overlap heavily, so simply adding them would introduce significant double-counting. These options essentially target—through different means—the avoidance of the same or similar emissions sources (e.g., the emissions from fossil-fuel power plants existing and yet to be built).

[3] Note also that the CCAC's policy recommendations concerning GHG emissions from electric generation are highly interactive with its residential, commercial, institutional, and industrial (RCII) policy recommendations that concern electricity use, because reducing electricity demand can offset the need for new generation, often at a lower cost or even with a savings. The combined results reported here take into account the many overlaps among energy supply and RCII policy options that reduce the demand for power.

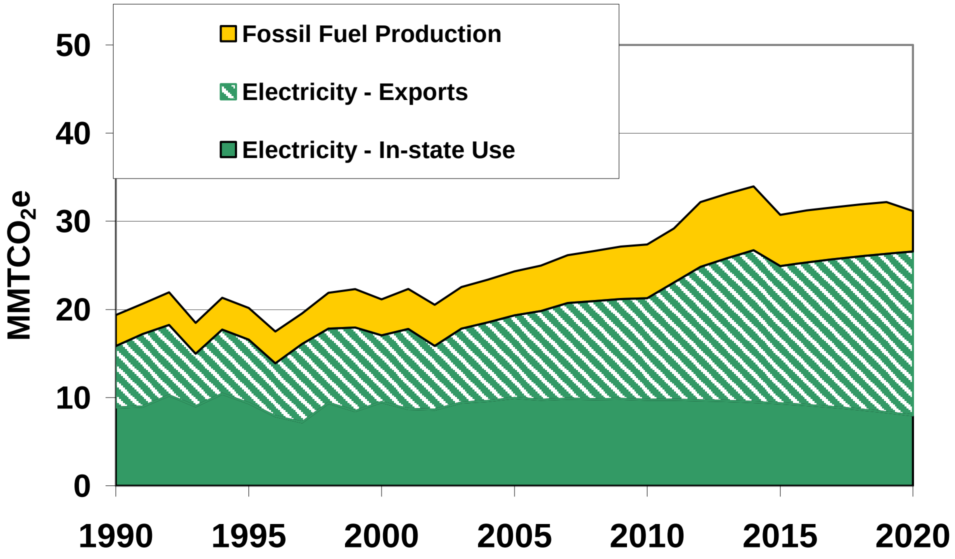
[4] The net cost savings are based on fuel expenditures, operation, maintenance, and administrative costs and amortized, incremental equipment costs. All NPV analyses here use a 5% real discount rate.

Figure 4-3. Impact of policy recommendations on energy supply sector emissions, reference case



Note: It is important to emphasize that these results assume moderate growth in energy production as outlined in the Reference Case projections. If, instead, energy production grows rapidly—particularly in terms of new coal-to-liquid facilities and coal-fired power plants—as described in the High Fossil Fuel Case, the electricity supply policy could lead to more significant impacts. As shown in Figure 4-4, (in comparison with Figure 4-2), the CCAC energy supply recommendations could reduce GHG emissions in the high fossil fuel case by 84 $MMtCO_2e$ cumulatively from 2007 through 2020 and by almost 19 $MMtCO_2e$ per year by 2020. The NPV costs of the options for which costs were estimated (electricity options only) are projected to add to $870 million through the year 2020.

Figure 4-4. Impact of policy recommendations on energy supply sector emissions, high fossil fuel production case



Note: Figures 4-2 and 4-4 show CTL emissions on a life cycle basis, over and above those of the traditional petroleum fuels they would displace. Because policy option ES-12 would require that coal liquids produce fewer life cycle emissions than their petroleum-based counterparts, CTL emissions are not visible in this chart.

The CCAC policy recommendations described in more detail in Appendix G not only offer GHG emissions savings but also offer significant additional benefits. Development and demonstration of carbon storage in Montana, for instance, may be accompanied by a corresponding increase in expertise and related jobs in the state. Leadership in commercializing these technologies would also contribute to the growth and influence of Montana-based companies serving markets elsewhere. Energy reliability and security could be enhanced by greater penetration of distributed and renewable energy resources, as would experience in transmission system management. These co-benefits, including improved air quality and other environmental benefits, are indeed important drivers for many of the CCAC's recommendations.

Energy Supply Sector
Policy Descriptions

The energy supply sector includes emissions mitigation opportunities related to electricity generation and oil and gas production. Electrical energy options include mitigation activities associated with the generation, transmission, and distribution of electricity, whether generated through the combustion of fossil fuels or by renewable energy sources; in a centralized power station supplying the grid or by distributed generation facilities; or in the case of some options, for consumption within Montana or exported from the state. Oil and gas mitigation options include mitigation activities associated with the extraction, transportation, and processing of oil and natural gas, including processing of liquid fuels from coal. Carbon capture and storage options can apply to both electrical generation and fossil fuel production, while market-based mechanisms apply to all activities.

ES-1 Environmental Portfolio Standard (Renewables and Energy Efficiency)

A renewable portfolio standard (RPS) is a requirement that utilities must supply a certain percentage of electricity from an eligible renewable energy source(s). An environmental portfolio standard (EPS) expands that notion to include energy efficiency as an eligible resource as well. In some cases (as in Montana), utilities can also meet their RPS (or EPS) requirements by purchasing certificates from eligible energy projects, typically referred to as Renewable Energy Certificates in the case of RPS policies.

The CCAC unanimously recommends that Montana extend the existing RPS to include renewable energy requirements for 2020 and 2025 and require utilities to pursue cost-effective end-use energy conservation (both electricity and natural gas). Each investor-owned and public utility (including member-owned electric cooperatives) should a) meet 20% of its load using renewable energy resources by 2020, increasing to 25% by 2025 and b) implement a plan to obtain 100% of achievable cost-effective energy conservation by 2025. By 2010, each utility must identify its achievable cost-effective energy conservation for the subsequent 10 years. Utilities must update their energy efficiency assessments and plans regularly, possibly every 2 years.

ES-2 Renewable Energy Incentives and Barrier Removal

This policy option reflects financial incentives and other efforts, such as improving the ability to integrate intermittent wind resources and to encourage investment in renewable energy sources by businesses that sell power commercially (smaller scale renewable sources are covered in ES-4). This option provides additional support to the renewable portion of the EPS in ES-1 with the goal of increasing the supply of renewable energy and reducing its cost.

The CCAC recommends that Montana offer incentives that could include some of the following aspects:

- The state, including the Montana Public Service Commission (PSC) and Montana's representatives on the Northwest Power and Conservation Council, should work with other regional actors to utilize to the greatest possible extent the region's vast hydroelectric resources for the provision of integration services necessary to accommodate significant increases in generation from wind power in Montana and regionally.
- Carbon markets, whether current voluntary offsets markets or future compliance markets (allowances and/or offsets), could provide an important mechanism for promoting renewable energy projects. At present, there is uncertainty regarding the shape of these markets and the best strategies for the state to pursue.
- Financial incentives through tax policies, production tax credits (federal), and Public Utility Regulatory Policy Act (PURPA) requirements.
- Recent change in property tax specification for wind projects could be expanded to other renewable forms of generation as appropriate.
- Incentives for locating manufacturing plants in the state for renewable generation, with potential sunset provisions as industries mature in Montana.
- Incentives for technologies that support improved integration of intermittent (e.g., wind) resources, including but not limited to advanced energy storage technologies.
- Target incentives to community wind projects.
- Tax incentives for transmission lines that carry wind power (which were included in the recently passed House Bill 3 [HB 3] from the 2007 Montana Legislative Special Session).
- A planning process that, among other things, will evaluate potential wind power sites and associated transmission infrastructure in order to develop a priority list of transmission system upgrades that will enable development of those wind power sites.
- Develop a system that certifies and recognizes new wind projects that have implemented measures in project construction and operation so as to minimize impacts to wildlife, critical wildlife habitat, national and state parks, and other areas of special concern. The Montana Department of Environmental Quality (DEQ) should work collaboratively with stakeholders to establish the criteria for such a system in order to formalize the best management practices that Montanans agree make sense for active but low-impact wind power development.

ES-3 Research and Development (R&D), Including R&D for Energy Storage and Advanced Fossil Fuel Technologies

R&D funding can be targeted toward a particular technology or group of technologies as part of a state program with a mission to build an industry around that technology in the state and/or to set the stage for adoption of the technology for use in the state. For example, an agency can be established with a mission to help develop and deploy energy storage technologies. R&D funding can also be made available to any renewable or other advanced technology through an open bidding procedure (i.e., driven by bids received rather than by a focused strategy to develop a particular technology). Funding can also be given for demonstration projects to help commercialize technologies that have already been developed but are not yet in widespread use. Funding could be provided to increase collaboration between existing institutions for R&D on technologies.

The CCAC recommends that Montana, potentially working with other partners, pursue an R&D program that targets, among other technologies, carbon sequestration technologies, compressed air, and other storage technologies to increase penetration of intermittent renewable energy (including wind power) and direct carbon fuel cells. Funding sources could include federal R&D funding for a high-altitude advanced fossil demonstration project(s) in Montana as authorized by the Energy Policy Act of 2005, a small pool of state funding for R&D efforts, industry contributions (e.g., licensing fees), and the coal severance tax (e.g., for clean coal, sequestration, and compressed air storage, among others). The program could establish an energy technology program in the Montana university system, attract federal R&D funding, grow technology expertise, issue advanced degrees, and aim for resulting “multiplier” benefits. It could also include industrial participation and make available the results of R&D and pilot programs to inform industrial development.

ES-4 Incentives and Barrier Removal (Including Interconnection Rules and Net Metering Arrangements) for Combined Heat and Power (CHP) and Clean Distributed Generation (DG)

This option focuses on CHP and clean distributed generation (DG) located on-site at consumer facilities that do not sell power commercially. There are numerous barriers to CHP and clean DG, including inadequate information, institutional barriers, high transaction costs because of small projects, high financing costs because of lender unfamiliarity and perceived risk, “split incentives” between building owners and tenants, and utility-related policies such as interconnection requirements, high standby rates, and exit fees. The lack of standard offer or long-term contracts, payment at avoided cost levels, and lack of recognition for emissions reduction value provided also create obstacles.

The CCAC recommends that Montana take several steps to increase incentives and decrease barriers for CHP and DG. These steps could include increasing incentives for installation and development of CHP and DG systems, including small distributed wind and solar hot water. These incentives could be funded in part through improving or expanding the Alternative Energy Revolving Loan Program (AELRP). Existing interconnection rules can be a barrier, and the CCAC recommends creating standardized interconnection and net metering rules for CHP and

DG systems, while considering needs of smaller systems and the potential impact that net metering may have on cross-subsidies between consumers. The CCAC also recommends considering a DG effort—similar to the establishment of the Rural Electrification Administration in the 1930s—in order to use grants, loans, and the initiation of green co-ops to overcome many of the road blocks to DG implementation. The CCAC encourages the development of a set of state-issued licenses for renewable energy system technicians and installers.

ES-5 Incentives for Advanced Fossil Fuel Generation and Carbon Capture and Storage or Reuse (CCSR), Including Combined Hydrogen and Electricity Production with Geological Carbon Sequestration

Advanced fossil technologies produce fewer carbon dioxide (CO_2) emissions per kilowatt-hour (kWh) as the result of more efficient generating technologies (e.g., supercritical coal and integrated gasification combined cycle [IGCC]) and/or carbon capture and storage or reuse (CCSR). Differing technologies may apply either before or after fuel combustion.

The CCAC recommends that Montana direct DEQ or direct the state to enter into a regional collaborative effort to develop standards and protocols for CCSR. It also recommends that Montana strengthen the Major Facility Siting Act to enable eminent domain for pipelines to transport CO_2 and protect landowners with appropriate siting requirements and address liability issues associated with carbon capture and storage. Finally, it recommends that Montana create a requirement that all fossil-fuel–fired electric generation facilities must meet a technology/fuel-neutral emissions level expressed in tCO_2/MWh (megawatt-hour). Facilities must file a plan with the DEQ Air Permitting Section that details the facility’s commitment to capture and/or sequester (by geological or terrestrial means) CO_2 emissions, as an attribute of operating plans and permits and as needed to achieve this level. CCAC recommends that DEQ petition the Montana Board of Environmental Review for such a rule with specific suggested language. CCAC also suggests that the legislature approve supporting legislation. The CCAC recommends an emissions goal of 0.5 tCO_2/MWh (or 1,100 lbs/MWh), decreasing over time commensurate with best available control technology.

ES-6 Efficiency Improvements and Repowering of Existing Plants

Efficiency improvements refer to increasing generation efficiency at power stations through incremental improvements at existing plants (e.g., more efficient boilers and turbines, improved control systems, or combined cycle technology). Repowering existing power plants refers to switching to lower or zero emitting fuels at existing plants or to new capacity additions. This includes co-firing biomass at coal burning plants or the use of natural gas in place of coal or oil.

The CCAC recommends that the state investigate and implement policies that encourage the reduction of GHG emissions per MWh produced or, in the case of renewable energy facilities, encourage an increase of output at existing facilities. The co-firing of biomass at coal and other fossil fuel plants and advanced technologies, such as oxyfuel combustion, deserve particular attention. Policies to encourage efficiency improvements and repowering of existing plants could include incentives or regulations as described in ES-5 above, with adjustments for financing opportunities and emission rates of existing plants.

ES-7 Demand-Side Management

CCAC recommendations for demand-side management, meaning the provision of energy efficiency programs for electricity and natural gas conservation, is included in options ES-1 (above) and RCII-1 (discussed in Chapter 3).

ES-8/9 Market-Based Mechanisms to Establish a Price Signal for GHG Emissions (GHG Cap-and-Trade or Tax)

Market-based mechanisms are used to establish a price on GHG emissions (or CO_2 specifically). Presently, the cost of emitting CO_2 into the atmosphere is free. With a cost attached to carbon emissions, emitters would have a strong incentive to modify their practices, and economic inefficiencies inherent in the present system would be addressed, leading to a reduction in GHG emissions.

There are two principal ways to place a value on carbon: a carbon tax or a cap-and-trade system. Among the important considerations with respect to either implementation mechanism are the sources and sectors to which it would apply, the level and timing, how “leakage” is addressed, and how potential revenues are invested.

Some CCAC members believe that a national carbon tax is the preferred strategy. Other CCAC members believe that a national cap-and-trade system is not only preferred but stands a more realistic chance of being adopted than a national carbon tax. Collectively, however, the CCAC determined not to take a position on these competing mechanisms because we recognize that our ability to influence national policy is limited. The CCAC underscores that one of these mechanisms, or some other mechanism, needs to be adopted by the federal government in the near future if the nation is to achieve significant reductions in GHG emissions.

Overall, the CCAC recommends that Montana investigate and advocate for a national GHG cap-and-trade or tax system. In addition, the state should participate fully in the Western Regional Climate Action Initiative, which will consider development of a regional market-based mechanism.

ES-10 Generation Performance Standards or GHG Mitigation Requirements for New (and/or Existing) Generation Facilities, With/Without GHG Offsets

A generation performance standard (GPS) could take several forms. In the case of a GHG Emissions Performance Standard, as enacted in California and in Washington State, it is a mandate requiring load-serving entities (LSEs) to acquire electricity with an emissions rate below a specified mandatory standard. In the case of power plant GHG performance standards, as are in place in Oregon and Washington, it can be a requirement that power plant developers build and operate new electrical generation with an emission rate (e.g., X lbs CO_2/MWh) below a specified mandatory standard. In some cases (as in Oregon and Washington), GHG offsets or credits can be used for compliance. GHG offsets are GHG emission savings from project-based activities in sectors or regions not covered by the standard or regulations, which typically need to meet specific criteria laid out in the regulation.

The CCAC recommends that the state implement GHG Emission Performance Standards and align these standards to the extent possible with those adopted in California and Washington State. These standards would establish a maximum GHG emission rate that is equal to or less than that of a new, natural gas combined cycle (NGCC) power plant for new, long-term financial commitments to baseload electrical generating resources by LSEs; it would apply to both in-state and imported electricity. In doing so, the state should consider a longer term phase-in to account for the availability of technological options and to ensure no reduction in electricity supply reliability. The standard is based on net emissions from electricity production and does not count CO_2 stored in geologic formations as emissions from the power plant (e.g., sequestration would count as emissions savings within a GPS standard). Note that this option should complement and work with any future cap-and-trade or carbon tax system (ES-8/9).

ES-11 Methane and CO_2 Reduction in Oil and Gas Operations, Including Fuel Use and Emissions Reduction in Venting and Flaring

Methane (CH_4) and CO_2 emissions in the oil and gas industry can be reduced by a number of means. Natural gas consists primarily of methane, a very potent GHG; therefore, any leaks during production, processing, and transportation/distribution should be addressed. Among the practices recommended are preventive maintenance (improving the overall efficiency of the gas production and distribution system), reducing flashing losses (releases when pressure drops at storage tanks, wells, compressor stations, or gas plants), and changing and replacing parts and devices to reduce leaks and improve efficiency. CO_2 emissions in the oil and gas industry can also be reduced by improving energy efficiency by a) using new efficient compressors, b) optimizing gas flow to improve compressor efficiency, c) improving performance of compressor cylinder ends, d) capturing compressor waste heat, e) replacing compressor driver engines, and f) using waste heat recovery boilers.

The CCAC recommends that Montana adopt a policy to encourage natural gas companies in the state to participate in EPA's Natural Gas STAR Program and provide enforcement and verification of participation. This is especially helpful for a state like Montana where many of the operators are smaller companies that probably have not considered the leak prevention and other methods available through the Natural Gas STAR Program. The CCAC recommends that the state consider whether participation by smaller companies would be a significant burden and possibly provide incentives if needed. The CCAC suggests a goal of reducing methane emissions by 30% below business as usual (BAU) levels by 2020.

ES-12 GHG Reduction in Refinery Operations, Including in Future Coal-to-Liquids Refineries

Methane and CO_2 emissions can be reduced in the production of liquid fuels at oil refineries or at CTL plants through various energy efficiency and process options, including enhanced combined heat and power along with carbon capture and storage. CTL plants are energy-intensive and emit 10 times more CO_2 than conventional oil refineries in order to produce liquid fuels. Emissions reductions from CTL production can be achieved through polygeneration, biomass blending, and most significantly through carbon capture and storage. CTL fuels production is especially amenable to CO_2 capture and sequestration, because emissions are largely generated from a single source and are already concentrated because the syngas produced from the feedstock fuel must be cleansed of excess CO_2 before entering the Fischer-Tropsch reactor.

The CCAC has serious concerns about the high GHG emissions associated with the production of coal liquids and recommends that the state require that all CTL facilities located in Montana meet a performance-based standard, reflecting a best available control technology approach. A suggested goal is that CTL plants must produce fuels with life cycle GHG emissions [at least] 20%–30% below petroleum-based fuels. This could imply that CTL facilities would capture and store CO_2 from the start of operations, assuming this technology is considered commercially available, producing fuels with 20% to 30% lower life cycle emissions relative to standard petroleum-based fuels. Any CTL plant would likely also be a poly-generation plant and would produce electricity along with fuel and other products.

The CCAC recommends that this policy option aim to improve maintenance at oil refineries as well as CTL plants and ensure that best practices are being followed (cross-cut with safety issues).

ES-13 CO_2 Capture and Storage or Reuse (CCSR) in Oil & Gas Operations, Including Refineries and Coal-to-Liquids Operations

Due to overlaps with other options, CCSR is incorporated within ES-5 and ES-12.

Chapter 5
Transportation and Land Use

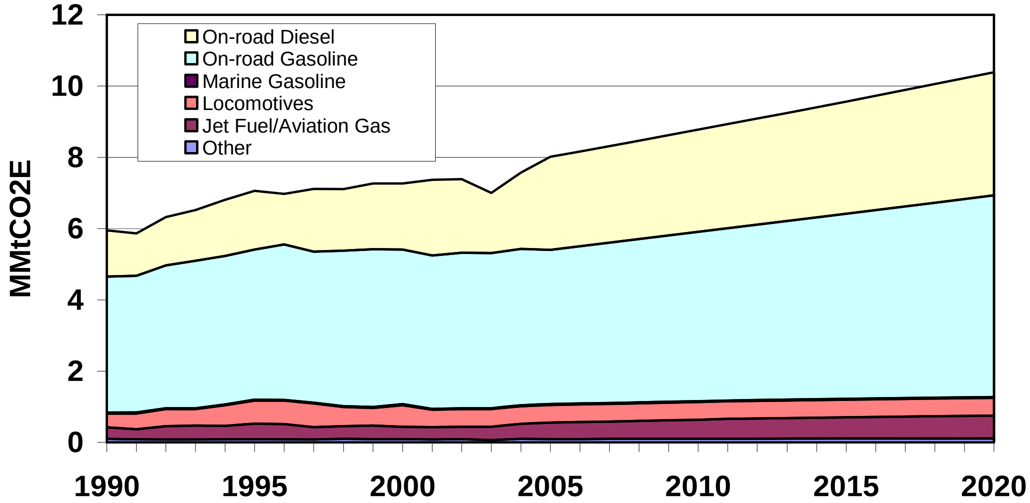
Overview of GHG Emissions

The transportation sector is a major source of greenhouse gas (GHG) emissions in Montana—currently accounting for about 20% of the state's gross GHG emissions. The transportation technologies and fuels used are key determinants of those emissions, along with population, economic growth, and various land use policies that all affect the demand for transportation services. GHG emissions from the transportation sector totaled about 7.3 million metric tons of carbon dioxide equivalents (MMtCO$_2$e) in 2000.

Figure 5-1 shows historical and projected transportation and land use (TLU) GHG emissions by fuel and source and illustrates their rapid growth. TLU emissions are expected to grow significantly from 1990 to 2020. Montana state projections suggest on-road vehicle miles traveled (VMT) will continue to increase at an estimated rate of 1.92% annually, with relatively higher growth in freight VMT also expected.

In 2005 Congress enacted the Energy Policy Act which contained a provision for a national renewable fuel standard that will likely increase the use of alternative fuels in Montana. This was classified as a "recent action" and was accounted for in the TLU Technical Work Group (TWG) analysis.

Figure 5-1. Historical and projected GHG emissions from the transportation and land use sector, Montana, 1990 to 2020



MMtCO$_2$e = million metric tons of carbon dioxide equivalents

Key Challenges and Opportunities

The principal means of reducing TLU emissions includes improving vehicle fuel efficiency, substituting gasoline and diesel with lower emission fuels, modal switches to lower emission means of travel, and various strategies to decrease the growth in fuel use and VMT.

In Montana and in the nation as a whole, vehicle fuel efficiency has improved little since the late 1980s, yet many studies have documented the potential for substantial increases consistent with maintaining vehicle size and performance. The use of alternative fuels with lower GHG emissions is growing in Montana, and larger market penetration is possible. Montana also has taken some steps to increase transit options and encourage alternative growth and development patterns.

Overview of Policy Recommendations and Estimated Impacts

The Climate Change Advisory Committee (CCAC) recommends a set of 13 policy options for the transportation and land use sector that offer the potential for major economic benefits and emissions savings. These policy recommendations could lead to emissions reductions from reference case projections of 1.01 MMtCO$_2$e for the year 2020, cumulative savings of nearly 5.54 MMtCO$_2$e from 2006 through 2020, and net cost *savings* of more than $321 million to the Montana economy through the year 2020 on a net present value (NPV) basis.[1] The weighted average cost of saved carbon from the policy options for which quantitative estimates of both costs and savings were prepared was –$67/MtCO$_2$e.

The estimated impacts of the individual policies are shown in Table 5-1 below. The CCAC policy recommendations described briefly here (and in more detail in Appendix H) not only result in significant emissions and costs savings but also offer a host of additional benefits as well. These benefits include (but are by no means limited to) reduced local air pollution, more livable, healthy communities, and economic development and job growth from in-state alternative fuel production.

In order for the TLU policy options recommended by the CCAC to yield the levels of savings described here, the options should be implemented in a timely, aggressive, and thorough manner. Notably, the state Clean Car Program must clear several hurdles before Montana or any other state can adopt it, including EPA approval of the original California Clean Car Program (that other states can then opt into) and a court challenge to the underlying notion of regulation of GHG emissions from vehicles. If, for any reason, Montana is not able to implement the Clean Car Program, other options could play a larger role. For example, the policies to be studied under the Financial and Market Incentives for Low GHG Vehicle Ownership and Use (TLU-4) could improve fuel efficiency through some combination of “feebates,” vehicle excise taxes that vary with fuel economy, and other programs. Feebate proposals usually have two parts: 1) a fee on relatively high emissions/lower fuel economy vehicles and 2) a rebate or tax credit on low emissions/higher fuel economy vehicles. A multistate approach to feebates is recommended here because of the drawbacks of Montana (or any state) acting alone in this area.

Greater use of lower carbon fuels (TLU-6) can be accomplished through a combination of voluntary and mandatory measures. The Low Carbon Fuel Standard recommended as part of TLU-6 can increase the use of ethanol and biodiesel.

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[1] The net cost savings are based on fuel expenditures, operations, maintenance, and administrative costs, and amortized, incremental equipment costs. All NPV analyses here use a 5% real discount rate.

To be most effective, the group of policies aimed at Growth and Development (TLU-5) will require change at every level of government, and as such will be most effective with focused leadership by the state, including training, outreach, and technical assistance to local governments.

Table 5-1. CCAC-recommended policy options and results for the TLU sector

	Policy Option	GHG Reductions (MMtCO$_2$e)			Net Present Value 2006–2020 (Million $)	Cost-Effectiveness ($/tCO$_2$e)	Level of Support
		2010	**2020**	**Total 2007–2020**			
TLU-1	Light-Duty Vehicle Clean Car Standards	0.00	0.95	4.92	–$492	–$100	UC
TLU-2	Fuel Efficient Replacement Tires Program	0.00	0.03	0.14	–$86	–$90	UC
TLU-3	Consumer Information on Vehicle Miles Per Gallon (MPG)	*Included in TLU–1 and TLU–2*					UC
TLU-4	Financial and Market Incentives for Low GHG Vehicle Ownership and Use	*Included in TLU–1*					UC
TLU-5	Growth and Development Bundle	0.00	0.14	0.77	<$0	<$0	UC
TLU-6	Low Carbon Fuels	0.00	0.04	0.39	N/A	N/A	UC
TLU-7	Heavy-Duty Vehicle Emissions Standards and Retrofit Incentives	0.00	0.02	0.16	$12.8	$79	UC
TLU-8	Heavy-Duty Vehicle and Locomotive Idle Reduction	0.01	0.02	0.13	–$5.6	–$44	UC
TLU-9	Procurement of Efficient Fleet Vehicles	*Included in TLU-1, TLU-6 through TLU-8, and TLU–11*					UC
TLU-10	Transportation System Management	*Not quantified*					UC
TLU-11	Intermodal Freight Transportation	0.02	0.09	0.59	N/A	N/A	UC
TLU-12	Off-Road Engines and Vehicles GHG Emissions Reductions	*Not quantified*					UC
TLU-13	Reduced GHG Emissions from Aviation	*Not quantified*					UC
	Sector Total After Adjusting For Overlaps	0.02	0.96	6.1	–$492	–$93	

Transportation and Land Use Sector Policy Descriptions

The TLU sector includes emissions and mitigation opportunities related to vehicle technologies, fuel choices, transit options, and demand for transportation services.

TLU-1 Light-Duty Vehicle Clean Car Standards

The CCAC recommends that Montana adopt the Light-Duty Vehicle Clean Car Standards (also known as the “Pavley” standards or California GHG Emission Standards) in order to reduce GHG emissions from new light-duty vehicles (LDVs). The standards, which must still be approved by the United States Environmental Protection Agency (US EPA), would take effect in model year 2011 (calendar year 2010). Other Clean Car Program elements include standards requiring reductions in smog- and soot-forming pollutants and promoting introduction of very low-emitting technologies into new vehicles.

New cars and light trucks in all states must comply with federal emission standards and, generally speaking, states have the choice of adopting the stronger set of standards applicable in California. In 2005, California finalized a set of standards that would require reductions of GHG emissions of about 30% from new vehicles, phased in from 2009 to 2016, through a variety of means. Eleven states have already adopted the California Clean Car Program standards: California, Connecticut, Maine, Massachusetts, New Jersey, New York, Oregon, Pennsylvania, Rhode Island, Vermont, and Washington.

TLU-2 Fuel Efficient Replacement Tires Program

The CCAC recommends that Montana improve the fuel economy of the LDV fleet by setting minimum energy efficiency standards for replacement tires and requiring that greater information about low-rolling resistance (LRR) replacement tires be made available to consumers at the point of sale.

Manufacturers currently use LRR tires on new vehicles, but they are not readily available to consumers as replacement tires. When installing original equipment tires, carmakers use LRR tires as a way to contribute to meeting the federal corporate automobile fuel economy (CAFE) standards. When replacing the original tires, consumers often purchase less efficient tires. Currently, tire manufacturers and retailers are not required to provide information about the fuel efficiency of replacement tires. An appropriate state agency would initiate a fuel efficient tire replacement program. The program could include consumer education, product labeling, and minimum standards elements. These programs would be developed under a rule development process that would incorporate the best scientific information, including the results from tests of tires conducted by the tire manufacturers, data from the California Energy Commission, and other data reviewed by the National Academy of Sciences.

TLU-3 Consumer Information on Vehicle Miles Per Gallon (MPG)

The CCAC recommends that Montana work to provide consumers with information about the fuel efficiency and cost in relation to the purchase, maintenance, and operation of their vehicles. Consumers would receive real-time information on the miles per gallon (MPG) while their vehicles are in operation and alerts when their tire pressure is too low (i.e., devices like Air Alert Valve Caps). Generally, a set of four light-emitting diode (LED) tire alert self-calibrating tire pressure valve caps cost about $22.00, and MPG monitoring systems, such as ScanGauge, are about $100.00. In addition, consumers would receive public education and information relating to the impact that vehicle maintenance practices have on the operation of their vehicles. Finally, consumers would be encouraged to consider the MPG of vehicles before and at the time of vehicle purchase.

TLU-4 Financial and Market Incentives for Low GHG Vehicle Ownership and Use

The CCAC recommends that Montana further study and develop policy options that create incentives and disincentives for the purchase and operation of vehicles with varying fuel economy. The policies to be studied and developed includes the following:

1. *Feebates.* A multistate feebate program, including other western states of Arizona, California, and New Mexico. Feebate proposals usually have two parts: 1) a fee on relatively high emissions/lower fuel economy vehicles; and 2) a rebate or tax credit on low emissions/higher fuel economy vehicles. Legislation for this policy option will be needed.
2. *Excise Taxes.* A change in new vehicle excise taxes that increases taxes for relatively high-emitting vehicles and reduces taxes for relatively low-emitting vehicles. Overall, excise tax revenue would remain the same.
3. *Labeling.* A consumer labeling program that provides buyers with better information on the GHG emissions of new vehicles.

Together, these incentives could change the vehicle fleet technology mix through a combination of demand- and supply-side changes.

TLU-5 Growth and Development Bundle

The CCAC recommends that Montana pursue a bundle of options that encompass several components intended to reduce GHG emissions through promotion of multimodal transit options and land use practices and policies. These policies contribute to GHG emissions reductions by reducing vehicle trips and VMT.

Potential actions include the following programs and program elements:

1. Infill, densification, and brownfield redevelopment;
2. Mixed-use and transit-oriented development;
3. Smart Growth planning, modeling, and tools;
4. Targeted open space protection;
5. Expanding transit infrastructure and service; and
6. Expanding transportation choices.

In general, neighborhood center development/redevelopment options are recommended to reduce VMT resulting from inefficient development patterns and locations. Smart Growth principles should be implemented to manage the location, density, development pattern, and infrastructure and to meet basic human needs of new growth.

TLU-6 Low Carbon Fuels

The CCAC recommends that Montana seek to increase the use and market penetration of low carbon fuels (LCFs) to offset traditional fossil fuels such as gasoline, diesel, jet fuel, and others derived from crude oil. Additionally, the policy aims to increase production opportunities for LCFs derived from Montana crops and other low carbon transportation alternatives such as hydrogen, natural gas, and electricity. TLU-6 will evaluate the merits of LCFs based on their net carbon impact and will remain consistent with Agriculture, Forestry, and Waste Management Policy Option 2 (AFW-2), which increases biodiesel production in the state.

Various options or a combination of options to increase LCF use would include:

- Carbon fuel accounting,
- Fuel quality standards,
- LCF infrastructure development,
- LCF standard and credits for compliance,
- High carbon fuel tax,
- State government fleet ‘leadership’ programs for adoption of LCFs, and
- Carbon reduction requirements.

LCFs demonstrate tangible economic benefits to rural economies. An LCF policy provides for strong, proactive measures to address economic and environmental issues where agricultural concerns yearn for economic sustenance and higher crop prices, or new and higher paying industry jobs to sustain the existing economy.

TLU-7 Heavy-Duty Vehicle Emissions Standards and Retrofit Incentives

The CCAC recommends that Montana work with other states and the EPA to advance GHG emissions standards for on-road heavy-duty vehicles (HDVs). In addition, the state would adopt incentive programs to reduce particulate matter (PM) emissions from existing on-road HDVs. Diesel particulate matter includes black carbon aerosols, which are thought to contribute to global warming through positive radiative forcing.

Approaches to diesel engine emission reductions include vehicle scrappage and replacement, repowering (engine replacement), and retrofit with exhaust after-treatment devices. Two devices commonly used to reduce diesel PM emissions are diesel oxidation catalysts and diesel particulate filters. These devices can be used on certain model year engines of heavy-duty trucks, motor coaches, and transit and school buses.

TLU-8 Heavy-Duty Vehicle and Locomotive Idle Reduction

The CCAC recommends that Montana reduce the amount of time that trucks, buses, and locomotives idle. It would involve promoting and expanding the use of technologies that reduce long-term idling, including the use of truck stop electrification. It would also encourage development of local ordinances banning unnecessary idling by HDVs and locomotives in most situations.

Truck stop electrification involves truck plazas that are equipped with electrification systems that allow drivers to shut off their engines and draw electrical power and in some cases, heating, cooling, and communication and entertainment options from a ground source. Different systems may or may not require the purchase of an adaptor to connect to the tractor.

In addition to truck stop electrification, other available technologies that reduce HDV idling include automatic engine shut-down/start-up system controls, auxiliary power units, and direct-fired heaters. Technologies to reduce locomotive idling include automatic engine shut-down/start-up system controls and hybrid-electric switcher engines.

TLU-9 Procurement of Efficient Fleet Vehicles

The CCAC recommends that Montana state and local government agencies “lead by example” by enacting procurement policies and/or joining the EPA SmartWay program and utilizing the SmartWay Upgrade Kits that result in adoption of lower emitting vehicle fleets. There are three primary components of the EPA SmartWay program: creating partnerships, reducing all unnecessary engine idling, and increasing the efficiency of LDVs, HDVs, rail, and intermodal operations.

Targets are listed under the Policy Design section of Appendix H and will be based on the availability of energy-saving technologies and overall efficiency of the life of the vehicle.

This policy option strengthens Montana’s commitment to reduce GHG emissions through fuel efficiency in vehicles owned by the state while also encouraging private and public agency fleets that have the potential to develop incentive programs for local governments to help with the initial costs of purchasing such vehicles.

TLU-10 Transportation System Management

The CCAC recommends that Montana seek to reduce GHG emissions from the transportation sector through improvements to transportation system management. These efforts would focus on the improvement, management, and operation of the transportation infrastructure, with a focus on the roads and highway systems.

TLU-11 Intermodal Freight Transportation

The CCAG recommends that Montana encourage the expansion of intermodal rail service for Montana shippers. In addition, the state would strive to increase the competitiveness of rail rates for all Montana shippers. Transportation of freight by railroad generally results in less fuel use and GHG emissions than transportation by truck. The best candidates for diversion from truck to rail are commodities that can move by intermodal rail transportation, which involves shipping containers or truck trailers placed on rail flatcars.

TLU-12 Off-Road Engines and Vehicles GHG Emissions Reductions

The CCAC recommends that Montana reduce emissions from off-road engines. Off-road (also called non-road) engines and vehicles are significant emitters of GHGs and consumers of petroleum-based fuels. Emissions from off-road engines can be reduced by adoption of GHG emissions standards and through retrofit technologies. The efforts would be expected to be consistent with efforts to reduce off-road emissions of other regulated air pollutants. In the state of Montana, these reductions would affect the following equipment categories: airport service, construction, industrial, lawn and garden, agriculture, light commercial, logging, recreational (including snowmobiles and snow coaches), and recreational marine.

TLU-13 Reduced GHG Emissions from Aviation

The CCAC recommends that Montana encourage the federal government to take actions to reduce GHG emissions from the aviation portion of the transportation sector. Those actions could include promotion and use of existing aircraft technologies and programs to reduce emissions, such as Reduced Vertical Separation Minimums (RVSM), Required Navigation Performance (RNP), System for Assessing Aviation’s Global Emissions (SAGE), and Voluntary Airport Low Emissions (VALE) Program.

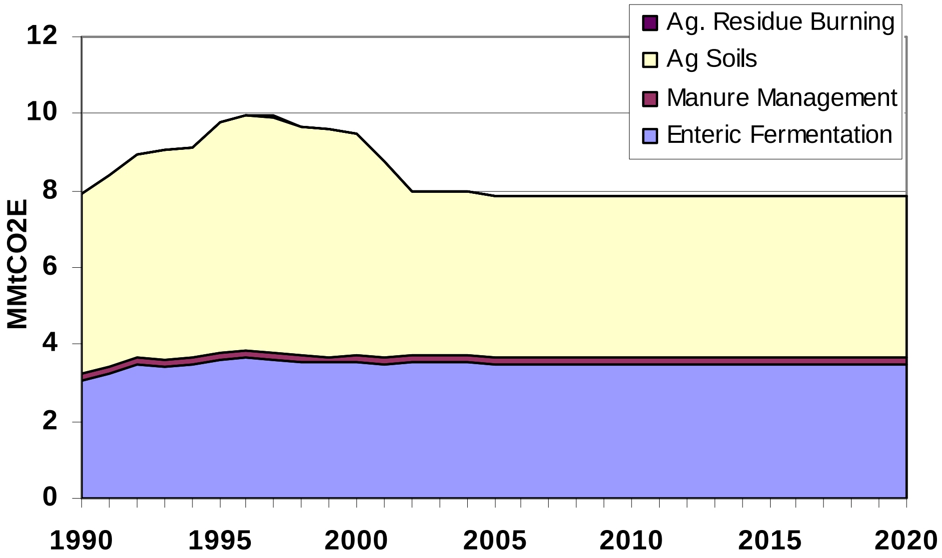
Working in cooperation with other state governments, the State of Montana would seek to develop and encourage a set of federal policies that would significantly reduce GHG emissions reductions from the in-air operation of airplanes.

Chapter 6
Agriculture, Forestry, and Waste Management

Overview of GHG Emissions

The agriculture, forestry, and waste management (AFW) sectors have a significant impact on Montana's current greenhouse gas (GHG) emissions. For agriculture, net emissions were 9.5 million metric tons of carbon dioxide equivalent ($MMtCO_2e$) in 2000, accounting for about one-fourth of Montana's gross GHG emissions. Agricultural emissions include methane (CH_4) and nitrous oxide (N_2O) emissions from enteric fermentation, manure management, agricultural soils, and agricultural residue burning. As shown in Figure 6-1, emissions from agricultural soils account for the largest portions of agricultural emissions. The agricultural soils category includes N_2O emissions resulting from activities that increase nitrogen in the soil, such as fertilizer application (synthetic, organic, and livestock) and production of nitrogen-fixing crops.

Figure 6-1. Historical and projected GHG emissions from the agriculture sector, Montana, 1990–2020



Total gross emissions from agricultural sources fluctuated from 8 to 10 $MMtCO_2e$ from 1990 through 2005. Figure 6-1 shows that projected emissions are held constant between 2005 and 2020. This is because of a lack of information that suggests significant future change in Montana agricultural practices or activity levels. On the basis of limited data, agricultural soils are estimated to sequester about 2.3 $MMtCO_2$ per year.

Forestland emissions refers to the net carbon dioxide (CO_2) flux[1] from forested lands in Montana, which account for about 24% of the state's land area. As shown in Table 6-1,

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[1] "Flux" refers to both emissions of CO_2 to the atmosphere and removal (sinks) of CO_2 from the atmosphere.

U.S. Forest Service (USFS) data suggest that Montana forests and the use of forest products sequestered, on average, 23.1 $MMtCO_2$ per year from 1989 to 2004. The data show an accumulation of carbon in each of the forest carbon pools during this period. These rates of sequestration are assumed to remain constant through 2020 (as discussed in the Inventory and Forecast [I&F] Report, the soil carbon flux is left out of the totals because of large uncertainties).

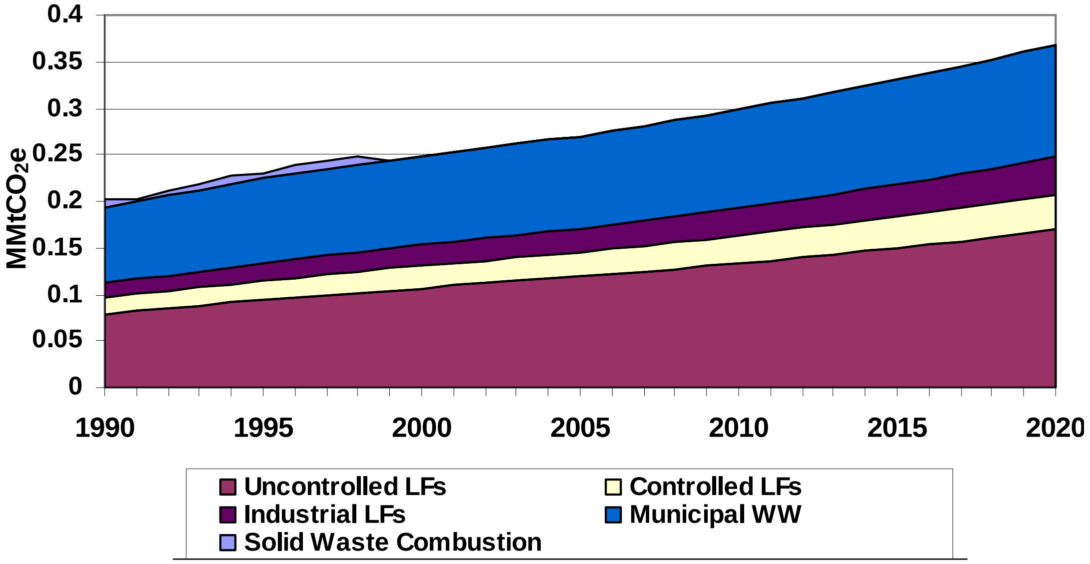
Table 6-1. GHG emissions (sinks) from the forestry sector

Forest Carbon Pool	1990–2020* $MMtCO_2e$
Live trees	–9.6
Standing dead trees	–2.04
Live understory	–0.83
Down and dead trees	–0.81
Forest floor	–7.3
Soil organic carbon	–8.7
Harvested wood products and landfilled forestry waste	–2.5
Total (excludes soil organic carbon)	**–23.1**

*Based on USFS data from 1989 to 2004.

The waste management sector includes both solid waste management and wastewater treatment. Sources include methane from solid waste landfilling. (As organic wastes decompose in landfills they generate methane.) Wastewater (WW) treatment plants produce both methane and nitrous oxide emissions. This sector contributes relatively little to Montana's GHG emissions (see Figure 6-2). In 2000, these sources produced an estimated GHG emissions of 0.3 $MMtCO_2e$, which was less than 1% of the state's gross emissions.

Figure 6-2. Montana GHG emissions from the waste management sector



LF = landfill; WW = wastewater treatment.

Opportunities for GHG mitigation in the AFW sector involve measures that can reduce emissions within the sector or reduce emissions in other sectors. For example, production of liquid biomass fuels can offset emissions in the transportation and in the residential, commercial, institutional, and industrial (RCII) sectors, while biomass energy can reduce emissions in the energy supply (ES) or RCII sectors. Similarly, actions taken to increase waste recycling in the waste management sector can reduce emissions not only in the state (e.g., landfill methane) but also outside the state (e.g., emissions associated with the energy used to produce products from recycled materials versus from virgin materials).

The primary opportunities for GHG mitigation are as follows:

- **Production of renewable fuels (in-state production from in-state feedstocks)—**renewable fuels, such as ethanol from crops, crop residue, forestry residue, or municipal solid waste, can produce significant reductions when they are used to offset consumption of fossil fuels (gasoline consumption in the transportation sector). This is particularly true when these fuels are produced using processes and/or feedstocks that emit much lower GHG emissions than those from conventional sources (e.g., starch-based ethanol).
- **Beneficial use of forest biomass—**expanded use of biomass energy from residue removed from forested areas during treatments to reduce fire risk can achieve GHG benefits by offsetting fossil fuel consumption (to produce electricity, steam, or heat).
- **Protection of forest and agricultural land from conversion to developed use—**by protecting these areas from development, the carbon in aboveground biomass and belowground soil organic carbon can be maintained, and additional emissions of CO_2e to the atmosphere can be avoided. Indirectly, these opportunities will also support the smart-growth policies in the transportation sector.
- **Increase the level of organic carbon in soil—**by using conservation tillage/no-till and other soil management practices and, potentially, through the use of organic farming techniques. These practices have been shown to result in significant increases in soil carbon compared with conventional cultivation. Additional GHG reductions are also possible to the extent that these techniques reduce fossil fuel consumption because of less intensive use of farm equipment. Also, policies aimed at protecting existing soil carbon in agricultural soils under conservation programs can avoid future GHG emissions to the extent that acres returning to active conventional cultivation are minimized.
- **Enhance solid waste recovery and recycling—**reducing the quantity of materials being landfilled reduces future landfill methane emissions potential, while recycling reduces emissions associated with the manufacturing of products from raw materials. Analysis has shown that enhanced waste recovery and recycling can produce overall life cycle GHG reductions (both within and outside of Montana) that are greater than the current levels of emissions from solid waste management (landfilling) within the state.

Additional opportunities for reducing GHGs include afforestation/reforestation of non-forested lands (in both forested and urban areas), restocking forest lands, improving management of existing forest stands, and expanding usage of wood products for building materials. The increased planting and restocking of trees in urban areas has benefits in carbon sequestration and also has other energy and environmental benefits.

Key Challenges and Opportunities

In the agricultural sector, production of ethanol and biodiesel were found to offer substantial GHG reduction potential with an estimated reduction of 0.54 $MMtCO_2e$ by 2020 (combined benefit of Policy Options AFW-2 and AFW-3). This is the benefit from in-state production using Montana-grown feedstocks and/or lower GHG production methods. These two policy options are linked with the low-carbon fuels policy in the transportation and land management (TLU) sector (TLU-6, Low Carbon Fuels). TLU-6 seeks to achieve greater consumption of lower carbon fuels in the state, while these two AFW options seek to promote lower carbon fuel production in the state (to help meet future demand). The benefits for both biodiesel and ethanol are based on production methods and feedstocks that have lower GHG emissions than conventional processes. For ethanol, this means processes that achieve much better GHG reductions than production from conventional corn-based ethanol. These processes could include cellulosic hydrolysis, biomass gasification combined with biofuels production, or alternative starch-based production (fermentation processes fueled by renewable fuels). The analysis conducted to estimate benefits assumed that the ethanol would be produced using cellulosic hydrolysis. For biodiesel, crop production should be promoted that results in significantly better vegetable oil yields than soybean oil, which is currently the most prominent feedstock in the United States. Candidates include vegetable oil crops like canola, camelina, sunflower, mustard, or safflower that have much higher yields, or emerging technologies like algal oil production.

For biofuels, the challenges in Montana will be to identify and promote appropriate feedstocks for the production of these fuels. Limited analysis by the Climate Change Advisory Committee (CCAC) suggests that sufficient feedstock for cellulosic ethanol is available to meet the increased consumption resulting from the TLU-6 (Low Carbon Fuel) policy. There is limited capacity within the state for crop production to support biodiesel production without the use of cropland that is currently used for other purposes or is part of the Conservation Reserve Program (the analysis showed a need for 1.2 million acres devoted to vegetable oil production by 2020). Hence, careful study is needed to identify available croplands and appropriate crops for vegetable oil production.

Funding and/or incentives will be needed to support the development of biofuels production capacity, including research and development (for production processes and feedstocks) and scale-up of production facilities. In addition to planning for the production of vegetable oil, sufficient planning is needed to promote in-state production for the other primary feedstock to biodiesel fuel (methanol or ethanol). The CCAC is unaware of any commercial-scale production of either of these feedstocks in Montana. Additional research and development will be needed to ensure that these alcohols are produced from renewable in-state resources (e.g., manure energy, biomass gasification, cellulosic hydrolysis) to maximize the GHG benefits.

As shown in the policy option descriptions in Appendix I, the implementation mechanisms developed for the agriculture and forestry sectors should focus on methods that avoid conflict with potential future market-based GHG reduction programs. These include GHG credits that could be generated in the agricultural sector through renewable fuels projects, soil carbon projects, and possibly other project types. New regulations that mandate emission reductions or specific agricultural practices could limit Montana agriculture from taking part in emerging carbon markets. Implementation mechanisms that are incentive and education based can avoid these conflicts.

By combining the agricultural and forestry land protection options (AFW-5), 0.12 MMtCO$_2$e/year in GHG emissions is estimated to be saved in 2020. To achieve these reductions, the state will need to work closely with local planning agencies, land owners, and nongovernmental organizations to identify lands suitable for acquisition/conservation easements and funding mechanisms. Another benefit of these options is the reduction in vehicle miles traveled (VMT) due to more efficient development patterns. More efficient development is covered under TLU-5.

Adoption of soil carbon management programs, such as conservation tillage/no-till methods (AFW-1) has been shown to result in significant benefits by 2020 (0.37 MMtCO$_2$e/year). The reductions associated with increases in soil carbon and reduced fossil fuel consumption have both been quantified. The reductions to be achieved by the organic farming element could not be quantified with available information on the net GHG reduction potential of organic farming methods on Montana crop systems. The challenges in Montana will be to identify and communicate opportunities for growers to adopt these methods to achieve the levels of participation envisioned in the policy design (394,404 acres by 2020). A strong educational and outreach program will be needed.

Option AFW-4 seeks to retain cropland in an uncultivated state from conservation programs such as those in the U.S. Farm Bill, thereby preventing the oxidation of soil carbon and subsequent CO$_2$ emissions. More than one million acres are expected to be retired from the Farm Bill's Conservation Reserve Program (CRP) by 2020. If these acres are returned to active cultivation, not only will already stored soil carbon be lost, but the annual sequestration of additional CO$_2$ by these soils will also be impaired. About 2.1 MMtCO$_2$ would be protected by maintaining these acres in some type of conservation program. The CCAC recognizes that additional work is needed to identify appropriate implementation approaches for this option. The reductions for AFW-4 were not included in the total GHG reductions for this sector. These emissions relate to the protection of agricultural soil carbon, and the potential emissions were not included in the GHG forecast for the agricultural sector.

Also in the forestry sector, the expanded use of biomass feedstocks for energy use (AFW-7) has a significant potential for GHG benefits (0.15 MMtCO$_2$e/year by 2020). These reductions are associated with the collection and use of additional woody biomass not consumed within the renewable energy options in the ES and RCII sectors. The estimated benefits focused on those obtained by utilizing biomass energy from forest treatment projects (to reduce fire risk). Success will be achieved through close cooperation between Montana, federal agencies (e.g., USFS), and private industry to identify biomass resources and effective end uses for the resources, as well as the development of a collection and distribution industry.

Overview of Policy Recommendations and Estimated Impacts

The CCAC recommends a set of 12 policy options for the AFW sector that offer the potential for major economic benefits and emissions savings. As summarized in Table 6-2, the AFW policy recommendations could lead to emissions reductions from reference case projections of

2.4 MMtCO$_2$e per year by 2020, cumulative savings of around 17 MMtCO$_2$e from 2007 through 2020, and a net cost of approximately $446 million through the year 2020 on a net present value (NPV) basis.[2] The weighted average cost of saved carbon from the policy options for which quantitative estimates of both costs and savings were prepared was $26/MtCO$_2$e. These reflect only the effects of the policy options in the AFW sectors, noting that the AFW policy options achieve emission reductions not only from the AFW source sectors, but also from other source sectors (e.g., transportation sector from biofuels production and ES or RCII sectors from biomass energy production).

Note that the total NPV costs for the sector include the costs for AFW-4, but that the GHG reductions have not been included in the totals (as described above, the potential emissions were not included in the inventory and forecast). Since the GHG reductions for AFW-4 were not included in the totals, the total cost-effectiveness does not include the costs of this option.

The CCAC policy recommendations described briefly here (and in more detail in Appendix I) not only result in significant emissions savings, but also offer a host of additional benefits. These benefits include 1) support of Montana agricultural producers in the production of biofuels crops, development of new markets for agricultural byproducts, production of crops to support locally consumed foods, and training/outreach covering energy production and organic farming;
2) creation of jobs in the biomass energy and liquid biofuels feedstock/production industries;
3) healthier forests with lower fire risk through the development of markets for forestry residue; and 4) research and development work to be conducted by Montana universities to support many of the policies for this sector.

Table 6-2. CCAC-recommended policy options and results for the AFW sector

	Policy Option	GHG Reductions (MMtCO$_2$e)			Net Present Value 2007–2020 (Million $)	Cost-Effective-ness ($/tCO$_2$e)	Level of Support
		2010	2020	Total 2007–2020			
AFW-1	Agricultural Soil Carbon Management–Conservation/No-Till	0.15	0.37	3.7	0	0	UC
	Agricultural Soil Carbon Management–Organic Farming	*Not quantified*					
AFW-2	Biodiesel Production (Incentives for Feedstocks and Production Plants)	0.02	0.15	0.9	13	14	UC
AFW-3	Ethanol Production	0.02	0.39	2.2	10	4	UC
AFW-4*	Incentives for Enhancing GHG Benefits of Conservation Provisions of Farm Bill Programs	0.5	1.6	15	181	12	UC
AFW-5	Preserve Open Space and Working Lands–Agriculture	0.003	0.02	0.12	5	32	UC
	Preserve Open Space and Working Lands–Forests	0.03	0.1	0.9	3	3	

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[2] The net cost savings are based on fuel expenditures, operations, maintenance, and administrative costs, and amortized, incremental equipment costs. All NPV analyses here use a 5% real discount rate.

	Policy Option	GHG Reductions (MMtCO$_2$e)			Net Present Value 2007–2020 (Million $)	Cost-Effective-ness ($/tCO$_2$e)	Level of Support
		2010	2020	Total 2007–2020			
AFW-6[†]							
AFW-7[‡]	Expanded Use of Biomass Feedstocks for Energy Use	0.04	0.15	1.1	–25	–23	UC
AFW-8	Afforestation/Reforestation Programs–Restocking	0.09	0.5	3.4	41	12	UC
	Afforestation/Reforestation Programs–Urban Trees	0.001	0.006	0.04	–0.1	–3	
AFW-9	Improved Management and Restoration of Existing Stands	0.05	0.2	1.3	159	119	UC
AFW-10	Expanded Use of Wood Products for Building Materials	*Not quantified*					UC
AFW-11	Programs to Promote Local Food and Fiber	0.01	0.02	0.12	0.5	5	UC
AFW-12	Enhanced Solid Waste Recovery and Recycling	0.05	0.55	3.3	58	17	UC
	Sector Total After Adjusting for Overlaps	**0.44**	**2.4**	**17**	**446**	**26**	
	Reductions From Recent Actions	**0**	**0**	**0**	**0**	**0**	
	Sector Total Plus Recent Actions	**0.44**	**2.4**	**17**	**446**	**26**	

UC = unanimous consent.

* The reductions for AFW-4 were not included in the total GHG reductions for this sector. These emissions relate to the protection of agricultural soil carbon for conservation program acres that are being retired and might return to active cultivation. Since these potential emissions were not included in the GHG forecast for the agricultural sector, the potential reductions have been left out of the totals. The NPV costs include the costs of AFW-4, while the calculation of cost-effectiveness does not include the costs or reductions of AFW-4.

[†] AFW-6 was folded into AFW-7 through AFW-9.

[‡] For AFW-7, these reductions are associated with the use of additional woody biomass not consumed within the renewable energy options in the ES and RCII sectors.

Agriculture, Forestry, and Waste Management Sector Policy Descriptions

The Agriculture, Forestry, and Waste Management (AFW) sectors include emissions and mitigation opportunities related to use of biomass energy, protection and enhancement of forest and agricultural carbon sinks, programs to promote local food and organic farming, production of renewable fuels, and methods to increase soil carbon, achieve afforestation on non-forested lands, and recycling of waste material.

AFW-1 Agricultural Soil Carbon Management Programs: Conservation/No-Till and Organic Farming

Use of conservation tillage/no-till and other soil management practices can increase the level of organic carbon in the soil, which sequesters carbon dioxide from the atmosphere. In addition, some practices lower fossil fuel consumption through less intensive equipment use. Other practices, such as the application of bio-char can also increase the level of soil carbon and improve the soil. Organic farming methods may tend toward an increased use of these soil management practices. This option is designed to increase the acreage using soil management practices that lead to higher soil carbon content for both conventional and organic farming.

Montana should adopt programs to increase the acres of cropland managed using best management practices, including conservation/no-tillage practices, by 50%. An organic farming component is also included in this policy design pending an assessment of the GHG benefits. The initial goal will be to increase the organic acreage 15% above projected levels in 2015 and to 50% above 2025 levels for practices known to achieve net GHG benefits.

AFW-2 Biodiesel Production (Incentives for Feedstocks and Production Plants)

The use of biodiesel offsets the consumption of diesel fuel produced from oil (fossil diesel). Since biodiesel has a lower GHG content than fossil diesel (being derived from biogenic sources), overall GHG emissions are reduced. By producing biodiesel in the state for consumption within the state, the highest benefits can be achieved, since the fuel is transported over shorter distances to the end user (compared with importing biodiesel to Montana from other states). This option covers incentives needed to increase biodiesel production in Montana.

This policy seeks to produce sufficient biodiesel from Montana feedstocks to meet 2%, 10%, and 20% of 2004 Montana petroleum diesel consumption by 2010, 2015, and 2020, respectively.

Note that this policy option is linked with the low-carbon fuels policy in the transportation and land use sector (TLU-6). That policy option seeks to achieve greater consumption of lower carbon fuels in the state, while this option seeks to promote lower carbon fuel production in the state (to help meet future demand).

AFW-3 Ethanol Production

Offset fossil fuel use (gasoline) with production and use of starch-based and cellulosic ethanol. Offsetting gasoline use with ethanol can reduce GHGs to the extent that the ethanol is produced with lower GHG content than gasoline. Provide incentives for the production of ethanol from crops, forest sources, animal waste, and municipal solid waste. Also encourage cellulosic ethanol production research and development already initiated by the Montana Department of Agriculture.

This policy option seeks to achieve in-state production levels of 50 million gallons per year (MGY) of starch-based ethanol production capacity and 2 MGY of cellulosic production by

2010; achieve in-state production of 110 MGY of starch-based and 25 MGY of cellulosic production by 2015; and achieve in-state production levels of 250 MGY starch-based and 50 MGY of cellulosic production by 2020.

Note that this policy option is linked with the low-carbon fuels policy in the transportation and land use sector (TLU-6). That policy option seeks to achieve greater consumption of lower carbon fuels in the state, while this option seeks to promote lower carbon fuel production in the state (to help meet future demand).

AFW-4 Incentives for Enhancing GHG Benefits of Conservation Provisions of Farm Bill Programs

Agricultural lands that have been placed into conservation programs such as those in the U.S. Farm Bill may sequester carbon dioxide by implementing practices that build soil carbon over time. For example, land in the CRP is taken out of production and, in the absence of tillage practices, soil carbon is sequestered over time. This option seeks to extend the GHG benefits of current Farm Bill programs, looking particularly at land that is scheduled to retire from Farm Bill programs and potentially go back into production.

AFW-5 Preserve Open Space and Working Lands: Agriculture and Forests

Reduce the rate at which existing crop/pasture, rangeland, and forests are converted to developed uses. Specifically, reduce the rate of conversion by 50% from current levels by 2020. The carbon sequestered in the soils and above ground biomass of these open spaces and working lands is often much higher than in developed land uses. Policies that preserve open space and working lands provide additional GHG benefits by reducing the VMT that would otherwise occur from unwise or unplanned development (note relationship to growth and development under Option TLU-5).

AFW-7 Expanded Use of Biomass Feedstocks for Energy Use

This policy seeks to expand the use of biomass from forests, agriculture, and other sources for energy. Biomass can be used to produce liquid fuels, including cellulosic ethanol, or to produce energy in the form of electricity, heat, or steam. The latter is covered by this option.

Carbon in biomass is considered biogenic under sustainable systems; carbon dioxide emissions from biomass energy combustion are replaced by future carbon sequestration in new biomass. Expanded use of biomass energy in place of fossil fuels results in net emissions reductions by shifting from high to low carbon fuels (when sustainably managed), provided the full life cycle of energy requirements for producing fuels does not exceed the energy content of the renewable resource. Expanded use of biomass energy can be promoted by increasing the amount of biomass produced and used for renewable energy and by providing incentives for the production and use of renewable energy supplies.

This policy option aims to increase the usage of woody biomass residue for renewable electricity, heat, and steam generation to 450,000 tons/year by 2020. It also aims to use 540,000 dry tons of agricultural residues annually by 2020.

AFW-8 Afforestation and Reforestation Programs: Restocking and Urban Trees

Increase carbon stored in forests through expanding the forestland base. Establishing new forests, either on historically non-forested land ("afforestation") or on land that has not been managed as forest land for some time ("reforestation") increases the amount of carbon in biomass and soils compared with preexisting conditions. Afforestation and reforestation accomplished with stocking/planting and other practices (e.g., soil preparation and erosion control) can increase carbon stocks above baseline levels and ensure conditions that support forest growth.

One of the goals is to ensure restocking on 20% of the accessible forest lands impacted by stand replacement fires since year 2000 (estimated at 70,000 acres) to stocking rates of 200–400 trees/acre (depending on forest type). For future lands impacted by wildfire, this policy option aims to restock forest lands impacted by stand replacement fires (estimated at 20,000 acres/year) within 5 years post-fire. It is also recommended that Montana plant 42,250 new trees in its communities by 2020 through programs such as the Department of Natural Resources and Conservation's (DNRC's) Urban and Community Forestry Program.

AFW-9 Improved Management and Restoration of Existing Stands

This policy seeks to increase forest carbon stocks through changes in management practices on existing forestland. The goal is to initiate programs to increase forest productivity by 20% on 700,000 acres of private and state forest lands by 2020. This policy is not restricted to working through existing forest health programs to promote new practices that increase tree density, enhance forest growth rates, alter rotation times, or decrease the chances of biomass loss from fires, pests, and disease. In addition, increasing the transfer of biomass to long-term storage in wood products can increase net carbon sequestration, provided a proper balance is maintained where enough biomass remains on site as residues serving as nutrient inputs to the forest. Practices may include management of rotation length, biomass density, biomass energy use, and sustainable use of wood products.

AFW-10 Expanded Use of Wood Products for Building Materials

This policy seeks to enhance the use and lifetime of durable wood products. The CCAC recommends that Montana adopt programs to expand use of wood products by 5% over current baseline rates of use. Durable products made from wood prolong the length of time forest carbon is stored and not emitted to the atmosphere. Following their useful life (which could be measured in decades), wood products disposed of in landfills may store carbon for long periods under conditions that minimize decomposition. Additional GHG benefits can be achieved when methane gas is captured from landfills and used as an energy source (carbon originally stored in wood products becomes methane gas during decomposition). Increasing carbon stored in the wood products pool increases carbon sequestration from forests. This can be achieved through improvements in production efficiency, product substitution, expanded product lifetimes, and other practices. In addition, increasing the efficiency of the manufacturing life cycle for wood products enhances GHG benefits.

AFW-11 Programs to Promote Local Food and Fiber

Programs that promote the production, distribution, and consumption of locally grown food and fiber products reduce transportation and manufacturing emissions by offsetting the consumption of products with higher embodied energy. Food and fiber products consumed in the United States can travel thousands of miles before reaching a grocery or clothing store in the form of a final product (on average, a typical food product travels 1,500 miles and changes hands 33 times). Increasing the percentage of locally grown food and fiber consumed in Montana will significantly reduce fossil fuel use and its associated GHG emissions. The goal is to have 30% of the food consumed in Montana grown, harvested, and processed in Montana by 2020.

AFW-12 Enhanced Solid Waste Recovery and Recycling

Programs are needed to increase the quantity of materials recovered for recycling with specific attention given to materials with the greatest ability to reduce energy consumption during the manufacturing process and to materials that may be used as a fuel source (e.g., clean wood waste). Reducing the quantity of materials being landfilled reduces future landfill methane emissions potential, while recycling reduces emissions associated with the manufacturing of products from raw materials.

This policy aims to increase Montana solid waste recycling rates to 17% by 2008, 22% by 2011, 25% by 2015, and 28% by 2020 using a variety of methods, including source reduction, reuse, recycling, and composting.

Chapter 7
Cross-Cutting Issues

Overview of Cross-Cutting Issues

Some issues relating to climate policy cut across multiple or all sectors. These issues were addressed by a distinct technical work group under the Montana Climate Change Advisory Committee (CCAC). The issues include inventorying and forecasting greenhouse gas (GHG) emissions, reporting GHG emissions by entities, registering any GHG reductions achieved by entities for possible future credit and/or recognition, instituting a variety of public education and outreach initiatives, establishing goals for reducing statewide GHG emissions in Montana, and leading by example by reducing the state government's own GHG emissions. The Cross-Cutting Issues Technical Work Group (CC TWG) developed policy options for each of these issues.

Key Challenges and Opportunities

During the course of the CCAC's efforts, broad state interest in GHG reporting and registries coalesced in the establishment of *The Climate Registry*, a uniform GHG reduction registry platform suitable for all states. Building on the progress established by the California Climate Action Registry and the Eastern Climate Registry, several states developed a unified path forward that promises to meet most, if not all, of the GHG reporting and registry needs of the states, including voluntary GHG reporting, mandatory GHG reporting, and allowance reconciliation. Ultimately, this registry could serve as the foundation for trading and other transactions associated with GHG reductions. Consistent with the recommendations being prepared by the CCAC, Governor Schweitzer committed Montana as one of the first states to participate in *The Climate Registry*, which now includes all but a handful of the U.S. states, as well as many Canadian provinces and some states in Mexico. Montana's participation in the formation of *The Climate Registry* should enhance its ability to ensure that key sources and sectors (e.g., oil and gas production and biological carbon sequestration) are included as soon as possible.

Also consistent with this direction, the CCAC recognized the importance of improving Montana's ability to inventory and forecast its own GHG emissions. These are essential elements of understanding where emission reduction opportunities lie, what emission trends are evident, and the extent to which progress is being made against goals. The CCAC also noted the importance of concerted public education and outreach efforts in reducing GHG emissions. The results of public education and outreach programs may be difficult to measure, but public understanding of climate risks and solutions is ultimately the foundation upon which successful climate action policy and implementation is built.

Establishing GHG reduction goals or targets is another key cornerstone to progress. The CCAC addressed this issue in two respects: 1) establishing a statewide GHG reduction goal and 2) making recommendations by which the state government itself could lead by example in reducing its own emissions. The CCAC recommended that Montana establish a statewide, economy-wide GHG reduction goal to reduce gross GHG emissions to 1990 levels by 2020, for both consumption-based and production-based emissions and, further, to reduce emissions to

80% below 1990 levels by 2050. The CCAC also strongly recommended the early and aggressive implementation of its comprehensive set of recommendations, along with a corresponding set of incentives to promote early adoption. The CCAC further recommended that the Montana state government lead by example in reducing its own GHG emissions to 1990 levels by 2018 (2 years earlier than the statewide goal) and 5% below 1990 levels by 2020 (5% lower than the statewide goal for 2020).

Also of note regarding reduction goals are several regional and other GHG emission reduction efforts now underway across the country. Two of these, the Western Climate Initiative (WCI) and the Chicago Climate Exchange (CCX), were considered by the CCAC. The CCAC recommended that Montana join the WCI, which seeks to reduce regional GHG emissions by 15% from 2005 levels by 2020, bringing regional emissions down to nearly 1990 levels. The CCAC also recommended that Montana consider joining the CCX. Doing so would commit the state to a 6% reduction from 1998–2001 levels by 2010 and could potentially provide revenue for the state through GHG reductions achieved on state-owned grazing and forest trust lands.

Overview of Policy Recommendations

Cross-cutting issues include policies and measures that apply across the board to all sectors and activities. Cross-cutting recommendations typically encourage, enable, or otherwise support emissions mitigation activities and/or other climate actions. The CCAC recommends that six such policies be adopted and implemented by Montana. All are enabling policies that are not quantified in terms of tons of GHG reduction or costs.

First, a rigorous GHG emissions inventory program is vital to understanding GHG emissions levels, where mitigation opportunities lie, and how much progress is being made. A forecasting function is equally important to assess trends and likely emissions levels going forward. Montana’s involvement in *The Climate Registry* will assist the state in measuring future progress, recognizing and sharing emission reduction accomplishments, and protecting entities’ interests by rigorously recording their early GHG reduction efforts and accomplishments. Public awareness of climate change is essential to the public’s acceptance of concerted climate action, so a comprehensive public education and outreach program is warranted. Finally, establishing statewide GHG reduction goals and demonstrating leadership by example toward meeting them is also essential to progress. Montana state government has set rigorous, well-defined GHG emission reduction goals for the state and identified several ways that it can lead by example, including a) an even more aggressive goal for the state’s own emissions, b) consideration of climate-neutral bonding for projects that involve state funding, c) requiring evaluation of GHG emissions as part of environmental assessments and environmental impact statements, and d) joining WCI and possibly CCX.

Detailed descriptions of the individual Cross-Cutting Issues policy options as presented to and approved by the CCAC can be found in Appendix J.

Table 7-1. CCAC-recommended policy options and results for Cross-Cutting Issues

	Policy Option	GHG Reductions (MMtCO$_2$e)			Net Present Value 2007–2020 (Million $)	Cost-Effectiveness ($/tCO$_2$e)	Level of Support
		2012	2020	Total 2007–2020			
	Cross-Cutting Issues						
CC-1	GHG Inventories and Forecasts	*Not quantified*					UC
CC-2	State GHG Reporting	*Not quantified*					UC
CC-3	State GHG Registry	*Not quantified*					UC
CC-4	State Climate Public Education and Outreach	*Not quantified*					UC
CC-5*							
CC-6	Options for Statewide GHG Goals or Targets	*Not quantified*					2020 Goal: UC 2050 Goal: Super-majority
CC-7	The State Government's Own GHG Emissions (Lead by Example)	*Not quantified*					UC

UC = unanimous consent.

* There is no policy option CC-5 (Adaptation), because this catalog option was determined not to be a priority for analysis by the CCAC.

Cross-Cutting Issues Policy Descriptions

CC-1 GHG Inventories and Forecasts

GHG emissions inventories and forecasts are essential to understanding the magnitude of all emission sources and sinks (both natural and those resulting from human endeavors), the relative contribution of various types of emission sources and sinks to total emissions, and the factors that affect trends over time. Inventories and forecasts will inform state leaders and the public on statewide trends and opportunities for mitigating emissions or enhancing sinks, and will help verify GHG reductions associated with implementation of Montana's Climate Action Plan. Development of GHG emissions inventory and forecasting systems for Montana should integrate with existing Montana Department of Environmental Quality (DEQ) functions and should take advantage of expertise found in the state's colleges and universities. Opportunities for public participation by voluntary self-reporting of individual and community GHG reductions (with appropriate privacy protection) should also be made available. The inventory and forecast function will be an ongoing effort that will improve over time, based on more and better emissions data.

The CCAC recommends that Montana develop its capacity for statewide GHG emissions inventories and forecasts by conducting a periodic, consistent, and complete inventory of emission sources and sinks on a continuing basis, with forecasts covering a 20-year planning horizon. This inventory should be updated every two years and include both production- and consumption-based approaches. The forecast should project what emissions will be in future years, allowing for expected economic growth and implementation of mitigation options and provide a basis for documenting reductions and credits from year to year. This process should be implemented as soon as possible, and all emission sources and sinks (both natural and those resulting from human endeavors) should be included. It should be conducted so as to encourage awareness, understanding, and broad participation in reducing state GHG emissions by sources, citizens, and communities.

CC-2 State GHG Reporting

A GHG reporting system is designed to provide for measuring and then reporting emissions. GHG reporting can help sources identify emission reduction opportunities and manage risks associated with possible future GHG mandates by moving up the learning curve. GHG reporting is a precursor for participation in GHG reduction programs and a GHG emissions reduction registry. Tracking and reporting of GHG emissions is also useful in the construction of periodic state GHG inventories and makes it easier for sources to receive recognition and goodwill for successful emission reduction efforts. Reporting and the related inventory function will also provide valuable information for assessing the efficacy of measures implemented to reduce GHG emissions going forward. Self-reporting by individuals and communities should also be allowed to encourage awareness, understanding, and broad participation on the part of the pubic.

The CCAC recommends that Montana develop GHG reporting requirements and opportunities for its emission sources and citizens as soon as possible. Subject to consistently rigorous quantification, GHG reporting should not be constrained to particular sectors, sources, or approaches, in order to encourage GHG mitigation activities from all quarters. Mandatory GHG reporting should be established for sources holding air quality permits with the Montana DEQ and then phased in by sectors as rigorous, standardized quantification protocols, base data, and tools become available, and as responsible parties become known. Entities should be encouraged to report GHG emissions voluntarily before mandatory reporting applies to them, and the state, municipalities, and other jurisdictions should be encouraged to report emissions associated with their own activities and any programs they may implement. Every effort should be made to maximize consistency with federal, regional, and other states' GHG reporting programs, and reporting of project-based emissions reductions should be allowed when properly identified as such and quantified with equally rigorous consistency.

CC-3 State GHG Registry

A GHG registry enables measurement and recording of GHG emissions reductions in a central repository with a "transaction ledger" capacity to support tracking, management, and ownership of emission reductions as well as to encourage GHG reductions. It assists with baseline protection and/or the crediting of actions by implementing programs and parties in relation to possible emissions reduction goals. And it can also provide a mechanism for regional, multistate, and cross-border cooperation. Subject to appropriately rigorous quantification and verification, participation in a GHG registry should not be constrained to particular sectors, sources, or approaches so as to encourage GHG mitigation activities from all quarters. In particular, a GHG registry should be able to incorporate activities associated with all policy options implemented in Montana, whether reflective of reductions in emissions of GHGs or increases in biological or geological sequestration of carbon.

The CCAC notes that the State of Montana has joined 39 other U.S. states in the effort to develop a national GHG registry through *The Climate Registry*. Being a charter state in this effort should help ensure that Montana's needs and priorities are addressed in the course of developing *The Registry.* To the extent that Montana's needs may not be fully met by *The Climate Registry,* the state should consider developing supplemental or ancillary registry capacity or opportunities. Montana's participation in *The Climate Registry* should include or cover all of the activities associated with all policy options that the CCAC recommends and the Governor accepts. A mechanism should be provided whereby Montana sources and stakeholders can keep abreast of—and provide input to—state and national registry efforts as they evolve. Additional elements are detailed in Appendix J, Cross-Cutting Issues – Policy Recommendations.

CC-4 State Climate Public Education and Outreach

Explicitly articulated public education and outreach can support GHG emissions reduction efforts at all levels in the context of emissions reduction programs, policies, or goals. Public education and outreach is vital to fostering a broad awareness of climate change issues and effects (including co-benefits, such as clean air and public health) among the state's citizens. Such awareness is necessary to engage citizens in actions to reduce GHG emissions. Public education and outreach efforts should integrate with and build upon existing outreach efforts involving climate change and related issues in the state. Ultimately, public education and outreach will be the foundation for the long-term success of all the policy actions proposed by the CCAC as well as those which may evolve in the future.

The CCAC recommends that the state lead by example in its own education and outreach activities by establishing a proactive public education and outreach capability and using it to target education and outreach activities to policy makers, younger generations, community leaders and community-based organizations, the general public, and industrial and economic sectors. Specific public education and outreach suggestions are provided in the accompanying technical Appendix J. The overarching goal is a wholesale shift in public consciousness away from uninformed consumerism to a commitment to choices that enhance personal, community, and statewide health and contribute to productive, thriving natural systems. To support monitoring of this goal, it is recommended that the state conduct a voluntary survey of a cross-section of Montana residents' lifestyles to elucidate the level of awareness of sources of individual GHG emissions and steps currently being taken to reduce them. The survey will provide a baseline for a parallel, more qualitative report that will accompany the more technical reporting by nonresidential sectors. Public education and outreach efforts should begin as soon as possible, continue evolving and spreading over time, and involve all parties and sectors.

CC-6 Options for Statewide GHG Goals or Targets

The CCAC will recommend actions that can be taken in Montana to reduce the state's contribution to climate change. Consistent with this charge, the establishment of a statewide goal or target can provide vision and direction, a framework within which implementation of CCAC policy recommendations can proceed effectively, and a basis of comparison for regular periodic assessments of progress. In pursuit of similar climate progress, at least 16 other states have established GHG reduction goals or targets.

The CCAC recommends that Montana establish a statewide, economy-wide GHG reduction goal to reduce gross GHG emissions to 1990 levels by 2020, for both consumption-based and production-based emissions and, further, to reduce emissions to 80% below 1990 levels by 2050. In lieu of establishing a specific target sooner than 2020, the CCAC also strongly recommends the early and aggressive implementation of the CCAC's comprehensive recommendations, along with a corresponding set of incentives to promote early adoption.

CC-7 The State Government's Own GHG Emissions (Lead by Example)

The CCAC recommends three actions with respect to leading by example in reducing the state's own GHG emissions. (A fourth action, CC-7.2 *Climate-Neutral Bonding*, was initially considered by the CC TWG but subsequently incorporated into the design and quantification of policy option RCII-12 and is not repeated here.) The three recommendations are 1) CC-7.1 *Establish a Target for Reducing the State Government's Own GHG Emissions*, 2) CC-7.3 *Require Evaluation of GHG Emissions in Environmental Studies*, and 3) CC-7.4 *Join the Western Climate Initiative (WCI) and Consider Joining the Chicago Climate Exchange (CCX).*

CC-7.1. State government is responsible for providing a multitude of services for the public that are delivered through very diverse operations and result in wide-ranging GHG emission activities. Montana State government can take the lead in demonstrating that reductions in GHG emissions can be achieved through analysis of current operations, identification of significant GHG sources, and implementation of changes in technology, procedures, behavior, operations, and services provided. The state can also encourage local governments, school districts, universities, and other entities in implementing similar GHG reduction strategies by closely partnering with them. The CCAC recommends that the state establish a target to reduce GHG emissions from state operations to 1990 levels by 2018 (2 years earlier than the statewide goal) and to 5% below 1990 levels by 2020 (5% lower than the statewide goal for 2020).

CC-7.3. Environmental Assessments (EA) and Environmental Impact Statements (EISs) are written analyses of the potential environmental impacts of a proposed action or project. Requiring consideration of GHG emissions to be included as part of EA and EIS processes and documents would enable comparison of reference case GHG emissions levels to future GHG emissions levels as a result of proposed projects. Such information could be helpful in targeting development decisions that minimize GHG emissions or in pointing out the need for authority to regulate GHG emissions. The CCAC recommends that agencies be instructed to include data regarding reference case and estimated future GHG emissions in EA and EIS documents. This information will guide officials and developers in choosing technologies and activities resulting in development that protects the environment and reduces additional contributions of GHGs.

CC-7.4. The Western Climate Initiative (WCI) is a joint effort by the states of Washington, Oregon, California, Arizona, and New Mexico (since joined by the state of Utah and the Canadian provinces of British Columbia and Manitoba) to develop a regional GHG reduction goal and identify market-based mechanisms by which it can be achieved.[1] WCI is also seen as a precursor to a national market-based system for GHG reductions and may serve as a model for a national program. By joining WCI, Montana would commit to more broadly applicable GHG reductions—both geographically and among economic sectors—and participate in the development of mechanisms for achieving these goals. One part of the overall strategy will likely be the utilization of offsets, which often include terrestrial sequestration actions to increase the absorption of carbon dioxide (CO_2) as a result of land management activities. Joining WCI will give Montana the opportunity to help define the nature and quality of terrestrial offsets over a large region of the country, helping to ensure that terrestrial offsets play an appropriate role in achieving the GHG reduction goals established by WCI and then, subsequently, under a national regime.

The Chicago Climate Exchange (CCX) is also a market-based effort. Its membership is broad and extensive and includes three other states along with many U.S. cities and dozens of corporations. Joining CCX would require a reduction in Montana's own GHG emissions of 6% (from 1998–2001 levels) by 2010. As a condition for joining CCX, Montana would likely seek eligibility for a portion of its required reductions to be achieved from state trust lands through offsets from agricultural and forestland sequestration projects. Thus, joining CCX could provide potential revenue for the state through GHG reductions achieved on state-owned grazing and forest trust lands. By developing and utilizing such offsets and ensuring that these do, in fact, constitute actual reductions in emissions, Montana could get early experience on this learning curve, allowing it to become a ground floor player in terrestrial CO_2 offset markets while WCI's offset policies are being developed. Ultimately, joining CCX could encourage more CO_2 reductions to be made in Montana and could provide additional revenues to the state as well as to private and tribal landowners.

The CCAC recommends that the State of Montana join WCI (with respect to Montana's economy-wide GHG emissions) and consider whether to take advantage of the trading platform provided by joining CCX (with respect to state government GHG emissions) and commit to meeting their respective GHG emission reduction obligations. The aspirations and reach of the WCI, coupled with the techniques developed and applied by the CCX, may produce more effective, less costly outcomes than either entity would produce alone.

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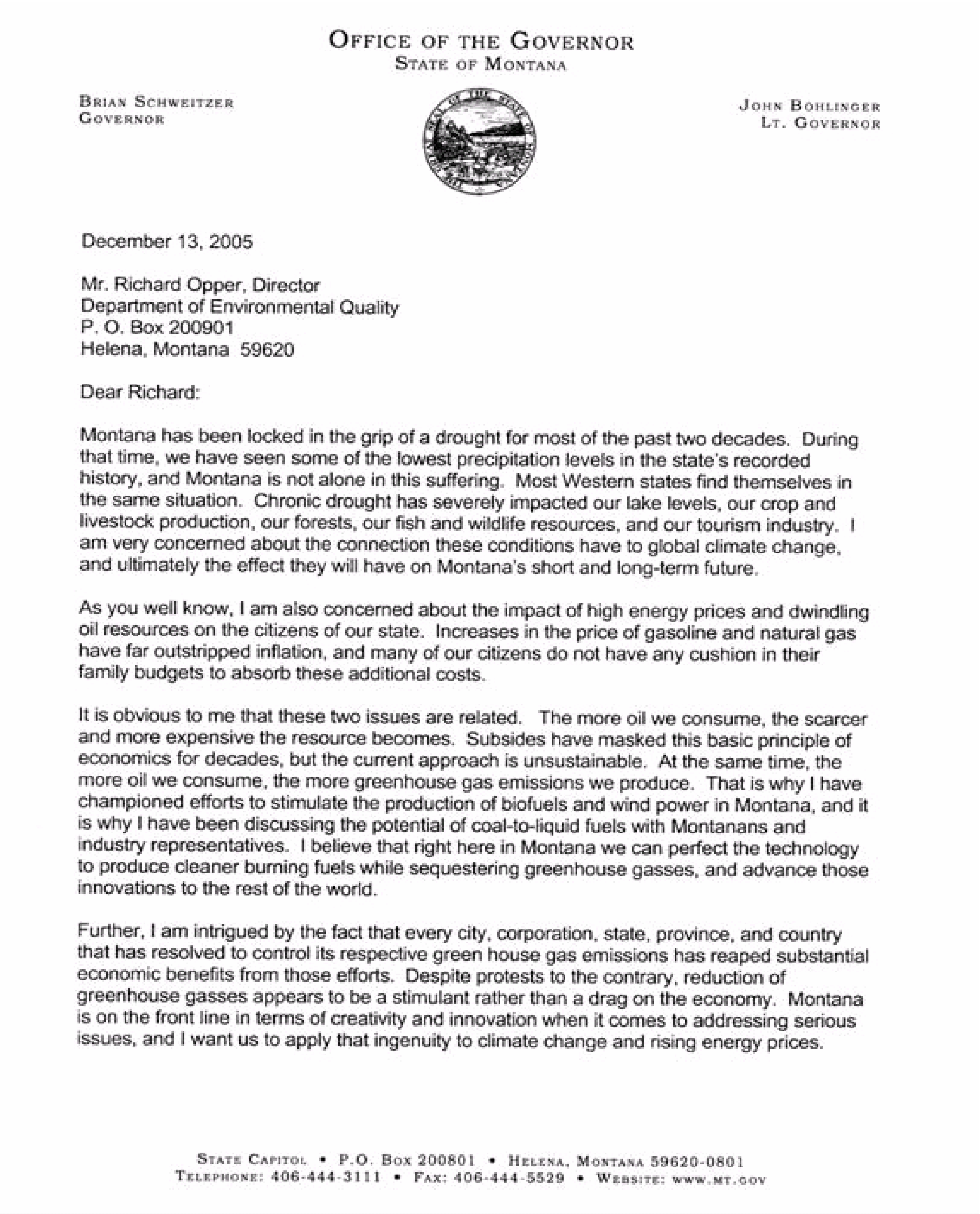
[1] After the CCAC approved this recommendation, the WCI announced agreement on a goal of reducing regional GHG emissions by 15% from 2005 levels by 2020.

Appendix A
Letter From Governor Schweitzer



OFFICE OF THE GOVERNOR
STATE OF MONTANA

BRIAN SCHWEITZER
GOVERNOR

JOHN BOHLINGER
LT. GOVERNOR

December 13, 2005

Mr. Richard Opper, Director
Department of Environmental Quality
P. O. Box 200901
Helena, Montana 59620

Dear Richard:

Montana has been locked in the grip of a drought for most of the past two decades. During that time, we have seen some of the lowest precipitation levels in the state's recorded history, and Montana is not alone in this suffering. Most Western states find themselves in the same situation. Chronic drought has severely impacted our lake levels, our crop and livestock production, our forests, our fish and wildlife resources, and our tourism industry. I am very concerned about the connection these conditions have to global climate change, and ultimately the effect they will have on Montana's short and long-term future.

As you well know, I am also concerned about the impact of high energy prices and dwindling oil resources on the citizens of our state. Increases in the price of gasoline and natural gas have far outstripped inflation, and many of our citizens do not have any cushion in their family budgets to absorb these additional costs.

It is obvious to me that these two issues are related. The more oil we consume, the scarcer and more expensive the resource becomes. Subsides have masked this basic principle of economics for decades, but the current approach is unsustainable. At the same time, the more oil we consume, the more greenhouse gas emissions we produce. That is why I have championed efforts to stimulate the production of biofuels and wind power in Montana, and it is why I have been discussing the potential of coal-to-liquid fuels with Montanans and industry representatives. I believe that right here in Montana we can perfect the technology to produce cleaner burning fuels while sequestering greenhouse gasses, and advance those innovations to the rest of the world.

Further, I am intrigued by the fact that every city, corporation, state, province, and country that has resolved to control its respective green house gas emissions has reaped substantial economic benefits from those efforts. Despite protests to the contrary, reduction of greenhouse gasses appears to be a stimulant rather than a drag on the economy. Montana is on the front line in terms of creativity and innovation when it comes to addressing serious issues, and I want us to apply that ingenuity to climate change and rising energy prices.

STATE CAPITOL • P.O. BOX 200801 • HELENA, MONTANA 59620-0801
TELEPHONE: 406-444-3111 • FAX: 406-444-5529 • WEBSITE: WWW.MT.GOV

I ask you to establish a Climate Change Advisory Group that will examine agriculture, forestry, energy, government and other sectors of our state. I want this broad-based group of Montana citizens to identify ways in which we can reduce our collective greenhouse gas emissions while saving money, conserving energy, and bolstering our economy. By July 2007, I would like the group to produce a Climate Change Action Plan that includes recommendations for reducing greenhouse gas emissions in Montana and conserving energy in various sectors of our economy. Doing good things for our economy and the environment can become a growth industry for the state. It is time to tap into the creativity of our citizens to make this happen.

Sincerely,

BRIAN SCHWEITZER
Governor

Appendix B
Description of Climate Change Advisory Committee Process

This appendix contains a memo by the Center for Climate Strategies describing the facilitated stakeholder process that the CCAC would follow (first presented at the initial CCAC meeting, July 13, 2006).

To: Montana Climate Change Advisory Committee (CCAC)

Cc: Richard Opper, Director Montana Department of Environmental Quality

From: Tom Peterson, The Center for Climate Strategies

Date: July 9, 2006

Background, Purpose and Goals of the Process

On December 13, 2005 Governor Schweitzer issued a letter directing the Montana Department of Environmental Quality (MDEQ) to establish a Climate Change Advisory Committee (CCAC), a broad based group of Montana citizens appointed by the Governor to develop a state climate action plan by July 2007. Under MDEQ's direction, this initiative will examine state level greenhouse gas reduction (GHG) opportunities in all sectors in Montana, and take into consideration opportunities to "save money, conserve energy, and bolster the Montana economy." The Center for Climate Strategies (CCS) will work in partnership with MDEQ to provide facilitation and technical support for climate action planning process to meet these goals.

The goals of this process include:

1) Development of a current and comprehensive inventory and forecast of GHG emissions in Montana from 1990 to 2020;
2) Development of a comprehensive set of individual policy recommendations to the Governor to reduce GHG emissions in Montana.

The CCAC process will seek (but not mandate) consensus on these findings and recommendations. Statewide GHG reduction goals, to the extent that they are developed, will be based on further discussions with MDEQ and this group.

Timing and Milestones

The first meeting of the CCAC will be held July 13, 2006, with up to five additional CCAC meetings to be held through July 2007. We plan for two to three Technical Work Group (TWG) conference calls to be held between CCAC meetings. CCS will provide the final report with CCAC recommendations and findings to the MDEQ by June 30, 2007 following a period of review by the CCAC and the public.

Draft CCAC Calendar

Date	Meeting*
July 2006	1st CCAC meeting
September 2006	2nd CCAC meeting
December 2006	3rd CCAC meeting
February 2007	4th CCAC meeting
May 2007	5th CCAC meeting
June 2007	6th CCAC meeting
July 2007	Final CCAC Report Due
Between CCAC Meetings	TWG conference calls and meetings

* Draft agendas for CCAC meetings and TWG discussions are provided in attachment 1.

Process Design

Activities of the CCAC process will be stepwise, fact-based, consensus driven, transparent, and inclusive.

Key steps and parameters of the process include the following:

- The CCAC process will seek but not mandate consensus. Preliminary votes will be taken informally to assess the level of consensus and potential barriers. Final votes will document CCAC support at levels of: unanimous consent, super majority, and majority. Barriers to consensus will be identified and alternatives developed as possible.
- The process will start with examination of a catalog of states actions and expand it to cover all potential options of interest to the CCAC. With assistance from the TWGs, the CCAC will then identify initial draft priority options for analysis, and then develop straw policy designs for each proposal with assistance by CCS.
- Following approval of proposed policy designs, CCS will propose quantification methods for approval by the TWGs and CCAC, including general principles and guidelines for quantification of benefits and costs, and provide initial results for each draft policy option. Additional development of policy options will be based on need.
- Recommendations will include both quantified and non-quantified actions, with emphasis on numerical analysis of GHG reduction potential and cost effectiveness as possible. Additional issues will be evaluated on a case-by-case basis pending CCAC input and available resources.
- For each draft potential policy option identified by the CCAC, CCS will prepare a policy option template with assistance from the TWGs for CCAC review and approval (see attachment 2).
- Mitigation of all GHGs will be examined, including carbon dioxide, methane, nitrous oxide, and synthetic gases. Units will be expressed in metric tons (MT) carbon dioxide

equivalents (CO2e), or in million metric tons carbon dioxide equivalent (MMTCO2e).

- The CCAC and TWGs will explore solutions in all sectors and across all potential implementation methods. Recommendations may include state level and multi-state actions (regional and national), as well as voluntary and mandatory approaches.
- Historical emissions and carbon storage inventories and reference case projections will be developed for years 1990-2020. Recommendations for action will include the present to year 2020, with estimated benefit and cost impacts being reported for years 2010 and 2020.
- The final report by CCS will document CCAC recommendations and views on each policy option, including alternative views as needed. It will also include a summary of the Montana GHG Emissions Inventory and Forecast.

Participant Roles and Responsibilities

State Agencies

MDEQ will oversee and coordinate the CCAC process. The state will provide logistical support for meetings, facilities, and public notice, with assistance by CCS. Other state agencies may participate as advisors to the process.

Center for Climate Strategies

CCS will provide facilitation and technical support to the CCAC and TWGs during the process as a neutral and expert party.

Scientific Advisory Panel

The Scientific Advisory Panel will assist the CCAC by providing scientific expertise and advice on specific fact-finding issues.

Climate Change Advisory Committee

The CCAC will make recommendations on specific policy actions as well as approval of a final Montana GHG emissions inventory and forecast. Final decisions will be made by vote.

Technical Work Groups

TWG members will be comprised primarily of CCAC members assigned to specific sectors of interest, as well as other individuals with technical expertise and interest. The TWGs will be tasked with providing guidance to CCAC members on priorities for analysis, technical analysis and design of options, alternative approaches, and final recommendations. TWGs sectors include: (1) energy supply (including heat and power fuel supply, and waste energy recapture), (2) commercial, industrial and residential (including energy efficiency and conservation, as well as industrial process and waste management), (3) transportation and land use, (4) agriculture and forestry, and (5) cross cutting issues (such as reporting, registries, and education).

The Public

Public observation and input will be provided as a part of CCAC and TWG meetings.

Participant Guidelines

Advisory Committees and technical work group members are expected to follow certain codes of conduct during the process, including:

- Attendance is strongly requested at all meetings to provide continuity to the stepwise process. Alternates may be named when absolutely necessary.
- Active involvement in proposals and evaluations is needed from each member to fully support the process of joint policy development.
- Good faith participation and full support of the process are required.
- In exchanging information and views, CCAC members should make fact-based offers and statements, and refrain from personal criticisms.
- CCAC and work group members should not represent the state or Advisory Committees in contacts with the media.

Funding for the CCAC process is provided primarily by a number of private foundations, with support from MDEQ.

ATTACHMENT 1:

DRAFT ADVISORY COMMITTEE AND TECHNICAL WORK GROUP MEETING AGENDAS

MEETING ONE

- Introductions
- Purpose and goals
- Review of the CCAC process
- Review of the catalog of possible state climate mitigation actions
- Review of the Montana emissions inventory & forecasts
- Discussion of key policy opportunities & issues
- Formation of TWG’s, next meeting agenda, time, location, date

Interim work group calls will cover: (1) suggested revisions to the draft inventory and reference case projections, (2) review and suggested modifications to the catalog of policy options, and (3) early ranking of options and suggested initial priorities for analysis.

MEETING TWO

- Recommended updates to inventories and baseline forecasts
- Discussion of additional actions to the catalog of possible Montana policy actions
- Approval of initial priorities for work group analysis
- Review of TWG plans, including development of straw policy design proposals
- Identification of cross-cutting issues

Interim work group calls will cover: (1) suggested final revisions to the emissions inventory and reference case projections, (2) suggested modifications to the list of initial priorities for analysis for CCAC review, (3) suggested policy designs for specific policy actions for CCAC review, and (4) next steps on design and analysis of initial policy options.

MEETING THREE

- Final agreement on inventories and baseline forecasts
- Approval of TWG lists of initial policy priorities for analysis
- Discussion of policy design and implementation mechanisms for policy options; process for developing straw proposals
- Briefing on cross cutting issues and policy options

Interim TWG calls will cover: (1) development of straw proposals for design parameters for individual options, (2) identification of potential implementation mechanisms for options, 3) next steps for analysis of options, and (4) identification of crosscutting policy needs.

MEETING FOUR

- Review of policy options list, straw proposals for policy design, and early results of analysis
- Guidance to TWGs on additions, deletions and modifications of options
- Identification of alternative policy designs and implementation mechanisms for work groups, as needed
- Review and revision of cross cutting policy options

Interim TWG calls will cover: (1) revisions to draft final policy priorities and design parameters, including implementation mechanisms, (2) next steps for draft analysis of options and design alternatives, and (3) next steps on formulation of cross cutting policy options and mechanisms.

MEETING FIVE

- Review of options list, with results of analysis and cumulative emissions reductions potential
- Identification of consensus and non-consensus options
- Identification of barriers and alternatives for non-consensus options, with guidance for additional work on options to TWG’s
- Review of final report progress and plans

Interim TWG calls will cover: (1) final revisions to design parameters, including implementation mechanisms, (2) final analysis of options, alternatives, and (3) final steps on formulation of cross cutting policy options and mechanisms.

MEETING SIX

- Progress report on non-consensus policy options list and cumulative emissions reductions potential
- Identification of consensus and non-consensus options from remaining list
- Identification of barriers and alternatives for non-consensus options, proposals for resolution by the CCAC
- Discussion and final resolution of barriers and determination of consensus for remaining options

- Summary of the process, review of next steps for review and transmittal of the final report

FINAL REPORT TO MDEQ

- CCS will provide final CCAC recommendations to MDEQ in a report including the following items:
    1. Executive Summary
    2. Background
    3. Inventory and Forecast of Montana GHG Emissions
    4. Policy Recommendations for the Following Sectors:
        a. Agriculture, Forestry and Waste Management;
        b. Energy Supply;
        c. Residential, Commercial and Industrial;
        d. Transportation and Land Use; and
        e. Cross Cutting Issues
    5. Appendices

ATTACHMENT 2:

POLICY OPTION TEMPLATE

Policy Description

[Insert text as appropriate]

Policy Design

[Insert text as appropriate]

- **Timing:**
- **Goals:**
- **Coverage of parties:**
- **Other:** [Insert text if/as appropriate]

Implementation Mechanisms

[Insert text as appropriate]

Related Policies/Programs in Place

[Insert text as appropriate]

Type(s) of GHG Reductions

[Insert text as appropriate]

Estimated GHG Savings and Costs per MtCO$_2$e

[Insert text as appropriate]

- **Data Sources:**
- **Quantification Methods:**
- **Key Assumptions:**

Key Uncertainties

[Insert text as appropriate]

Additional Benefits and Costs

[Insert text as appropriate]

Feasibility Issues

[Insert text as appropriate]

Status of Group Approval

[Pending or Completed]

Level of Group Support

[Insert text as appropriate]

Barriers to Consensus

[Insert text as appropriate]

Appendix C
Members of Technical Work Groups

* = Member of Climate Change Advisory Committee
CCS = Center for Climate Strategies
MDEQ = Montana Department of Environmental Quality

AGRICULTURE, FORESTRY, AND WASTE MANAGEMENT

Julie Anderson, Montana Department of Natural Resources
Robert Boettcher, Organic Farmer*
Cliff Bradley, Montana Microbial Products, LLC
Ross Bricklemyer, Montana State University
Ted Dodge, National Carbon Offset Coalition
Jim Evanoff, Yellowstone National Park / National Park Service
Bob Kearns, Montana Microbial Products, LLC
Dave Kelsey, Farmer / Rancher
Chad Lee, Montana Department of Agriculture
Richard Liebert, Rancher
Sterling Miller, National Wildlife Federation
Gary Perry, Senator, Senate District 35*
Trudi Peterson, Sustainable Rancher*
Neil Sampson, Sampson Group
Collin Watters, Montana Department of Agriculture
Lowell Whitney, Montana Department of Natural Resources

Bill Bahr, MDEQ
Jeff Blend, MDEQ
Pat Crowley, MDEQ
Bob Habeck, MDEQ
Lou Moore, MDEQ
Lynda Saul, MDEQ
Alison Bailie, CCS
Katie Bickel, CCS
Holly Lindquist, CCS
Thomas Peterson, CCS
Steve Roe, CCS
Randy Strait, CCS

ENERGY SUPPLY

Buck Buchanan, Teacher
Jeff Chaffee, Bison Engineering
Sue Dickenson, Representative, House District 25*
Bill Drummond, Western Montana Generating & Transmission Cooperative

Mary Fitzpatrick, Self-Employed*
Bob Green, Rio Tinto Energy America
Tim Gregori, Southern Montana Electric Generation and Transmission Cooperative*
Patrick Judge, Montana Environmental Information Center*
Mark Lambrecht, PPL Montana*
Charles McGraw, Natural Resources Defense Council*
Shane Mogenson, Nance Petroleum*
Bob Raney, Montana Public Service Commission*
Ken Thornton, Citizens for Clean Energy
Dave Wheelihan, Montana Electric Cooperative Association

Jeff Blend, MDEQ
Paul Cartwright, MDEQ
Lou Moore, MDEQ
Lisa Peterson, MDEQ
Dan Walsh, MDEQ
Alison Bailie, CCS
David Von Hippel, CCS
Michael Lazarus, CCS
Thomas Peterson, CCS

RESIDENTIAL, COMMERCIAL, INSTITUTIONAL, AND INDUSTRIAL

Buck Buchanan, Teacher
Jeff Chaffee, Bison Engineering
Andrew Eppel, City of Bozeman
Tim Gregori, Southern Montana Electric Generation and Transmission Cooperative*
Terry Holzer, Yellowstone Valley Electric Cooperative
Patrick Judge, Montana Environmental Information Center*
Wayne Kenefick, Graymont Limited
Steve Loken, Center for Resource Building Technology*
Krista Partridge, Kema, Inc.
Tom Power, University of Montana
Dave Ryan, National Center for Appropriate Technology*

Brian Green, MDEQ
Eric Merchant, MDEQ
Lou Moore, MDEQ
Lisa Peterson, MDEQ
Alison Bailie, CCS
David Von Hippel, CCS
Michael Lazarus, CCS

TRANSPORTATION AND LAND USE

Candi Beadry, City of Billings–Planning
Mark Brandt, Teamsters Local #2*

Garrett James Budds, National Wildlife Federation
Tim Davis, Montana Smart Growth Coalition
Matt Elsaesser, Student Advocates for Valuing the Environment (SAVE) Foundation
Jim Evanoff, Yellowstone National Park / National Park Service
Paul Ferry, Montana Department of Transportation, Helena Highways
Wayne Freeman, CTA LandWorks
Mike Kress, City of Missoula–Planning
Gary Perry, Senator, Senate District 35*
John Prinki, Carbon County Commission
Sandra Straehle, Montana Department of Transportation
Dick Turner, Montana Department of Transportation

Jim Boyer, MDEQ
Cyra Cain, MDEQ
Lou Moore, MDEQ
Lisa Peterson, MDEQ
Karl Hausker, CCS
Lewison Lem, CCS
Thomas Peterson, CCS
Will Schroeer, CCS

CROSS CUTTING ISSUES

Peggy Beltrone, Cascade County Commission*
Sue Dickenson, Representative, House District 25*
Ted Dodge, National Carbon Offset Coalition
Mary Fitzpatrick, Self-Employed*
Gloria Flora, Sustainable Obtainable Solutions*
Patrick Judge, Montana Environnemental Information Center*
Chuck McGraw, Natural Resources Defense Council*
Shane Mogenson, Nance Petroleum*
Cheryl Reichert, M.D., Citizens for Clean Energy
Diego Rivas, Montanans for a Healthy Climate
William Walks Along, Northern Cheyenne*

Jeff Blend, MDEQ
Jim Boyer, MDEQ
Lou Moore, MDEQ
Richard Opper, MDEQ
Ken Colburn, CCS
Thomas Peterson, CCS
Randy Strait, CCS

Appendix D
Greenhouse Gas (GHG) Emissions Inventory and Reference Case Projections

A separate report titled “Final Montana Greenhouse Gas Inventory and Reference Case Projections, 1990–2020,” dated September 2007, and its earlier draft were used throughout the Climate Change Action Committee’s (CCAC’s) process to provide detailed documentation on emissions. The final report is available on the CCAC’s Web site: http://www.mtclimatechange.us/CCAC.cfm.

Montana
Greenhouse Gas Inventory and Reference Case Projections 1990-2020

Center for Climate Strategies
September 2007

Principal Authors: Alison Bailie, Stephen Roe, Holly Lindquist, Alison Jamison

Montana Department of
ENVIRONMENTAL QUALITY

CCS
CENTER FOR CLIMATE STRATEGIES

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Executive Summary

The Center for Climate Strategies (CCS) prepared this report under contract to the Montana Department of Environment Quality (MDEQ). The report contains an inventory and forecast of the state's greenhouse gas (GHG) emissions from 1990 to 2020.

Montana's anthropogenic GHG emissions and sinks (carbon storage) were estimated for the period from 1990 to 2020. Historical GHG emission estimates (1990 through 2005) were developed using a set of generally accepted principles and guidelines for state GHG emissions estimates (both historical and forecasted), with adjustments by CCS as needed to provide Montana-specific data and inputs as possible. The initial reference case projections (2006-2020) are based on a compilation of various existing projections of electricity generation, fuel use, and other GHG emitting activities, along with a set of transparent assumptions. A second projection case was also developed to explore the potential impact on GHG emissions of higher growth projections for fossil fuel production and consumption in the State. Although uncertainties exist for future growth in many activities, the High Fossil Fuel Production case focuses only on higher levels of electricity generation (mostly coal-based), coal bed methane and conventional natural gas production, oil refinery production and coal-to-liquids plants. These activities produce large amounts of GHG emissions and projections for future growth show wide variation.

Table ES-1 provides a summary of Montana historical (1990 and 2005) and reference case projection (2010 and 2020) GHG emissions. Activities in Montana accounted for approximately 37 million metric tons (MMt) of *gross consumption-based*[1] carbon dioxide equivalent (CO_2e) emissions in 2005, an amount equal to 0.6% of total U.S. gross GHG emissions. Montana's gross GHG emissions are rising at about the same rate as the nation as a whole. Montana's gross GHG emissions were up 14% from 1990 to 2005, while national emissions rose by 16% during this period.

Figure ES-1 illustrates the state's emissions per capita and per unit of economic output. On a per capita basis, Montanans emit about 40 metric tons (Mt) of CO_2e, which is about twice the national average of 25 $MtCO_2e$. The reasons for the higher per capita intensity in Montana are varied but include the State's strong fossil fuel production industry, large agricultural industry, large distances for transportation, and low population base. Like the nation as a whole, per capita emissions have remained fairly flat, while economic growth exceeded emissions growth throughout the 1990-2004 period. During the 1990s, emissions per unit of gross product dropped by 25% nationally, and by 18% in Montana.

The principal sources of Montana's GHG emissions are electricity use (excluding electricity exports) and agriculture, each accounting for about 27% of Montana's gross GHG emissions. The next largest contributor to emissions is the transportation sector.

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[1] Excluding GHG emissions removed due to forestry and agricultural soils and excluding GHG emissions associated with exported electricity. Net emissions include the CO_2 sinks.

As illustrated in Figure ES-2 and shown numerically in Table ES-1, under the reference case projections, Montana's gross GHG emissions continue to grow, projected to climb to 42 MMtCO_2e by 2020, 30% above 1990 levels. As shown in Figure ES-3, transportation is projected to be the largest contributor to future emissions growth, followed by emissions associated with fossil fuel production and electricity use in the State. Net GHG emissions, which included net sinks from forestry activities and agricultural soils, are estimated to increase from about 7 MMtCO_2e in 1990 to 16 MMtCO_2e in 2020.

Some data gaps exist in this analysis, particularly for the reference case projections. Key tasks include developing a better understanding of the electricity generation sources currently used to meet Montana loads (in collaboration with state utilities), and review and revision of key emissions drivers (such as electricity, fossil fuel production, and transportation fuel use growth rates) that will be major determinants of Montana's future GHG emissions.

Emissions of aerosols, particularly "black carbon" (BC) from fossil fuel combustion, could have significant climate impacts through their effects on radiative forcing. Estimates of these aerosol emissions on a CO_2e basis were developed for Montana based on 2002 data. The results were a total of 2.6 MMtCO_2e, which is the mid-point of a range of estimated emissions (1.7 – 3.5 MMtCO_2e). Estimates for 2018 indicate that BC emissions from important contributing sectors, onroad and nonroad diesel engines, are expected to decline due to new federal emissions standards for engines and fuels. Details of this analysis are presented in Appendix I to this report. These estimates are not incorporated into the totals shown in Table ES-1 below to reflect the additional uncertainty in these estimates (based on the lack of a global warming potential for BC assigned by the IPCC). By including black carbon emission estimates in the inventory, however, additional opportunities for reducing climate impacts can be identified.

Table ES-1. Montana Historical and Reference Case GHG Emissions, Consumption-based, by Sector

(Million Metric Tons CO_2e)	1990	2000	2005	2010	2020	Explanatory Notes for Projections
Electric Sector	**8.9**	**9.5**	**10.0**	**10.0**	**11.0**	
Coal	15.8	16.2	18.5	20.2	22.5	See electric sector assumptions in appendix A
Natural Gas	0.0	0.0	0.0	0.4	0.4	
Petroleum Coke	0.0	0.8	0.8	0.8	0.8	
Net Exported Electricity	-7.0	-7.6	-9.4	-11.3	-12.8	
Res/Comm/Non-Fossil Ind (RCI)	**4.5**	**4.5**	**4.8**	**5.2**	**5.3**	
Coal	0.5	0.3	0.3	0.3	0.3	Based on USDOE regional projections from the *Annual Energy Outlook 2006.*
Natural Gas	2.1	3.1	2.9	3.2	3.3	
Oil	1.9	1.1	1.6	1.7	1.7	
Wood (CH_4 and N_2O)	0.0	0.0	0.0	0.0	0.0	Assumes no change after 2003
Transportation	**5.9**	**7.3**	**8.0**	**8.8**	**10.4**	
Motor Gasoline	3.8	4.4	4.4	4.8	5.7	Based on VMT growth provided by MDT and USDOE regional projections from the *Annual Energy Outlook 2006* for fuel efficiency changes.
Diesel[b]	1.7	2.5	3.1	3.4	3.9	
Natural Gas, LPG, other	0.1	0.1	0.1	0.1	0.1	
Jet Fuel, Aviation Gasoline	0.3	0.3	0.5	0.5	0.6	
Fossil Fuel Industry	**3.5**	**4.1**	**5.0**	**5.2**	**5.3**	
Natural Gas Industry	1.4	1.7	2.0	2.3	2.4	See Fossil Fuel Sector Appendix for Assumptions
Oil Industry	2.0	2.2	2.7	2.8	2.8	
Coal Mining (Methane)	0.2	0.2	0.2	0.2	0.2	Assumes no change after 2004
Coal to Liquids	n/a	n/a	n/a	n/a	n/a	Reference case assumes that no coal-to-liquids plants will be developed by 2020
Industrial Processes	**1.2**	**1.0**	**0.9**	**1.1**	**1.5**	
ODS Substitutes	0.0	0.2	0.4	0.5	0.9	Based on national projections (State Dept.)
SF_6 from Electric Utilities	0.1	0.1	0.0	0.0	0.0	Based on national projections (USEPA)
Cement & Other Industry	0.4	0.4	0.5	0.5	0.5	Increases with state population
Aluminum Industry	0.7	0.3	0.1	0.1	0.1	Projections constant at 2005 levels
Waste Management	**0.2**	**0.2**	**0.3**	**0.3**	**0.4**	
Solid Waste Management	0.1	0.2	0.2	0.2	0.2	Projections based on population.
Wastewater Management	0.1	0.1	0.1	0.1	0.1	Projections based on population.
Agriculture	**7.9**	**9.5**	**7.9**	**7.9**	**7.9**	
Livestock Management	3.2	3.7	3.6	3.6	3.6	Projections constant at 2005 levels
Ag. Soils and Residue Burning	4.7	5.8	4.2	4.2	4.2	Projections constant at 2005 levels
Total Gross Emissions	**32.2**	**36.1**	**36.8**	**38.5**	**41.7**	
Increase relative to 1990		*12%*	*14%*	*19%*	*30%*	
Forestry and Land Use	**-23.1**	**-23.1**	**-23.1**	**-23.1**	**-23.1**	Historical and projected emissions held at 2004 levels.
Agricultural Soils Sink	**-2.3**	**-2.3**	**-2.3**	**-2.3**	**-2.3**	Historical and projected emissions held at 1997 levels.
Net Emissions (including sinks)	**6.8**	**10.7**	**11.4**	**13.1**	**16.3**	

[a] Totals may not equal exact sum of subtotals shown in this table due to independent rounding; n/a = not applicable.

[b] Diesel fuel consumption in transportation includes locomotives.

Figure ES-1. Historical Montana and U.S. GHG emissions, per capita and per unit gross product

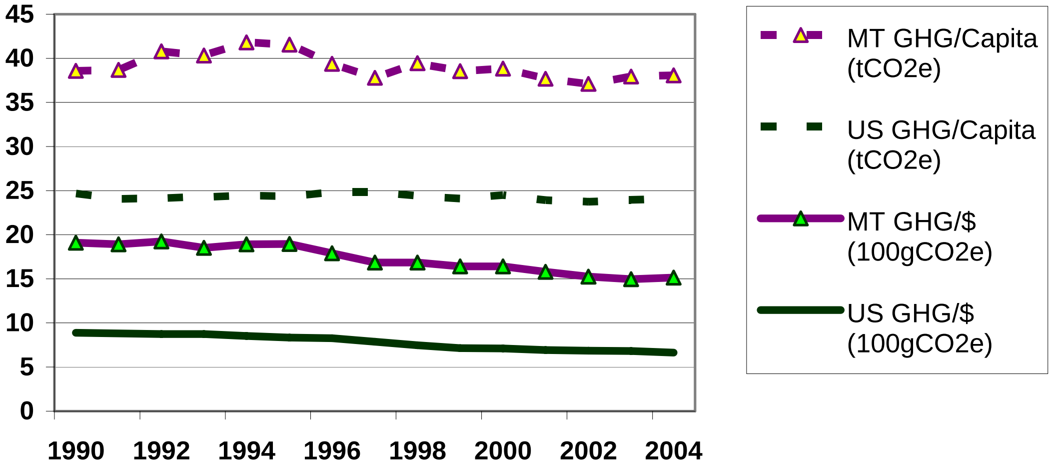

Figure ES-2. Montana gross GHG emissions by sector, 1990-2020: historical and reference case projection

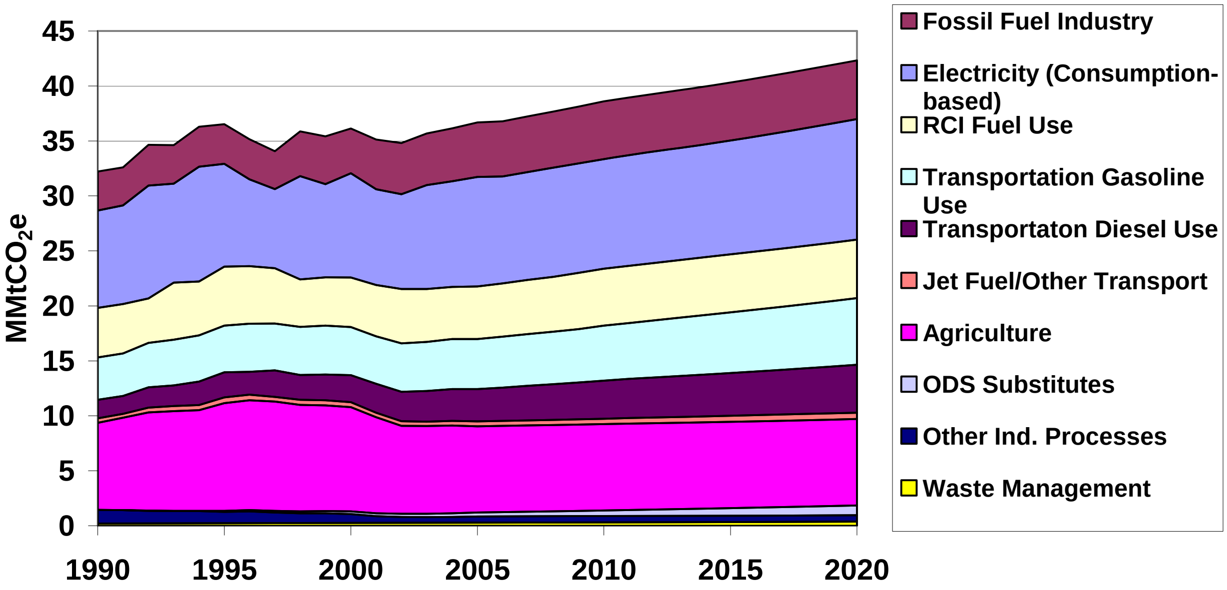

Figure ES-3. Sector contributions to emissions growth in Montana, 1990-2020: reference case projections

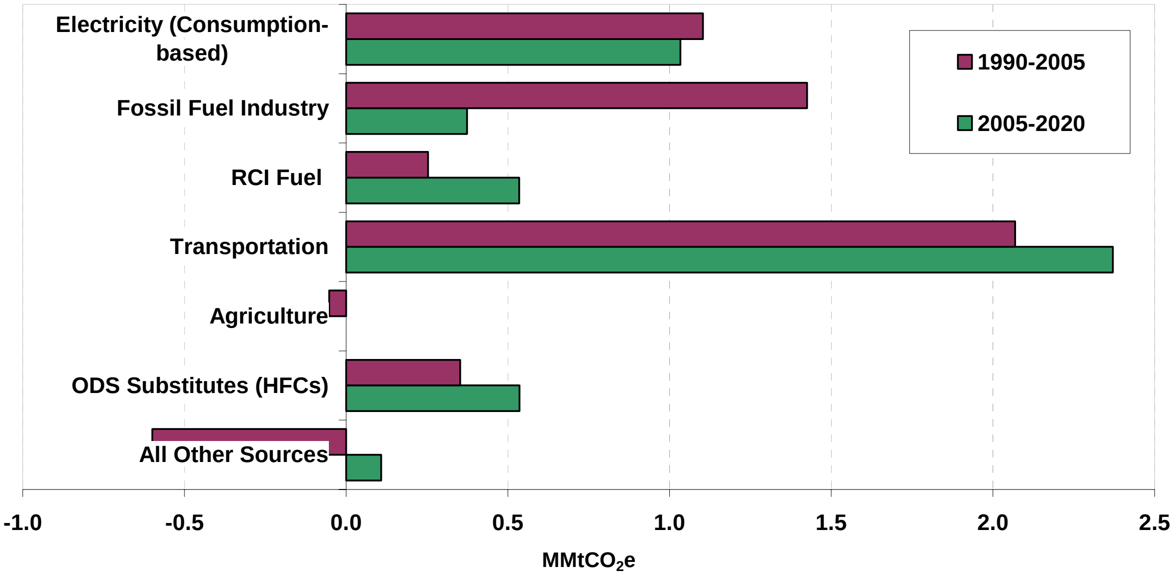

Figure ES-4 illustrates the growth in Montana's gross GHG emissions, under the alternative set of growth projections. Using the projection assumptions for the High Fossil Fuel case, Montana gross GHG emissions are estimated to grow to 52 MMtCO$_2$e in 2020 (compared with 42 MMtCO2e in the Reference Case in 2020). Of the 10 MMtCO$_2$e increase, 7 MMtCO$_2$e is due to Coal-to-Liquids (CTL) plant development (the Reference Case assumes that no CTL development occurs before 2020, while the High Fossil Fuel Case assumes 2 plants are developed). The remaining 3 MMtCO$_2$e difference in GHG emissions between the cases is due to higher assumed growth in oil refinery output and natural gas production (including coal bed methane). The High Fossil Fuel case also assumes that additional electricity transmission lines are developed between Montana and southern United States and, subsequently new coal-based power plants are built in Montana. These assumptions account for an additional 10 MMtCO$_2$e in 2020, but since these are production-based emissions, rather than consumption-based emissions, the difference is not included in the summary tables.

Figure ES-4. Montana gross GHG emissions by sector, 1990-2020: historical and high fossil fuel case projection

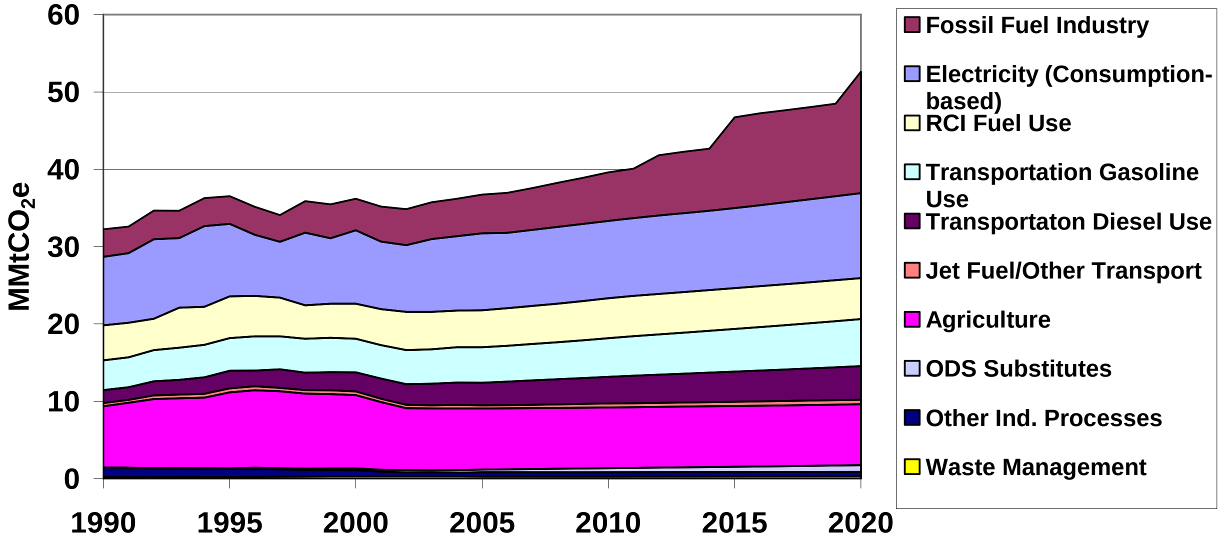

Table of Contents

Acronyms and Key Terms

AEO2006 – EIA's Annual Energy Outlook 2006

BOC – Bureau of Census

CAIT – Climate Analysis Indicators Tool

CCAC – Climate Change Advisory Committee

CCS – Center for Climate Strategies

CFCs – Chlorofluorocarbons

CH_4 – Methane*

CO_2 – Carbon Dioxide*

CO_2e – Carbon Dioxide equivalent*

EIA – U.S. DOE Energy Information Administration

EIIP – Emissions Inventory Improvement Project (US EPA)

GHG – Greenhouse Gases*

GSP – Gross State Product

GWh – Gigawatt-hours

GWP - Global Warming Potential*

HFCs – Hydrofluorocarbons*

HPMS – Highway Performance Monitoring System

IPCC – Intergovernmental Panel on Climate Change*

IPPs – Independent Power Producers

LFGTE – landfill gas collection system and landfill-gas-to-energy

LMOP – Landfill Methane Outreach Program

LNG – Liquefied natural gas

LPG – Liquefied petroleum gas

Mt - Metric ton (equivalent to 1.102 short tons)

MMt – Million Metric tons

MTBE – Methyl Tertiary Butyl Ether

MDEQ – Montana Department of Environment Quality

N_2O – Nitrous Oxide*

NASS – National Agricultural Statistics Service

ODS – Ozone-Depleting Substances

OPS – United States Office of Pipeline Safety

PFCs – Perfluorocarbons*

RCI – Residential, Commercial, and Industrial

SED – State Energy Data

SF_6 – Sulfur Hexafluoride*

SGIT – State Greenhouse Gas Inventory Tool

Sinks – Removals of carbon from the atmosphere, with the carbon stored in forests, soils, landfills, wood structures, or other biomass-related products.

TWh – terawatt-hours

U.S. EPA – United States Environmental Protection Agency

U.S. DOE – United States Department of Energy

USFS – United States Forest Service

VMT – Vehicle-miles traveled

* - See Appendix J for more information.

Acknowledgements

We appreciate all of the time and assistance provided by numerous contacts throughout Montana, as well as in neighboring states, and at federal agencies. Thanks go to in particular the many staff at several Montana state agencies for their inputs, and in particular to Richard Opper, Jim Boyer, Lisa Peterson, Jeff Blend, Lou Moore, and Cyra Cain of the Montana Department of Environment Quality who provided key guidance for this analytical effort.

Summary of Preliminary Findings

Introduction

The Center for Climate Strategies prepared this report under contract to the Montana Department of Environmental Quality. This report presents initial estimates of base year and projected Montana anthropogenic greenhouse gas (GHG) emissions and sinks for the period from 1990 to 2020. These estimates are intended to assist the state, the Climate Change Advisory Committee (CCAC), the Scientific Advisory Panel, and technical work groups (TWGs) with an initial, comprehensive understanding of current and possible future GHG emissions for Montana, and, thereby, to inform the upcoming analysis and design of GHG mitigation strategies.

Historical GHG emissions estimates (1990 through 2005)[2] were developed using a set of generally accepted principles and guidelines for state GHG emissions inventories, as described in the *Approach* section, relying to the extent possible on Montana-specific data and inputs. The initial reference case projections (2006-2020) are based on a compilation of various existing projections of electricity generation, fuel use, and other GHG-emitting activities, along with a set of simple, transparent assumptions described in the appendices of this report. These estimates should be viewed as preliminary input to the CCAC process and are subject to revisions as better data are identified.

This report covers the six types of gases included in the U.S. Greenhouse Gas Inventory: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Emissions of these GHGs are presented using a common metric, CO_2 equivalence (CO_2e), which indicates the relative contribution of each gas to global average radiative forcing on a Global Warming Potential- (GWP-) weighted basis. The final appendix to this report provides a more complete discussion of GHGs and GWPs. As stated in the Executive Summary, CCS also added current emission estimates for black carbon (BC) based on 2002 data from the Western Region Air Partnership (WRAP). Future year (2018) estimates for important contributing sectors were also incorporated (see Appendix I). Black carbon is an aerosol species with a positive climate forcing potential (that is, the potential to warm the atmosphere, as GHGs do).

It is important to note that the preliminary emissions estimates reflect the *GHG emissions associated with the electricity sources used to meet Montana's demands,* corresponding to a consumption-based approach to emissions accounting (see Approach Section below). Another way to look at electricity emissions is to consider the *GHG emissions produced by electricity generation facilities in the State.* For many years, Montana power plants have tended to produce considerably more electricity than is consumed in the State – emissions associated with exported electricity are excluded from the consumption-based emissions. This report covers both methods of accounting for emissions, but for consistency, all total results are reported as *consumption-based.*

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[2] The last year of available historical data varies by sector; ranging from 2000 to 2005.

Montana Greenhouse Gas Emissions: Sources and Trends

Table 1 provides a summary of GHG emissions estimated for Montana by sector for the years 1990, 2000, 2005, 2010, and 2020. A key conclusion from the values reported in Table 1 is that Montana's historic net GHG emissions were negative (see 1990) – in other words, the GHG emissions removed from the atmosphere due to forestry (increases in forest biomass stocks) and other land uses were greater than the GHG emissions generated in the state from fossil fuel combustion and other activities. However, due to the growth in GHG emissions since 1990, the state's net emissions have turned positive and Montana is now estimated to be a net source of GHG emissions. We note that there are significant uncertainties associated with estimating forest carbon sink estimates. Details on the methods and data sources used to construct the forestry estimates are provided in Appendix H**.** In the sections below, we discuss GHG emission sources (positive, or *gross*, emissions) and sinks (negative emissions) separately in order to identify trends, projections and uncertainties clearly.

This next section of the report provides a summary of the historical emissions (1990 through 2005) followed by a summary of the forecasted reference case projection year emissions (2006 through 2020), and key uncertainties and next steps. We also provide an overview of the general methodology, principals, and guidelines followed for preparing the inventories. Appendices A through H provide the detailed methods, data sources, and assumptions for each GHG sector.

Appendix I provides information on 2002 BC estimates for Montana. CCS estimated that BC emissions ranged from 1.7 – 3.5 $MMtCO_2e$ with a mid-point of 2.6 $MMtCO_2e$. A range is estimated based on the uncertainty in the global modeling analyses that serve as the basis for converting BC mass emissions into their carbon dioxide equivalents (see Appendix I for more details). Since the IPCC has not yet assigned a global warming potential for BC, CCS has excluded these estimates from the GHG summary shown in Table 1 below. Future year estimates (based on 2018 data from the WRAP) for important contributing sectors (onroad and nonroad engines) were also assessed. These assessments indicate that the contributions from onroad and nonroad engines are expected to decline by 2020 due to new national standards for engines and fuels.

Table 1. Montana historical and reference case GHG emissions, consumption-based by sector[a]

(Million Metric Tons CO_2e)	1990	2000	2005	2010	2020	Explanatory Notes for Projections
Electric Sector	**8.9**	**9.5**	**10.0**	**10.0**	**11.0**	
Coal	15.8	16.2	18.5	20.2	22.5	See electric sector assumptions in appendix A
Natural Gas	0.0	0.0	0.0	0.4	0.4	
Oil	0.0	0.8	0.8	0.8	0.8	
Net Exported Electricity	-7.0	-7.6	-9.4	-11.3	-12.6	
Res/Comm/Non-Fossil Ind (RCI)	**4.5**	**4.5**	**4.8**	**5.2**	**5.3**	
Coal	0.5	0.3	0.3	0.3	0.3	Based on USDOE regional projections from the *Annual Energy Outlook 2006.*
Natural Gas	2.1	3.1	2.9	3.2	3.3	
Oil	1.9	1.1	1.6	1.7	1.7	
Wood (CH_4 and N_2O)	0.0	0.0	0.0	0.0	0.0	Assumes no change after 2003
Transportation	**5.9**	**7.3**	**8.0**	**8.8**	**10.4**	
Motor Gasoline	3.8	4.4	4.4	5.2	5.7	Based on VMT growth provided by MDT and USDOE regional projections from the *Annual Energy Outlook 2006* for fuel efficiency changes.
Diesel[b]	1.7	2.5	3.1	3.4	3.9	
Natural Gas, LPG, other	0.1	0.1	0.1	0.1	0.1	
Jet Fuel, Aviation Gasoline	0.3	0.3	0.5	0.5	0.6	
Fossil Fuel Industry	**3.5**	**4.1**	**5.0**	**5.2**	**5.3**	
Natural Gas Industry	1.4	1.7	2.0	2.3	2.4	See Fossil Fuel Sector Appendix for Assumptions
Oil Industry	2.0	2.2	2.7	2.8	2.8	
Coal Mining (Methane)	0.2	0.2	0.2	0.2	0.2	Assumes no change after 2004
Coal to Liquids	n/a	n/a	n/a	n/a	n/a	Reference case assumes that no coal-to-liquids plants will be developed by 2020
Industrial Processes	**1.2**	**1.0**	**0.9**	**1.1**	**1.5**	
ODS Substitutes	0.0	0.2	0.4	0.5	0.9	Based on national projections (State Dept.)
SF_6 from Electric Utilities	0.1	0.1	0.0	0.0	0.0	Based on national projections (USEPA)
Cement & Other Industry	0.4	0.4	0.5	0.5	0.5	Increases with state population
Aluminum Industry	0.7	0.3	0.1	0.1	0.1	Projections constant at 2005 levels
Waste Management	**0.2**	**0.2**	**0.3**	**0.3**	**0.4**	
Solid Waste Management	0.1	0.2	0.2	0.2	0.2	Projections based on population.
Wastewater Management	0.1	0.1	0.1	0.1	0.1	Projections based on population.
Agriculture	**7.9**	**9.5**	**7.9**	**7.9**	**7.9**	
Livestock Management	3.2	3.7	3.6	3.6	3.6	Projections constant at 2005 levels
Ag. Soils and Residue Burning	4.7	5.8	4.2	4.2	4.2	Projections constant at 2005 levels
Total Gross Emissions	**32.2**	**36.1**	**36.8**	**38.5**	**41.7**	
Increase relative to 1990		*12%*	*14%*	*19%*	*30%*	
Forestry and Land Use	**-23.1**	**-23.1**	**-23.1**	**-23.1**	**-23.1**	Historical and projected emissions held at 2004 levels.
Agricultural Soils Sink	**-2.3**	**-2.3**	**-2.3**	**-2.3**	**-2.3**	Historical and projected emissions held at 1997 levels.
Net Emissions (including sinks)	**6.8**	**10.7**	**11.4**	**13.1**	**16.3**	

[a] Totals may not equal exact sum of subtotals shown in this table due to independent rounding. n/a = not applicable.
[b] Diesel fuel consumption in transportation includes locomotives, see appendix C for more information.

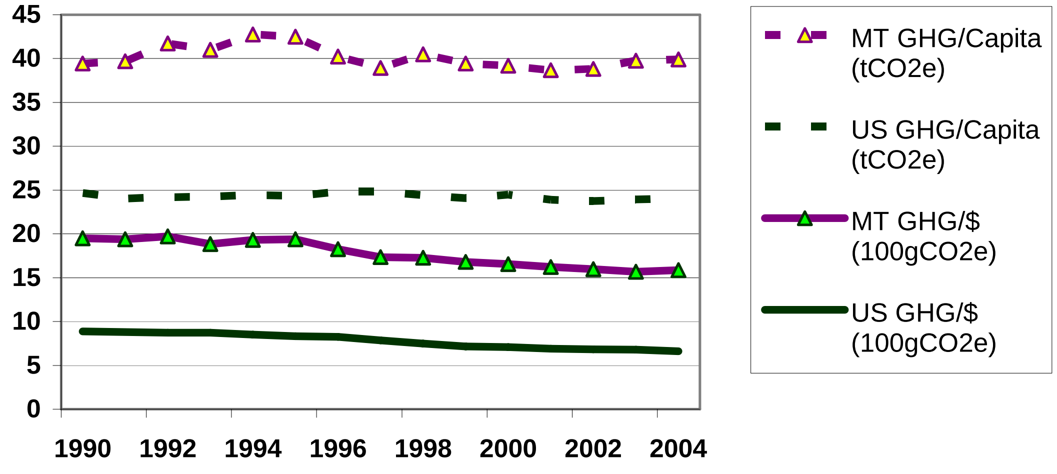
Historical Emissions

Overview

Preliminary analyses suggest that in 2005, activities in Montana accounted for approximately 37 million metric tons (MMt) of carbon dioxide equivalent (CO_2e) emissions, an amount equal to 0.6% of total U.S. GHG emissions.[3] Montana's *gross* GHG emissions are rising at about the same rate as the nation as a whole. [4] Montana's gross GHG emissions were up 14% from 1990 to 2005, while national emissions rose by 16% during this period.

Although Montana's GHG emissions are low on an absolute scale compared to the total national output, on a per capita basis, Montanans emit about 40 metric tons (Mt) of CO_2e, much higher than the national average of 25 $MtCO_2e$. Figure 1 illustrates the state's emissions per capita and per unit of economic output. The reasons for the higher per capita intensity in Montana are varied but include the State's strong fossil fuel production industry, large agricultural industry, large distances for transportation, and low population base. Figure 1 also shows that like the nation as a whole, per capita emissions have remained fairly flat, while economic growth exceeded emissions growth throughout the 1990-2004 period. From 1990 to 2004, emissions per unit of gross product dropped by 25% nationally, and by 18% in Montana.

Figure 1. Montana and US gross GHG emissions, per capita and per unit gross product



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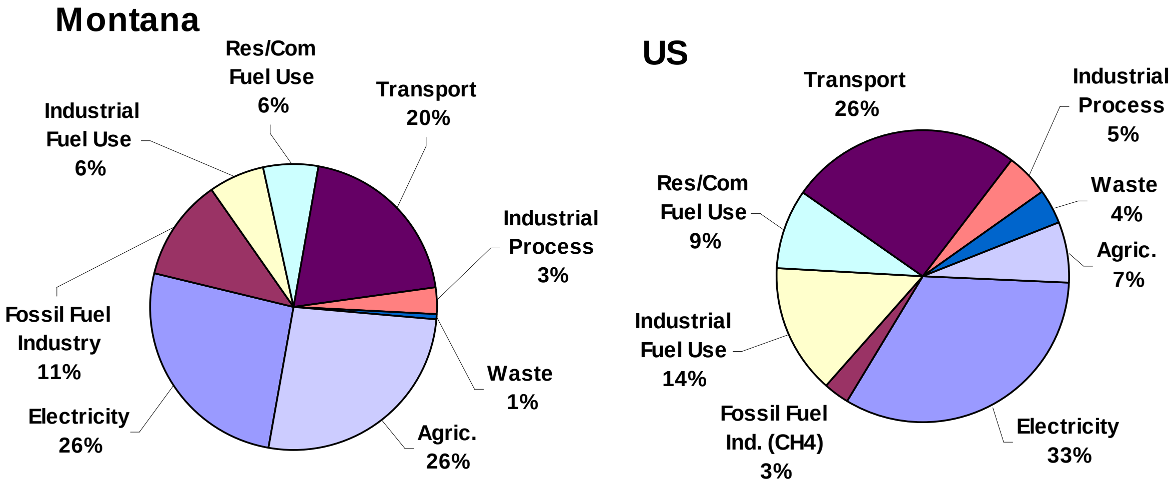
[3] United States emissions estimates are drawn from US EPA 2006. *Inventory of US Greenhouse gas Emissions and Sinks:1990-2004*.

[4] *Gross* emissions estimates only include those sources with positive emissions. Carbon sequestration in soils and vegetation is included in *net* emissions estimates. All emissions reported in this section for Montana reflect consumption-based accounting (excluding emissions from electricity exports). On a national basis, little difference exists between *production-based* and *consumption-based* accounting for GHG emissions because net electricity imports are less than 1% of national electricity generation.

Electricity use, transportation and agriculture are the State's principal GHG emissions sources. Together, the combustion of fossil fuels for electricity generation used in-state and in the transportation sector account for about 46% of Montana's *gross* GHG emissions, as shown in Figure 2. The relative contribution of agricultural emissions (methane and N_2O emissions from manure management, fertilizer use, and livestock) is much higher in Montana (26%) than in the nation as a whole (7%) This is a result of more agricultural activity per capita in Montana compared to the US. The remaining use of fossil fuels – natural gas, oil products, and coal -- in the residential, commercial, and industrial (RCI) sectors and the emissions from fossil fuel production constitute another 23% of state emissions.

Figure 2. Gross GHG emissions by sector, 2000, Montana and U.S.



Note: Totals might not add up to 100% due to independent rounding.

Industrial process emissions comprise almost 3% of state GHG emissions in 2000, but these emissions are rising rapidly due to the increasing use of HFC as substitutes for ozone-depleting chlorofluorocarbons.[5] Other industrial process emissions result from CO_2 released during aluminum and cement production, soda ash, limestone, and dolomite use. Landfills and wastewater management facilities produce CH_4 and N_2O emissions accounting for the remaining 1% of the state's emissions in 2000.

Forestry activities in Montana are estimated to be net sinks for GHG emissions (-23.1 $MMtCO_2$; see Appendix H). Also, agricultural soils are estimated to sequester an additional -2.3 $MMtCO_2$ (see Appendix F). For the 1990 to 2005 historic emission estimates, the annual forest carbon fluxes of forestlands were assumed to be at the same levels as those calculated for 2004. Montana's total net GHG emissions in 1990 are estimated at 7 $MMtCO_2e$/yr, increasing to 11 $MMtCO_2e$/yr in 2005.

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[5] Chlorofluorocarbons (CFCs) are also potent GHGs; however they are not included in GHG estimates because of concerns related to implementation of the Montreal Protocol. See final Appendix (Appendix J).

A Closer Look at the Three Major Sources: Electricity, Agriculture and Transportation

As shown in Figure 2, the electric, agriculture and transportation sectors are the largest contributors to Montana's gross consumption-based emissions. These sectors accounted for 26%, 26% and 20%, respectively, of total GHG emissions in 2000.

It is important to note that the electricity emissions estimates reflect the *GHG emissions associated with the electricity sources used to meet Montana demands*, corresponding to a consumption-based approach to emissions accounting (see Section 2). Another way to look at electricity emissions is to consider the *GHG emissions produced by electricity generation facilities in the state.* For many years, Montana power plants have produced almost twice the electricity that is consumed in the state – in the year 2000, for example, Montana exported 41% of the electricity produced in the state. As a result, in 2000, emissions associated with electricity consumption (9.5 $MMtCO_2e$) were much lower than those associated with electricity production (17.1 $MMtCO_2e$).[6]

While we estimate both the emissions from electricity production and consumption, unless otherwise indicated, tables, figures, and totals in this report reflect electricity consumption emissions. The consumption-based approach can better reflect the emissions (and emissions reductions) associated with activities occurring in the state, particularly with respect to electricity use (and efficiency improvements), and is particularly useful for policy-making. Under this approach, emissions associated with electricity exported to other states would need to be covered in those states' accounts in order to avoid double counting or exclusions. (Indeed, Arizona, California, Oregon, New Mexico, and Washington are currently considering such an approach.)

Emissions from agricultural sources, CH_4 and N_2O emissions from enteric fermentation, manure management, agricultural soils and crop residue burning, ranged from about 8 to 10 $MMtCO_2e$ during the period 1990 to 2005. Total GHG emissions increased from 8 $MMTCO_2e$ in 1990 to a high of 10 $MMTCO_2e$ in 1996 before dropping back to 8 $MMTCO_2e$ in 2002 and remaining at this level. Except for emissions from agricultural soils, emissions in each subsector were fairly static. For agricultural soils, emissions grew through the mid-1990's, but then have begun to fall since the late 1990's. Emissions from agricultural soils are N_2O emissions from the use of synthetic fertilizers, crop residue, nitrogen fixing crops, and manure application. Manure application is the largest contributor to the emissions from agricultural soils.

Like electricity emissions, GHG emissions from transportation fuel use have risen steadily since 1990 at an average rate of slightly over 2% annually. In 2005, gasoline-powered vehicles accounted for about 54% of transportation GHG emissions. Diesel consumption accounted for another 39%; air travel for roughly 6%, and the remainder of transportation emissions came from natural gas and liquefied petroleum gas (LPG) vehicles and lubricants (See appendix C for details on these calculations). As the result of Montana's population and economic expansion

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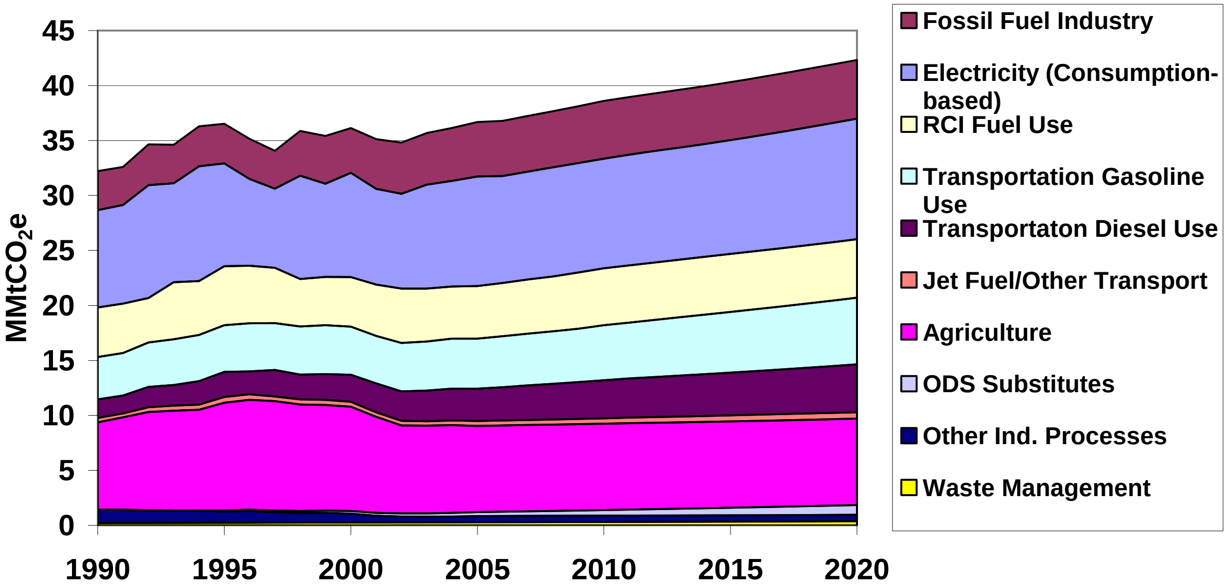
[6] Estimating the emissions associated with electricity use requires an understanding of the electricity sources (both in-state and out-of-state) used by utilities to meet consumer demand. The current estimate reflects some very simple assumptions described in Appendix A.

and an increase in miles traveled during the 1990s through 2005, gasoline use has grown at rate of 0.9% annually. Meanwhile, diesel use has risen 4% annually, suggesting an even more rapid growth in rail and truck freight movement within the State.

Reference Case Projections

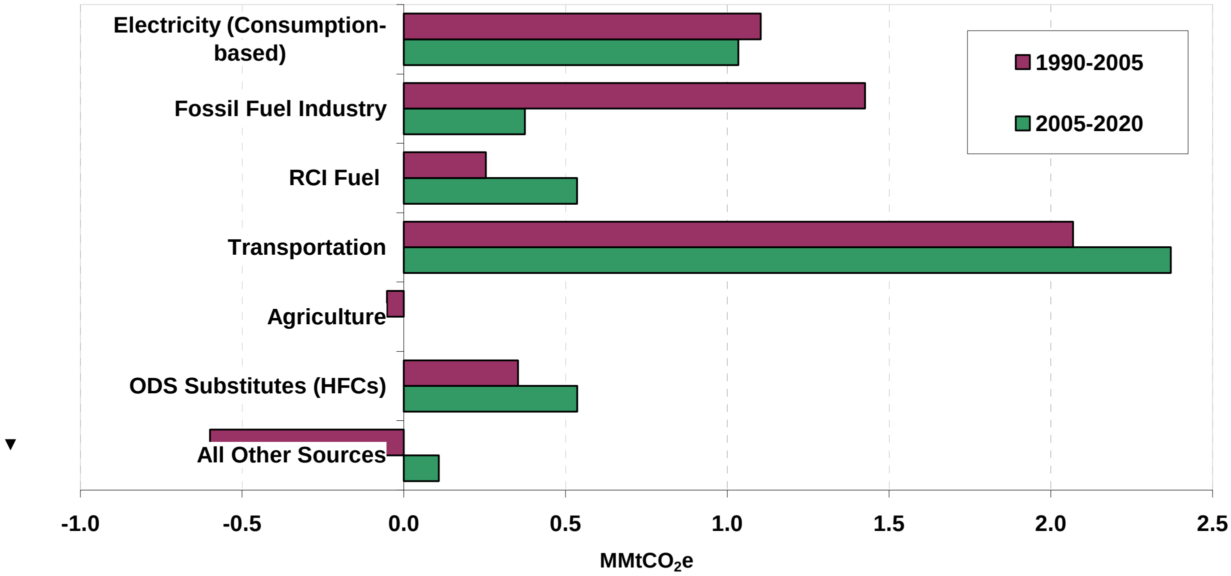
Relying on a variety of sources for projections of electricity and fuel use, as noted below and in the appendices, we developed a simple reference case projection of GHG emissions through 2020. As illustrated in Figure 3 and shown numerically in Table 1, under the reference case projections, Montana gross GHG emissions continue to grow steadily, climbing to 42 $MMtCO_2e$ by 2020, 30% above 1990 levels. Transportation is projected to be the largest contributor to future emission growth, followed by the electric sector, as shown in Figure 4. Other major sources of emissions growth include the fossil fuel industry, and fuel use in buildings and non-fossil fuel industry (RCI). The decrease in GHG emissions from *All Other Sources* in Figure 4 is driven by the drop in aluminum production from 1990 to 2005.

Figure 3. Montana gross GHG emissions by sector, 1990-2020: historical and projected under reference case assumptions



*RCI – direct fuel use in residential, commercial and industrial sectors (excluding the fossil fuel production industry) ODS Substitutes – Ozone Depleting Substances Substitutes. Other Ind. Processes includes process-related GHG emissions from aluminum production, soda ash, cement, limestone and dolomite use.

Figure 4. Sector contributions to emissions growth in Montana, 1990-2020: historic and reference case projections



*RCI – direct fuel use in residential, commercial and industrial sectors (excluding the fossil fuel production industry)
ODS Substitutes – Ozone Depleting Substances Substitutes, HFC - Hydrofluorocarbons.

High Fossil Fuel Production Scenario

Given the many factors impacting energy production-related emissions and a diversity of assumptions by stakeholders within the energy sector, developing a “reference case” projection for the most likely development of Montana’s electricity and fossil fuel production sectors is particularly challenging. The principal uncertainty of interest is on the high side, given the many plans and initiatives to increase coal utilization locally and nationally. As a result, we explore an alternative scenario of future energy supply development – the high fossil fuel production scenario. The high fossil fuel scenario assumes:

- Additional new transmission lines will be built to export power from Montana. The total additional transmission lines in this case would have a capacity of 2,500 additional MW over the reference case addition of 500 MW, or 3,000 total additional MW capacity, relative to current levels. The new power plants built in Montana to use the capacity of the additional transmission lines are assumed to be a mix of 67% fluidized bed coal and 33% wind.
- Total natural gas production triples between 2005 and 2010, and increases an additional 74% above 2010 levels by 2020. Much of this increase is driven by increased coal bed methane development. To support this production, the scenario assumes two new natural gas transmission lines cross the State.
- Montana refining capacity increases, both through expansion of existing refineries and the addition of a new refinery, for refining of Athabasca crude from Alberta’s oil sands.
- Two commercial coal-to-liquids plants are assumed to begin operation in Montana and coal mining increases modestly to support these plants.

The above assumptions reflect the high end of estimates for future fossil fuel development, under favorable conditions.

Table 4 presents a summary of GHG emissions from the electric sector in Montana on a production basis for both the reference case and the high fossil fuel scenario and on a consumption basis, which has the same estimated emissions for each case. Though the GHG emissions are significantly different from each other, each set of estimates is valid depending on circumstances. The difference between the emissions in the reference case and the high fossil fuel scenario estimates reflect the uncertainty in future energy development in Montana. From 2005 to 2020, using production-based accounting, GHG emissions from Montana's electric sector grow by 4.5 MMtCO2e in the reference case and 14.9 MMtCO2e in the high fossil fuel scenario. The consumption-based emissions represent a focus on the emissions associated with electricity consumption in Montana – this focus is important when evaluating the effects of actions directed at in-state electricity conservation. See Appendix A for more details on these GHG emission estimates.

Table 4. Summary GHG emissions for Montana electric sector

(Million Metric Tons CO2e)	1990	2000	2005	2010	2020
Production-based					
Reference case	**15.8**	**17.1**	**19.3**	**21.5**	**23.8**
High Fossil Fuel Scenario	**15.8**	**17.1**	**19.3**	**21.5**	**34.2**
Consumption-based	**8.9**	**9.5**	**10.0**	**10.0**	**11.0**

Note: Consumption-based emissions are the same for both the reference case and the high fossil fuel scenario because electricity consumption in Montana is the same for both cases.

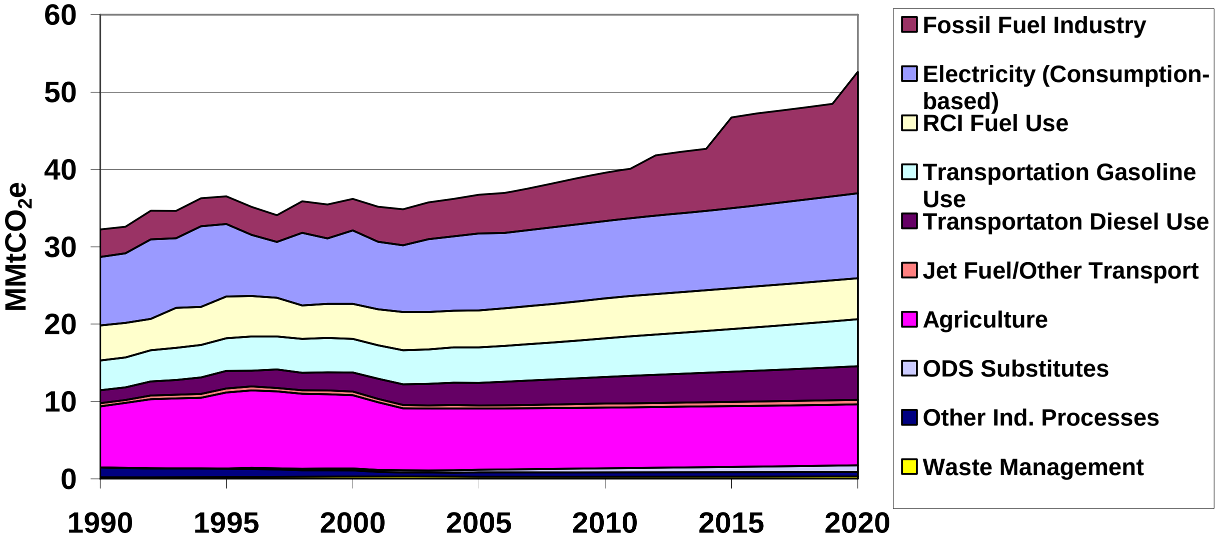
Table 5 presents a summary of GHG emissions from the Montana fossil fuel sector for both the reference case and the high fossil fuel scenario. The projected growth between 2005 and 2020 is only 7% in the reference case and 216% in the high fossil fuel case, in which a number of unconventional technologies reach commercial scale production.

Table 5. Comparison of total fossil fuel industry GHG emission for reference and high fossil fuel scenario

(Million Metric Tons CO2e)	1990	2000	2005	2010	2015	2020
Reference Case	**3.5**	**4.1**	**5.0**	**5.2**	**5.3**	**5.3**
Natural Gas Industry	1.4	1.7	2.0	2.3	2.3	2.4
Oil Industry	2.0	2.2	2.7	2.8	2.8	2.8
Coal-to-Liquids	n/a	n/a	n/a	n/a	n/a	n/a
Coal Mining	0.2	0.2	0.2	0.2	0.2	0.2
High Fossil Fuel Scenario	**3.5**	**4.1**	**5.0**	**6.2**	**11.7**	**15.7**
Natural Gas Industry	1.4	1.7	2.0	2.9	3.4	3.6
Oil Industry	2.0	2.2	2.7	3.1	4.4	4.4
Coal-to-Liquids	0.0	0.0	0.0	0.0	3.7	7.3
Coal Mining	0.2	0.2	0.2	0.2	0.2	0.3

Figure 5 illustrates the Montana gross GHG emissions under the high fossil fuel scenario assumptions. In this case, gross GHG emissions are projected to grow to 52 MMtCO$_2$e by 2020, 61% above 1990 levels.

Figure 5. Montana gross GHG emissions by sector, 1990-2020: historical and projected under high fossil fuel scenario assumptions



Key Uncertainties

Some data uncertainties exist in this inventory, and particularly in the reference case projections. Potential improvements to this work include developing a better understanding of the electricity generation sources currently used to meet Montana loads (in collaboration with state utilities), and review and revision of key drivers such as the electricity and transportation fuel use growth rates that will be major determinants of Montana’s future GHG emissions (See Table 6). These growth rates are driven by uncertain economic, demographic, and land use trends (including growth patterns and transportation system impacts), all of which could be refined further.

Perhaps the variable with the most important implications for GHG emissions is the type and number of power plants built in Montana between now and 2020. The assumptions on VMT and air travel growth also have large impacts on the GHG emission growth in the state. Finally uncertainty remains on estimates for historic GHG sinks from forestry and agriculture, and projections for these emissions will greatly impact the net GHG emissions attributed to Montana.

Table 6. Key annual growth rates for Montana, historical and projected

	1990-2005	2005-2020	Sources
Population	1.0%	0.6%	U.S. Bureau of Census
Employment			Montana Department of Labor website, based on analysis by the U.S. Bureau of labor and Statistics
Goods	2.5%	0.9%	
Services	2.3%	1.7%	
Electricity Sales	0.0%	1.6%	EIA data for 1990-2004 (0% growth is mix of increased residential and commercial electricity sales countered by large decrease in industrial sales), projections based on plans from Montana utilities (all sectors projected to have increased sales)
Vehicle Miles Traveled	1.7%	1.9%	Federal Highway Administration, Highway Statistic; projections from Montana Department of Transportation

* Population and employment projections for Montana were used together with US DOE's Annual Energy Outlook 2006 projections of changes in fuel use on a per capita and per employee, as relevant for each sector. For instance, growth in Montana's residential natural gas use is calculated as the Montana population growth times the change in per capita natural gas use for the Mountain region. Montana population growth is also used as the driver of growth in cement production, soda ash consumption, dolomite and limestone use.

Emissions of aerosols, particularly black carbon from fossil fuel combustion, could have significant impacts in terms of radiative forcing (i.e., climate impacts). Methodologies for conversion of black carbon mass estimates and projections to their global warming potential on a CO_2e basis involve significant uncertainty at present, but CCS has developed and used a recommended approach for estimating black carbon emissions based on methods used in other States. The current (2002) estimate is 2.6 $MMtCO_2e$/yr. Future year emissions for important sectors (onroad and nonroad diesel engines) are expected to decline due to new federal engine and fuel standards. As the scientific knowledge of the climate forcing effects of aerosols advances, the estimates presented here could be refined.

Approach

The principal goal of the inventories and reference case projections is to provide the state, CCAC, and TWGs with a general understanding of Montana's historical, current, and projected (expected) GHG emissions. The following explains the general methodology and the general principals and guidelines followed during development of these GHG inventories for Montana.

General Methodology

We prepared this analysis in close consultation with Montana agencies, in particular, the MDEQ staff. The overall goal of this effort is to provide simple and straightforward estimates, with an emphasis on robustness, consistency and transparency. As a result, we rely on reference forecasts from best available state and regional sources where possible. Where this is lacking, we use straightforward spreadsheet analysis and constant extrapolations of historical trends rather than complex modeling.

In most cases, we follow the same approach to emissions accounting for historical inventories used by the US EPA in its national GHG emissions inventory[7] and its guidelines for states.[8] These inventory guidelines were developed based on the guidelines from the Intergovernmental Panel on Climate Change, the international organization responsible for developing coordinated methods for national GHG inventories.[9] The inventory methods provide flexibility to account for local conditions. The electricity sector is one area in which we expand the US EPA inventory approach by evaluating consumption-based and production-based emissions, as described above. The key sources of activity and projection data are shown in Table 7. Table 7 also provides the descriptions of the data provided by each source and the uses of each data set in this analysis.

General Principles and Guidelines

A key part of this effort involves the establishment and use of a set of generally accepted accounting principles for evaluation of historical and projected GHG emissions, as follows:

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[7] US EPA, Feb 2005. *Draft Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2003.* http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2005.html .

[8] http://yosemite.epa.gov/oar/globalwarming.nsf/content/EmissionsStateInventoryGuidance.html.

[9] http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm .

Table 7. Key sources for Montana data, inventory methods, and growth rates

Source	Information provided	Use of Information in this Analysis
US EPA State Greenhouse Gas Inventory Tool (SGIT)	US EPA SGIT is a collection of linked spreadsheets designed to help users develop State GHG inventories. US EPA SGIT contains default data for each State for most of the information required for an inventory. The SGIT methods are based on the methods provided in the Volume 8 document series published by the Emissions Inventory Improvement Program (http://www.epa.gov/ttn/chief/eiip/techreport/volume08/index.html)	Where not indicated otherwise, SGIT is used to calculate emissions from residential/commercial/industrial fuel combustion, industrial processes, agriculture and forestry, and waste. We use SGIT emission factors (CO_2, CH_4 and N_2O per BTU consumed) to calculate energy use emissions.
US DOE Energy Information Administration (EIA) State Energy Data (SED)	EIA SED source provides energy use data in each State, annually to 2001.	EIA SED is the source for most energy use data. We also use the more recent data for electricity and natural gas consumption (including natural gas for vehicle fuel) from EIA website for years after 2001. Emission factors from US EPA SGIT are used to calculate energy-related emissions.
US DOE Energy Information Administration Annual Energy Outlook 2006 (AEO2006)	EIA AEO2006 projects energy supply and demand for the US from 2005 to 2030. Energy consumption is estimated on a regional basis. Montana is included in the Mountain Census region (AZ, CO, ID, MT, NM, NV, UT, and WY)	EIA AEO2006 is used to project changes in per capita (residential), per employee (commercial/industrial) energy consumption through 2020.
American Gas Association - Gas Facts	Natural gas transmission and distribution pipeline mileage.	Pipeline mileage from Gas Facts used with SGIT to estimate natural gas transmission and distribution emissions.
US EPA Landfill Methane Outreach Program (LMOP)	LMOP provides landfill waste-in-place data.	Waste-in-place data used to estimate annual disposal rate, which was used with SGIT to estimate emissions from solid waste. Additional data from MDEQ staff will be incorporated, when received.
US Forest Service	Data on forest carbon stocks for multiple years.	Data are used to calculate carbon dioxide flux over time (terrestrial CO2 sequestration in forested areas)
USDS National Agricultural Statistics Service (NASS)	USDA NASS provides data on crops and livestock.	Crop production data used to estimate agricultural. residue and soils emissions; livestock population data used to estimate manure and enteric fermentation emissions. Emission factors are from the EPA SGIT.

- **Transparency:** We report data sources, methods, and key assumptions to provide open review and opportunities for additional revisions later based on stakeholder and technical work group input.

- **Consistency:** To the extent possible, the inventory and projections are designed to be externally consistent with current or likely future systems for state and national GHG emission reporting. We have used US EPA tools for state inventories and projections as a starting point. These initial estimates were then augmented to conform to local data and conditions, as informed by Montana-specific sources and experts.

- **Comprehensive Coverage of Gases, Sectors, State Activities, and Time Periods.** This analysis aims to comprehensively cover GHG emissions associated with activities in Montana. It covers all six GHGs covered by U.S. and other national inventories: CO_2, CH_4, N_2O, SF_6, HFCs, and PFCs.

- **Priority of Significant Emissions Sources:** In general, activities with relatively small emissions levels may not be reported with the same level of detail as other activities.

- **Priority of Existing State and Local Data Sources:** In gathering data and in cases where data sources conflicted, we placed highest priority on local and state data and analyses, followed by regional sources, with national data used as defaults where necessary or simplified assumptions such as constant extrapolation of trends.

- **Use of Consumption-Based Emissions Estimates:** To the extent possible, we estimated emissions that are caused by activities that occur in Montana. For example, we reported emissions associated with the electricity consumed in Montana. The rationale for this method of reporting is that it can more accurately reflect the impact of state based policy strategies such as energy efficiency on overall GHG emissions, and it resolves double counting and exclusion problems with multi emissions issues. This approach can differ from how inventories are compiled, for example, on an in-state production basis, in particular for electricity.

For electricity, we estimate, in addition to the emissions due to fuels combusted at electricity plants in the State, the emissions related to electricity *consumed* in Montana. This entails accounting for the electricity sources used by Montana utilities to meet consumer demands. As we refine this analysis, we may also attempt to estimate other sectoral emissions on a consumption basis, such as accounting for transportation fuel used in Montana, but purchased out-of-state. In some cases this can require venturing into the relatively complex terrain of life cycle analysis. In general, we recommend considering a consumption-based approach where it will significantly improve the estimation of the emissions impact of potential mitigation strategies.[10]

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[10] For example re-use, recycling, and source reduction can lead to emission reductions resulting from lower energy requirements for material production (such as paper, cardboard, and aluminum), even though production of those materials, and emissions associated with materials production, may not occur within the state.

Some data gaps exist in this analysis, particularly for the reference case projections. Key tasks include developing a better understanding of the electricity generation sources currently used to meet Montana loads (in collaboration with state utilities), and review and revision of key emissions drivers (such as electricity and transportation fuel use growth rates) that will be major determinants of Montana's future GHG emissions.

Emissions of aerosols, particularly "black carbon" from fossil fuel combustion, could have significant climate impacts through their effects on radiative forcing. No estimates of these aerosol emissions have been developed for Montana as of yet. By including black carbon emission estimates in the inventory, however, additional opportunities for reducing climate impacts could be identified. CCS is currently conducting inventory and forecast work for a number states in coordination with the Western Governors' Association. Black carbon estimates produced as part of that process will be added to Montana's inventory when they are available.

Appendix A. Electricity Use and Supply

For at least the last 15 years, electricity generation has been a major export industry for Montana. The state exported 41% of the electricity it produced in 2000, and the inventory analysis indicates that exports in 2005 were about 40%. Export levels have varied between 37% and 47% since 1990,[11] depending on many factors including water levels for hydro-electric generation, economics and availability of power in neighboring regions, and Montana's own electricity demand. Montana electricity generation has been primarily a mix of coal and hydroelectricity. Generation from these two sources has been almost equal in some years, but recently coal sources have dominated. In 2004, coal accounted for 65% of generation, hydro for 33%, fuel oil for 2%, with the remaining sources (natural gas, biomass, and wind) contributing less than 0.5%. Coal-fired power plants produce as much as twice the CO_2 emissions per Megawatt-hour of electricity as natural gas-fired power plants, which dominate other states' production. In 2004, Montana emitted approximately 0.69 MtCO2e/MWh from electricity generation, compared to a national average of 0.65 MtCO2e/MWh.[12]

As noted earlier, one of the key questions for the state to consider is how to treat GHG emissions that result from consumption of electricity that is produced outside the state. In other words, should the state consider the GHG emissions associated with the state's electricity consumption or its electricity production, or some combination of the two? Since this question still needs to be resolved, this section examines electricity-related emissions from both a production and consumption basis.

This appendix describes Montana's electricity sector in terms of net consumption and production, including the assumptions used to develop the reference case projections. It then describes Montana's electricity trade and potential approaches for allocating GHG emissions for the purpose of determining the state's inventory and reference case forecasts. Finally, key assumptions and results are summarized.

We considered two sources of data in developing the inventory of CO_2 emissions from Montana power plants – 1) EIA's State Energy Data (SED) provides data on energy consumption, which then need to by multiplied by emission factors (i.e., tons of CO2, N2O and CH4 per unit of energy consumed) to calculate total GHG emissions and 2) U.S. EPA's Clean Air Markets Data[13] provides data on GHG emissions from larger plants (greater than 25 MW capacity) based on data from emissions monitors at the plants. We used the EIA's State Energy Data (SED) rather than EPA data because of its coverage of all power plants and because of inconsistencies that we found in the EPA data. Although the two sources provided similar estimates for CO_2 emissions in recent years, the EPA database shows the sum of emissions from individual power plants to be up to 10% greater than SED estimates for the entire state in earlier years (1997 and 1999). We discussed this with EPA and learned that EPA data tend to be conservative (i.e., overestimate emissions) because the data are reported as part of a regulatory program, and that during early years of the data collection program, missing data points were sometimes assigned a

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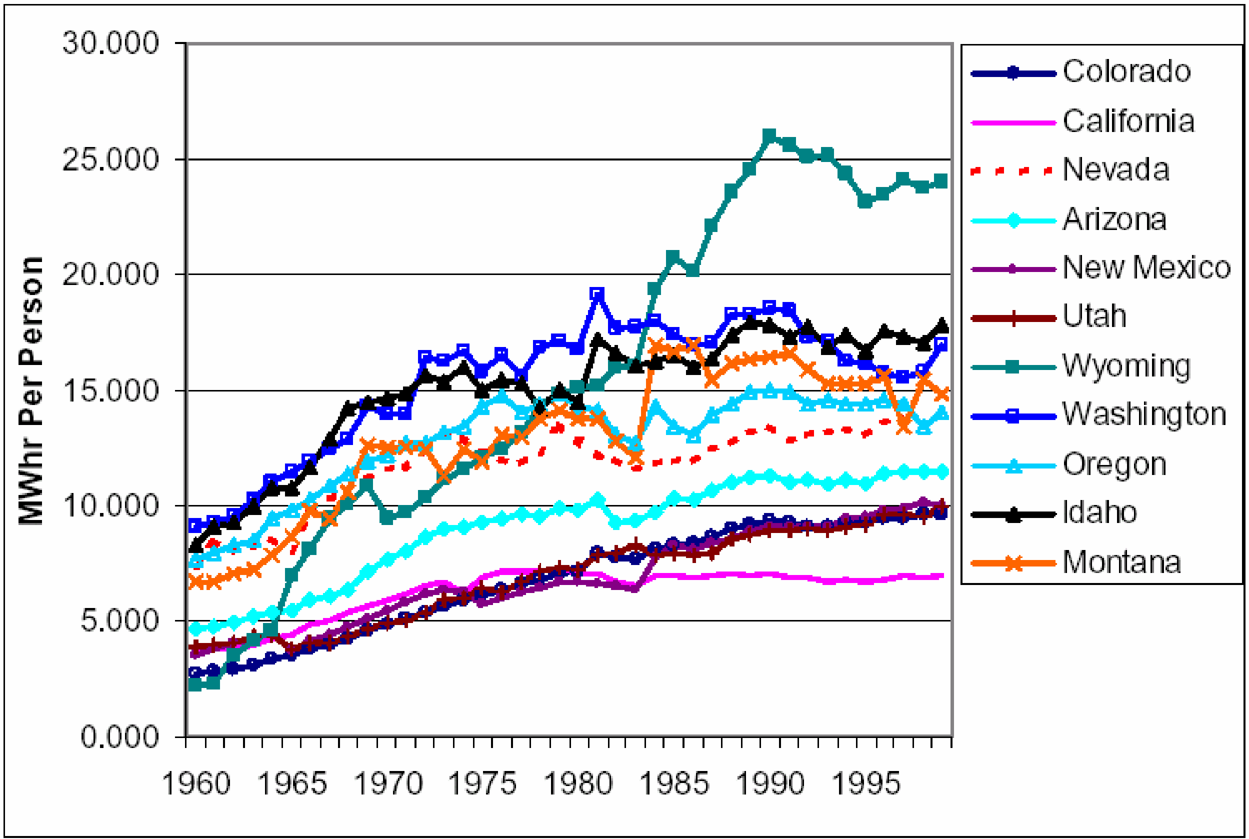
[11] eGRID2002 software (US EPA, http://www.epa.gov/cleanenergy/egrid/whatis.htm).
[12] EPA GHG Inventory.
[13] http://camddataandmaps.epa.gov/gdm/ .

large value as a placeholder. We applied SGIT emission factors to EIA's SED to develop the historic inventory of GHG emissions in the electricity sector.

Electricity Consumption

At about 14,000 kWh/capita (2004 data), Montana has relatively high electricity consumption per capita. By way of comparison, the per capita consumption for the U.S. was about 12,000 kWh per year.[14] Figure A1 shows Montana's rank compared to other western states from 1960-1999; while showing greater variation than most states, Montana's per capita consumption has been relatively high (4th out of 11).

Figure A1. Electricity consumption per capita in Western States, 1960-1999



Source: Northwest Power Council, 5th Power Plan, Appendix A

As shown in Figure A2, electricity sales in the industrial sector of Montana have varied significantly over time, with a large decrease in 2001 due to the high prices and uncertainty of the electricity crisis.[15] Industrial sector sales have slowly increased since that year. The

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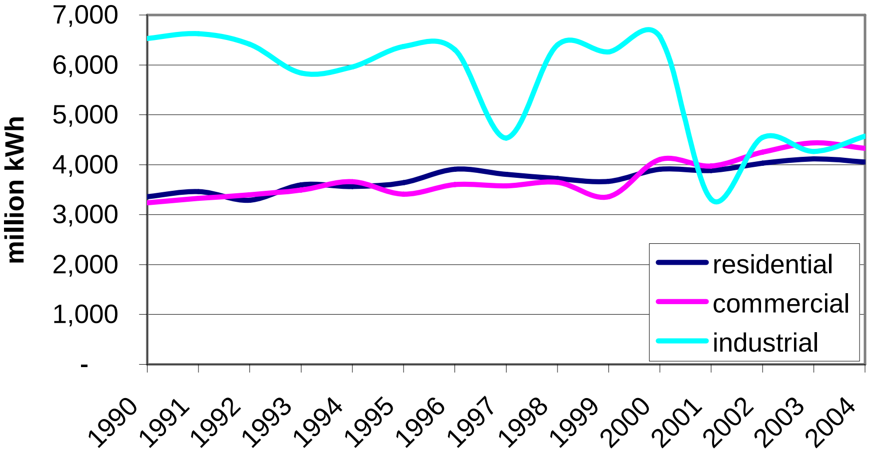
[14] Census bureau for U.S. population, Energy Information Administration for electricity sales.

[15] MT DEQ 2004. *Understanding Energy in Montana*. http://leg.mt.gov/css/publications/lepo/2005_deq_energy_report/2005deqenergytoc.asp .

commercial and residential sectors have seen a more consistent trend of increases since 1990, with some variation year to year.[16]

Figure A2. Electricity consumption by sector in Montana, 1990-2004



In 2004, Montana had 44 entities involved in providing electricity to state customers. The state's two largest investor-owned utilities, MDU Resources and NorthWestern Energy, serve approximately 63% of the customers, and 43% of the electricity sales, as illustrated in Table A1. The two smaller investor-owned utilities, Avista and Black Hills Power, served about 50 customers in 2004, accounting for about 0.1% of sales in Montana. The state's 30 electric cooperatives serve 33% of the customers and 26% of sales. Five power marketers (Conoco Inc, Energy West Resources, Granite Power Energy, Hinson Power Company and PPL Energy Plus) provided electricity to less than 0.05% of retail customers, but accounted for over 22% of sales. Power marketers either produce energy or deliver electricity to customers so that the electricity produced is not sold directly to retail customers, but instead is sold to delivery companies. Three federal entities (Bonneville Power Administration, U.S. Bureau of Indian Affairs – Mission Valley Power, and Western Area Power Administrator) plus the city of Troy municipal utility account for the remaining 8% of sales and 4% of customers.

Table A1. Retail Electricity Sales by Montana Utilities (2004)

	Ownership Type	2004 MWh
Top 5 providers of Retail Electricity, ranked by retail sales		
NorthWestern Energy LLC	Investor-Owned	5,318,700
PPL EnergyPlus LLC	Power Marketer	2,362,601
Flathead Electric Coop Inc	Cooperative	1,274,131
MDU Resources Group Inc	Investor-Owned	610,855
Bonneville Power Admin	Power Marketer	570,960
Total Sales, Top Five Providers		10,137,247
Total, all Montana		12,956,782

Source: EIA state electricity profiles

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[16] Electricity consumption figures here only include purchased electricity, and do not include electricity generated and consumed internally by specific industries, such as mining.

Overall, total electricity consumption decreased at an average annual rate of 0.1% from 1990 to 2004, but this value masks the many trends shown in Figure A2. During this period, the residential sector grew by an average of 1.4% per year, the commercial sector by 2.1% per year, and the industrial sector dropped by 2.5% per year.

A variety of sources were considered for initial projections of growth in electricity sales. Northwestern Energy provided projected retail sales in the Montana Energy Forum report.[17] The projections from the Montana-Dakota Utility (MDU) were provided by the Montana Public Service staff report from load forecasts in MDU's 2005 Integrated Resource Plan.[18] The 5th Power Plan from the Northwest Power and Conservation Council (NWPPC) also provided projected electricity growth for its share of Montana. The AEO2006 provides projections of electricity consumption for the Mountain census region. Since this census region includes states such as Arizona and New Mexico, which have much higher projected population and economic growth than Montana, these projections were adjusted to account for Montana's projected population and employment growth. These projections are summarized in Table A2 below.

Table A2. Electricity growth rates, projections

	Sample Projections					
	Northwestern Energy		MDU	NWPPC	AEO2006*	
	2004-2010	2010-2020	2004-2024	2000-2025	2004-2010	2010-2020
Residential	0.02%	0.2%	0.2%	n/a	1.5%	1.0%
Commercial	2.2%	1.2%	1.0%	n/a	2.9%	1.0%
Industrial	1.5%	0.0%	2.8%	n/a	0.8%	0.2%
Total	*1.3%*	*0.5%*	*0.90%*	*0.63%*	*1.7%*	*0.7%*

*AEO2006 projections have been adjusted for Montana's projected population and employment growth
Note that the sources do not report their projections based on consistent future time periods, also MDU and NWPPC only provided one average growth rate over the time period indicated, rather than annual variations.

To develop the projections for the reference case, the growth rates for NorthWestern Energy and MDU were applied to each utilities electricity sales in 2005. These utilities accounted for 41% and 5% of Montana's electricity sales respectively. Electricity growth for the remaining electricity sales (provided by electricity co-operatives and public utilities) was based on the average rate from the two utilities, NorthWestern Energy and MDU (0.2% per year for residential, 1.1% for commercial and 1.4% for industrial). The resulting projections for Montana are shown in Table A3.

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[17] http://www.montanaenergyforum.com/

[18] Email to CCS from Bob Raney, December 4, 2006.

Table A3. Electricity growth rates, historic and reference case projections

	Historic		Projections	
	1990-2005	2002-2005	2005-2010	2010-2020
Residential	1.5%	1.6%	0.1%	0.2%
Commercial	2.2%	1.7%	1.8%	1.1%
Industrial	-2.1%	1.7%	1.5%	1.3%
Total	*0.2%*	*1.7%*	*1.2%*	*0.9%*

Source: Historic from EIA data, Projections based on growth rates from NorthWestern Energy and MDU.

For comparison, Montana’s average annual growth rates by sector are also included in Table A3, for both 1990 to 2005 and also for the more recent time period, 2002 to 2005. Although industrial sector electricity sales have declined on average in the last fifteen years, both Table A3 and the previous Figure A2 show that much of that decrease occurred between 2000 and 2002. The projected growth rates for electric sales in this sector are similar to the more recent trends.

Electricity Generation – Montana’s Power Plants

As mentioned above and displayed in Figure A3, coal figures prominently in electricity generation and accounts for almost all the GHG emissions from power plants in Montana. Table A4 reports the emissions from the four largest plants in Montana. The largest plant, Colstrip, accounts for 82% of Montana’s GHG emissions. Colstrip is a large facility with 4 generator units built between 1976 and 1984, having a combined capacity of over 2,100 MW. It runs primarily on coal but also consumes propane, distillate oil, and petroleum coke. Ownership of the plant is shared by PPL Montana (36%), Puget Sound Energy (33%), Portland General Electric (14%), Avista (10%) and PacifiCorp West (7%).[19] PPL Montana is a subsidiary of PPL Corporation (Pennsylvania Power and Light) and the company is based in Billings. However, the other companies owning shares of Colstrip, and most of their customers, are based outside of Montana.

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[19] EPA’s Emission & Generation Resource Integrated database (EGRID), http://www.epa.gov/cleanenergy/egrid/index.htm .

Figure A3. Electricity generation and CO2 emissions from Montana power plants, 2004

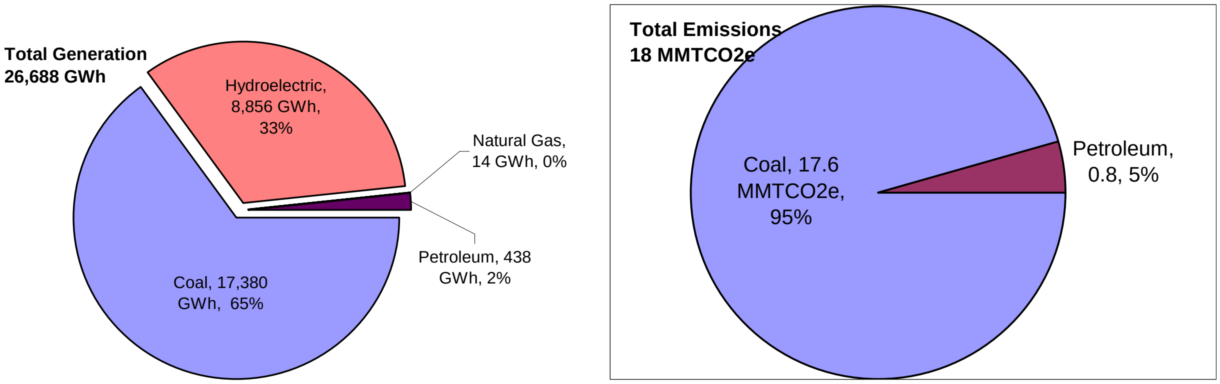


Table A4. CO2 emissions from individual Montana power plants, 1995-2004

(Million Metric Tons CO2e)	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Colstrip	*13.8*	*11.4*	*15.3*	*16.9*	*16.9*	*15.0*	*16.8*	*14.8*	*15.9*	*16.0*
Glendive Generating Stati	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*0.01*	*0.04*
J E Corette	*1.2*	*1.1*	*0.8*	*0.7*	*1.1*	*1.3*	*1.1*	*1.2*	*1.4*	*1.4*
Lewis & Clark	*0.4*	*0.3*	*0.3*	*0.4*	*0.3*	*0.5*	*0.5*	*0.4*	*0.5*	*0.5*
Other units	*1*	*1*	*0*	*0*	*0.0*	*0*	*0.0*	*0.0*	*0*	*1*
Total	**17**	**14**	**16**	**18**	**18**	**17**	**18**	**16**	**18**	**18**

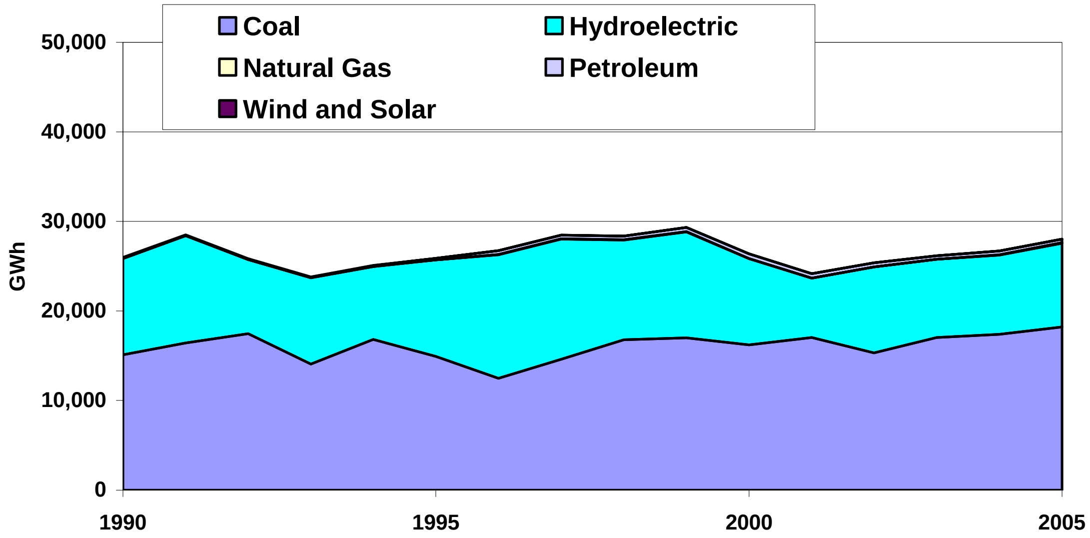
Source: U.S. EPA Clean Air Markets database for named plants (http://camddataandmaps.epa.gov/gdm/). Total emissions calculated from fuel use data provided by U.S. DOE EIA. Only CO_2 emissions are reported by Clean Air Markets database.

Figure A4 shows historical sources of electricity generation in the state by fuel source from 1990 through 2005. Table A5 shows the growth in generation by fuel type between 1990 and 2004. Overall generation grew by 3 percent between these two years, but as shown in Figure A4, generation levels vary greatly year to year. Coal generation shows the greatest increase in absolute terms over the 14-year period. Petroleum coke grew by the greatest percentage due to the BGI power plant starting up in 1995, but consumption of this fuel started at an extremely low level in 1990.

Table A5. Growth in Electricity Generation in Montana 1990-2004.

	Generation (GWh)		Growth
	1990	2004	
Coal	15,120	17,380	15%
Hydroelectric	10,717	8,856	-17%
Natural Gas	41	14	-67%
Biomass and waste	75	0	-100%
Petroleum Coke	27	438	1500%
Total	25,980	26,688	3%

Figure A4. Electricity generation in Montana 1990 - 2005



Source: EIA data, note that natural gas, wind and solar generation are less than 100 GWh in most years and are not visible in the figure.

Future Generation and Emissions

Estimating future generation and GHG emissions from Montana power plants requires estimation of new power plant additions and production levels from new and existing power plants. There are, of course, large uncertainties, especially related to the timing and nature of new power plant construction.

The future mix of plants in Montana remains uncertain as the trends in type of new builds are influenced by many factors. The most recent fossil-fuel plants have been natural gas-fired; however, there are concerns that natural gas prices may increase over the next decade, which could cause a trend towards a more coal-dominated mix. Recent announcements by several utilities indicate that coal will dominate new builds; Rocky Mountain Power, Inc.’s Hardin Generating Station is the first coal-fired power plant to be built in the state in the last 20 years (Thompson River Co-Gen, built in Thompson Falls in 2004, is currently not operating due to permit violations). Montana has also recently announced a renewable portfolio standard (RPS), requiring investor-owned utilities to generate (or purchase) a minimum amount of electricity from renewable sources. The RPS will likely spur additional new wind projects in the state. Table A6 presents data on new and proposed plants in Montana.

Table A6. New and proposed power plants in Montana

	Plant Name	Fuel	Status	Capacity MW	Expected Ann Generation GWh	Notes
Wind Plants	Judith Gap	wind	On-line 2006	135	355	The project will generate about 150 megawatts of power from 90 turbines.
	McCormick Ranch	wind	Proposed	120	315	
	Valley County Wind Energy Project	wind	Proposed	50 (2008) 100 (2010) 150 (2013) 200 (2016)	130 (2008) 260 (2010) 390 (2013) 520 (2016)	Proposal by Wind Hunter LLC for a project in north-central Valley County.
New plants	Rocky Mountain Hardin	Sub-bituminous coal	On-line 2006	135	1,005	3-year contract to sell 100% of electricity to British Columbia.
	Tiber Dam	water	On-line 2004	7	39	
	Thomson River Co-Gen	Sub-bituminous coal	On-line (but not operating)	16		
	Basin Creek, Equity Partner, LLC	Natural gas	On-line 2006	54.9	433	Offsets purchased so that power plant will meet the Oregon Standard for CO2 emissions
Proposed plants	SME Highwood Generating Station	lignite coal	Air quality permit issueded.	270	2,010	
	Silver Bow	Natural gas	Permitted	500	3,942	Permit application Jan-2001. Major permits secured Mar-2002.
	Roundup Bull Mountain, Broadview	lignite coal IGCC	Proposed	300		Proposed coal to liquids plant permitting proposed to be supplemental to MT DEQ air permits issued Feb 2003 for previously proposed steam-electric plant.

Given the many factors impacting electricity related emissions and a diversity of assumptions by stakeholders within the electricity sector, developing a “reference case” projection for the most likely development of Montana’s electricity sector is particularly challenging. The principal uncertainty of interest is on the high side, given the many plans and initiatives to increase coal utilization locally and nationally. As a result, we explore two cases of future electric sector development – the reference case and the high fossil fuel production scenario (these two cases were also developed for the fossil fuel production sector). For each case, simple assumptions were made to develop projections for electric generation, relying to the extent possible on existing proposals for future changes to Montana’s transmission infrastructure.

The reference case projections assume:

- Existing transmission lines are upgraded in Montana but no new lines are built. These upgrades will allow an additional 500 MW of additional capacity to be built in the state, over the period 2008 - 2020.

- New fossil fuel plants will be coal plants, which are assumed to be pulverized coal with heatrates at on average 9000 BTU/kWh.

The high fossil fuel production case projections assume:

- Additional new transmission lines will be built to export power from Montana. The total additional transmission lines in this case would have a capacity of 2,500 additional MW over the reference case addition of 500 MW, or 3,000 total additional MW capacity, relative to current levels. This scenario assumes the following transmission lines are available, or lines of similar capacity:
    - A transmission line capable of carrying 300 MW of power from Montana to Alberta-British Columbia is approved and functioning by 2009. An example of such a project is the Montana Alberta Tie Line.[20] This is a privately funded transmission line proposed between Alberta and Montana capable of transferring 300 MW of power South North (and 300 MW of power North South, with capability of transfer to California).[21]
    - A transmission line capable of carrying 2,200 MW of power from Montana to Las Vegas (or that general area) will be approved and functioning by 2012. The proposed Northern Lights transmission line, to be operated by Transcanada, is an example of such a project.[22] According to MDEQ staff, it is very possible that such a line would initially carry up to 1,500 MW and eventually enough generation could be built in Montana to fill the 3,000 MW line.[23] An estimate of 2, 200 MW is an approximate mid-point between these potential capacity levels.
- The high fossil fuel scenario assumes that new power plants will be built in Montana to use the full capacity of these two assumed lines by 2020. The new plants are assumed to be a mix of 65% fluidized bed coal and 35% wind. These new power plants are in addition to the new plants described in the reference case.

Both cases assume:

- Generation from existing non-hydro plants is based on 2004 levels. Generation from existing hydro-electric plants is assumed to be 10,356 GWh per year, the average generation from the last ten years (EIA electric power annual data, 1995-2004). New plants and changes to existing plants due to plant renovations and overhauls that result in higher capacity factors are counted as new generation.

- The Renewable Portfolio Standard requirements are assumed to be met by in-state wind generation. Renewable generation must meet a minimum of 10% of sales from investor-owned utilities in 2010 and 15% in 2015 and every year thereafter.

- Electricity sales grow at 1.2% per year from 2006-2010 and 0.9% per year from 2011-2020, as described previously.

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[20] http://www.matl.ca/

[21] ABB Engineering. 2006. System Feasibility Report: Montana Alberta Tie Line (MATL) project. Executive summary. http://www.matl.ca/documents/ABB_Executive.pdf

[22] http://www.transcanada.com/pdf/company/projects/NorthernLights_LR.pdf

[23] Email from Jeff Blend, MDEQ to Alison Bailie, CCS, November 13, 2006.

Electricity Trade and Allocation of GHG Emissions

Montana is part of the interconnected Western Electricity Coordinating Council (WECC) region - a vast and diverse area covering 1.8 million square miles and extending from Canada through Mexico, including all or portions of 14 western states. The inter-connected region allows electricity generators and consumers to buy and sell electricity across regions, taking advantage of the range of resources and markets. Electricity generated by any single plant enters the interconnected grid and may contribute to meeting demand throughout much of the region, depending on sufficient transmission capacity. Thus, it is challenging to define which emissions should be allocated to Montana, and secondly in estimating these emissions both historically and into the future. Some utilities track and report electricity sales to meet consumer demand by fuel source and plant type; however, tracing sales to individual power plants may not be possible.

In 2004, electricity consumption in Montana was 13 terawatt-hours (TWh), while electricity generation was 27 TWh. Also as mentioned above, Montana utilities own less than half of the largest generating plant in the state. Thus, a significant portion of the electricity generated and economic benefits may serve consumers and investors in other states.

Since almost all states are part of regional trading grids, many states that have developed GHG inventories have grappled with the problem of how to account for emissions. Several approaches have been developed to allocate GHG emissions from the electricity sector to individual states for inventories.

In many ways the simplest approach is *production-based* – emissions from power plants within the state are included in the state’s inventory. The data for this estimate are publicly available and unambiguous. However, this approach is problematic for states that import or export significant amounts of electricity. Because of the state's small imports and the uncertainty of the magnitude of future net imports, the question of consumption- versus production-based emissions may not be as important in Montana as in other states with greater percentages of net imports or exports. Under a production-based approach, characteristics of Montana electricity consumption would not be captured since only emissions from in-state generation would be considered.

An alternative is to estimate *consumption-based* or *load-based* GHG emissions, corresponding to the emissions associated with electricity consumed in the state. The load-based approach is currently being considered by states that import significant amounts of electricity, such as California, Oregon, and Washington.[24] By accounting for emissions from imported electricity, states can account for increases or decreases in fossil fuel consumed in power plants outside of the State, due to demand growth, efficiency programs, and other actions in the state. The difficulty with this approach is properly accounting for the emissions from imports and exports.

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[24] See for example, the reports of the Puget Sound Climate Protection Advisory Committee http://www.pscleanair.org/specprog/globclim/, the Oregon Governor’s Advisory Group On Global Warming http://egov.oregon.gov/ENERGY/GBLWRM/Strategy.shtml, and the California Climate Change Advisory Committee, Policy Options for Reducing Greenhouse Gas Emissions From Power Imports - Draft Consultant Report http://www.energy.ca.gov/2005publications/CEC-600-2005-010/CEC-600-2005-010-D.PDF.

Since the electricity flowing into or out of Montana is a mix of all plants generating on the inter-connected grid, it is impossible to physically track the electrons.

The approach taken in this initial inventory is a simplification of the consumption-based approach. This approach, which one could term "*Net-Consumption-based*," estimates consumption-based emissions as in-state (production-based) emissions times the ratio of total in-state electricity consumption to in-state generation (net of losses).

This method does not account for differences in the type of electricity that is imported or exported from the state, and as such, it provides a simple method for reflecting the emissions impacts of electricity consumption in the state. More sophisticated methods – e.g., based on individual utility information on resources used to meet loads – can be considered for further improvements to this approach.

Summary of Assumptions and Reference Case Projections

As noted, projecting generation sources, sales, and emissions for the electric sector out to 2020 requires a number of key assumptions, including economic and demographic activity, changes in electricity-using technologies, regional markets for electricity (and competitiveness of various technologies and locations), access to transmission and distribution, the retirement of existing generation plants, the response to changing fuel prices, and the fuel/technology mix of new generation plants. The key assumptions described above are summarized in Table A7.

Table A7. Key assumptions and methods for electricity projections for Montana

Assumptions for Both Scenarios

Electricity sales	Average annual growth of 1.2% from 2006 to 2010 and 0.9% per year from 2010 to 2020, based on growth rates from Northwestern Energy and MDU.
Transmission and Distribution losses	10% losses are assumed, based on average statewide losses, 1994-2000, (data from the US EPA Emission & Generation Resource Integrated Database[25])
Renewable Portfolio Standard	Montana's Renewable Portfolio Standard will be met by Northwestern Energy and MDU, 10% of State sales met by renewable generation by 2010, 15% by 2015 and in subsequent years. New renewables are assumed to be wind.
Heat Rates	The assumed heat rates for new gas and coal generation are 7000 Btu/kWh and 9000 Btu/kWh, respectively, based on estimates used in similar analyses.[26]
Operation of Existing Facilities	Existing facilities are assumed to continue to operate as they were in 2004. Changes in existing facilities that result in energy efficiency changes are captured under the new non-renewable generation sources.

Assumptions for Reference Case

New Electric Transmission Capacity	Transmission lines capable of carrying an additional 500 MW of new capacity will be on-line by 2020
New Generation Sources	All of the new generation capacity will be fluidized bed coal plants.

Assumptions for High Fossil Fuel Scenario

New Electric Transmission Capacity	Transmission lines capable of carrying an additional 3,000 MW of new capacity will be on-line by 2020
New Generation Sources	65% of new generation capacity will be fluidized bed coal plants, with wind generation accounting for the remaining 35%.

Results – Reference Case

Figure A5 shows historical sources of electricity generation in the state by fuel source, along with projections to the year 2020 based on the assumptions described above for the reference case. Based on the above assumptions for new generation, total generation increases by an average rate of 1.5%ercent from 2005 to 2020 and coal continues to dominate new generation.

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[25] http://www.epa.gov/cleanenergy/egrid/index.htm.

[26] See, for instance, the Oregon Governor's Advisory Group on Global Warming http://egov.oregon.gov/ENERGY/GBLWRM/Strategy.shtml.

Figure A5. Electricity generated by Montana power plants, 1990-2020, reference case

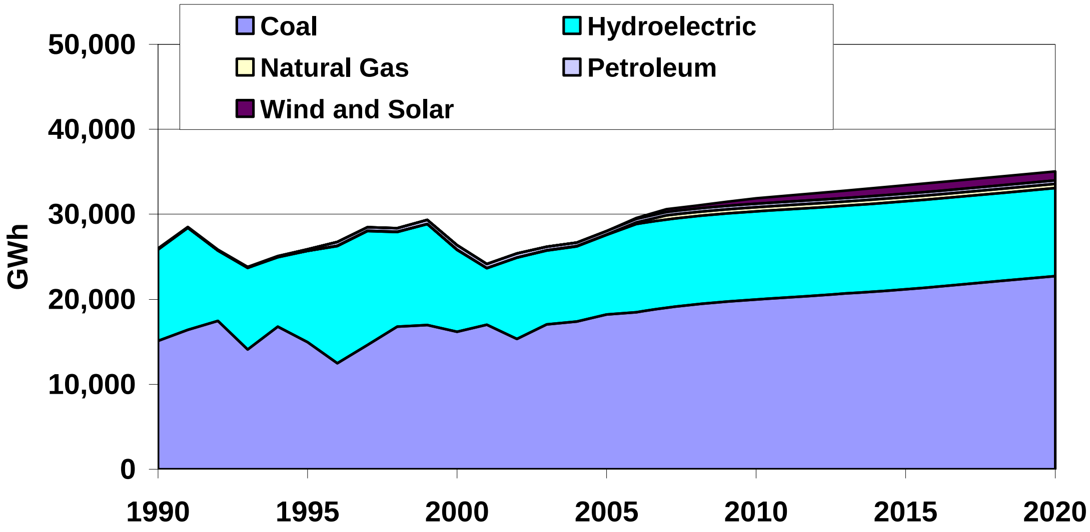


Figure A6 illustrates the GHG emissions associated with the mix of electricity generation shown in Figure A5. From 2005 to 2020, the emissions from Montana electricity generation are projected to grow at 1.3% per year, similar to the growth in electricity generation. The emission intensity (emissions per MWh) of Montana electricity is projected to decrease slightly, by about 2.4% (from 0.69 $MtCO_2$/MWh in 2005 to 0.67 $MtCO_2$/MWh in 2020).

Figure A6. Montana GHG emissions associated with electricity production (production-basis), includes exports, reference case

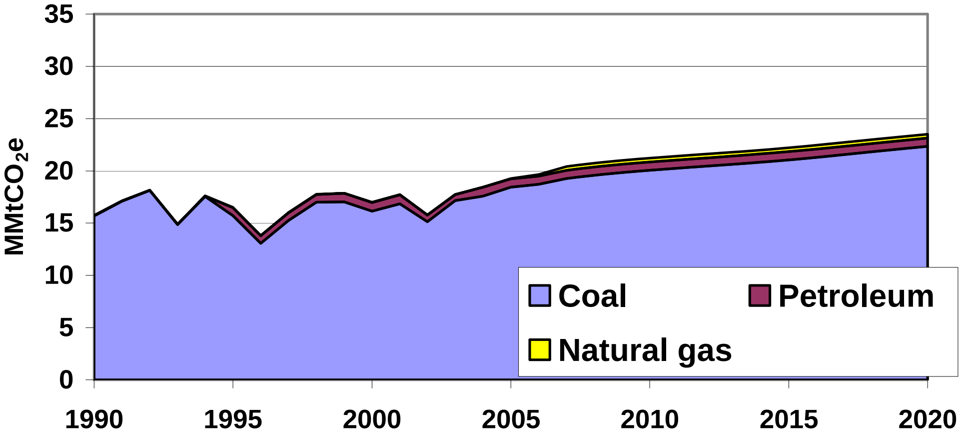
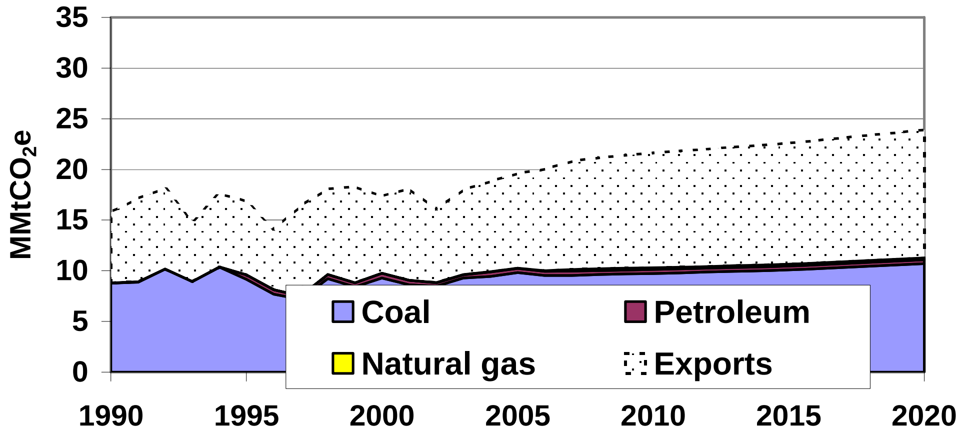


Figure A7 shows the "net-consumption-basis" emissions from 1990 to 2020. Total emissions match those shown in the previous "production-basis" chart; here, however, a significant fraction is attributed to net electricity exports as shown in the top area. Net-consumption based emissions grow at an average 0.6% per year from 2005 to 2020. This growth is lower than the average growth in total electricity sales for this period (1.0% per year) as the State RPS causes renewable generation to meet a larger fraction of in-state electricity sales.

Figure A7. Montana GHG emissions associated with electricity use (consumption-basis) and exports



Results – High Fossil Fuel Scenario

Figure A8 shows historical sources of electricity generation in the state by fuel source, along with projections to the year 2020 based on the assumptions described above for the high fossil fuel scenario. Based on the above assumptions for new generation, coal continues to dominate new generation throughout the forecast period but wind generation also grows strongly. Total generation increases by 3.9 percent per year from 2005 to 2020.

Figure A8. Electricity generated by Montana power plants, 1990-2020, high fossil fuel scenario

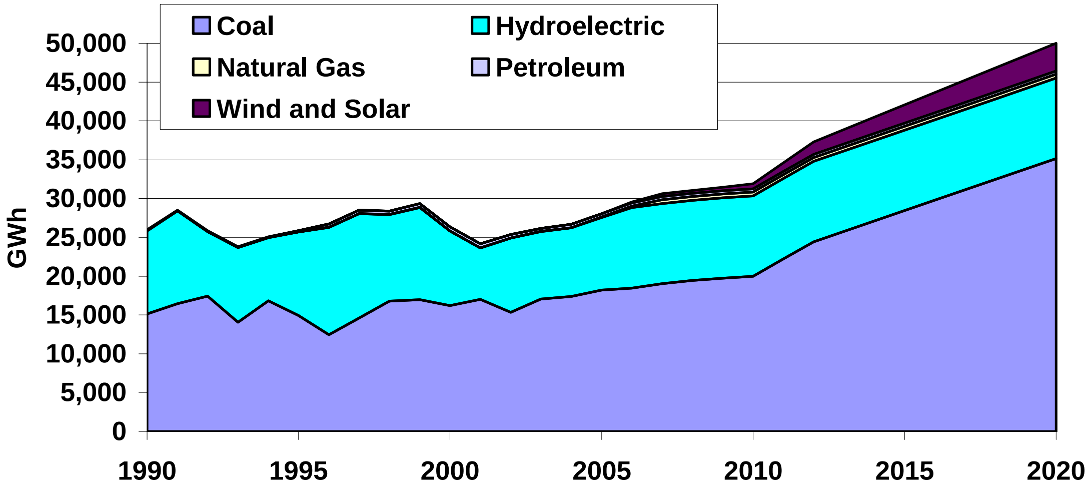
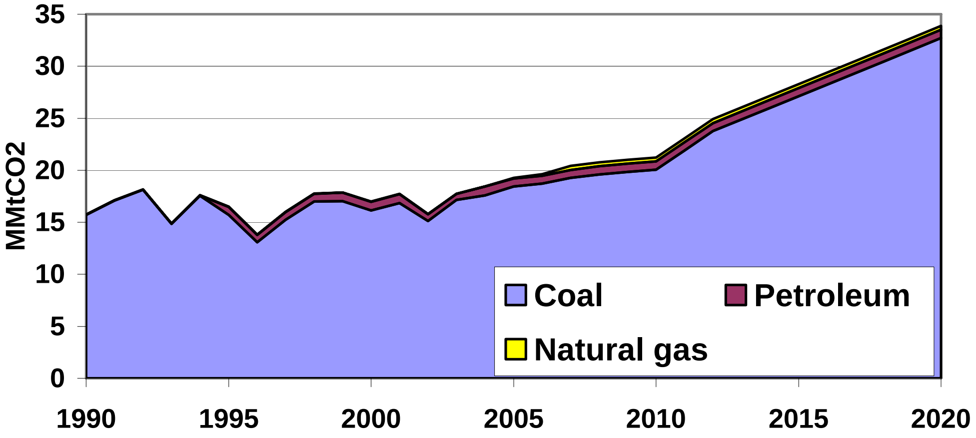


Figure A9 illustrates the GHG emissions associated with the mix of electricity generation shown in Figure A8. From 2005 to 2020, the emissions from Montana electricity generation are projected to grow at 3.8% per year, similar to the growth in electricity generation. The emission intensity (emissions per MWh) of Montana electricity is projected to decrease slightly, by about 2% (from 0.69 $MtCO_2$/MWh in 2005 to 0.68 $MtCO_2$/MWh in 2020). Although wind generation accounts for 35% of new electricity capacity, wind has lower capacity factors than coal generation and no new hydro-electric plants are assumed to be built so coal continues to dominate electricity production.

Figure A9. Montana CO2 emissions associated with electricity production (production-basis), includes exports, high fossil fuel scenario



The "net-consumption-basis" emissions for the high fossil fuel case are the same as for the reference case because the additional generation that is built under the high fossil fuel scenario is assumed to be used for export to other states.

Table A8 presents a summary of GHG emissions from the electric sector in Montana on a production basis for both the reference case and the high fossil fuel scenario and on a consumption basis, which has the same estimated emissions for each case. Though the GHG emissions are significantly different from each other, each set of estimates is valid depending on circumstances. From 2005 to 2020, using production-based accounting, GHG emissions from Montana's electric sector grow by 4.5 MMtCO2e in the reference case and 14.9 MMtCO2e in the High Fossil Fuel Scenario. The difference between the emissions in the reference case and the high fossil fuel scenario estimates reflect the uncertainty in future energy development in Montana. The consumption-based emissions represent a focus on the emissions associated with electricity consumption in Montana – this focus is important when evaluating the effects of actions directed at in-state electricity conservation.

Table A8. Summary GHG emissions for Montana electric sector

(Million Metric Tons CO2e)	1990	2000	2005	2010	2020
Production-based					
Reference case	**15.8**	**17.1**	**19.3**	**21.5**	**23.8**
High Fossil Fuel Scenario	**15.8**	**17.1**	**19.3**	**21.5**	**34.2**
Consumption-based	**8.9**	**9.5**	**10.0**	**10.0**	**11.0**

Note: Consumption-based emissions are the same for both the reference case and the high fossil fuel scenario because electricity consumption in Montana is the same for both cases.

Appendix B. Residential, Commercial, Industrial and Institutional Fossil Fuel Combustion (excluding fuel used by fossil fuel production industry)

The RCII[27] sectors produce CO_2, CH_4, and N_2O emissions when fuels are combusted for space heating, process heating, and other applications. Carbon dioxide accounts for over 99% of these emissions on an $MMtCO_2e$ basis. In addition, since these sectors consume electricity, one can also attribute electricity use emissions to these sectors.[28] This is particularly important to consider as the CCAC begins to explore options to improve energy efficiency (see Figures B1-B3), because the emissions associated with electricity use exceed those from direct fuel use in each sector, especially in residential and commercial buildings.

Direct use of coal, oil, natural gas, and wood[29] in the RCII sectors accounted for an estimated 12% of gross GHG emissions in 2005. However, if emissions associated with RCII electricity use are included, RCII energy use then accounts for 42% of gross GHG emissions.

Emissions for direct fuel use were estimated using the U.S. EPA's SGIT. Two changes were made to the default data provided in SGIT. First, the 2000 consumption estimates were updated using more recent data from EIA's website. The default data in the SGIT workbook are from EIA's *State Energy Data 2000*; however, the 2000 consumption estimates were revised in the 2001 edition of State Energy Data[30] and new data were provided for 2001. Secondly, EIA provides electricity consumption and natural gas consumption estimates for 2002, 2003 and 2004 as part of the *Electricity Production Annual*[31] and the *Natural Gas Navigator*.[32] These data were included in the Montana inventory.

Reference case emissions for direct fuel combustion were estimated based on fuel consumption forecasts from EIA *Annual Energy Outlook 2006*, with adjustments for Montana's projected population and employment growth. Table B1 and Table B2 report the historic and projected growth rates for electricity and fuels respectively.

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[27] The industrial sector includes agricultural energy use as well but this section excludes fuel used by the fossil fuel production industry. Emissions from energy used in that industry are reported in Appendix F.

[28] One could similarly allocate GHG emissions due to natural gas transmission and distribution and other sources, but we have not done so here due to the relatively small level of emissions.

[29] Emissions from wood combustion include only N2O and CH4. Carbon dioxide emissions from biomass are assumed to be "net zero" consistent with U.S. EPA and IPCC methodologies, and any net loss of carbon stocks due to biomass fuel use should be picked up in the land use and forestry analysis.

[30] *State Energy Data 2001*, Energy Information Administration, Department of Energy

[31] http://www.eia.doe.gov/cneaf/electricity/epa/epa_sprdshts.html

[32] http://tonto.eia.doe.gov/dnav/ng/ng_cons_sum_dcu_SMT_a.htm

Table B1. Electricity sales annual growth rates, historical and projected

Sector	**1990-2004**	**2004-2020**
Residential	1.4%	1.5%
Commercial	2.1%	2.9%
Industrial	-2.5%	0.1%
Total	**-0.1%**	**1.6%**

Table B2. Historic and projected average annual growth in energy use, by sector and fuel, 1990-2020

	1990-2004	**2004-2010**	**2010-2015**	**2015-2020**
Residential				
Natural gas	1.2%	1.6%	1.2%	0.8%
Petroleum	-0.5%	0.2%	0.4%	-0.1%
Commercial				
Natural gas	0.7%	1.3%	2.5%	1.9%
Petroleum	-0.8%	-1.5%	0.8%	0.4%
Industrial				
Natural gas	5.7%	2.3%	-1.1%	-1.4%
Petroleum	-1.8%	1.9%	0.2%	-0.4%
Coal	-2.9%	0.5%	-1.5%	-1.6%

Figures B1, B2, and B3 illustrate historic and projected emissions for the RCII sectors from 1990 to 2020. Electricity consumption accounts for the largest component of each sector's emissions. The commercial sector shows the highest emissions growth, due to assumed strong growth in both electricity and natural gas consumption. Commercial electricity use grows faster than employment, while per-employee direct fuel use decreases. Residential sector emissions show strong growth with electricity and natural gas use growing faster than population. The historical industrial sector emissions show significant variation. Industrial energy consumption in Montana has been dominated by a relatively small number of large operations and the variation reflects market variation plus plant adjustments to energy prices.[33] The assumed growth rate for industrial sector fuel and electricity consumption is also higher than the growth in employment. For both the commercial and industrial sectors, energy consumption and resulting GHG

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[33] While information on energy consumption by plant or industry were not available, general information was provided by MT DEQ 2004. *Understanding Energy in Montana*. http://leg.mt.gov/css/publications/lepo/2005_deq_energy_report/2005deqenergytoc.asp

emissions are projected to grow at a slower pace than GSP indicating an overall decrease in GHG intensity.[34]

Figure B1. Residential sector GHG emissions from fuel consumption

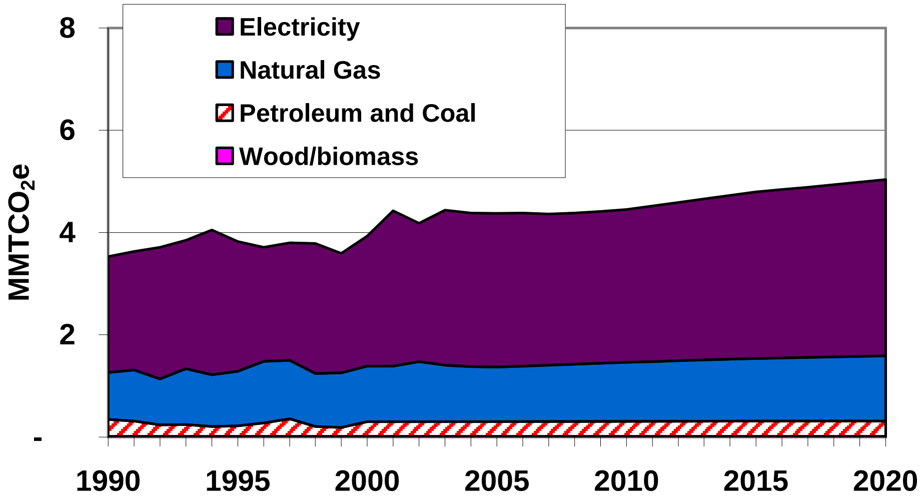
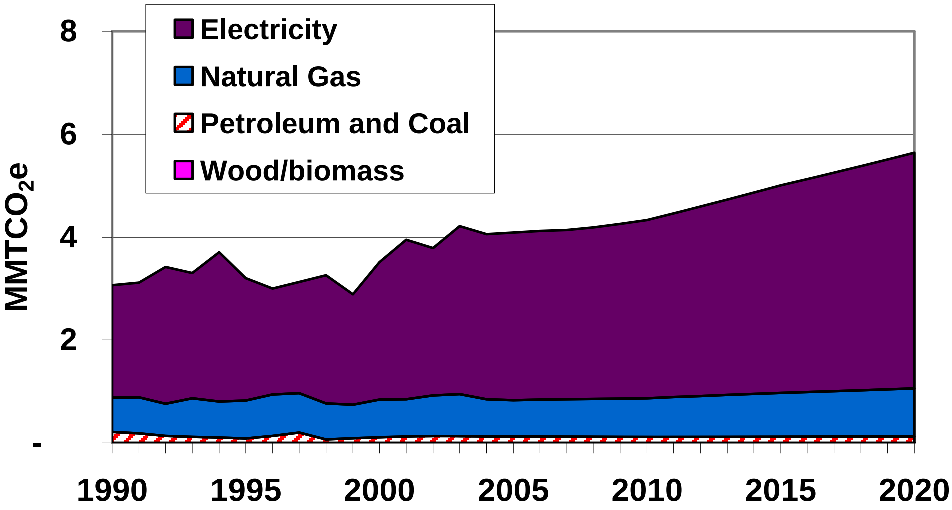


Figure B2. Commercial sctor GHG emissions from fuel consumption



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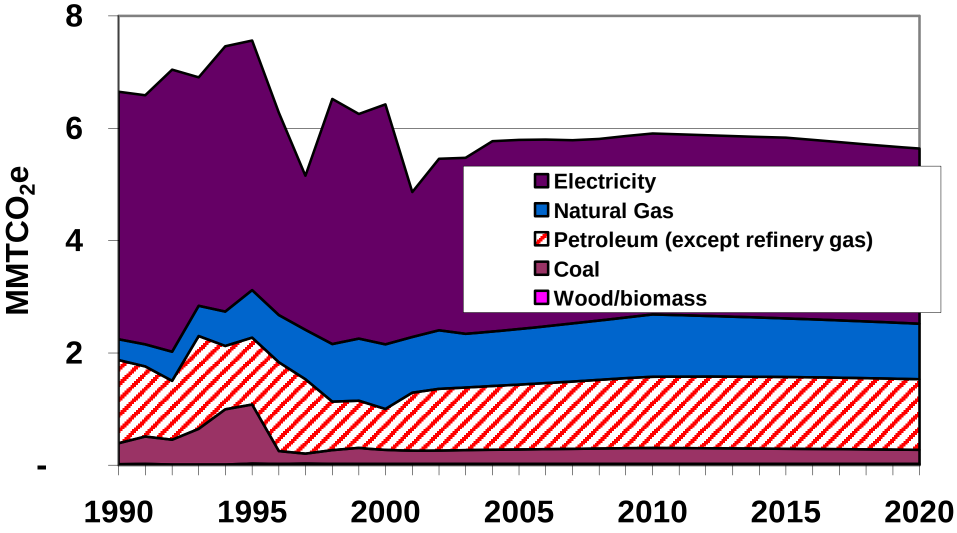
[34] These estimates of growth relative to population and employment reflect expected responses – as modeled by the EIA NEMS model -- to changing fuel and electricity prices and technologies, as well as structural changes within each sector (subsectoral shares, energy use patterns, etc.).

Figure B3. Industrial sector GHG emissions from fuel consumption



Key sources of uncertainty underlying the estimates are as follows:

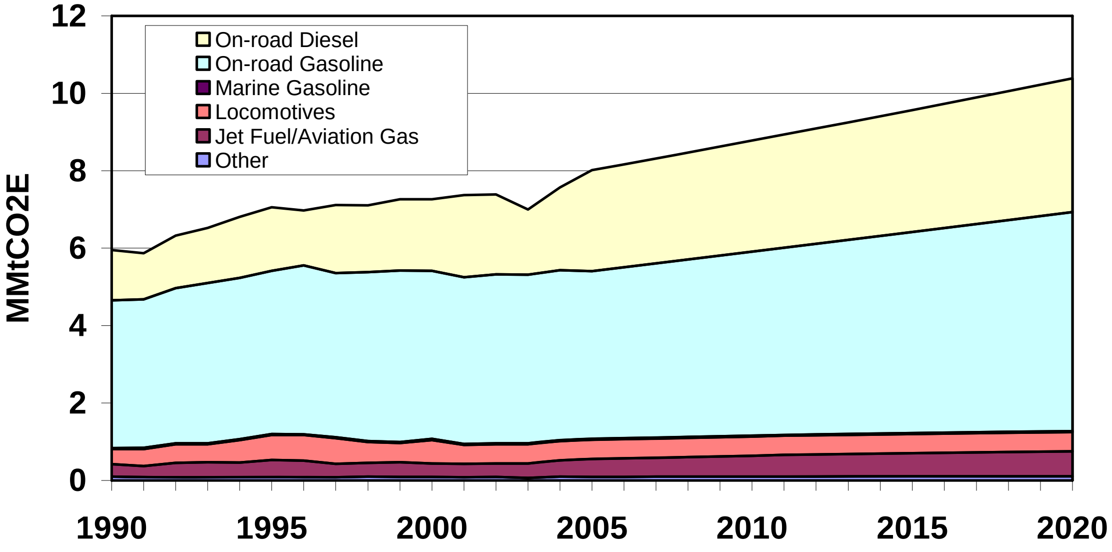
- Population and economic growth are the principal drivers for electricity and fuel use and are subject to significant uncertainties.
- The projections assume no large long-term changes in relative fuel and electricity prices, as compared with current levels and U.S. DOE projections. Price changes would influence consumption levels and encourage switching among fuels.
- It is assumed that energy consumed at military bases and national laboratories are included in the energy statistics from the EIA. However, under-reporting may have occurred, and estimating that impact is beyond the scope of this effort.
- Growth of major industries – the energy consumption projections assume no new large energy-consuming facilities and no major changes in mining activity. A few large new facilities – or the decline of major industries – could significantly impact energy consumption and subsequent emissions.

Appendix C. Transportation Energy Use

The transportation sector is a major source of GHG emissions in Montana – accounting for about 21% of Montana's gross GHG emissions in 2005. Carbon dioxide accounted for about 95% of transportation GHG emissions from fuel use in 1990 and increases to about 97% of transportation GHG emissions from fuel use by 2020. The proportion of CO_2 increases from 1990 to 2020 because of the increasing number of vehicles with advanced control technologies that reduce CH_4 and N_2O. Most of the remaining GHG emissions from the transportation sector are due to N_2O emissions from gasoline engines.

As shown in Figure C1, gasoline consumption accounts for the largest share of transportation GHG emissions. This category includes both onroad and marine gasoline; although, only a small fraction (less than 1%) of the total is marine gasoline. Emissions from gasoline vehicles increased by about 13% from 1990 – 2005 to cover 54% of total transportation emissions in 2005. GHG emissions from diesel fuel consumption increased significantly more than gasoline emissions – an overall increase of 84% from 1990 to 2005, with a couple dips such as in 2003 when emissions dropped by 15%, compared to the previous year, followed by a 21% increase from 2003 to 2004. By 2005 diesel consumption accounted for nearly 39% of GHG emissions from the transportation sector. Air travel fuel consumption and emissions grew by 44% between 1990 and 2005, with much of the increase occurring between 2001 and 2005. Combustion of natural gas and LPG and oxidation of lubricants accounted for only about 1% of transportation emissions in 2005.

Figure C1. Transportation GHG emissions by fuel, 1990-2020



GHG emissions from transportation are expected continue these growth trends over the next 15 years due to increased demand for current modes of transportation and alternative fuels such as natural gas. Vehicle miles traveled (VMT) projections supplied by the Montana Department of Transportation (MDT) suggest that VMT for road vehicles will grow at a rate of 1.92% per year between 2005 and 2020.[35] These VMT projections combined with vehicle fuel efficiency projections from EIA's *Annual Energy Outlook* (AEO), which account for technology changes, fuel prices, and legislation, yield an average growth rate of about 1.8% per year in gasoline consumption and 1.9% for diesel between 2006 and 2020.

These assumptions combine to project a 75% increase in GHG emissions from the transportation sector from 1990 to 2020. GHG emissions from diesel consumption are expected to increase from 1.7 $MMtCO_2e$ in 1990 to 3.9 $MMtCO_2e$ in 2020, while GHG emissions associated with air travel are expected to double during this time period. There is strong historical and projected growth in natural gas vehicle fuel consumption; however, the overall consumption of this fuel is small compared to other fuels. While gasoline emissions still account for the greatest share of the transportation emissions in 2020, the share of these emissions shrinks from 65% in 1990 to 55% in 2020, with the increased rate of diesel emissions accounting for the decreased share of onroad gasoline emissions. The high overall growth in transportation sector emissions suggests many opportunities and challenges for reducing Montana's GHG emissions.

The EPA SGIT was used to prepare the inventory and reference case projections. For onroad vehicles, the CO_2 emission factor is in units of lb/MMBtu and the CH_4 and N_2O emission factors are both in units of grams/VMT. Key assumptions in this analysis are listed in Table C1. The default data within SGIT were used (with the exception of natural gas) to estimate emissions, with the most recently available fuel consumption data (2005) from EIA SED, 2002 VMT estimates from FHWA's Highway Statistics, and estimates of 2002-2004 natural gas consumption from EIA's Natural Gas Navigator added.[36,37,38] For natural gas, the default data includes pipeline fuel. For this inventory, pipeline fuel is included in the natural gas transmission category; therefore, this data was replaced by the consumption for vehicle fuel only.

Fuel consumption data from EIA includes nonroad gasoline and diesel fuel consumption with commercial and industrial sectors. Therefore, nonroad emissions were included in the RCII emissions in this inventory (see Appendix B). Table C2 shows how EIA divides gasoline and diesel fuel consumption between the transportation, commercial, and industrial sectors.

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[35] Personal Communication. Lewison Lem, Strategic Consulting, reporting information provided by Bill Cloud, MDT.

[36] Energy Information Administration, State Energy Consumption, Price, and Expenditure Estimates (SEDS), http://www.eia.doe.gov/emeu/states/_seds.html

[37] Federal Highway Administration, Highway Statistics 2002, http://www.fhwa.dot.gov/policy/ohim/hs02/index.htm

[38] Energy Information Administration, http://tonto.eia.doe.gov/dnav/ng/ng_cons_sum_dcu_SMT_a.htm .

Table C1. Key assumptions and methods for the transportation inventory and projections

Vehicle Type and Pollutants	Methods
On-road gasoline, diesel, natural gas, and LPG vehicles – CO_2	**Inventory (1990 – 2005)** EPA SGIT and fuel consumption from EIA SED and EIA Natural Gas Navigator. **Reference Case Projections (2006 – 2020)** Transportation fuel consumption projections for the Mountain Region from EIA Annual Energy Outlook 2006.
On-road gasoline and diesel vehicles – CH_4 and N_2O	**Inventory (1990 – 2005)** The onroad vehicle CH_4 and N_2O emission factors by vehicle type and technology type were updated to the latest factors used in the U.S. EPA's *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2003.* VMT taken from FHWA's *Highway Statistics* was added for 2002. **Reference Case Projections (2006 – 2020)** The average annual growth rate for VMT is assumed to be 1.92% per year from 2002 to 2020, based on projections provided by the MDT to the Transportation Sector Technical Working Group of the Montana CCAC.
Non-highway fuel consumption (jet aircraft, gasoline-fueled piston aircraft, gasoline-fueled boats) – CO_2, CH_4 and N_2O	**Inventory (1990 – 2005)** EPA SGIT and fuel consumption from EIA SEDS. **Reference Case Projections (2006 – 2020)** Transportation fuel consumption projections for the Mountain Region from EIA Annual Energy Outlook 2006.

Table C2. EIA classification of gasoline and diesel consumption

Sector	Gasoline Consumption	Diesel Consumption
Transportation	Highway vehicles, marine	Vessel bunkering, military use, railroad, highway vehicles
Commercial	Public non-highway, miscellaneous use	Commercial use for space heating, water heat, and cooking
Industrial	Agricultural use, construction, industrial and commercial use	Industrial use, agricultural use, oil company use, off-highway vehicles

Key uncertainties

One uncertainty is the consumption of international bunker fuels included in jet fuel consumption from EIA. This fuel consumption associated with international air flights should not be included in the state inventory; however, data were not available to subtract this consumption from total jet fuel estimates. Another source of uncertainty is the lack of VMT data for alternative fuel vehicles. VMT for these vehicles are assumed to be included in the gasoline and diesel VMT estimates; therefore, CH_4 and N_2O emissions from these vehicles are included in the gasoline and diesel emission estimates. The CH_4 and N_2O emissions for these vehicles are small compared to the total emissions. Also, CH_4 and N_2O emission factors for these vehicles are similar to those of gasoline and diesel vehicles; therefore, the effect on the total emissions estimate is assumed to be small.

Another uncertainty is the contribution of out-of-state travel and non-residents to the estimates of Montana's transportation GHG emissions. Following guidelines from US EPA SGIT for state GHG emissions, the GHG emission estimates for Montana are based on energy consumption data from the US EIA. The EIA data reflect fuel sales in the state, rather than fuel consumption.

It is possible for vehicles to purchase fuel in Montana that is then consumed in a different state. Also out-of-state drivers will consume fuel while traveling in Montana. While the non-resident contribution is an uncertainty for any state GHG estimate, the affect may be relatively larger in Montana due to the large fraction of out-of-state travelers. For example, in the *2002 Nonresident All Year and Four Season Comparison: Visitor Profile*[39], the Institute for Travel and Recreational Research reports that nonresidents accounted for up to 46% of the traffic on one section of I-90. Data are not available to reliably determine the contribution of nonresident travelers to Montana's GHG emissions but future analysis could provide some rough estimates.

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[39] http://www.itrr.umt.edu/research/NonresSeason02.pdf

Appendix D. Industrial Processes

Emissions in this category span a wide range of activities, and reflect non-combustion sources of CO_2 from industrial manufacturing (cement, lime, and soda ash production plus emissions from limestone and dolomite use), the release of hydrofluorocarbons (HFCs) from cooling and refrigeration equipment, perfluorocarbons (PFCs) from aluminum production, and the release of sulfur hexafluoride (SF6) from electricity transformers.

Overall, industrial processes and related emissions, as shown in Figure D1, showed an overall decrease from 1990 though 2003 but are expected to continue to grow strongly through 2020. Note, that the total contribution to Montana's GHG emissions from this category remains quite small, less than 3% of total gross emissions. The contributions of each sub-category are shown in Figure D2 and explained below.

Figure D1. GHG emissions from industrial processes, 1990-2020

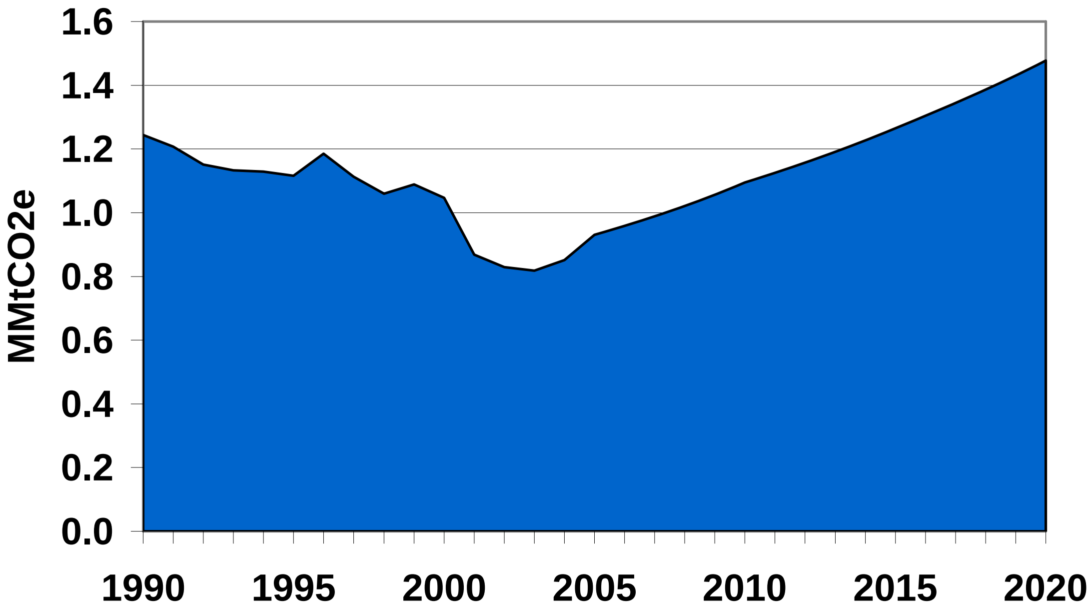
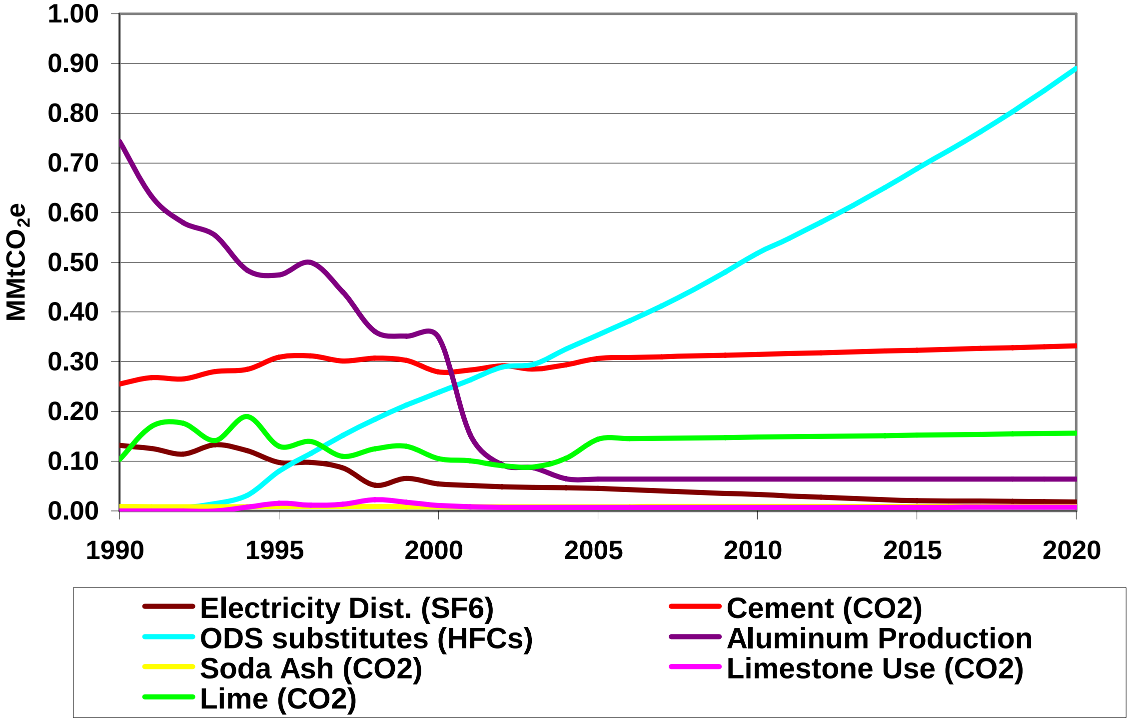


Figure D2. GHG emissions from industrial processes, 1990-2020, by source



Aluminum production generates two types of perfluorocarbons – tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6) – which are highly potent greenhouse gases. As shown in Figure D2, estimated GHG emissions from this source in Montana have shown significant ups and downs in the past, based partly on the variation in aluminum production and partly on changes to the manufacturing process that have led to lower GHG emissions.[40] High uncertainty exists with this data since the industry in Montana did not provide data on production or on GHG emissions per unit of production. Based on data from MDEQ and default values from SGIT, estimated GHG emissions from aluminum production decreased from about 0.75 MMtCO2e in 1990 to less than 0.1 MMtCO2e in 2005. The reference case projections assume that GHG emissions from this source will remain near 2005 levels through 2020.

Cement production emits CO_2 during the calcination process, whereby calcium carbonate ($CaCO_3$) is converted to calcium oxide (CaO). This process also requires significant energy consumption. Emissions related to fuel use at cement plants are reported in the RCI section above. The process emissions are directly related to the amount of clinker and masonry cement produced. For 1990-2005, GHG emissions are calculated as the production from this plant by a standard emission factor of 0.507 tons CO_2/ton clinker.[41] Cement production is projected to increase at the same rate as population.

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[40] Data on aluminum production was provided by MDEQ for 2002, 2003, 2004 and 2005. Production for other years and the GHG emissions rate per aluminum production are based on SGIT defaults.

[41] Annual production from the cement plants came from Eric Merchant, MDEQ based on information provided by cement manufacturers (Montana City and Holcim).

After 2005, emissions from HFCs in refrigeration and air conditioning equipment dominate the category and show strong growth through 2020. HFCs are being used to substitute for ozone-depleting substances (ODS), most notably CFCs (also potent warming gases) in compliance with the *Montreal Protocol*.[42] Even low amounts of HFC emissions, from leaks and other releases under normal use of the products, can lead to high GHG emissions. Emissions from the ODS substitutes in Montana are estimated to have increased from 0.0002 $MMtCO_2e$ in 1990 to 0.08 $MMtCO_2e$ in 2002, with further increases of 8% per year expected from 2005 to 2020. The estimates for the emissions in Montana are based on the state's population and estimates of emissions per capita from the U.S. EPA national GHG inventory.[43]

Emissions of SF_6 from electrical equipment have experienced declines since the early-nineties (see Figure D2), mostly due to voluntary action by industry. SF_6 is used as an electrical insulator and interrupter in the electricity transmission and distribution system. Emissions for Montana from 1990 to 2003 were estimated based on the estimates of emissions per kWh from the U.S. EPA GHG inventory (U.S. EPA 2005 *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2003*) and Montana's electricity consumption. The U.S. Climate Action Report[44] shows expected decreases in these emissions at the national level, and the same rate of decline is assumed for emissions in Montana. The decline in emissions in the future reflects expectations of future actions by the electric industry to reduce these emissions.

Emissions from lime manufacture production are based on the amounts of these products produced in Montana[45] multiplied by emissions factors from SGIT. Emissions from soda ash, limestone and dolomite use are estimated by the state consumption of the products for various uses – uses such as sorbants for flue gas desulphurization processes for electric power plants or industry and material for glass making will heat limestone to a sufficiently high temperature to cause release of CO_2 emissions.[46] The assumed trend is for these emissions to remain at 2002 levels through 2020.

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[42] ODS substitutes are primarily associated with refrigeration and air conditioning, but also many other uses such as fire extinguishers, solvent cleaning, aerosols, foam production ns for ODS substitutes depend on technology characteristics in a range of equipment. For the US national inventory, a detailed stock vintaging model was used, but such analysis has not been completed at the state level. This report uses the EPA SGIT procedure of estimating state-level emissions based on the state's fraction of US population and the US emissions. Growth rates are based on growth in projected national emissions from recent EPA report, US EPA 2004, *Analysis of Costs to Abate International ODS Substitute Emissions*, EPA 430-R-04-006. http://yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/RAMR62AS98/$File/IMAC%20Appendices%206-24.pdf

[44] U.S. Department of State, *U.S. Climate Action Report 2002*, Washington, D.C., May 2002. http://yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/SHSU5BNQ76/$File/ch5.pdf

[45] Lime production from Eric Merchant, MTDEQ based on information provided by Graymont Lime.

[46] Consumption data is from the United States Geological Survey (USGS).

Key Uncertainties

Since emissions from industrial processes are determined by the level of production and the production processes of a few key industries, there is relatively high uncertainty regarding future emissions. Future emissions depend on the competitiveness of Montana manufacturers, and the specific nature of their production processes.

The projected largest source of future industrial emissions, HFCs used in cooling applications, is subject to a number of uncertainties as well. First, historical emissions are based on national estimates for emission factors; Montana-specific estimates are currently unavailable. Second, emissions will be driven by future choices regarding air conditioning technologies and coolants used, for which a number of options currently exist.

Appendix E. Fossil Fuel Production Industry[47]

Greenhouse gas (GHG) emissions are released during the production, processing, transmission, distribution, and consumption of fossil fuels. This appendix reports GHGs emitted as a result of these activities, both combustion emissions from fuel consumption in the production, processing, and transport of fossil fuels,[48] as well as fugitive emissions from coal mining and oil and gas systems. Fugitive emissions are releases of methane (CH_4) and carbon dioxide (CO_2) gases released via leakage and venting at coal mines, oil and gas fields, processing facilities, and pipelines. Nationally, fugitive emissions from natural gas systems, petroleum systems, and coal mines accounted for 2.8% of total US GHG emissions in 2004 on a CO_2 equivalent basis.[49]

Industry Overview

Oil production in Montana peaked in 1968 at 49million barrels annually.[50] Montana currently ranks 10th in oil production among US states, accounting for about 1% of US crude oil production. Montana's proved crude oil reserves sit at 364 million barrels (bbls), 1% of US proved reserves. Montana has 4 petroleum refineries, with a combined crude oil distillation capacity of 66 million barrels annually.[51] Alberta crude oil is the primary crude oil source for these refineries: in recent years, Alberta has provided 75% for the crude oil processed by Montana refineries, with 4% coming from Montana and 21% from Wyoming.[52]

Montana currently produces more natural gas than it consumes. For example, in 2002, Montana produced 86 billion cubic feet (Bcf) and consumed 70 Bcf . Natural gas price increases since 2000 have resulted in increased Montana gas production. Coal bed methane has not yet become a significant source of natural gas production in the state, but is expected to play a larger role in the near future.[53] There is interest in coal-to-liquids development in Montana, as indicated by Governor Brian Schweitzer's October 2, 2006 announcement of plans for a coal-to-liquids plant near Roundup.[54] Still, any commercial scale coal-to-liquids production appears to be a number of years away.[55]

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[47] This category includes emissions from the production, processing and transmission of natural gas, oil and coal. Emissions are released due to energy consumption (mostly CO2) and methane release (venting or leaks) during processing and transmission.

[48] Note that any GHG emissions resulting from energy consumed in the mining of coal are excluded from this sector, due to lack of disaggregated data for this activity. Instead, these GHG emissions are aggregated within the emissions reported for the industrial sector (see Appendix B).

[49] "The US Inventory of Greenhouse Gas Emissions and Sinks", US EPA, 2005.

[50] "Understanding Energy in Montana", MDEQ Report for the EQC, October 2004, Accessed at http://www.leg.mt.gov/css/publications/lepo/2005_deq_energy_report/2005deqenergytoc.asp

[51] US DOE Energy Information Administration website.

[52] "Understanding Energy in Montana", DEQ Report for the EQC, October 2004.

[53] Understanding Energy in Montana", DEQ Report for the EQC, October 2004, Accessed at http://www.leg.mt.gov/css/publications/lepo/2005_deq_energy_report/2005deqenergytoc.asp

[54] On-line news sources – CBS, Reuters, Billings Gazette, etc. Accessed December 15, 2006.

[55] Montana Governor Brian Schweitzer Hot Topics Accessed at http://governor.mt.gov/hottopics/faqsynthetic.asp Accessed January 15, 2007.

Montana has six operational coal mines which produced 40 million short tons of coal in 2005.[56] Of Montana's six coal mines, one is underground, while five are surface mines.

Oil and Gas Industry Emissions

Emissions of carbon dioxide (CO_2) and methane (CH_4) occur at many stages of production, processing, transmission, and distribution of fossil fuels. With over 4,000 oil wells and over 5,000 gas wells in the state, 3 operational gas processing plants, 4 oil refineries, and over 10,000 miles of gas pipelines[57], there are significant uncertainties associated with estimates of the state's GHG emissions from the fossil fuels sector. This is compounded by the fact that there are no regulatory requirements to track CO_2 or methane emissions. As a result, greenhouse gas emissions can only be estimated based on industry-wide averages reported at the state level.

Fortunately, the State Greenhouse Gas Inventory Tool (SGIT) developed by the US EPA facilitates development of an estimate of state-level fugitive greenhouse gas emissions from gas and oil systems.[58] Methane emission estimates are calculated by multiplying emissions-related activity levels (e.g. miles of pipeline, number of compressor stations) by aggregate emission factors. Key information sources for the activity data are the EIA, Gas Facts, and Energize Montana. Methane emissions were estimated using SGIT, with reference to the EIIP guidance document.

Table E1 provides an overview of the required data and data sources used to calculate inventory estimates.

Coal Production Emissions

Methane occurs naturally in coal seams, and is typically vented during mining operations for safety reasons. Coal mine methane emissions are usually considerably higher, per unit of coal produced, from underground mining than from surface mining.

Methane emissions from coal mines in this inventory are as reported by the EPA, and include emissions from underground coal mines, surface mines, and post-mining activities.[59] As Montana currently has only one underground mine, coal mine methane emissions are a small contribution to total fossil fuel emissions. Note that any GHG emissions resulting from energy consumed in the mining of coal are excluded from this sector, due to lack of disaggregated data. Instead, these GHG emissions are aggregated within the emissions reported from the industrial sector (see Appendix B).

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[56] Energy Information Administration data.

[57] Data from the Energy Information Administration and the American Gas Association's annual publication "Gas Facts".

[58] Methane emissions were calculated using SGIT, with reference to Emission Inventory Improvement Program, Volume VIII: Chapter. 5. "Methods for Estimating Methane Emissions from Natural Gas and Oil Systems", March 2005.

[59] Emissions from EPA *Inventory of Greenhouse Gas Emissions and Sinks: 1990-2004* (April 2006) http://yosemite.epa.gov/OAR/globalwarming.nsf/UniqueKeyLookup/RAMR6MBLPF/$File/06upfront.pdf

Table E1. Approach to estimating historical carbon dioxide and methane emissions from natural gas and oil systems

	Approach to Estimating Historical Emissions	
Activity	***Required Data for SGIT***	***Data Source***
Natural Gas Drilling and Field Production	Number of wells	EIA
	Miles of gathering pipeline	Gas Facts[60]
Natural Gas Processing	Number of gas processing plants	EIA[61]
Natural Gas Transmission	Miles of transmission pipeline	Gas Facts
	Number of gas transmission compressor stations	EIIP[62]
	Number of gas storage compressor stations	EIIP[63]
	Number of LNG storage compressor stations	Unavailable, assumed negligible.
Natural Gas Distribution	Miles of distribution pipeline	Gas Facts
	Total number of services	Gas Facts
	Number of unprotected steel services	Ratio estimated from 2002 data[64]
	Number of protected steel services	Ratio estimated from 2002 data
Natural Gas Industry (fuel use)	Annual amount of energy consumed	EIA[65]
Coal Bed Methane – Entrained CO_2	Average % CO_2	Industry and Government Contacts
Oil Production	Annual production	EIA[66]
Oil Refining (fuel use)	Annual amount of energy consumed	EIA[67]
Oil Refining	Annual amount refined	EIA[68]
Oil Transport	Annual oil transported	Unavailable, assumed oil refined = oil transported

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[60] No Gas Facts available for 1991 and 1993, so a linear relationship was assumed to extrapolate from the previous and subsequent year.

[61] EIA reported data for 1995 and 2004.

[62] Number of gas transmission compressor stations = miles of transmission pipeline x 0.006 EIIP. Volume VIII: Chapter 5. March 2005.

[63] Number of gas storage compressor stations = miles of transmission pipeline x 0.0015 EIIP. Volume VIII: Chapter 5. March 2005.

[64] Gas Facts reported unprotected and protected steel services for 2002, but only total services for other years. Therefore the ratio of unprotected and protected steel services in 2002 was assumed to be the ratio for all other years (0.4891 for protected services and 0.0045 for unprotected services). This yields more congruent results than the EIIP guidance of using multipliers of 0.2841 total services for protected steel services, and 0.0879 for unprotected steel services.

[65] Energy Information Administration reports natural gas lease fuel, plant fuel, pipeline and distribution use, and refinery gas.

[66] Data extracted from the Petroleum Supply Annual for each year.

[67] Data on refinery gas consumption from EIA's State Energy Data.

[68] Refining assumed to be equal to the total input of crude oil into PADD IV times the ratio of Montana's refining capacity to PADD IV's total refining capacity. No data for 1995 and 1997, so linear relationship assumed from previous and subsequent years.

Future Fossil Fuel Industry Emissions

Estimating potential future GHG emissions from oil and gas systems and coal mining requires estimation of production, processing, and transport of these fossil fuels. Future projections of methane emissions from oil and gas systems are calculated based on two key drivers:

- Consumption – projections of natural gas consumption in Montana.
- Production – projected production of coal, natural gas, and oil, including unconventional sources, are included in the fossil fuel scenarios below.

Due to the high levels of uncertainty surrounding future fossil fuel activity in Montana, particularly around the development of 'unconventional' sources and the GHG emissions associated with these, two scenarios were developed for future fossil fuel emissions – the reference case and the high fossil fuel production scenario (these two cases were also developed for the electric sector). For each case, simple assumptions were made to develop projections for fossil fuel activities, relying to the extent possible on existing proposals and announcements regarding oil, gas, and coal projects in Montana.

Reference Case

Projected emissions for the reference case are generally based on an assumption of a continuation of recent trends in production and processing trends in the state, or on an assumption of emission levels holding flat at current levels (where trends are hard to discern or no new facilities are planned). Simple assumptions were made for activities with minimal impact on the inventory, such as gas processing and coal mine methane. Assumptions for the reference case projections are outlined in Table E2.

Table E2. Key assumptions and methods for reference case projections for Montana

Activity	***Key Assumptions***
Natural Gas Drilling and Field Production	Emissions follow trend of natural gas production, which continues to grow at 4.5% annually until 2010, then holds flat until 2020.[69]
Natural Gas Processing	With only 3 gas processing plants in the state (declining from 8 in 1995), gas processing emissions projected to hold flat until 2020.[70]
Natural Gas Transmission	Emissions continue to grow at an average of 0.5% annually.[71]
Natural Gas Distribution	Distribution emissions projected to follow growth in natural gas consumption, based on AEO regional projections.[72]

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[69] Assumption based on calculations from EIA data, supported by discussion in "Understanding Energy in Montana", DEQ Report for the EQC, October 2004, Accessed at http://www.leg.mt.gov/css/publications/lepo/2005_deq_energy_report/2005deqenergytoc.asp . Based on EIA data, marketed natural gas production averaged 4.5% growth annually between 1990 and 2005.

[70] Assumption based on EIA gas processing data. Historically, natural gas production, processing, and transmission have grown at differing rates; therefore, projected growth rates also differ.

[71] Natural gas transmission emissions grew at an average annual rate of 0.51% between 1990 and 2002.

Coal Bed Methane	Assumes very limited CBM activity (production system emissions accounted for in natural gas drilling and field production, above.) Entrained CO2 estimates assumed negligible given minimal CBM activity.
Oil Production	Emissions follow trend of state oil production, which is projected to grow at 5% annually until 2010, then hold flat until 2020.[73]
Oil Refining	Assumes little growth in state refining, emissions projected to hold flat at 2004 levels.
Oil Transport	Emissions follow trend of state oil refining, as above.
Coal Mining Methane	Emissions held flat at 2004 levels[74]
Coal-to-Liquids	Assumes no commercial production.

High Fossil Fuel Scenario

Unlike the reference case, the high fossil fuel scenario assumes that regional fossil fuel production and processing activities increase rapidly and that a number of unconventional oil, gas, and coal activities gain considerable traction over the next 15 years in the State. Renewed interest in a number of unconventional technologies is already apparent in response to concerns about energy security and high energy prices, along with increased activity in neighboring states and internationally.

This scenario assumes the following additional activities occur in Montana by 2020:

- Coal bed methane development begins in 2006 and proceeds fairly rapidly, based on estimates from the Montana Environmental Impact Statement.[75] In this scenario, total natural gas production triples between 2005 and 2010, and increases an additional 74% above 2010 levels by 2020.[76]
- Montana refining capacity increases, both through expansion of existing refineries and the addition of a new refinery, for refining of Athabasca crude from Alberta's oil sands.[77]
- Two new natural gas transmission lines cross the state.
- Two commercial coal-to-liquids plants are operating in Montana.

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[72] Assumption based on regional projections from the EIA's Annual Energy Outlook 2006 (AEO2006).

[73] Assumption based on "Understanding Energy in Montana", DEQ Report for the EQC, October 2004, Accessed at http://www.leg.mt.gov/css/publications/lepo/2005_deq_energy_report/2005deqenergytoc.asp and supported by Tom Richmond of the Montana Board of Oil and Gas.

[74] Note that coal mine methane emissions are a very small portion of total fossil fuel industry emissions.

[75] 'Final Statewide Oil and Gas Environmental Impact Statement and Proposed Amendment of the Powder River and Billings Resource Management Plans', January 2003, U.S Dept. of the Interior and the State of Montana. Assumes Year 1 in this document is 2005, as advised by Jeff Blend, MT DEQ, November 9, 2006.

[76] From 'Final Statewide Oil and Gas Environmental Impact Statement and Proposed Amendment of the Powder River and Billings Resource Management Plans'. CBM well projections (pg 4-117) and assumption that the average CBM production well in Montana produces 125,000 cubic feet per day, pg 4-111. Conventional natural gas projections outlined in Table E3.

[77] Additional oil production, beyond the growth projected in the reference case, was not included in the high fossil fuel scenario. It is possible that additional oil production could occur but the overall GHG emissions associated with the increased oil production in Montana are low compared with GHG emissions from increased oil refining, petroleum product consumption, or energy consumed in coal to liquids refining.

- Coal mining increases modestly with coal-to-liquids development in the State.

Table E3 outlines the key assumptions for the high fossil fuel case, both from conventional and unconventional sources.

Table E3. Key assumptions and methods for high fossil fuel scenario projections

Activity	*Key Assumptions and Methods*
Natural Gas Drilling and Field Production	Conventional natural gas increases at 6.5% annually until 2010, then holds flat (as in reference case) until 2020[78].
Natural Gas Processing	Emissions follow trend of conventional natural gas production, as above.[79]
Natural Gas Transmission	Assumes two new natural gas transmission lines cross the State, operational in 2012 and 2016.[80]
Natural Gas Distribution	*Same as reference case*.
Coal Bed Methane	Assumes CBM production growth as predicted in the Montana Environmental Impact Statement,[81] averaging almost 80% annual growth in the first five years, and slowing to about 6% average annual growth between 2012 and 2020. Note that levels of entrained CO_2 above pipeline specification in CBM wells has not been included[82]
Oil Production	*Same as reference case*[83]
Oil Refining	Assumes additional refining capacity of 50,000 bbl/day at existing refineries, and a new 100,000 bbl/day refinery,[84] for an average annual growth of 4.4% between 2005 and 2020.
Oil Transport	Emissions follow trend of state oil refining, as above.
Coal Mining Methane	Emissions hold flat at 2004 levels until startup of coal-to-liquids plants, as below.[85]

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[78] Personal communication with Paul Cartwright, MDEQ. January 8, 2007.

[79] While natural gas processing has been declining in recent years, increased production of conventional gas and coal bed methane will likely result in some increased gas processing in the state.

[80] E-mail communication with Jeff Blend, MDEQ, December 15th, 2006. Distance across Montana, north to south, estimated at 400 miles using google maps.

[81] 'Final Statewide Oil and Gas Environmental Impact Statement and Proposed Amendment of the Powder River and Billings Resource Management Plans', January 2003, U.S Dept. of the Interior and the State of Montana. Assumes Year 1 in this document is 2006, based on direction from Jeff Blend, MDEQ, November 9, 2006.

[82] Depending on entrained CO2 levels in Montana CBM, this could be a significant source of CO2.

[83] Personal communication with Paul Cartwright, MDEQ. January 8, 2007. Unless a new oil pipeline is projected for the State, there are no signals to indicate higher sustained oil production growth.

[84] Personal communication, Paul Cartwright, MDEQ, January 9, 2007.

[85] Based on coal-to-liquids data provided by Diane Kearney, EIA, using methodology described in D. Gray and G. Tomlinson, Coproduction: A Green Coal Technology, Technical Report MP 2000-28 (Mitretek, March 2001), a 22,000bbl/day CTL plant will require approximately 4 million short tons coal per year.

Coal-to-Liquids	Assumes first 22,000 bbl/day coal-to-liquids plant in 2015, second 22,000 bbl/day plant by 2020.[86]

Results – Reference Case

Table E4 displays the estimated methane emissions from the fossil fuel industry in Montana from 1990 to 2005, with reference case projections to 2020. Emissions from this sector grew by 40% from 1990 to 2005, and are projected to increase modestly, by a further 7%, between 2005 and 2020. The oil and natural gas industries are the largest contributors to fossil fuel greenhouse gas emissions in Montana currently. A trend that is further reflected in the reference case projections for Montana.

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[86] Coal-to-liquids plant capacity estimates and assumption that CTL development will have to be paired with some level of carbon capture and storage (likely enhanced oil recovery) based on input from Paul Cartwright, MDEQ, Jan 09 2007. Assumed 30% of CO2 is sequestered due to losses underground from enhanced oil recovery (Paul C, MDEQ), backed by IEA. 2004. *Prospects for* CO2 *Capture and Storage*, p. 81, which reports the proportion retained in EOR varying between 20%–67%. Greenhouse gas emissions intensity estimate provided by Diane Kearney at EIA. Model plant based on methodology described in D. Gray and G. Tomlinson, Coproduction: A Green Coal Technology, Technical Report MP 2000-28 (Mitretek, March 2001). Assumes 40% of emissions attributed to co-gen plant, thus not included in Appendix E. Note that any potential fugitive emissions from CTL are not included due to a lack of data.

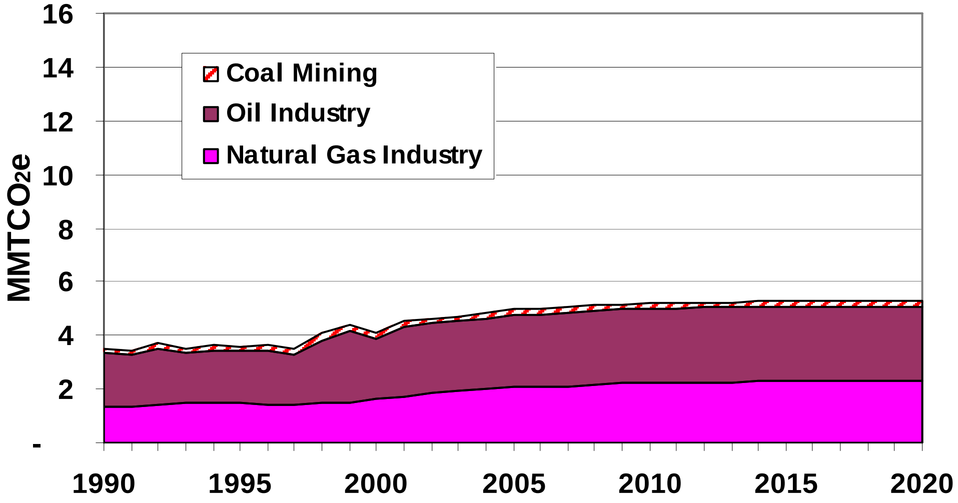
Table E4. GHG emissions and reference case projections for the fossil fuel industry in Montana

(Million Metric Tons CO_2e)	1990	2000	2005	2010	2015	2020
Fossil Fuel Industry	**3.5**	**4.1**	**5.0**	**5.2**	**5.3**	**5.3**
Natural Gas Industry	1.4	1.7	2.0	2.3	2.3	2.4
Total Fuel Use (CO_2)	0.2	0.6	0.7	0.8	0.8	0.8
Total Methane Emissions (CH_4)	1.1	1.1	1.3	1.5	1.5	1.6
Total Entrained (CO_2)	0.0	0.0	0.0	0.0	0.0	0.0
Production	0.3	0.4	0.7	0.8	0.8	0.8
Fuel Use (CO_2)	*0.1*	*0.1*	*0.2*	*0.3*	*0.3*	*0.3*
Methane Emissions (CH_4)	*0.2*	*0.3*	*0.4*	*0.5*	*0.5*	*0.5*
Processing	0.2	0.1	0.1	0.1	0.1	0.1
Fuel Use (CO_2)	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Methane Emissions (CH_4)	*0.2*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*
Entrained Gas (CO_2)	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Transmission	0.7	1.0	1.0	1.1	1.1	1.1
Fuel Use (CO_2)	*0.1*	*0.4*	*0.4*	*0.5*	*0.5*	*0.5*
Methane Emissions (CH_4)	*0.6*	*0.6*	*0.6*	*0.6*	*0.7*	*0.7*
Distribution	0.1	0.1	0.2	0.2	0.3	0.3
Methane Emissions (CH_4)	*0.1*	*0.1*	*0.2*	*0.2*	*0.3*	*0.3*
Oil Industry	2.0	2.2	2.7	2.8	2.8	2.8
Production	0.1	0.1	0.3	0.3	0.3	0.3
Methane Emissions (CH_4)	*0.1*	*0.1*	*0.3*	*0.3*	*0.3*	*0.3*
Refineries	1.8	2.1	2.4	2.4	2.4	2.4
Fuel Use (CO_2)	1.8	2.1	2.4	2.4	2.4	2.4
Methane Emissions (CH_4)	0.0	0.0	0.0	0.0	0.0	0.0
Coal-to-Liquids (CO_2)	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Coal Mining (CH_4)	0.2	0.2	0.2	0.2	0.2	0.2

Note that CH_4 in the above table refers to the type of emission e.g. fugitive methane emission. All values in the above table are reported as million metric tons carbon dioxide equivalent (CO_2e). Distribution fuel use is included with transmission fuel use. Oil production fuel use is included in industrial fuel use (Appendix B).

Figure E1 displays the reference case methane emissions from coal mining, and natural gas and oil production, processing, and transport in the state, on a CO_2 equivalency basis.

Figure E1. Fossil fuel industry reference case emission trends (Million metric tons CO2e)



Results – High Fossil Fuel Case

Table E5 displays the estimated greenhouse gas emissions for the high fossil fuel scenario for Montana. For the high fossil fuel scenario, representing fairly rapid fossil fuel development, GHG emissions are projected to increase by a further 216% from 2005 to 2020. In this scenario, increased refining production and coal-to-liquids development have the most dramatic impact on increasing GHG emissions for the state. Also significant are the projected GHG emissions from natural gas transmission and coal bed methane production.

Table E5. GHG emissions and high fossil fuel scenario projections for the Montana fossil fuel industry.

(Million Metric Tons CO$_2$e)	1990	2000	2005	2010	2015	2020
Fossil Fuel Industry	**3.5**	**4.1**	**5.0**	**6.1**	**11.7**	**15.7**
Natural Gas Industry	1.4	1.7	2.0	2.8	3.3	3.6
Total Fuel Use (CO$_2$)	0.2	0.6	0.7	0.8	0.8	0.9
Total Methane Emissions (CH$_4$)	1.1	1.1	1.3	2.0	2.5	2.7
Total Entrained (CO$_2$)	0.0	0.0	0.0	0.0	0.0	0.0
Production	0.3	0.4	0.7	1.4	1.8	1.9
Fuel Use (CO$_2$)	*0.1*	*0.1*	*0.2*	*0.3*	*0.3*	*0.3*
Methane Emissions (CH$_4$)	*0.2*	*0.3*	*0.4*	*1.1*	*1.5*	*1.6*
Processing	0.2	0.1	0.1	0.1	0.1	0.1
Fuel Use (CO$_2$)	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Methane Emissions (CH$_4$)	*0.2*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*
Entrained Gas (CO$_2$)	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Transmission	0.7	1.0	1.0	1.1	1.2	1.3
Fuel Use (CO$_2$)	*0.1*	*0.4*	*0.4*	*0.4*	*0.5*	*0.5*
Methane Emissions (CH$_4$)	*0.6*	*0.6*	*0.6*	*0.6*	*0.7*	*0.7*
Distribution	0.1	0.1	0.2	0.2	0.3	0.3
Methane Emissions (CH$_4$)	*0.1*	*0.1*	*0.2*	*0.2*	*0.3*	*0.3*
Oil Industry	2.0	2.2	2.7	3.1	4.4	4.4
Production	0.1	0.1	0.3	0.3	0.3	0.3
Methane Emissions (CH$_4$)	*0.1*	*0.1*	*0.3*	*0.3*	*0.3*	*0.3*
Refineries	1.8	2.1	2.4	2.8	4.1	4.1
Fuel Use (CO$_2$)	1.8	2.1	2.4	2.8	4.1	4.1
Methane Emissions (CH$_4$)	0.0	0.0	0.0	0.0	0.0	0.0
Coal-to-Liquids (CO$_2$)	0.0	0.0	0.0	0.0	3.7	7.3
Coal Mining (CH$_4$)	0.2	0.2	0.2	0.2	0.2	0.3

Note that CH$_4$ in the above table refers to the type of emission e.g. fugitive methane emission. All values in the above table are reported as million metric tons carbon dioxide equivalent (CO$_2$e). Distribution fuel use included with transmission fuel use. Oil production fuel use included in industrial fuel use (Appendix B).

Figure E2 displays the high fossil fuel case methane emissions from natural gas and oil production, processing, and transport, and coal mining in the state, on a CO_2 equivalency basis.

Figure E2. Fossil fuel industry high fossil fuel scenario emission trends (Million metric tons CO2e)

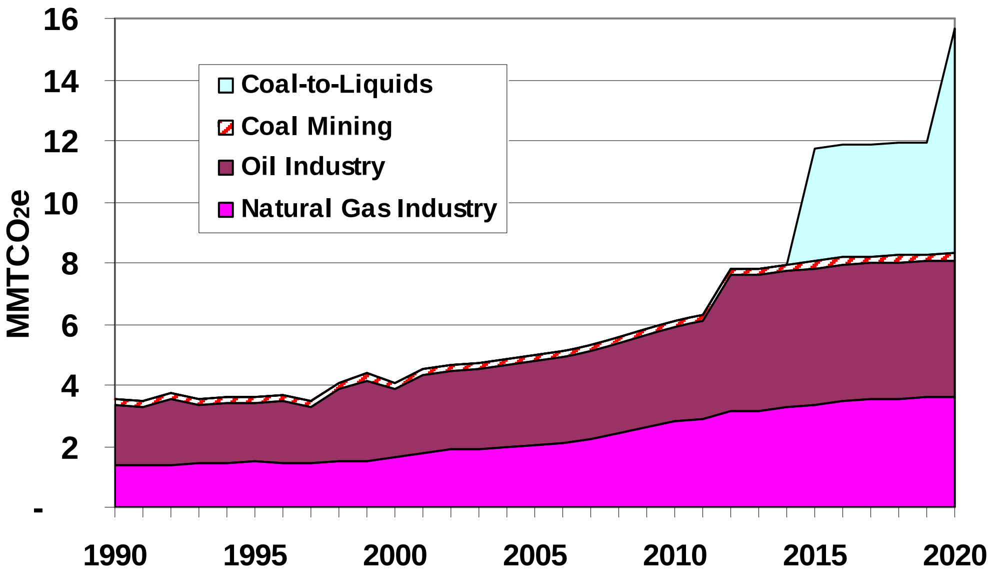


Table E6 presents a summary of GHG emissions from the Montana fossil fuel sector for both the reference case and the high fossil fuel scenario. The difference between the projected emissions in the reference case and the high fossil fuel scenario is a reflection of the uncertainty surrounding future energy developments in Montana. The projected growth between 2005 and 2020 is only 7% in the reference case and 216% in the high fossil fuel case, in which a number of unconventional technologies reach commercial scale production. Under the high fossil fuel scenario, GHG emissions in 2020 are 10 MMtCO2e higher than in the reference case, adding approximately 19% to the state's production-based emissions in that year.

Table E6. Comparison of total fossil fuel industry GHG emissions for reference and high fossil fuel scenario

(Million Metric Tons CO2e)	1990	2000	2005	2010	2015	2020
Reference Case	**3.5**	**4.1**	**5.0**	**5.2**	**5.3**	**5.3**
Natural Gas Industry	1.4	1.7	2.0	2.3	2.3	2.4
Oil Industry	2.0	2.2	2.7	2.8	2.8	2.8
Coal-to-Liquids	n/a	n/a	n/a	n/a	n/a	n/a
Coal Mining	0.2	0.2	0.2	0.2	0.2	0.2
High Fossil Fuel Scenario	**3.5**	**4.1**	**5.0**	**6.2**	**11.7**	**15.7**
Natural Gas Industry	1.4	1.7	2.0	2.9	3.4	3.6
Oil Industry	2.0	2.2	2.7	3.1	4.4	4.4
Coal-to-Liquids	0.0	0.0	0.0	0.0	3.7	7.3
Coal Mining	0.2	0.2	0.2	0.2	0.2	0.3

Key Uncertainties

Key sources of uncertainty underlying the estimates of historic emissions and both future scenarios are as follows:

- Projections of future production of fossil fuels. These industries are difficult to forecast with the mix of drivers: economics, resource supply, demand, and regulatory procedures. Large price swings, resource limitations, or changes in regulations could significantly affect technological innovation, future production levels, and the associated GHG emissions.
- Current levels of fugitive emissions. These are based on industry-wide averages, and until estimates are available for local facilities significant uncertainties remain.
- Other uncertainties include the fraction of entrained CO_2 in projected CBM production, the actual emissions intensity of any coal-to-liquids production, and potential emission reduction improvements to production, processing, and pipeline technologies.
- In addition, any oil pipeline constraints and/or potential oil pipeline projects which would impact oil transmission pipeline capacity have not been considered.

Appendix F. Agriculture

The emissions discussed in this appendix refer to non-energy emissions and sinks from agricultural practices. Energy emissions (fossil fuel combustion in agricultural equipment) are included in the RCI sector estimates. The agricultural emissions here include emissions from livestock, agricultural soil management and field burning.

Emissions Data and Methods

Agricultural emissions include CH_4 and N_2O emissions from enteric fermentation, manure management, agricultural soils and crop residue burning. Emissions were estimated with the use of EPA's SGIT. Data on crops and animals in the state from 1990 to 2002 from the USDA National Agriculture Statistical Service are incorporated as defaults within SGIT. Newer information from NASS on cattle populations (up to 2005) were incorporated into SGIT, as these are one of the primary drivers of GHG emissions in the agricultural sector. However, these newer data had little effect on the estimated emissions.

State-specific crop residue burning data were also investigated. In Montana, the only crop residue known to be burned is irrigated wheat. The default acreage burned in SGIT is 3%. Data from a WRAP-sponsored study suggest that only 1% of wheat residue is burned.[87] Other than cattle, activity data for all other crop and livestock sectors were held constant from 2002 – 2005.

Data and Methods for Soil Carbon Sinks

Carbon dioxide is either emitted or sequestered as a result of agricultural practices. Net carbon fluxes from agricultural soils have been estimated by researchers at the Natural Resources Ecology Laboratory at Colorado State University and are reported in the U.S. Inventory of Greenhouse Gas Emissions and Sinks[88] and the U.S. Agriculture and Forestry Greenhouse Gas Inventory. The estimates are based on the IPCC methodology for soil carbon adapted to conditions in the U.S. Preliminary state-level estimates of CO_2 fluxes from mineral soils and emissions from the cultivation of organic soils were reported in the U.S. Agriculture and Forestry Greenhouse Gas Inventory.[7] Currently, these are the best available data at the state-level for this category. The inventory did not report state-level estimates of CO_2 emissions from limestone and dolomite applications; hence, this source is not included in this inventory at present.

Carbon dioxide fluxes resulting from specific management practices were reported. These practices include: conversions of cropland resulting in either higher or lower soil carbon levels; additions of manure; participation in the Federal Conservation Reserve Program (CRP); and cultivation of organic soils (with high organic carbon levels). For Montana, Table F1 below shows a summary of the latest estimates available from the USDA.[89] The latest data available are

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[87] *Non-Burning Management Alternatives on Agricultural Lands in the Western United States, Volume I: Agricultural Crop Production and Residue Burning in the Western United States*, Eastern Research Group, 2002.

[88] U.S. Inventory of Greenhouse Gas Emissions and Sinks: 1990-2004 (and earlier editions), U.S. Environmental Protection Agency, Report # 430-R-06-002, April 2006. Available at: http://www.epa.gov/climatechange/emissions/usinventoryreport.html.

[89] U.S. Agriculture and Forestry Greenhouse Gas Inventory: 1990-2001. Global Change Program Office, Office of the Chief Economist, U.S. Department of Agriculture. Technical Bulletin No. 1907. 164 pp. March 2004. http://www.usda.gov/oce/global_change/gg_inventory.htm; the data are in Appendix B table B-11. The table

for 1997 agricultural practices. These data show that changes in agricultural practices are estimated to result in a net sink of 2.3 $MMtCO_2e$/yr in Montana. Since data are not yet available from USDA to make a determination of whether the emissions are increasing or decreasing, the net sink of 2.3 $MMtCO_2e$/yr is assumed to remain constant.

Table F1. GHG emissions from soil carbon changes due to cultivation practices (MMtCO2e)

Changes in cropland			**Changes in Hayland**				**Other**			**Total**[4]
Plowout of grassland to annual cropland[1]	Cropland manage-ment	Other cropland[2]	Cropland converted to hayland[3]	Hayland manage-ment	Cropland converted to grazing land[3]	Grazing land manage-ment	CRP	Manure application	Cultivation of organic soils	Net soil carbon emissions
1.91	(0.59)	0.00	(1.28)	(0.07)	(0.48)	0.00	(1.80)	(0.08)	0.11	(2.30)

Based on USDA 1997 estimates. Parentheses indicate net sequestration.

[1] Losses from annual cropping systems due to plow-out of pastures, rangeland, hayland, set-aside lands, and perennial/horticultural cropland (annual cropping systems on mineral soils, e.g., corn, soybean, cotton, and wheat).

[2] Perennial/horticultural cropland and rice cultivation.

[3] Gains in soil carbon sequestration due to land conversions from annual cropland into hay or grazing land.

[4] Total does not include change in soil organic carbon storage on federal lands, including those that were previously under private ownership, and does not include carbon storage due to sewage sludge applications.

Historic Emissions and Projections

As shown in Figure F1, emissions from agricultural sources remain fairly stable from 1990 through 2020. Historically, total emissions for the sector have ranged from about 8 to 10 $MMtCO_2e$. Except for emissions from agricultural soils, emissions in each subsector were fairly static. For agricultural soils, emissions grew through the mid-1990's, but then have begun to fall since the late 1990's. Emissions from agricultural soils are N_2O emissions from the use of synthetic fertilizers, crop residue, nitrogen fixing crops, and manure application. Manure application is the largest contributor to the emissions from agricultural soils. There was no rice cultivation in Montana and therefore, no CH_4 and N_2O emissions from this sector.

No information was identified that suggested significant future changes in Montana agricultural practices or activity levels. Historical activity levels, based on USDA NASS data, do not show any significant positive or negative trends in Montana agricultural sectors. Therefore, emissions were held constant from 2005 – 2020.

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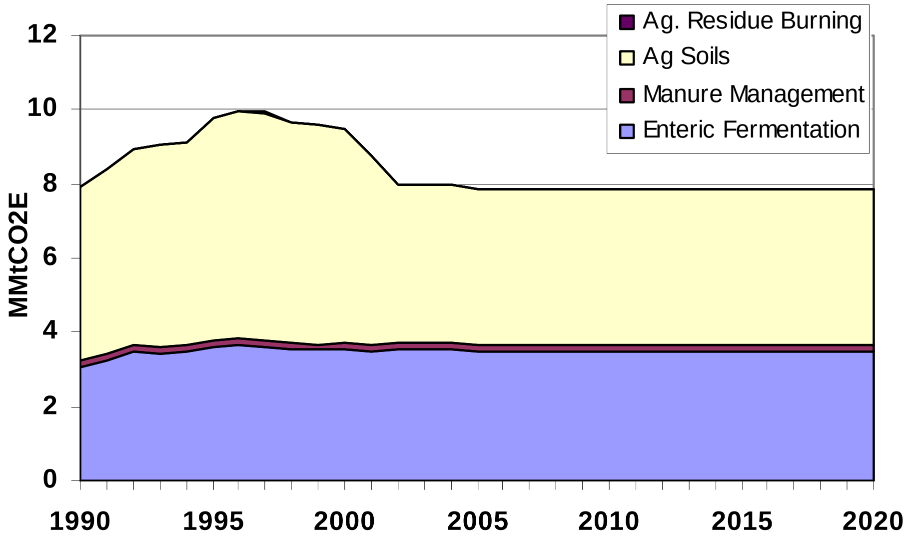
contains two separate IPCC categories: "carbon stock fluxes in mineral soils" and "cultivation of organic soils." The latter is shown in the second to last column of Table F1. The sum of the first nine columns is equivalent to the mineral soils category.

Figure F1. Gross GHG emissions from agriculture



Note: From 2005 forward, agricultural activity (and emissions) are held constant. Gross emissions exclude soil carbon sinks.

Appendix G. Waste Management

Overview

GHG emissions from waste management include:

- Solid waste landfills – CH_4 emissions from landfills and waste combustion, accounting for identified CH_4 that is flared or captured for energy production;

- Solid waste combustion – emissions of CO_2, CH_4 and N_2O from controlled waste combustion (e.g. in waste to energy plants) or uncontrolled combustion (e.g. residential open burning of solid waste) and

- Wastewater management – CH_4 and N_2O from municipal and industrial wastewater treatment facilities.

Inventory & Forecast

Solid Waste Landfills

For solid waste management, we used the U.S. EPA SGIT, the U.S. EPA LMOP landfills database,[90] and additional landfill data from MDEQ to estimate emissions.[91] The data from MDEQ on additional landfill sites, their years of operation, waste in place, and use of landfill gas controls covered 30 sites. Data were sufficient from 25 of these sites to develop the inputs needed to SGIT to estimate emissions. To obtain the annual disposal for each landfill needed by SGIT, the waste-in-place was divided by the number of years of operation. This average annual disposal rate for each landfill was assumed for all years that the landfill was operating.

CCS used SGIT to model emissions for two different sets of landfills: (1) uncontrolled landfills; and (2) landfills with a landfill gas collection system and control (e.g. flare, leachate evaporation system, or other combustion device). The following three sites made up the controlled landfill group: Flathead County; Bozeman; and Missoula. For each of these landfills, we assumed that the overall collection and control efficiency is 75%.[92] The remaining sites were placed into the uncontrolled landfills category. No waste in place data were available for the following five uncontrolled sites, and these were excluded from the modeling: City of Hardin; Coral Creek; Lake County; Town of Chester; and Park County.

CCS used the SGIT default for industrial landfills. This default is based on national data indicating that industrial landfilled waste is emplaced at approximately 7% of the rate of MSW emplacement. No controls were assumed for industrial waste landfilling.

Growth rates for the 2005-2020 time-frame were developed from the growth in emissions during the period from 1995-2005. This period was selected due to the changes that occurred in the solid waste industry from the mid-1980s thru the early 1990s as a result of new regulations

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[90] LMOP database is available at: http://www.epa.gov/lmop/proj/index.htm. Database downloaded June 2006.
[91] Rick Thompson, MDEQ, personal communications with S. Roe, CCS, June and August, 2006.
[92] As per EPA's AP-42 Section on Municipal Solid Waste Landfills: http://www.epa.gov/ttn/chief/ap42/ch02/final/c02s04.pdf.

covering the solid waste industry. For uncontrolled landfills, the growth rate based on the historical emissions data was 2.4%/yr. For controlled sites, the growth rate is also 2.4%. For industrial waste landfilling, the growth was 3.2%/yr.

Solid Waste Combustion
The only municipal waste combustion facility in Montana was closed in 2005. SGIT defaults data were used to estimate emissions. These data included waste combustion tonnages from 1990-1998. No waste combustion data were provided for the post-1999 period. Projected emissions are assumed to remain at zero.

No data were identified to estimate emissions from open burning of solid waste (e.g. residential burn barrels).

Municipal Wastewater Treatment
GHG emissions from municipal wastewater treatment were also estimated. Emissions are calculated in EPA's SGIT based on state population, assumed biochemical oxygen demand (BOD) and protein consumption per capita, and emission factors for N_2O and CH_4. The key SGIT default values are shown in Table G1 below. The growth factor used to project emissions from 2005 to 2020 was 1.26%/yr (based on emissions growth from 1990-2005), which is slightly higher than the state's population growth rate over the 1990 to 2005 period.

Industrial Wastewater Treatment
For industrial wastewater emissions, SGIT provides default assumptions and emission factors for three industrial sectors: fruits & vegetables, red meat & poultry, and pulp & paper. Production rates or wastewater flows for each of these three sectors are needed to estimate CH_4 emissions. There are no known fruit/vegetable processing facilities in the state.[93] CCS did not identify any other data on wastewater flows for use in assessing emissions from the pulp & paper or meat & poultry industries.

Table G1. SGIT key default values for municipal wastewater treatment

Variable	Value
BOD	0.065 kg /day-person
Amount of BOD anaerobically treated	16.25%
CH_4 emission factor	0.6 kg/kg BOD
Montana residents not on septic	75%
Water Treatment N2O emission factor	4.0 g N_20/person-yr
Biosolids Emission Factor	0.01 kg N_2O-N/kg sewage-N

Source: US EPA. *State Greenhouse Gas Inventory Tool.* Draft Guidance http://www.epa.gov/ttn/chief/eiip/techreport/volume08/

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[93] Bonnie Lovelace & Jeff May, MDEQ, personal communications with S. Roe, CCS, June 19-21, 2006.

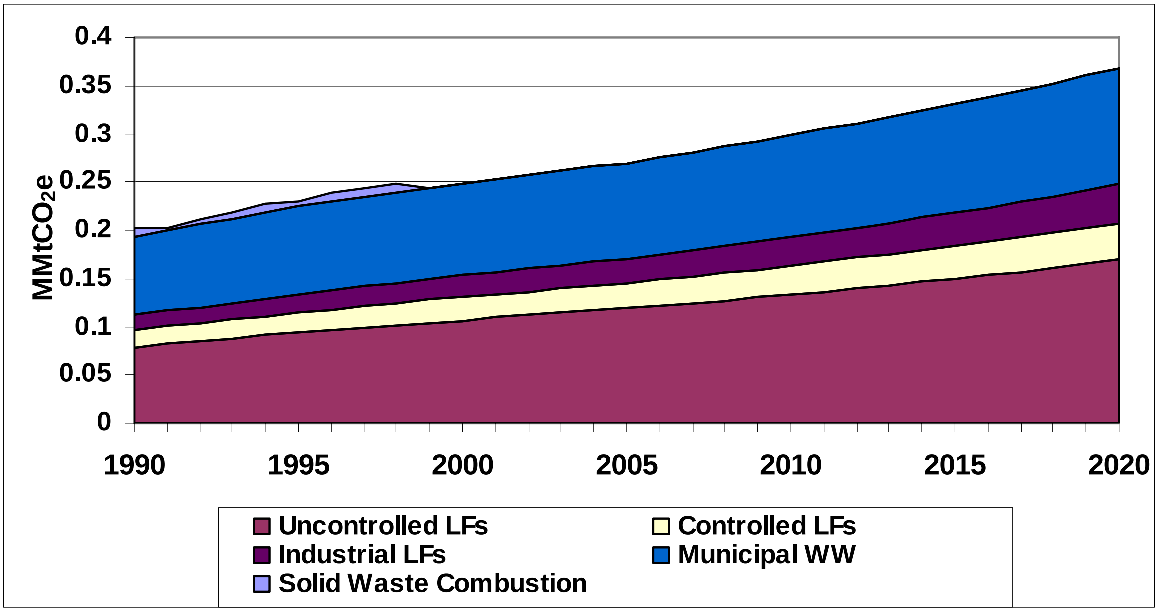
Results

Figure G1 shows the emission estimates for the waste management sector. Overall, the sector accounts for 0.27 $MMtCO_2e$ in 2005. Total sector emissions were estimated to be 0.20 $MMtCO_2e$ in 1990 and are estimated to grow to 0.37 $MMtCO_2e$ by 2020 under business as usual conditions.

For the reference case projections for MSW landfills, growth from the 2005 level was assumed to follow patterns in emissions growth at controlled and uncontrolled landfills between 1995 and 2005. Uncontrolled sites contributed 44% of the waste management sector emissions in 2005 (0.12 $MMtCO_2e$) and are projected to contribute 46% in 2020 (0.17 $MMtCO_2e$). Controlled sites contributed 10% of the waste management sector emissions in 2005 (0.03 $MMtCO_2e$), and the percent contributions are expected to remain the same in 2020 (0.04 $MMtCO_2e$). Industrial landfills contributed 9% in 2005 (0.03 $MMtCO_2e$), and this percentage contribution is expected to increase to 11% in 2020 (0.04 $MMtCO_2e$).

Emissions from municipal wastewater treatment were forecasted based on emissions growth from 1990-2005 (similar to population growth during this period). In 2005, municipal wastewater emissions were estimated to be 0.10 $MMtCO_2e$ (37% of waste management sector emissions) and are expected to grow to 0.12 $MMtCO_2e$ by 2020 (33% of waste management sector emissions). As mentioned above, no data were identified to estimate emissions from the industrial wastewater treatment sector.

Figure G1. Montana GHG emissions from waste management



Appendix H. Forestry

Overview

Forestland emissions refer to the net CO_2 flux[94] from forested lands in Montana, which account for about 24% of the state's land area.[95] The dominant forest type in Montana is Douglas Fir, which makes up about 32% of forested lands.[96] Other important forest types are Lodgepole Pine (22%), Fir-Spruce (21%), and Ponderosa Pine (13%).

Forestlands are net sinks of CO_2 in Montana. Through photosynthesis, carbon dioxide is taken up by trees and plants and converted to carbon in biomass within the forests. Carbon dioxide emissions occur from respiration in live trees and decay of dead biomass. In addition, carbon is stored for long time periods when forest biomass is harvested for use in durable wood products. CO_2 flux is the net balance of carbon dioxide removals from and emissions to the atmosphere from the processes described above.

Inventory and Reference Case Projections

For over a decade, the United State Forest Service (USFS) has been developing and refining a forest carbon modeling system for the purposes of estimating forest carbon inventories. The methodology is used to develop national forest CO_2 fluxes for the official US Inventory of Greenhouse Gas Emissions and Sinks.[97] The national estimates are compiled from state-level data. The Montana forest CO_2 flux data in this report come from the national analysis and are provided by the USFS.

The forest CO_2 flux methodology relies on input data in the form of plot level forest volume statistics from the Forest Inventory Analysis (FIA). FIA data on forest volumes are converted to values for ecosystem carbon stocks (i.e., the amount of carbon stored in forest carbon pools) using the FORCARB2 modeling system. Coefficients from FORCARB2 are applied to the plot level survey data to give estimates of C density (Mg per hectare) for a number of separate C pools.

CO_2 flux is estimated as the change in carbon mass for each carbon pool over a specified time frame. Forest volume data from at least two points in time are required. The change in carbon stocks between time intervals is estimated at the plot level for specific carbon pools (Live Tree, Standing Dead Wood, Under-story, Down & Dead Wood, Forest Floor, and Soil Organic Carbon) and divided by the number of years between inventory samples. Annual increases in carbon density reflect carbon sequestration in a specific pool; decreases in carbon density reveal

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[94] "Flux" refers to both emissions of CO_2 to the atmosphere and removal (sinks) of CO_2 from the atmosphere.

[95] Table 9 in "Montana's Forest Resources", USDA Forest Service, Resource Bulletin INT-81, September 1993, Conner, Roger C. and O'Brien, Renee A. There are a total of 22,400,000 acres of timberland and 91,000 acres of woodland in Montana. The same table shows Montana has a total land and water area of 94,109,000 acres.

[96] Based on data from the USFS: http://www.fs.fed.us/ne/global/pubs/books/epa/states/MT.htm.

[97] U.S. Inventory of Greenhouse Gas Emissions and Sinks: 1990-2004 (and earlier editions), US Environmental Protection Agency, Report # 430-R-06-002, April 2006. Available at: http://www.epa.gov/climatechange/emissions/usinventoryreport.html.

CO_2 emissions or carbon transfers out of that pool (e.g., death of a standing tree transfers carbon from the live tree to either the standing dead wood or down & dead pool). The amount of carbon in each pool is also influenced by changes in forest area (e.g. an increase in area could lead to an increase in the associated forest carbon pools and the estimated flux). The sum of carbon stock changes for all forest carbon pools yields a total net CO_2 flux for forest ecosystems.

In preparing these estimates, USFS estimates the amount of forest carbon in different forest types as well as different carbon pools. The different forests include those in the national forest system and those that are not federally-owned (private and other public forests). USFS also provides information on forests categorized as being either woodlands (forests with low productivity) and non-woodlands (e.g. timberlands or productive forest systems).

Carbon pool data for two periods are used to estimate CO_2 flux for each pool. The data shown in Table H1 are a summary of the FIA data used to derive the carbon pool and flux estimates that are summarized in Table H2. As shown in Table H1, the current forest carbon pool estimates are derived from 2004 FIA data. The previous inventory data came from a previous FIA cycle in 1989.

Table H1. Forestry data used to estimate forest CO2 flux

Forest	Current Inventory Source	Past Inventory Source	Avg. Year[1]	Interval[2] (yr)	Current Forest Area (10^3 hectares)	Previous Forest Area (10^3 hectares)
National Forests	FISDB21_MT_02_2005	FISDB21_MT_01_1989	2004.6	8.6	6,070	5,909
Non-Nat Forests	FISDB21_MT_02_2005	FISDB21_MT_01_1989	2004.6	15.6	4,053	3,488
				Totals	**10,123**	**9,397**

[1] Average year for the current FIA inventory data.
[2] The number of years between the current inventory source and the past inventory source (does not match database years).

The data in Table H1 show an increase of 726 kilo-hectares (1.8 million acres) in forested area during the period of analysis (1989-2004), which is approximately 115,000 acres per year. As mentioned under key uncertainties below, some of this difference is likely driven by methodological differences in survey methods between the two FIA cycles. Another forest grouping assessed by the USFS was the non-National Forests reserved forests (areas where no timber harvesting occurs). Because these areas were not well represented in the earlier FIA cycle, USFS suggested that CCS leave these out of the estimation of forest flux (essentially assuming that no net changes in carbon pools occurred in these areas). Hence, they are not shown in Table H1 and excluded from the flux estimates in Table H2. Additionally, discussions with USFS have indicated that the soil carbon pool estimates carry a high level of uncertainty and in many cases might not be statistically different than zero.[98] Although estimates are provided in Table H2 for organic soil carbon, these values are excluded from the totals in Table ES-1 and Table 1, at the start of the document.

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[98] Rich Birdsey, USFS, personal communication with CCS, May 2007.

Table H2 provides a summary of the size of the forest carbon pools for the final survey period and the resultant flux estimates (in units of C and CO_2) developed by the USFS. A total of 21 $MMtCO_2$ is estimated to be sequestered in Montana forests each year with most of this accumulating in the live tree and forest floor carbon pools. Note that this analysis averages out annual fluctuations in carbon sequestration rates over an approximate 9 year time interval in National Forests and 16 years in non-National Forest areas.

In addition to the forest carbon pools, additional carbon stored as biomass is removed from the forest for the production of durable wood products; carbon remains stored in the products pool or is transferred to landfills where much of the carbon remains stored over a long period of time. An estimated 2.5 $MMtCO_2e$ is sequestered annually in wood products; these data are based on the latest estimates from USFS.[99] Additional details on all of the forest carbon inventory methods can be found in Annex 3 to EPA's 2006 GHG inventory for the U.S.[100]

Table H2. Forestry CO2 flux estimates for Montana

Forest	Carbon Pool (MMt Carbon)					
	Live Tree	**Standing Dead**	**Under-story**	**Down & Dead**	**Forest Floor**	**Soil Organic**
National Forests	464	56	14	34	202	239
Non-National Forests	190	26	12	14	117	159
Totals	**654**	**82**	**26**	**48**	**318**	**398**

Forest	Carbon Pool Flux (MMt C/yr)					
	Live Tree	**Standing Dead**	**Under-story**	**Down & Dead**	**Forest Floor**	**Soil Organic**
National Forests	-2.63	-0.42	-0.06	-0.21	-1.07	-0.83
Non-National Forests	-0.02	-0.14	-0.17	-0.01	-0.91	-1.53
Totals	**-2.6**	**-0.56**	**-0.23**	**-0.22**	**-2.0**	**-2.4**

Forest	Carbon Pool Flux (MMt CO_2/yr)					
	Live Tree	**Standing Dead**	**Under-story**	**Down & Dead**	**Forest Floor**	**Soil Organic**
National Forests	-9.66	-1.53	-0.21	-0.78	-3.93	-3.06
Non-National Forests	0.06	-0.51	-0.62	-0.03	-3.35	-5.63
Totals	**-9.6**	**-2.04**	**-0.83**	**-0.81**	**-7.3**	**-8.7**

Total Forest Flux =	**-29.3**
Total Forest Flux = (excluding soil organic carbon)	**-20.6**
Harvested Wood Products =	**-2.5**
Total Statewide Flux = (excluding soil organic carbon)	**-23.1**

NOTE: Totals may not add exactly due to rounding.
USFS have indicated that the soil carbon pool estimates carry a high level of uncertainty

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[99] Data provided by Jim Smith, USFS, to CCS in December 2006.

[100] Annex 3 to EPA's 2006 report can be downloaded at: http://yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/RAMR6MBLNQ/$File/06_annex_Chapter3.pdf.

For the 1990 and 2000 historic emission estimates as well as the reference case projections, the annual forest carbon fluxes of forestlands were assumed to be at the same levels as those shown in Table H2. This assumes that the underlying increase in forest area continues into the future at a constant annual rate and that growth rates of existing forests also remain constant. This may overestimate the real future forestry sink, however there is no clear approach to adjusting the flux estimates. Also, it is unclear whether near term climate change (10-15 year) will impact the current flux estimates significantly. Hence, we have assumed no change in the estimated future sinks for 2010 and 2020.

In order to provide a more comprehensive understanding of GHG sources/sinks from the forestry sector, CCS also developed some rough estimates of state-wide emissions for methane and nitrous oxide from wildfires and prescribed burns. A study published earlier this year in *Science* indicated an increasing frequency of wildfire activity in the western U.S. driven by a longer fire season and higher temperatures.[101]

CCS used 2002 emissions data developed by the Western Regional Air Partnership (WRAP) to estimate CO_2e emissions for wildfires and prescribed burns.[102] The CO_2e from methane emissions from this study were added to an estimate of CO_2e for nitrous oxide to estimate a total CO_2e for fires (the carbon dioxide emissions from fires are captured within the carbon pool accounting methods described above). The nitrous oxide estimate was made assuming that N_2O was 1% of the emissions of nitrogen oxides (NO_x) from the WRAP study. The 1% estimate is a common rule of thumb for the N_2O content of NO_x from combustion sources.

The results for 2002 are that fires contributed about 0.21 $MMtCO_2$e of methane and nitrous oxide from about 190,000 acres burned. Over 90% of the CO_2e was contributed by CH_4. Note that this level of activity compares to a similar area burned in Montana in 1996 (186,000).[103] A comparison 2002 estimate was made using emission factors from a 2001 global biomass burning study[104] and the total tons of biomass burned from the 2002 WRAP fires emissions inventory. This estimate is nearly 0.26 $MMtCO_2$e with about equal contributions from methane and nitrous oxide on a CO_2e basis. Although not indicated by the estimates provided above for 1996 and 2002, there are large swings in fire activity from year to year. Because of this and the current lack of data for multiple years, CCS did not include these estimates in with the annual forestry flux estimates presented in the emissions summaries of this report. However, it appears that CH_4 and N_2O emissions from forest fires typically contribute less than 1 $MMtCO_2$e/yr in Montana.

Key Uncertainties

It is important to note that there were methodological differences in the two FIA cycles that can produce different estimates of forested area and carbon density. Recent FIA surveys are a result of an expanded focus in the FIA program, which historically was only concerned with timber

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[101] Westerling, A.L. et al, “Warming and Earlier Spring Increases Western U.S. Forest Wildfire Activity”, *Sciencexpress,* July 6, 2006.

[102] *2002 Fire Emission Inventory for the WRAP Region Phase I – Essential Documentation*, prepared by Air Sciences, Inc., June 2004.

[103] *1996 Fire Emission Inventory,* Draft Final Report, prepared by Air Sciences, Inc., December 2002.

[104] M. O. Andreae and P. Merlet, “Emission of trace gases and aerosols from biomass burning”, *Global Biogeochemical Cycles*, Vol. 15, No. 4, pp. 955-966, December 2001.

resources, while more recent surveys have aimed at a more comprehensive gathering of forest biomass data. In addition the FIA program has moved from a periodic to annual sampling design. These changes are believed to have resulted in more forest being sampled in recent years than in the past and direct comparison of old and new FIA datasets can show larger than real changes in forest areas in certain places. In addition, surveys since 1999 include all dead trees on the plots, but data prior to that are variable in terms of these data.

The effect of these changes in survey methods has not been systematically addressed by the USFS. The decision to exclude carbon fluxes on non-NF reserved lands in Montana was done in consultation with the USFS to account in part for this potential systematic error.

As stated in the previous section, emission estimates for methane and nitrous oxide from fires were left out of the statewide flux estimates due to a lack of data for years other than 1996 and 2002 (emissions of carbon dioxide from fires are captured in the carbon flux accounting methods used by the USFS). Based on the level of activity in 2002, these additional emissions are on the order of 0.2 $MMtCO_2e$/yr and would not have a significant impact on the overall flux estimates shown in Table H2.

We expect that there will be additional revisions to the USFS forest carbon estimated in the near future as new FIA data are made available. For Montana, the latest FIA subcycle shows about a half a million fewer forested acres than the previous subcycle. Hence, this could result in slightly lower carbon sequestration estimates in future revisions by the USFS. The difference in acreage appears to be due to the recent implementation of a change in the definition of forested area.[105] The old definition was based on a minimum of 5% forest crown cover (in order for an area to be considered a forest). The new definition is based on a minimum of 10% crown cover.

As mentioned above, CCS included the forestry estimates without the soil carbon pool in the emissions summary tables (see Tables ES-1 and Table 1) for this report, since the USFS has indicated a high level of uncertainty for this carbon pool. These uncertainties are likely to remain until additional data from measurements and potentially improved modeling methods are developed.

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[105] Larry Deblander, USFS, Ogden Research Station, personal communication with S. Roe, CCS, May 2007.

Appendix I. Inventory and Forecast for Black Carbon

This appendix summarizes the methods, data sources, and results of the development of an inventory and forecast for black carbon (BC) emissions in Montana. Black carbon is an aerosol (particulate matter) species with positive climate forcing potential but currently without a global warming potential defined by the IPCC (see Appendix J for more information on black carbon and other aerosol species). BC is synonymous with elemental carbon (EC), which is a term common to regional haze analysis. An inventory for 2002 was developed based on inventory data from the Western Regional Air Partnership (WRAP) regional planning organization[106] and other sources. This appendix describes these data and methods for transforming the mass emission estimates for BC into carbon dioxide equivalents (CO_2e) in order to present the emissions within a GHG context.

In addition to the particulate matter (PM) inventory data from WRAP, PM speciation data from EPA's SPECIATE database were also used: These data include PM fractions of elemental carbon (aka black carbon) and primary organic aerosols (aka organic material or OM). These data come from recent updates to EPA's SPECIATE database.[107] These new profiles have just recently been released by EPA. As will be further described below, both BC and OM emission estimates are needed to assess the CO_2e of black carbon emissions. While BC and OM emissions data are available from the WRAP regional haze inventories, CCS favored the newer speciation data available from EPA for the purposes of estimating BC and OM. In particular, better speciation data are now available from EPA for important BC emissions sources (e.g., fossil fuel combustion sources).

After assembling the BC and OM emission estimates, the mass emission rates were transformed into their CO_2e estimates using information from recent global climate modeling. This transformation is described in later sections below.

Development of BC and OM Mass Emission Estimates

The BC and OM mass emission estimates were derived by multiplying the particulate matter less than 2.5 microns ($PM_{2.5}$) emission estimates by the appropriate aerosol fraction for BC and OM. The aerosol fractions were taken from Pechan's ongoing work to update EPA's SPECIATE database.

After estimating both BC and OM emissions for each source category, we used the BC estimate as described below to estimate the CO_2e emissions. Also, as described further below, the OM emission estimate was used to determine whether the source was likely to have positive climate forcing potential. The mass emission results for 2002 are shown in Table 1 below.

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[106] Tom Moore, Western Regional Air Partnership, data files provided to Steve Roe, CCS, December 2006.
[107] Version 4.0 of the SPECIATE database and report: http://www.epa.gov/ttn/chief/software/speciate/index.html#related.

Development of CO_{2e} for BC+OM Emissions

We used similar methods to those applied previously in Connecticut for converting BC mass emissions to CO_2 equivalents.[108] These methods are based on the modeling of Jacobson (2002)[109] and his updates to this work (Jacobson, 2005a).[110] Jacobson (2005a) estimated a range of 90:1 to 190:1 for the climate response effects of BC+OM emissions as compared to CO_2 carbon emissions (depending on either a 30-year or 95-year atmospheric lifetime for CO_2). It is important to note that the BC+OM emissions used by Jacobson were based on a 2:1 ratio of OM:BC (his work in these papers focused on fossil fuel BC+OM; primarily diesel combustion, which has an OM:BC ratio of 2:1 or less).

For Maine and Connecticut, ENE (2004) applied climate response factors from the earlier Jacobson work (220 and 500) to the estimated BC mass to estimate the range of CO_2e associated with BC emissions. Note that the analysis in the northeast was limited to BC emissions from onroad diesel exhaust. An important oversight from this work is that the climate response factors developed by Jacobson (2002, 2005a) are on the basis of CO_2 carbon (not CO_2). Therefore, in order to express the BC emissions as CO_2e, the climate response factors should have been adjusted upward by a factor of 3.67 to account for the molecular weight of CO_2 to carbon (44/12).

For this inventory, we started with the 90 and 190 climate response factors adjusted to CO_2e factors of 330 and 697 to obtain a low and high estimate of CO_2e for each sector. An example calculation of the CO_2e emissions for 10 tons of $PM_{2.5}$ from onroad diesel exhaust follows:

BC mass = (10 tons $PM_{2.5}$) x (0.613 ton EC/ton $PM_{2.5}$) = 6.13 short tons BC

Low estimate CO_2e = (6.13 tons BC) (330 tons CO_2e/ton BC+OM) (3 tons BC+OM/ton BC) (0.907 metric ton/ton) = 5,504 metric tons CO_2e

High estimate CO_2e = (6.13 tons BC) (697 tons CO_2e/ton BC+OM) (3 tons BC+OM/ton BC) (0.907 metric ton/ton) = 11,626 metric tons CO_2e

NOTE: The factor 3 tons BC+OM/ton BC comes directly from the global modeling inputs used by Jacobson (2002, 2005a; i.e. 2 tons of OM/ton of BC).

For source categories that had an OM:BC mass emission ratio >4.0, we zeroed out these emission estimates from the CO_2e estimates. The reason for this is that the net heating effects of OM are not currently well understood (overall OM is thought to have a negative climate forcing effect or a net cooling effect). Therefore, for source categories where the PM is dominated by

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[108] ENE, 2004. Memorandum: “Diesel Black Carbon Calculations – Reductions and Baseline” from Michael Stoddard, Environment Northeast, prepared for the Connecticut Stakeholder Dialog, Transportation Work Group, October 23, 2003.

[109] Jacobson, 2002. Jacobson, M.Z., “Control of fossil-fuel particulate black carbon and organic matter, possibly the most effective method of slowing global warming”, *Journal of Geophysical Physical Research*, volume 107, No. D19, 4410, 2002.

[110] Jacobson, 2005a. Jacobson, M.Z., “Updates to ‘Control of fossil-fuel particulate black carbon and organic matter, possibly the most effective method of slowing global warming”, *Journal of Geophysical Research Atmospheres*, February 15, 2005.

OM (e.g. biomass burning), the net climate response associated with these emissions is highly uncertain and potentially have a negative climate forcing potential. Further, OM:BC ratios of 4 or more are well beyond the 2:1 ratio used by Jacobson in his work.

Results and Discussion

We estimate that BC mass emissions in Montana total about 2.6 MMtCO$_2$e in 2002. This is the mid-point of the estimated range of emissions. The estimated range is 1.7 – 3.5 MMtCO$_2$e (see Table I-1), which is roughly 5 to 10% of the estimated emissions for the six Kyoto gases. The primary contributing sectors in 2002 were nonroad diesel (31%), rail (29%), and onroad diesel (24%).

CCS expects that there will be a drop in the future BC emissions for the onroad and non-road diesel sectors due to new engine and fuels standards that will reduce particulate matter emissions. If data on projected emissions (2018) are available from the WRAP before this report is finalized, they will be incorporated for comparison to the 2002 emissions. Based on work conducted in other states, the onroad diesel will likely see the largest reductions. Another significant contributor to BC emissions in Montana is commercial/industrial wood-fired boilers, which make up a large fraction of the "non-electricity generating unit (EGU) other" emissions. Residential wood combustion is also included in this sector, however the OM:BC ratio is >4 so the emissions were not converted to CO$_2$e.

Wildfires and miscellaneous sources such as fugitive dust from paved and unpaved roads contributed a significant amount of particulate matter and subsequent BC and OM mass emissions (see Table I-1); however the OM:BC ratio is >4 for these sources, so the BC emissions were not converted to CO$_2$e.

CCS also performed an assessment of the primary BC contributing sectors from the 2018 WRAP forecast. A drop in the future BC emissions for the onroad and nonroad diesel sectors is expected due to new engine and fuels standards that will reduce particulate matter emissions. For the nonroad diesel sector the estimated 0.80 MMtCO$_2$e in 2002 drops to 0.78 MMtCO$_2$e in 2018. For the onroad diesel sector, 0.62 MMtCO$_2$e was estimated for 2002 dropping to 0.15 MMtCO$_2$e in 2018. Emissions from the rail sector rose only slightly in 2018 from the 2002 levels. No significant reductions are expected in the other emission sectors. The development of emission estimates for each of the smaller source sectors was beyond the scope of this analysis.

While the state of science in aerosol climate forcing is still developing, there is a good body of evidence supporting the net warming impacts of black carbon. Aerosols have a *direct* radiative forcing because they scatter and absorb solar and infrared radiation in the atmosphere. Aerosols also alter the formation and precipitation efficiency of liquid water, ice and mixed-phase clouds, thereby causing an *indirect* radiative forcing associated with these changes in cloud properties (IPCC, 2001).[111] There are also a number of other indirect radiative effects that have been modeled (e.g. Jacobson, 2002).

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[111] IPCC, 2001. Climate Change 2001: The Scientific Basis, Intergovernmental Panel on Climate Change, 2001.

The quantification of aerosol radiative forcing is more complex than the quantification of radiative forcing by greenhouse gases because of the direct and indirect radiative forcing, and the fact that aerosol mass and particle number concentrations are highly variable in space and time. This variability is largely due to the much shorter atmospheric lifetime of aerosols compared with the important greenhouse gases (i.e. CO_2). Spatially and temporally resolved information on the atmospheric burden and radiative properties of aerosols is needed to estimate radiative forcing.

The quantification of indirect radiative forcing by aerosols is especially difficult. In addition to the variability in aerosol concentrations, some quite complicated aerosol influences on cloud processes must be accurately modeled. For example, the warm (liquid water) cloud indirect forcing may be divided into two components. The first indirect forcing is associated with the change in droplet concentration caused by increases in aerosol cloud condensation nuclei. The second indirect forcing is associated with the change in precipitation efficiency that results from a change in droplet number concentration. Quantification of the latter forcing necessitates understanding of a change in cloud liquid-water content and cloud amount. In addition to warm clouds, ice clouds may also be affected by aerosols.

To put the radiative forcing potential of BC in context with $CO_{2,}$ the Intergovernmental Panel on Climate Change estimated the radiative forcing for a doubling of the earth's CO_2 concentration to be 3.7 watts per square meter (W/m^2). For BC, various estimates of current radiative forcing have ranged from 0.16 to 0.42 W/m^2 (IPCC, 2001). These BC estimates are for direct radiative effects only. There is a higher level of uncertainty associated with the direct radiative forcing estimates of BC compared to those of CO_2 and other GHGs. There are even higher uncertainties associated with the assessment of the indirect radiative forcing of aerosols.

Table I-1. 2002 BC emission estimates

Sector	Subsector	Mass Emissions			CO_2e		Contribution to CO2e
		BC	OM	BC + OM	Low	High	
		Metric Tons			Metric Tons		
Electric Generating Units (EGUs)							
	Coal	26	37	62	25,380	53,605	1.5%
	Oil	0	0	0	0	0	0.0%
	Gas	0	0	0	0	0	0.0%
	Other	0	4	4	0	0	0.0%
Non-EGU Fuel Combustion (Residential,Commercial, and Industrial)							
	Coal	24	35	59	24,230	51,176	1.5%
	Oil	12	10	22	12,098	25,552	0.7%
	Gas	0	117	117	0	0	0.0%
	Other[a]	557	2,254	2,812	146,366	309,142	8.8%
Onroad Gasoline (Exhaust, Brake Wear, & Tire Wear)		62	251	313	19,414	41,004	1.2%
Onroad Diesel (Exhaust, Brake Wear, & Tire Wear)		444	186	631	395,855	836,093	23.7%
Aircraft		20	52	71	19,547	41,286	1.2%
Railroad[b]		482	158	640	477,446	1,008,424	28.6%
Other Energy Use							
	Nonroad Gas	16	45	62	15,952	33,693	1.0%
	Nonroad Diesel	519	170	689	513,844	1,085,301	30.8%
	Other Combustion[c]	0	4	4	0	0	0.0%
Industrial Processes		73	841	914	18,913	39,946	1.1%
Agriculture[d]		305	5,230	5,534	0	0	0.0%
Waste Management							0.0%
	Landfills	0	4	4	0	0	0.0%
	Incineration	0	0	0	283	598	0.0%
	Open Burning	110	1,413	1,523	0	0	0.0%
	Other	0	0	0	0	0	0.0%
Wildfires/Prescribed Burns		1,561	11,550	13,111	0	0	0.0%
Miscellaneous[e]		2,164	35,104	37,268	0	0	0.0%
Total		**6,377**	**57,464**	**63,842**	**1,669,327**	**3,525,821**	**100%**

[a] Primarily wood-fired commercial/industrial boilers with some large diesel engines.
[b] Railroad includes Locomotives and Railroad Equipment Emissions.
[c] Other Combustion includes Motor Vehicle Fire, Structure Fire, and Aircraft/Rocket Engine Fire & Testing Emissions.
[d] Agriculture includes Agricultural Burning, Agriculture/Forestry and Agriculture, Food, & Kindred Spirits Emissions.
[e] Miscellaneous includes Paved/Unpaved Roads and Catastrophic/Accidental Release Emissions.

Appendix J. Greenhouse Gases and Global Warming Potential Values: Excerpts from the *Inventory of U.S. Greenhouse Emissions and Sinks: 1990-2000*

Original Reference: Material for this Appendix is taken from the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 - 2000*, U.S. Environmental Protection Agency, Office of Atmospheric Programs, EPA 430-R-02-003, April 2002 (http://epa.gov/climatechange/emissions/usinventoryreport.html). Michael Gillenwater directed the preparation of this appendix.

Introduction

The *Inventory of U.S. Greenhouse Gas Emissions and Sinks* presents estimates by the United States government of U.S. anthropogenic greenhouse gas emissions and removals for the years 1990 through 2000. The estimates are presented on both a full molecular mass basis and on a Global Warming Potential (GWP) weighted basis in order to show the relative contribution of each gas to global average radiative forcing.

The Intergovernmental Panel on Climate Change (IPCC) has recently updated the specific global warming potentials for most greenhouse gases in their Third Assessment Report (TAR, IPCC 2001). Although the GWPs have been updated, estimates of emissions presented in the U.S. *Inventory* continue to use the GWPs from the Second Assessment Report (SAR). The guidelines under which the *Inventory* is developed, the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC/UNEP/OECD/IEA 1997) and the United Nations Framework Convention on Climate Change (UNFCCC) reporting guidelines for national inventories[112] were developed prior to the publication of the TAR. Therefore, to comply with international reporting standards under the UNFCCC, official emission estimates are reported by the United States using SAR GWP values. This excerpt of the U.S. *Inventory* addresses in detail the differences between emission estimates using these two sets of GWPs. Overall, these revisions to GWP values do not have a significant effect on U.S. emission trends.

Additional discussion on emission trends for the United States can be found in the complete Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2000.

What is Climate Change?

Climate change refers to long-term fluctuations in temperature, precipitation, wind, and other elements of the Earth's climate system. Natural processes such as solar-irradiance variations, variations in the Earth's orbital parameters, and volcanic activity can produce variations in climate. The climate system can also be influenced by changes in the concentration of various gases in the atmosphere, which affect the Earth's absorption of radiation.

The Earth naturally absorbs and reflects incoming solar radiation and emits longer wavelength terrestrial (thermal) radiation back into space. On average, the absorbed solar radiation is balanced by the outgoing terrestrial radiation emitted to space. A portion of this terrestrial radiation, though, is itself absorbed by gases in the atmosphere. The energy from this absorbed terrestrial radiation warms the Earth's surface and atmosphere, creating what is known as the "natural greenhouse effect." Without the natural heat-trapping properties of these atmospheric gases, the average surface temperature of the Earth would be about 33°C lower (IPCC 2001).

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[112] See FCCC/CP/1999/7 at www.unfccc.de.

Under the UNFCCC, the definition of climate change is “a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.” Given that definition, in its Second Assessment Report of the science of climate change, the IPCC concluded that:

> *Human activities are changing the atmospheric concentrations and distributions of greenhouse gases and aerosols. These changes can produce a radiative forcing by changing either the reflection or absorption of solar radiation, or the emission and absorption of terrestrial radiation (IPCC 1996).*

Building on that conclusion, the more recent IPCC Third Assessment Report asserts that “[c]oncentrations of atmospheric greenhouse gases and their radiative forcing have continued to increase as a result of human activities” (IPCC 2001).

The IPCC went on to report that the global average surface temperature of the Earth has increased by between 0.6 ± 0.2°C over the 20th century (IPCC 2001). This value is about 0.15°C larger than that estimated by the Second Assessment Report, which reported for the period up to 1994, “owing to the relatively high temperatures of the additional years (1995 to 2000) and improved methods of processing the data” (IPCC 2001).

While the Second Assessment Report concluded, “the balance of evidence suggests that there is a discernible human influence on global climate,” the Third Assessment Report states the influence of human activities on climate in even starker terms. It concludes that, “[I]n light of new evidence and taking into account the remaining uncertainties, most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations” (IPCC 2001).

Greenhouse Gases

Although the Earth’s atmosphere consists mainly of oxygen and nitrogen, neither plays a significant role in enhancing the greenhouse effect because both are essentially transparent to terrestrial radiation. The greenhouse effect is primarily a function of the concentration of water vapor, carbon dioxide, and other trace gases in the atmosphere that absorb the terrestrial radiation leaving the surface of the Earth (IPCC 1996). Changes in the atmospheric concentrations of these greenhouse gases can alter the balance of energy transfers between the atmosphere, space, land, and the oceans. A gauge of these changes is called radiative forcing, which is a simple measure of changes in the energy available to the Earth-atmosphere system (IPCC 1996). Holding everything else constant, increases in greenhouse gas concentrations in the atmosphere will produce positive radiative forcing (i.e., a net increase in the absorption of energy by the Earth).

Climate change can be driven by changes in the atmospheric concentrations of a number of radiatively active gases and aerosols. We have clear evidence that human activities have affected concentrations, distributions and life cycles of these gases (IPCC 1996).

Naturally occurring greenhouse gases include water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and ozone (O_3). Several classes of halogenated substances that contain fluorine, chlorine, or bromine are also greenhouse gases, but they are, for the most part, solely a product of industrial activities. Chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) are halocarbons that contain chlorine, while halocarbons that contain bromine are referred to as bromofluorocarbons (i.e., halons). Because CFCs, HCFCs, and halons are stratospheric ozone depleting substances, they are covered under the Montreal Protocol on Substances that Deplete the Ozone Layer. The UNFCCC defers to this earlier international treaty; consequently these gases are not included in national greenhouse gas inventories. Some other fluorine containing halogenated substances—hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6)—do not deplete stratospheric ozone but are potent greenhouse gases. These latter substances are addressed by the UNFCCC and accounted for in national greenhouse gas inventories.

There are also several gases that, although they do not have a commonly agreed upon direct radiative forcing effect, do influence the global radiation budget. These tropospheric gases—referred to as ambient air pollutants—include carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and tropospheric (ground level) ozone (O_3). Tropospheric ozone is formed by two precursor pollutants, volatile organic compounds (VOCs) and nitrogen oxides (NO_x) in the presence of ultraviolet light (sunlight). Aerosols—extremely small particles or liquid droplets—often composed of sulfur compounds, carbonaceous combustion products, crustal materials and other human induced pollutants—can affect the absorptive characteristics of the atmosphere. However, the level of scientific understanding of aerosols is still very low (IPCC 2001).

Carbon dioxide, methane, and nitrous oxide are continuously emitted to and removed from the atmosphere by natural processes on Earth. Anthropogenic activities, however, can cause additional quantities of these and other greenhouse gases to be emitted or sequestered, thereby changing their global average atmospheric concentrations. Natural activities such as respiration by plants or animals and seasonal cycles of plant growth and decay are examples of processes that only cycle carbon or nitrogen between the atmosphere and organic biomass. Such processes—except when directly or indirectly perturbed out of equilibrium by anthropogenic activities—generally do not alter average atmospheric greenhouse gas concentrations over decadal timeframes. Climatic changes resulting from anthropogenic activities, however, could have positive or negative feedback effects on these natural systems. Atmospheric concentrations of these gases, along with their rates of growth and atmospheric lifetimes, are presented in Table 10.

Table 10. Global atmospheric concentration (ppm unless otherwise specified), rate of concentration change (ppb/year) and atmospheric lifetime (years) of selected greenhouse gases

Atmospheric Variable	CO_2	CH_4	N_2O	SF_6[a]	CF_4[a]
Pre-industrial atmospheric concentration	278	0.700	0.270	0	40
Atmospheric concentration (1998)	365	1.745	0.314	4.2	80
Rate of concentration change[b]	1.5[c]	0.007[c]	0.0008	0.24	1.0
Atmospheric Lifetime	50-200[d]	12[e]	114[e]	3,200	>50,000

Source: IPCC (2001)

[a] Concentrations in parts per trillion (ppt) and rate of concentration change in ppt/year.

[b] Rate is calculated over the period 1990 to 1999.

[c] Rate has fluctuated between 0.9 and 2.8 ppm per year for CO_2 and between 0 and 0.013 ppm per year for CH4 over the period 1990 to 1999.

[d] No single lifetime can be defined for CO_2 because of the different rates of uptake by different removal processes.

[e] This lifetime has been defined as an “adjustment time” that takes into account the indirect effect of the gas on its own residence time.

A brief description of each greenhouse gas, its sources, and its role in the atmosphere is given below. The following section then explains the concept of Global Warming Potentials (GWPs), which are assigned to individual gases as a measure of their relative average global radiative forcing effect.

Water Vapor (H_2O). Overall, the most abundant and dominant greenhouse gas in the atmosphere is water vapor. Water vapor is neither long-lived nor well mixed in the atmosphere, varying spatially from 0 to 2 percent (IPCC 1996). In addition, atmospheric water can exist in several physical states including gaseous, liquid, and solid. Human activities are not believed to directly affect the average global concentration of water vapor; however, the radiative forcing produced by the increased concentrations of other greenhouse gases may indirectly affect the hydrologic cycle. A warmer atmosphere has an increased water holding capacity; yet, increased concentrations of water vapor affects the formation of clouds, which can both absorb and reflect solar and terrestrial radiation. Aircraft contrails, which consist of water vapor and other aircraft emittants, are similar to clouds in their radiative forcing effects (IPCC 1999).

Carbon Dioxide (CO_2). In nature, carbon is cycled between various atmospheric, oceanic, land biotic, marine biotic, and mineral reservoirs. The largest fluxes occur between the atmosphere and terrestrial biota, and between the atmosphere and surface water of the oceans. In the atmosphere, carbon predominantly exists in its oxidized form as CO_2. Atmospheric carbon dioxide is part of this global carbon cycle, and therefore its fate is a complex function of geochemical and biological processes. Carbon dioxide concentrations in the atmosphere increased from approximately 280 parts per million by volume (ppmv) in pre-industrial times to 367 ppmv in 1999, a 31 percent increase (IPCC 2001). The IPCC notes that "[t]his concentration has not been exceeded during the past 420,000 years, and likely not during the past 20 million years. The rate of increase over the past century is unprecedented, at least during the past 20,000 years." The IPCC definitively states that "the present atmospheric CO_2 increase is caused by anthropogenic emissions of CO_2" (IPCC 2001). Forest clearing, other biomass burning, and some non-energy production processes (e.g., cement production) also emit notable quantities of carbon dioxide.

In its second assessment, the IPCC also stated that "[t]he increased amount of carbon dioxide [in the atmosphere] is leading to climate change and will produce, on average, a global warming of the Earth's surface because of its enhanced greenhouse effect—although the magnitude and significance of the effects are not fully resolved" (IPCC 1996).

Methane (CH_4). Methane is primarily produced through anaerobic decomposition of organic matter in biological systems. Agricultural processes such as wetland rice cultivation, enteric fermentation in animals, and the decomposition of animal wastes emit CH_4, as does the decomposition of municipal solid wastes. Methane is also emitted during the production and distribution of natural gas and petroleum, and is released as a by-product of coal mining and incomplete fossil fuel combustion. Atmospheric concentrations of methane have increased by about 150 percent since pre-industrial times, although the rate of increase has been declining. The IPCC has estimated that slightly more than half of the current CH_4 flux to the atmosphere is anthropogenic, from human activities such as agriculture, fossil fuel use and waste disposal (IPCC 2001).

Methane is removed from the atmosphere by reacting with the hydroxyl radical (OH) and is ultimately converted to CO_2. Minor removal processes also include reaction with Cl in the marine boundary layer, a soil sink, and stratospheric reactions. Increasing emissions of methane reduce the concentration of OH, a feedback which may increase methane's atmospheric lifetime (IPCC 2001).

Nitrous Oxide (N_2O). Anthropogenic sources of N_2O emissions include agricultural soils, especially the use of synthetic and manure fertilizers; fossil fuel combustion, especially from mobile combustion; adipic (nylon) and nitric acid production; wastewater treatment and waste combustion; and biomass burning. The atmospheric concentration of nitrous oxide (N_2O) has increased by 16 percent since 1750, from a pre industrial value of about 270 ppb to 314 ppb in 1998, a concentration that has not been exceeded during the last thousand years. Nitrous oxide is primarily removed from the atmosphere by the photolytic action of sunlight in the stratosphere.

Ozone (O_3). Ozone is present in both the upper stratosphere, where it shields the Earth from harmful levels of ultraviolet radiation, and at lower concentrations in the troposphere, where it is the main component of anthropogenic photochemical "smog." During the last two decades, emissions of anthropogenic chlorine and bromine-containing halocarbons, such as chlorofluorocarbons (CFCs), have depleted stratospheric ozone concentrations. This loss of ozone in the stratosphere has resulted in negative radiative forcing, representing an indirect effect of anthropogenic emissions of chlorine and bromine compounds (IPCC 1996). The depletion of stratospheric ozone and its radiative forcing was expected to reach a maximum in about 2000 before starting to recover, with detection of such recovery not expected to occur much before 2010 (IPCC 2001).

The past increase in tropospheric ozone, which is also a greenhouse gas, is estimated to provide the third largest increase in direct radiative forcing since the pre-industrial era, behind CO_2 and CH_4. Tropospheric ozone is produced from complex chemical reactions of volatile organic compounds mixing with nitrogen oxides (NO_x) in the presence of sunlight. Ozone, carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2) and particulate matter are included in the category referred to as "criteria pollutants" in the United States under the Clean Air Act and its subsequent amendments. The tropospheric concentrations of ozone and these other pollutants are short-lived and, therefore, spatially variable.

Halocarbons, Perfluorocarbons, and Sulfur Hexafluoride (SF_6). Halocarbons are, for the most part, man-made chemicals that have both direct and indirect radiative forcing effects. Halocarbons that contain chlorine—chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), methyl chloroform, and carbon tetrachloride—and bromine—halons, methyl bromide, and hydrobromofluorocarbons (HBFCs)—result in stratospheric ozone depletion and are therefore controlled under the Montreal Protocol on Substances that Deplete the Ozone Layer. Although CFCs and HCFCs include potent global warming gases, their net radiative forcing effect on the atmosphere is reduced because they cause stratospheric ozone depletion, which is itself an important greenhouse gas in addition to shielding the Earth from harmful levels of ultraviolet radiation. Under the Montreal Protocol, the United States phased out the production and importation of halons by 1994 and of CFCs by 1996. Under the Copenhagen Amendments to the Protocol, a cap was placed on the production and importation of HCFCs by non-Article 5 countries beginning in 1996, and then followed by a complete phase-out by the year 2030. The ozone depleting gases covered under the Montreal Protocol and its Amendments are not covered by the UNFCCC.

Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6) are not ozone depleting substances, and therefore are not covered under the Montreal Protocol. They are, however, powerful greenhouse gases. HFCs—primarily used as replacements for ozone depleting substances but also emitted as a by-product of the HCFC-22 manufacturing process—currently have a small aggregate radiative forcing impact; however, it is anticipated that their contribution to overall radiative forcing will increase (IPCC 2001). PFCs and SF_6 are predominantly emitted from various industrial processes including aluminum smelting, semiconductor manufacturing, electric power transmission and distribution, and magnesium casting. urrently, the radiative forcing impact of PFCs and SF_6 is also small; however, they have a significant growth rate, extremely long atmospheric lifetimes, and are strong absorbers of infrared radiation, and therefore have the potential to influence climate far into the future (IPCC 2001).

Carbon Monoxide (CO). Carbon monoxide has an indirect radiative forcing effect by elevating concentrations of CH_4 and tropospheric ozone through chemical reactions with other atmospheric constituents (e.g., the hydroxyl radical, OH) that would otherwise assist in destroying CH_4 and tropospheric ozone. Carbon monoxide is created when carbon-containing fuels are burned incompletely. Through natural processes in the atmosphere, it is eventually oxidized to CO_2. Carbon monoxide concentrations are both short-lived in the atmosphere and spatially variable.

Nitrogen Oxides (NO_x). The primary climate change effects of nitrogen oxides (i.e., NO and NO_2) are indirect and result from their role in promoting the formation of ozone in the troposphere and, to a lesser degree, lower stratosphere, where it has positive radiative forcing effects. Additionally, NO_x emissions from aircraft are also likely to decrease methane concentrations, thus having a negative radiative forcing effect (IPCC 1999). Nitrogen oxides are created from lightning, soil microbial activity, biomass burning – both natural and anthropogenic fires – fuel combustion, and, in the stratosphere, from the photo-degradation of nitrous oxide (N_2O). Concentrations of NO_x are both relatively short-lived in the atmosphere and spatially variable.

Nonmethane Volatile Organic Compounds (NMVOCs). Nonmethane volatile organic compounds include compounds such as propane, butane, and ethane. These compounds participate, along with NO_x, in the formation of tropospheric ozone and other photochemical oxidants. NMVOCs are emitted primarily from transportation and industrial processes, as well as biomass burning and non-industrial consumption of organic solvents. Concentrations of NMVOCs tend to be both short-lived in the atmosphere and spatially variable.

Aerosols. Aerosols are extremely small particles or liquid droplets found in the atmosphere. They can be produced by natural events such as dust storms and volcanic activity, or by anthropogenic processes such as fuel combustion and biomass burning. They affect radiative forcing in both direct and indirect ways: directly by scattering and absorbing solar and thermal infrared radiation; and indirectly by increasing droplet counts that modify the formation, precipitation efficiency, and radiative properties of clouds. Aerosols are removed from the atmosphere relatively rapidly by precipitation. Because aerosols generally have short atmospheric lifetimes, and have concentrations and compositions that vary regionally, spatially, and temporally, their contributions to radiative forcing are difficult to quantify (IPCC 2001).

The indirect radiative forcing from aerosols is typically divided into two effects. The first effect involves decreased droplet size and increased droplet concentration resulting from an increase in airborne aerosols. The second effect involves an increase in the water content and lifetime of clouds due to the effect of reduced droplet size on precipitation efficiency (IPCC 2001). Recent research has placed a greater focus on the second indirect radiative forcing effect of aerosols.

Various categories of aerosols exist, including naturally produced aerosols such as soil dust, sea salt, biogenic aerosols, sulphates, and volcanic aerosols, and anthropogenically manufactured aerosols such as industrial dust and carbonaceous aerosols (e.g., black carbon, organic carbon) from transportation, coal combustion, cement manufacturing, waste incineration, and biomass burning.

The net effect of aerosols is believed to produce a negative radiative forcing effect (i.e., net cooling effect on the climate), although because they are short-lived in the atmosphere—lasting days to weeks—their concentrations respond rapidly to changes in emissions. Locally, the negative radiative forcing effects of aerosols can offset the positive forcing of greenhouse gases (IPCC 1996). “However, the aerosol effects do not cancel the global-scale effects of the much longer-lived greenhouse gases, and significant climate changes can still result” (IPCC 1996).

The IPCC’s Third Assessment Report notes that “the indirect radiative effect of aerosols is now understood to also encompass effects on ice and mixed-phase clouds, but the magnitude of any such indirect effect is not known, although it is likely to be positive” (IPCC 2001). Additionally, current research suggests that another constituent of aerosols, elemental carbon, may have a positive radiative forcing (Jacobson 2001). The primary anthropogenic emission sources of elemental carbon include diesel exhaust, coal combustion, and biomass burning.

Global Warming Potentials

Global Warming Potentials (GWPs) are intended as a quantified measure of the globally averaged relative radiative forcing impacts of a particular greenhouse gas. It is defined as the cumulative radiative forcing—both direct and indirect effects—integrated over a period of time from the emission of a unit mass of gas relative to some reference gas (IPCC 1996). Carbon dioxide (CO_2) was chosen as this reference gas. Direct effects occur when the gas itself is a greenhouse gas. Indirect radiative forcing occurs when chemical transformations involving the original gas produce a gas or gases that are greenhouse gases, or when a gas influences other radiatively important processes such as the atmospheric lifetimes of other gases. The relationship between gigagrams (Gg) of a gas and Tg CO_2 Eq. can be expressed as follows:

$$\text{Tg CO}_2\text{ Eq} = (\text{Gg of gas}) \times (\text{GWP}) \times \left(\frac{\text{Tg}}{1{,}000\text{ Gg}}\right) \text{where,}$$

Tg CO_2 Eq. = Teragrams of Carbon Dioxide Equivalents
Gg = Gigagrams (equivalent to a thousand metric tons)
GWP = Global Warming Potential
Tg = Teragrams

GWP values allow policy makers to compare the impacts of emissions and reductions of different gases. According to the IPCC, GWPs typically have an uncertainty of roughly ±35 percent, though some GWPs have larger uncertainty than others, especially those in which lifetimes have not yet been ascertained. n the following decision, the parties to the UNFCCC have agreed to use consistent GWPs from the IPCC Second Assessment Report (SAR), based upon a 100 year time horizon, although other time horizon values are available (see Table 11).

> *In addition to communicating emissions in units of mass, Parties may choose also to use global warming potentials (GWPs) to reflect their inventories and projections in carbon dioxide-equivalent terms, using information provided by the Intergovernmental Panel on Climate Change (IPCC) in its Second Assessment Report. Any use of GWPs should be based on the effects of the greenhouse gases over a 100-year time horizon. In addition, Parties may also use other time horizons. (FCCC/CP/1996/15/Add.1)*

Greenhouse gases with relatively long atmospheric lifetimes (e.g., CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6) tend to be evenly distributed throughout the atmosphere, and consequently global average concentrations can be determined. The short-lived gases such as water vapor, carbon monoxide, tropospheric ozone, other ambient air pollutants (e.g., NO_x, and NMVOCs), and tropospheric aerosols (e.g., SO_2 products and black carbon), however, vary spatially, and consequently it is difficult to quantify their global radiative forcing impacts. GWP values are generally not attributed to these gases that are short-lived and spatially inhomogeneous in the atmosphere.

Table 11. Global warming potentials (GWP) and atmospheric lifetimes (years) used in the inventory

Gas	Atmospheric Lifetime	100-year GWP[a]	20-year GWP	500-year GWP
Carbon dioxide (CO_2)	50-200	1	1	1
Methane (CH_4)[b]	12±3	21	56	6.5
Nitrous oxide (N_2O)	120	310	280	170
HFC-23	264	11,700	9,100	9,800
HFC-125	32.6	2,800	4,600	920
HFC-134a	14.6	1,300	3,400	420
HFC-143a	48.3	3,800	5,000	1,400
HFC-152a	1.5	140	460	42
HFC-227ea	36.5	2,900	4,300	950
HFC-236fa	209	6,300	5,100	4,700
HFC-4310mee	17.1	1,300	3,000	400
CF_4	50,000	6,500	4,400	10,000
C_2F_6	10,000	9,200	6,200	14,000
C_4F_{10}	2,600	7,000	4,800	10,100
C_6F_{14}	3,200	7,400	5,000	10,700
SF_6	3,200	23,900	16,300	34,900

Source: IPCC (1996)
[a] GWPs used here are calculated over 100 year time horizon.
[b] The methane GWP includes the direct effects and those indirect effects due to the production of tropospheric ozone and stratospheric water vapor. The indirect effect due to the production of CO_2 is not included.

Table 12 presents direct and net (i.e., direct and indirect) GWPs for ozone-depleting substances (ODSs). Ozone-depleting substances directly absorb infrared radiation and contribute to positive radiative forcing; however, their effect as ozone-depleters also leads to a negative radiative forcing because ozone itself is a potent greenhouse gas. There is considerable uncertainty regarding this indirect effect; therefore, a range of net GWPs is provided for ozone depleting substances.

Table 12. Net 100-year global warming potentials for select ozone depleting substances*

Gas	Direct	Net_{min}	Net_{max}
CFC-11	4,600	(600)	3,600
CFC-12	10,600	7,300	9,900
CFC-113	6,000	2,200	5,200
HCFC-22	1,700	1,400	1,700
HCFC-123	120	20	100
HCFC-124	620	480	590
HCFC-141b	700	(5)	570
HCFC-142b	2,400	1,900	2,300
$CHCl_3$	140	(560)	0
CCl_4	1,800	(3,900)	660
CH_3Br	5	(2,600)	(500)
Halon-1211	1,300	(24,000)	(3,600)
Halon-1301	6,900	(76,000)	(9,300)

Source: IPCC (2001)

* Because these compounds have been shown to deplete stratospheric ozone, they are typically referred to as ozone depleting substances (ODSs). However, they are also potent greenhouse gases. Recognizing the harmful effects of these compounds on the ozone layer, in 1987 many governments signed the *Montreal Protocol on Substances that Deplete the Ozone Layer* to limit the production and importation of a number of CFCs and other halogenated compounds. The United States furthered its commitment to phase-out ODSs by signing and ratifying the Copenhagen Amendments to the *Montreal Protocol* in 1992. Under these amendments, the United States committed to ending the production and importation of halons by 1994, and CFCs by 1996. The IPCC Guidelines and the UNFCCC do not include reporting instructions for estimating emissions of ODSs because their use is being phased-out under the *Montreal Protocol*. The effects of these compounds on radiative forcing are not addressed here.

The IPCC recently published its Third Assessment Report (TAR), providing the most current and comprehensive scientific assessment of climate change (IPCC 2001). Within that report, the GWPs of several gases were revised relative to the IPCC's Second Assessment Report (SAR) (IPCC 1996), and new GWPs have been calculated for an expanded set of gases. Since the SAR, the IPCC has applied an improved calculation of CO_2 radiative forcing and an improved CO_2 response function (presented in WMO 1999). The GWPs are drawn from WMO (1999) and the SAR, with updates for those cases where new laboratory or radiative transfer results have been published. Additionally, the atmospheric lifetimes of some gases have been recalculated. Because the revised radiative forcing of CO_2 is about 12 percent lower than that in the SAR, the GWPs of the other gases relative to CO_2 tend to be larger, taking into account revisions in lifetimes. However, there were some instances in which other variables, such as the radiative efficiency or the chemical lifetime, were altered that resulted in further increases or decreases in particular GWP values. In addition, the values for radiative forcing and lifetimes have been calculated for a variety of halocarbons, which were not presented in the SAR. The changes are described in the TAR as follows:

New categories of gases include fluorinated organic molecules, many of which are ethers that are proposed as halocarbon substitutes. Some of the GWPs have larger uncertainties than that of others, particularly for those gases where detailed laboratory data on lifetimes are not yet available. The direct GWPs have been calculated relative to CO_2 using an improved calculation of the CO_2 radiative forcing, the SAR response function for a CO_2 pulse, and new values for the radiative forcing and lifetimes for a number of halocarbons.

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Appendix E
Methods for Quantification of Greenhouse Gas Mitigation Policy Options

This appendix summarizes key elements of the methodology for quantifying GHG impacts and costs that has been used in the CCAC analysis.

- Common units and results reported:
  - **Net GHG reduction potential** in million metric tons carbon dioxide equivalent ($MMtCO_2e$) using IPCC 100-year global warming potential based on the IPCC *Second Assessment Report.*[1] GHG reductions, relative to the reference case projection of GHG emissions without the options (i.e., business as usual), are reported for 2010, 2020, and cumulatively for the period 2007-2020. Where significant additional GHG reductions or costs occur beyond this period as a direct result of actions taken during the 2007-2020 period, these are indicated as appropriate.
  - **Net present value** (NPV) **cost** (or cost savings) for the period 2007-2020 in 2005 constant dollars, using a 5% real discount rate.[2] Positive numbers represent options with net costs; negative numbers represent options with net cost savings.
  - **Cost per metric ton of CO2 equivalent emissions reduced** (or removed) represented as $\$/MtCO_2e$. This unit of measure represents the 2007-2020 NPV cost associated with a policy recommendation, divided by its cumulative emission reductions over the same period.

- Consistent assumptions and methodologies: In order to ensure consistent results across options and TWGs, common factors and assumptions were used for items such as:
  - **Electricity avoided costs and emissions**: Common values – dollars per Megawatt hour ($/MWh) and tons of CO2 emissions per Megawatt hour (tCO2/MWh) – have been used for avoided electricity costs and avoided emissions respectively. Avoided electricity costs are based on the levelized value of the long-term standard Qualifying Facilities Tariff from the Montana Public Service Commission which is $49 per MWh.[3] Avoided

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[1] IPCC (1996) *Climate Change 1995: The Science of Climate Change*. Intergovernmental Panel on Climate Change; J.T. Houghton, L.G. Meira Filho, B.A. Callander, N. Harris, A. Kattenberg, and K. Maskell, eds.; Cambridge University Press. Cambridge, U.K.

[2] Capital investments with lifetimes longer than 2020 are represented in terms of levelized or amortized costs, in order to avoid "end effects."

[3] Estimate derived from contract data underlying the "the long-term, standard QF [Qualifying Facilities] tariff," "Option 1" ($49.90 per MWh, nominal cost average of quarterly contract costs from 2007 through 2014) as set by the Montana Public Services Commission, in an order covering Docket No. D2003.7.86, Order No. 6501f 2; Docket No. D2004.6.96, Order No. 6501f; and Docket No. D2005.6.103, Order No. 6501f, dated December 19, 2006. The $49.90 cost indicated is shown in paragraph 184 of the Montana Public Service Commission (PSC) document. Cost shown here extends the stream of nominal costs in the original Northwestern Energy/ PPL Montana (NWE/PPL) document by including values for 2015 to 2020 that increment the 2014 average value at the rate of inflation, levelizes the resulting 2007 to 2020 stream, and adjusts the levelized value to 2005 dollars.

    emissions, for analysis of individual options, is consistent with the state-level inventory and forecast developed as part of the CCAC process. To estimate emissions reductions from the full set of options, an integrated analysis was undertaken. Adjustments were made to the totals in the Energy Supply sector to reflect the aggregated impacts of the integrated analysis.
    - **Fuel costs and projected escalation**: Fossil fuel price escalation has been indexed to USDOE projections as indicated in its 2007 Annual Energy Outlook.
    - **Emission increasing activities**: Some options may involve some increased demand for energy or other potential emission sources (e.g. Combined Heat and Power systems can increase fuel demand in the industrial and commercial sectors). Such direct emissions increases are factored into the analysis.[4]

- Aggregation of impacts: Some options overlap in terms of coverage, both within and across sectors. CCS begins the quantification of options by assuming that an individual policy is implemented in a "standalone" fashion, as if no other new policies are being adopted. Following this, CCS examines the likely interactions of policies assuming they are adopted as a group. For many policies, there are no interactions (e.g., the carbon sequestered by trees does not interact with the effects of increased energy efficiency). In these cases, the quantification of emission reductions and costs for different policies can simply be added together. However, there are numerous cases where one cannot simply add together the impacts associated with two options.[5] In order to avoid double-counting of GHG reduction potential and cost (e.g. more than one option avoiding the same emissions source), interactive effects were estimated where possible, and emission reduction totals reflect these overlaps. In other words, the total emissions reductions for the state are lower than the sum of the results for individual options, as noted in the totals for each TWG.

- Geographic scope and lifecycle analysis:
    - **GHG impacts of policy options are estimated regardless of the physical location of emissions reductions**. For instance, a major benefit of recycling is the reduction in material extraction and processing (e.g. aluminum production). While a policy option may increase recycling in Montana, the reduction in emissions may occur where this material is produced. Where significant emissions impacts are likely to occur outside the

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[4] Some policy options could also result in emissions leakage, either positive or negative. Negative leakage would occur if a policy leads emitting activities to shift to areas outside its target area or increases activity as a result of lowering the cost of service (e.g., the rebound effect). For example, if not considered carefully, policies to protect forest lands could shift forest clearing activities to other regions or states. Conversely, some policy options could result in positive leakage, through replication outside the target area (e.g., by lowering the price or increasing access to lower emitting technologies). Where such effects might be significant, these should be noted qualitatively.

[5] A hypothetical can illustrate this. Imagine the invention of an airplane that improves fuel economy by 50%. If such airplanes replaced the entire current fleet of airplanes, jet fuel consumption (and associated GHG tons) would decrease 50%. In parallel, imagine a "modal shift" policy that decreased demand for air travel by 50%. In isolation, this modal shift could decrease jet fuel consumption (and associated GHG tons) by 50%. However, if these occurred at the same time, the decrease in aviation emissions would *not* be 50% + 50% = 100%. Instead, fuel economy would interact with demand decrease so that aviation emissions would total 25% of their previous level, calculated as follows: (1 – 50%) × (1 – 50%). Thus the "interactive" decrease would be 75%, not 100%.

  state, this is indicated. These emissions reductions are counted towards Montana's emission reductions, since they result from actions taken by the state.
  - Related to the previous point, **lifecycle analysis** is applied wherever emissions impacts upstream (e.g., production, extraction) or downstream (e.g. waste disposal) from a specific activity constitute a significant fraction of a policy option's emissions impacts *and* studies are sufficient to enable estimation of lifecycle impacts. For example, lifecycle analysis is used to estimate the emissions benefits of biofuels relative to the fossil fuels that they might displace.

- Transparency: Data sources, methods, key assumptions, and key uncertainties are clearly indicated.

- Cost perspectives and inclusion: The general approach of direct (NPV) cost and cost-effectiveness analysis is used, as widely applied to GHG mitigation policy options.[6] Included are the direct, economic costs from the perspective of the state as whole (e.g. avoided costs of electricity rather than consumer electricity prices). This bottom-up approach is relatively transparent and is capable of reflecting the costs (and cost savings) associated with an individual policy option, in contrast to macroeconomic analysis, which aims to capture flows and interactions across all sectors of the economy.

  Examples of costs included:

  - Capital costs levelized (amortized) where appropriate, e.g. for improved buildings, vehicles, equipment upgrades, new technologies, manure digesters and associated infrastructure, ethanol production facilities, mass transit investment and operating expenses (net of any saved infrastructure costs such as roads),
  - Operation, maintenance, and other labor costs (or incremental costs relative to standard practice),
  - Fuel and material costs, e.g. for natural gas, electricity, biomass resources, water, fertilizer, material use, electricity transmission and distribution, and
  - Other direct costs, administrative costs, and other costs (where readily estimated), such as the grid integration costs for renewable energy. technologies, or the costs of administering an energy efficiency project, or of implementing smart growth programs (net of saved infrastructure costs).

  Examples of costs or benefits not included:

  - External costs such as the monetized environmental or social benefits/impacts (value of damage by air pollutants on structures, crops, etc.), quality-of-life improvements, or improved road safety, or other health impacts and benefits,
  - Energy security benefits,

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[6] See Section 2.4 of the IPCC Fourth Assessment Report, Working Group III, for more discussion of various economic analysis approaches. http://www.mnp.nl/ipcc/pages_media/AR4-chapters.html

- Macroeconomic impacts related to the impact of reduced or increased consumer spending, shifting of cost and benefits among actors in the economy, and
- Potential revenues from participation in a carbon market.

Appendix F
Residential, Commercial, Institutional, and Industrial Sectors Policy Recommendations

Summary List of Policy Option Recommendations

	Policy Option	GHG Reductions (MMtCO$_2$e)			Net Present Value 2007–2020 (Million $)	Cost-Effectiveness ($/tCO$_2$e)	Level of Support
		2010	2020	Total 2007–2020			
RCII-1	Demand-Side Management Programs, Efficiency Funds and Requirements (and Financial Incentives)	0.04	1.15	6.6	–$141	–$21	UC
RCII-2	Market Transformation and Technology Development Programs	0.03	0.30	1.9	–$43	–$23	UC
RCII-3	State-Level Appliance Efficiency Standards and State Support for Improved Federal Standards	0.05	0.20	1.5	–$55	–$36	UC
RCII-4	Building Energy Codes	0.03	0.25	1.6	–$15	–$10	UC
RCII-5	"Beyond Code" Building Design Incentives and Mandatory Programs	0.07	0.52	3.4	–$17	–$5	UC
RCII-6	Consumer Education Programs	*Not quantified*					UC
RCII-7	Support for Implementation of Clean Combined Heat and Power	*Quantified in coordination with the Energy Supply TWG (as a part of ES-4)*					UC
RCII-8	Support for Renewable Energy Applications	*Quantified in coordination with the Energy Supply TWG (as a part of ES-4)*					UC
RCII-9	Carbon Tax	*Not quantified*					UC
RCII-10	Industrial Energy Audits and Recommended Measure Implementation	0.07	0.56	3.6	–$93	–$26	UC
RCII-11	Low-Income and Rental Housing Energy Efficiency Programs	0.05	0.75	4.7	–$41	–$9	UC
RCII-12	State Lead by Example	0.03	0.33	2.0	–$11	–$6	UC
RCII-13	Metering Technologies With Opportunity for Load Management and Choice	0.02	0.12	0.9	–$11	–$12	UC
	Sector Total After Adjusting for Overlaps	**0.28**	**2.95**	**18.4**	**–$304**	**–$17**	**N/A**
	Reductions From Recent Actions						
RCII-1	Expand Energy Efficiency Funds	0.30	0.79	6.5			N/A
RCII-11	Low Income Energy Efficiency Programs	0.02	0.05	0.4			N/A
	Sector Total Plus Recent Actions	**0.59**	**3.79**	**25.3**			**N/A**

UC = unanimous consent.
N/A = not applicable.

Note: Negative values in the Net Present Value and the Cost-Effectiveness columns represent net cost **savings** associated with the options. Also note that totals in some columns may not add to the totals shown due to rounding.

RCII-1. Demand-Side Management Programs, Efficiency Funds, and Requirements (and Financial Incentives)

Policy Description

This policy option involves increasing the efficiency of electricity and natural gas use in Montana through demand-side management (DSM) programs, funds, and/or requirements. This option focuses on what are typically termed DSM activities—programs, usually delivered by utilities or government-designated agencies designed to reduce energy consumption and/or change the timing of energy use. Examples of DSM programs include technical assistance for and implementation of energy efficiency and renewable energy measures, electrical and natural gas demand response, alternative rate schedules, and research activities. Note that the activities described for this option may also support implementation of other options recommended by the Climate Change Action Committee (CCAC), such as Residential, Commercial, Institutional, and Industrial Policy Option 11 (RCII-11) and RCII-12.

Policy Design

This policy design is focused on increasing energy efficiency programs through investor-owned and cooperative utilities and is linked with the energy efficiency element of Energy Supply Policy Option 1 (ES-1), "Environmental Portfolio Standard (EPS)." ES-1 would require that each utility capture 100% of its achievable cost-effective energy efficiency over a period of 15 years.

Implementation of energy efficiency/energy conservation programs could include the following elements:

- Creation of an independent, nonprofit, statewide provider of energy efficiency services to support, in particular, the provision of energy-efficiency/conservation programs in the service territories of smaller utilities, including cooperatives. Consideration should also be given to allowing utilities, such as NorthWestern Energy, that already implement DSM programs funded by their customers through energy supply charges to opt out of the program. A statewide energy efficiency provider tasked with undertaking DSM programs for participating utilities—proportionate to the amount invested by the customers of those utilities—would realize significant efficiencies and would ensure that all Montanans and all Montana utilities benefit from the acquisition of what is typically the lowest cost resource.
- Establish a revolving loan program, similar to the Alternative Energy Revolving Loan Program at the Montana Department of Environmental Quality (MDEQ), to focus on energy-efficiency/conservation investments.
- New or expanded state tax credits may provide an additional means of increasing investments in energy efficiency, particularly for appliances and equipment that require a significant initial outlay on the part of consumers.

Goals/Timing: The goals for this option follow the goals from the ES-1 option:

Each investor-owned and public utility should:

- Meet 20% of its load using renewable energy resources by 2020, increasing to 25% by 2025.
- Implement a plan to obtain 100% of achievable cost-effective energy conservation by 2025.
    - By 2010, identify its achievable cost-effective energy conservation for the subsequent 10 years.
    - Update its energy-efficiency assessment and plan regularly, possibly every 2 years.

    "Energy conservation" refers to both electricity and natural gas.

Parties Involved: Investor-owned utilities, electric cooperatives, Montana Public Service Commission (PSC), state government.

Implementation Mechanisms

Environmental Portfolio Standard: The goals noted above would be implemented through an EPS, to be adopted on the basis of legislation, regulation or other agreement. This standard will modify the existing Renewable Portfolio Standard (RPS) that sets requirements for renewable energy production to add requirements for energy efficiency.

Expanded Demand-Side Management Programs: A series of energy efficiency and renewable energy programs will be needed to achieve the goals set out. These programs will be offered by utility companies, state government, professional associations, and other organizations.

It is expected that additional energy efficiency programs would focus on:

- Providing expanded residential and commercial energy audit programs and offering incentives and assistance for building owners to follow up on audit recommendations.
- Promoting technologies for efficient heating and cooling of buildings, including homes, churches, schools, and commercial buildings, as applicable and cost-effective. Relevant technologies could include (but would not be limited to) ground source heat pumps, high efficiency boilers, and evaporative coolers.
- Conserving space-conditioning energy by promoting weatherization (insulation, high-efficiency window systems, and other measures) of homes and other buildings.
- Promoting and expanding water heater demand-control programs to reduce peak period electrical energy use and promoting the use of higher-efficiency water heaters.
- Promoting the use of compact fluorescent lamps (CFLs) and other high-efficiency lighting and lighting control systems, including applications in the commercial and institutional sectors.
- Promoting the use of Energy Star® appliances.
- Promoting fuel switching when doing so cost-effectively reduces overall (electricity generation plus direct fuel use) GHG emissions.
- Expanding existing effective energy efficiency activities.

Note that this listing of options is not meant to preclude any existing or future DSM options that might be applicable to Montana—it is intended only as a list of promising examples for use of expanded Universal System Benefits (USB) funds or funds otherwise earmarked for energy efficiency investments. In many cases, examples of such programs already exist but could be expanded in scope and effectiveness with additional resources.

Expanded Information and Education: Effective implementation of expanded DSM programs may require a larger pool of qualified and reliable contractors to implement energy efficiency measures. Owners of homes and commercial buildings must also be educated to understand the benefits of energy conservation/improved energy-efficiency/DSM. Consumer and specialist education are therefore important as supporting mechanisms to enable implementation of this policy.

Independent, Nonprofit Provider of Energy Efficiency Services: As noted above, it may be more efficient to provide some efficiency services in some utility areas through an independent provider, particularly where smaller utilities may not themselves have the capacity to offer such services to their customers.

Revolving Loan Program: Financing may be needed by consumers in order to purchase the appliances and equipment recommended for energy efficiency. The Alternative Energy Revolving Loan Program could be expanded or other financing mechanisms could be developed.

Related Policies/Programs in Place

Universal Systems Benefits Program: As part of its 1997 restructuring legislation, Montana established its Universal System Benefits Program (USBP). Beginning January 1, 1999, all electric utilities began annually contributing 2.4% of their 1995 revenues to the USBP. As of 2006, the total funds estimated to be collected from electricity consumers by NorthWestern Energy were approximately $9.4 million. The funds support energy efficiency, renewable-energy resources, low-income energy assistance, renewable-energy research and development, and large customer rebates. The guidelines for expenditures of USB funds (both gas and electric) for 2006 are established in an interim order of the Montana PSC dated November 2005 and are presented in Table F-1.[1]

Table F-1. 2006 Electric and natural gas USB allocations

Program category	Electric USB expense target	%	Gas USB expense target	%
Conservation	$1,239,352	14	$327,000	11
Market transformation	$112,036	1	N/A	
Renewables	$651,094	8	N/A	
R&D	$89,261	1		
Low-income	$3,505,277	40	$2,547,372	89
Bill discounts	$1,853,584		$1,945,800	
Energy share	$575,000		0	

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[1] Montana PSC, Order No. 6679a in Dockets numbered D2004.7.99, D2004.12.292, and D2005.6.016. Table shown is from page 27 of the referenced order. Order is available as http://www.psc.mt.gov/eDocs/eDocuments/pdfFiles/D2004-12-192_6679a.pdf

Program category	Electric USB expense target	%	Gas USB expense target	%
Free weatherization	$962,843		$585,000	
Large customer	$3,126,527	36	N/A	
Total expenses	$8,723,547	100	$2,874,372	100
Projected USB revenue	$9,367,246		$2,278,585	
Surplus (deficiency)	$643,699		$(595,787)	

NorthWestern Energy programs have led to the installation of photovoltaics (PV) on residences, schools, fire stations, and commercial facilities throughout the state.

Electric cooperatives and Montana–Dakota Utilities Company (MDU) also contribute to the USBP. MDU support of the USB program for its electricity customers is shown in Table F-2. Rural electric cooperatives' contributions consisted primarily of energy efficiency and renewable energy programs included in the cost of the power the cooperatives bought from federal agencies such as the Bonneville Power Administration (BPA).

Table F-2. MDU 2006 electric USB allocations

Low-income discount	$92,252
Low-income weatherization	$127,200
Low-income energy audits	$10,000
Energy share endowment	$20,000
Energy share bill assistance	$26,000
Energy share furnace safety	$20,000
Low-income program promotion	$1,547
Commercial lighting rebates	$19,536
Total Montana–Dakota programs	$316,535
Large customer self-directed funds	$203,808
Amount transferred to State of Montana programs	$322,168
Total USB funds collected 2006	$842,510

A USB program applying to natural gas also exists (as authorized under MCA 69-3-1408). The natural gas USB program has recently been amended by the Montana Legislature (see http://data.opi.mt.gov/bills/2007/billpdf/HB0427.pdf), but what the impact of the amendment on existing USB-funded activities is not yet certain.

Montana's USBP is effective until December 31, 2009, when it is scheduled to "sunset." Note that the USB program has been scheduled to sunset on several previous occasions[2] but has been renewed each time. It is possible that the program will again be renewed in 2009 or will be replaced with a comparable or more effective program. Utilities may spend all or a portion of the funds on internal programs, or they may opt to contract or fund these programs externally. Large industrial customers with average monthly demand loads exceeding 1,000 kilowatts (kW) also

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[2] The history of USB legislation includes the following: 1997, SB 390 established USB for the period January 1, 1999 to July 1, 2003; 2003, SB 77 extended USB from July 1, 2003 to December 31, 2005; and 2005, SB 365 extended USB from December 31, 2005 to December 31, 2009.

fall under the law and may choose to "self-direct" the funds that would normally go to the USBP for internal energy programs.[3]

At present, some utilities, including NorthWestern Energy, have shifted some of what were previously USB funds spent on energy efficiency into their rate base and are thus supporting energy-efficiency programs in the same manner that electricity supply resources are supported.

Tax Incentives: There are many tax incentives designed to encourage investment in energy conservation and renewable energy in Montana. The incentives most applicable are the following: a $500 tax credit is available for investment in energy conservation (15-32-109 MCA [Montana Code Annotated]); a tax credit of $500 is available for investment in renewable energy systems (15-32-201 MCA); and a $1,500 tax credit is available for investment in a ground source heat pump or other geothermal heat source (15-32-115 MCA). A complete listing of tax incentives can be found at http://www.deq.mt.gov/Energy/Renewable/TaxIncentRenew.asp

The Alternative Energy Revolving Loan Program provides financing of up to $40,000 for renewable energy systems and for conservation done in association with renewable energy projects (MCA 75-25-101).

Type(s) of GHG Reductions

Principally, the reduction in GHG emissions (largely carbon dioxide [CO_2]) from avoided electricity production and avoided on-site fuel combustion. Less significant are the reduction in methane (CH_4) emissions from avoided fuel combustion and avoided pipeline leakage. Other GHG impacts are also conceivable but are likely to be small (black carbon, nitrous oxide [N_2O]) and/or very difficult to estimate (e.g., materials use, life cycle, market leakage).

Estimated GHG Reductions and Costs (or Cost Savings)

	Policy	Scenario/Element	Reductions		Cumulative Reductions 2007–2020 (MMtCO$_2$e)	NPV 2007–2020 ($ Millions)	Cost-Effectiveness ($/tCO$_2$)
			2010	2020			
RCII-1	Demand-Side Management Programs, Efficiency Funds and Requirements	Current/Expected Energy Efficiency Investment	0.29	0.78	6.5	N/A	N/A
	Electricity Savings	(as above)	0.24	0.63	5.3	N/A	N/A
	Natural Gas Savings	(as above)	0.05	0.15	1.2	N/A	N/A
RCII-1	Demand-Side Management Programs, Efficiency Funds and Requirements	New/Expanded Energy Efficiency Investments	0.04	1.15	6.6	–$141	–$21
	Electricity Savings	(as above)	0.03	0.92	5.4	–$79	–$15
	Natural Gas Savings	(as above)	0.01	0.23	1.2	–$61	–$49

NPV = net present value; N/A = not applicable.

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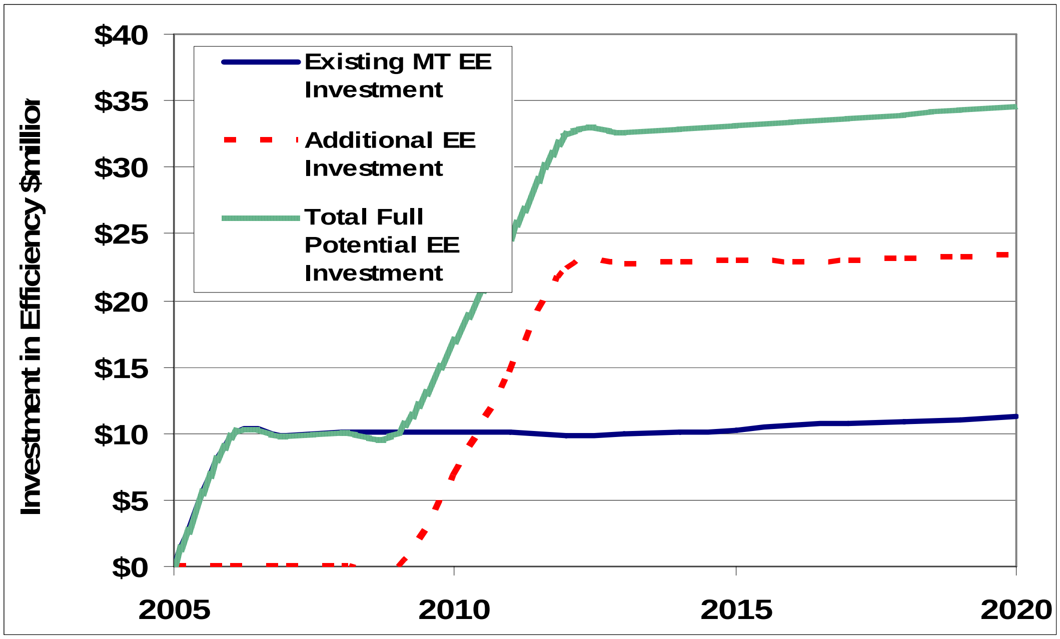
[3] Database of State Incentives for Renewables and Efficiency, available at http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=MT01R&state=MT&CurrentPageID=1&RE=1&EE=1

Note: Some totals in the table above may differ from the sum of their component elements due to rounding. Cost-effectiveness totals are weighted averages of component elements.

Figure F-1. Montana energy efficiency (EE) investments and potential



Data Sources: The analysis relies on the following key sources:

- The Energy Efficiency (EE) Task Force Report to the Clean and Diversified Energy Advisory Committee (CDEAC) of the Western Governors' Association (WGA), referred to here as the "WGA CDEAC EE report."[4] This report provides estimates of cost-effective efficiency potential and the average cost per megawatt-hour (MWh) saved ($25/MWh).
- Various other efficiency assessments by the Southwest Energy Efficiency Project (SWEEP), the Northwest Power Planning Council, and the California Energy Commission. Together, these sources suggest an average savings from utility energy efficiency programs of approximately 6 kWh per annual program dollar invested.
- Electricity avoided costs are provisionally based on the levelized value of long-term standard Qualifying Facilities Tariff from the Montana PSC ($49 per MWh).[5]

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[4] WGA, 2005. *The Potential for More Efficient Electricity Use in the Western United States, December 19, 2005.* http://www.westgov.org/wga/initiatives/cdeac/Energy%20Efficiency.htm

[5] Estimate derived from contract data underlying the "the long-term, standard QF [Qualifying Facilities] tariff," "Option 1" ($49.90 per MWh, nominal cost average of quarterly contract costs from 2007 through 2014) as set by the Montana PSC, in an order covering Docket No. D2003.7.86, Order No. 6501f 2; Docket No. D2004.6.96, Order No. 6501f; and Docket No. D2005.6.103, Order No. 6501f, dated December 19, 2006. The $49.90 cost indicated is shown in paragraph 184 of the PSC document. Cost shown here extends the stream of nominal costs in the original NWE/PPL (Northwestern Energy/PPL Montana) document by including values for 2015 to 2020 that increment the 2014 average value at the rate of inflation, levelize the resulting 2007 to 2020 stream, and adjust the levelized value to 2005 dollars.

- Average cost of gas DSM programs reported in S. Tegen, and H. Geller. 2006. "Natural Gas Demand-Side Management Programs: A National Survey," Southwest Energy Efficiency Project, www.swenergy.org
- Natural gas avoided costs based on costs of gas supply to Montana, with future gas costs estimated based on projections from the United States Department of Energy's (US DOE's) Annual Energy Outlook 2006.

Quantification Methods: Because Montana-specific electricity or gas efficiency potential studies are not presently in hand, estimates of efficiency savings and costs are based on regional studies and analyses/experience in other states. These studies were used to derive an estimate of efficiency savings per dollar spent on programs which, in turn, are used to translate spending levels into energy savings and program savings targets. The achievable efficiency potential was estimated based on the analysis of best practices and of other efficiency potential studies in the western United States (see WGA CDEAC EE, 2005). The WGA analysis suggests that savings of 0.8% to 1.0% per year is achievable, and we used the high end of that range here (1.0%), given the relatively low historical level of efficiency investment in Montana, at least until recent years (suggesting higher potential savings). The assumption of 1.0% annual energy savings results in an estimated annual energy efficiency investment level (for DSM only) on the order of 2.5% of revenues (for electric utilities). These estimates are based on programs and policies that aim for cost-effectiveness for all measures.[6]

Key Assumptions:

- Avoided costs of electricity ($49/MWh).
- Avoided cost of gas ($6.5/MMBtu, levelized).
- Average cost of electricity efficiency measures ($25/MWh saved). Note, however, that NorthWestern Energy's most recent default supply plan estimated an average levelized acquisition cost of energy efficiency of $20/MWh over a 20-year period, and the equivalent of about 870 GWh/year of cost-effective DSM potential, based on an avoided cost of $45/MWh.
- Average cost of gas efficiency measures ($2.1/MMBtu saved.)
- Full, achievable cost-effective efficiency improvements (1.0% reduction in sales per year).
- Savings target includes savings from existing programs.
- Savings from existing programs estimated based on the current (2005–2006) investments in efficiency by NorthWestern Energy (electric and gas) relative to total revenue from utility sales.
- Avoided electricity emissions (assumes that reductions in electricity generation requirements through 2010 will come from the average emissions rate of then-existing fossil-fueled

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[6] By way of comparison, this level of energy savings corresponds roughly, by 2020, with what would be Montana's share (based on a comparison of total 2005 electricity sales in Northwest states), of the conservation included in the Northwest Power and Conservation Council's *Fifth Northwest Electric Power and Conservation Plan.*

sources; by 2020 the predominant effect is assumed to be a reduction in reference case new coal and gas builds during the 2010–2020 period).

Key Uncertainties

- Montana-specific costs of DSM programs at savings levels modeled.
- Levels of spending/savings from existing DSM programs in Montana (some utilities).
- Impact of electricity energy efficiency programs on peak demand as well as energy requirements.

Additional Benefits and Costs

Benefits

- Reducing use of electricity and natural gas through this option also reduces emissions of local and regional air pollutants, such as sulfur and nitrogen oxides, which in turn reduce the human health and other impacts of those emissions.
- Reducing peak demand and improving the utilization of the electricity system.
- Reducing the risk of power shortages.
- Supporting local businesses and stimulating economic development.
- Reduction in transmission/distribution system costs.

Costs

None cited.

Feasibility Issues

- Costs and performance vary substantially between measures that might be considered for DSM programs. Some measures may present low capital costs and higher operating costs (or vice versa), and there is uncertainty about the costs and savings for other measures.

Interaction with appliance standards and utility programs.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

RCII-2. Market Transformation and Technology Development Programs

Policy Description

Market transformation is a relatively new term for energy efficiency programs that focus on voluntary efforts implemented by non-utility organizations to encourage greater uptake by consumers (residential, commercial, and industrial, as well as the professionals that service energy-using equipment) of cost-effective energy efficiency practices. Market transformation also seeks to ensure sufficient supplies of technologies and practitioners to meet the subsequent increased demand for energy efficiency. A market transformation program is thus designed to create a situation where the bulk of the private market automatically adopts or incorporates technologies or techniques that result in improved energy efficiency. The goal of a market transformation and technology development program is to position energy efficiency technologies and practices so that they will be demanded by the public, chosen by builders and manufacturers, and provided by retailers and contractors. Methods of transformation can be different for each technology or technique but often revolve around public and private review of quality and effectiveness, including partnerships between government agencies, retailers, manufacturers, and nongovernmental agencies. Market transformation programs can be statewide or regional.

Policy Design

Market transformation is an important goal for Montana and an important mechanism for cost-effectively bringing energy-efficient products and services to consumers. It is recognized, however, that Montana constitutes a limited market, by itself, for energy-efficient products. As a result, Montana should focus its efforts on joining, supporting, or increasing its participation in regional market transformation alliances (e.g., the Northwest Energy Efficiency Alliance [NEEA] and the Midwest Energy Efficiency Alliance) that develop and implement technologies for reduction of energy use and GHG emissions. This could include working to extend market transformation efforts currently focused on specific parts of the state to consumers statewide, as well as expanding the number and types of different energy-efficient products included in market transformation efforts in Montana.

Market transformation and technology development efforts should stress addressing technologies of particular significance to Montana. One example is the testing and monitoring of residential and commercial high-efficiency structures to determine their performance under Montana conditions and to identify barriers to implementation of energy-efficient building practices.

The state should consider the establishment of an independent entity or an entity within state government to assess cost-effective efficiency potential (per the EPS in RCII-1) and should work with other states in the region to assess efficiency potential. In developing a new or extended market transformation effort for Montana, the lessons learned from previous efforts should be carefully incorporated, and the costs to state government and to consumers of an extended market transformation program should be carefully evaluated.

Goals: By 2009, put in place mechanisms to allow broader coverage of market transformation programs in Montana to additional geographic areas and also with regard to technologies covered.

Timing: As above.

Parties Involved:

- State government,
- Utility companies,
- Professional and trade organizations,
- Non-profit organizations, and
- Educational institutions.

Other: Under development.

Implementation Mechanisms

The following are some of the important implementation mechanisms for this option.

Information and education: Education is a key component to convincing consumers to use a new or different product that will result in energy savings. Residential, commercial, institutional, and industrial consumers of energy can influence the products and services available by demanding more efficient choices as well as by purchasing efficient choices that are offered. Education of professionals who set standards or specify particular appliances and equipment is particularly needed. These groups would include architects, engineers, builders, contract managers, and purchasing agents

Electricity and gas pricing: Appropriate pricing will encourage purchase of higher efficiency appliances and equipment or control systems.

Rebates for high-efficiency appliances and equipment: As applicable and appropriate, rebate offers for high-efficiency appliances and equipment such as high-efficiency front-loading clothes washers, may be needed to spur market acceptance. These could be offered in conjunction with utility DSM programs.

Tax incentives: Tax credits or deductions for the purchase of higher efficiency appliances and equipment would offset the often higher first cost to purchase these appliances and equipment. Existing tax incentives could be expanded. It would be important to ensure that older equipment was disposed of in a manner that took it out of the market place rather than just adding additional appliances and equipment.

Financing mechanisms: All consumers, whether residential, commercial, institutional, or industrial, should have financing mechanisms easily available for energy efficient improvements.

These mechanisms could include:

- Residential—A revolving loan program similar to the Alternative Energy Revolving Loan Program or a program of conventional bank loans to fund investments in efficient appliances and equipment. Partnerships with financial institutions should be explored to make funds readily available at favorable interest rates. (For example, one credit union has been offering slightly lower interest rates for consumers who purchase hybrid autos.)
- Commercial—Technical and financial assistance to encourage businesses to invest in energy efficiency needs to be examined. This should include assistance with choosing and purchasing more efficient equipment and designing and installing more efficient manufacturing processes, as well as investing in building efficiency upgrades for owned and leased space.
- Institutional—Schools should be encouraged to take advantage of the performance contracting mechanisms made available by the 2005 Legislature (90-4-1103 MCA). Financing available through the Board of Investments for schools should be expanded to provide adequate funding to take advantage of attractive efficiency improvement opportunities. The state buildings energy program should be expanded to rapidly acquire energy efficiency upgrades, including emphasizing the use of new products and technologies to improve the energy efficiency of state buildings (see RCII-12).
- Industrial—Financing options to provide mechanisms to increase the rate of industrial energy-efficiency improvements need to be explored.

Technical assistance and Montana-specific information: Technical assistance specific to Montana's climate, resources, and cost of energy needs to be readily available to consumers in all sectors. This assistance would be most effective if provided by a combination of experts from MDEQ, professional organizations, nonprofit groups, and utility companies.

Related Policies/Programs in Place

The NEEA (www.nwalliance.org) is a nonprofit corporation supported by electric utilities, public benefits administrators, state governments, public interest groups, and energy efficiency industry representatives. These entities work together to make affordable, energy-efficient products and services available in the marketplace.[7]

NEEA participation is limited, in principle, to utilities west of the continental divide (in BPA's service area). NorthWestern Energy (NWE), BPA, and electric cooperatives in the BPA service area are all partners in NEEA and provide some funding. The electric cooperatives outside the BPA service area and Montana–Dakota Utility are not partners.

The Midwest Energy Efficiency Alliance: This group (www.mwalliance.org) uses a similar model of partners and goals but does not currently cover Montana, extending only as far west as Illinois. However, utilities in the eastern portion of Montana might find stronger connections with programs in this area.

Bonneville Power Administration: Montana has participated in a number of market transformation efforts with the BPA and the states of Oregon, Washington, and Idaho. These

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[7] See http://www.nwalliance.org/aboutus/index_aboutus.aspx

efforts have been effective in gaining a higher level of efficiency in new construction in the region. However, the efforts have focused primarily on western Montana, where funding was available for programs because that region is within the service territory of the BPA. Transfer of results to eastern Montana is occurring at a slower pace.

Department of Environmental Quality: The MDEQ provides technical assistance on energy efficiency and renewable energy; offers a loan program for renewable energy applications and financing for the improvement of state government buildings; trains builders and code officials; provides information to consumers; assists schools in entering into energy performance contracts; convenes working groups to further the development of wind, geothermal and biofuels; and collects data on energy use in the state. MDEQ actively participates in market transformation efforts with NEEA and transfers results of this work to areas outside of NEEA service territories as much as possible with very limited funding. The MDEQ offers these services primarily using federal grants from the US DOE and is designated as the State Energy Office to provide these services.

Montana State University–Integrated Design Lab: The Integrated Design Lab provides education and consulting and technical services to architects and engineers on energy-efficient lighting designs. Services offered through the lab include daylighting and electric lighting analysis, lighting system consultations, and education on efficient lighting techniques.

Type(s) of GHG Reductions

As with RCII-1, this option would principally yield reductions in GHG emissions (largely CO_2) from avoided electricity production and avoided on-site fuel combustion. Less significant are the reduction in CH_4 emissions from avoided fuel combustion and avoided pipeline leakage. Other GHG impacts are also conceivable but are likely to be small (black carbon, N_2O) and/or very difficult to estimate (e.g., materials use, life cycle, market leakage)

Estimated GHG Reductions and Costs (or Cost Savings)

	Policy	Scenario/Element	Reductions		Cumulative Reductions 2007–2020 (MMtCO$_2$e)	NPV 2007–2020 ($ Millions)	Cost-Effective-ness ($/tCO$_2$)
			2010	2020			
RCII-2	Market Transformation and Technology Development Programs		0.03	0.30	1.9	–$43	–$23

Data Sources: Market transformation program costs and performance based on programs and experience of the NEEA.

Quantification Methods: Apply program results, expressed in percent savings, from the Northwest to Montana.

Key Assumptions:

- Market transformation programs can reduce electricity demand by 0.2% annually.

- Implementation of specific measures and programs must be timed correctly for maximum impact on market adoption of new technologies.
- Avoided cost for electricity as noted in RCII-1.

Key Uncertainties

Degree to which savings from regional efforts will continue to accrue as they have in the recent past; degree to which Montana consumers not in the NEEA area will be able to use or replicate successful NEEA programs.

Additional Benefits and Costs

Benefits

- The non-energy and non-emission benefits are almost always going to be the economic drivers behind the success of these programs. Focusing only on emission reductions or only on payback through the energy efficiency of the user will eliminate many technologies when they could otherwise provide substantial economic benefits. An example is an improvement to an industrial production line that may have negligible overall energy consumption reduction at the plant but that decreases the energy consumption per unit produced (energy intensity) while speeding up production and retaining jobs in the state.
- Co-benefits could include transmission/distribution system costs reduction.
- Programs could help lower capital and installation costs.

Costs

None cited.

Feasibility Issues

None cited.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

RCII-3. State-Level Appliance Efficiency Standards and State Support for Improved Federal Standards

Policy Description

Appliance efficiency standards reduce the market cost of energy efficiency improvements by incorporating technological advances into base appliance models, thereby creating economies of scale. Appliance efficiency standards can be implemented at the state level for appliances not covered by federal standards, or where higher-than-federal standard efficiency requirements are appropriate.[8] Regional coordination for state appliance standards can be used to avoid concerns that retailers or manufacturers may a) resist supplying equipment to one state that has advanced standards or b) focus sales of lower efficiency models on a state with less stringent efficiency standards.

Policy Design

In recognition of the fact that Montana represents, on its own, a relatively limited market for appliances and equipment, this policy is designed to encourage the state to work with other states and with regional entities,[9] to

- Review federal appliance standards and work with federal agencies and others toward raising federal appliance and equipment energy efficiency standards where applicable.
- Implement, in concert with other states, higher-than-federal energy efficiency standards for appliances where technological advances allow. Analyses of possible energy efficiency standards that can be enacted at the state level are available at www.standardsasap.org[10] Draft legislative language can be found at http://www.apolloalliance.org/strategy_center/model_legislation/eelegis.cfm
- Develop and implement standards for residential-sector appliances not currently covered by federal standards.

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[8] In recent years, Arizona, Oregon, and Washington, among other states, adopted state standards for several appliances; this led to the inclusion of standards for these appliances in the 2005 federal energy bill.

[9] The CCAC noted the desirability of working with adjacent states, including Idaho and Wyoming, to adopt uniform standards, and possibly adopting standards across a wider region of the West, possibly including states covered in the Western Systems Coordinating Council.

[10] Appliances and equipment noted by the American Council for an Energy-Efficiency Economy and the Appliance Standards Awareness Project (in their report *Leading the Way: Continued Opportunities for New State Appliance and Efficiency Standards,* dated March 2006 (available at http://www.standardsasap.org/documents/a062.pdf) as being candidates for new or more stringent state-level standards included “bottle-type water dispensers, commercial boilers, commercial hot food holding cabinets, compact audio products, DVD players and recorders, liquid-immersed distribution transformers, medium-voltage dry-type distribution transformers, metal halide lamp fixtures, pool heaters, portable electric spas (hot tubs), residential furnaces and boilers, residential pool pumps, single-voltage external AC to DC power supplies, state-regulated incandescent reflector lamps, and walk-in (commercial) refrigerators and freezers.” Other devices sometimes mentioned as candidates for state-level standards (or for federal standards) include ceiling fans and ceiling fan light kits and commercial clothes washers.

- Develop and implement standards for commercial-sector appliances and equipment not currently covered by federal standards.

It is anticipated that the process of setting higher energy efficiency standards in Montana, in concert with other states, will encourage higher federal standards and higher volume manufacturing of higher efficiency appliances and equipment, resulting in wider distribution and likely lower prices for these devices.

Goals: Review standards and report to Governor by 2008, with adoption of changes in standards by 2009 (activities designed to be timed to coordinate with consideration of energy matters by the Montana State Legislature).

Timing: as above.

Parties Involved:

- Electric and gas utilities;
- State government agencies, including the MDEQ, the Department of Labor and Industry, and the Department of Commerce;
- Appliance manufacturers and appliance/equipment industry representatives; and
- Other states, particularly northwest states.

Other: None cited.

Implementation Mechanisms

Potential implementation mechanisms and supporting activities for this option include

Appliance standards: These could be promulgated by legislation or developed administratively.

Low-income assistance programs: Financial assistance to help low-income consumers with purchase of appliances meeting more stringent standards to reduce the higher-first-cost burden of higher efficiency appliances on those consumers.

State Lead by Example: Elevated energy standards for appliances and equipment purchased by public agencies.

Impacts on manufacturers: Work with manufacturers and consider impacts on manufacturers when setting new standards.

Related Policies/Programs in Place

None cited.

Type(s) of GHG Reductions

GHG impacts are similar to those noted for RCII-1 and RCII-2 above.

Estimated GHG Reductions and Costs (or Cost Savings)

	Policy	Scenario/Element	Reductions		Cumulative Reductions 2007–2020 (MMtCO$_2$e)	NPV 2007–2020 ($ Millions)	Cost-Effective-ness ($/tCO$_2$)
			2010	2020			
RCII-3	State-Level Appliance Efficiency Standards and State Support for Improved Federal Standards	Electricity Plus Natural Gas	0.05	0.20	1.5	–$55	–$36
		Electricity Savings	0.05	0.17	1.3	N/A	N/A
		Natural Gas Savings	0.00	0.03	0.2	N/A	N/A

N/A = not applicable.

Data Sources: Fractional savings and costs drawn from the Appliance Standards Awareness Project (ASAP) and American Council for an Energy-Efficient Economy (ACEEE), 2006. “Leading the Way: Continued Opportunities for New State Appliance and Equipment Efficiency Standards.”[11]

Quantification Methods: Results for Montana from the report above adapted by adjusting for different analysis period, discount rate, and energy prices.

Key Assumptions: Costs and savings from efficiency improvements via standards will be similar in Montana to those indicated in the ASAP/ACEEE report cited above.

Key Uncertainties

The effectiveness and cost-effectiveness of the higher-than-federal standards adopted by Montana will depend, in part, on the standards implemented by other states, including other states in the region.

Additional Benefits and Costs

Benefits

Reduction in water use for some appliance upgrades.

Costs

None cited.

Feasibility Issues

Feasibility enhanced by ongoing efforts in nearby states.

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[11] See, for example, the following from the Appliance Standards Awareness Project (ASAP) Web site: http://www.standardsasap.org/documents/a062states.htm and http://www.standardsasap.org/documents/a062_mt.pdf

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

RCII-4. Building Energy Codes

Policy Description

Building energy codes specify minimum energy efficiency requirements for new buildings or for existing buildings undergoing a major renovation. Given the long lifetime of most buildings, amending state and/or local building codes to include minimum energy efficiency requirements and periodically updating energy efficiency codes could provide long-term GHG savings. Implementation of building energy codes, particularly when much of the building occurs outside of urban centers, can require additional resources.

Policy Design

The proposed policy to improve energy efficiency–related elements of building codes in Montana to reduce the amount of fossil fuel energy input needed to operate buildings in the state, includes the following elements:

- Undertaking a comprehensive review of existing building codes in Montana to determine where increased energy efficiency can be achieved.
- Increasing standards such that the minimum performance of new and substantially renovated buildings, both commercial and residential, is at least 15% higher by 2010 than that required by today's building codes (International Energy Conservation Codes [IECC] 2003, though IECC 2006 codes are under consideration), and 30% higher by 2020.
- Encouraging and working toward achieving the goal of "carbon-neutral"[12] status for new buildings. Reductions in GHG emissions related to building energy use can be achieved through a combination of increased energy efficiency, switching to low- and no-carbon fuels (including solar energy) for previously fossil-fueled end-uses, purchases of "green power" from off-site providers, and/or installing on-site power generation fueled by renewable energy sources.
- Encouraging the use of recycled and local building materials.
- Expressing energy efficiency standards on a per-unit-floor-space basis for commercial buildings, and on a per-dwelling-unit basis for residential buildings.
- Periodically and regularly (no less frequently than every 3 years) reviewing building codes, including energy efficiency requirements of building codes, to ensure that they stay up-to-date. Include a review of standards related to air infiltration, building "tightness," and related ventilation requirements.
- Offering, and requiring as appropriate, education to equip building code officials, builders, designers, and others to effectively implement building energy code improvements. This might include, for example, developing a corps of licensed independent contractors who

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[12] "Carbon-neutral" status for a building means that any energy needs of a building, net of building design to reduce energy use and of on-site renewable energy use, should be supplied by renewable energy sources (such as "green power").

could inspect buildings for compliance with the new energy codes, especially in rural areas that currently may have minimal code inspection.

- Exploring new mechanisms, such as working with financial institutions, and the use of spot checks, to improve code implementation in rural areas.

Goals: See above.

Timing: See above. Code and enforcement changes begin to take effect in 2008.

Parties Involved:

- Building Codes Council, which includes representatives from the League of Cities and Towns as well as builders, engineers, local government officials, and representatives of state agencies;
- Code-enforcing jurisdictions;
- Citizens/consumer advocates, including expanding Council membership to include citizen representation;
- Department of Labor and Industry;
- MDEQ; and
- Electric utilities.

Other: Under development.

Implementation Mechanisms

Education and Technical Assistance: Education is expected to be a significant component of improving building codes. It may be necessary to increase the training of code officials, builders, and others and provide consumer education on building energy use. Continuing education programs for builders and others may be helpful in improving compliance with new codes.

Statewide Building Permit Program: Institute a statewide building permit program to ensure consistency with regard to code application and enforcement among buildings built in both urban and rural areas.

Additional Code Enforcement: Consider providing additional code enforcement to improve understanding of and compliance with more rigorous energy efficiency codes.

Utility Assistance: Consider using utility resources to help implement building energy codes—for example, having utilities review building designs and monitor energy performance. Utilities might play a role in enforcement through the application of interconnection rules, tariffs, and connection charges that encourage the construction of buildings that use energy efficiently and at an appropriate level.

Related Policies/Programs in Place

Building Codes: Montana has previously adopted the 2003 version of the IECC. The Montana Building Codes Council will consider adoption and amendments to the 2006 IECC during meetings sometime in 2007.

Legislative Interest: Recent legislative interest in state energy efficiency building codes is indicated by the 2003 Montana Senate Joint Resolution (No. 13), which called for "an interim study to investigate options for improving energy efficiency building codes laws and other energy efficiency and conservation practices."[13]

Type(s) of GHG Reductions

CO_2 reduction from avoided electricity production and avoided on-site fuel combustion.

Modest reduction in CH_4 emissions from avoided fuel combustion and avoided natural gas pipeline leakage, relatively small reductions in N_2O and black carbon emissions from avoided fuel consumption.

Estimated GHG Reductions and Costs (or Cost Savings)

	Policy	Scenario/Element	Reductions		Cumulative Reductions 2007–2020 ($MMtCO_2e$)	NPV 2007–2020 ($ Millions)	Cost-Effective-ness ($/$tCO_2$)
			2010	2020			
RCII-4	Building Energy Codes	Electricity Plus Natural Gas	0.03	0.25	1.6	–$15	–$10

Data Sources: WGA CDEAC EE report and detailed results prepared for that report by the Building Code Assistance Project (BCAP); US DOE Building Energy Survey and related documents. (Note that state-level building activity/building stock statistics were not available for this analysis.) BCAP analyses by state (including Montana) to derive base savings.

Quantification Methods: Apply general BCAP method to estimate code savings, but apply 15% and 30% target savings figures.

Key Assumptions: Average costs of building code improvements, ratio of gas improvements to electricity improvements.

Key Uncertainties

Relative cost of code improvements that are more aggressive than those reflected in the WGA analysis.

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[13] See http://data.opi.mt.gov/bills/2003/billhtml/SJ0013.htm

Additional Benefits and Costs

Benefits

- Potential to also yield water savings, comfort and indoor air quality improvements, with related improvements in health and productivity.
- Saving consumers and businesses money on their energy bills. More stringent energy codes for buildings will benefit low-income tenants by reducing their monthly energy bills.
- Reducing dependence on imported fuel sources and reducing vulnerability to energy price spikes.
- Electricity system benefits: reduced peak demand, reduced capital and operating costs, improved utilization and performance of the electricity system, reduced pollutant emissions from power plants and related public health improvements, and reduced water use in power plants.
- Supporting local businesses and stimulating economic development

Costs

None cited.

Feasibility Issues

Interaction with appliance standards and utility programs.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

RCII-5. “Beyond Code” Building Design Incentives and Mandatory Programs

Policy Description

This policy provides incentives and targets to induce the owners and developers of new and existing buildings to improve the efficiency with which energy and other resources are used in those buildings, along with provisions for raising targets periodically and resources to help achieve the desired building performance. Many “green building” programs have been developed that define standards for efficient energy and resource use and that encourage demand for these green buildings through recognition, incentives, and government mandates.[14] This policy includes elements to encourage the improvement and review of energy use goals over time and to encourage flexibility in contracting arrangements to encourage integrated energy- and resource-efficient design and construction.

Policy Design

A combination of financial incentives and regulatory policies would be used to induce owners and developers of new and existing buildings to improve their structures, or to build new structures that exceed energy efficiency (and net GHG emissions) provisions of building codes in force.

Goals:

- Reduce per-unit-floor-area consumption of grid electricity and natural gas by 20% by 2020 in existing buildings and by 50% in new buildings by 2020. Up to 10% of the targeted reduction for new homes can come from use of off-site electricity generation from renewable energy.[15] These requirements should be phased in over time and will have the following targets:
- Improve 25% of existing residential units in Montana by the year 2020.
- Improve 25% of existing commercial floor space in Montana by the year 2020.
- Provide incentives such that 25% of new or substantially remodeled residential units in Montana exceed building energy and GHG emissions codes in force by 20% in existing residences and 50% in new residences by the year 2020.
- Provide incentives such that 25% of new or substantially remodeled commercial floor space in Montana exceeds building energy and GHG emissions codes in force by 20% in renovated buildings and 50% in new buildings by the year 2020.

Timing: See above.

Parties Involved:

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[14] Existing programs include EPA’s Energy Star Homes and Leadership in Energy and Environmental Design (LEED).

[15] Note that this limit on the use of renewable off-site electricity generation is assumed to count only the renewable fraction of electricity purchased that is beyond that included in any statewide RPS.

- MDEQ, Department of Labor and Industry, local government permitting agencies;
- Utilities;
- Financial services industries; and
- Building industries.

Other: Under development.

Implementation Mechanisms

Implementation mechanisms, as noted above, could include a combination of financial assistance, special regulatory or administrative consideration for buildings projects that achieve "beyond code" performance, and other types of incentives. The following are specific examples of such mechanisms.

Fee Adjustments: Offering programs to adjust impact fees or connection fees—such as reduced fees for sewer and water hookups for homes that use less hot and cold water—for new and upgraded existing buildings that meet specific higher-than-code energy efficiency standards. Municipalities could be compensated for fee reductions from a revolving loan fund or by some other mechanism. Develop systems and programs that recognize reduced impacts and adjust fees accordingly. Such fees adjustments could be made by utilities, municipalities, or other entities, as applicable.

Permitting Advantages: Offer regulatory advantages, such as fast-track (expedited review) processing of applications, for buildings certified as having "beyond code" energy efficiency and environmental performance.

Rewards Programs: Develop systems and programs that reward "beyond code" energy efficiency and emissions reduction improvements, including "green mortgages," or adding "points" in project review processes for building features that meet or exceed environmental targets.

Property Tax Adjustments: Consider property tax adjustments that waive all or a portion of additional taxes on investments for improving building performance to "beyond code" levels.

Increased Tax Incentives: Increase existing tax incentives for building energy efficiency improvements.

Related Policies/Programs in Place

Existing Montana Residential Energy Tax Credits for selected energy efficiency improvements.

Type(s) of GHG Reductions

- CO_2 reduction from avoided electricity production and avoided on-site fuel combustion.
- Modest reduction in CH_4 emissions from avoided fuel combustion and avoided natural gas pipeline leakage, relatively small reductions in N_2O and black carbon emissions from avoided fuel consumption.

Estimated GHG Reductions and Costs (or Cost Savings)

	Policy	Scenario/Element	Reductions		Cumulative Reductions 2007–2020 (MMtCO$_2$e)	NPV 2007–2020 ($ Millions)	Cost-Effective-ness ($/tCO$_2$)
			2010	2020			
RCII-5	“Beyond Code” Building Design Incentives and Mandatory Programs	Electricity Plus Natural Gas	0.07	0.52	3.4	–$17	–$5
		Electricity Savings	0.06	0.43	2.8	–$9	–$3
		Natural Gas Savings	0.01	0.09	0.54	–$8	–$15

Data Sources: Costs of energy efficiency improvements based on studies of costs of building improvements and code changes.

Quantification Methods: Estimates of fractional savings in energy intensities needed to meet targets in new commercial and residential buildings. Allocates intensity savings among energy efficiency, renewable energy sources, and off-site green power.

Key Assumptions: Fractions of electric and gas intensity improvement accounted for by efficiency improvements, solar thermal, solar PV, increased biomass use, and purchases of renewable-generated power from off-site; fractional savings targets over (new) code levels; growth in housing stock and commercial sector floor space (linked to projections of Montana population growth); and incremental cost of green power.

Key Uncertainties

- Total commercial building space in Montana (regional estimates can be adapted to provide estimates if needed).
- Fractions of new and existing commercial buildings, and residential units, participating in program.

Additional Benefits and Costs

Benefits

Potential to also yield water savings and comfort and air quality improvements.

Costs

None cited.

Feasibility Issues

Interaction with appliance standards and energy efficiency programs.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

RCII-6. Consumer Education Programs

Policy Description

The ultimate effectiveness of emissions reduction activities in many cases depends on providing information and education to consumers, as well as to future consumers (primary and secondary school students), regarding the energy and GHG emissions implications of consumer choices. Public education and outreach is vital to fostering a broad awareness of climate change issues and effects (including co-benefits such as clean air and public health) among the state's citizens. Such awareness is necessary to engage citizens in actions to reduce GHG emissions. Public education and outreach efforts should integrate with and build upon existing outreach efforts involving climate change and related issues in the state. Ultimately, public education and outreach will be the foundation for the long-term success of all of the mitigation actions proposed by the CCAC, as well as those that may evolve in the future.

To effectively implement many of the other options in the residential, commercial, institutional, and industrial sectors, as well as in other sectors, specific and targeted education, outreach, and licensing requirements will be required for professionals in a variety of building-related and other trades to ensure that they have the expertise to support aggressive GHG mitigation options in Montana.

Policy Design

Elements of the design for this policy will

- Offer consumer education related to energy efficiency and the environmental consequences of energy and other choices.[16] Dovetail with public broadcasting media.
- Direct the Montana Office of Public Instruction and others to develop and implement curricula for primary and (particularly) secondary schools that educate students so that they can evaluate the implications of consumption choices.
- Implement and enhance professional education and certification programs for teachers and for those involved in providing products and services related to energy use and GHG emissions, so as to build the statewide pool of individuals trained to support RCII and other policy options. This training for professionals (including architects, engineers, builders, code inspectors, lighting and heating, ventilation, and air conditioning (HVAC) equipment installers, electricians, plumbers, and others) who advise the public on energy choices is seen as a crucial component to the success of other RCII initiatives.
- Provide education programs with a strong focus on energy savings in existing buildings that include follow-up surveys on the actions that have been implemented by participants.
- Educate businesses and retailers about the GHG emissions associated with products and supply chains. Explore regional efforts to rate the GHG emissions of products.

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[16] Note that there is overlap between this RCII option and some of the elements of an option (CC-4) being elaborated by the Cross-Cutting TWG.

- Discourage use of excessive lights, such as yard lights and unneeded street lights. The following are some possible guidelines:
    - Allow only cutoff or semi-cutoff luminaries.[17]
    - Allow only fluorescent lighting or high-intensity discharge (HID) bulbs in yard lights (no incandescent bulbs).
    - Limit lighting levels on pedestrian walkways to 1.0 fc (foot-candles) on the horizontal and vertical planes.
    - Limit lighting levels in parking areas to an average of 1.5 fc on the ground plane, with a uniformity ratio of 6:1 and a minimum of 0.25 fc.
    - Limit lighting levels on community roadways to 1.0 fc on the ground, with a 3:1 uniformity ratio.
    - Limit lighting levels for main roads to 1.5 fc.
    - Limit lighting levels for building entryways to 3.0 fc.
    - Encourage the use of motion detection switches and other types of control mechanisms to minimize the use of lights when they are not needed.

  Quantitative analysis of the impacts of these lighting guidelines is not expected to be undertaken.

Goals: Educate consumers, businesses, retailers, and children so they can make informed choices to reduce energy use, improve efficiency, and reduce environmental consequences of their actions. Educate energy efficiency professionals so they can better inform consumers and make wise decisions.

Timing: Synchronize education initiatives with development and implementation of other RCII options so that those who will make decisions related to energy efficiency and GHG emissions reduction and those who will implement improvements will have the background to do so effectively.

Parties Involved:

- Utilities,
- Government agencies (local, state, and federal),
- Private entities,
- Primary and secondary schools,
- Building trade organizations,
- Extension services, and

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[17] To reduce glare, cutoff luminaires (light fixtures) allow very little or no light above the horizontal (a maximum of 2.5% of the fixture's light output at an angle of 90 degrees from the fixture, and 5% at an angle of 80 degrees from the fixture), and semi-cutoff luminaires produce limited light above the horizontal (a maximum of 5% of the fixture's light output at an angle of 90 degrees from the fixture, and 20% at an angle of 80 degrees from the fixture). See, for example, http://www.lrc.rpi.edu/programs/NLPIP/lightinganswers/lightpollution/cutoffShielded.asp#

- Colleges and universities (including involving both in the development of curriculum for education programs)

Other: Additional discussion of information and education under Cross-Cutting recommendations, CC-4.

Implementation Mechanisms

The following are potential implementation mechanisms for this option.

Financial Support for Training: Financial support for energy efficiency training sessions. This could involve, for example, funding to bring in speakers and organize workshops and conferences.

Advertising: Wide advertisement of education and training sessions and regular and consistent offering of such services.

Incentives: Offering incentives or vouchers (e.g., for energy efficient products or other goods or services) for consumers who undertake consumer education and/or change their consumption patterns so as to reduce GHG emissions (this could be applied in a manner analogous to safe driver discounts for car insurance).

Education for Primary and Secondary School Children: Develop or improve curricula for primary and secondary schools on the topics of energy efficiency and GHG emissions and climate change so that students can evaluate the impacts of the choices they make.

Related Policies/Programs in Place

Training for Building Professionals: Some training is provided by professional organizations, utility companies, and MDEQ.

Education: Montana Energy Education Council (MEEC) provides training for teachers and students on energy.

Dark Sky Ordinance: In Bozeman, the Dark Sky ordinance limits light pollution by regulating outdoor lighting.

Type(s) of GHG Reductions

These education and information programs are crucial in enabling and supporting GHG emissions reductions in a number of RCII areas and in other sectors, but their direct GHG reduction impacts are very difficult to assess.

Estimated GHG Reductions and Costs (or Cost Savings)

Because this option supports many other RCII (and some ES) options and because it is difficult to attribute specific GHG-savings, the emissions reductions associated with this option will not be quantified.

Data Sources: Under development.

Quantification Methods: Under development.

Key Assumptions: Under development.

Key Uncertainties

None cited.

Additional Benefits and Costs

None cited.

Feasibility Issues

Potential contribution of consumer education programs to reducing GHG emissions is difficult to estimate.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

RCII-7. Support for Implementation of Clean Combined Heat and Power

Policy Description

Distributed generation with clean combined heat and power (CHP) systems reduces fossil fuel use and GHG emissions both through the improved efficiency of the CHP systems, relative to separate heat and power technologies, and by avoiding transmission and distribution losses associated with central power stations that are located far away from where the electricity is used. Implementation of these systems by residential, commercial, institutional, and industrial energy consumers should be encouraged through a combination of regulatory changes and incentive programs.

Policy Design

The Energy Supply TWG developed a similar option as a part of ES-4, "Incentives and Barrier Removal (Including Interconnection Rules and Net Metering Arrangements) for Combined Heat and Power (CHP) and Clean Distributed Generation (DG)." Please see description of ES-4 for additional details.

Goals: See ES-4 description.

Timing: See ES-4 description.

Parties Involved: See ES-4 description.

Other: See ES-4 description.

Implementation Mechanisms

See ES-4 description.

Related Policies/Programs in Place

See ES-4 description.

Type(s) of GHG Reductions

CO_2 reduction from avoided electricity production and avoided on-site fuel combustion less additional on-site CO_2 emissions from fuel used in CHP systems.

Other gases: Modest potential changes in emissions of CH_4 from avoided fuel combustion and avoided natural gas pipeline leakage, net of any additional on-site emissions or additional leakage from increased gas use, likely relatively small reductions in emissions of N_2O from avoided fuel combustion, net of any increased on-site emissions, and also some possible small net changes in emissions of black carbon, depending on the balance between avoided and additional consumption of oil, coal, and biomass fuels, and of emission control.

Estimated GHG Reductions and Costs (or Cost Savings)

See ES-4 description.

Data Sources: See ES-4 description. Includes estimates of potential from WGA *Clean and Diversified Energy Initiative Combined Heat and Power White Paper* (January 2006).

Quantification Methods: See ES-4 description. Approach is modeling of the incremental implementation of a target fraction of Montana's CHP potential achieved through adoption of CHP systems fueled with gas, coal, or biomass.

Key Assumptions: See ES-4 description. Includes CHP generation capacity (as a fraction of Montana's potential, by sector) achieved via this option, and types of fuels used in CHP.

Key Uncertainties

- Ultimate CHP potential in Montana.
- Heating fuels and electricity actually displaced by CHP.

Additional Benefits and Costs

Benefits

- Programs could help to lower capital and installation costs of CHP.
- Develop local expertise with CHP systems.
- Develop market for locally derived biomass fuels.
- Utility system co-benefits.
- Cost savings and decreased impacts of transmission and distribution (by deferring or displacing the need for additions).

Costs

None cited.

Feasibility Issues

None cited.

Status of Group Approval

Completed (as a part of ES-4).

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

RCII-8. Support for Renewable Energy Applications

Policy Description

Distributed electricity generation sited at residences and commercial and industrial facilities and powered by renewable energy sources (typically solar but also wind and hydro), displaces fossil-fueled generation and avoids electricity transmission and distribution losses, thus reducing GHG emissions. This policy can also encourage consumers to switch from using fossil fuels to using renewable fuels in applications such as water, process, and space heating, as well as to supply new energy services using fuels that produce low or no GHG emissions. Increasing the use of renewable energy applications in homes, businesses, and institutions in Montana can be achieved through a combination of regulatory changes and incentives.

Policy Design

This policy was also developed in the Energy Supply section under option ES-4 and considered by the Agriculture, Forestry and Waste Management (AFW) sector under option AFW-7. More details on the policy are provided as part of the description of option ES-4.

The design of this policy may include the following elements:

- Utility incentives for consumers to develop distributed generation, including net metering policies.
- Removal of barriers to the implementation of distributed generation, including revising interconnection rules as appropriate.
- Tax or other incentives, or favorable tax treatment, for investments in distributed generation.

This policy encompasses solar (thermal and photovoltaic) systems and biomass fuels for use in homes and business, as well as geothermal (ground source) heat pumps.

Goals: Goals for this option are incorporated in those developed as a part of Energy Supply option ES-4, “Incentives and Barrier Removal (Including Interconnection Rules and Net Metering Arrangements) for Combined Heat and Power (CHP) and Clean Distributed Generation (DG).” Current penetration of solar photovoltaic systems in the NWE service territory in Montana suggest that about 0.1% or less of Montana homes currently use these systems. The penetration of solar thermal water heating systems is also quite limited.

Timing: See ES-4 description.

Parties Involved: See ES-4 description.

Other: See ES-4 description.

Implementation Mechanisms

See ES-4 description.

Related Policies/Programs in Place

National “Million Solar Roofs” program, adopted in 1997, suggests a target of 1,000 home systems (of 3 kW) for Montana by 2010. NWE and other Montana utilities offer net metering programs for some distributed generation.

Type(s) of GHG Reductions

CO_2 reduction from avoided electricity production and avoided on-site fuel combustion.

Modest reduction in CH_4 emissions from avoided fuel combustion and avoided natural gas pipeline leakage, relatively small reductions in N_2O and black carbon emissions from avoided fuel consumption.

Estimated GHG Reductions and Costs (or Cost Savings)

See results and related material provided in the description for ES-4.

Data Sources: As above.

Quantification Methods: As above.

Key Assumptions: As above.

Key Uncertainties

None cited.

Additional Benefits and Costs

None cited.

Feasibility Issues

None cited.

Status of Group Approval

Completed (as a part of ES-4).

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

RCII-9. Carbon Tax

This option was being considered jointly with the Energy Supply TWG. See descriptions for options ES-8 and ES-9.

Policy Description

A CO_2 tax would be a tax on each ton of CO_2 emitted from an emissions source covered by the tax. A CO_2 tax could be imposed upstream based on carbon content of fuels (e.g., fossil fuel suppliers) or at the point of combustion and emission (e.g., typically large point sources such as power plants or refineries). Taxed entities would pass some or all of the cost on to consumers, change production to lower emissions, or a combination of the two. As the suppliers respond to the tax, consumers would see the implicit cost of CO_2 emissions in products and services and would adjust their behavior to purchase substitute goods and services that result in lower CO_2 emissions. CO_2 tax revenue could go completely to state revenue and be used in a variety of ways such as income tax reduction or policies and programs to assist with CO_2 reductions. CO_2 tax revenue can also be directed to helping the competitiveness of industries or assisting communities most affected by the tax.

Policy Design

The RCII TWG has coordinated with the Energy Supply TWG in considering and developing this option. The ES TWG has expressed the sense that a regional/national approach would be far preferable to Montana-alone tax (which should likely not be considered).

Goals: None identified.

Timing: None identified.

Parties Involved: None identified.

Other: None identified.

Implementation Mechanisms

Carbon tax revenues should be used, in part, to offset the impact of carbon taxes on low-income customers. This could be accomplished, for example (and as applicable) by using carbon tax proceeds to fund weatherization projects that will reduce energy costs for low-income households.

Related Policies/Programs in Place

See Annex 1: “Summary Table of Carbon Tax Programs,” for information on selected carbon tax initiatives to date in Europe, Japan, and North America.

Type(s) of GHG Reductions

See ES-8/ES-9.

Estimated GHG Reductions and Costs (or Cost Savings)

Largely a qualitative analysis focusing on review of existing studies germane to the Montana situation and on the impacts in Montana of the implementation of a national or regional carbon tax. The focus of analysis will thus be on regional programs and design elements rather than on specific quantification of this option.

Data Sources: See ES-8/ES-9.

Quantification Methods: See ES-8/ES-9.

Key Assumptions: See ES-8/ES-9.

Key Uncertainties

None cited.

Additional Benefits and Costs

None cited.

Feasibility Issues

None cited.

Status of Group Approval

Completed (as a part of ES-8/ES-9).

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

RCII-10. Industrial Energy Audits and Recommended Measure Implementation

Policy Description

This policy option includes providing industrial-sector energy technical assistance (energy audits) to identify and recommend options for reducing fossil energy and electricity use and for reducing non-energy emissions of GHGs. For example, an agency could be set up (or housed at an existing post-secondary institution) that hires experts who will visit industrial sites to assess current practices and equipment and provide recommendations for reducing GHG emissions. A combination of incentives, expertise, and information to implement recommended options are included in the policy to encourage the operators of industrial-sector facilities to follow up on audit recommendations.

Policy Design

The cost-effective potential for industrial electricity savings in Montana has been estimated at 40 to 84 MW. To address this potential, a program of energy audits for the industrial sector is recommended, coupled with a program of low- or no-interest loans designed to encourage industrial customers to take up energy efficiency measures that reduce both electricity and natural gas consumption.

Goals: The estimated cost-effective potential for industrial-sector electricity savings noted above (40 to 84 MW) is approximately 6% to 12 % of Montana's industrial-sector electricity use in 2005. Savings of 10% of industrial electricity and natural gas use is taken as an overall target for RCII-10 programs to achieve by 2020. The goal of this option is to address 8% of this (10% reduction in industrial electricity and gas use) target annually, starting in 2009 with a phase-in year, and continuing thereafter.

Energy consumers covered by this option, as a rule of thumb, are expected to be those with peak electricity demand of about 1 MW, using, for example, the qualification rules for self-directing universal systems benefits funds in Montana.[18]

Timing: As noted above.

Parties Involved:

- Industrial consumers of electricity and natural gas,
- State government agencies,
- Electric utilities,
- Industrial audit providers (engineers and technicians, including specialists in equipment for particular industries), and

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[18] See, for example, http://data.opi.state.mt.us/bills/mca/69/8/69-8-402.htm, Montana Annotated Code 2005, § 69-8-402, "Universal system benefits programs."

- Suppliers of industrial energy efficiency measures.

Other: None cited.

Implementation Mechanisms

Low-Cost Financing: Low- or no-interest loans for efficiency improvements, particularly for efficiency improvements for larger equipment.

Monitoring and Evaluation: Monitoring and evaluation arrangements to confirm effectiveness of installed measures, thus ensuring that emissions reduction levels are appropriately matched to incentives (including tax credits) awarded.

Energy Star Incentives: Provide incentives and information to encourage industries to adopt US EPA Energy Star standards and measures.

Tax Incentives: Tax incentives for industrial energy efficiency improvements, possibly as an extension to the energy-related tax incentives recently adopted by the legislature (House Bill [HB] 3 in the 2007 Special Session).

Waste Heat to Energy: Encourage collaboration between utilities and large industries that may have waste heat that could be tapped for power generation (this may also be an implementation option for RCII-7 and ES-4).

Self-Audits and Incentives: Offer opportunities for industrial facilities to self-identify measures for GHG reduction and to apply for incentives to implement identified measures that lead to demonstrable and cost-effective GHG emissions reduction.

Related Policies/Programs in Place

Universal Systems Benefit Funds: Industries may self-direct USB payments into their facilities for efficiency upgrades.

Montana Manufacturing Extension Service: MMES provides assistance to small manufacturing businesses to improve process and system efficiencies. While not targeted at energy use, energy can be a part of efficiency improvements.

Type(s) of GHG Reductions

GHG impacts are likely similar in nature to those noted for RCII-1 and other options above, except to the extent that audit recommendations included emissions reduction efforts that targeted non-energy emissions, GHG impacts will vary on a case-by-case basis.

Estimated GHG Reductions and Costs (or Cost Savings)

	Policy	Scenario/Element	Reductions		Cumulative Reductions 2007–2020 (MMtCO$_2$e)	NPV 2007–2020 ($ Millions)	Cost-Effective-ness ($/tCO$_2$)
			2010	2020			
RCII-10	Industrial Energy Audits and Recommended Measure Implementation		0.07	0.56	3.6	–$93	–$26

Data Sources: Estimate of cost-effective industrial-sector energy efficiency potential in Montana from John Campbell of NWE.

Quantification Methods: The savings target above, the rate at which it is addressed by the option, and the average (2005) consumption of electricity and gas per industrial consumer are used to derive a target number of audits per year which, in turn, is used to estimate electricity and natural gas savings, by year, from the option. The costs of saved energy from the measures applied under this option are calculated based on the assumptions regarding the average simple payback and lifetime of energy efficiency options noted below. Net costs of energy savings for electricity and natural gas are calculated as the difference between the cost of saved energy for the measures installed and the avoided costs for electricity and natural gas in Montana.

Key Assumptions:

- Cost-effective industrial electricity savings are as noted above and are available with an average simple payback of 2.5 to 3 years, based on industrial power costs.
- Available savings through industrial-sector natural gas measures are similar to those for electricity measures and provide similar simple paybacks.
- The average lifetime of industrial-sector energy efficiency improvements is taken to be 12 years.

Key Uncertainties

Actual savings available from industrial sector measures and average costs of those measures.

Additional Benefits and Costs

None cited.

Feasibility Issues

None cited.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

RCII-11. Low Income and Rental Housing Energy Efficiency Programs

Policy Description

Energy efficiency programs are a key component of other RCII options, and energy efficiency programs typically yield significant economic benefits (as well as GHG reductions) to consumers who participate. Low-income consumers, however, are frequently unable to participate in energy efficiency programs because they lack funds to pay for improvements or, in the case of renters, an inability to either make changes to their residences or fully benefit from any cost savings. In recognition of this barrier, this policy urges the implementation of programs specifically targeted to the needs of low-income residents for services such as home weatherization or replacement of manufactured homes for which weatherization is inappropriate, updating or repairing inefficient appliances, and funding for renewable energy systems. These programs could be designed to offer low-income residents energy efficiency services with a minimum of up-front costs and should be marketed through an aggressive campaign of outreach to low-income households and communities. Programs designed to work with both landlords and tenants could also be considered and are particularly important in university towns where weatherization of rental homes is difficult due to a transient population, low tenant incomes, and a limited supply of housing.

Policy Design

Goals:

- Starting in 2009, increase energy efficiency by 30% in 50% of eligible low-income residential units in Montana by the year 2015.
- Increase energy efficiency by 50% in 75% of eligible low-income residential units in Montana by the year 2020.
- Eligible homes are those whose household income is below 150% of the federal poverty level.
- Extend program to rental housing in general.

Timing: As above.

Parties Involved:

- Government housing and other state and federal government agencies,
- Weatherization service providers,
- Owners of rental property,
- Tribal representatives and authorities,
- Community Action Agencies and Human Resource Development Councils,

- The Montana Conservation Corps working with and within the Governor's "Warm Hearts/Warm Homes" initiative,[19] and
- Nongovernmental organizations such as AARP Montana (formerly the American Association of Retired Persons), which can assist with education and outreach; Habitat for Humanity.

Other: None cited.

Implementation Mechanisms

Implementation mechanisms could include the following.

Energy Audits and Implementation: Residential energy audits and installation of measures identified as needed in the audits.

Grants: Weatherization grants to qualified homeowners.

Financing: Low-interest loan programs for homeowners and/or rental property owners or managers.

Education for Installers: Training programs for weatherization providers, possibly in collaboration with some of the parties noted above.

Replace Substandard Manufactured Housing: State support for financing or purchase of efficient manufactured housing to replace manufactured (or other) housing that cannot be practically weatherized.[20] Replaced homes will be permanently removed from the housing stock and their components will be recycled to the extent practicable.

Increase Efficiency in Program Delivery: Controlling overall program costs and increasing the number of homes that can be serviced by focusing on installation of measures shown by experience to provide significant energy savings in the majority of homes (such as additional ceiling insulation), even if a full assessment of energy efficiency improvement needs has not been performed on a given dwelling. This may include developing a list of prescribed measures (including, for example, R-38 ceiling insulation) to be applied to most of the homes weatherized.

Prioritize Services: Prioritize providing services to homes that currently have minimal weatherization, including homes that have already applied for services but have not yet received them because of a lack of resources.[21]

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[19] See, for example, http://deq.mt.gov/Energy/warmhomes/. Note that the residential weatherization activities currently performed by Conservation Corp staff are typically limited to rapid, low-cost or no-cost measures.

[20] An outlay of $354,886 was authorized in the Montana budget (HB 2 in the 2007 special session) for a revolving loan program for manufactured home replacement. See http://data.opi.mt.gov/bills/specsess/0507/billpdf/HB0002.05.pdf .

[21] Over time, as homes with minimal weatherization are serviced, it is possible that the amount of effort (and cost) required to raise the energy efficiency in the average home in the program to goal levels may rise. Improvements in weatherization technologies and in procedures for carrying out low-income and rental housing energy efficiency in Montana, however, may help to counteract this trend.

Additional implementation mechanisms aimed at rental dwellings could include the following.

Tax Credits for Landlords: Income tax credits for rental property owners who weatherize rental properties to meet energy efficiency standards set by the program.

Utility Bill Disclosure: Time of sale or rental disclosure of utility bills for a dwelling.

Tenants' Rights to Know Utility Costs: Tenants' rights laws relating to energy efficiency, possibly including tenants' rights to request an energy audit of their rental property.

Rental Property Efficiency Requirements: Command-and-control requirements similar to those applied to rental of private homes to vacationers, including, for example, a program for licensing or certification of the energy efficiency of rental properties.[22]

Related Policies/Programs in Place

Tax Credits: Last year 3% of eligible Montana households used state tax credits for energy conservation.

Low-Income Weatherization Assistance Program: This Department of Public Health and Human Services (DPHHS) program currently provides weatherization and related health and safety improvement services to about 1,700 qualifying low-income households annually, with average savings equal to about 22% of household energy use.

Warm Homes Campaign: Governor Schweitzer launched an initiative to provide assistance to all Montana households, but particularly to low-income households, in the winter of 2005–2006. This campaign focuses on neighbors helping neighbors and includes using the Montana Conservation Corps to provide simple weatherization in some homes each fall.

Type(s) of GHG Reductions

GHG impacts are likely to be similar to those noted for RCII-1 and other options related to building energy efficiency improvements.

Estimated GHG Reductions and Costs (or Cost Savings)

	Policy	Scenario/Element	Reductions		Cumulative Reductions 2007–2020 (MMtCO$_2$e)	NPV 2007–2020 ($ Millions)	Cost-Effective-ness ($/tCO$_2$)
			2010	2020			
RCII-11	Low Income and Rental Housing Energy Efficiency Programs		0.05	0.75	4.7	–$41	–$9

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[22] The overall energy consumption of a rental home is a function of both the energy efficiency of the home itself and of how the tenants use energy. Both parameters should be taken into account when judging whether a structure meets efficiency standards.

Data Sources: Average costs and savings achieved by low-income weatherization programs currently operating in Montana obtained from representatives of the DPHHS and the Missoula Community Action Program form the basis for extrapolation of per-household costs to reach the performance goals listed above.

Discussions with DPHHS experts involved in the existing Montana low-income household energy efficiency program have informed the revised estimates presented above.

Quantification Methods: Starting with an estimate of eligible low-income and rental households, estimate the rate of penetration of the program over time (with eligible households reduced by the number of households participating in the existing DPHHS program), and apply target savings rates and costs to estimate savings in electricity and heating fuel use, option total cost, and option cost net of avoided electricity and fuel costs.

Key Assumptions:

- Savings of 30% of energy use in low-income households are available at an average cost of $2,900 per housing unit for energy efficiency–related options.[23]
- Savings of 50% of energy use in low-income households are available at an average cost of $5,400 per housing unit for energy efficiency–related options.
- The average consumption of electricity, gas, and other heating fuels in low-income households is similar to the average consumption in all households in Montana.[24]
- The 2005 estimated fraction of persons with incomes below 150% of the federal definition of poverty, 23.7%, holds throughout the analysis period.[25] The same fraction of occupied housing units is assumed to be occupied by households with incomes below 150% of the poverty level. Based on U.S. Census Bureau statistics, this equates to about 20.3% of **all** Montana homes (occupied or not).
- An additional 14.6% of Montana housing units are rental units occupied by households with incomes above 150% of the federal definition of poverty and are thus eligible for the program.
- Low-income weatherization programs in Montana currently operating reach 1,700 households per year and continue to do so.

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[23] The existing MDEQ low-income assistance program also implements health- and safety-related measures that do not necessarily provide energy efficiency (or GHG-reduction) benefits. The average per-household costs shown are net of the estimated costs of these primarily health- and safety-related measures.

[24] This assumption should be reviewed but takes into account that although low-income homes may be smaller than average homes in Montana, they use more energy per unit floor space than average homes because of poor insulation and other problems. It may also be that low-income customers may depend on electric heating to a higher degree, on average, than other customers.

[25] 2005 fraction of Montana residents of all ages living at incomes below 150% of the poverty threshold, from http://pubdb3.census.gov/macro/032006/pov/new46_135150_01.htm. Data used to derive the fraction of rental units occupied by residents with incomes above the poverty level are from the U.S. Bureau of the Census 2005 American Community Survey, Table S2503: Financial Characteristics, accessed through http://factfinder.census.gov/, and from year 2000 U.S. Bureau of the Census data on the income level of households in rental units in Montana.

Key Uncertainties

None cited.

Additional Benefits and Costs

Benefits

Additional comfort for low-income residents.

Costs

None cited.

Feasibility Issues

None cited.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

RCII-12. State Lead by Example

Policy Description

The Montana state government can provide leadership in moving the state toward a stock of buildings with much higher energy efficiency and toward improving efficiency in the operations of state buildings. The proposed policy provides energy efficiency targets that are much higher than code standards for new state-funded buildings. Efficiency targets should also be applied to state-leased buildings and to other government buildings. The proposed policy also includes elements to encourage the improvement and review of efficiency goals over time and to encourage flexibility in contracting arrangements to encourage integrated energy efficient design and construction. Targets are also provided for upgrading energy efficiency in existing state government facilities.

Policy Design

Key elements of this policy include the following.

- New state government buildings will be in operation for many years and should be designed and constructed in a manner that greatly exceeds the minimum standards set by the building code for energy efficiency. If savings are not achieved in design and construction, opportunities for efficiency will be lost. Because buildings built for state government will be in operation for many years, savings will pay for themselves many times in operating costs reductions. All new state buildings should be should be Leadership in Energy and Environmental Design (LEED)-certified at the "silver" level,[26] and meet or exceed the energy efficiency and renewable energy goals below.
- Existing state government buildings should be upgraded for energy efficiency achieving 100% of cost-effective energy efficiency over a period of 15 years. To achieve this, all state buildings should be benchmarked in the next 3 years.
- State government should consider the environmental impacts as well as the energy efficiency of its operations. Waste should be reduced, recycling should be increased, and toxic or harmful chemicals should be avoided.
- Contracts for leasing building space and entering into building maintenance agreements for owned or leased buildings should require efficiency in operations.
- State government purchasers should purchase Energy Star–certified appliances and equipment where available. Energy Star–certified appliances and equipment use less energy to operate and typically pay for any additional cost in operational savings in a short time period. Procurement officers should specify Energy Star for bulk purchase programs and in contracts that may be used by local governments. State government should also purchase appliances and equipment with higher-than-standard energy efficiency for device types where Energy Star ratings do not apply.

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[26] See www.usgbc.org. Note also that an analysis by KEMA of DSM options for buildings in Montana is currently underway.

- County and local governments should be encouraged to adopt the same or similar policies covering their buildings and purchases.

State government should consider a requirement for carbon-neutral bonding for new construction and building renovations. Climate-neutral bonding means that there is no net increase in GHG emissions within the bond issuing agency's geographical jurisdiction after the project becomes operational. A climate-neutral performance standard will require architects and engineers to design buildings that minimize the amount of energy they use in the first place. High-performance buildings meeting a climate-neutral requirement and built to meet or exceed the state's existing sustainable building guidelines will save taxpayers money over the long term as a result of their lower operating costs.

Goals:

- Reduce per-unit-floor-area consumption of grid electricity and natural gas by 20% by 2020 in existing buildings and by 40% in new buildings by 2020. These requirements should be phased in over time.
- Require 25% of electrical energy use to be generated from renewable sources by 2025 in new and existing buildings. These goals may be met through any combination of on-site generation and green power purchases. Green power purchases must be in excess of the amount of renewable energy supplied as a standard product by the utility in order to count toward the goal (that is, must be in excess of the renewable energy included in grid power as a part of any RPS.
- Implement bulk-purchase programs that affect 10% of government energy demand by 2020, reducing that demand by 20%.

Timing: See above. Begin implementing program by 2010, with full implementation as above.

Parties Involved: State agencies such as MDEQ, building owners, developers, municipal governments, financial institutions (for climate-neutral bonding), building inspectors, architects, engineers, and air monitoring professionals.

Other: None specified.

Implementation Mechanisms

Collect Data on State Building Energy Use: A key implementation mechanism for this option will be to first provide a thorough assessment of the status and energy consumption of all existing state buildings, including establishing a database of buildings and building attributes including floor area, insulation level, energy-using equipment, and history of energy consumption. This assessment would serve as the basis for evaluation of efficiency improvement opportunities in state buildings.

Benchmark State Buildings: Benchmarking is a process of using the data on building size, use, and energy use to quickly compare a building against others of similar size and use to get an idea of how efficiently the building is operating. It is an important step in identifying opportunities for savings and prioritizing work to be done.

Commission State Buildings: Building commissioning is a process of reviewing and tuning up the operation of building systems and controls much like the tune-up of a vehicle. Potential targets for commissioning might include commissioning of state buildings upon completion of construction or renovation and whenever the energy use in a building shows an unexpected and unexplained increase in energy use.

Purchase Green Power: Enter into agreements to purchase green power for a portion of the states electricity needs. Increase purchases over time until 25% of power needs are met through direct use of renewable energy or green power purchased by 2025.

Energy Use Targets: Set targets for energy use in the operation of state buildings, potentially including capping state building energy use per square foot. Motion sensors are a specific technology for reducing lighting energy use in government buildings that may have broad application in Montana.

Renovate State Buildings Through an Expanded State Buildings Energy Program: Renovate all state buildings with more than 10,000 square feet and smaller buildings identified through energy benchmark process as having a high potential for energy savings within 15 years. Expand the State Buildings Energy Program to provide funds for energy audits, engineering analyses, and renovation costs.

Increase the Efficiency of Operations Through Purchasing and End-of-Life Disposal or Recycling: Establish policies for purchasing only energy efficient products and services by specifying Energy Star–certified and other efficient equipment and appliances, stocking only energy efficient and environmentally preferable products in Central Stores, and planning for end-of-life disposal of equipment and other goods when initial purchase is made. Purchase items that can be recycled rather than thrown away.

Develop and Use Renewable Energy Resources: Evaluate the potential for direct use of solar, wind, biomass, geothermal, and hydro power to meet the needs of state government operations. Take advantage of these renewable resources whenever it is cost-effective to do so, and as a means to lead by example in investing in these systems when it is practical to do so.

Carbon-Neutral Bonding: Climate-neutral bonding will require that any building projects financed with the issuance of state, county, or local/municipal bonds result in no net increase in GHG emissions.

- If a new construction project is projected to result in an emissions increase, there must be GHG emissions offsets within the state or particular jurisdiction. Offsets could include on-site renewable energy development, renewable energy purchases, energy efficiency (in existing state buildings), carbon sequestration (tree planting), and switching to cleaner or renewable fuels. Any GHGs emitted after the bond-financed project becomes operational will have to be offset.
- The new buildings could also offset their emissions by purchasing renewable electricity from their local utility. Paying a premium for what’s known as “green pricing” electricity will usually be a more expensive offset option than energy efficiency.

- A community or state could install their own renewable energy project as a way to offset their GHG emissions.
- Monitor building emissions over time.

Related Policies/Programs in Place

The Montana State Buildings Energy Program: This program provides funding for energy conservation in state buildings as authorized by each Legislature.[27] Some monitoring of building energy use has been carried out under the program. The State Buildings Energy Conservation Bond program is designed to finance energy improvement projects on state-owned buildings. The MDEQ administers the program, which typically uses bond proceeds to fund the projects and energy savings to repay the bonds. The 2007 Legislature authorized $3 million in funding for this program. Previous legislatures had authorized general obligation bonds in amount up to $3.75 million per biennium. The state of Montana encourages agencies to participate in the program to achieve available energy savings and requires that all renovations to state buildings that are proposed through the Architecture and Engineering Division be evaluated for energy savings and possible funding through the State Buildings Energy Program (90-4-605 MCA).

Waste Reduction in State Government: MDEQ is responsible for assisting state agencies in developing waste reduction plans under the Integrated Solid Waste Management Act (75-10-111). The MDEQ and the Department of Administration have responsibility for a program to develop specifications for supplies that have recycled content (75-10-806 MCA).

Type(s) of GHG Reductions

As with RCII-1 and other energy efficiency and building improvement options, this option would principally yield reductions in GHG emissions (largely CO_2) from avoided electricity production and avoided on-site fuel combustion. Less significant are the reduction in CH_4 emissions from avoided fuel combustion and avoided pipeline leakage. Other GHG impacts are also conceivable, but are likely to be small (black carbon, N_2O) and/or very difficult to estimate (materials use, life cycle, market leakage).

Estimated GHG Reductions and Costs (or Cost Savings)

	Policy	Scenario/Element	Reductions 2010	Reductions 2020	Cumulative Reductions 2007–2020 (MMtCO$_2$e)	NPV 2007–2020 ($ Millions)	Cost-Effectiveness ($/tCO$_2$)
RCII-12	State Lead by Example	Total for Policy	0.03	0.33	2.0	–$11	–$6
		Building Improvement	0.03	0.31	2.0	–$10	–$5
		Bulk Purchasing	0.00	0.01	0.1	–$1	–$22

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[27] See, for example, *State Bonding Program Update,* available at http://leg.mt.gov/content/publications/fiscal/interim/financecmty_dec2001/state_bonding_program.pdf. As of May 2007, the Montana State Bonding Energy Conservation Program has been funded at $3 million for the 2008–2009 biennium.

Note: Some totals in the table above may differ from the sum of their component elements due to rounding.

Data Sources: Costs of energy efficiency improvements ($37/MWh electrical energy saved and $4.7/MMBtu gas saved) are based on studies of costs of building improvements and code changes (WGA CDEAC EE Report; see full reference and derivation of cost estimates in Annex 2). An incremental cost of $12/MWh saved is assumed for the bulk purchase component of this option, based on the costs of existing market transformation programs.

Quantification Methods: Estimate fractional savings in energy intensities needed, after code improvements, in new and existing government buildings. To do this, the per-unit-floor-area goals described above (energy use intensities) are adjusted to account for savings already provided through code improvements being phased in under RCII-4. Required reductions in energy use are then allocated among energy efficiency and renewable energy sources (including green power), and the portion of each component of building electricity and fossil energy use reduction is calculated.

Key Assumptions: Fractions of electric and gas intensity improvement accounted for by efficiency improvements, solar thermal, solar PV, green power purchase beyond RPS requirements, and/or increased biomass use; fractional savings targets over new code levels. Fractional savings (20%) and fraction of state electricity demand addressed (10%) by bulk purchase program.

Key Uncertainties

- Total government building space in Montana (regional estimates currently used).[28]
- Fraction of government agencies occupying leased space in Montana (assumed to be 20% of total government-owned space).[29]
- Rate of building renovations versus new construction in the government sector (presently estimated at 50%).[30]

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[28] Montana state government, including the university system, is estimated to have 16,995,890 square feet of state-owned building space in buildings that are 1,500 sq ft or larger. It also leases 3,000,000 sq ft of space. (Data on square footage of buildings greater than 1,500 square feet are from Montana Department of Labor and Industry, Tort-Claims Division. Non-university leased area is 1.5 million square feet, based on data from the Department of Administration.) Data on non-state government floor space in Montana have not yet been identified; thus, estimates for total government-sector floor space in Montana are based on regional (Mountain states) estimates of government floor space normalized to Montana's population.

[29] By way of comparison, assuming that the Montana University system uses the same amount of leased space as non-university buildings, total leased space used by state government (including University) organizations is 17.6% of total owned space.

[30] It has been estimated that 15% of construction for state government is new construction, and 85% is renovation of existing buildings (source: 2008/2009 Montana Budget Book, Department of Administration Long-Range Building Plan), but it is unclear at this writing what fraction of the referenced renovation is likely to involve changes in building envelopes or energy systems, or whether this ratio is likely to hold for non-state government buildings. As these issues are clarified, a revision to the renovations-to-new-construction ratio used for analysis may be in order.

Additional Benefits and Costs

Benefits

Co-benefits could include transmission/distribution system costs reduction.

Costs

None cited.

Feasibility Issues

Costs for this option are uncertain, depending on the measures included.

Potential interaction with appliance standards and utility programs.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

RCII-13. Metering Technologies With Opportunity for Load Management and Choice

Policy Description

Providing energy consumers with price and other information via metering that allows consumers to more clearly identify the outcomes of their choices is a potentially useful tool in improving energy efficiency, reducing GHG emissions, and saving consumers money in Montana. This policy encourages the implementation of electricity metering technologies and tariff systems, including real-time energy pricing and rates that reflect the cost and GHG implications of the resources that must be used to provide power. This provides consumers with incentives to manage their energy consumption to reduce both costs and GHG emissions.

Policy Design

Building on experience in Europe[31] and elsewhere, Montana utilities would implement a system of metering of electricity demand and consumption that a) allows a consumer to purchase electricity from specific types of generating resources and b) allows the distribution utility and electricity generators to provide information on the cost and source of the electricity that the consumer is using at any given time. This system allows for interaction on a time-sensitive basis between the consumer, the utility, and the generating source. Through utility reports, the state can review the choices made by the consumers and can target state incentives, rules, and tax structures to move electricity consumption and production toward choices that produce lower GHG emissions.

This option could accommodate different types of electricity tariff structures, including time of use rates (which typically have impacts on the overall cost of generation but modest if any impacts on GHG emissions) and increasing-cost block rate structures (in which tier rate structures charge more per unit used as consumers use more electricity per month), which can encourage electricity conservation. The metering system can also be used by the customer to place restrictions on the timing and amount of energy use, including restricting overall demand.

Goals: Develop and implement a pilot program of installation of smart meters at residential and some nonresidential customers' sites starting in 2009, with a target implementation of 45,000 residential meters by 2011. The pilot program would thus result in the installation of smart meters in less than 10% of homes in Montana. Following the pilot program, implement a program resulting in the installation of smart meters for an additional 30% of residences by 2020.

Timing: As above.

Parties Involved: Utilities, electricity generators, electricity consumers, state regulatory agencies.

Other: Under development.

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[31] For example, see the ENEL Contatore Elettronico program offered in Italy.

Implementation Mechanisms

Technical Committee: Set up a stakeholder technical committee to consider the option, and report back with technical recommendations, which could include a recommendation to move forward with pilot programs in applicable consumer classes.

Pilot Program: The steps in carrying out the smart metering pilot program noted above include the following:

- Design pilot program (stakeholder/utility representatives/consumers).
- Implement and evaluate pilot program.
- Publish results of pilot program with recommendations.
- Proceed with statewide implementation of meters if the pilot program is successful.

Continued Utility Investment: Encourage continued investment on the part of utilities, communities, and other parties to enhance the benefits of introduction of new metering technologies.

Related Policies/Programs in Place

NWE is considering running a time-of-use pilot program in Missoula. NWE and the Montana PSC are investigating the cost-effectiveness of the program and have not yet decided whether to implement it.

Type(s) of GHG Reductions

As with RCII-1 and other energy efficiency and conservation options, this option would principally yield reductions in GHG emissions (largely CO_2) from avoided electricity production and avoided on-site fuel combustion. Less significant are the reduction in CH_4 emissions from avoided fuel combustion and avoided pipeline leakage. Other GHG impacts are also conceivable, but are likely to be small (black carbon and N_2O) and/or very difficult to estimate (e.g., materials use, life cycle, or market leakage).

Estimated GHG Reductions and Costs (or Cost Savings)

	Policy	Scenario/Element	Reductions		Cumulative Reductions 2007–2020 ($MMtCO_2e$)	NPV 2007–2020 ($ Millions)	Cost-Effective-ness ($\$/tCO_2$)
			2010	2020			
RCII-13	Metering Technologies with Opportunity for Load Management and Choice	Policy Total	0.02	0.12	0.9	–$11	–$12
		Pilot Program	0.02	0.03	0.4	–$5	–$13
		Full Program	0.00	0.09	0.5	–$6	–$11

Data Sources: Experience with smart meters in other jurisdictions.[32]

Quantification Methods: Based on goals above, phase in smart meter use in Montana, apply meter cost and savings estimates below, and estimate GHG benefits and electricity avoided costs.

Key Assumptions:

- Average incremental installed cost per meter: $200.
- Average electricity use reduction per meter: 8%.

Key Uncertainties

None cited.

Additional Benefits and Costs

Benefits

None cited.

Costs

To the extent that low-income households may be covered by new metering and rate policies, low-income residents may be adversely affected, as they often live in substandard rental housing that uses a significant amount of energy, but they lack both the ability and the incentives to upgrade appliances, heating equipment, or the building envelope.

Feasibility Issues

None cited.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

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[32] For example, *Smart Meters: Commercial, Policy and Regulatory Drivers,* by Gill Owen and Judith Ward, describes experience with smart meters in the UK and reports one to several percent net savings in electricity consumption from implementation of smart meters, as well as peak reduction impacts. Dated March 2006, published by Sustainability First, available at http://www.sustainabilityfirst.org.uk/docs/smart%20meters%20pdf%20version.pdf .

Annex 1 to Policy Options Descriptions: Survey of Carbon Tax Programs

Carbon Tax Programs in Other Cities, Countries, and Provinces

Jurisdiction	Status: Start Date	Tax Rate–Applicability	Where Tax Applied	Use of Revenue
Finland[1]	1990 Revised 1997 Revised 2002	1990 \$1.54/ton 1993 \$3.00/ton 1997–1998 Electricity: \$0.007/kWh Heating: \$22.53/ton CO_2 Natural gas: \$11.26/ton CO_2	1990 Fuels 1997 Electricity consumption not fuels reduced for industry Exemption for international aviation, shipping, and refineries	Reimbursement via lower payroll taxes
Norway[2]	1991 Revised 1999	Petrol: \$55.90/ton CO_2 Mineral oil: \$30.16/ton CO_2 Oil and gas in North Sea: \$52.05/ton CO_2	Producers and importers of oil products Exemption for foreign shipping, fishing, external aviation	Reduce other taxes
Sweden[3]	1991 Revised 2004	CO_2: \$100/ton 2004 increases: Gasoline: \$0.02/L Diesel: \$0.04/L Vehicle Tax Electricity: \$0.002/kWh (excludes industry)	Oil, coal, natural gas, liquefied petroleum gas, petrol, and domestic aviation fuel Reduced industrial rate Exemption for high-energy industries, i.e., horticulture, mining, manufacturing, and pulp/paper industry	Offset by income tax relief Estimated revenue \$523 million
Denmark[4]	1992 Revised 1999	Commercial: \$14.30/ton CO_2 Households: \$7.15/ton CO_2	Buildings	Reallocated as subsidies for energy efficiency activities and voluntary agreements

Jurisdiction	Status: Start Date	Tax Rate–Applicability	Where Tax Applied	Use of Revenue
Germany[5]	1999 Revised 2000	1999 Gasoline: \$0.04/L Heating fuel: \$0.03/L Natural gas: \$0.02/kWh Electricity: \$0.01/kWh 2000–2003 annual increases Gasoline: \$0.04 per L Electricity: \$0.003 per kWh	Electricity, heating fuel, natural gas, gasoline	Tax breaks for commuters Reduce labor costs via pension contributions
Japan[6]	2001	Green taxation Subsidies for high efficiency automobiles	Vehicles	
UK	2001–	Electricity: \$0.0084 per kWh Coal and natural gas: \$0.0029 per kWh Levy will rise with inflation annually beginning in 2007	Electricity generation includes nuclear Renewable exempt	Reduced national insurance rate Fund for energy efficiency initiatives
Netherlands	2005	Fossil electricity: \$0.08 per kWh for small consumers Renewable exemption: \$0.04 per kWh Rates indexed to inflation	Electricity and fuel consumption Renewable sources with green certificate exempt	Reduced income and corporate tax rates
City of Boulder, CO	Approved 2006 Start 2007 Expiration 2013	Electricity: (kWh) \$0.0022 for residential \$0.0004 for commercial \$0.0002 for industrial use Max increases: \$0.0049 for residential \$0.0009 for commercial \$0.0003 for industrial use	Electricity use	Funding for city's Climate Action Plan Programs to increase energy efficiency, renewable energy use, reduce motor vehicle emissions, and take further steps to meeting Kyoto protocol targets
Australia: State of West Australia[7]	Under current consideration	\$19.58/ton CO_2		
Canada: Province of Quebec[8]	2006	To be determined by Quebec Energy Board \$1 Billion estimated 6-year revenue	Non-renewable fossil fuels sold in bulk to retailers	Green Fund Public transportation, energy efficiency for buildings

[1] http://www.norden.org/pub/ebook/2001-566.pdf;

[2] http://ideas.repec.org/p/ssb/dispap/337.html

[3] http://pubs.acs.org/hotartcl/est/98/dec/hanish.html

[4] http://www.iea.org/Textbase/pm/?mode=cc&id=156&action=detail

[5] http://www.iea.org/textbase/publications/free_new_Desc.asp?PUBS_ID=1097

[6] http://www.iea.org/textbase/nppdf/free/2000/japan2003.pdf

[7] http://www.news.com.au/story/0,23599,21171914-2,00.html

[8] http://www.cbc.ca/news/background/kyoto/carbon-tax.html

Annex 2 to Policy Options Descriptions: Printouts of Selected Portions of Worksheets Used To Prepare Estimates of Costs and Benefits of Residential, Commercial, Institutional, and Industrial Mitigation Options

Printouts below reflect status of analyses of options as of June 26, 2007.

Estimate of Mitigation Option Costs and Benefits for Montans RCII GHG Analysis

GHG Emissions Totals for Montana RCII GHG Analysis

Date Last Modified:	*6/26/2007*	*C. Lee/D. Von Hippel*

Summary Results and Totals for RCII Mitigation Options

		GHG Reductions ($MMtCO_2e$)				
	Option Name	**2010**	**2020**	**Cost-Eff ($\$/tCO_2e$)**	**NPV 2007-2020 ($million)**	**Cumulative Emissions Reductions (MMt CO_2e, 2007-2020)**
RCII-1	Expand Energy Efficiency Funds	0.04	1.15	-$21	-$141	6.6
RCII-2	Market Transformation and Technology Development Programs	0.03	0.30	-$23	-$43	1.9
RCII-3	State Level Appliance Efficiency Standards and State Support for Improved Federal Standards	0.05	0.20	-$32	-$48	1.5
RCII-4	Building Energy Codes	0.03	0.25	-$10	-$15	1.6
RCII-5	"Beyond Code" Building Design Incentives and Mandatory Programs	0.07	0.52	-$5	-$17	3.4
RCII-6	Consumer Education Programs	Not Quantified				
RCII-7	Support for Implementation of Clean Combined Heat and Power	0.0	0.0			0.0
RCII-8	Support for Renewable Energy Applications	0.0	0.0			0.0
RCII-9	Carbon Tax	Not Quantified				
RCII-10	Industrial Energy Audits and Recommended Measure Implementation	0.07	0.56	-$26	-$93	3.6
RCII-11	Low income energy efficiency programs	0.05	0.75	-$9	-$41	4.7
RCII-12	State Lead by Example	0.03	0.33	-$6	-$11	2.0
RCII-13	Metering technologies with opportunity for load management and choice	0.03	0.12	-$12	-$11	0.9
	Total Gross Savings	0.41	4.18	-$16	-$421	26.2

Adjustment for Estimated Overlap Between RCI Options					
Overlap between RCI Options					
RCII-2, Overlap with RCII-1	0.02	0.20		-$29	1.2
RCII-3, Overlap with RCII-1 and RCII-2	0.00	0.00		$0	0.0
RCI-4, Overlap with RCII-1 through RCII-3	0.00	0.00		$0	0.0
RCI-5 Overlap with RCII-1 through RCII-4	0.03	0.23		-$12	1.5
RCII-7, Overlap with Other Quantified Policies	See Energy Supply Results				
RCII-8, Overlap with Other Quantified Policies	See Energy Supply Results				
RCII-9, Overlap with Other Quantified Policies	Not Quantified				
RCII-10 Overlap with Other Quantified Policies	0.04	0.28		-$47	1.8
RCII-11 Overlap with Other Quantified Policies	0.03	0.45		-$25	2.8
RCII-12 Overlap with Other Quantified Policies	0.00	0.03		-$1	0.2
RCII-13 Overlap with Other Quantified Policies	0.01	0.04		-$4	0.3
Total Estimated Overlap Among RCII Policies	0.13	1.23		-$117	7.8
Total Savings Net of Overlaps	0.28	2.95	-$17	-$304	18.4

Additional Emissions Savings from Recent Actions (not included in forecast or in policy options above)

		GHG Reductions ($MMtCO_2e$)			**Cumulative Emissions Reductions (MMt CO_2e, 2007-2020)**
	Option Name	**2010**	**2020**		
RCII-1	Expand Energy Efficiency Funds	0.30	0.79		6.5
RCII-11	Low income energy efficiency programs	0.02	0.05		0.4
	Total	0.32	0.83		7.0

Total Emissions Reductions Net of Overlaps (including recent actions)	0.59	3.79		25.3

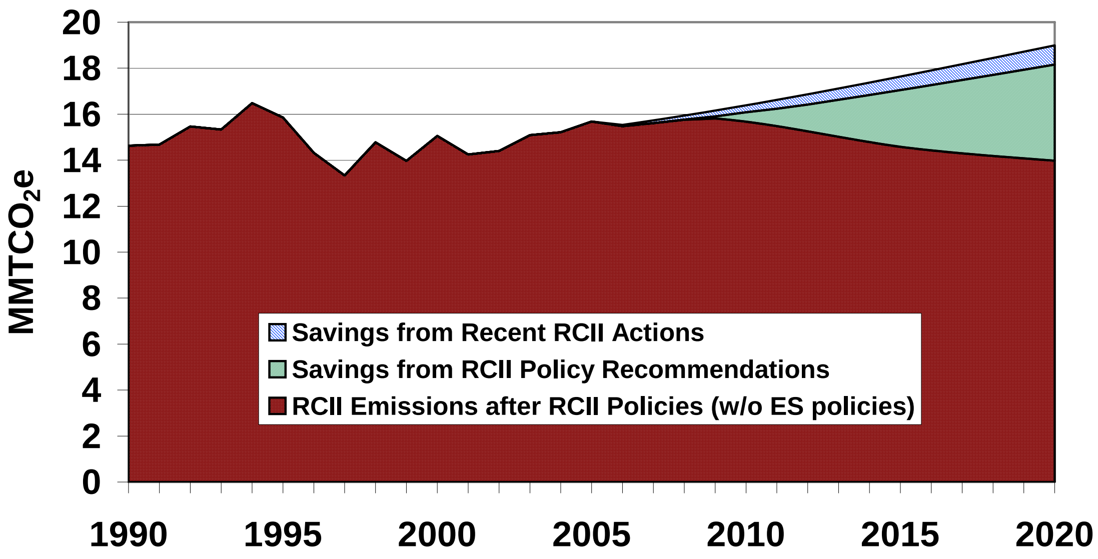
Note: Some totals in the tables above may differ from the sum of their component elements due to rounding.

TABLE BELOW SHOWS NET ADJUSTED SAVINGS BY OPTION

Summary Results and Totals for RCII Mitigation Options

		GHG Reductions				
	Option Name	**2010**	**2020**	**Cost-Eff ($/tCO$_2$e)**	**NPV 2006-2020 ($million)**	**Cumulative Emissions Reductions (MMt CO$_2$e, 2006-2020)**
RCII-1	Expand Energy Efficiency Funds	0.04	1.15	-$21	-$141	6.6
RCII-2	Market Transformation and Technology Development Programs	0.01	0.10	-$23	-$15	0.6
RCII-3	State Level Appliance Efficiency Standards and State Support for Improved Federal Standards	0.05	0.20	-$32	-$48	1.5
RCII-4	Building Energy Codes	0.03	0.25	-$10	-$15	1.6
RCII-5	"Beyond Code" Building Design Incentives and Mandatory Programs	0.04	0.29	-$3	-$5	1.9
RCII-6	Consumer Education Programs	Not Quantified				
RCII-7	Support for Implementation of Clean Combined Heat and Power	See Energy Supply Results				
RCII-8	Support for Renewable Energy Applications	See Energy Supply Results				
RCII-9	Carbon Tax	Not Quantified				
RCII-10	Industrial Energy Audits and Recommended Measure Implementation	0.04	0.28	-$26	-$47	1.8
RCII-11	Low income energy efficiency programs	0.0	0.3	-$9	-$16	1.9
RCII-12	State Lead by Example	0.0	0.3	-$5	-$10	1.9
RCII-13	Metering technologies with opportunity for load management and choice	0.0	0.1	-$12	-$7	0.6
	Total Savings	0.28	2.95	-$17	-$304	18.4

Note: Some totals in the table above may differ from the sum of their component elements due to rounding.



NOTES ON ESTIMATES OF OVERLAP BETWEEN POLICIES

Note 1:

The overlap between RCII-2 and RCII-1 is assumed to be approximately 66%
as RCII-1, which includes all cost-effective DSM potential, would be expected to cover many of the
same measures as the market transformation programs in RCII-2.

Note 2:

RCII-3 and RCII-4 have no overlap with RCI-1 and RCII-2, since savings from appliance/equipment efficiency
and buildings in RCII-1 and -2 would be over and above standards and codes.

Note 3:

RCII-5, "Beyond Code" building improvements, will not (by definition) overlap with RCII-3 or RCII-4,
but will likely overlap with RCII-2 and especially RCII-1, which may be the source of incentives for
many building improvements. The overlap between these options is assumed to be 50%
RCII-5 gross savings (and costs) except for the "green power" and customer-sited renewable energy components
of RCII-5, which do not overlap with other options.

Note 4:

RCII-10, "Industrial Energy Audits", will likely overlap with RCII-1, which would be expected to provide some of the
incentives for implementation of audit recommendations, and possibly (depending on design) overlap more modestly
with RCII-2 through RCII-5. The overlap between RCII-10 and other options is assumed to be 50%
of RCII-10 gross savings (and costs).

Note 5:

RCII-11, "Low Income and Rental Unitl Energy Efficiency", will likely overlap with RCII-1, which would be expected
to provide some of the incentives for implementation of weatherization
and other measures, but not all, as RCII-11 includes measures beyond what are currently "cost-effective"
(relative to electric avoided costs). There will also likely be some overlap between RCII-5 and RCII-11, though
the two options may use different implementation mechanisms. The overlap between RCII-11
and other options is assumed to be 60% of RCII-11 gross savings (and costs).

Note 6:

For State Lead by Example, an overlap between RCI-12 and other options of 10% assumes
relatively few government-sector improvements are subsidized by utility programs or energy efficiency funds.
Overlap does not apply to the "green power" or renewable energy components of RCII-12.

Note 7:

For metering technologies, assume that 33% of reduction in consumption credited to
the adoption of these technologies comes about as consumers are spurred to take advantage of incentives available
thorugh RCII-1 and other options, with the remainder of the reductions coming about through changes in behavior and
other modifications not related to other RCII options.

Estimate of Mitigation Option Costs and Benefits for Montana RCII GHG Analysis

Common Assumptions for Montana RCII GHG Analysis

Date Last Modified: *4/25/2007 C.Lee/D. Von Hippel*

Common Assumptions

Real Discount Rate 5%

Levelized, Avoided Costs (2006-2020, 2005$)

Electricity - Sales-Weighted Average $ 49.13 $/MWh

Estimate derived from contract data underlying the "the long-term, standard QF [Qualifying Facilities] tariff", "Option 1" ($49.90 per MWh, nominal cost average of quarterly contract costs from 2007 through 2014) as set by the Montana Public Services Commission, in an order covering DOCKET NO. D2003.7.86, ORDER NO. 6501f 2, DOCKET NO. D2004.6.96, ORDER NO. 6501f, and DOCKET NO. D2005.6.103, ORDER NO. 6501f, dated December 19, 2006. The $49.90 cost indicated is shown in paragraph 184 of the PSC document. Cost shown here extends the stream of nominal costs in the original NWE/PPL document by including values for 2015 to 2020 that increment the 2014 average value at the rate of inflation, levelizes the resulting 2007 to 2020 stream, and adjusts the levelized value to 2005 dollars. See "AvCost" worksheet in this workbook.

Electricity - Residential $49 $/MWh
Electricity - Commercial $49 $/MWh
Electricity - Industrial $49 $/MWh

Levelized Costs not differentiated by sector for this analysis.

Natural Gas $6.5 $/MMBtu

Note: In the absence (as of 3/26/07) of MT-specific avoided gas costs, we derive a placeholder estimate for MT avoided gas costs by starting with average 2005 NC citygate gas costs and escalating costs based on escalation in weighted-average regional AES2006 estimates for gas cost by sector. These values should be replaced by MT-specific costs when and if available.

Prices

Electricity Price - Sales-Weighted, Levelized $66 $/MWh

Prices are based on DOE data for prices in 2005 http://www.eia.doe.gov/cneaf/electricity/esr/esr_sum.html. Changes from 2006 to 2020 are based on the relative changes in projected SERC reliability Corporation region prices in US DOE Annual Energy Outlook 2006 (same % changes). AEO 2006 projects prices to declining to below 2005 levels from 2008 onward.

Electricity - Residential Prices (Levelized, 2006-2020) $81 $/MWh
Electricity - Commercial Prices (Levelized, 2006-2020) $69 $/MWh
Electricity - Industrial Prices (Levelized, 2006-2020) $50 $/MWh

Natural Gas (Delivered, RCII sales-weighted average) $9.5 $/MMBtu

Natural gas prices are estimated as described for electricity above.

Natural Gas - Residential Prices (Levelized, 2006-2020) $9.7 $/MMBtu
Natural Gas - Commercial Prices (Levelized, 2006-2020) $9.2 $/MMBtu
Natural Gas - IndustrialPrices (Levelized, 2006-2020) $7.5 $/MMBtu

Biomass - All Users $3.2 $/MMBtu

Estimate based on 1999 national study of state-by-state biomass resource resource assessments--see worksheet "Biomass_Data" in this workbook. Price equivalent of $51/dry ton at 16 MMBtu/dry ton. Replace with more MT-specific estimates (for example, from AF group when available).

Coal - Industrial Users $0.7 $/MMBtu

average coal heat content of 26.75 MMBTU/ton, based on 2001 USDOE/EIA data. USDOE/EIA figures for 2005 "other industrial users" are withheld for MT. The MT average coal price of $11.63 per ton is given for "Electric Utility Plants". Based on a ratio of 1.55 ($25.89/$16.71) for the "Other Industrial Users" to "Electric Utility Plants" for the state of Wyoming. The MT "Other Industrial Users" coal price is estimated at $18.02. www.eia.doe.gov/cneaf/coal/page/acr/table34.html

Oil - Distillate/Diesel $12.5 $/MMBtu

USDOE/EIA data are not available for MT or PADD IV. US average priced for heating oil of $gives NC average prices for heating oil of $2.34 per gallon in 2005/06 heating season. This cost does not include fuel taxes. An appendix to the 2006 Annual Energy Outlook by USDOE/EIA (see http://www.eia.doe.gov/oiaf/aeo/pdf/appendixes.pdf) lists an energy content for distillate oil of 5.799 MMBtu/bbl, or 0.138 MMBtu/gallon.

LPG $11.0 $/MMBtu

USDOE/EIA data are not available for MT. The US average average prices given for propane are $1.01 per gallon in 2005/06 heating season. This cost does not include fuel taxes. Prices expressed on $/MMBtu basis a conversion factor of 0.09133 MMBtu/gallon (see "Fuel Data" woksheet)

Landfill Gas - All Users $5.0 $/MMBtu

Placeholder Estimate

Biogas Gas - All Users $5.0 $/MMBtu

Placeholder Estimate

Emission Rates, etc.	2010	2020	Units
Electricity T&D losses (fraction of total generation)	7.4%	7.0%	

Estimated based on US DOE Annual Energy Outlook figures for 2005 - 2025 for "total sales" and "total net energy for load" as reported in "Table 72. Electric Power Projections for EMM Region, Western Electricity Coordinating Council / Northwest Power Pool Area - 11", from http://www.eia.doe.gov/oiaf/aeo/supplement/sup_elec.xls.

	2010	2020	Units
Avoided electricity emissions rate	1.020	0.838	tCO_2/MWh

Assumes that reductions in electricity generation requirements through 2010 will come from the average emissions rate of then-existing fossil-fueled sources; by 2020 the predominant effect is assumed to be a reduction in reference case new more efficient coal builds during the 2010-2020 period.

Notes	2010	2020	Units

Multi-Gas Emission Factors

Except as noted, the following emission factors are calculated from values in the Montana Inventory and Forecast prepared for the CCAC, and reflect the average emissions over 2000 to 2020 per BTU and physical amount of fuel. They include combustion CH4 and N20 as well as CO2 emissions for consistency with the inventory.

	tCO_2e/billion BTU	
LPG - RCII	63.294	
Coal - RCII	93.714	
Natural Gas - RCII	52.921	
Biomass - RCII	2.500	
Oil - RCII	74.342	*Placeholder--assumed equal to CO_2 factor for misc pet prods from North Carolina (but used little in MT analysis)*
Landfill Gas - RCI	0.260	*Placeholder Value, from Steve Roe. Does not count benefit of capture of landfill gas.*
Biogas - RCII	5.000	*Placeholder Value-- May in fact be negative*

GDP Deflators (to 2005$)

Cost Year	Index
1997	1.18
1998	1.16
1999	1.15
2000	1.12
2001	1.09
2002	1.08
2003	1.05
2004	1.03
2005	1.00
2006	0.97
Implied annual average inflation, 1997 to 2006	2.1%

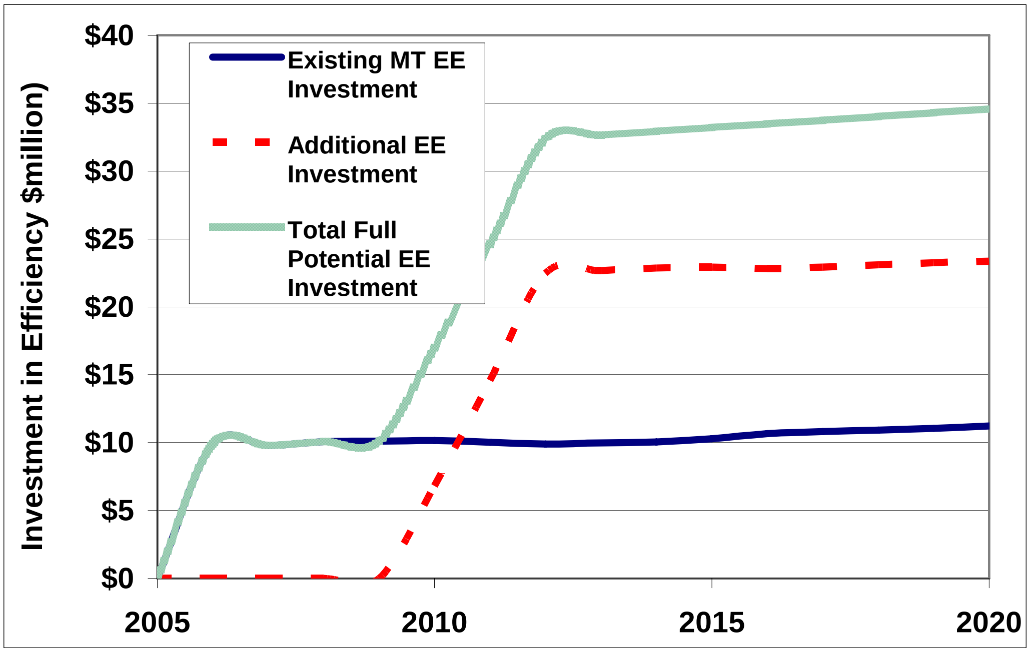
GDP Deflators indexed to 2000 dollars from
http://www.bea.gov/bea/dn/nipaweb/TableView.asp#Mid

2004	109.426
2005	112.737
2006	116.043

Natural Gas Conversion	1.03	million Btu/ thousand cf
Electricity Conversion	3413	MMBTU/ GWh

Other Data, Assumptions, Calculations		2010	2020/all	Units
Analysis				
RCII Electricity Sales	*(from inventory)*	14,283	15,684	GWh
Residential		4,245	4,329	GWh
Commercial		4,889	5,469	GWh
Industrial		5,150	5,885	GWh
Conversion Factor:GWh/Billion Btu			0.29306	
RCII Electricity Prices (statewide averages, real 2005 dollars)				
Residential		$78	$81	$/MWh
Commercial		$66	$70	$/MWh
Industrial		$49	$51	$/MWh
2005 electricity prices are from EIA (see "Retail_Prices_Elec" worksheet in this workbook). http://tonto.eia.doe.gov/dnav/ng/ Changes in sectoral electricity prices indexed to DOE EIA Annual Energy Outlook 2006 national forecast.				
Total Implied Electricity Revenues (RCII, statewide)		$906	$1,029	$million
Residential		$331	$350	$million
Commercial		$323	$380	$million
Industrial		$252	$299	$million
RCII Gas Sales	*(from inventory)*	60,107	63,216	Billion Btu
Residential		21,876	24,123	Billion Btu
Commercial		14,255	17,694	Billion Btu
Industrial		23,976	21,398	Billion Btu
Conversion Factor: Million Btu per Thousand Cubic feet			1.03	MMBtu/Mcf
RCII Gas Prices (statewide averages, real 2005 dollars)				
Residential		$9.12	$8.86	$/MMBtu
Commercial		$8.68	$8.08	$/MMBtu
Industrial		$7.01	$6.46	$/MMBtu
2005 gas prices are from EIA (see "NGPrices current" worksheet in this workbook). http://tonto.eia.doe.gov/dnav/ng/xls/ng_sum_lsum_dcu_SNC_a.xls. Changes in sectoral gas prices indexed to future gas prices from DOE EIA Annual Energy Outlook 2006 national forecast.				
Total Implied Gas Revenues (RCII, statewide)		$491	$495	$million
Residential		$199	$214	$million
Commercial		$124	$143	$million
Industrial		$168	$138	$million
Energy Efficiency Investment				
Recent Actions				
Fraction of Electricity Revenues Invested		0.8428%	0.8428%	
Efficiency Spending for Recent Actions (Electricity)		$7.6	$8.7	$million
Cumulative reduction in sales from existing investment		1.541%	4.463%	(Electric)
Fraction of Gas Revenues Invested		0.5132%	0.5132%	
Efficiency Spending for Recent Actions (Gas)		$2.5	$2.5	$million
Cumulative reduction in sales from existing investment		1.663%	4.536%	(Gas)
Full Potential Efficiency investment				
Target New Electricity Savings per Year		30.35	104.78	GWh
Fraction of Electricity Revenues Invested		0.6%	1.7%	
Implied Electricity Energy Efficiency investment per Year		$5.1	$17.5	$million
Target New Gas Savings per Year		131.76	442.06	Billion Btu
Fraction of Gas Revenues Invested		0.4%	1.2%	
Efficiency investment, New/Expanded (Gas)		$1.8	$5.9	$million

Additional Results	2010	2020	Units
Current/expected Energy Efficiency Investments			
Reduction in Electricity Use	220	700	GWh
as % of overall projected sales in that year	1.541%	4.463%	
Reduction in Generation Requirements	238	756	GWh
GHG Emission Savings from Electricity Use Reduction	**0.24**	**0.63**	$MMtCO_2e$
Reduction in Gas Use	999	2,868	Billion Btu
as % of overall projected sales in that year	1.663%	4.536%	
Reduction in Gas Consumption	999	2,868	Billion Btu
GHG Emission Savings from Gas Use Reduction	**0.05**	**0.15**	$MMtCO_2e$
Cumulative Emissions Reductions, Electricity (2007-2020)		**5.3**	
Cumulative Emissions Reductions, Gas (2007-2020)		**1.2**	
Cumulative Emissions Reductions, Electricity plus Gas (2007-2020)		**6.5**	
Full Cost-effective Potential Energy Efficiency Investments			
Reduction in Electricity Use from New/Expanded Investments	30	1,021	GWh
as % of overall projected sales	0.2%	6.5%	(Electric)
Incremental Reduction in Generation Requirements	33	1,102	GWh
GHG Emission Savings	**0.03**	**0.92**	$MMtCO_2e$
Reduction in Gas Use	132	4,315	Billion Btu
as % of overall projected sales in that year	0.2%	6.8%	
Reduction in Gas Consumption	132	4,315	Billion Btu
GHG Emission Savings from Gas Use Reduction	**0.01**	**0.23**	$MMtCO_2e$
Economic Analysis - New/Expanded Energy Efficiency Invesments			
Net Present Value, Electricity Savings (2007-2020)		**-$79**	$million
Cumulative Emissions Reductions, Electricity (2007-2020)		**5.4**	$MMtCO_2e$
Cost-Effectiveness, Electricity		**-$15**	$\$/tCO_2e$
Net Present Value, Gas Savings (2007-2020)		**-$61**	$million
Cumulative Emissions Reductions, Gas (2007-2020)		**1.2**	$MMtCO_2e$
Cost-Effectiveness, Gas		**-$49**	$\$/tCO_2e$
Incremental GHG Emission Savings, Electricity and Gas	**0.04**	**1.15**	$MMtCO_2e$
Net Present Value, Electricity Savings (2007-2020)		**-$141**	$million
Cumulative Emissions Reductions, Electricity plus Gas (2007-2020)		**6.6**	$MMtCO_2e$
Cost-Effectiveness, Electricity plus Gas		**-$21**	$\$/tCO_2e$



NOTES AND DATA FROM SOURCES

Note 1:

The Energy Efficiency Task Force Report to the Clean and Diversified Energy Advisory Committee of the Western Governors Association,
The Potential for More Efficient Electricity Use in the Western United States, January, 2006. This report is referred to here as the "WGA CDEAC EE report" and can be found at: http://www.westgov.org/wga/initiatives/cdeac/Energy%20Efficiency-full.pdf.

Estimate of Mitigation Option Costs and Benefits for Montana RCII GHG Analysis

RCII-2 Market Transformation and Technology Development Programs

Date Last Modified:	*3/26/2007*	*D. Von Hippel/A Bailie/C. Lee*

Key Data and Assumptions	2010	2020/all	Units
First Year Results Accrue		**2010**	
Savings from Alliance Programs			
Reduction in overall electricity use		**0.2%**	per year

Based on WGA (2005) - The Potential for More Efficient Electricity Use in the Western United States, Energy Efficiency Task Force Report to the Clean and Diversified Energy Advisory Committee of the Western Governors' Association. This study estimates that market transformation programs could achieve reductions in electricity consumption of about 0.2% per year, based on programs and experience similar to those of the Northwest Energy Efficiency Alliance. See NEEA 2004 Annual Report. www.nwalliance.org/resources/documents/A_2004AR.pdf. These savings are in addition to those achieved through building energy codes and utility DSM programs (no double counting).

For Montana, a key implementation strategy could be support for and expansion of programs similar to NEEA's into areas of MT not now covered by those programs.

Assumed Cost of Market Transformation Program Savings		**$12**	$/MWh

From WGA EE Task Force study (2005), which cites the Retrospective Analysis of the Northwest Energy Efficiency Alliance (Violette, Ozog, and Cooney, 2003).

Avoided Electricity Cost		**$49**	$/MWh

See common assumptions.

Other Data, Assumptions, Calculations	2010	2020/all	Units
Total Statewide Electricity Sales	**14,283**	**15,684**	**GWh**

Results	2010	2020	Units
Total Net GHG Emission Savings	**0.03**	**0.30**	$MMtCO_2e$
Net Present Value (2007-2020)		**-$43**	$million
Cumulative Emissions Reductions (2007-2020)		1.9	$MMtCO_2e$
Cost-Effectiveness		**-$23**	$\$/tCO_2e$
TOTAL Reduction in Electricity Sales	29	329	GWh (sales)
as share of projected sales	0.2%	2.1%	
Reduction in Generation Requirements	31	354	GWh (generation)

Estimate of Mitigation Option Costs and Benefits for Montana RCII GHG Analysis

RCII-3 State Level Appliance Efficiency Standards and State Support for Improved Federal Standards

Date Last Modified:	*3/26/2007*	*D. Von Hippel/A Bailie/C. Lee*

Key Data and Assumptions	**2010**	**2020/all**	**Units**
First Year Results Accrue		**2010**	
Projected Electricity Savings from 15 Proposed Standards (in 2020)		**184**	GWh
Projected Natural Gas Savings from 15 Proposed Standards (in 2020)		**553**	million ft^3
Projected NPV Savings (to 2030, $2005)		**$185**	million

The above findings are drawn from ASAP and ACEEE, 2006. "Leading the Way: Continued Opportunities for New State Appliance and Equipment Efficiency Standards", http://www.standardsasap.org/stateops.htm and http://www.standardsasap.org/a062_mt.pdf. The NPV results were derived using a 5% discount rate, and electricity prices of 8.7c/kWh ($13.6/thousand cubic ft gas) residential and 6.9c/kWh ($11.7/thousand cubic ft gas) commercial. The resulting NPV savings are thus slightly higher than would be obtained using our avoided delivered electricity and gas cost estimates.

Adjustment factor for NPV timespan		**0.527**	

This is the ratio of NPV values from 2007-2020 vs. 2005-2030 for a constant net benefit starting in 2012.

Adjustment factor for different electricity and gas avoided costs		**0.563**	

Simple adjustment assumes the benefits are largely on the electricity side, and equals the ratio of incremental cost savings per MWh using the following values (appliance standards cost from WGA 2005; ASAP/ACEEE assumes average of res and comm):

Average cost of efficiency improvements via standards		**$12**	$/MWh
Average cost of electricity in ASAP/ACEEE study		**$78**	$/MWh
Avoided cost of electricity used here (res/comm avg)		**$49**	$/MWh

Other Data, Assumptions, Calculations	**2010**	**2020/all**	**Units**
National Savings	14	52	TWh

ASAP/ACEEE, 2006. Assume here same ratio of 2010 to 2020 savings in MT for electricity. All gas-saving standards come into force in 2012, so no 2010 gas savings

Results	**2010**	**2020**	**Units**
Electricity			
Reduction in Electricity Sales	50	184	GWh (sales
Reduction in Generation Requirements	54	198	GWh (gene
GHG Emission Savings	**0.05**	**0.17**	MMtCO$_2$e
Cumulative Emissions Reductions (2007-2020)		1.3	MMtCO$_2$e
Natural Gas			
Reduction in Gas Use	0	570	Billion BTU
GHG Emission Savings	**0.00**	**0.03**	MMtCO$_2$e
Cumulative Emissions Reductions (2007-2020)		0.20	MMtCO$_2$e
Total for Policy (Natural gas and electricity)			
GHG Emission Savings	**0.05**	**0.20**	MMtCO$_2$e
Net Present Value (2007-2020)		**-$55**	$million
Cumulative Emissions Reductions (2007-2020)		1.5	MMtCO$_2$e
Cost-Effectiveness		**-$36**	$/tCO$_2$e

Estimate of Mitigation Option Costs and Benefits for Montana RCII GHG Analysis

RCII-4 Building Energy Codes

Date Last Modified: *5/1/2007 D. Von Hippel/A Bailie*

Key Data and Assumptions	2010	2020/all	Units
First Year Results Accrue		**2008**	

Electricity	2010	2020/all	Units
Levelized Cost of Electricity Savings		**$37.2**	$/MWh
Based on 7 year payback as estimated in WGA CDEAC EE Report. (See Note 1, below.)			
Levelized Cost of Natural Gas Savings		**$4.7**	$/MMBtu
Based on 7 year payback as estimated in WGA CDEAC EE Report. (See Note 1, below.)			
Avoided Electricity Cost		**$49**	$/MWh
Weighted average over total 2007-2020 electricity savings for this policy in each sector. See common assumptions ("Common Factors" worksheet in this workbook).			
Avoided Natural Gas Cost		**$6.5**	$/MMBtu
See common assumptions ("Common Factors" worksheet in this workbook)			

Other Data, Assumptions, Calculations	2010	2020/all	Units
Adjustment for Inclusion of Rennovated Residential Space as Well as New Under New Code Requirements.		**1.00**	
Adjustment for Inclusion of Rennovated Commercial Space as Well as New Under New Code Requirements.		**1.50**	
Adjustment for Inclusion of New Industrial Space in Estimated Savings due to New Code Requirements (applied to total residential plus commercial savings) (See ***Note 3***)		**110.0%**	
Ratio of Electricity Savings to Gas Savings: Residential Sector	199	199	GWh/TBtu
Ratio of Electricity Savings to Gas Savings: Commercial Sector	316	316	GWh/TBtu

(Currently set at 1.0 so that no rennovated residential space is included--need to ask an MT building professional for an opinion on this value.)

*(Currently set at 1.5 so that about 1 unit of renovated space is included per unit of new space (initial assumption--see **Note 4**). It may be useful to get further information regarding this value.*

Estimated based on relative MT usage of electricity and gas by sector in 2004. Alternative factors could be derived from other sources to account for differeMTes in expected levels of electricity and natural gas savings.

Results	2010	2020	Units
Electricity			
Recent Actions not included in forecast -- assume all recent savings are included in forecast			
Reduction in Electricity Sales: Residential	0	0	GWh (sales)
Red		0	GWh (sales)
Red		0	GWh (sales)
TOT		0	GWh (sales)
Reduction in Generation Requirements	0	0	GWh (generation)
GHG Emission Savings	**0.00**	**0.00**	$MMtCO_2e$

These rows are not used currently but are retained in case there is need to estimate savings from current activities

Savings due to Additional Effort in RCII-4	2010	2020	Units
Reduction in Electricity Sales: Residential	10	101	GWh (sales)
Reduction in Electricity Sales: Commercial	11	104	GWh (sales)
Reduction in Electricity Sales: Industrial	2	20	GWh (sales)
TOTAL Reduction in Electricity Sales	23	225	GWh (sales)
Reduction in Generation Requirements	25	242	GWh (generation)
GHG Emission Savings	**0.03**	**0.20**	$MMtCO_2e$

Economic Analysis (for Electricity Savings due to Additional Effort in RCII-4)		
Net Present Value (2007-2020)	**-$9.6**	$million
Cumulative Emissions Reductions (2007-2020)	1.3	$MMtCO_2e$
Cost-Effectiveness	**-$7.44**	$\$/tCO_2e$

Natural Gas

Recent Actions not included in forecast

These rows are not used currently but are retained in case there is need to estimate savings from current activities

Reduction in Gas Sales: Residential	0	0	Billion BTU
Reducti		0	Billion BTU
Reducti		0	Billion BTU
Reducti		0	Billion BTU
GHG Emission Savings	0	0.00	$MMtCO_2e$

Savings due to Additional Effort in RCII-4

Reduction in Gas Sales: Residential	50	509	Billion BTU
Reduction in Gas Sales: Commercial	36	328	Billion BTU
Reduction in Gas Sales: Industrial	7	65	Billion BTU
Reduction in Gas Use	92	902	Billion BTU
GHG Emission Savings	0.00	0.05	$MMtCO_2e$

Economic Analysis (for Savings due to Additional Effort in RCI-6)

Net Present Value (2007-2020)	**-$5.7**	$million
Cumulative Emissions Reductions (2007-2020)	0.3	$MMtCO_2e$
Cost-Effectiveness	**-$20.21**	$\$/tCO_2e$

Summary Results for RCII-4	**2010**	**2020**	**Units**
Recent Actions Not Included in Forecast (Current/planned building code changes)			
Electric GHG Emission Savings	**0.00**	**0.00**	$MMtCO_2e$
Gas GHG Emission Savings	**0.00**	**0.00**	$MMtCO_2e$
Total GHG Emission Savings	**0.00**	**0.00**	$MMtCO_2e$
Total for Option (Natural gas and electricity)			
GHG Emission Savings	**0.03**	**0.25**	$MMtCO_2e$
Net Present Value (2007-2020)		**-$15**	$million
Cumulative Emissions Reductions (2007-2020)		1.6	$MMtCO_2e$
Cost-Effectiveness		**-$9.73**	$\$/tCO_2e$

NOTES AND DATA FROM SOURCES

Note on Overall Approach to Analysis

The analysis for this option is based on structure used by the Building Codes Assistance Project (see http://www.bcap-energy.org). The analysis uses existing energy consumption and parameters to account for savings due to energy used for space conditioning in different climates and the estimated impact of building codes.

From Mitigation Option Description, the goals of the option are

- Increase standards such that the minimum performance of new and substantially-renovated buildings, both commercial and residential, is at least 15% higher by 2010 than that required by today's building codes (IECC 2003, though IECC 2006 codes are under consideration, see below), and 30% higher by 2020.

This analysis estimates the savings from full enforcement of the existing MT building code (according to energycodes.gov, "The MT Building Code CouMTil has adopted the 2003 IECC with MT amendments effective July 1, 2006. The amendments include adoption of ASHRAE 90.1-2004. Chapter 11 of the 2003 IRC has also been adopted and includes MT amendments; the effective date for the new 2006 MT Residential Code has been delayed until July 1, 2007.", but other suggests that IECC 2006 code adoption will be considered in summer, 2007.
IECC is the International Energy Conservation Code.

For 2008, this analysis assumes that the 2006 code (based on IECC 2003) achieves energy savings of

residential	3%	, eg standard practice is equivalent to about 1998 IECC levels
commercial	6%	, eg standard practice is equivalent to about ASHRAE 2001 levels

This assumption is based on notes provided by the Building Codes Assistance Project
(see notes on cells in column T and V in table below)

For enforcement rates, the analysis assumes:

50%	rate of energy code enforcement currently, before mitigation action (no source for this estimate, needs review by TWG)
95%	rate of energy code enforcement with this mitigation option in place

These are rough estimates and more appropriate values for Montana are welcomed.

For 2010, this analysis assumes that the current national building code will be approximately IECC 2003, or the equivalent of MT's 2006 code. Thus the options will achieve

15%	savings, relative to 2008 improvements, by 2010, and
30%	savings, relative to 2008 improvements, by 2020.

Annual energy savings are estimated using the table below are result in estimated savings of

2008 (code enforcement)

residential	0.001	TWh
Commercial	0.001	TWh

2010 (15% energy savings)

residential	0.007	TWh
Commercial	0.005	TWh

The above values are based on energy and households in 2005, these values are adjusted to provide future savings based on increased number of houses. See below

	RESIDENTIAL							
STATE	**TOTAL HOUSING UNITS**	**NEW HOUSING UNITS AUTHORIZED BY PERMIT (PRIVATELY OWNED)**		**Ratio - new units / existing units**	**TOTAL ELECTRICITY ENERGY USE (TWh) 2005**	**Estimated Electric energy use, new residential units (TWh)**	**Electric space conditioning multiplier (see "HVAC and Fuel Mix" worksheet)**	**energy use for space conditioning - new res buildings (TWh)**
full enforcement of 2003 IECC								
MT	433,454	5097		0.0118	4.2	0.05	16.1%	0.0080
15% improvement								
MT						0.0488		

COMMERCIAL						ENERGY SAVINGS POTENTIAL (TWh)					
Ratio - new/existing	**TOTAL ELECTRICITY ENERGY USE (TWh) 2005**	**Energy Intensity Correction Factor by Climate Zone and Vintage**	**Percentage of electric energy for Heating, Cooling, and Lighting**	**Commercial electric energy use for Heating, Cooling, & Lighting for new buildings (TWh)**	**STATE**	**Residential Savings Multiplier reflecting change from 2006 state code to 2004/2006 IECC.**	**Energy Savings Potential Residential New Construction**	**Energy Savings Potential Replacement Window**	**Commercial Savings Multiplier reflecting change from 2006 state code to ASHRAE 90.1-2004.**	**Energy Savings Potential Commercial New Construction**	**STATE**
0.0124	4.5	1.13	0.54	0.03	**MT**	0.030	0.001	0.000	0.060	0.001	**MT**
				0.03	**MT**	0.150	0.007	N/A	0.150	0.005	**MT**

Incremental annual energy savings		2007	2008	2009	2010	2011
Residential	TWh	0	0.0010	0.0010	0.008	0.007
Commercial	TWh	0	0.0010	0.0010	0.005	0.005
Growth factor, population based relative to population growth from 2005 (energy savings based on 2005 data)			1.14	1.15	1.16	0.98
Factor to increase 2010 savings to match 2020 goal			100%	100%	100%	110%

Montana	New housing units	5,097	2005

The following parameters are used to adjust the total electricity consumption in the residential sector to electricity use for space conditioning (data from the Residential Energy Consumption Survey (EIA)). A parameter for the commercial sector is used to adjust estimates of commercial electric energy use for Heating, Cooling, & Lighting for new buildings for climate.

July 2002-June 2003 State Heating Degree Days (HDD)

			Residential		**Commercial**
	HDD65	CDD65	RECS Climate Zone	% electric space conditioning	
MT	7525	252	1	16.1%	1.1309

Sources: http://lwf.ncdc.noaa.gov/oa/documentlibrary/hcs/hdd.200507-200607.pdf
http://lwf.ncdc.noaa.gov/oa/documentlibrary/hcs/cdd.200501-200607.pdf

Energy Intensity Correction Factor by Climate Zone

All Buildings	1.1538
>7000 HDD	1.1309
5500-7000	1.2408
4000-5499	1.0297
<4000	1.1986
>2000 CDD & <4000 HDD	1.1953

Household Electricity End Use

	Climate Zone				
	<2000 CDD				>2000 CDD and <4000 HDD
	>7000 HDD	5500-7000 HDD	4000-5499 HDD	<4000 HDD	
	Quadrillion Btus				
Climate Category	**1**	**2**	**3**	**4**	**5**
Space-Heating	0.03	0.08	0.12	0.08	0.09
Electric AC (central & room)	0.02	0.08	0.11	0.11	0.30
Water Heating	0.04	0.06	0.08	0.07	0.11
Refrigerators	0.04	0.13	0.11	0.10	0.15
Other Appliance & Lighting	0.18	0.52	0.43	0.37	0.48
TOTAL	0.31	0.87	0.85	0.73	1.13
Percent Electric Space Conditioning	**16.1%**	**18.4%**	**27.1%**	**26.0%**	**34.5%**

Source: 2001 RECS (http://www.eia.doe.gov/emeu/recs/recs2001/detailcetbls.html#space)

Additional Notes

Note 1:

From The Energy Efficiency Task Force Report to the Clean and Diversified Energy Advisory Committee of the Western Governors Association.
The Potential for More Efficient Electricity Use in the Western United States, January, 2006. This report is referred to here as the "WGA CDEAC EE report" and can be found at: http://www.westgov.org/wga/initiatives/cdeac/Energy%20Efficiency-full.pdf.
The CDEAC report provides a cost of saved energy (electricity) based on an average 7-year payback for code improvements (page 42).

For Montana, the equivalent cost is estimated as follows for electricity and natural gas

Note 2:

Based on results from Table 5.8 of the 2002 Energy Consumptions by Manufacturers--Data Tables published by the US Department of Energy's Energy Information Administration, and available as http://www.eia.doe.gov/emeu/mecs/mecs2002/data02/pdf/table5.8_02.pdf, approximately 18% of industrial electricity use in the West Census region is used for HVAC, lighting, and "other facility support", with 6.7% of natural gas used for HVAC and "other facility support".

In Montana, as of 2005, total electricity use by sector was as follows (from Retail Sales of Electricity by State by Sector by Provider, downloaded from http://www.eia.doe.gov/cneaf/electricity/epa/epa_sprdshts.html (file sales_revenue.xls)

	MWh	Fraction of Total
Residential	4,221,448	31%
Commercial	4,473,394	33%
Industrial	4,783,996	35%
Total	13,478,838	100%

Thus industrial use of electricity for non-process uses in Montana may be roughly 10.0% of total Residential and Commercial electricity use. This figure is used as an initial rule of thumb in estimating the contribution of savings from this policy from industrial sector measures.

Note 3:

The estimate of one unit of renovated space per unit of new construction in the commercial sector is an initial estimate only.

It is clear, however, that the renovation market represents a substantial opportunity for improving energy efficiency through code changes. A study of the non-residential renovation market in California (Remodeling and Renovation of Nonresidential Buildings in California, by Donald R. Dohrmann, John H. Reed, Sylvia Bender, Catherine Chappell, and Pierre Landry, available as http://www.energy.ca.gov/papers/2002-08-18_aceee_presentations/PANEL-10_DOHRMANN.PDF) suggests that by 1999 the value of renovations and additions to non-residential space was similar to that in new non-residential space, based on building permit data. As a market with newer buildings, it is possible that Montana has less renovation per unit building activity than California.

Note 4:

Calculated based on July-2004 to July-2005 estimate of total housing units in Montana from http://www.census.gov/popest/housing/HU-EST2005.html (see "2005 Total Housing Units" worksheet in this workbook). Since this figure implicitly nets out demolitions, it may somewhat undercount new units. The source: http://www.census.gov/const/C40/Table2/t2yu200512.txt provides an estimate of 5,068 "New Privately Owned Housing Units Authorized", which may be somewhat of an over-estimate for total new housing units in Montana, as it would presumably include some permitted units not ultimately built. We use the former estimate at present as the basis for calculation of future growth in housing units.

Estimate of Mitigation Option Costs and Benefits for Montana RCII GHG Analysis

RCII-5 **"Beyond Code" Building Design Incentives and Mandatory Programs**

Local Building Materials and Advanced Construction

Date Last Modified: 6/6/2007 D. Von Hippel/A Bailie

Key Data and Assumptions	2010	2020/all	Units
First Year Results Accrue		2008	
Based on goal set in Mitigation Option Design for RCII-7 (version dated 10/27/06) that reads "Ramp up program starting in 2007 to full effectiveness by 2012, except where noted otherwise".			

Electricity	2010	2020/all	Units
Levelized Cost of Electricity Savings		$37.2	$/MWh
As estimated for RCII-4. Based on 7-year payback as estimated in WGA CDEAC EE Report. (See Note 1 in RCII-4.)			
Levelized Cost of Natural Gas Savings		$4.7	$/MMBtu
As estimated for RCII-4. Based on 7-year payback as estimated in WGA CDEAC EE Report. (See Note 1 in RCII-4.)			
Avoided Electricity Cost		$49	$/MWh
See "AvCost" and "Common Factors" worksheets in this workbook.			
Avoided Natural Gas Cost		$6.5	$/MMBtu
See "NG prices aeo2006" and "Common Factors" worksheets in this workbook.			

Other Data, Assumptions, Calculations	2010	2020/all	Units
Inputs to/Intermediate Results of Calculation of Electricity and Gas Savings			
Average Electricity and Gas Savings Beyond Code Levels (new commercial and residential buildings)	25%	50%	
The description for this option currently includes the following: "Reduce per-unit-floor-area consumption of grid electricity and natural gas by 20% by 2020 in existing buildings, and by 50% in new buildings by 2020. Up to 10% of the targeted reduction for new homes can come from use of off-site electricity generation from renewable energy . These requirements should be phased in over time...". This is interpreted to mean that participating buildings will be on average 25 percent more efficient than code in 2010, and an estimated average of 50 percent more efficient than code in 2020.			
Note in particular that the level of savings shown here is beyond that already included in Option RCII-4, and thus already includes an improvement in efficiency relative to average current practice.			
Total Commercial Floorspace in Montana (million square feet)	242	256	
Estimated (see "MT_Activities_Est" worksheet in this workbook) based on USDOE EIA CBECS (comercial survey) data for the Mountain region, extrapolated using projected Montana population as a driver.			
Est. area of new commercial space per year in MT (million square feet)	1.8	1.2	
Calculated based on annual floorspace estimates above.			
Total Residential Housing Units in Montana	444,698	469,553	
Assumes 2005 ratio of new homes to increase in population holds through 2020. Based on 2005 MT housing units as provided in U.S Census Bureau annual data, http://www.census.gov/popest/housing/HU-EST2005.html.			
Implied persons per housing units in Montana (for reference only)	2.18	2.18	
Estimated number of new residential units per year	3,317	2,154	
Calculated based on estimates above.			
Implied Average Electricity Consumption per Square Foot Commercial Space in Montana as of 2005 (see Note 2)		19.18	kWh/yr
Implied Average Natural Gas Consumption per Square Foot Commercial Space in Montana as of 2005 (see Note 2)		44.87	kBtu/yr
Implied Average Electricity Consumption per Housing Unit in Montana as of 2005 (see Note 2)		9.85	MWh/yr
Implied Average Natural Gas Consumption per Housing Unit in Montana as of 2005 (see Note 2)		47.69	MMBtu/yr

NEW BUILDINGS

Electricity Use per New/Renovated Commercial Sq. Ft. After RCII-4 Application	**16.2**	**13.2**	kWh/yr
Reduces future per-unit electricity use based on savings from building code improvements (15 percent improvement by 2010, 30 percent by 2020) included in RCII-4.			
Nat. Gas Use per New/Renovated Commercial Sq. Ft. After RCII-4 Application	**35.4**	**25.9**	kBtu/yr
Assumes the same pattern of code improvement as for electricity use, as described above.			
Implied Electricity Use per New/Renovated Commercial Square Foot After RCII-4 Application, Relative to Average in Montana as of 2005	**84.3%**	**68.7%**	
Implied Natural Gas Use per New/Renovated Commercial Square Foot After RCII-4 Application, Relative to Average in Montana as of 2005	**78.8%**	**57.6%**	
Electricity Use per New/Renovated Residential Unit After RCII-4 Application	**7.4**	**5.0**	MWh/yr
Reduces future per-unit electricity use based on savings from building code improvements (15 percent improvement by 2010, 30 percent by 2020) included in RCII-4.			
Natural Gas Use per New/Renovated Residential Unit After RCII-4 Application	**35.5**	**23.3**	kBtu/yr
Reduces future per-unit electricity use based on savings from building code improvements (20 percent improvement by 2010) included in RCII-4.			
Implied Electricity Use per New/Renovated Residential Unit After RCII-4 Application, Relative to Average in Montana as of 2005	**75.4%**	**50.8%**	
Implied Natural Gas Use per New/Renovated Residential Unit After RCII-4 Application, Relative to Average in Montana as of 2005	**74.5%**	**48.9%**	
Date program of improvement of new buildings fully "ramped up"		2012	
Placeholder estimate pending TWG review.			
Fraction of new commercial buildings participating in program at full program level		25%	/yr
Fraction of new residential buildings converted included under program by 2020		25%	/yr
Implied fraction of new commercial floorspace included in program	**15.0%**	**25.0%**	/yr
Note that government-sector floorspace is covered under RCI-12.			
Implied commercial floorspace included in program (million square feet)	**0.271**	**0.293**	/yr
Implied fraction of new residential units included in program	**15.0%**	**25.0%**	/yr
Implied new residential units included in program	**498**	**539**	/yr

EXISTING BUILDIINGS

Fraction of existing buildings (buildings existing as of 2005) upgraded under program		25%	
Date by which upgrading goal for existing buildings achieved		2020	
As included in goals for policy option.			
Date program of improvement of existing buildings fully "ramped up"		2012	
Assumed same as for new buildings.			
Fraction of existing buildings (buildings existing as of 2005) upgraded annually from 2012 on:		2.27%	
Adjust until the value at right ~ 0.25 (adjustment for lower penetration during ramp-in period)	0.2497		
Fraction of existing buildings (buildings existing as of 2005) upgraded annually:	**1.4%**	**2.3%**	
Electricity and Gas savings from upgrading existing commercial buildings		20%	
As included in goals for policy option.			
Electricity and Gas savings from upgrading existing residential buildings		20%	
As included in goals for policy option.			

CALCULATION OF SAVINGS

Required Elect/Gas Improvement in New Commercial and Residential Space After RCII-4 Policy Relative to Average in After Application of RCII-4 *Calculated based on inputs above.*	**25.0%**	**50.0%**	
Implied total electricity savings in new commercial buildings from RCII-5 *First-year savings--not cumulative.*	**1.10**	**1.93**	GWh/yr
Implied total gas savings in new commercial buildings from RCII-5 *First-year savings--not cumulative.*	**2.40**	**3.79**	GBtu/yr
Implied total electricity savings in new residential buildings from RCII-5 *First-year savings--not cumulative.*	**0.92**	**1.35**	GWh/yr
Implied total gas savings in new residential buildings from RCII-5 *First-year savings--not cumulative.*	**4.42**	**6.28**	GBtu/yr
Implied total electricity savings in existing commercial buildings from RCII-5 *First-year savings--not cumulative.*	**12**	**20**	GWh/yr
Implied total gas savings in existing commercial buildings from RCII-5 *First-year savings--not cumulative.*	**29**	**48**	GBtu/yr
Implied total electricity savings in existing residential buildings from RCII-5 *First-year savings--not cumulative.*	**11**	**19**	GWh/yr
Implied total gas savings in existing residential buildings from RCII-5 *First-year savings--not cumulative.*	**56**	**93**	GBtu/yr

Average Fraction of Improvement in Electric Energy Intensities from:

Energy Efficiency Improvement	83%	80%
Solar Thermal Energy (hot water/space heat/space cooling)	5%	7%
On-site Solar PV	1%	2%
On-site Biomass/Biogas/Landfill Gas Energy Use	1%	1%
Green Power Purchase (from off-site, beyond electricity supply RPS)	10%	10%

All "placeholder" assumptions, except on-site biomass/biogas/landfill gas energy use calculated so that values sum to 100%.

Average Fraction of Improvement in Gas Energy Intensities from:

Energy Efficiency Improvement	94%	91%
Solar Thermal Energy (hot water/space heat/space cooling)	5%	7%
On-site Solar PV	0%	0%
On-site Biomass/Biogas/Landfill Gas Energy Use	1%	2%
Green Power Purchase (from off-site, beyond electricity supply RPS)	0%	0%

All "placeholder" assumptions, except on-site biomass/biogas/landfill gas energy use calculated so that values sum to 100%.

Adjustment for Inclusion of Rennovated Commercial Space as Well as New Under Program. *Currently set at 1.5 so that about 0.5 unit of renovated space is included per unit of new space (initial assumption). See Note 4. It may be useful to get further MT-specfic information regarding this value.*		**1.50**
Adjustment of Energy Use per Unit Floor Area for Commercial Buildings in Program Relative to Average Commercial Building in Montana *Placeholder assumption.*	1.00	1.00

Adjustment for Inclusion of Rennovated Residential Units as Well as New Under Program.	**1.00**

Currently set at 1.0 so that no renovated space is included per unit of new space (initial assumption). It may be useful to obtain further MT-specfic information regarding this value.

Implied Cumulative Impacts of Option, New Commercial Space (Electricity savings)

Energy Efficiency Improvement	**2.9**	**25.1**	GWh
Solar Thermal Energy (hot water/space heat/space cooling)	**0.2**	**1.8**	GWh
On-site Solar PV	**0.0**	**0.5**	GWh
On-site Biomass/Biogas/Landfill Gas Energy Use	**0.0**	**0.3**	GWh
Green Power Purchase (from off-site, beyond electricity supply RPS)	**0.4**	**3.1**	GWh

Implied Cumulative Impacts of Option, New Commercial Space (Natural Gas savings)

Energy Efficiency Improvement	**7.4**	**59.7**	GBtu/yr
Solar Thermal Energy (hot water/space heat/space cooling)	**0.4**	**3.8**	GBtu/yr
On-site Solar PV	**-**	**-**	GBtu/yr
On-site Biomass/Biogas/Landfill Gas Energy Use	**0.1**	**1.0**	GBtu/yr
Green Power Purchase (from off-site, beyond electricity supply RPS)	**-**	**-**	GBtu/yr

Implied Cumulative Impacts of Option, Existing Commercial Space (Electricity savings)

Energy Efficiency Improvement	**20.2**	**182.1**	GWh
Solar Thermal Energy (hot water/space heat/space cooling)	**1.2**	**13.4**	GWh
On-site Solar PV	**0.2**	**3.3**	GWh
On-site Biomass/Biogas/Landfill Gas Energy Use	**0.2**	**2.2**	GWh
Green Power Purchase (from off-site, beyond electricity supply RPS)	**2.4**	**22.3**	GWh

Implied Cumulative Impacts of Option, Existing Commercial Space (Natural Gas savings)

Energy Efficiency Improvement	**53.6**	**483.5**	GBtu/yr
Solar Thermal Energy (hot water/space heat/space cooling)	**2.9**	**31.3**	GBtu/yr
On-site Solar PV	**-**	**-**	GBtu/yr
On-site Biomass/Biogas/Landfill Gas Energy Use	**0.6**	**7.8**	GBtu/yr
Green Power Purchase (from off-site, beyond electricity supply RPS)	**-**	**-**	GBtu/yr

Implied Cumulative Impacts of Option, New Residential Space (Electricity savings)

Energy Efficiency Improvement	**0.9**	**12.3**	GWh
Solar Thermal Energy (hot water/space heat/space cooling)	**0.1**	**0.9**	GWh
On-site Solar PV	**0.0**	**0.2**	GWh
On-site Biomass/Biogas/Landfill Gas Energy Use	**0.0**	**0.2**	GWh
Green Power Purchase (from off-site, beyond electricity supply RPS)	**0.1**	**1.5**	GWh

Implied Cumulative Impacts of Option, New Residential Space (Natural Gas savings)

Energy Efficiency Improvement	**5.0**	**66.0**	GBtu/yr
Solar Thermal Energy (hot water/space heat/space cooling)	**0.3**	**4.3**	GBtu/yr
On-site Solar PV	**-**	**-**	GBtu/yr
On-site Biomass/Biogas/Landfill Gas Energy Use	**0.1**	**1.1**	GBtu/yr
Green Power Purchase (from off-site, beyond electricity supply RPS)	**-**	**-**	GBtu/yr

Implied Cumulative Impacts of Option, Existing Residential Space (Electricity savings)

Energy Efficiency Improvement	**19.1**	**171.8**	GWh
Solar Thermal Energy (hot water/space heat/space cooling)	**1.1**	**12.6**	GWh
On-site Solar PV	**0.2**	**3.2**	GWh
On-site Biomass/Biogas/Landfill Gas Energy Use	**0.2**	**2.1**	GWh
Green Power Purchase (from off-site, beyond electricity supply RPS)	**2.3**	**21.1**	GWh

Implied Cumulative Impacts of Option, Existing Residential Space (Natural Gas savings)

Energy Efficiency Improvement	**104.6**	**943.8**	GBtu/yr
Solar Thermal Energy (hot water/space heat/space cooling)	**5.6**	**61.2**	GBtu/yr
On-site Solar PV	**-**	**-**	GBtu/yr
On-site Biomass/Biogas/Landfill Gas Energy Use	**1.1**	**15.3**	GBtu/yr
Green Power Purchase (from off-site, beyond electricity supply RPS)	**-**	**-**	GBtu/yr

Additional Inputs to/Intermediate Results of Costs Analyses

Incremental Capital Cost of Solar Water Heater (relative to electric or gas unit)	**$3,500**	**$3,000**	

Placeholder Assumption, assuming gradual decline in real costs of solar collectors. By way of example, ***source in Note 4*** *below notes a 2005 solar hot water heater cost in New Mexico of about $4,000.*

Factors for Annualizing Capital Costs (SWH and PV Systems)

Interest Rate (real)		8%	/yr
Economic Life of System		20	years
Implied Annualization Factor		10.19%	%/yr

Estimated Average Floorspace per Commercial Building (square feet)		**13,313**	

Estimate,for the Mountain Region, see ***Note 5***

Water Heating

Estimate of total Commercial Delivered Energy Intensity (kBtu/square ft.-yr)	**118**	**119**	

National average estimate, all fuels, all end-uses, see ***Note 5***

Estimated Fraction of Delivered Energy Used for Water Heating		**9.6%**	

National average estimate, see ***Note 5***

Estimated Average Required kBtu/yr Delivered Water Heating Energy Per Commercial Building	**150,302**	**151,580**	

Use of Electricity and Other (non-solar) Energy Sources per (non-solar) Household in Absence of Policy

Electricity	**5,030**	**4,790**	kWh

Placeholder value based on NM jurisdication. See ***Note 10***

Approximate Water Heating Capacity Required Relative to Residential Unit	**9**	**9**	
Estimated annual levelized cost of solar hot water per unit output	**20.77**	**18.70**	$/MMBtu

Based on inputs to/results of solar hot water heating analysis above.

Adjustment to solar thermal costs for inclusion of space heat/cooling measures	1.00	1.00	

Placeholder assumption--Value of 1.0 implies that solar space heat and cooling will cost the same per unit output as solar water heating.

Implied Per Unit Cost Electricity Avoided by Solar WH/SH/Cooling	**65.91**	**59.32**	$/MWh
Implied Per Unit Cost Natural Gas Avoided by Solar WH/SH/Cooling	**14.54**	**13.09**	$/MMBtu

Assumes delivered solar WH/SH/Cooling replaces electric with EF of 0.93, gas with EF of 0.70 (and therefore one MMBtu of delivered solar heat is the equivalent of more than one MMBtu of each fuel).

Inputs to Cost Estimates for Residential Solar PV Systems (Data from Source in Note 6)

Average Capacity of Solar PV System Installed on New Homes (kW)	**2.00**	**2.00**	

Assumption, consistent with capacity assumption used in Source in ***Note 6***

Capital Costs for PV Systems for New Homes

Module	**$ 3,345**	**$ 2,003**	
BOS (Balance of System)	**$ 1,235**	**$ 739**	
Installation	**$ 409**	**$ 143**	
Total System - $/kW	**$ 4,989**	**$ 2,885**	
Total System - $	**$ 9,978**	**$ 5,769**	
Additional Cost Per Household for Solar-Ready Wiring/Meters/Roof Structures, Assuming 20% of BOS and Installation Costs	**$ 329**	**$ 176**	
Average full-capacity-equivalent hours of operation for Solar PV Systems:	**1,643**	**1,643**	

Placeholder value based on data for New Mexico from New Mexico Solar Energy Association--See ***Note 4****. This value may be somewhat high as an average for Montana.*

Commercial System Capital costs/kW Relative to New Residential *Rough assumption, but similar to values in literature--See* ***Note 7*** *.*	80%	80%	
Federal Solar Tax Credits: Commercial Sector--See ***Note 8***	10%	10%	
Reduce Captial Costs for Solar Tax Credits and Related Deductions?		**YES**	
Estimated annual levelized cost of on-site Solar PV *Based on solar PV cost assumptions described above. See also* ***Note 9*** *.*	**223**	**129**	$/MWh
Fuel Cost for On-site Biomass/Biogas/Landfill Gas Energy Use *Based on costs for Biomass fuel, which will likely dominate this category of fuel inputs. See "Common Assumptions" worksheet in this workbook. If significantly processed biomass fuels (such as pelletized fuels) are required, this cost may need to be increased.*		3.19	$/MMBtu
Relative Efficiency of On-site Biomass/Biogas/Landfill Gas displacing electricity *Placeholder assumption.*		0.75	
Factor to reflect probable higher costs of on-site Biomass/Biogas/Landfill Gas Equipment Relative to Electric Equipment *Placeholder assumption--In most cases, heating/water heating equipment designed to use biomass-derived fuels will be more expensive than equipment designed to use electricity. This factor loads these incremental capital costs into estimated fuel costs.*		2.00	
Implied Per Unit Cost Electricity Avoided by Biomass/Biogas/Landfill Gas	**28.95**	**28.95**	$/MWh
Incremental Cost for Green Power Purchase (from off-site, beyond supply RPS) *Placeholder assumption, but should be linked to assumptions for relevant ES options, if necessary.*	25.00	20.00	$/MWh

Results	**2010**	**2020**	**Units**
Electricity (Conventional)			
Reduction in Electricity Sales: Residential	24	226	GWh (sales)
Reduction in Electricity Sales: Commercial	28	254	GWh (sales)
TOTAL Reduction in Electricity Sales	52	480	GWh (sales)
Reduction in Generation Requirements	56	516	GWh (generation)
GHG Emission Savings	**0.06**	**0.43**	$MMtCO_2e$
Economic Analysis			
Net Present Value (2007-2020)		**-$9**	$million
Cumulative Emissions Reductions (2007-2020)		2.8	$MMtCO_2e$
Cost-Effectiveness		**-$3.16**	$\$/tCO_2e$
Natural Gas			
Reduction in Gas Use, Residential Sector	117	1,092	Billion BTU
Reduction in Gas Use, Commercial Sector	65	587	Billion BTU
TOTAL Reduction in Gas Sales	182	1,679	Billion BTU
GHG Emission Savings	**0.01**	**0.09**	$MMtCO_2e$
Economic Analysis			
Net Present Value (2007-2020)		**-$8**	$million
Cumulative Emissions Reductions (2007-2020)		0.54	$MMtCO_2e$
Cost-Effectiveness		**-$14.52**	$\$/tCO_2e$
Biomass/Biogas/Landfill Gas Fuel Use			
Biomass Fuels Use	**4.17**	**46.91**	GBtu/yr
Added GHG Emissions from Biomass Fuels Use	**0.00001**	**0.00012**	$MMtCO_2e$
Cumulative added Emissions from Biomass Fuels (2007-2020)		0.0007	$MMtCO_2e$

Summary Results for RCII-5	**2010**	**2020**	**Units**
Total for Option (Natural gas and Electricity less Biomass)			
GHG Emission Savings	**0.07**	**0.52**	MMtCO$_2$e
Net Present Value (2007-2020)		**-$16.8**	$million
Cumulative Emissions Reductions (2007-2020)		3.4	MMtCO$_2$e
Cost-Effectiveness		**-$4.98**	$/tCO$_2$e

Additional Summary Results for RCII-5 for Reporting	**2010**	**2020**	**Units**
Total Green Power Purchased Under RCII-5	5	48	GWh (sales)
Total Green Power Generation to Serve RCII-5	6	52	GWh (generation)
GHG Emission Savings from Green Power Component	**0.01**	**0.04**	MMtCO$_2$e
Net Present Value (2007-2020) of Green Power component of RCII-5		**$3.9**	$million
Total Renewable Energy Under RCII-5	1	12	GWh (at consumer site)
Total Reduction in Conventional Generation due to Renewable Energy Under RCII-5	1	13	GWh (equivalent at central generator)
Net Present Value (2007-2020) of renewable energy component of RCII-5	**0.00**	**0.01**	MMtCO$_2$e
		$3.4	$million

NOTES AND DATA FROM SOURCES

Note 1:

From The Energy Efficiency Task Force Report to the Clean and Diversified Energy Advisory Committee of the Western Governors Association.
The Potential for More Efficient Electricity Use in the Western United States, January, 2006. This report is referred to here as the "WGA CDEAC EE report" and can be found at:
http://www.westgov.org/wga/initiatives/cdeac/Energy%20Efficiency-full.pdf.
See Note 1 in RCII-4 worksheet in this workbook.

Note 2:

Based on results from Table B.5 of the 2003 Commercial Buildings Energy Consumption Survey, Detailed Tables dated October 2006 and published by the US Department of Energy's Energy Information Administration, and available as http://www.eia.doe.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/pdf2003/alltables.pdf, as described in "MT_Activities_Est" worksheet in this workbook.

Following data on electricity sales in Montana as of 2005 as described in "Utility_Sales" worksheet in this workbook.
Downloaded from http://www.eia.doe.gov/cneaf/electricity/epa/epa_sprdshts.html (file sales_revenue.xls)

	MWh	Fraction of Total
Residential	4,221,448	31%
Commercial	4,473,394	33%
Industrial	4,783,996	35%
Total	13,478,838	100%

For natural gas consumpation, consumption data from the USDOE EIA downloaded from http://www.eia.doe.gov/oil_gas/natural_gas/applications/eia176query.html are are follows:
(See "EIA_NG_Data" worksheet in this workbook for raw EIA data)

	Sales (Million Cubic Feet of Natural Gas)			
	Residential	Commercial	Industrial	Total
2005	19,834	10,162	398	30,394
Fraction of 2005 Total	65%	33%	1%	100%

Note 3:

The estimate of 0.5 unit of renovated space per unit of new construction in the commercial sector is a rough assumption.

It is likely that the ratio of commercial space undergoing major renovation to new commerial space will fluctuate year by year, and it may be necessary to get a more specific figure for this parameter. It is clear, however, that the renovation market represents a substantial opportunity for improving energy efficiency through code changes. A study of the non-residential renovation market in California (Remodeling and Renovation of Nonresidential Buildings in California, by Donald R. Dohrmann, John H. Reed, Sylvia Bender, Catherine Chappell, and Pierre Landry, available as http://www.energy.ca.gov/papers/2002-08-18_aceee_presentations/PANEL-10_DOHRMANN.PDF) suggests that by 1999 the value of renovations and additions to non-residential space was similar to that in new non-residential space, based on building permit data. As California includes a significant fraction of older buildings in its building stocks, renovations may be a smaller fraction of building activity in Montana.

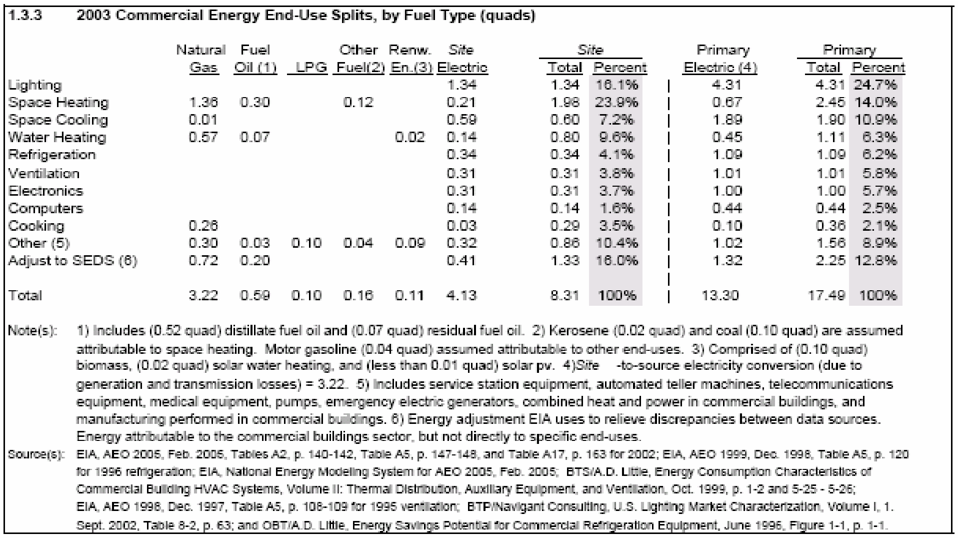
Note 4:

Based on midpoint of "4 to 5 kilowatt-hours (kWh) of usable electrical energy per day in New Mexico on average". From http://www.nmsea.org/Downloads/System_Sizing_Cost.pdf, "Buying Solar Energy Systems", New Mexico Solar Energy Association.

Note 5:

Based on data in the 2003 Commercial Buildings Energy Consumption Survey Detailed Tables published by the US Department of Energy's Energy Information Administration, and available as http://www.eia.doe.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/pdf2003/allbc.pdf, the average floorspace per building for all commercial buildings in the Mountain West (including malls) was 13,313 square feet (calculated from data in Tables A5 and A6).

The USDOE Office of Energy Efficiency and Renewable Energy's 2005 Building Energy Databook provides the following data, which were used to prepare a rough estimate of water heating requirements for commercial buildings in Montana. The table below is found on page 1-10 of the source document, which is available at http://buildingsdatabook.eren.doe.gov/docs/2005bedb-0805.pdf

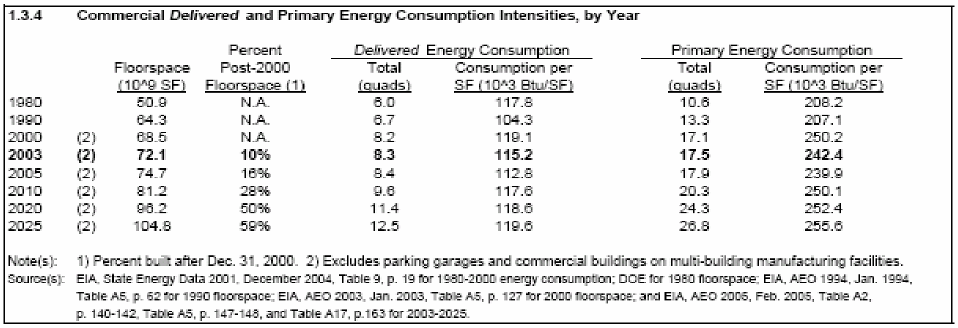


1.3.3 2003 Commercial Energy End-Use Splits, by Fuel Type (quads)

	Natural Gas	Fuel Oil (1)	LPG	Other Fuel(2)	Renw. En.(3)	*Site* Electric	*Site*		Primary Electric (4)	Primary	
							Total	Percent		Total	Percent
Lighting						1.34	1.34	16.1%	4.31	4.31	24.7%
Space Heating	1.36	0.30		0.12		0.21	1.98	23.9%	0.67	2.45	14.0%
Space Cooling	0.01					0.59	0.60	7.2%	1.89	1.90	10.9%
Water Heating	0.57	0.07			0.02	0.14	0.80	9.6%	0.45	1.11	6.3%
Refrigeration						0.34	0.34	4.1%	1.09	1.09	6.2%
Ventilation						0.31	0.31	3.8%	1.01	1.01	5.8%
Electronics						0.31	0.31	3.7%	1.00	1.00	5.7%
Computers						0.14	0.14	1.6%	0.44	0.44	2.5%
Cooking	0.26					0.03	0.29	3.5%	0.10	0.36	2.1%
Other (5)	0.30	0.03	0.10	0.04	0.09	0.32	0.86	10.4%	1.02	1.56	8.9%
Adjust to SEDS (6)	0.72	0.20				0.41	1.33	16.0%	1.32	2.25	12.8%
Total	3.22	0.59	0.10	0.16	0.11	4.13	8.31	100%	13.30	17.49	100%

Note(s): 1) Includes (0.52 quad) distillate fuel oil and (0.07 quad) residual fuel oil. 2) Kerosene (0.02 quad) and coal (0.10 quad) are assumed attributable to space heating. Motor gasoline (0.04 quad) assumed attributable to other end-uses. 3) Comprised of (0.10 quad) biomass, (0.02 quad) solar water heating, and (less than 0.01 quad) solar pv. 4)*Site* -to-source electricity conversion (due to generation and transmission losses) = 3.22. 5) Includes service station equipment, automated teller machines, telecommunications equipment, medical equipment, pumps, emergency electric generators, combined heat and power in commercial buildings, and manufacturing performed in commercial buildings. 6) Energy adjustment EIA uses to relieve discrepancies between data sources. Energy attributable to the commercial buildings sector, but not directly to specific end-uses.

Source(s): EIA, AEO 2005, Feb. 2005, Tables A2, p. 140-142, Table A5, p. 147-148, and Table A17, p. 163 for 2002; EIA, AEO 1999, Dec. 1998, Table A5, p. 120 for 1996 refrigeration; EIA, National Energy Modeling System for AEO 2005, Feb. 2005; BTS/A.D. Little, Energy Consumption Characteristics of Commercial Building HVAC Systems, Volume II: Thermal Distribution, Auxiliary Equipment, and Ventilation, Oct. 1999, p. 1-2 and 5-25 - 5-26; EIA, AEO 1998, Dec. 1997, Table A5, p. 108-109 for 1995 ventilation; BTP/Navigant Consulting, U.S. Lighting Market Characterization, Volume I, 1. Sept. 2002, Table 8-2, p. 63; and OBT/A.D. Little, Energy Savings Potential for Commercial Refrigeration Equipment, June 1996, Figure 1-1, p. 1-1.



1.3.4 Commercial *Delivered* and Primary Energy Consumption Intensities, by Year

		Floorspace (10^9 SF)	Percent Post-2000 Floorspace (1)	*Delivered* Energy Consumption		Primary Energy Consumption	
				Total (quads)	Consumption per SF (10^3 Btu/SF)	Total (quads)	Consumption per SF (10^3 Btu/SF)
1980		50.9	N.A.	6.0	117.8	10.6	208.2
1990		64.3	N.A.	6.7	104.3	13.3	207.1
2000	(2)	68.5	N.A.	8.2	119.1	17.1	250.2
2003	**(2)**	**72.1**	**10%**	**8.3**	**115.2**	**17.5**	**242.4**
2005	(2)	74.7	16%	8.4	112.8	17.9	239.9
2010	(2)	81.2	28%	9.6	117.6	20.3	250.1
2020	(2)	96.2	50%	11.4	118.6	24.3	252.4
2025	(2)	104.8	59%	12.5	119.6	26.8	255.6

Note(s): 1) Percent built after Dec. 31, 2000. 2) Excludes parking garages and commercial buildings on multi-building manufacturing facilities.

Source(s): EIA, State Energy Data 2001, December 2004, Table 9, p. 19 for 1980-2000 energy consumption; DOE for 1980 floorspace; EIA, AEO 1994, Jan. 1994, Table A5, p. 62 for 1990 floorspace; EIA, AEO 2003, Jan. 2003, Table A5, p. 127 for 2000 floorspace; and EIA, AEO 2005, Feb. 2005, Table A2, p. 140-142, Table A5, p. 147-148, and Table A17, p.163 for 2003-2025.

Note 6:
Source: Worksheet "Solar Homes Summary table.xls", with calculations in support of the California Million Solar Homes Initiative, authored by XENERGY, Inc., and provided by M. Lazarus. Selected annual data provided.

Note 7:
Source: International Energy Agency (IEA), TRENDS IN PHOTOVOLTAIC APPLICATIONS Survey report of selected IEA countries between 1992 and 2004. Report #IEA-PVPS T1-14:2005.
Page 18.
"Indicative costs" in 2004 in USD per kWp (assumedly DC output) for on-grid PV systems in the US:

<10 kW	7000 to 10,000
>10 kW	6300 to 8500

In EIA Projections of Renewable Energy Costs, presented in "Forum on the Economic Impact Analysis of NJ’s Proposed 20% RPS" by Chris Namovicz of the USDOE EIA (Energy Information Administration), dated February 22, 2005, and available as http://www.eia.doe.gov/oiaf/pdf/rec.pdf, a wind power average cost of

6000	dollars/kW is provided for a 25 kW Commercial system, or
8200	dollars/kW for a 2 kW Residential system, with

"Large potential for cost reduction".

Note 8:
A description of the new Federal Solar Tax Credits for businesses and residences as contained in the Energy Policy Act of 2005 (EPAct 2005) (see, for example, http://www.seia.org/getpdf.php?iid=21) provides for 30% (of system cost) tax credits for solar PV investments by businesses in 2006 and 2007, reverting to 10% thereafter. For residences, the credit in 2006 and 2007 is 30% with a "cap" of $2000, reverting to zero after 2007. For the purpose of this analysis, we are modeling the federal tax credit at its long-term (10% business, 0% residential) level, as no systems are added in 2006 and 2007.

Note 9:
For simplicity, in this analysis, a single stream of annual solar PV costs per MWh have been used for both commercial and residential PV installations. In fact, these costs will differ by sector, with residential systems costing more per kW on a total cost basis due to their smaller scale, but costing many homeowners less per kW because they can constitute part of the purchase price of a home, or be purchased with home equity loans, making the interest on their capital cost deductable from federal income taxes. These factors are assumed, for this analysis, to approximately offset.

Note 10:
Value for 2010 assumes 228 therms per HH using natural gas for water heat, based on value on p.
Natural Gas Energy Efficiency in the Service Territory of PNM, as prepared for PNM by GDS Associates, Inc, and dated May, 2005. Estimates for Electricity calculated based on average EF of .93 for Electricity, .7 for Natural Gas/LPG. Value in 2020 assumes 5% reduction in water heating energy use between 2010 and 2020 due to reduction in number of people per household plus naturally occuring energy efficiency improvements.

Estimate of Mitigation Option Costs and Benefits for Montana RCII GHG Analysis

RCII-10 Industrial Energy Audits and Recommended Measure Implementation

Date Last Modified: 4/25/2007 D. Von Hippel

Key Data and Assumptions	2010	2020/all	Units
First Year Results Accrue		2009	
Levelized Cost of Electricity Savings from Technical Assistance Recommendations			
Industrial Sector		$15.1	$/MWh
Estimated based on assumptions below. Payback period is an average of the average payback range of 2.5 to 3 years cited by John Campbell of NorthWestern Energy as consistent with an industrial energy efficiency resource of 40 to 84 MW for Montana as a whole. The average measure lifetime shown below is a rough assumption for industrial-sector measures. The levelized cost is calculated as the annual payment required per MWh saved over the lifetime of the efficiency improvements, using a real discount rate of 5 percent/yr.			
Levelized Cost of Natural Gas and Other Fuels Savings			
Industrial Sector		$2.05	$/MMBtu
Calculated based on lifetime assumption and average first cost for industrial gas energy efficiency improvements shown below.			
Assumed ave. simple payback, Industrial Sector energy efficiency improvements		2.75	years
Assumed average lifetime for Industrial Sector energy efficiency improvements		12	years
Average estimated industrial electricity rates in MT, 2010 to 2020		$49	$/MWh
Average estimated industrial gas rates in MT, 2010 to 2020		$6.59	$/MMBtu
Implied average cost of industrial sector electric efficiency improvements		$134	$/(MWh/yr)
Investment per unit annual savings			
Implied average first cost of industrial sector gas efficiency improvements		$18.13	$/(MMBtu/yr)
Investment per unit annual savings			
Avoided Electricity Cost		$49	$/MWh
Levelized value--See "Common Factors" worksheet			
Avoided Natural Gas Cost		$6.5	$/MMBtu
Levelized value--See "Common Factors" worksheet			
Avoided LPG Cost		$11.0	$/MMBtu
Avoided Oil Cost		$12.5	$/MMBtu
Potential Cost-effective Energy Savings from Implementing Recommended Measures		10%	
Within the range of the industrial energy efficiency resource of 40 to 84 MW for Montana as a whole as estimated by John Campbell, assuming a load factor of about 80 percent and year 2005 Montana industrial electricity use. This value is assumed to be applicable for both electricity and natural gas measures.			
Fraction of Potential Energy Savings Achieved Annually Under Option		8%	
Program target.			
First Year in which Full Program Savings Achieved		2010	
Years between first year that program results accrue and first year in which full progam savings are achieved are years in which program effort is phased in.			
Annual Technical Assistance Visits: Residential Sector		-	
Annual Technical Assistance Visits: Commercial Sector		-	
Esimated Annual Audits: Industrial Sector	364	364	
For reference only, not an input. Calculated based on program assumptions.			
Total Technical Assistance Visits Over Life of Program		4,183	

Other Data, Assumptions, Calculations	2010	2020/all	Units

Inputs to/Intermediate Results of Calculation of Electricity and Gas Savings

Fraction of Potential Energy Savings Achieved Annually Under Option	8.0%	8.0%	

Industrial Sector

Estimated Industrial-sector (Electricity) Customers	4,547	4,547	
Average annual growth in customer numbers, 2005 to 2020		0.0%	

Initial estimate--USDOE EIA data on industrial customer count in Montana since 1990 seems to fluctuate significantly year to year, and is probably not a true reflection of the actual number of industrial customers in the state.

Estimated Total Industrial Sector Energy Use

Electricity	5,150	5,886	GWh
Natural Gas	23,976	21,398	Billion Btu
LPG	1,170.3	1,159.4	Billion Btu
Oil (Distillate Oil)	13,104.3	12,982.6	Billion Btu

Average energy consumption per industrial (electricity) customer

Electricity	1,132.7	1,294.4	MWh
Natural Gas	5,272.9	4,706.0	MMBtu
LPG	257.4	255.0	MMBtu
Oil (Kerosene and Distillate Oil)	2,882.0	2,855.2	MMBtu

Average Savings from Application of Measures from Technical Assistance Visits

Electricity		10%	
Natural Gas and Other Fuels		10%	

As noted above.

Include LPG and Oil in analysis?		NO	

Estimated Savings From Application of Measures (first-year savings, not cumulative)

Electricity	41.2	47.1	GWh
Natural Gas	191.8	171.2	Billion Btu
LPG	-	-	Billion Btu
Oil (Kerosene and Distillate Oil)	-	-	Billion Btu

Results	**2010**	**2020**	**Units**
Electricity Savings			
Reduction in Electricity Sales: Industrial	62	505	GWh (sales)
TOTAL Reduction in Electricity Sales	62	505	GWh (sales)
Reduction in Generation Requirements	66	543	GWh (generation)
GHG Emission Savings	**0.07**	**0.46**	MMtCO$_2$e
Economic Analysis			
Net Present Value (2007-2020)		**-$63**	$million
Cumulative Emissions Reductions (2007-2020)		3.0	MMtCO$_2$e
Cost-Effectiveness		**-$21.18**	$/tCO$_2$e
Natural Gas and Other Fuel Savings			
Reduction in Natural Gas Use: Industrial	94	1,917	Billion BTU
TOTAL Reduction in Natural Gas Sales	**94**	**1,917**	Billion BTU
Reduction in LPG Use: Industrial	0	0	Billion BTU
TOTAL Reduction in LPG Sales	**0**	**0**	Billion BTU
Reduction in Oil Use: Industrial	0	0	Billion BTU
TOTAL Reduction in Oil Sales	**0**	**0**	Billion BTU
GHG Emission Savings	**0.00**	**0.10**	MMtCO$_2$e
Economic Analysis			
Net Present Value (2007-2020)		**-$30**	$million
Cumulative Emissions Reductions (2007-2020)		0.6	MMtCO$_2$e
Cost-Effectiveness		**-$49.86**	$/tCO$_2$e

Summary Results for RCII-10	**2010**	**2020**	**Units**
Total for Policy (Electricity, Natural Gas and Other Fuels)			
GHG Emission Savings	**0.07**	**0.56**	MMtCO$_2$e
Net Present Value (2007-2020)		**-$93**	$million
Cumulative Emissions Reductions (2007-2020)		3.6	MMtCO$_2$e
Cost-Effectiveness		**-$25.93**	$/tCO$_2$e

NOTES AND DATA FROM SOURCES

Note 1:

From The Energy Efficiency Task Force Report to the Clean and Diversified Energy Advisory Committee of the Western Governors Association.
The Potential for More Efficient Electricity Use in the Western United States, January, 2006. This report is referred to here as the "WGA CDEAC EE report" and can be found at: http://www.westgov.org/wga/initiatives/cdeac/Energy%20Efficiency-full.pdf.

Estimate of Mitigation Option Costs and Benefits for Montana RCII GHG Analysis

RCII-11 Low income and rental housing energy efficiency programs

Date Last Modified:	*6/6/2007 D. Von Hippel*

Key Data and Assumptions	2010	2020/all	Units
First Year Results Accrue		**2009**	
First Target: Achieve		**30%**	
Energy savings in		**50%**	
of eligible homes (household incomes less than 150 percent of Federal Poverty level) by the year		**2015**	
Ramp-up of First Target Program Complete by		**2011**	
Second Target: Achieve		**50%**	
Energy savings in		**75%**	
of eligible homes by the year		**2020**	
Start year for second target program		**2012**	
Ramp-up of Second Target Program Complete by		**2015**	
Average Cost per Home ($2005) to achieve first target		**$4,000**	
Rough estimate provided by Kane Quenemoen of MT Department of Public Health and Human Services (personal communication), based on an extrapolation of current program experience (an average of about 22 percent savings with an investment of $2700.			
Average Cost per Home ($2005) to achieve second target (directly)		**$6,500**	
Estimate provided as a starting point for analysis (range, $6000 - $7000) by Kane Quenemoen of MT Department of Public Health and Human Services (personal communication). Note that this value may change over time as homes with more severe energy-efficiency problems are weatherized, and the remaining pool of potential participants has more moderate energy use, on average, than those already treated. Future changes in technology could also, of course, affect future costs.			
Average Cost per Home ($2005) to "upgrade" from first to second target		**$2,500**	
Difference of costs above (but placeholder estimate).			
Of the above, average amount per Home ($2005) spent on health and safety measures with limited impact on energy efficiency		**$1,100**	
Estimate provided by Kane Quenemoen of MT Department of Public Health and Human Services (personal communication), based on current program experience.			
Average Lifetime of Efficiency Improvements		25	years
Assumption, but consistent with long-lived weatherization investments.			
Avoided Electricity Cost		**$49**	$/MWh
Levelized value--See "Common Factors" worksheet			
Avoided Natural Gas Cost		**$6.5**	$/MMBtu
Levelized value--See "Common Factors" worksheet			
Avoided Distillate Oil Cost		**$12.5**	$/MMBtu
Avoided LPG Cost		**$11.0**	$/MMBtu
Avoided Wood Cost		**$3.2**	$/MMBtu

Other Data, Assumptions, Calculations	**2010**	**2020/all**	**Units**
Total number of homes in Montana	444,698	469,553	

Uses 2005 number of housing units (from US Census data) as starting point, and with number of households assumed to grow at the same rate as population (See "MT_Activities" worksheet in this workbook)..

Fraction of Montana homes (total, not just "occupied") meeting income eligibility requirements in 2005		**20.33%**	
Fraction of Montana homes occupied by renters but with households NOT meeting income eligibility requirements in 2005		**14.63%**	
Annual average change in eligible fractions, 2006 to 2020		0.0%	
Implied fraction of households eligible for program	34.96%	34.96%	

Uses 2005 fraction of Montana residents below 150 percent of Federal powerty level. See ***Note 1****, below. (Also see "US Poverty Data" worksheet in this workbook. Data from U.S. Bureau of the Census,http://pubdb3.census.gov/macro/032006/pov/new46_135150_01.htm.)*

Implied number of households eligible for program net of those participating in existing program	146,959	138,648	

Makes the simplifying assumption that those housing units that have participated in existing MT Department of Public Health and Human Services low-income housing program from 2006 on are not eligible for the expanded program. See below for assumptons on the existing program.

Annual Average Energy Use per Household in (based on inventory estimates)			
Electricity	9.55	9.22	MWh
Natural Gas	49.78	51.98	MMBtu
Distillate Oil	2.27	2.19	MMBtu
LPG	7.79	7.52	MMBtu
Wood	3.74	3.10	MMBtu

Currently assumes that average energy use in low-income households is similar to the average energy use (for all fuels) in all households in MT. In fact, low income homes are likely to be both smaller (and thus require fewer energy services) then average homes, but are likely also less efficient--the data are not presently at hand to judge how these countervailing factors might balance (or not).

Fraction of eligible households meeting first target annually after start-up		8.3%	
Fraction of eligible households meeting first target annually	5.56%	0.00%	
Cumulative faction of eligible households meeting first target	8.33%	50.00%	
Number of households participating annually for first target	8,149	-	
Total number of households meeting first target by 2020		71,709	
Fraction of eligible households meeting second target annually after start-up		10.0%	
Fraction of eligible households meeting second target annually	0.00%	10.00%	
Cumulative faction of eligible households meeting second target	0.00%	75.00%	
Number of households participating annually for second target	-	13,249	
Total number of households meeting second target by 2020		103,986	
Assumed "cap" on total fraction of households participating:		75%	
Implied number of households "upgraded" from first to second target		32,278	
"Upgraded" households distributed over last 6	years of program		
Number of households "upgraded" annually from first to second target	-	5,380	
Number of households annually meeting second target directly (not upgraded)	-	7,870	
Annual Average Energy Savings per Household reaching first target			
Electricity	2.86	2.77	MWh
Natural Gas	14.93	15.60	MMBtu
Distillate Oil	0.68	0.66	MMBtu
LPG	2.34	2.25	MMBtu
Wood	1.12	0.93	MMBtu

Annual Average Energy Savings per Household upgrading to second target

Electricity	1.91	1.84	MWh
Natural Gas	9.96	10.40	MMBtu
Distillate Oil	0.45	0.44	MMBtu
LPG	1.56	1.50	MMBtu
Wood	0.75	0.62	MMBtu

Annual Average Energy Savings per Household reaching second target directly

Electricity	4.77	4.61	MWh
Natural Gas	24.89	25.99	MMBtu
Distillate Oil	1.14	1.10	MMBtu
LPG	3.90	3.76	MMBtu
Wood	1.87	1.55	MMBtu

First-year (not cumulative) Energy Savings for Households reaching first target

Electricity	23.34	-	GWh
Natural Gas	121.69	-	Billion Btu
Distillate Oil	5.56	-	Billion Btu
LPG	19.05	-	Billion Btu
Wood	9.14	-	Billion Btu

First-year (not cumulative) Energy Savings for Households upgrading to second target

Electricity	-	9.92	GWh
Natural Gas	-	55.93	Billion Btu
Distillate Oil	-	2.36	Billion Btu
LPG	-	8.09	Billion Btu
Wood	-	3.34	Billion Btu

First-year (not cumulative) Energy Savings for Households reaching second target directly

Electricity	-	36.28	GWh
Natural Gas	-	204.55	Billion Btu
Distillate Oil	-	8.62	Billion Btu
LPG	-	29.58	Billion Btu
Wood	-	12.20	Billion Btu

Total Annual Investment Costs for all improvements	$ 32,598	$ 64,602	$ thousand

Includes health and safety-related measures with limited impact on energy use.

Annual Investment Costs for energy-efficiency-related improvements	$ 23,633	$ 50,028	$ thousand

Net of health and safety-related measures with limited impact on energy use.

Implied levelized cost of saved energy for households reaching first target

Electricity	$ 72	$ 74	$/MWh

Calculated only for electricity, because the same investment also yields savings for other fuels.

Implied levelized cost of saved energy for households upgrading to second target

Electricity	$ 93	$ 96	$/MWh

Implied levelized cost of saved energy for households reaching second target directly

Electricity	$ 80	$ 83	$/MWh

Implied first-year levelized cost of saved energy for households reaching first target in that year	$ 1,676,839	$ -
Implied first-year levelized cost of saved energy for households upgrading to second target in that year	$ -	$ 954,239
Implied first-year levelized cost of saved energy for households reaching second target directly in that year	$ -	$ 3,015,238

Implied cumulative levelized cost of all participating households	$ 2,520	$ 47,955	$ thousand

Assumptions for Existing Low-income Weatherization Program (Recent Actions)

Number of homes weatherized per year	1700
Fractional energy savings in existing houses under current program	22%

Estimates based on recent MT Department of Public Health and Human Services program accomplishments provided by Kane Quenemoen of MT Department of Public Health and Human Services (personal communication).

Results	**2010**	**2020**	**Units**
Electricity Savings--Existing Program			
Reduction in Electricity Sales: Residential	18	53	GWh (sales)
TOTAL Reduction in Electricity Sales	18	53	GWh (sales)
Reduction in Generation Requirements	20	57	GWh (generation)
GHG Emission Savings	**0.02**	**0.05**	MMtCO$_2$e
Natural Gas and Other Fuel Savings--Existing Program			
Reduction in Natural Gas Use: Residential	92	283	Billion BTU
Reduction in Distillate Oil Use: Residential	4	13	Billion BTU
Reduction in LPG Use: Residential	15	43	Billion BTU
Reduction in Wood Use: Residential	7	20	Billion BTU
GHG Emission Savings from above	**0.01**	**0.02**	MMtCO$_2$e
Electricity Savings--Expanded Program			
Reduction in Electricity Sales: Residential	35	597	GWh (sales)
TOTAL Reduction in Electricity Sales	35	597	GWh (sales)
Reduction in Generation Requirements	38	643	GWh (generation)
GHG Emission Savings	**0.04**	**0.54**	MMtCO$_2$e
Economic Analysis			
Net Present Value (2007-2020)		**$61**	$million
Cumulative Emissions Reductions (2007-2020)		3.4	MMtCO$_2$e
Cost-Effectiveness		**N/A**	$/tCO$_2$e
Natural Gas and Other Fuel Savings--Expanded Program			
Reduction in Natural Gas Use: Residential	182	3,256	Billion BTU
Reduction in Distillate Oil Use: Residential	8	143	Billion BTU
Reduction in LPG Use: Residential	29	491	Billion BTU
Reduction in Wood Use: Residential	14	216	Billion BTU
GHG Emission Savings from above	**0.01**	**0.21**	MMtCO$_2$e
Economic Analysis			
Net Present Value (2007-2020) (Avoided cost savings only)		**-$102**	$million
Cumulative Emissions Reductions (2007-2020)		1.3	MMtCO$_2$e
Cost-Effectiveness		**N/A**	$/tCO$_2$e

Summary Results for RCII-11	**2010**	**2020**	**Units**
Total for Policy (Electricity, Natural Gas and Other Fuels)			
GHG Emission Savings	**0.05**	**0.75**	MMtCO$_2$e
Net Present Value (2007-2020)		**-$41**	$million
Cumulative Emissions Reductions (2007-2020)		4.7	MMtCO$_2$e
Cost-Effectiveness		**-$8.75**	$/tCO$_2$e

NOTES AND DATA FROM SOURCES

Note 1

Montana demographics - by income level

Source: U.S. Census Bureau, Current Population Survey, 2006 Annual Social and Economic Supplement.

From: http://pubdb3.census.gov/macro/032006/pov/new46_100125_01.htm

and http://pubdb3.census.gov/macro/032006/pov/new46_135150_01.htm.

	All income levels	Below 100% of Poverty	Below 150% of Poverty
	(thousands of persons)		
Montana population (2005 data)	926	128	219
Percentage of population	100%	14%	23.7%

ratio of 150% poverty to 100% poverty:
1.711

Total Occupied Housing Units in MT, 2005:	368,268
Total Occupied Rental Housing Units in MT, 2005:	113,810

(From 2005 American Community Survey, downloaded from http://factfinder.census.gov; see "US Poverty Data" worksheet in this workbook).

Implied number of housing units occupied by households with income below 150% of poverty level in MT as of 2005 87,096

Data Source for Poverty Status x Rental Status Estimates

Geographic Summary Level - State

Geographic Areas - State in [Montana]

Demographic Universe - Renter Occupied Housing Units

Demographic Characteristics - Person Poverty Status Recode (12) in [Less than 25%; 25.0% to 49.9%; 50.0% to 74.9%; 75.0% to 99.9%; 100.0% to 124.9%; 125.0% to 134.9%; 135.0% to 149.9%; 150.0% to 184.9%; 185.0% to 199.9%; 200.0% to 249.9%; 250.0% to 299.9%; 300.0% or more]

State	Person Poverty Status Recode (12)	Metrics Count	Cumulative totals, 2000
Montana	**Less than 25%**	6,023	Households
	25.0% to 49.9%	5,294	under
	50.0% to 74.9%	9,055	150% of
	75.0% to 99.9%	10,116	poverty level
	100.0% to 124.9%	9,872	
	125.0% to 134.9%	3,646	
	135.0% to 149.9%	5,875	49,881
	150.0% to 184.9%	11,750	Households
	185.0% to 199.9%	3,690	over
	200.0% to 249.9%	11,391	150% of
	250.0% to 299.9%	9,459	poverty level
	300.0% or more	24,796	61,086
	Total	**110,967**	
Total		**110,967**	

Source: U.S. Census Bureau, Census 2000 Sample Data File

Data users who create their own tabulations using data from the Census 2000 Sample Data File should cite the Census Bureau as the source of the original data only.

Individuals for whom poverty status is determined. Poverty status was determined for all people except institutionalized people, people in military group quarters, people in college dormitories, and unrelated individuals under 15 years old.

Above Sent by Pam Harris of the Census and Information Center, Montana Department of Commerce, attached to email to Greg Powell of Pembina/CCS on June 6, 2007 with subject "RE: Montana census data"

From above, year 2000 fraction of households in rental housing with income over 150 percent of poverty level 55.0%

Assuming that this ratio holds for the year 2005 as well, the number of rental housing units in MT occupied by households with incomes above 150% of the poverty level is estimated at: 62,651

Estimate of Mitigation Option Costs and Benefits for Montana RCII GHG Analysis

RCII-12 **State Lead by Example**

Date Last Modified: *6/26/2007 D. Von Hippel/A Bailie*

Key Data and Assumptions	2010	2020/all	Units
First Year Results Accrue *Based on goal set in Policy Option Design for RCII-12 (version dated 5/1/07).*		**2010**	
Electricity			
Levelized Cost of Electricity Savings *Based on estimate in WGA CDEAC EE Report. (See Note 1, below.) Although this estimate is based on building efficiency improvements driven by code changes, it is on the order of estimates for the costs of efficiency improvements for "beyond code" changes included in a recent report by the Southwest Energy Efficiency Project (SWEEP--see Note 2). Value here adjusted for NC prices based on 7-year payback estimated in WGA CDEAC EE Report. (See Note 1 in RCI-4.)*		**$37.2**	$/MWh
Levelized Cost of Natural Gas Savings *As estimated for RCII-4. Based on 7-year payback as estimated in WGA CDEAC EE Report. (See Note 1 in RCII-4.)*		**$4.7**	$/MMBtu
Bulk Purchase Program:			
Fraction of State agency electricity demand addressed by bulk purchasing program *Target for Program.*		**10%**	
Fraction of all-sector (excluding government) electricity demand addressed by bulk purchasing program *Policy assumed to cover government demand only.*		**0%**	
Average lifetime of devices included in bulk purchasing program *Placeholder estimate--designed to be an average between longer-lived equipment such as water heaters and air conditioners, and shorter-lived devices such as computers.*		**10**	years
Fractional savings from bulk purchase program relative to standard-efficiency equipment, appliances, and other devices. *Placeholder estimate, but consistent with an average of fractional savings possible with many different types of higher-than-standard efficiency appliances, equipment, and other devices.*		**20%**	
Assumed Cost of Bulk Purchase Program Savings *Pending receipt of more specific information, assumed to be similar to the cost of market transformation programs. Figure used is the same as used in RCII-2 worksheet in this workbook (From WGA EE Task Force study (2005), which cites the Retrospective Analysis of the Northwest Energy Efficiency Alliance (Violette, Ozog, and Cooney, 2003).)*		**$12**	$/MWh
Target Year for Achieving Purchase Level *Target consistent with timing of building efficiency improvement element.*		**2020**	
Avoided Electricity Cost *See "AvCost" and "Common Factors" worksheets in this workbook.*		**$49**	$/MWh
Avoided Natural Gas Cost *See "NG prices aeo2006" and "Common Factors" worksheets in this workbook.*		**$6.5**	$/MMBtu

Other Data, Assumptions, Calculations	2010	2020/all	Units
Inputs to/Intermediate Results of Calculation of Electricity and Gas Savings from Beyond-code Building Improvements			
Average Electricity and Gas Savings Beyond Code Levels (new government buildings) *The description for this option currently includes the following: "Reduce per-unit-floor-area consumption of grid electricity and natural gas by 20% by 2020 in existing buildings, and by 40% in new buildings by 2020. These requirements should be phased in over time." The values shown above for these parameters are initial assumptions.* ***Note in particular that the level of savings shown here is beyond that already included in Option RCII-4, and thus already includes an improvement in efficiency relative to average current practice.***	**9%**	**9%**	
Total Commercial Floorspace in Montana (million square feet) *Estimated (see "MT_Activities_Est" worksheet in this workbook) based on USDOE EIA CBECS (commercial survey) data for the Mountain region, extrapolated using projected Montana population as a driver.*	**242**	**256**	

Est. area of new commercial space per year (million square feet)	**1.8**	**1.2**	

Calculated based on estimates above.

Implied Average Electricity Consumption per Square Foot Commercial Space in Montana as of 2005 (see ***Note 3***)		19.18	kWh/yr
Implied Average Natural Gas Consumption per Square Foot Commercial Space in Montana as of 2005 (see ***Note 3***)		44.87	kBtu/yr
Electricity Use per New/Renovated Commercial Sq. Ft. After RCII-4 Application	**16.2**	**13.2**	kWh/yr

Based on application of RCI-4 (15-30% efficiency improvement)--see calculations and notes in "RCI-4" worksheet in this workbook. with ultimate savings of 15 percent relative to current building codes by 2010, and 30 percent by 2030.

Nat. Gas Use per New/Renovated Commercial Sq. Ft. After RCII-4 Application	**35.4**	**25.9**	kBtu/yr

Assumes the same pattern of code improvement as for electricity use, as described above.

Implied Electricity Use per New/Renovated Commercial Square Foot After RCII-4 Application, Relative to Average in Montana as of 2005	**84.3%**	**68.7%**
Implied Natural Gas Use per New/Renovated Commercial Square Foot After RCII-4 Application, Relative to Average in Montana as of 2005	**84.3%**	**68.7%**

Required Net Elect/Gas Use per Square Foot New Government Space	First Year	**75%**
After RCII-4 Policy Relative to Average in Montana in 2005	In 2020	**60%**

Placeholder estimate, to be revised in consultation with TWG (based on pattern of improvement implied by meeting specifications in RCII-12 Option Design).

Required Net Elect/Gas savings per Square Foot Existing Government Space After RCII-4 Policy Relative to Average in Montana in 2005	**1.8%**	**20.0%**

Based on "20 percent improvement by 2020" as noted in RCII-12 Option Design.

Government floorspace (including leased) by year (million square feet)	**74**	**78**	
Implied total electricity savings in existing buildings from RCII-12	**25**	**297**	GWh/yr
Implied total gas savings in existing buildings from RCII-12	**60**	**695**	GBtu/yr

Average Fraction of Improvement in Electric Energy Intensities from:

Energy Efficiency Improvement	91%	80%
Solar Thermal Energy (hot water/space heat/space cooling)	3%	5%
On-site Solar PV	1%	3%
On-site Biomass/Biogas/Landfill Gas Energy Use	2%	4%
Green Power Purchase (from off-site, beyond electricity supply RPS)	3%	8%

All "placeholder" assumptions, but based on RCII-12 goal "Require 25% of energy use to be generated from renewable sources by 2025 in new and existing buildings. These goals may be met through any combination of on-site generation and “green power” purchases." On-site biomass/biogas/landfill gas energy use calculated so that values sum to 100%.

Average Fraction of Improvement in Gas Energy Intensities from:

Energy Efficiency Improvement	95%	80%
Solar Thermal Energy (hot water/space heat/space cooling)	5%	7%
On-site Solar PV	0%	0%
On-site Biomass/Biogas/Landfill Gas Energy Use	0%	13%
Green Power Purchase (from off-site, beyond electricity supply RPS)	0%	0%

All "placeholder" assumptions, based on goal cited above, except on-site biomass/biogas/landfill gas energy use calculated so that values sum to 100%.

Adjustment for Inclusion of Rennovated Commercial Space as Well as New Under New Code Requirements.		**1.50**

Currently set at 1.5 so that about 0.5 unit of renovated space is included per unit of new space (initial assumption). See Note 4. It may be useful to get further MT-specfic information regarding this value.

Adjustment of Energy Use per Unit Floor Area for State/State-funded Buildings Relative to Average Commercial Building in Montana	1.00	1.00

Placeholder assumption.

Fraction of New/Renovated Commercial Space in Government Buildings		25.4%	

This estimate includes state-owned buildings plus local government buildings, including schools. Estimate is based on the fraction of commercial-sector floorspace in state and local-owned government buildings in the Mountain region, as described in CBECS 2003 data (see "MT_Activities_Est" worksheet in this workbook), pending receipt of MT-specific data.

Adjustment to Exclude Floor Area of New/Renovated State/State-funded buildings not included in option.	1.00	1.00	

Placeholder assumption. Reduce below 1.0 if, for example, the option is designed to exclude small or special-use buildings.

Implied Annual Square Feet New Building Space Covered by Policy (million)	**0.83**	**0.54**	

Implied Cumulative Impacts of Option, New Government Space (Electricity savings)

Energy Efficiency Improvement	**1.14**	**9.20**	GWh
Solar Thermal Energy (hot water/space heat/space cooling)	**0.04**	**0.41**	GWh
On-site Solar PV	**0.01**	**0.20**	GWh
On-site Biomass/Biogas/Landfill Gas Energy Use	**0.02**	**0.31**	GWh
Green Power Purchase (from off-site, beyond electricity supply RPS)	**0.04**	**0.55**	GWh

Implied Cumulative Impacts of Option, New Government Space (Natural Gas savings)

Energy Efficiency Improvement	**2.59**	**19.84**	GBtu/yr
Solar Thermal Energy (hot water/space heat/space cooling)	**0.14**	**1.31**	GBtu/yr
On-site Solar PV	-	-	GBtu/yr
On-site Biomass/Biogas/Landfill Gas Energy Use	**0.00**	**1.23**	GBtu/yr
Green Power Purchase (from off-site, beyond electricity supply RPS)	-	-	GBtu/yr

Implied Cumulative Impacts of Option, Existing Government Space (Electricity savings)

Energy Efficiency Improvement	**23.17**	**237.64**	GWh
Solar Thermal Energy (hot water/space heat/space cooling)	**0.76**	**14.85**	GWh
On-site Solar PV	**0.25**	**8.91**	GWh
On-site Biomass/Biogas/Landfill Gas Energy Use	**0.51**	**11.88**	GWh
Green Power Purchase (from off-site, beyond electricity supply RPS)	**0.76**	**23.76**	GWh

Implied Cumulative Impacts of Option, Existing Government Space (Natural Gas savings)

Energy Efficiency Improvement	**56.60**	**556.02**	GBtu/yr
Solar Thermal Energy (hot water/space heat/space cooling)	**2.98**	**48.65**	GBtu/yr
On-site Solar PV	-	-	GBtu/yr
On-site Biomass/Biogas/Landfill Gas Energy Use	**0.00**	**90.35**	GBtu/yr
Green Power Purchase (from off-site, beyond electricity supply RPS)	-	-	GBtu/yr

Additional Inputs to/Intermediate Results of Costs Analysis for Building Improvements

Estimated annual levelized cost of solar hot water per unit output	**20.77**	**18.70**	$/MMBtu

Based on inputs to/results of solar hot water heating included in RCII-5.

Adjustment to solar thermal costs for inclusion of space heat/cooling measures	1.00	1.00	

Placeholder assumption--Value of 1.0 implies that solar space heat and cooling will cost the same per unit output as solar water heating.

Implied Per Unit Cost Electricity Avoided by Solar WH/SH/Cooling	**65.91**	**59.32**	$/MWh
Implied Per Unit Cost Natural Gas Avoided by Solar WH/SH/Cooling	**14.54**	**13.09**	$/MMBtu

Assumes delivered solar WH/SH/Cooling replaces electric with EF of 0.93, gas with EF of 0.70 (and therefore one MMBtu of delivered solar heat is the equivalent of more than one MMBtu of each fuel).

Estimated annual levelized cost of on-site Solar PV	**223**	**129**	$/MWh

Based on inputs to/results of solar PV analysis included in RCI-5.

Fuel Cost for On-site Biomass/Biogas/Landfill Gas Energy Use		**3.19**	$/MMBtu

Based on costs for Biomass fuel, which will likely dominate this category of fuel inputs. See "Common Assumptions" worksheet in this workbook. If significantly processed biomass fuels (such as pelletized fuels) are required, this cost may need to be increased.

Relative Efficiency of On-site Biomass/Biogas/Landfill Gas displacing electricity		0.75	

Placeholder assumption.

Factor to reflect probable higher costs of on-site Biomass/Biogas/Landfill Gas Equipment Relative to Electric Equipment		2.00	

Placeholder assumption--In most cases, heating/water heating equipment designed to use biomass-derived fuels will be more expensive than equipment designed to use electricity. This factor loads these incremental capital costs into estimated fuel costs.

Implied Per Unit Cost Electricity Avoided by Biomass/Biogas/Landfill Gas	**28.95**	**28.95**	$/MWh
Incremental Cost for Green Power Purchase (from off-site, beyond supply RPS)	25.00	15.00	$/MWh

Placeholder assumptions.

Implied use of biomass/biogas/landfill gas by year	**2.42**	**146.83**	Billion Btu

Inputs to/Intermediate Results of Analysis of Bulk Purchase Element

Government Building Electricity Use	1,390	1,188	GWh

Net of efficiency measures from other programs and options. Does not currently include local government electricity use.

Fractional implementation of Bulk Purchase Program targets	9.1%	100.0%	
Annual Savings from Bulk Purchase Program (not cumulative)			
State Agency Program	0.3	2.4	GWh
All-sectors (non-State) Program [not included in this policy]	0.0	0.0	GWh

Results	2010	2020	Units
Electricity (Conventional), Building Improvement Elements/Green Power Purchase			
Reduction in Electricity Sales: Residential (not included here)	0	0	GWh (sales)
Reduction in Electricity Sales: Commercial (government)	27	308	GWh (sales)
TOTAL Reduction in Electricity Sales	27	308	GWh (sales)
Reduction in Generation Requirements	29	331	GWh (generation)
GHG Emission Savings	**0.03**	**0.28**	MMtCO$_2$e
Economic Analysis			
Net Present Value (2007-2020)		**-$7**	$million
Cumulative Emissions Reductions (2007-2020)		1.8	MMtCO$_2$e
Cost-Effectiveness		**-$3.72**	$/tCO$_2$e
Electricity Savings Through Bulk Purchase Program			
Reduction in Electricity Sales: Residential (not included here)	0	0	GWh (sales)
Reduction in Electricity Sales: Commercial (government)	0	15	GWh (sales)
TOTAL Reduction in Electricity Sales	0	15	GWh (sales)
Reduction in Generation Requirements	0	16	GWh (generation)
GHG Emission Savings	**0.00**	**0.01**	MMtCO$_2$e
Economic Analysis			
Net Present Value (2007-2020)		**-$1.4**	$million
Cumulative Emissions Reductions (2007-2020)		0.06	MMtCO$_2$e
Cost-Effectiveness		**-$22.47**	$/tCO$_2$e
Natural Gas			
Reduction in Gas Use	62	717	Billion BTU
GHG Emission Savings	**0.00**	**0.04**	MMtCO$_2$e
Economic Analysis			
Net Present Value (2007-2020)		**-$3**	$million
Cumulative Emissions Reductions (2007-2020)		0.2	MMtCO$_2$e
Cost-Effectiveness		**-$15.17**	$/tCO$_2$e
Biomass/Biogas/Landfill Gas Fuel Use			
Biomass Fuels Use	**2.42**	**146.83**	Billion BTU
Added GHG Emissions from Biomass Fuels Use	**0.00001**	**0.00037**	MMtCO$_2$e
Cumulative added Emissions from Biomass Fuels (2007-2020)		0.0016	MMtCO$_2$e

Summary Results for RCI-12	2010	2020	Units
Total for Policy (Natural gas and electricity less biomass)			
GHG Emission Savings	**0.03**	**0.33**	$MMtCO_2e$
Net Present Value (2007-2020)		**-$11.4**	$million
Cumulative Emissions Reductions (2007-2020)		2.0	$MMtCO_2e$
Cost-Effectiveness		**-$5.55**	$\$/tCO_2e$
Total for Policy Less Bulk Purchase Program			
GHG Emission Savings	**0.03**	**0.31**	$MMtCO_2e$
Net Present Value (2007-2020)		**-$9.9**	$million
Cumulative Emissions Reductions (2007-2020)		2.0	$MMtCO_2e$
Cost-Effectiveness		**-$5.00**	$\$/tCO_2e$

Additional Summary Results for RCII-12 for Reporting	2010	2020	Units
Total Green Power Purchased Under RCII-12	1	24	GWh (sales)
Total Green Power Generation to Serve RCII-12	1	26	GWh (generation)
GHG Emission Savings from Green Power Component	**0.00**	**0.02**	$MMtCO_2e$
Net Present Value (2007-2020) of Green Power component of RCII-12		**$1.2**	$million
Total Renewable Energy Under RCII-12	2	37	GWh (at consumer site)
Total Reduction in Conventional Generation due to Renewable Energy Under RCII-12	2	39	GWh (equivalent at
Net Present Value (2007-2020) of renewable energy component of RCII-12	**0.00**	**0.03**	$MMtCO_2e$
		$2.4	$million

<u>NOTES AND DATA FROM SOURCES</u>

Note 1:

From <u>The Energy Efficiency Task Force Report</u> to the Clean and Diversified Energy Advisory Committee of the Western Governors Association.
The Potential for More Efficient Electricity Use in the Western United States, January, 2006. This report is referred to here as the “WGA CDEAC EE report” and can be found at:
http://www.westgov.org/wga/initiatives/cdeac/Energy%20Efficiency-full.pdf.

In the WGA CDEAC EE report, Building Code improvements were effectively modeled in two steps.
The first, assumed to be effectively a baseline action, in the context of this study,
but called the "Current Activities" case, brought codes up to recent IIEC levels as follows:

> "In particular, we assume adoption of a recent version of the IECC leads to 5% electricity savings on average in states in colder or moderate climates, and 13% savings in homes in very hot climates (AZ, TX, and NV). Regarding commercial buildings, we assume adoption of the code leads to 10% electricity savings in moderate and colder states, and 15% savings in very hot states (Kinney, Geller, and Ruzzin 2003). For California, we used estimates of the electricity savings from building code upgrades adopted in 2001 and 2005 (Mahone, et al. 2005). These savings levels are prior to the adjustment for savings realization mentioned in Table V.1" [Quote from footnote, page 40]

The second increase, to the CDEAC "Best Practices" Scenario, included the following improvements:

> "This [Best Practices] scenario assumes that the International Energy Conservation Code, 2004 version, is adopted in 2007 in all states except California, as California has its own more stringent standard. It is assumed that state and/or local building energy codes are upgraded in 2011 (3% improvement) and in 2015 (additional 6% improvement). This scenario also assumes that compliance and enforcement are improved and that a 90% savings realization rate is achieved. Finally, we assume that California’s current building energy codes will be upgraded in 2009 (3%), 2013 (6%) and 2017 (3%)." [Quote from page 41]

The CDEAC report provides a cost of saved energy (electricity) of 4.74 cents/kWh,
in 2005 dollars, based on an average 7-year payback for code improvements (page 42).

Note 2:

The Southwest Energy Efficiency Project's (SWEEP) Report
<u>Increasing Energy Efficiency in New Buildings in the Southwest: Energy Codes and Best Practices</u>
includes state-by-state estimates of the potential savings from two scenarios of building code and "beyond code" efficiency improvements.

Note 3:

Based on results from Table B.5 of the 2003 Commercial Buildings Energy Consumption Survey, Detailed Tables dated October 2006 and published by the US Department of Energy's Energy Information Administration, and available as http://www.eia.doe.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/pdf2003/alltables.pdf, as described in "MT_Activities_Est" worksheet in this workbook.

Following data on electricity sales in Montana as of 2005 as described in "Utility_Sales" worksheet in this workbook.
Downloaded from http://www.eia.doe.gov/cneaf/electricity/epa/epa_sprdshts.html (file sales_revenue.xls)

	MWh	Fraction of Total
Residential	4,221,448	31%
Commercial	4,473,394	33%
Industrial	4,783,996	35%
Total	13,478,838	100%

For natural gas consumption data from the USDOE EIA downloaded from
http://www.eia.doe.gov/oil_gas/natural_gas/applications/eia176query.html are are follows:
(See "EIA_NG_Data" worksheet in this workbook for raw EIA data)

	Sales (Million Cubic Feet of Natural Gas)			
	Residential	Commercial	Industrial	Total
2005	19,834	10,162	398	30,394
Fraction of 2005 Total	65%	33%	1%	100%

Note 4:

The estimate of 0.5 unit of renovated space per unit of new construction in the commercial sector is a rough assumption.
It is likely that the ratio of commercial space undergoing major renovation to new commerial space will fluctuate year by year, and it may be necessary to get a more specific figure for this parameter. It is clear, however, that the renovation market represents a substantial opportunity for improving energy efficiency through code changes. A study of the non-residential renovation market in California (Remodeling and Renovation of Nonresidential Buildings in California, by Donald R. Dohrmann, John H. Reed, Sylvia Bender, Catherine Chappell, and Pierre Landry, available as http://www.energy.ca.gov/papers/2002-08-18_aceee_presentations/PANEL-10_DOHRMANN.PDF) suggests that by 1999 the value of renovations and additions to non-residential space was similar to that in new non-residential space, based on building permit data. As California includes a significant fraction of older buildings in its building stocks, renovations may be a smaller fraction of building activity in Montana.

Estimate of Mitigation Option Costs and Benefits for Montana RCII GHG Analysis

RCII-13 Metering Technologies with opportunity for load management and choice

Date Last Modified: *5/21/2007 D. Von Hippel/Michael Lazarus*

Key Data and Assumptions	2010	2020/all	Units
The following calculation estimates GHG emissions reduction from only one element of RCII-13, inverted block tariff structures. Other elements of provide GHG emissions reductions largely through supporting other policies in the RCII and Energy Supply sectors.			
First Year Results Accrue		**2009**	
Savings from Smart Meters and related rate structures for Residential Consumers			
Reduction in Residential Electricity Use		**8%**	
TWG members familiar with this technology suggest potential savings of 8 to 10 percent of consumption. A review of smart metering-related studies and pilot installations (Smart meters: commercial, regulatory and policy drivers, by Gill Owen and Judith Ward of Sustainability First, dated March 2006, Appendicies document "Appendix 2 – Smart metering experience and studies", p. 19 to 34 in document available as http://www.sustainabilityfirst.org.uk/docs/smartmeterspdfappendices.pdf) suggests potential savings in a similar range.			
Cost of Smart Meters per Meter		**$200**	
Assumed Cost of Implementation of Tariffs for Smart Meters		**$0**	$/MWh
In practice, there are likely to be some costs associated with smart meter tariff structures, including program costs, changes to billing systems, and possibly (in some cases) changes to metering or meter-reading systems. These costs are not explicitly accounted for in this analysis, but are likely to be quite small relative to the electricity cost savings achieved through the policy.			
Avoided Electricity Cost (Residential)		**$49**	$/MWh
See common assumptions.			
Target Number of Smart Meters Installed Under Pilot Program		**45,000**	
End Date of Pilot Program		**2011**	
Target Fraction Additional Residential Consumers Using Smart Meters, Full Program		**30%**	
Placeholder Assumption.			
Start Date of Full Program		**2012**	
Full Phase-in Date of Full Program		**2020**	

Other Data, Assumptions, Calculations	2010	2020/all	Units
Residential Electricity Sales	**4,245**	**4,329**	**GWh**
Residential Customers	**456,073**	**481,564**	
Implied Consumption per Customer	**9.31**	**8.99**	**MWh**
Cumulative Number of Installed Meters Under Pilot Program	**30,000**	**45,000**	
Cumulative Number of Installed Meters Under Full Program	**-**	**144,469**	
Factors for Annualizing Capital Costs (Residential Smart Meters)			
Interest Rate (real)		7%	/yr
Economic Life of Meter *(Rough estimate)*		15	years
Implied Annualization Factor		10.98%	%/yr
Implied Annualized Cost of Meters		$ 21.96	/meter-yr
Intermediate Cost Results, Pilot Program			
Total up-front meter costs for meters installed in each year	**$ 3,000**	**$ -**	thousand
Annualized Meter Costs	**$ 659**	**$ 988**	thousand
Intermediate Cost Results, Pilot Program			
Total up-front meter costs for meters installed in each year	**$ -**	**$ 3,328**	thousand
Annualized Meter Costs	**$ -**	**$ 3,172**	thousand

Results	**2010**	**2020**	**Units**
Electricity			
TOTAL Reduction in Electricity Sales, Pilot Program	23	33	GWh (sales)
Reduction in Generation Requirements, Pilot Program	25	36	GWh (generation)
TOTAL Reduction in Electricity Sales, Full Program	0	104	GWh (sales)
Reduction in Generation Requirements, Full Program	0	112	GWh (generation)
Totals for Pilot Program			
Total Net GHG Emission Savings, Pilot Program	**0.03**	**0.03**	MMtCO$_2$e
Net Present Value (2007-2020), Pilot Program		**-$5**	$million
Cumulative Emissions Reductions (2007-2020), Pilot Program		0.4	MMtCO$_2$e
Cost-Effectiveness, Pilot Program		**-$13**	$/tCO$_2$e
Totals for Full Program			
Total Net GHG Emission Savings, Full Program	**0.00**	**0.09**	MMtCO$_2$e
Net Present Value (2007-2020), Full Program		**-$6**	$million
Cumulative Emissions Reductions (2007-2020), Full Program		0.5	MMtCO$_2$e
Cost-Effectiveness, Full Program		**-$12**	$/tCO$_2$e
Totals for Policy (Pilot plus Full Programs)			
Total Net GHG Emission Savings	**0.03**	**0.12**	MMtCO$_2$e
Net Present Value (2007-2020)		**-$11**	$million
Cumulative Emissions Reductions (2007-2020)		0.9	MMtCO$_2$e
Cost-Effectiveness		**-$12**	$/tCO$_2$e

Appendix G
Energy Supply
Policy Recommendations

Summary List of CCAC-Recommended High Priority Policy Options

	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2007–2020 (Million $)	Cost-Effective-ness ($/$tCO_2e$)	Level of Support
		2012	2020	Total 2007–2020			
	Energy Supply						
ES-1	Environmental Portfolio Standard (Renewables and Energy Efficiency)						UC
	Efficiency/Conservation	0.03	0.92	5.4	–$79	–$15	UC
	Renewable Energy	0.0	1.6	5.5	$53	$10	UC
ES-2	Renewable Energy Incentives and Barrier Removal	*Not Quantified Separately (see ES-1 and ES-4)*					UC
ES-3	Research and Development (R&D), Including R&D for Energy Storage and Advanced Fossil Fuel Technologies	*Not quantified*					UC
ES-4	Incentives and Barrier Removal for Combined Heat and Power (CHP) and Clean Distributed Generation (DG)						UC
	Distributed Renewables	0.03	0.10	0.8	$16	$21	UC
	Combined Heat and Power	0.2	0.7	5.0	$81	$16	UC
ES-5	Incentives for Advanced Fossil Fuel Generation and Carbon Capture and Storage or Reuse (CCSR)						UC
	Reference Case	0	1.0	4.5	$135	$30	UC
	High Fossil Fuel Scenario	0	5.2	24.4	$733	$30	UC
ES-6	Efficiency Improvements and Repowering of Existing Plants	*Not Quantified*					UC
ES-7	Demand-Side Management	*Not Quantified Separately (see ES-1 and RCII-1)*					UC
ES-8/9	Market-Based Mechanisms to Establish a Price Signal for GHG Emissions (GHG Cap-and-Trade or Tax)	*Not Quantified*					UC
ES-10	Generation Performance Standards or GHG Mitigation Requirements for New (and/or Existing) Generation Facilities, With / Without GHG Offsets	0.1	0.8	4.7	$60	$13	UC
ES-11	Methane and CO_2 Reduction in Oil and Gas Operations, Including Fuel Use and Emissions Reduction in Venting and Flaring						UC
	Reference Case	0.1	0.5	3.9	Not estimated	Likely net benefit	UC
	High Fossil Fuel Case	0.3	0.8	6.6			UC

	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2007–2020 (Million $)	Cost-Effectiveness ($/$tCO_2e$)	Level of Support
		2012	2020	Total 2007–2020			
ES-12	GHG Reduction in Refinery Operations, Including in Future Coal-to-Liquids Refineries						UC
	Coal-to-Liquids – High Fossil Fuel Case	0	9.9	35	Not estimated	Not estimated	UC
	Petroleum Refining - Reference Case	0.02	0.24	1.5	Not estimated	Not estimated	UC
	Petroleum Refining - High Fossil Fuel Case	0.03	0.38	2.2	Not estimated	Not estimated	UC
ES-13	CO_2 Capture and Storage or Reuse (CCSR) in Oil & Gas Operations, Including Refineries and Coal-to-Liquids Operations	*Incorporated in ES-5 and 12*					UC
	Sector Total After Adjusting for Overlaps (Among ES Options and After Demand Reductions From RCI Options)						
	Reference Case	**0.4**	**4.2**	**21.9**	**$272**	**$17**	
	High Fossil Fuel Case	**0.4**	**18.7**	**79.4**	**$870**	**$24**	

UC = unanimous consent

Note: Positive numbers for net present value (NPV) and cost-effectiveness reflect net costs. Negative numbers reflect net cost savings.

* Reflects costs (and emissions reductions) only for those items quantified.

Approach for the Estimation of Emissions Reductions From Electricity Policies (Production-basis vs. Consumption-Basis) for Reporting Greenhouse Gas Emission Reductions

The Climate Change Advisory Committee (CCAC) process has discussed two accounting approaches for estimating electricity emissions: 1) the consumption-basis approach, which aims to reflect the emissions associated with electricity sources used to deliver electricity to consumers in the state and 2) the production-basis approach, which considers the emissions from Montana power plants, regardless of where the electricity is delivered. The emissions impact of Energy Supply (ES) policy options will differ depending on which approach or perspective is taken. For instance, an Environmental Portfolio Standard (EPS, ES-1) will result in increased delivery of renewable electricity and energy efficiency programs to Montana consumers, thereby directly displacing the delivery of fossil fuel–based electricity (i.e., a consumption-based impact).

The impacts of an EPS from a production-based perspective are more uncertain. An EPS might well avoid or delay the construction of new fossil-fired power plants in Montana, to the extent these plants might otherwise be sited in Montana and contracted to meet Montana demands. This option's effect on the operation of existing coal plants is less clear, since these plants could well continue to generate and sell more electricity to other states. Other options, such as Incentives for Advanced Fossil Fuel Generation and Carbon Capture and Storage (ES-5) will focus directly on reducing emissions from electricity production. In this case, the effects on electricity generation for Montana's consumption is less clear; for example, much of the lower greenhouse gas (GHG) generation could be exported.

Avoided Electricity Emissions

To estimate emissions reductions from policy options that are expected to displace conventional grid-supplied electricity (i.e., those that reduce grid demand such as efficiency/conservation, renewable energy, and combined heat and power) a simple, straightforward approach is used. Through 2010, we assume that these policy options would displace generation from the then-current mix of fuel-based electricity sources. We assume that sources without significant fuel costs would not be displaced, e.g., hydro or other renewable generation. After 2010, we assume that the policy options are likely to avoid a mix of new capacity additions (plants built after 2006) and existing fossil fuel-based generation. The assumed ratio between existing and new resources has the fraction of new resources increasing from 0% in 2010 to 100% in 2020.

This approach provides a transparent way to estimate emissions reductions and to avoid double counting (by ensuring that the same megawatt hours [MWh] from a fossil fuel source is not "avoided" more than once). It also yields results that are consistent with the state-level inventory and forecast developed as part of the CCAC process. It can be considered a "first-order" approach; it does not attempt to capture a number of factors such as the distinction between peak, intermediate, and baseload generation; issues in system dispatch and control; impacts of non-dispatchable and intermittent sources such as wind and solar; or the dynamics of regional electricity markets. These relationships are complex and could mean that policy options affect generation and emissions (as well as costs) in a manner somewhat different than estimated here. Nonetheless, this approach provides reasonable first-order approximations of emissions impacts and offers the advantages of simplicity and transparency that are important for stakeholder processes.

Note that for options that target individual facilities (e.g., ES-5, Incentives for Advanced Fossil Fuel Generation and Carbon Capture and Storage), avoided emissions are based directly on the assumed displaced resource (e.g., conventional pulverized coal [PC] plant with no capture).

Reference Case and High Fossil Fuel Case

Two scenarios were developed for projections of Montana's future GHG emissions from the electricity sector and the fossil fuel production sector. The two scenarios acknowledge the significant uncertainty of future energy production in Montana (due to economics and policy actions in Montana, other states, Canada, and internationally)—the Reference Case assumes lower growth in electricity generation and fossil fuel production than the High Fossil Fuel Case. The GHG emissions reductions associated with several of the ES options depend on which scenario is being considered. For example, the High Fossil Fuel Case assumes a greater number of coal plants will be developed than in the Reference Case—and the High Fossil Fuel Case will have a larger potential to reduce GHG emissions from carbon capture and storage than the Reference Case. For the relevant options, the GHG emission reductions and costs are reported for both the Reference Case and the High Fossil Fuel Case.

Option Implementation—Single Options vs. Combined Options Assessment

The emissions reduction and cost estimates shown for each individual option presume that each option is implemented alone. Many options, particularly for electricity supply, are related in so far as they target the displacement of the same reference case resources (e.g., growth in emissions from new coal plants), or otherwise have interactive effects. Therefore, if multiple options are implemented, the results will not simply be the sum of each individual option result. For this reason, we have conducted a "combined policies" assessment to estimate total emission reductions of all recommended policies that captures the overlap among policies. For example, demand reduction (RCII options that are additional to the energy conservation/efficiency requirements of ES-1) and customer-sited renewable energy (ES-4) reduce requirements for grid electricity; as a result, fewer MWh from renewables are needed to meet the targets described in option ES-1. The effect of these interactions—lower emissions savings and costs than the sum of individual options—is reflected in the combined policy results shown in the bottom two lines of the Summary List of Recommended High Priority Mitigation Options.

ES-1. Environmental Portfolio Standard (Renewables and Energy Efficiency)

Policy Description

A renewable portfolio standard (RPS) is a requirement that utilities must supply a certain percentage of electricity from an eligible renewable energy source(s). For example, an RPS of 5% would mean that for every 100 kilowatt hours (kWh) a utility or a load-serving entity (LSE) supplies to end users, 5 kWh must be generated from renewable resources. An environmental portfolio standard (EPS) expands that notion to include energy efficiency as an eligible resource as well. About 20 states currently have an RPS in place (including Montana), while a handful have implemented an EPS (Washington and Nevada among them). In some cases (as in Montana), utilities can also meet their RPS or EPS requirements by purchasing certificates from eligible energy projects, typically referred to as Renewable Energy Certificates in the case of RPS policies.

Policy Design

This policy options involves extending the existing RPS to include renewable energy requirements for 2020 and 2025 and requiring utilities to pursue cost-effective end-use energy conservation.[1]

Goals: Each investor-owned utility (IOU) and public utility (including member-owned electric cooperatives) should

- Meet 20% of its load using renewable energy resources by 2020, increasing to 25% by 2025.
- Implement a plan to obtain 100% of achievable cost-effective energy conservation by 2025.
    - By 2010, identify its achievable cost-effective energy conservation for the subsequent 10 years.
    - Update its energy efficiency assessment and plan regularly, possibly every 2 years.

    "Energy conservation" refers to both electricity and natural gas.

Timing: See above.

Parties Involved: IOUs, electric cooperatives, Montana Public Service Commission (PSC), state government.

Other: None cited.

Implementation Mechanisms

The following aspects will need to be addressed prior to the implementation of this option:

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[1] End-use energy conservation comprises changes at electricity customer sites to 1) reduce energy used to provide services—such as heating, cooling, illumination, and entertainment—through increased energy efficiency of appliances and other technologies and 2) reduce demand for these services—for example, by turning off unused lights and televisions and turning down thermostats.

- Ensure that the utilities are not punished for pursuing energy efficiency. [Note: "decoupling" of utility revenues from the level of utility sales is a strategy for removing this barrier that has been proposed, and in some cases implemented, in other states.]
- Define "cost-effective" and strategies (incentives/penalties) to ensure that the energy savings are achieved.
- Adjust cost cap in existing bill.
- Consider the possibility of different standards for cost cap to apply to IOUs and co-operatives.

Given concerns about how an RPS could be enforced with respect to electric cooperatives (since cooperatives are not regulated by the PSC), further investigation regarding enforcement mechanisms for cooperatives is needed.

The CCAC noted that technologies and measures for increasing electricity production at hydroelectric and other related facilities (e.g., irrigation drops) through turbine additions and upgrades should be considered as eligible for the RPS.

Related Policies/Programs in Place

Montana's RPS, enacted in April 2005 as part of the Montana Renewable Power Production and Rural Economic Development Act (69-8-1001 through 69-8-1008, Montana Code Annotated [MCA]), requires public utilities to obtain a percentage of their retail electricity sales from eligible renewable resources according to the following schedule:

- 5% in 2008 through 2009,
- 10% in 2010 through 2014, and
- 15% in 2015 and thereafter.

Eligible renewable resources include wind, solar, geothermal, existing hydroelectric projects (10 MW or less), landfill or farm-based methane gas, wastewater-treatment gas, low-emission, nontoxic biomass, and fuel cells where hydrogen is produced with renewable fuels. Facilities must begin operation after January 1, 2005, and must be either a) located in Montana or b) located in another state and delivering electricity to Montana.

Utilities can meet the standard by entering into long-term purchase contracts for electricity bundled with renewable-energy credits (RECs), by purchasing the RECs separately, or a combination of both. The law includes cost caps that limit the additional cost utilities must pay for renewable energy and allows cost recovery from ratepayers for contracts preapproved by the Montana PSC. RECs sold through voluntary utility green power programs may not be used for compliance.

The RPS includes specific procurement requirements to stimulate rural economic development. For example, the utilities must buy a portion of the required renewable energy (electricity + credits) from community renewable-energy projects with a maximum individual nameplate capacity of 5 megawatts (MW). These include projects in which local owners have a controlling interest and that are interconnected on the utility's side of the meter. In 2015, these projects must provide a total of at least 75 MW of renewable-energy capacity. In addition, public utilities must enter into contracts that include a preference for Montana workers.[2]

Montana's Universal System Benefits Program (USBP) also supports energy efficiency and renewable energy and is described more fully under option RCII-1.

Type(s) of GHG Benefit(s)

CO_2: By creating a substantial market in renewable generation and energy efficiency programs, an EPS can reduce fossil fuel use in power generation and thus reduce CO_2 emissions.

Black Carbon: To the extent that generation from coal and oil would be displaced by renewables, black carbon emissions would decrease.

Estimated GHG Savings and Costs Per Ton

	Policy	Scenario/Element	Reductions		Cumulative Reductions 2007–2020 (MMtCO$_2$e)*	NPV 2007–2020 ($ Million)	Cost-Effectiveness ($/tCO$_2$)
			2010	2020			
ES-1	Environmental Portfolio Standard	Efficiency / Conservation (electricity only)	0.03	0.92	5.4	–$79	–$15
ES-1	Environmental Portfolio Standard	Renewable Energy	0.0	1.6	5.5	$53*	$10[†]

Note: Positive numbers for Net Present Value (NPV) and Cost-Effectiveness reflect net costs. Negative numbers reflect net cost **savings.**

* Analyzed on the basis of **consumption-based emissions**, since the EPS is focused on load.

[†] Costs for renewable energy are highly dependent on assumptions regarding federal Production Tax Credit (PTC). For the purposes of analysis, it is assumed that the credit will end in 2010. However, the PTC has been renewed several times and could well be renewed again. If the PTC were extended beyond 2010, this could lead to lower costs or even net cost savings.

Results using alternative assumptions are presented in the Key Uncertainties section below.

Data Sources, Quantification Methods, and Key Assumptions (for quantified actions)

Data Sources:

- Renewable Energy Technology costs from Western Governors' Association 2006 (WGA 2006) *Task Force Reports from the Clean and Diversified Energy Initiative,*[3] Energy Information Administration (EIA) Annual Energy Outlook (AEO),[4] National Renewable Energy Laboratory.[5]

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[2] www.dsireusa.org/library/includes/tabsrch.cfm?state=MT&type=RPS&back=regtab&Sector=S&CurrentPageID=7&EE=1&RE=1

[3] http://www.westgov.org/wga/initiatives/cdeac/index.htm

[4] http://www.eia.doe.gov/oiaf/aeo/assumption/index.html

[5] http://www.nrel.gov/analysis/power_databook/

- Other data sources as noted below.

Quantification Methods: Analysis of the EPS involves the following steps: 1) estimate the level and costs of cost-effective energy conservation (electricity and gas) that are achievable in Montana (see RCII-1); 2) identify the type of renewable generation that would most likely be used to meet the renewable energy requirements in 2010, 2015, and 2020; 3) estimate the costs associated with each type of renewable technology; 4) estimate the type, cost, and GHG emissions of the conventional generation that would be avoided by the increased energy efficiency and renewable energy (see description in the above "Approach" section on avoided costs and emissions); and 5) calculate the difference in costs and GHG emissions between the EPS scenario and the reference case.

This option will be analyzed in two stages: the first stage estimates the costs and emission reductions from energy efficiency alone (from the RCII-1 analysis), while the second stage considers the costs and reductions from the additional renewable energy generation requirements. Costs and emission reductions are calculated as incremental to the reference case, which includes energy efficiency savings expected from current and planned utility programs and the renewable energy generation to meet the existing RPS (see the "Related Policies/Programs in Place" section below).

Key Assumptions:

- **Efficiency potential and cost—**See RCII-1.
- **Renewable energy mix—**It is assumed that the renewable portion of the Montana EPS would be met with a combination of wind and biomass. For this preliminary analysis, it is assumed that the renewable mix is made up of 90% wind and 10% biomass.
- **Renewable energy costs—**The costs of the new renewable systems are based on those used in the EIA Annual Energy Outlook for 2007, except where better (e.g., updated or more local) data are available. The cost of renewable generation includes costs associated with connecting renewable technologies to the electric grid and transmitting the renewable generation to loads (see below). The cost of wind generation also includes costs associated with integrating wind into the system, as detailed below.
- **Production tax credit—**For qualifying renewable energy technologies, a federal tax credit of $18/MWh (inflated) is assumed for the first 10 years of operation for new facilities that commence operation by the end of 2010.
- **Transmission expansion costs—**Since many renewable resources are located away from existing transmission lines, additional transmission would likely be needed. Since the precise nature of those additional costs would require calculations beyond the scope of the current analysis, we propose using an average cost of $80/kW for all new resources, based on a recent scenario analysis by the WGA Clean and Diversified Energy Advisory Committee (CDEAC).[6]

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[6] CDEAC Transmission Report in the High Renewables case has an average incremental transmission cost of 80 $/kW compared with the reference case, i.e., 84,641 MW incremental capacity with additional transmission expansion costs of $6,786 million.

- **Reference technology costs—**For overall consistency, we use technology costs from EIA's Annual Energy Outlook for 2007, as shown in Table G-1.[7] While prices have recently gone up significantly for wind turbines, as well as for other technologies including coal units due to tight markets and high materials prices, these estimates reflect a longer-term view. See discussion under "Key Uncertainties."

Table G-1. Assumptions used for biomass and wind technology parameters

	Technology Parameters						
	2010			2020			
Technology	Total Overnight Cost ($/kW)	Variable O&M (mills/kWh)	Fixed O&M ($/kW)	Total Overnight Cost ($/kW)	Variable O&M (mills/kWh)	Fixed O&M ($/kW)	Project Life (Years)
Biomass	1,833	3.0	50	1,721	3.0	50	30
Wind	1,194	0	28	1,194	0	27	20

O&M = operation and maintenance.

All costs are expressed in year 2005 dollars and represent expectations as of late 2006.

Source: Assumptions for the Annual Energy Outlook 2007, Renewable Fuels and Electricity Supply sections.[8]

- **Wind integration costs—**The cost of integrating wind at various levels of wind penetration is estimated on the basis of studies by utilities in the Northwest (Avista, Idaho Power, Puget Sound Energy, and Pacificorp) as compiled for the *Northwest Wind Integration Action Plan* (March 2007).[9] In general, wind integration costs rise with increasing penetration of wind in the grid, as shown in Table G-2. However, these estimates are subject to considerable uncertainty (see discussion below under "Key Uncertainties").

Table G-2. Wind integration costs

Wind Capacity Fraction of System Peak	Average Wind Integration Cost ($/MWh of Wind Generation)
0%	0.0
5%	$3
10%	$6
20%	$8
30%	$12.5

- **Avoided costs—**Electricity avoided costs are provisionally based on the levelized value of long-term standard Qualifying Facilities Tariff from the Montana PSC ($49 per MWh).[10]

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[7] Electric Market Module, EIA Assumptions to the Annual Energy Outlook 2006.

[8] http://www.eia.doe.gov/oiaf/aeo/assumption/index.html

[9] http://www.nwcouncil.org/energy/Wind/library/2007-1.pdf

[10] Estimate derived from contract data underlying the "the long-term, standard QF [Qualifying Facilities] tariff," "Option 1" ($49.90 per MWh, nominal cost average of quarterly contract costs from 2007 through 2014) as set by the Montana Public Services Commission, in an order covering Docket No. D2003.7.86, Order No. 6501f 2; Docket No. D2004.6.96, Order No. 6501f; and Docket No. D2005.6.103, Order No. 6501f, dated December 19, 2006. The

- **Avoided electricity emissions—S**ee description in the above "Approach" section on avoided emissions.

Key Uncertainties

Capital costs: Wind capital costs used for the analysis above (around $1,200/kW) are based on the United States Department of Energy's (US DOE's) most recent long-term projections. In the past couple of years, wind capital costs have been higher than these levels.[11] Some recent utility Integrated Resource Plans (IRPs) suggest the current capital costs of a 100–200 MW facility may be as high as $1,700/kW (not including land/site acquisition).[12] This higher cost appears to be due in large part to an increase in the costs of materials (e.g., steel) and to the rapid expansion of the wind industry globally.

Avoided costs: Significant increases in capital costs have also been witnessed in recent years for other power plant types, including coal plants. If higher than projected costs persist into the next decade for power plants that would be avoided through increased renewable electricity generation, the assumptions for avoided cost of electricity may also be too low.

Production tax credit: As noted, costs for renewable energy are highly dependent on assumptions regarding the federal Production Tax Credit (PTC). The PTC has been renewed several times and could well be renewed again, leading to lower costs of the RPS to Montana.

Wind integration costs: The market for integration services is constrained at present, and there are indications that the cost of such services will increase, at least in the near term. When NorthWestern Energy's (NWE's) Judith Gap project came online, the reported cost for wind integration was approximately $7/MWh.[13] However, NWE has announced publicly that the entities that provided that service in the past may not provide the service in the future, and if they do, the cost will likely increase.

If costs for integration services increase significantly, and if other measures to reduce the need for such services are not undertaken, achieving the renewable energy goals set forth here could

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$49.90 cost indicated is shown in paragraph 184 of the PSC document. Cost shown here extends the stream of nominal costs in the original NorthWestern Energy/PPL Montana (NWE/PPL) document by including values for 2015 to 2020 that increment the 2014 average value at the rate of inflation, levelize the resulting 2007 to 2020 stream, and adjust the levelized value to 2005 dollars.

[11] Recent utility plans in the region have used the following costs: Avista 2005 IRP–$1,191 (100 MW), IPC 2006 IRP–$1,610 (100 MW), NorthWestern Energy 2006 DSP–$1,010 (100 MW), Northwest Power and Conservation Council 2007 Report (2006$)–$1,500 (150 MW), PacifiCorps 2004 IRP update (2005$)–$1,474 (50 MW), Portland General 2007 IRP (2006$)–$1,700 (100 MW), Puget Sound 2005 IRP (2006$)–$1,438 (150 MW), Seattle City Light 2006 Draft IRP (2006$)–$1,500.

[12] For example, see Standard and Poor's Viewpoint (May 11, 2007, "Which Power Generation Technologies Will Take the Lead in Response to Carbon Controls?") and US DOE 2007 Annual Report on U.S. Wind Power Installation, Cost, and Performance Trends: 2006. National Renewable Energy Laboratory.

[13] "NWE has reported to the Montana Public Service Commission a wind integration cost of $6.75/MWh for the Judith Gap project for 2006. This value is yet to include the expenses for the operation of the Basin Creek gas-fired plant that are solely attributable to wind integration. The wind integration costs for Basin Creek have not been finalized for 2006. The NWE control area has a wind penetration of 8.7% and is currently purchasing all of its control area services at market-based rates." Northwest Wind Integration Action Plan, March 2007.

come at a higher cost. For this purpose, an illustrative sensitivity analysis is shown below with a value for future integration costs at high penetration levels reaching $20/MWh.[14]

Impacts of Alternative Assumptions

In order to test the sensitivity of above uncertainties on the estimated costs and cost-effectiveness, we re-estimated the options with alternative assumptions for the key uncertainties.

Table G-3 summarizes the alternative assumptions that we tested, and the changes to the cost and cost-effectiveness results. Each alternative assumption was tested individually, but the effects of combining the alternative assumptions can be roughly estimated by summing the changes.

For example, Table G-3 indicates that if the capital cost of new wind plants is $1,800/kW, rather than the initial assumption of $1,194/kW, then the estimated costs of the option will *increase* by $67 million (NPV) or $12/MtCO$_2$e, relative to the costs based on the initial assumptions (presented above). So with higher estimates for the capital cost of new wind, the total cost is approximately $119 million (NPV) and the cost-effectiveness is about $22/MtCO$_2$e. Using the assumption that the PTC will be extended to 2015, the initial costs would *decline* by $19 million (NPV) or $3/MtCO$_2$e. Assuming both the higher capital cost of wind and a 2015 extension of the PTC leads to an increased cost of $48 million (NPV) or $9/MtCO$_2$e.

Table G-3. Summary of alternative assumptions, changes to cost, and cost-effectiveness results

			Change in Results, Relative to Initial Assumptions	
	Initial Assumptions	**Alternative Assumptions**	**Costs ($ millions)**	**Cost-Effectiveness ($/tCO$_2$)**
Capital cost of wind	$1,194/kW	$1,800/kW	+$67	+$12
Avoided cost of electricity	$49/MWh	$63/MWh	–$47	–$9
PTC sunset	2010	2015	–$19	–$3
Wind capacity fraction of system peak	**Average Wind Integration Cost ($/MWh of Wind Generation)**		+$35	+$6
0%	$0	$0		
5%	$3	$7		
10%	$6	$20		
20%	$8	$20		
30%	$12.5	$20		

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[14] There was considerable discussion by TWG and CCAC members as to the choice of this specific value. Some members state that not only are current regional integration costs a fraction of this amount but there is also no reasonable likelihood that integration costs will approach this amount in the future, while one CCAC member contends that such a high cost, or even a higher cost, is indeed conceivable. Given the nature of the sensitivity analysis, the $20/MWh was retained, with the caveat that there is no specific reference to support this exact figure and that further analysis is needed.

Sources: Initial Assumptions, see above; Alternative Assumptions, based on general ranges determined during research. Alternatives for the capital cost of wind are based on sources in footnote 12, and wind integration costs were suggested by Technical Work Group (TWG) members. Alternative for the avoided cost of electricity is based on the estimated future costs of power provided by Standard and Poor's Viewpoint (May 11, 2007 *Which Power Generation Technologies Will Take the Lead in Response to Carbon Controls?)*. $63/MWh reflects the average of the costs of pulverized coal ($58/MWh) and natural gas combined cycle ($68/MWh).

Additional Benefits and Costs

None cited.

Feasibility Issues

None cited.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

ES-2. Renewable Energy Incentives and Barrier Removal

Policy Description

This policy option reflects financial incentives and other efforts, such as improving the ability to integrate intermittent wind resources to encourage investment in renewable energy sources by businesses that sell power commercially (smaller-scale renewable sources are covered in ES-4).

Policy Design

This option is designed to provide additional support to the renewable portion of the renewable and energy-efficiency portfolio standard in ES-1 by providing incentives for utilities and other potential builders/developers/owners of renewable energy supply facilities as well as local manufacturers of renewable energy technologies. The goal of this option is to increase the supply of renewable energy and reduce its cost. This option is designed to support facilities that sell power commercially (as opposed to, for example, consumer-sited facilities that sell power to the grid via net metering; the latter facilities are covered under ES-4).

This option is also designed to help overcome barriers to increased penetration of renewable resources, in particular, the ability to integrate wind resources into the Montana grid.

The policy option could include the following aspects; also note the suggestions under Implementation Measures, below:

- The state, including the PSC and Montana's representatives on the Northwest Power and Conservation Council (NWPCC), should work with other regional actors to utilize to the greatest possible extent the region's vast hydroelectric resources for the provision of integration services necessary to accommodate significant increases in generation from wind power in Montana and regionally.
- The state should provide research and development funds and should invest in technologies, such as compressed air energy storage, that can help ameliorate issues associated with wind's variability and uncertainty. See ES-3.
- Carbon markets, whether current voluntary offsets markets or future compliance markets (allowances and/or offsets), could provide an important mechanism to promote renewable energy projects. At present, there is uncertainty regarding the shape of these markets and the best strategies for the state to pursue.

Goals: Renewable generation goals are same as for ES-1.

Timing: Implement in a time frame that best supports ES-1. Since renewable goals for ES-1 will start in 2008, incentives are needed as soon as practicable. Changes to legislation will need to wait until the end of 2009.

Parties Involved: PSC, NWPPC, state government, utilities

Other: None cited.

Implementation Mechanisms

The following could be included:

- Tax policies, production tax credits (federal), Public Utility Regulatory Policy Act (PURPA) requirements (Montana has mini-PURPA law).
- Montana's HB 3 (House Bill 3) from the 2007 Special Session—the "Clean and Green Energy Bill." Recent change in property tax specification for wind projects could be expanded to other renewable forms of generation as appropriate.
- Incentives for locating manufacturing plants in the state for renewable generation, with potential sunset provisions as industries mature in Montana.
- Incentives for technologies that support improved integration of intermittent (e.g., wind) resources, including but not limited to advanced storage technologies.
- Target incentives to community wind projects.
- Tax incentives for transmission lines that carry wind power (incentives are included in Montana HB 3; see below under "Related Policies/Programs in Place").
- A planning process that, among other things, will evaluate potential wind power sites and associated transmission infrastructure in order to develop a priority list of transmission system upgrades that will enable development of those wind power sites.
- Develop a system that certifies and recognizes new wind project proposals that have implemented measures in project siting, construction, and operation so as to minimize impacts to wildlife, critical wildlife habitat, national and state parks, and other areas of special concern. The MDEQ should work collaboratively with stakeholders to establish the criteria for such a system in order to formalize the best management practices.

Related Policies/Programs in Place

Related policies and programs include the following:

- **Montana HB 3 ("Clean and Green Energy Bill")—**Gives permanent property tax rate reductions from 12% to 3% of market value for new investments in transmission lines carrying "clean" electricity and "clean" liquid and also carbon sequestration pipelines. New integrated gasification combined cycle (IGCC) (with sequestration), natural gas combined cycle (NGCC), and geothermal generation. Carbon capture equipment on older power plants goes down from 6% to 3%. New DC converter stations serving two regional power grids go from 6% to 2.25%. Property tax rate abatements (non-permanent incentives) from 3% to 1.5% are available for new investments in biodiesel, biomass, biogas, and coal gasification (includes coal-to-liquids [CTL] with sequestration, ethanol, geothermal generating, NGCC with carbon offsets, transmission lines and pipelines carrying "clean" products or CO_2, carbon sequestration equipment, renewable energy manufacturing plants, and research and development equipment for clean coal or renewable energy). These breaks last for 15 years after startup, with up to an additional 4 years coverage for construction. DC converter stations serving two regional grids go from 2.25% to 1.125% for 15 years, with up to an additional 4 years during construction. Agricultural land 660 feet either side of any new transmission lines is exempt from property tax. To receive these benefits, MDEQ must certify that the projects meet the conditions of the bill.

- **Tax incentives for renewable energy—**A variety of tax incentives are available for individuals and businesses.[15] The Montana Code Annotated (MCA) includes:
    - **Corporate Property Tax Reduction for New/Expanded Generating Facilities (15-24-1402 MCA)—**Montana generating plants producing 1 MW or more by means of an alternative renewable energy source are eligible for the new or expanded industry property tax reduction. If approved by the local government, the facility is taxed at 50% of its taxable value in the first 5 years after the construction permit is issued. Each year thereafter, the percentage is increased by equal percentages until the full taxable value is attained in the tenth year.
    - **Generation Facility Corporate Tax Exemption (15-6-225 MCA)—**New electricity-generating facilities built in Montana with a nameplate capacity of less than 1 MW and that use an alternative renewable energy source are exempt from property taxes for 5 years after start of operation.
- **Retail Green Power (69-8-210(4) MCA)—**NWE must offer customers an opportunity to purchase a separately marketed (and possibly differently priced) product composed of power from biomass, wind, solar, or geothermal resources.
- **Clean renewable energy bonds (HB 330)—**This recently enacted legislation enables local government bond financing of renewable energy projects.[16]

Type(s) of GHG Reductions

See ES-1.

Estimated GHG Reductions and Costs (or Cost Savings)

Not quantified.

As noted above, this option supports the achievement of the renewable energy targets articulated in ES-1. To the extent that incentives enable exceedance of these targets, there may be additional emission reductions and costs (or savings).

Key Uncertainties

None cited.

Additional Benefits and Costs

None cited.

Feasibility Issues

None cited.

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[15] A summary can be found at: http://deq.mt.gov/Energy/Renewable/TaxIncentRenew.asp

[16] http://data.opi.mt.gov/bills/2007/billpdf/HB0330.pdf

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

ES-3. Research and Development (R&D), Including R&D for Energy Storage and Advanced Fossil Fuel Technologies

Policy Description

R&D funding can be targeted toward a particular technology or group of technologies as part of a state program with a mission to build an industry around that technology in the state and/or to set the stage for adoption of the technology for use in the state. For example, an agency can be established with a mission to help develop and deploy energy storage technologies. R&D funding can also be made available to any renewable or other advanced technology through an open bidding procedure (i.e., driven by bids received rather than by a focused strategy to develop a particular technology). Funding can also be given for demonstration projects to help commercialize technologies that have already been developed but are not yet in widespread use. Funding could be provided to increase collaboration between existing institutions for R&D on technologies.

Policy Design

This policy could include efforts to

- Seek partners for, and aim to attract, federal R&D funding for high-altitude advanced fossil demonstration project(s) in Montana as authorized by the Energy Policy Act of 2005. Consider the FutureGen process as a potential source of lessons on how to develop and succeed at funding a demonstration project. Demonstration projects are typically located near active R&D programs.
- Establish emerging energy technology program in the Montana university system, attract federal R&D funding, grow technology expertise, issue advanced degrees, and aim for resulting multiplier benefits. Consider elements of the Big Sky Carbon Sequestration Partnership (BSCSP) as a model. Choose areas for R&D that match well with the Montana resource base.[17] Target carbon sequestration technologies, compressed air, and other storage technologies to increase penetration of intermittent renewable energy (including wind power) and direct carbon fuel cells.
- Create a small pool of state funding for R&D efforts. Even though overall volume would be limited, it could have important symbolic value and help leverage larger amounts of external funding. Consider such funding for the university program and/or the BSCSP.
- Seek industry participation and contributions (e.g., licensing fees) to help pay for R&D activities.

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[17] Montana has significant coal reserves as well as a number of promising sites for CO_2 storage and enhanced oil recovery. For instance, Southern Montana Electric has suggested that its proposed facility (Highwood Generating Station [HGS], Great Falls, MT) may represent an ideal location to integrate the concept of CCSR into facility design and plan of operations. HGS is very well situated in close proximity to geologic formations providing a great opportunity to test the technology of carbon capture and storage on a commercial scale that demonstrates economic feasibility.

- Make available the results of R&D and pilot programs to inform industrial development.
- Consider options to provide incentives for energy storage technologies such as batteries and compressed air storage.
- Use coal severance tax to fund research and development programs (per above) in clean energy technologies, including clean coal, sequestration, and compressed air storage, among others. (Note that the 2007 Legislature recently passed HB 715 requiring a portion of the research and commercialization expendable trust [as defined in MCA 90-3-1002] be used for clean coal R&D projects or renewable resource R&D projects.)[18]

Goals: No specific goals identified.

Timing: Not relevant.

Parties Involved: Montana university system.

Other: None cited.

Implementation Mechanisms

Under development.

Related Policies/Programs in Place

Big Sky Carbon Sequestration Partnership—is led by Montana State University and is one of the US DOE's seven regional partnerships. BSCSP's goal is to develop infrastructure to support and enable future carbon sequestration field tests and deployment in Montana, Idaho, Wyoming, Washington, and Oregon.

Zero Emission Research and Technology Center—is a partnership involving Montana State University, as well as US DOE laboratories and West Virginia University. ZERT is a research collaborative focused on understanding the basic science of underground (geologic) carbon dioxide storage to mitigate GHGs from fossil fuel use and to develop technologies that can ensure the safety and reliability of that storage.

FutureGen—is a public-private partnership to design, build, and operate the world's first coal-fueled, near-zero emissions power plant, at a cost exceeding US$1 billion. The commercial-scale plant will prove the technical and economic feasibility of producing low-cost electricity and hydrogen from coal while nearly eliminating emissions. Two candidate sites in Illinois and Texas are being evaluated for siting of the FutureGen project.

Type(s) of GHG Reductions

Under development.

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[18] HB 715, http://data.opi.mt.gov/bills/2007/billpdf/HB0715.pdf

Estimated GHG Reductions and Costs (or Cost Savings)

Not quantified. Given the difficulties in predicting the direct impact of R&D programs on GHG emissions, the emissions reduction resulting from this option will not be quantified, though a rough estimate of option cost is desirable.

Key Uncertainties

None cited.

Additional Benefits and Costs

None cited.

Feasibility Issues

None cited.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

ES-4. Incentives and Barrier Removal (Including Interconnection Rules and Net Metering Arrangements) for Combined Heat and Power (CHP) and Clean Distributed Generation (DG)

Policy Description

This option is focused on CHP and DG located on-site at consumer facilities that do not sell power commercially. There are numerous barriers to CHP and clean DG, including inadequate information, institutional barriers, high transaction costs because of small projects, high financing costs because of lender unfamiliarity and perceived risk, split incentives between building owners and tenants, and utility-related policies like interconnection requirement, high standby rates, and exit fees. The lack of standard offer or long-term contracts, payment at avoided cost levels, and lack of recognition for emissions reduction value provided also creates obstacles. Policies to remove these barriers include improved interconnection policies, improved rates and fees policies, streamlined permitting, recognition of the emission reduction value provided by CHP and clean DG, financing packages and bonding programs, power procurement policies, and education and outreach.

Policy Design

Key elements of design for this CHP/DG incentives and barrier removal policy include[19]

- Creating standardized interconnection rules for CHP and DG systems to increase investor and developer certainty and predictability and reduce transaction costs.
- Considering offering different interconnection and net metering rules for smaller (residential-size, 5–10 kW) systems, because it might be easier for cooperatives to agree on a standard for these systems than for larger systems.
- Removing barriers to the adoption of CHP and DG systems by customers of Montana utilities, including electric co-ops, while taking into account the potential impact that net metering may have on cross-subsidies between consumers.
- Increasing incentives for installing CHP and DG systems.
- Increasing incentives for the development of small distributed wind systems.
- Increasing incentives for the development of solar hot water.
- Improving or expanding the Alternative Energy Revolving Loan Program (supported by air pollution noncompliance fees[20]) to defray some of initial costs of CHP and DG systems.

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[19] Two papers on the topic of reducing barriers to CHP and DG in Montana have been prepared: *Reducing Market Barriers to Small-Scale Distributed Generation in Montana,* and *Reducing Regulatory Barriers to Small-Scale Distributed Generation in Montana,* both dated May, 2004, and prepared for the Montana Department of Environmental Quality by Thomas Yoder and Brian Gurney of the Center for Applied Economic Research Montana State University–Billings.

[20] Another reference to this option is *Distributed Energy Generation, Benefits, Barriers and Best Practices,* Report to the 60th Legislature Energy and Telecommunications Interim Committee, dated September 2006, prepared by

- Encouraging the development of a set of state-issued licenses for renewable energy system technicians and installers. These licenses would be separate from existing electricity and plumbing trade licenses and would be tailored to the renewable energy industry, covering, for example, DC electricity wiring and roofing skills related to installation of solar photovoltaics (PV), solar hot water, and other renewable energy systems, as well as safety concerns related to system installation. The state licensing of renewable energy technicians/installers will increase consumer confidence in renewable energy contractors.
- Considering clean CHP as a net-metering eligible resource.
- Considering establishing a DG effort similar to the establishment of the Rural Electrification Administration in the 1930s that was able to electrify vast rural sections of America in a very short time period, using grants, loans, and the initiation of green co-ops to overcome many of the road blocks to DG implementation. Because of net metering, these co-ops would only have to be involved with the purchase, installation, and maintenance of the DG systems.

Goals: Goals used to estimate potential benefits are indicated under “Key Assumptions” below (470 MW of CHP, 4.5 MW of solar PV, and 30 MW of small wind by 2020).

Timing: As indicated below.

Parties Involved: State government and regulators, electric utilities, and renewable energy and CHP industry.

Other: None cited.

Implementation Mechanisms

As indicated in the policy design above.

Related Policies/Programs in Place

Montana Financial Incentives

- **Alternative Energy Investment Corporate Tax Credit (15-32-401 MCA)—**Commercial and net metering alternative energy investments of $5,000 or more are eligible for a tax credit of up to 35% against individual or corporate tax on income generated by the investment.
- **Residential Alternative Energy System Tax Credit (15-32-201 MCA)—**Residential taxpayers who install an energy system using a recognized non-fossil form of energy on their home after December 31, 2001, are eligible for a tax credit equal to the amount of the cost of the system and installation of the system, not to exceed $500. The tax credit may be carried over for the next 4 taxable years.
- **Residential Geothermal Systems Credit (15-32-115 MCA)—**Resident Montana taxpayers who install a geothermal heating or cooling system in their principal dwelling can claim a tax credit based on installation costs, not to exceed $1,500.

Casey A. Barrs, available at http://leg.mt.gov/content/committees/interim/2005_2006/energy_telecom/staff_reports/DEG_consolidated_8-21-06%20(2).pdf

- **Bonneville Environmental Foundation–Renewable Energy Grant—**Using revenues generated from the sales of Green Tags, BEF, a not-for-profit organization, accepts proposals for funding renewable energy projects located in the Pacific Northwest (Oregon, Washington, Idaho, and Montana). Any private person, organization, or local or tribal government located in the Pacific Northwest may participate. Projects that generate electricity are preferred. Acceptable projects include solar PV, solar thermal electric, wind, hydro, biomass and animal waste-to-energy.
- **BEF–Solar 4R Schools—**This program began in 2002 to install small-scale solar energy systems at schools interested in increasing the visibility of renewable energy. BEF will generally completely fund or supply 1.1 kW system installations, fund up to 33% of other larger renewable energy projects, and provide curriculum modules developed for schools. The school agrees to own and maintain the solar energy system, provide access to the system, and implement an educational outreach strategy.
- **Renewable Energy Systems Exemption (15-6-224 and 15-32-102 MCA)—**Montana's property tax exemption for recognized non-fossil forms of energy generation or low emission wood or biomass combustion devices may be claimed for 10 years after installation of the property. The exemption is allowed for single-family residential dwellings up to $20,000 in value and for multifamily residential dwellings or a nonresidential structure up to $100,000 in value.
- **Alternative Energy Revolving Loan Program (75-25-101 MCA)—P**rovides loans to individuals, small businesses, local government agencies, units of the university system, and nonprofit organizations to install alternative energy systems that generate energy for their own use. The program is funded by air quality penalties collected by the MDEQ. In 2005, SB 50 (Senate Bill 50) amended the loan program, increasing maximum loan amount to $40,000 (subject to available funds) and extending the repayment period to 10 years. Interest rates are set annually and are fixed for the term of the loan. The rate for 2006 is 5.0%.
- **Universal System Benefits Programs (69-8-402 MCA)—**All distribution utilities and cooperatives must collect a Universal System Benefits Charge (USBC), which is used for renewable energy programs, as well as low-income assistance and weatherization, energy efficiency, and R&D programs. Beginning January 1, 1999, 2.4% of each utility's annual retail sales revenue in Montana for the calendar year ending December 31, 1995, was established as the initial funding level for universal system benefits programs. The USBC will remain in effect until December 31, 2009. Utilities, cooperatives, and large customers can self-direct their funds to approved internal programs.

Montana Rules, Regulations, and Policies

- **Net metering (69-8-601 et seq. MCA)—**Net metering is an arrangement that allows surplus energy generated by the customer's renewable energy system to go back to the utility electric system. The customer receives "credit" at retail rates for the electricity put back up to the amount of power the customer actually consumes at his/her location. Only NWE is required by legislation to offer net metering. Montana–Dakota Utilities and the rural electric cooperatives are voluntarily offering net metering. Terms of the offers vary by utility and can differ from these legislative requirements.

- **Interconnection Standards (69-8-604 MCA)—**Montana's net metering legislation, enacted in 1999, requires interconnected facilities to comply with all national safety, equipment and power-quality standards. NWE has published a standard interconnection agreement for net-metered facilities; the agreement includes language on the technical requirements for interconnecting. Technical language mirrors the state law requirements with respect to national standards but also requires a manual, lockable, external disconnect switch. NWE does not require system owners to purchase additional liability insurance, but encourages system owners to confirm with their insurance provider the limits of coverage applicable to interconnected systems.
- **Electric Cooperatives–Net Metering—**The Montana Electric Cooperatives' Association (MECA) developed and adopted a model Interconnection of Small Customer Generation Facilities policy in 2001. The model policy includes guidelines for net metering, which have been adopted in whole or part by most of the 26 electric cooperatives in Montana.

Type(s) of GHG Benefit(s)

CO_2: By providing a financial incentive for renewable generation, more renewable facilities would be installed and more electricity from renewables would be generated. This very-low-carbon generation would displace generation from conventional fossil fuel generation leading to CO_2 reductions.

Black Carbon: To the extent that generation from coal would be displaced by renewables, black carbon emissions would decrease.

Estimated GHG Savings and Costs Per Ton

	Policy	Scenario	Reductions		Cumulative Reductions 2007–2020 ($MMtCO_2e$)*	NPV 2007–2020 ($ millions)	Cost-Effective-ness ($\$/tCO_2$)
			2010	2020			
ES-4	Renewable DG†	4.5 MW PV by 2020, 1% of homes with solar hot water by 2015, 30 MW of small wind by 2020	0.03	0.10	0.8	$16	$21
ES-4	CHP	CHP potential of 470 MW	0.17	0.7	5.0	$81	$16
ES-4	Combined DG & CHP		0.20	0.8	5.8	$97	$17

* Analyzed on the basis of **consumption-based emissions**, since this option reduces load and does not directly affect decisions about new capacity additions in Montana.

† Results are highly dependent on assumptions for small wind, which have large uncertainty.

Data Sources, Quantification Methods, and Key Assumptions (for quantified actions)

A. Renewable Distributed Generation (customer-sited renewable energy)

Data Sources: WGA's Clean and Diversified Energy Initiative; EIA Annual Energy Outlook 2007 assumptions; Energy Trust of Oregon, a Comparative Analysis of Community Wind Power Development Options in Oregon.

Quantification Methods: Starting with the goals for each technology (see below), assumptions regarding the annual penetration of new distributed systems are generated. Estimates of cost and performance for different kinds of renewable systems and costs/emissions of avoided electricity are then used to estimate the overall net GHG emissions reduction and net cost of the policy.

Key Assumptions:

- **Goals/Potential:**

  Goal for rooftop solar (PV) systems is Montana's share of Million Solar Roofs initiative—1,500 systems by 2020, each system about 3 kW, so 4.5 MW by 2020.[21]

  Goal for small wind is 30 MW by 2020.

  Goal for solar hot water is to have systems installed in 1% of new homes by 2015, based on WGA's estimate of an achievable goal of 500,000 systems installed by 2015 for the entire region. The Montana fraction was estimated using the same fraction as that used for WGA estimates of solar PV by state (accounting for electricity use, solar insulation [the amount of sunlight/solar radiation], and population growth).

- **Technology costs:** From WGA 2006 Task Force Reports from the Clean and Diversified Energy Initiative,[22] EIA,[23] and Energy Trust of Oregon (Table G-4).[24]

Table G-4. Costs for solar PV, solar hot water, and wind technologies

Technology	Capital Cost ($/kW)	Capacity Factor	Project Life (Years)	Source/Notes
Solar PV	Residential: $5,500 (2010) $4,010 (2020) Commercial $2,680 (2010) $2,140 (2020)	20%	20	WGA Clean and Diversified Energy Initiative report on Solar PV
Solar hot water	$2,800 (2010) $2,200 (2020)	75%	20	EIA Annual Energy Outlook assumptions
Wind	$2,388 (2010) $1,094 (2020)	35%	20	Energy Trust of Oregon for 2020, 2010 rough estimate

- **Avoided costs:** See ES-1 above, also accounting for avoided transmission and distribution costs.

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[21] Personal communication, Pat Judge MEIC and Chris Daum, Oasis Montana, February 2007.

[22] http://www.westgov.org/wga/initiatives/cdeac/index.htm

[23] http://www.eia.doe.gov/oiaf/aeo/assumption/index.html

[24] *A Comparative Analysis of Community Wind Power Development Options in Oregon* http://www.oregon.gov/ENERGY/RENEW/Wind/docs/CommunityWindReportLBLforETO.pdf

- **Avoided electricity emissions:** See description in the above "Approach" section on avoided emissions.

B. Combined Heat and Power

Data Sources:

- The *Combined Heat and Power White Paper*, January 2006, to the Clean and Diversified Energy Initiative (CDEI) of the WGA; and the *2003 Commercial Buildings Energy Consumption Survey Detailed Tables*, published by the US DOE's EIA.

Quantification Methods: Starting with an estimate for Montana's share of CHP potential in the West, as provided in the "CHP White Paper" referenced above, assumptions regarding the penetration of and fuel shares for new CHP systems and estimates of future capacity of CHP developed under the policy are generated. Estimates of CHP cost and performance for different kinds of systems are then used to estimate the overall net GHG emissions reduction and net cost of the policy.

Key Assumptions: Key assumptions are the CHP potential in Montana, the analysis based on a potential of 470 MW (per the WGA/CDEI source above);[25] this potential grows with commercial and industrial loads, and the potential can be realized at a rate of about 2%–3% of total potential per year (Table G-5). Gas-fired systems are assumed to dominate new CHP, but some biomass- and coal-fired–capacity is also assumed. Systems are assumed to operate an average of 5,000 hours per year (at full capacity), and 90% of co-generated heat is assumed to be usable (and displaces heat from purchased fuels).

Table G-5. Technology characteristics of new CHP equipment

Technology	Capital Cost ($/kW)		Fraction of New CHP Capacity	
	2010	2020	2010	2020
Natural gas	$1260	$1180	90%	85%
Biomass	$1510	$1430	5%	12%
Coal	$1260	$1180	5%	3%

Source: EIA *Assumptions for Annual Energy Outlook 2007 (Industrial Sector)* for capital costs—based on a 3MW gas turbine with additional costs assumed for biomass, fraction of capacity by fuel type are assumptions for this policy.

- **Avoided costs:** See ES-1 above.
- **Avoided electricity emissions:** See description in the above "Approach" section on avoided emissions.

Key Uncertainties

None cited.

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[25] An alternate estimate of CHP potential is 1,092 MW from a 2004 analysis by the Western Resource Advocates, *A Balanced Energy Plan for the Interior West* at: http://www.westernresourceadvocates.org/energy/clenergy.php

Additional Benefits and Costs

None cited.

Feasibility Issues

None cited.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

ES-5. Incentives for Advanced Fossil Fuel Generation and Carbon Capture and Storage or Reuse (CCSR), Including Combined Hydrogen and Electricity Production with Geological Carbon Sequestration

Policy Description

Advanced fossil technologies produce fewer CO_2 emissions per kWh as a result of more efficient generating technologies (supercritical coal, IGCC) and/or CCSR. Differing technologies may apply either before or after fuel combustion.

Policies for advanced fossil technologies can include regulations or incentives to promote advanced technologies for new or existing coal or natural gas plants. A technology regulation might require that new coal plants achieve a certain CO_2 emission rate. Incentives may be in the form of direct subsidies, assistance in securing financing and/or off-take agreements, or a guaranteed cost recovery for prudently incurred utility investments.

Policy Design

This policy option would

- Direct MDEQ or direct the state to enter into a regional collaborative effort to develop standards and protocols for CCSR.
- Strengthen the Major Facility Siting Act to enable eminent domain for pipelines to transport CO_2 and protect landowners with appropriate siting requirements.
- Address liability issues associated with carbon capture and storage.
- Create a requirement that all fossil-fuel–fired electric generation facilities must meet a technology/fuel-neutral emissions level expressed in tCO_2/MWh as needed to achieve this level. Facilities must file a plan with the MDEQ, Air Permitting Section, that details the facility's commitment to capture and/or sequester (by geological or terrestrial means) carbon dioxide emissions, as an attribute of operating plans and permits.
    - CCAC recommends that MDEQ petition the Montana Board of Environmental Review (BER) for such a rule with specific suggested language.
    - CCAC also suggests the legislature approve supporting legislation. The CCAC recommends an emissions goal of 0.5 tCO_2/MWh (or 1,100 lbs/MWh), decreasing commensurate with best available control technology.

Goals: None yet specified. Quantification of this option will investigate the potential emissions and cost consequences of implementing CCSR for new facilities anticipated under the GHG forecast (and the high fossil fuel scenario.)

Timing: To be determined.

Parties Involved: Electrical generating facilities, Montana PSC, MDEQ, BER.

Other: None cited.

Implementation Mechanisms

Carbon Sequestration: Rule changes would have to be made by the MDEQ to the Major Facility Siting Act regarding sequestration pipelines and then brought before the BER for approval.

Technology Emissions Level Requirement: A rule would have to be established by the BER that requires all fossil-fuel–fired electric generation facilities to meet a technology/fuel-neutral emissions level expressed in tCO_2/MWh. Upon finalization of such a rule, the MDEQ would review and approve applications filed by generation facilities that detail the facility's analysis of its plan to meet the applicable standard. This would become a new integral part of the air permitting process for generation facilities. After issuance of permits with technology/fuel-neutral emission limits for CO_2, MDEQ would verify compliance with the applicable standards.

Related Policies/Programs in Place

Montana HB 3 ("Clean and Green Energy Bill"): Gives permanent property tax rate reductions from 12% to 3% of market value for new investments in transmission lines carrying "clean" electricity and "clean" liquid, along with carbon sequestration pipelines. New IGCC (with sequestration), NGCC, geothermal generation, carbon capture equipment on older power plants go down from 6% to 3%. New DC converter stations serving two regional power grids go from 6% to 2.25%. Property tax rate abatements (non-permanent incentives) from 3% to 1.5% are available for new investments in biodiesel, biomass, biogas, coal gasification (includes CTL) with sequestration, ethanol, geothermal generating, NGCC with carbon offsets, transmission lines and pipelines carrying "clean" products or CO_2, carbon sequestration equipment, renewable energy manufacturing plants, and R&D equipment for clean coal or renewable energy. These breaks last for 15 years after startup, with up to an additional 4 years coverage for construction. DC converter stations serving two regional grids go from 2.25% to 1.125% for 15 years, with up to an additional 4 years during construction. Agricultural land 660 feet on either side of any new transmission line is exempt from property tax. To receive these benefits, MDEQ must certify the projects meet the conditions of the bill. Such certification would likely follow a process similar to the Tax Certification/Classification of Air Pollution Control Equipment that is currently administered by the MDEQ.

Air Permits: MDEQ receives applications, reviews impacts, and issues permits for emissions**.**

Type(s) of GHG Benefit(s)

CO_2: Reductions in CO_2 emissions can be achieved by encouraging more efficient generation and/or through carbon capture and storage.

Black Carbon: Similarly, all other air emissions could decrease, especially with coal gasification and/or carbon capture and storage, since combustion is avoided.

Estimated GHG Savings and Costs Per Ton

	Policy	Scenario	Reductions		Cumulative Reductions 2007–2020 ($MMtCO_2e$)*	NPV 2007–2020 ($ Million)	Cost-Effective-ness ($\$/tCO_2$)
			2010	2020			
ES-5	Advanced Coal/Fossil Technologies	Reference Case	0	1.0	4.5	$135	$30
ES-5	Advanced Coal/Fossil Technologies	High Fossil Fuel Case	0	5.2	24.4	$733	$30

* Analyzed on the basis of **production-based emissions**.

Reuse of CO_2 in enhanced oil recovery could lower costs substantially; however, one would also need to consider whether the same level of sequestration would occur due to potential leakage.

Data Sources, Quantification Methods, and Key Assumptions (for quantified actions)

Given the uncertainty regarding this policy option—and with respect to the ultimate costs and performance of CCSR technologies—only an illustrative quantification is possible. To this end, we compiled estimates of the possible costs and emissions savings associated with introducing CCSR technologies under the reference case and high fossil case scenarios, under the assumptions noted below. It is important to emphasize that achieving the illustrative outcomes reported here would likely require a number of policy and other actions well beyond the items currently listed in the policy design described above, as well as confidence that these technologies will perform as projected.

Data Sources:

- The recently released Massachusetts Institute of Technology (MIT) report, “The Future of Coal” (2007), [26] which provides estimates of costs and emissions savings from various coal technologies with and without carbon capture and storage.
- The Intergovernmental Panel on Climate Change (IPCC) Special Report on Carbon Dioxide Capture and Storage (2006),[27] which provides other estimates, including rough estimates of the costs of CO_2 transport and storage.
- United States Environmental Protection Agency (US EPA) report, “Environmental Footprints and Costs of Coal-Based Integrated Gasification Combined Cycle and Pulverized Coal Technologies” (July 2006), which contains cost and performance estimates for various coal plant types and CO_2 capture, accounting also for high elevation issues with IGCC as might be encountered in Montana.
- Advanced Coal Task force report and spreadsheets from WGA 2006 *Clean and Diversified Energy Initiative.*[28]

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[26] http://web.mit.edu/coal/

[27] http://www.ipcc.ch/activity/srccs/index.htm

[28] http://www.westgov.org/wga/initiatives/cdeac/index.htm

Quantification Methods: See additional information at the end of this section.

Key Assumptions:

- **Projected levels of new coal builds.** This amounts to about 400 MW in the reference case and 2,000 MW in the high fossil fuel case (see the inventory/forecast documentation referenced in Appendix D). Due to the added energy requirements of capture (and transport and storage) technologies of 14%–40% (depending on CCS technologies), the plants would need to be sized larger by roughly this amount. These added energy requirements are factored into the cost and emission savings estimates provided here.
- An implicit assumption is that support, incentives, and/or requirements for advanced coal and CCSR will not affect the overall amount of coal builds in Montana.
- **Timing and extent of carbon capture and storage.**
    - All new coal generation from [2010] onwards would be provided by CCSR-capable technologies instead of conventional coal plants.
    - CCSR would commence at new coal plants as of 2015, and the fraction of CO_2 captured would be as noted in the goals above. This corresponds to the fraction of capture analyzed in major analyses (IPCC, MIT, above); however, it is quite possible that lower fraction of capture may be pursued.
- **Costs and operational characteristics of advanced coal and capture technologies, including CO_2 transport and storage.** Ranges of cost and performance estimates for the major elements of CCSR systems, as drawn from MIT, IPCC, and EPA studies, are shown in Table G-6. Cost estimates are shown in terms of overall costs per tonne of CO_2 avoided, and depend on technology and technical assumptions (see table notes for Table G-6). Given the range, for the illustrative analysis, we use the most recent estimates from the MIT study, which found that "for new plant construction, a CO_2 emission price of approximately $30/tonne would make CCS cost competitive with coal combustion and conversion systems without CCS. This would be sufficient to offset the cost of CO_2 capture and pressurization (about $25/tonne) and CO_2 transportation and storage (about $5/tonne). This estimate of CCS cost is uncertain; it might be larger and with new technology, perhaps smaller." (p. xi, MIT, 2007)
- Detailed bottom-up technology cost estimates for Montana-specific conditions and factors would be ideal, but do not appear warranted for this process, given the overall uncertainties regarding future costs and performance of these technologies. Montana-specific factors that might influence cost and performance include coal quality and high elevation (which could decrease the performance of IGCC units), and the location of suitable storage site or enhanced oil or coal bed methane recovery sites.

Table G-6. Summary of carbon capture storage and reuse cost estimates for new coal plants (all costs in $/tCO$_2$ avoided, transported, or stored)

	MIT, 2007	IPCC, 2006*	EPA, 2006
New PC or FBC coal plant with CCS	\$39–\$48[†][‡]	\$30–\$70 \$10–\$40 (with EOR)	\$35 (supercritical)
New IGCC plant with CCS (avoided cost)	\$19–\$24[†]	\$20–\$70 \$0–\$40 (with EOR)	\$24
Cost of transport and storage	\$5 inclusive	\$1–\$8 transport \$0.5–\$8 net injected storage (excluding potential revenues from EOR or ECBM) \$0.1–\$0.3 injected for monitoring and verification	\$0.5–\$2 transport (220 miles)
Overall reduction in CO$_2$ per kWh produced		81%–88% PC 81%–91% IGCC	

PC = pulverized coal; FBC = fluidized bed combustion; CCS = combined capture and storage; EOR = enhanced oil recovery; IGCC = integrated gasification combined cycle.

All estimates are for CO$_2$ avoided and assumed 90% capture.

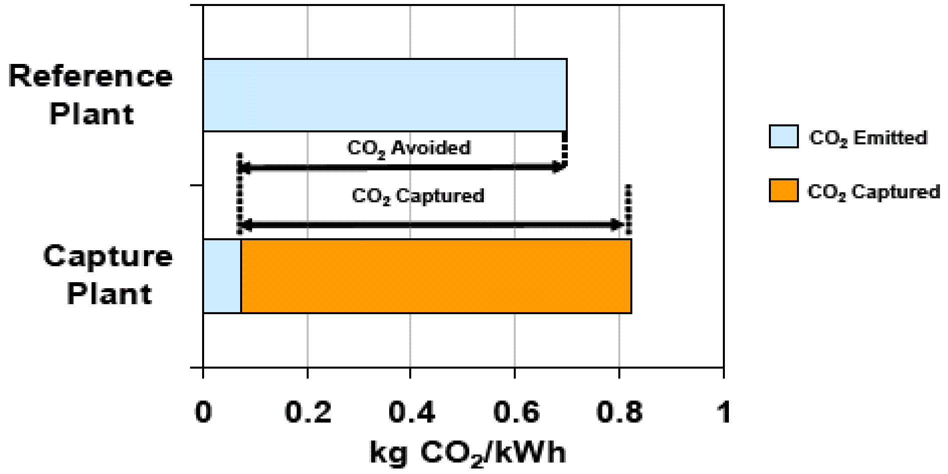
* Reference plant is a PC coal plant

[†] Low end of range generally reflects avoided plant with the same technology; high end of range generally reflects avoidance of a supercritical (high efficiency) PC plant.

[‡] Range reflects several plant types such as subcritical, supercritical, fluidized bed.

Another approach to consider is the avoided cost of capturing CO$_2$, as illustrated in Figure G-1.

Figure G-1. Illustration of avoided cost for CO$_2$ capture.



Source: USEPA, 2006

All costs shown above reflect "avoided costs" not "capture costs," i.e., costs are spread over the amount of CO$_2$ avoided, which is less than the amount of CO$_2$ captured.

Key Uncertainties

Discussed in the above section.

Additional Benefits and Costs

As with ES-12, the CCAC recognizes the potential impact of increased oil and gas production through the use of CO_2 from carbon capture for enhanced oil or coal bed methane recovery.

Feasibility Issues

Timeframe in which advanced coal technologies become economically viable.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

ES-6. Efficiency Improvements and Repowering of Existing Plants

Policy Description

Efficiency improvements refer to increasing generation efficiency at power stations through incremental improvements at existing plants (e.g., more efficient boilers and turbines, improved control systems, or combined cycle technology). Repowering existing power plants refers to switching to lower or zero emitting fuels at existing plants, or for new capacity additions. This includes co-firing biomass as coal plant fuel or the use of natural gas in place of coal or oil. Policies to encourage efficiency improvements and repowering of existing plants could include incentives or regulations as described in ES-5 above, with adjustments for financing opportunities and emission rates of existing plants.

Policy Design

The state should investigate and implement policies that encourage the reduction of GHG emissions per MWh produced, or in the case of renewable energy facilities, encourage an increase of output at existing facilities. The co-firing of biomass at coal and other fossil fuel plants, and advanced technologies, such as oxyfuel combustion, deserve particular attention.

Goals: Under development.

Timing: Under development.

Parties Involved: Under development.

Other: None cited.

Implementation Mechanisms

None cited.

Related Policies/Programs in Place

None identified.

Type(s) of GHG Reductions

CO_2 and black carbon emissions associated with coal energy generation would decrease to the extent that those facilities become more efficient (and therefore need less input fuel to meet electricity demand).

Estimated GHG Reductions and Costs (or Cost Savings)

Not quantified.

Key Uncertainties

None cited.

Additional Benefits and Costs

None cited.

Feasibility Issues

None cited.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

ES-7. Demand-Side Management

This option was investigated by the RCII TWG.

ES-8/9. Market-Based Mechanisms to Establish a Price Signal for GHG Emissions (GHG Cap-and-Trade or Tax)

Policy Description

Establishing a price on GHG emissions (or carbon dioxide specifically) is considered essential in order to reduce GHG emissions. Presently the cost of emitting carbon dioxide into the atmosphere is free. With a cost attached to carbon emissions, emitters would have a strong incentive to modify their practices, and economic inefficiencies inherent in the present system would be addressed, leading to a reduction in GHG emissions.

There are two principal ways to place a value on carbon: a carbon tax or a cap-and-trade system.

A GHG tax, or specifically a tax on CO_2, would be a tax on each ton of CO_2 (equivalents) emitted from an emissions source covered by the tax. A CO_2 tax could be imposed upstream based on carbon content of fuels (e.g., fossil fuel suppliers) or at the point of combustion and emission (e.g., typically large point sources such as power plants or refineries). Taxed entities would pass some or all of the cost on to consumers, change production to lower emissions, or a combination of the two. As the suppliers respond to the tax, consumers would see the implicit cost of CO_2 emissions in products and services and would adjust their behavior to purchase substitute goods and services that result in lower CO_2 emissions. CO_2 tax revenue could be used in a variety of ways such as payroll or income tax reductions or for policies and programs to assist in decreasing CO_2 emissions. CO_2 tax revenue could also be directed to increasing the competitiveness of industries or assisting communities most affected by the tax.

A cap-and-trade system uses a more indirect approach to placing a value on carbon. It is a market mechanism in which GHG emissions are limited or capped at a specified level, and those participating in the system can trade allowances (an allowance is a permit to emit one ton of CO_2). By allowing trading, participants with lower costs of compliance can choose to over-comply and sell their additional reductions to participants for whom compliance costs are higher. In this fashion, overall costs of compliance are lower than they would be otherwise.

For every ton of CO_2 released, an emitter must hold an allowance. The total number of allowances issued or allocated is the cap. The government can assign a certain amount of allowances to emission sources, hold back allowances for distribution to developing sources (e.g., new entrants), auction some or all of them, or provide a combination of these options. Participants can range from a small group within a single sector to the entire economy. The compliance obligation can be imposed upstream (at the fuel extraction or import level) or downstream at points of fuel consumption.

Among the important considerations with respect to a cap-and-trade program are the sources and sectors to which it would apply; the level and timing of the cap; how the level of the cap may change over time, if at all (e.g., through a specifically declining cap); how allowances would be distributed (e.g., whether load-based or generation-based); how new market entrants are accommodated; and how "leakage"[29] is addressed. Further emissions reductions are achieved by decreasing the number of allowances over time. Other questions include what if any offsets would be allowed, over what region the program would be implemented (e.g., nationally or regionally), and whether compliance with the cap could be achieved given "leakage" from nonparticipating states and coal-fired generation located on tribal lands not subject to the cap. Thus, the effectiveness of a cap-and-trade system is correlated with the extent and scope of its coverage. Further issues to consider include which GHGs are covered; whether there is linkage to other trading programs; banking and borrowing of allowances; credit for early reductions; what, if any, incentive opportunities may be included; use of revenue accrued from permit auctions, if any; and provisions for encouraging energy efficiency.

Both of these mechanisms would be most effective implemented on a national level. This is largely because the nation's carbon footprint is so large, cutting across virtually all sectors of our economy; accordingly a national strategy and program for reducing GHG emissions is desirable. However, both a carbon tax and a cap-and-trade program could be implemented on a state or regional basis. It is likely that if a carbon tax were to be instituted at some other level than federal, it would be by an individual state, owing to the political difficulties of having more than one state impose an identical tax. Conversely, if a cap-and-trade program is contemplated, it does not make sense for most states to go it alone but, rather, to join in a multistate effort in order to take advantage of a larger market for conducting transactions.

Most economists prefer the vehicle of a tax because it is a more direct way to influence behavior, sends a clearer price signal, and relies on existing markets rather than on the establishment of an entirely new market, is easier to adjust if reductions achieved differ from projected results, and would arguably lead to a more efficient outcome in that economic decisions would be more closely matched to product value.

However, many observers believe that a carbon tax stands little chance of being enacted, either nationally or on a statewide basis. Taxes are often controversial and difficult to enact.

A cap-and-trade system, as the above discussion suggests, will also be difficult to implement, but the successful sulfur dioxide program under the Clean Air Act, which cost-effectively led to significant reductions of that pollutant on a nationwide basis, serves as a positive precedent. Allowing participants to sell allowances creates proponents for such a system, namely those who think they will benefit from it.

There is one regional GHG cap-and-trade system in the United States in the process of being implemented and another under likely development. The cap-and-trade system designed by the Northeast States' Regional Greenhouse Gas Initiative (RGGI)—an effort by the states of Connecticut, Delaware, Maine, Maryland, New Hampshire, New Jersey, New York, Rhode Island, and Vermont—will begin operation in 2009 and is limited to power plant emissions.[30] The Western Climate Initiative (WCI) is an effort by 6 states (Washington, California, Oregon, Arizona, New Mexico, and Utah) and two Canadian provinces (British Columbia and Manitoba),

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[29] Emissions "leakage" can occur, for instance, if production is shifted to higher-emitting sources not included within the cap.

[30] http://www.rggi.org/

that aims to design "a regional market-based multi-sector mechanism, such as a load-based cap-and-trade program, to achieve the regional GHG reduction goal."[31] In contrast to RGGI, the WCI is economy-wide. While the exact mechanism to be used has not yet been decided, it is widely believed that some form of a cap-and-trade program will be chosen.

Some CCAC members believe that a national carbon tax is the preferred strategy. Other CCAC members believe that a national cap-and-trade system is not only preferred but stands a more realistic chance of being adopted than a national carbon tax. Collectively, however, the CCAC determines not to take a position on these competing mechanisms because we recognize that our ability to influence national policy is limited. The CCAC underscores that one of these mechanisms, or some other mechanism, needs to be adopted by the federal government in the near future if the nation is to achieve significant reductions in GHG emissions.

That does not mean that Montana is powerless to affect the direction of these policies, however. The establishment of the WCI puts significant pressure on the federal government to act. Moreover, since it seems likely that the WCI will employ a cap-and-trade system, the effort creates additional momentum for the creation of a national cap-and-trade system. The more states that join WCI, the greater the pressure and the more momentum generated. In addition, and very important to our thinking, Montana's influence on the design of a national cap-and-trade system will be relatively limited, but in the context of a western regional effort, Montana's ability to influence matters will be comparatively great. Accordingly, the CCAC recommends that Montana seek to join the WCI.

Policy Design

The state should investigate and advocate for a national GHG cap-and-trade or tax system.

The state should participate fully in the Western Regional Climate Action Initiative, which will consider development of a regional market-based mechanism.

Goals: Not specified.

Timing: Not specified.

Parties Involved: Other Western states.

Other: None cited.

Implementation Mechanisms

Among the important considerations with respect to a cap-and-trade program are the sources and sectors to which it would apply, the level and timing of the cap, how allowances would be distributed (e.g., whether load-based or generation-based), how new market entrants would be accommodated, and how leakage would be addressed. Other factors include how allowances would be reduced over time; what if any offsets would be allowed; over what region the program would be implemented (e.g., nationally or regionally); and whether compliance with the cap could be achieved, given "leakage" from nonparticipating states and coal-fired generation

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[31] The State of Utah and the Provinces of British Columbia and Manitoba joined after the initiative was announced.

located on tribal lands not subject to the state-imposed cap. Further issues to consider include which GHGs are covered; whether there is linkage to other trading programs; banking and borrowing; early reduction credit; what, if any, incentive opportunities may be included; use of any revenue accrued from permit auctions; and provisions for encouraging energy efficiency.

The principal example of an existing implementation of a GHG cap-and-trade system in the United States today is the Northeast States' RGGI: http://www.rggi.org/.

In February 2007, Washington, California, Oregon, Arizona, and New Mexico signed the Western Regional Climate Action Initiative. This became the above mentioned Western Climate Initiative (www.wertnrclimateinitiative.org). It WCI partners agreement states:

> "This collaboration shall include, but is not limited to:
>
> - Setting an overall regional goal, within six months of the effective date of this initiative, to reduce emissions from our states collectively, consistent with state-by-state goals;
> - Developing, within eighteen months of the effective date of this agreement, a design for a regional market-based multi-sector mechanism, such as a load-based cap and trade program, to achieve the regional GHG reduction goal; and
> - Participating in a multi-state GHG registry to enable tracking, management, and crediting for entities that reduce GHG emissions, consistent with state GHG reporting mechanisms and requirements."[32]

Various carbon tax policies have been implemented in Europe, Australia, and Japan. Several have been proposed in the U.S., but only the City of Boulder, CO has implemented a carbon tax. In some cases carbon taxes are used to offset other taxes such as income or wage/ payroll taxes, in others they are used to support public transportation, high efficiency vehicles, and energy alternatives. Attachment A at the end of this document provides brief information on the approaches of existing programs.

Related Policies/Programs in Place

None identified.

Type(s) of GHG Reductions

A cap-and-trade or tax system would directly target the reduction in emissions of the GHGs included in the program. To the extent that generation from coal and oil would decline under a cap-and-trade system, black carbon emissions would also likely decrease.

Estimated GHG Reductions and Costs (or Cost Savings)

Not quantified.

Key Uncertainties

None cited.

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[32] http://www.ecy.wa.gov/climatechange/docs/07Mar_WesternRegionalClimateActionInitiative.pdf

Additional Benefits and Costs

Effects on or opportunities to assist low-income groups with tax revenue re-distribution are important considerations.

Benefits

Carbon dioxide emissions reductions will typically be accompanied by reductions in the emissions of other air pollutants.

Costs

There is a concern that a Montana-only mechanism would put the state at a competitive disadvantage for attracting and retaining businesses.

Feasibility Issues

The political feasibility of a carbon tax has been widely debated.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

ES-10. Generation Performance Standards or GHG Mitigation Requirements for New (and/or Existing) Generation Facilities, With/Without GHG Offsets

Policy Description

A generation performance standard (GPS) could take several forms. In the case of a GHG Emissions Performance Standard, as enacted in California and in Washington State, it is a mandate requiring load serving entities (LSEs) to acquire electricity. In the case of a power plant GHG performance standard, as in place in Oregon and Washington, it can be a requirement that power plant developers build and operate new generation, with an emission rate (e.g., X lbs CO_2/MWh) below a specified mandatory standard that does not exceed a specified GHG emissions profile. In some cases, GHG offsets or credits can be used for compliance (e.g., Oregon and Washington). GHG offsets are GHG emission savings from project-based activities in sectors or regions not covered by the standard or regulations, which typically need to meet specific criteria laid out in the regulation.

A market-based variation of a GPS would allow generators with emission rates lower than the GPS to sell their extra “credits” to generators with emission rates higher than the GPS.

A third variation of a GPS is to establish the standard and allocate allowances based on that standard every year. In this variation, as electricity generation increases, plants would receive more permits. Utilities could trade permits in order to achieve the standard, but there would be no fixed cap on emissions. This variation provides a financial incentive (via the trading) for generators to reduce emissions so that they can sell unneeded permits to generators who have high emissions.

Various GPS policies in place are summarized at the end of this section.

Policy Design

The state should implement Greenhouse Gas Emission Performance Standards and align these standards to the extent possible with those adopted in California and in Washington State. These standards establish a maximum GHG emission rate for new, long-term financial commitments to electricity-generating resources by LSEs and would apply to both in-state and imported electricity (see Table G-7). In doing so, the state should consider a longer-term phase-in to account for the availability of technological options.

Note that this option should complement and work with any future cap-and-trade or carbon tax system (ES-8/9).

Table G-7. Survey of GHG standards in other states

State	Start Date	GHG Emissions Performance Standard	Applicability	Additional information
GHG Emission Performance Standards (long-term financial commitments to electrical generating resources)—"load-based"				
California: SB No. 1368 (approved Sep. 2006)[33] CPUC interim opinion (Jan. 2007)[34]	2007	Equal to or less than a new NGCC power plant. Interim rule: 1,100 lbs of CO_2e/MWh.	New long-term financial commitments to baseload electricity generation by LSEs. (Applies to in-state or imported electricity.)	Ensures no reduction in energy supply reliability. Emissions based on net emissions from electricity production. CO_2 stored in geologic formations shall not be counted as emissions from the power plant (interim opinion: for sequestration projects, lifetime emissions count, plan but immediate storage not needed). Allows for added return where applicable (1/2%–1%) for zero- or low-carbon generating resources.
Washington: SB 6001[35]	July 1, 2008	Equal to or less than 1,100 lbs of CO_2e/MWh.	New, long-term financial commitments to baseload electricity generation by IOUs and consumer-owned utilities.	Ensures no reduction in energy supply reliability. Emissions based on net emissions from electricity production. CO_2 stored in geologic formations shall not be counted as emissions from the power plant.
Carbon Dioxide Emission Standards For *New* Energy Facilities—"facility-based"				
Oregon: HB 3283[36]	1997; updated 2003	Meet emissions standard. 17% better than the most efficient base-load gas plant currently operating in the United States (0.675 lb. CO_2 per kWh).	New energy facilities.	Compliance options: • implement offset projects directly; • pay a fee of \$0.85/MtCO_2 using a qualified organization that purchases/manages offsets (below market cost of offsets).

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[33] http://www.energy.ca.gov/ghgstandards/documents/sb_1368_bill_20060929_chaptered.pdf

[34] http://www.cpuc.ca.gov/PUBLISHED/FINAL_DECISION/64072.htm

[35] http://www.leg.wa.gov/pub/billinfo/2007-08/Pdf/Bills/Senate%20Passed%20Legislature/6001-S.PL.pdf

[36] http://www.oregon.gov/ENERGY/SITING/docs/ccnewst.pdf ;

State	Start Date	GHG Emissions Performance Standard	Applicability	Additional information
Washington: HB 3141 & RCW 80.70.020, WAC 173-407	2003; updated 2004	CO_2 mitigation plan to offset 20% of CO_2e emissions over a 30-year period.	New energy facilities > 350 MW (EFSEC rules); 25–350 MW (Department of Ecology rules); or output increases at existing facilities.	Compliance options: - implement offset projects directly; - pay a fee of \$1.60/MtCO_2 using a qualified organization that purchases/manages offsets (below market cost of offsets).
Carbon Dioxide Emission Standards For *Existing* Energy Facilities—"facility-based"				
Massachusetts: Amendment to 310 CMR 7.29[37]	2006 cap; 2008 rate	Cap: Emissions cannot exceed historical emissions Rate: Emissions must not exceed 1,800 lb CO_2/MWh.	Six current power generation facilities in Massachusetts.	Compliance may be met via emission reductions, avoided emissions, or sequestered emissions.

CPUC = California Public Utility Commission; EFSEC = [Washington] Energy Facility Site Evaluation Council.

Goals: Establish a GHG emissions performance standard that

- Applies to new long-term financial commitments to baseload electricity generation by load-serving entities;
- Is equal to or less than a new, NGCC power plant;
- Ensures no reduction in energy supply reliability;
- Is based on net emissions from electricity production;
- Does not count CO_2 stored in geologic formations as emissions from the power plant; and
- Includes a mechanism to update standard as conditions evolve.

Timing: The goal is to have a policy in place in 2010**.**

Parties Involved: Under development.

Other: None cited.

Implementation Mechanisms

None cited.

Related Policies/Programs in Place

In 2007, the regular session of the Montana Legislature adopted HB 25, which repealed most of what remained of Montana's deregulation law. It also authorized NWE to invest in new power generation facilities, with certain limitations. In situations where NWE might seek advance

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[37] http://trinityconsultants.com/State_Regulatory_News.asp?st=MA&n=313; http://www.mass.gov/dep/air/laws/ghgappb.pdf

approval for a facility, the new law forbids NWE from acquiring an equity interest in a new coal-fired power plant until the state or federal government has adopted a carbon capture and sequestration standard, unless that plant voluntarily captures and sequesters at least 50% of its carbon dioxide. For power plants that are fueled primarily by natural gas or syngas, NWE would have to obtain certified "cost-effective carbon offsets" in an amount specified by the PSC, but that cannot result in an increase in the price of electricity of more than 2.5%. The definition of offsets includes direct capture at the plant, in addition to market purchases. The PSC is not allowed to approve any such resource until the final air quality permit is in place and the public has had an opportunity to review and comment on it. The PSC is charged with developing rules to implement HB 25 by March 31, 2008. For the final text of the bill, see http://data.opi.mt.gov/bills/2007/billpdf/HB0025.pdf

Type(s) of GHG Benefit(s)

CO_2: A GPS program would directly target reductions CO_2 emissions.

Black Carbon: To the extent that generation from coal and oil would decline under a GPS program, black carbon emissions would also decrease.

Estimated GHG Savings and Costs per Ton

	Policy	Scenario	Reductions		Cumulative Reductions 2007–2020 ($MMtCO_2e$)*	NPV 2007–2020 ($ Millions)	Cost-Effectiveness ($/tCO$_2$)
			2010	2020			
ES-10	Generation Performance Standard	Reference Case–Compliance Mix	0.1	0.8	4.7	$60	$13
Range of results depending on compliance option							
ES-10	Generation Performance Standard	Compliance Option 1: NGCC	0.1	0.7	3.9	$49	$12
ES-10	Generation Performance Standard	Compliance Option 2: Coal with partial CCS	0.0	0.5	2.7	$82	$30
ES-10	Generation Performance Standard	Compliance Option 3: Added renewable energy	0.1	1.2	6.8	$60	$9

* Analyzed on the basis of consumption-based emissions, since the GPS in its design above is focused on load.

Data Sources, Quantification Methods, and Key Assumptions (for quantified actions)

Data Sources: As listed under ES-1 and ES-5.

Quantification Methods: The analysis compares the costs and CO_2 emissions of compliance with the GHG Emission Performance Standard, as defined above with the costs and CO_2 emissions of reference case resources. It involves the following steps: 1) estimate the amount of new generation expected to be needed by LSEs to meet load growth, retirements, or terminated contracts; 2) estimate the amount of the likely mix of this new generation needed (based on the inventory/projections); 3) identify the likely amount of generation with emission rates exceeding the performance standard; and 4) estimate the cost of (a mix of) alternative resources that can meet the standard.

Key Assumptions:

- **Amount of load-serving generation likely to be affected—**A GHG Emission Performance Standard, as described above, would apply to any new long-term financial commitments to baseload electricity generation by LSEs. The challenge is when and where such commitments might be needed. In principle, they would arise where an LSE is in need of new baseload resources due to a) load growth, b) plant retirement or derating, or c) the lapse of existing contracts for baseload resources. Since it is difficult to project b) or c), we simply assume that all new load growth after the start of the policy would be affect by this rule. On one hand, some load growth would be met with existing or non-baseload resources; on the other hand, some new financial commitments will likely arise from cases b) or c). Thus, while imperfect, this approach enables us to make some rough estimates.
- **Replacement mix—**The principal alternatives that meet the GHG Emission Performance Standard would likely be natural gas CC plants, coal with CCSR, or renewable energy facilities. The emissions savings and costs of this policy will depend on the cost-competitiveness (and other factors) of these alternative, replacement resources, as illustrated in Table G-8. For purposes of developing a single estimate, the following replacement mix is assumed:
    - ○ 2010: 50% renewables and 50% natural gas;
    - ○ 2020: 33% renewables, 33% natural gas, 33% coal CCSR.
- **Costs and emissions rate of avoided (coal) resources—**For consistency with other options, the avoided cost ($49/MWh) is used as a proxy for coal electricity costs. Note that the recent MIT Future of Coal study used as the basis for ES-5 suggests almost the same levelized cost of electricity ($48.4/MWh) for subcritical PC.
- **Costs of alternative resources—**The busbar cost (a common approach to comparing costs of generation alternatives) uses levelized cents/kWh or $/MWh of alternative resources based on the same assumptions defined above for renewable energy sources (see ES-1) and coal plants with carbon capture and storage (see ES-5). The cost of natural gas resources is estimated based on information from the EIA's *Annual Energy Outlook 2006/2007*.[38]

Table G-8. Characteristics of alternative resources (assumptions)

Alternative Resource	Bus Bar Cost ($/MWh)	Emissions Rate (lb CO_2/MWh)	Incremental Emission Savings (Relative to PC)
Natural gas	$60	782	58%
Renewable mix	$41–$68	0	100%
Coal CCSR	($30/t$CO_2$)	1,100	40%

Key Uncertainties

None cited.

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[38] http://www.westgov.org/wieb/electric/Transmission%20Protocol/SSG-WI/pnw_5pp_02.pdf

Additional Benefits and Costs

None cited.

Feasibility Issues

None cited.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

ES-11. Methane and CO_2 Reduction in Oil and Gas Operations, Including Fuel Use and Emissions Reduction in Venting and Flaring

Policy Description

There are a number of ways in which methane (CH_4) and CO_2 emissions in the oil and gas industry can be reduced. Natural gas consists primarily of methane; therefore, any leaks during production, processing, and transportation/distribution should be addressed. In addition to reducing GHG emissions, stopping these leaks may be economically beneficial because it can prevent the waste of valuable product.

US EPA's Natural Gas STAR Program offers numerous methods of preventing leaks. These methods, called best management practices (BMPs) and partnership reduction opportunities (PROs), are divided by industry sub-sector: production, processing, and transportation/ distribution. Among the practices recommended are preventive maintenance (improving the overall efficiency of the gas production and distribution system), reducing flashing losses (releases when pressure drops at storage tanks, wells, compressor stations, or gas plants), and changing and replacing parts and devices to reduce leaks and improve efficiency.

There are several ways in which CO_2 emissions in the oil and gas industry can be reduced by improving energy efficiency, including a) installing new efficient compressors, b) optimizing gas flow to improve compressor efficiency, c) improving performance of compressor cylinder ends, d) capturing compressor waste heat, e) replacing compressor driver engines, and f) installing waste heat recovery boilers.

Regulations, incentives, and/or support programs can be applied to achieve these reductions (see ES-5 for examples).

Policy Design

The state should adopt a policy to assist and encourage natural gas companies in the state to participate in EPA's Natural Gas STAR program and provide enforcement and verification of participation. This is especially helpful for a state like Montana where many of the operators are smaller companies that probably have not considered the leak prevention and other methods available through the Natural Gas STAR Program. The Natural Gas STAR Program allows individual companies to work with EPA representatives to develop an implementation plan for BMPs and PROs that are appropriate for that specific company. The state should consider whether participation by smaller companies would be a significant burden and possibly provide incentives if needed.

Goals: A goal of reducing methane emissions by 30% below business-as-usual (BAU) levels is suggested based on the analysis of cost-effective, achievable reductions shown below.

Timing: The goal should be implemented by 2020.

Parties Involved: MDEQ, Bureau of Land Management (BLM), United States Forest Service (USFS), Department of State Lands, Montana Petroleum Association, Society of Petroleum Engineers, and oil and gas companies.

Other: None cited.

Implementation Mechanisms

The state should consider organizing a Natural Gas STAR Program workshop for oil and gas companies operating in-state, in collaboration with US EPA.

MDEQ, along with BLM and the USFS, should develop monitoring capabilities to ensure that BMPs, especially if associated with permit requirements, are fully implemented.

Related Policies/Programs in Place

EPA Natural Gas STAR program—is a voluntary partnership with US EPA, which currently includes several Montana natural gas companies and encourages companies across the natural gas and oil industries to adopt cost-effective technologies and practices that improve operational efficiency and reduce emissions of methane. Natural Gas STAR Program partners sign a Memorandum of Understanding (MOU) wherein they agree to evaluate the Program's recommended BMPs for reducing methane emissions and implement them when they are cost-effective for the company. Partners develop a customized implementation plan and submit annual reports showing emissions reductions undertaken.

Remote control of wells and capture of waste gas—Many oil well operations in eastern Montana are remotely controlled to save vehicle mileage and better prevent spills. Most waste gas is being captured rather than vented in state operations.

Type(s) of GHG Benefit(s)

CO_2: CO_2 emissions would be reduced directly through the fuel use and flaring reductions.

CH_4: Methane emissions would also be reduced, mostly through decreased venting and leak reductions.

Estimated GHG Savings and Costs Per Ton

	Policy	Scenario	Reductions		Cumulative Reductions 2007–2020 (MMtCO$_2$e)	NPV 2007–2020 ($ Million)	Cost-Effective-ness ($/tCO$_2$)
			2010	2020			
ES-11	CH_4/CO_2 Reduction in Oil & Gas Industry	Reference Case	0.1	0.5	3.9	Not yet estimated	Likely net benefit
ES-11	CH_4/CO_2 Reduction in Oil & Gas Industry	High Fossil Fuel Case	0.3	0.8	6.6	Not yet estimated	Likely net benefit

Data Sources, Quantification Methods, and Key Assumptions (for quantified actions)

Data Sources:

- Capital cost and other information for individual technologies and practices are available at EPA's Natural Gas STAR Program Web site, http://www.epa.gov/gasstar/techprac.htm#tabnav
- Natural Gas Systems, 1999. US EPA. http://www.epa.gov/methane/reports/03-naturalgas.pdf
- Addendum to the U.S. Methane Emissions 1990–2020: 2001 Update for Inventories, Projections, and Opportunities for Reductions. US EPA. http://www.epa.gov/methane/reports/2001update.pdf
- Emissions estimates are from the Montana Inventory and Forecast (available at: www.mtclimatechange.us/CCAC.cfm).

Table G-9. Methane and carbon dioxide emissions estimates, 2005–2020

	MMtCO$_2$e		
	2005	**Reference case 2020**	**High Fossil Fuel 2020**
Methane emissions			
Natural gas industry			
Production	0.43	0.54	1.64
Processing	0.08	0.08	0.08
Transmission	0.57	0.67	0.74
Distribution	0.15	0.28	0.28
Oil industry			
Production	0.26	0.33	0.33
Refining	0.01	0.01	0.01
Transmission and distribution	N/A	N/A	N/A
CO$_2$ emissions (combustion)			
Natural gas industry			
Production	0.11	0.11	0.12
Processing	N/A	N/A	N/A
Transmission and distribution	0.15	0.28	0.28
Oil industry			
Production	**Included in industrial sector**		
Refining	2.44	2.44	4.12

Quantification Methods: GHG reductions would be based on a specified goal level if one is established. Note that GHG reduction technologies and practices cover a wide variety of actions, and the costs would vary significantly by site and application and are thus difficult to consolidate. A simple, rough, and partial analysis can be conducted for methane emissions in the natural gas industry based on information contained in the US EPA reports noted above. See also the additional information at the end of this section as provided by the US EPA Natural Gas STAR Program.

Key Assumptions:

- **Cost and emissions savings (natural gas industry methane emissions)—**As indicated in the national analysis shown in US EPA, 2001. The data in Table G-10 suggest that 30% reductions are achievable at no net cost or net economic savings (due to recovered gas); this estimate is used for the results shown above (assumed to phase in between 2010 and 2015). The implicit assumption is that these national averages are relevant for current Montana conditions, and mix of activities. Some of these emissions reductions may already be underway or completed in the state. (Such efforts would not necessarily be reflected in the inventory/forecast estimates above, which also utilize national average factors.)

Table G-10. Natural gas emission reductions achievable at different carbon equivalent prices (at 20% discount rate)

Year (Baseline emissions, MMtCe)	**2005 (36.5)**		**2010 (37.4)**		**2015 (38.5)**		**2020 (39.8)**	
Carbon Value $/tCe	**Reductions**		**Reductions**		**Reductions**		**Reductions**	
($20)	3.7	10%	3.8	10%	5.7	15%	7.5	19%
($10)	9.1	25%	9.3	25%	9.9	26%	10.5	26%
$0	10.4	28%	11.2	30%	11.5	30%	11.8	30%
$10	11.9	33%	12.2	33%	12.6	33%	12.9	33%
$20	12.2	33%	12.5	33%	12.9	33%	13.3	33%
$30	12.7	35%	13.0	35%	13.3	35%	13.7	35%
$40	12.7	35%	13.0	35%	13.6	35%	14.2	36%
$50	14.6	40%	15.0	40%	15.6	40%	16.2	41%
$75	16.2	44%	16.6	45%	17.3	45%	17.9	45%
$100	17.6	48%	18.0	48%	18.7	49%	19.4	49%
$125	18.2	50%	18.8	50%	19.4	50%	20.1	51%
$150	18.3	50%	18.8	50%	19.5	51%	20.2	51%
$175	18.3	50%	18.8	50%	19.5	51%	20.2	51%
$200	18.3	50%	18.8	50%	19.5	51%	20.2	51%
Remaining emissions	**18.2**	**50%**	**18.6**	**50%**	**19.0**	**49%**	**19.6**	**49%**

MMtCe = million metric tons of carbon equivalents.

Source: US EPA, 2001 (applies to methane only)

Key Uncertainties

None cited.

Additional Benefits and Costs

None cited.

Feasibility Issues

None cited.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

Additional Information relevant to ES-11

Table G-11. Sources of methane emissions from oil and gas activities (1997)

Industry sector	Natural Gas Industry Sources of Emissions	Percent of Total and Amount	Crude Oil Industry Sources of Emissions	Percent of Total and Amount
Production	Wellheads, dehydrators, separators, gathering lines, and pneumatic devices	25% 8.4 MMtCe or 1.5 Tg	Wellheads, separators, venting and flaring, other treatment equipment	49% 0.7 MMtCe or 0.13 Tg
Processing	Compressors and compressor seals, piping, pneumatic devices, and processing equipment	12% 4.1 MMtCe or 0.7 Tg	Waste gas streams during refining	2% 0.1 MMtCe or 0.01 Tg
Transmission and Storage	Compressor stations (blowdown vents, compressor packing, seals, valves), pneumatic devices, pipeline maintenance, accidents, injection/withdrawal wells, pneumatic devices, and dehydrators	37% 12.4 MMtCe or 2.2 Tg	Transportation tanker operations, crude oil storage tanks	48% 0.7 MMtCe or 0.13 Tg
Distribution	Gate stations, underground non-plastic piping (cast iron mainly), and third-party damage	26% 8.6 MMtCe or 1.5 Tg	Not applicable	
Total		**33.5 MMtCe or 5.8 Tg**		**1.6 MMtCe or 0.27 Tg**

Totals may not sum due to independent rounding.

Source: US EPA, 1999 and US EPA, 2000.

The following additional information was provided by US EPA Natural Gas STAR Program representatives:

Cost curves for methane emissions reduction from oil and gas systems in Montana (\$/tCO$_2$)—While no marginal abatement cost curves for methane emissions reductions are available for Montana, it is reasonable to assume that Montana cost curves will be similar to national estimates. EPA has national pricing and mitigation information available online (http://www.epa.gov/methane/projections.html). EPA has analyzed many reduction technologies and their respective reduction efficiencies, as well as U.S.-based capital and operation/maintenance costs. There is also additional data in a recent EPA report titled "Global Mitigation of Non-CO$_2$ Greenhouse Gases" (EPA Report 430-R-06-005, www.epa.gov/nonco2/econ-inv/index.html). An additional source that may provide food for thought is an article prepared by the Natural Gas STAR Program and published in the *Oil & Gas Journal*, July 12, 2004 (www.icfi.com/Markets/Energy/doc_files/InternationalMethane-oilgasjournal.pdf) The article shows that approximately 60% of methane emissions can be mitigated for less than \$10/tCO$_2$e.

- **Information regarding specific programs that could be put in place at the state level in Montana to implement methane emissions reductions from oil and gas systems**—The Natural Gas STAR Program maintains a library of technical documents detailing actual projects that industry partners have found to be cost-effective ways to reduce methane emissions at http://www.epa.gov/gasstar/resources.htm. Based on the sector emissions profile and our understanding of pertinent sector-specific emission sources, the following list identifies key opportunities for methane savings:

Fugitive emissions:

- Conducting directed inspection and maintenance with optical imaging at production, processing, transmission, and distribution facilities.
- Installing composite wrap for non-leaking pipeline defects.

Recover gas from designed vents:

- Reducing methane emissions from pneumatic devices in the natural gas industry.
- Installing rupture pin shutoff devices.
- Installing vapor recovery units.

Dehydrator emissions:

- Optimizing glycol circulation and install flash tank separators in dehydrators.
- Installing electric pumps on dehydrators.
- Installing zero-emissions dehydrators.

Compressor emissions:

- Replacing wet seals with dry seals in centrifugal compressors.
- Replacing reciprocating compressor rod packing systems.
- Altering operational practices when taking compressors offline.

Production optimization:

- Installing plunger lift systems in gas wells.
- Implementing gas well “smart” automation systems.
- Conducting green completions (reduced emissions completions).

ES-12. GHG Reduction in Refinery Operations, Including in Future Coal-to-Liquids Refineries

Policy Description

There are a number of ways in which CH_4 and CO_2 emissions can be reduced in the production of liquid fuels at oil refineries or Coal-to-Liquid (CTL) plants. These options include various efficiency measures including enhanced combined heat and power along with carbon capture and storage.

CTL plants are energy-intensive and emit 10 times more CO_2 than conventional oil refineries in order to produce liquid fuels.[39] Emissions reductions from CTL production can be achieved through poly-generation, biomass blending, and most significantly through carbon capture and storage. CTL fuels production is especially amenable to CO_2 capture and sequestration because emissions are largely generated from a single source and are already concentrated, because the syngas produced from the feedstock fuel must be cleansed of excess CO_2 before entering the Fischer-Tropsch reactor.[40] Regulations, incentives, and/or support programs can be applied to achieve these reductions (see ES-5 for some examples).

Policy Design

There are serious concerns about the high GHG emissions associated with the production of coal liquids. This policy option would require that all CTL facilities located in the State of Montana meet a performance-based standard, reflecting a best available control technology approach, which could imply that

- CTL facilities would capture and store CO_2 from the start of operations, assuming this technology is considered commercially available, producing fuels with 20% to 30% lower life cycle emissions relative to standard petroleum-based fuels.
- Any CTL plant would likely also be a poly-generation plant, and would produce electricity along with fuel and other products.
- In addition, this policy option would aim to improve maintenance at oil refineries and ensure that best practices are being followed (cross-cut with safety issues).

Goals: The goal for CTL is to produce fuels with life cycle GHG emissions [at least] 20%–30% below petroleum-based fuels.

Timing: Under development.

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[39] International Energy Agency, 2006. *Energy Technology Perspectives.* Well-to-wheel GHG emissions from coal liquids are approximately twice those of conventional oil products. Cogeneration and carbon capture and storage can reduce those emissions to levels similar to, or slightly below, those of conventional oil products.

[40] Brandt, A. R. and A.E. Farrell (2006) Scraping the Bottom of the Barrel: CO2 Emission Consequences of a Transition to Low-Quality and Synthetic Petroleum Resources. Forthcoming in Climatic Change http://erg.berkeley.edu/people/faculty/Brandt_Scraping_Public.pdf

Parties Involved: Under development.

Other: None cited.

Implementation Mechanisms

Performance standard, as noted above.

Related Policies/Programs in Place

None identified relating to GHG reductions in refinery operation, including future CTL refineries.

Type(s) of GHG Benefit(s)

CO_2: CO_2 emissions would be reduced directly through fuel use reductions

CH_4: CH_4 could also be reduced due to process changes (e.g., leak reductions, as appropriate)

Estimated GHG Savings and Costs Per Ton

	Policy	Scenario	Reductions 2010	Reductions 2020	Cumulative Reductions 2007–2020 (MMtCO_2e)	NPV 2007–2020 ($ Million)	Cost-Effective-ness ($/t$CO_2$)
ES-12a	Coal-To-Liquid (CTL) Production	**High Fossil Fuel Case** CTL—High Fossil Fuel Case: 20%–30% lower life cycle emissions than diesel (via CCS, biomass co-firing, poly-generation)	0	9.9	35	Not estimated	Not estimated
ES-12b	Petroleum Refining	**Reference Case**	0.02	0.24	1.5	Not estimated	Not estimated
		High Fossil Fuel Case	0.03	0.38	2.2	Not estimated	Not estimated

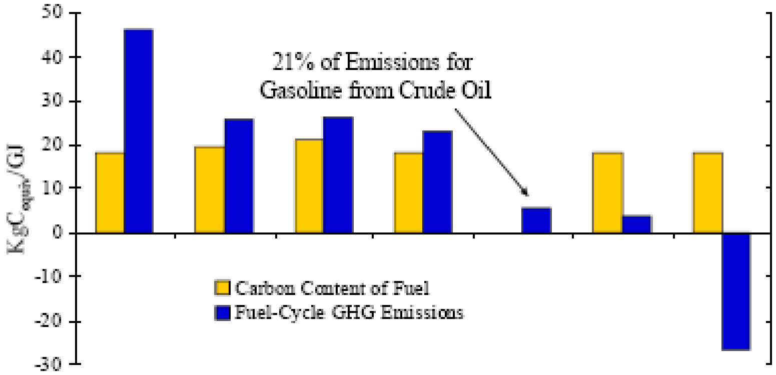
Data Sources, Quantification Methods, and Key Assumptions (for quantified actions)

ES-12a—Coal-To-Liquid (CTL) Production

Data Sources:

- R.H. Williams, E. Larson, et al. 2006. Synthetic fuels in a world with high oil and carbon prices. 8th International Conference on Greenhouse Gas Control Technologies, Norway. http://www.futurecoalfuels.org/documents/032007_williams.pdf
- R.H. Williams. "$1 a gallon synthetic liquid fuel with near-zero GHG emissions from coal + biomass using near-term technology." Congressional Research and Development Caucus, January 27, 2005 (Figure G-2). http://www.mtclimatechange.us/ewebeditpro/items/O127F10781.pdf

Figure G-2. Fuel C content, fuel-cycle GHG emissions for a limited sample of fuels/primary energy sources

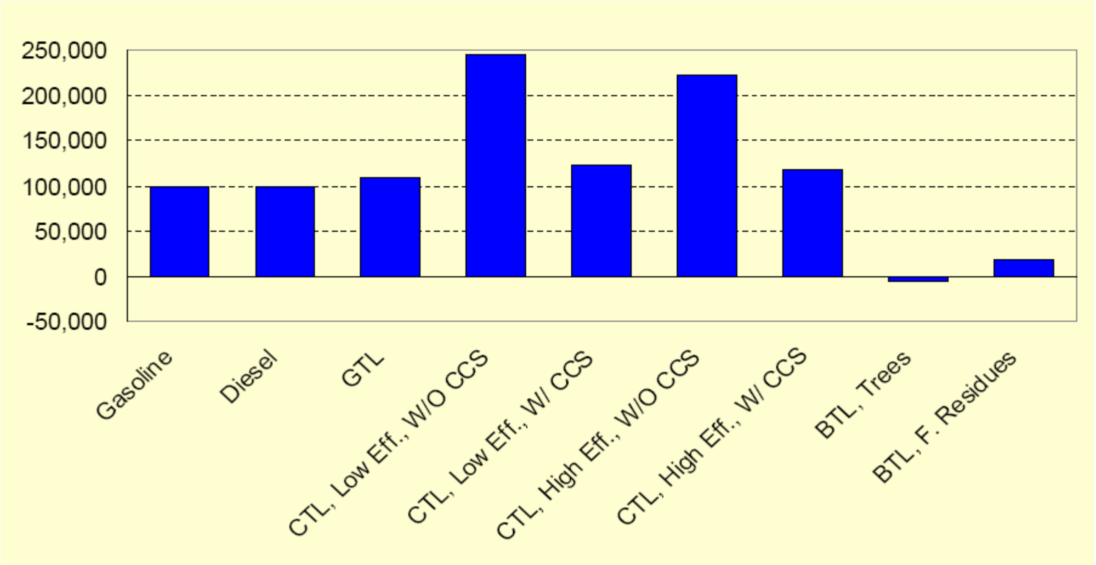


Energy Carrier	DME	Gasoline	Diesel	DME	Hydrogen	DME	DME
Primary Energy Source	Coal	Crude Oil	Crude Oil	Coal	Coal	Biomass	Biomass
CO_2 Capture and Storage?	No	No	No	Yes	Yes	No	Yes

DME = dimethyl ether.

- R.H. Williams, and E.D. Larson. 2003. A comparison of direct and indirect liquefaction technologies for making fluid fuels from coal. *Energy for Sustainable Development,* VII:102–129, http://www.princeton.edu/~energy/publications/pdf/2003/dclversussicl.pdf
- M. Wang, May Wu, and Hong Huo. 2007. “Life-Cycle Energy and Greenhouse Gas Results of Fischer-Tropsch Diesel Produced from Natural Gas, Coal, and Biomass,” Center for Transportation Research, Argonne National Laboratory, 2007 SAE Government/Industry Meeting, Washington, DC, May 14–16, 2007 (Figure G-3).

Figure G-3. GHG emissions per million Btu of fuel produced and used



Note: GHG emissions here include CO_2, CH_4, and N_2O. Numerical units of GHG emissions in grams of CO2e/mmBtu). CCS not considered for BTL in this study.

BTL = biomass-to-liquids; CCS = carbon capture and storage; CTL = coal-to-liquids.

Source: Wang et al., 2007.

A.R. Brandt, and A.E. Farrell. 2006. "Scraping the Bottom of the Barrel: CO_2 Emission Consequences of a Transition to Low-Quality and Synthetic Petroleum Resources." Forthcoming in Climatic Change. http://erg.berkeley.edu/people/faculty/Brandt_Scraping_Public.pdf

Quantification Methods: Given the large uncertainties and variation among technologies that might be employed for CTL production, quantification is limited to a broad comparison of life cycle emissions impacts. As illustrated above, researchers at the Center for Transportation Research at Argonne National Laboratory (Wang et al., using the GREET model) and Princeton University (Williams et al.) reach similar conclusions regarding the emissions impact of CTL and CCS. Table G-12 uses the results from Wang et al. (2007) since it provides a simple comparison assuming similar fuel output (diesel from CTL). Note that for the Montana GHG inventory, it was assumed that 30% of the CO_2 emissions would be captured and stored.

Table G-12. Comparison of CTL and carbon capture and storage GHG emissions

	Life Cycle Emissions Relative to Petroleum Product (Diesel)	Upstream* GHG Emissions in 2020 ($MMtCO_2e$)	GHG Emissions Reductions in 2020 ($MMtCO_2e$)
CTL production, no CCS	2.25	13.7	–
CTL production (as in high fossil fuel projection, with 30% CCS)	1.73†	7.3	–
CTL production with full CCS	1.23	2.3	5.1
No CTL production	1.0	0	7.3
CTL production with CCS, biomass co-firing, and poly-generation	1.2 to –1.3 (depending on fraction co-fired)	–	5 to 17
ES-12a goal: 20%–30% lower emissions than petroleum products	0.75 (midpoint)	–2.6	9.9

CCS = carbon capture and storage. CTL = coal-to-liquids.

* Net of emissions from diesel combustion (same in all cases).

† Unlike other figures shown here (full life cycle, multi-gas, from Wang et al., 2007 above), this estimate is based on CO_2 emissions from coal use at the CTL plant only.

Key Assumptions: See above.

ES-12b: Petroleum Refining

Data Sources: US EPA, 2007. Energy Trends in Selected Manufacturing Sectors: Opportunities and Challenges for Environmentally Preferable Energy Outcomes.[41]

Quantification Methods: US EPA (2007) estimates that energy intensity in the petroleum refinery industry could decline by 0.9% per year in an advanced energy scenario, based on US DOE's Scenarios for a Clean Energy Future study, which modeled a policy implementation

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[41] http://www.resourcesaver.org/file/toolmanager/CustomO16C45F77356.pdf

pathway via voluntary energy efficiency commitments.[42] The US EPA and US DOE studies do not estimate cost impacts for individual sectors; the overall savings across the entire U.S. economy is projected at $80 billion in 2020,+ though the US DOE study suggests overall cost savings in the industrial sector.

Key Assumptions: The 0.9% per year rate of decrease in energy use per unit output is assumed to be roughly applicable to existing and potential future refineries in Montana. It is assumed that emissions would decline with energy savings. (The US EPA 2007 study notes that "as the sector's primary energy source is refinery gas—a byproduct of the production process—there is minimal potential for a large-scale shift toward cleaner fuel inputs.")

Key Uncertainties

Confirm sufficient availability of biomass supply in state.

Additional Benefits and Costs

As with ES-5.

Feasibility Issues

None cited.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

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[42] http://www.ornl.gov/sci/eere/cef/CEFCh5.pdf

Table G-13. Opportunity assessment for the petroleum refining industry

Opportunity	Ranking	Assessment (including potential barriers)
Cleaner fuels	Low	As the sector's primary energy source is refinery gas—a byproduct of the production process—there is minimal potential for a large-scale shift toward cleaner fuel inputs.
Increased CHP	High	Though the petroleum refining industry has relatively low demand for electricity, it has the third-largest cogeneration capacity among manufacturing industries. The industry meets 30 percent of its electricity requirements with onsite power generation, most of which is cogenerated.[282] Due to the magnitude of the industry's steam requirements, cogeneration is generally a cost-effective way of meeting this demand. According to DOE analysis there is substantial potential to increase CHP capacity in the refining industry, and also to increase waste heat reduction and recovery (particularly in lower-quality steam and exit gases).[283] As mentioned previously, DOE expects that in the future, increased synthetic fuel production will be a driver of increased cogenerating capacity to the degree that onsite demand for electricity could be exceeded.[284] New CHP installations also face barriers in terms of utility rates and interconnection requirements if electricity production is expected to exceed onsite demand, and also from NSR/PSD permitting.[285]
Equipment retrofit/ replacement	Medium	For capital-intensive industries, CEF predicts that the largest energy efficiency gains will come from replacement of old equipment with state-of-the-art equipment.[286] Opportunities lie with furnaces, heat exchange equipment (replacement with helical, vertical heat exchangers), sensors and controls, equipment used in separation processes, and containment vessels.[287] Continuous reforming technology improves the efficiency of transportation fuel refining; Digital Equipment Condition Monitoring is a process control technology that allows the system to operate closer to maximum efficiency. Retrofits can also reduce energy losses from steam systems (pipes, traps, and valves). API cites cost and regulatory barriers to energy efficiency improvement, noting "energy efficiency is not usually a business driver and is difficult to justify as an investment when capital recovery is too long."[288] To avoid NSR, refineries may find it easier to retrofit existing equipment as opposed to installing the latest energy-efficient technologies.
Process improvement	Medium	The most energy-intensive processes in petroleum refining include distillation (atmospheric and vacuum), hydrotreating, alkylation, and reforming.[289] Energy losses can be reduced through implementation of energy management best practices, minimization of energy-intensive processes such as distillation, process optimization to reduce downtime and maintenance requirements, and replacement of solid phase catalysts with ionic liquids.[290] API has the objective of increasing usage of less energy-intensive biological processes, including bioprocessing of crude, biotreatment of wastewater, and bioremediation of soil and groundwater contamination. API cites uncertainties about future product requirements as inhibiting some process-related changes. There is uncertainty about future performance-related requirements on the part of consumers, as well as uncertainty about future regulatory requirements.[291]
R&D	Medium	API notes the following R&D focus areas: replacements for existing separation processes, improved process yields through development of more selective catalysts, development of better pathways for hydrocarbon conversion, and bioprocessing.[292] Promising technologies are currently in development, such as membrane separation technologies that increase the efficiency of distillation units by 20 percent. Under Climate VISION, the R&D Challenge focuses on technologies that reduce/sequester carbon emissions.[293] The industry has developed mission statements and roadmaps for crucial R&D priority efforts as part of its efforts with DOE/IOF; see http://www.eere.energy.gov/industry/petroleum_refining/. With the elimination of most of the nation's small, inefficient refineries and expansion of remaining, larger, more efficient refineries, refining margins have improved in 2004 and 2005. The industry's strengthened financial position may help attract capital necessary for R&D and other large-scale improvements. API notes the following factors that inhibit the development of new energy-saving technologies and processes in the petroleum refining industry: a number of technical barriers (intrinsic process inefficiency, lack of understanding about mechanisms leading to fouling, inadequate sensing and measuring techniques, inadequate process models), regulatory requirements, costs and risks associated with developing new technology, and a lack of long-term commitment to fundamental research.[294]

ES-13. CO_2 Capture and Storage or Reuse (CCSR) in Oil & Gas Operations, Including Refineries and Coal-to-Liquids Operations

Note: Due to overlaps with other options, CCSR is now considered within ES-5 and ES-12 and is no longer considered separately.

Attachment A: Survey of Carbon Tax Programs

Jurisdiction	Status: Start Date	Tax Rate–Applicability	Where Tax Applied	Use of Revenue
Finland[1]	1990 Revised 1997 Revised 2002	1990 \$1.54 per ton 1993 \$3.00 per ton 1997–1998 Electricity: \$0.007 per kWh Heating: \$22.53 per ton CO_2 Natural gas: \$11.26 per ton CO_2	1990 Fuels 1997 Electricity consumption not fuels reduced for industry Exemption for international aviation, shipping, and refineries	Reimbursement via lower payroll taxes
Norway[2]	1991 Revised 1999	Petrol: \$55.90 per ton CO_2 Mineral Oil: \$30.16 per ton CO_2 Oil and gas in North Sea: \$52.05 per ton CO_2	Producers and importers of oil products Exemption for foreign shipping, fishing, external aviation	Reduce other taxes
Sweden[3]	1991 Revised 2004	CO_2: \$100 per ton 2004 increases: Gasoline: \$0.02 per L Diesel: \$0.04 per L Vehicle Tax Electricity: \$0.002 per kWh (excludes industry)	Oil, coal, natural gas, liquefied petroleum gas, petrol, and domestic aviation fuel Reduced industrial rate Exemption for high-energy industries, i.e., horticulture, mining, manufacturing, and pulp/paper industry	Offset by income tax relief Est. revenue \$523 million
Denmark[4]	1992 Revised 1999	Commercial \$14.30 per ton CO_2 Households \$7.15 per ton CO_2	Buildings	Reallocated as subsidies for energy efficiency activities and voluntary agreements

Jurisdiction	Status: Start Date	Tax Rate–Applicability	Where Tax Applied	Use of Revenue
Germany[5]	1999 Revised 2000	1999 Gasoline: $0.04 per L Heating fuel: $0.03 per L Natural gas:$0.02 per kWh Electricity: $0.01 per kWh 2000-2003 annual increases Gasoline: $0.04 per L Electricity: $0.003 per kWh	Electricity, heating fuel, natural gas, gasoline	Tax breaks for commuters; Reduce labor costs via pension contributions
Japan[6]	2001	Green taxation Subsidies for high efficiency automobiles	Vehicles	
UK	2001-	Electricity: $0.0084 per kWh Coal and Natural gas: $0.0029 per kWh Levy will rise with inflation annually beginning in 2007	Electricity generation includes nuclear Renewable exempt	Reduced National Insurance rate Fund for energy efficiency initiatives
Netherlands	2005	Fossil electricity: $0.08 per kWh for small consumers Renewable exemption: $0.04 per kWh Rates indexed to inflation.	Electricity and fuel consumption. Renewable sources with green certificate exempt.	Reduced income and corporate tax rates
City of Boulder, CO	Approved 2006 Start 2007 Expiration 2013	Electricity: (kWh) $.0022 for residential $0.0004 for commercial $0.0002 for industrial use Max increases: $0.0049 for residential $0.0009 for commercial $0.0003 for industrial use	Electricity use	Funding for city's Climate Action Plan: Programs to increase energy efficiency, renewable energy use, reduce motor vehicle emissions, and take further steps to meeting Kyoto protocol targets

Jurisdiction	Status: Start Date	Tax Rate–Applicability	Where Tax Applied	Use of Revenue
Australia: State of West Australia[7]	Under current consideration	\$19.58 per ton CO_2		
Canada: Province of Quebec[8]	2006	To be determined by Quebec Energy Board \$1 billion est. 6-year revenue	Non-renewable fossil fuels sold in bulk to retailers	Green Fund: Public transportation, energy efficiency for buildings

[1] http://www.norden.org/pub/ebook/2001-566.pdf;

[2] http://ideas.repec.org/p/ssb/dispap/337.html

[3] http://pubs.acs.org/hotartcl/est/98/dec/hanish.html

[4] http://www.iea.org/Textbase/pm/?mode=cc&id=156&action=detail

[5] http://www.iea.org/textbase/publications/free_new_Desc.asp?PUBS_ID=1097

[6] http://www.iea.org/textbase/nppdf/free/2000/japan2003.pdf

[7] http://www.news.com.au/story/0,23599,21171914-2,00.html

[8] http://www.cbc.ca/news/background/kyoto/carbon-tax.html

Appendix H
Transportation and Land Use Policy Recommendations

Summary List of Policy Option Recommendations

	Policy Options	GHG Reductions ($MMtCO_2e$)			Net Present Value 2006–2020 (Million $)	Cost-Effectiveness ($/$tCO_2e$)	Level of Support
		2010	2020	Total 2007–2020			
TLU-1	Light-Duty Vehicle Clean Car Standards	0.00	0.95	4.92	–$492	–$100	UC
TLU-2	Fuel Efficient Replacement Tires Program	0.00	0.03	0.14	–$86	–$90	UC
TLU-3	Consumer Information on Vehicle Miles Per Gallon (MPG)	*Included in TLU–1 and TLU–2*					UC
TLU-4	Financial and Market Incentives for Low GHG Vehicle Ownership and Use	*Included in TLU–1*					UC
TLU-5	Growth and Development Bundle	0.00	0.14	0.77	<$0	<$0	UC
TLU-6	Low Carbon Fuels	0.00	0.04	0.39	N/A	N/A	UC
TLU-7	Heavy-Duty Vehicle Emissions Standards and Retrofit Incentives	0.00	0.02	0.16	+$12.8	+$79	UC
TLU-8	Heavy-Duty Vehicle and Locomotive Idle Reduction	0.01	0.02	0.13	–$5.6	–$44	UC
TLU-9	Procurement of Efficient Fleet Vehicles	*Included in TLU-1, TLU-6 through TLU-8, and TLU–11*					UC
TLU-10	Transportation System Management	*Not quantified*					UC
TLU-11	Intermodal Freight Transportation	0.02	0.09	0.59	N/A	N/A	UC
TLU-12	Off-Road Engines and Vehicles GHG Emissions Reductions	*Not quantified*					UC
TLU-13	Reduced GHG Emissions from Aviation	*Not quantified*					UC
	Sector Total Before Adjusting For Overlaps	0.03	1.29	7.10	–$570	–$89	UC
	Sector Total After Adjusting For Overlaps	0.02	0.96	6.1	–$321	–$93	UC

$MMtCO_2e$ = million metric tons of carbon dioxide equivalents; GHG = greenhouse gas; N/A = not applicable.

TLU-1. Light-Duty Vehicle Clean Car Standards

Policy Description

Adopt the State Clean Car Program (also known as the “Pavley” standards or California GHG Emission Standards) in order to reduce greenhouse gas (GHG) emissions from new light-duty vehicles (LDVs). The standards, which must still be approved by the United States Environmental Protection Agency (US EPA), would take effect in model year 2011 (calendar year 2010). Other Clean Car Program elements include standards requiring reductions in smog- and soot-forming pollutants and promoting introduction of very low-emitting technologies into new vehicles.

New cars and light trucks in all states must comply with federal emission standards and, generally speaking, states have the choice of adopting a stronger set of standards applicable in California. In 2005, California finalized a set of standards that would require reductions of GHG emissions of about 30% from new vehicles, phased in from 2009 to 2016, through a variety of means. Eleven states have already adopted the California Clean Car Program standards: California, Connecticut, Maine, Massachusetts, New Jersey, New York, Oregon, Pennsylvania, Rhode Island, Vermont, and Washington.

Policy Design

This policy design is focused on achieving high levels of efficiency by requiring vehicles sold in Montana to meet higher levels of efficiency than is required nationally. This policy recognizes that Montana by itself would not have influence in setting standards, but by joining efforts of other states would ensure that efficient vehicles are sold in Montana, and that less efficient vehicles that could no longer be sold in other states are not sent to Montana because of lower standards there.

Goal Levels: Go beyond the federal emissions standards for cars and light trucks within the parameters of the California standards. (Note: States can choose between the federal standard or go with the more stringent California standards, in which Montana would need a bidding process or public involvement before or during legislative or regulatory process for transparency.)

Timing: A regulatory program could begin with vehicle model year 2011. To meet federal compliance, a rule-writing process would take place by the appropriate agencies so that Montana can implement the California standards.

Parties Involved: Applies to model year 2011 new cars and light trucks. The law would directly affect automobile manufacturers, car dealers, and consumers. Compliance concerns would affect manufacturers and dealers.

Other: The California standards currently are being litigated and have not been approved by the EPA. Timing will be affected by the date of enactment of legislation, likely litigation, and the regulatory process.

Implementation Mechanisms

Regulatory Program: Institute a regulatory program beginning with vehicle model year 2011.

Related Policies/Programs in Place

None.

Estimated GHG Savings and Cost Per Ton

Light-Duty Vehicle Clean Car Standard	2010	2020	Units
GHG emission savings	0.00	0.95	$MMtCO_2e$
Net present value (2006–2020)	N/A	–$492	$ Million
Cumulative emissions reductions (2006–2020)	0.00	4.92	$MMtCO_2e$
Cost-effectiveness	N/A	–$100	$\$/MtCO_2e$

N/A = not applicable.

Data Sources:

- Center for Climate Strategies (CCS), Draft Montana Greenhouse Gas Inventory and Reference Case Projections.
- Diane Brown and Elizabeth Ridlington, “Cars and Global Warming: Policy Options to Reduce Arizona’s Global Warming Pollution from Cars and Light Trucks,” AZ Public Interest Research Group (PIRG) Education Fund: February 2006, http://www.arizonapirg.org/AZ.asp?id2=22371
- Elizabeth Ridlington, Tony Dutzik, and Christopher Phelps, “Cars and Global Warming: Policy Options to Reduce Connecticut’s Global Warming Pollution from Cars and Light Trucks,” Spring 2005.

Quantification Methods:

- CCS compared results from New England states, California, and a National PIRG model obtained using comparable modeling methods. CCS found that while all three modeling efforts were valid, reasonable, and comparable, some of the PIRG model assumptions and methods were relatively conservative, while the California and New England modeling results were relatively optimistic. CCS further refined the PIRG model results consistent with a middle range scenario that produced results less conservative than the PIRG results and less optimistic than those from California and New England.
- While PIRG projected a 13.7% reduction in LDV emissions with this policy for Arizona, a CCS refinement estimated a 15.5% reduction. CCS applied this same refined percentage reduction in emissions to the reference case for Montana. A linear ramp-up period is also assumed, reaching 100% of the 15.5% reduction by year 2020.

Key Assumptions:

The three modeling efforts have established a valid and reasonable method of projecting GHG emissions reductions from this policy. The CCS comparison of the three modeling methods provides some independent professional validation of the models and their results. The key assumption projected by CCS is that the most likely scenario for emissions reductions would fall between the more conservative scenario projected by the PIRG model and the more optimistic scenario projected by the California and New England models.

Key Uncertainties

Fleet turnover rates for light-duty vehicles and future patterns of consumer purchase choices between passenger cars and light-duty trucks, e.g., sport utility vehicles (SUVs).

Additional Benefits and Costs

None identified.

Feasibility Issues

Possible vehicle registration leakage (e.g., people might go to Idaho to purchase their vehicles to avoid these standards).

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None identified.

TLU-2. Fuel Efficient Replacement Tires Program

Policy Description

Improve the fuel economy of the LDV fleet by setting minimum energy efficiency standards for replacement tires and requiring that greater information about low-rolling resistance (LRR) replacement tires, including all season/all weather LRR tires, be made available to consumers at the point of sale. Snow and mud LRR tires are currently available, and tire manufacturers, such as Michelin, are currently researching and developing fuel efficient all weather replacement tires.

Vehicle manufacturers currently use LRR tires on new vehicles, but they are not easily available to consumers as replacement tires. When installing original equipment tires, carmakers use LRR tires to meet federal corporate automobile fuel economy standards (CAFE). When replacing the original equipment tires, consumers often purchase less fuel-efficient tires and potentially more costly tires (depending on annual vehicle miles traveled [VMT]). Currently, tire manufacturers and retailers are not required to provide information about the fuel efficiency of replacement tires.

An appropriate state agency would initiate a fuel efficient tire replacement program. The program would include consumer education, product labeling, and minimum standards elements.

These programs would be developed under a rule development process. All programs would incorporate the best scientific information, including the test results of tires conducted by the tire manufacturers, the California Energy Commission, and the National Academy of Sciences.

Policy Design

This policy is designed to encourage consumer choice and example by state government.

Goal Levels: Establish voluntary energy efficiency standards that achieve an average 4.5% gain in fuel economy.

Timing: By 2009, the state or appropriate agency would initiate a fuel efficient tire replacement program for the state fleet if all season/all weather tires are available and are incorporated into legislatively approved rental rates, establish voluntary energy efficiency standards for replacement tires, and develop a marketing program for fuel efficient replacement tires.

By 2011, the state or appropriate agency would ensure that a proportion of tires replaced on state-owned and -leased vehicles will be LRR tires (if they are available for the vehicle type and are rated for all season/all weather service) and would establish legislation to set LRR standards for tires with mandatory manufacture labeling.

Parties Involved: Montana Department of Environmental Quality (MDEQ), Montana Department of Transportation (MDT), LRR manufacturers, tire distributors, Montana University System.

Implementation Mechanisms

The program would include consideration of the technical feasibility and cost of such a program, the relationship between tire fuel efficiency and tire safety, potential effects on tire life, and impacts on the potential for tire recycling. In addition, the program would exempt certain classes of tires that sell in low volumes, including specialty and high-performance tires.

The minimum standard is likely to be less stringent than the energy efficiency of original tires provided by the automobile manufacturers on new purchase vehicles. Such a regulation would improve the fuel efficiency of the overall LDV fleet but not necessarily the fuel efficiency of all tires since consumers would still make choices in the marketplace. The replacement tires in the future would be, on average, more fuel efficient than those historically purchased but are likely to be, on average, not as fuel efficient as the tires included as original equipment by the automobile manufacturers.

Information and Education: Provide information to general public and commercial businesses (i.e., taxi and food delivery services) that use light-duty vehicles for daily business that the improved fuel efficiency is directly related to decreased rolling resistance. Information on the potential annual costs savings using LRR tires would also be provided. For example, a car averaging 15,000 miles per year would have fuel savings of over $80 (at $2.25 per gallon). A chart of recommended tire models would be included with information on product labeling and minimum standards elements. Best scientific information including the results from tests of tires conducted by the tire manufacturers, the California Energy Commission, and the National Academy of Sciences would be reviewed and incorporated.

The manufacturers of the LRR tires would be contacted to encourage promotion of their relevant products through regional newspaper and television advertising. The producers of LRRs may freely provide promotional materials.

Promotion and Marketing:

- **State Lead by Example—**The state will lead by example by initiating a fuel efficient tire replacement program. This would include all weather fuel efficient tires and would require legislative approval for rental rates for vehicles, both owned and leased.

  Over time, all state fleet tires in need of replacement will be changed to LRR tires, if available for the vehicle type and season.

Voluntary LRR Standards: Establish voluntary LRR standards that achieve an average 4.5% gain in fuel economy.

Encourage Procurement of LRR Tires:

- Encourage local/county governments to act consistently with and support state procurement on their behalf.
- Encourage federal agencies located within the state to act accordingly with and support state actions.
- Encourage businesses that depend on vehicles to conduct daily business to act accordingly with and support state actions.

Marketing Program: Develop a marketing program with tire dealers and consumers to encourage the purchase of LRR tires. This effort might include a voluntary labeling program for tire fuel efficiency.

University Research: Encourage the Montana University System to conduct research on alternative noncombustible applications for used tires.

Web Site: All state-supported programs would have dedicated detailed Web sites. In addition to information and materials, program participation by the various governmental agencies and individual businesses (i.e., success stories) would also be documented and extolled.

Technical Assistance: Contact the LRR manufacturers and tire distributors to coordinate objectives and obtain technical support for outreach materials.

Funding Mechanisms and/or Incentives: Replacement of tires on state fleet vehicles is already budgeted through the MDT annual funding processes.

Voluntary and or Negotiated Agreements: Work with the manufactures and affected parties to achieve objectives with flexibility of the timelines.

Codes and Standards: The State of California has developed substantial information pertaining to LRR tires because of legislative actions that require tires to be replaced with more efficient ones. Associated documentation identifies testing methods and LRR standards. The appropriate state agency can review the information and establish suitable Montana standards.

Pilots and Demonstrations: Coordinate with product developers to help them promote their technologies.

Reporting: The state will develop a system for tracking purposes so that the state can eventually determine the turnover to LRR tires and the benefits achieved from the conversion. A simple tracking system could be established relatively easily by contacting the primary tire distributors of the major Montana cities on an annual basis, and estimates could be gathered from their inventories.

Enforcement: No enforcement actions are necessary initially since this is a voluntary program. After the mandatory labeling is in effect, spot checks at the primary tire distributors in the main Montana cities would be annually conducted by the county health departments and the state staffs.

Related Policies/Programs in Place

In October 2003, the State of California adopted the world’s first fuel-efficient replacement tire law (AB 844). This law directed the California Energy Commission to develop a State Efficient Tire Program that includes the following issues: a) develop a consumer education program, b) require that retailers provide labeling information to consumers at the point of sale, and c) promulgate through a rule development process a minimum standard for the fuel efficiency of replacement tires sold. The California rule development process began in January 2007.

Although the climate in California is significantly more moderate than that in Montana, all season/all weather LRR tires may be made available. Michelin tire manufacturers are currently researching and developing all-weather tires.

Estimated GHG Savings and Cost Per Ton

Assuming 5% market penetration with an increase to 10% at Year 2020:

Fuel Efficient Tire Replacement	2010	2020	Units
GHG emission savings	0.00	0.03	$MMtCO_2e$
Net present value (2006–2020)	N/A	–$86	$ Million
Cumulative reductions (2006–2020)	0.00	0.14	$MMtCO_2e$
Cost-effectiveness	N/A	–$90	$/MtCO₂e

N/A = not applicable; $MMtCO_2e$ = million metric tons of carbon dioxide equivalents.

Data Sources:

- Tires and Passenger Vehicle Fuel Economy, Transportation Research Board/National Research Council (NRC), 2006.
- California State Fuel-Efficient Tire Report, California Energy Commission, January 2003.

Quantification Methods:

CCS evaluated and compared a series of existing assessments, as follows:

At the request of the United States Congress, the National Research Council of the National Academy of Sciences (NRC/NAS) conducted a study of the feasibility of reducing rolling resistance in replacement tires. The 2006 NRC/NAS study made the following conclusions:

- “Reducing the average rolling resistance of replacement tires by a magnitude of 10% is technically and economically feasible.
- Tires and their rolling resistance characteristics can have a meaningful effect on vehicle fuel economy and consumption.”

A 2003 study commissioned by the California Energy Commission found that about 300 million gallons of gasoline per year can be saved in that state with LRTs. A set of four LRTs would cost consumers an estimated $5 to $12 more than conventional replacement tires. The fuel-efficient tires would reduce gasoline consumption by 1.5% to 4.5%, saving the typical driver $50 to $150 over the 50,000-mile life of the tires. Consumers would save more than $470 million annually at current retail prices or approximately $1.4 billion over the 3-year lifetime of a typical set of replacement tires.

CCS estimated the reduction in GHG emission from this policy using the Montana Greenhouse Gas Inventory and Reference Case Projections as a baseline and using an emission reduction factor of 4.5% (the upper end of the range of reported fuel conservation due to LRR replacement tires).

Key Assumptions:

The estimate of costs associated with LRR replacement tires accounts for faster tire wear (assuming that tires have lower tread) and an increase in the cost of production that is passed through to consumers. According to the NRC/NAS study, consumers would pay an additional

$12.00 per year to replace tires (including installation), and they would pay an additional $1.00 per tire because of increased production costs.

Key Uncertainties

The LRR fuel efficient tires program is based on off-the-shelf technologies and products that already exist in the consumer marketplace. These tires are already available in the marketplace, and are comparable with the tires included as original equipment on newly purchase LDVs.

Additional Benefits and Costs

Reductions in criteria air pollutants.

Feasibility Issues

None identified.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None identified.

TLU-3. Consumer Information on Vehicle Miles Per Gallon (MPG)

Policy Description

Provide consumers with information about the fuel efficiency and cost in relation to the purchase, maintenance, and operation of their vehicles. Consumers would receive real-time information on MPG while their vehicles are in operation and alerts when their tire pressure is too low (i.e., devices such as Air Alert Valve Caps). Generally, a set of four light-emitting diode (LED) self-calibrating tire pressure valve caps such as Tire Alert cost about $22.00, and real time MPG monitoring systems such as ScanGauge are about $100.00. In addition, consumers would receive public education and information relating to the impact that vehicle maintenance practices have on the operation of their vehicles. Finally, consumers would be encouraged to consider a vehicle's MPG before and at the time of purchase of their vehicles.

Policy Design

This policy is designed to impact consumer choice and behavior.

Goals: Greatly increase the awareness and availability of consumer information on MPG to result in greater fuel efficiency across the state.

Timing: Program would begin in 2008, with program expansion as resources are made available.

Parties Involved: MDEQ, MDT, Montana Motor Vehicle Division, product manufacturers, product distributors, Montana University System.

Implementation Mechanisms

Information and Education: The manufacturers of such energy-saving technologies would be contacted to encourage promotion of their relevant products through regional newspaper and television advertising in addition to working with potential distributors (auto shops, car dealerships, electronic stores) to provide information about the products. In addition to these technologies, vehicle maintenance and operations that have effects on the fuel efficiency of private vehicles can be implemented in driver education courses.

Promotion and Marketing:

- Establish consumer information for both add-on technologies and original equipment that provide real-time MPG information, tire pressure valves, and early and late engine check warnings lights.
- Encourage local and county governments to act consistently with and support state procurement on their behalf.
- Encourage federal agencies located within the state to act accordingly with and support state actions.
- Encourage businesses that depend on vehicles to conduct daily business to act accordingly with and support state actions.

- Develop a marketing program with vehicle and product manufacturers and consumers to encourage the purchase of energy saving technologies. This effort might include a voluntary labeling program for “green purchases.”

State Lead by Example:

- The state will lead by example by initiating a consumer information program for energy efficient driving practices and devices for all state vehicles, both owned and leased.
- Encourage the Montana University System to conduct research on energy saving technologies and their effects on changing consumer behavior.
- MDT will use its Web site to post consumer-friendly information or links to information on fuel efficiency in relation to the purchase, maintenance, and operations of vehicles.
- All state-supported programs would have dedicated detailed Web sites. In addition to information and materials, program participation by the various governmental agencies and individual businesses (i.e., success stories) would also be documented and extolled.

Technical Assistance: Contact the product manufacturers and distributors to coordinate objectives and obtain technical support for outreach materials.

Voluntary and or Negotiated Agreements: Work with the manufacturers and affected parties to achieve objectives with flexibility of the timelines.

Codes and Standards: The appropriate state agency can review the technical and feasibility information and establish suitable Montana standards.

Pilots and Demonstrations: Coordinate with product developers to help them promote their technologies on the shelf and on the Internet.

Reporting: The state will develop a tracking system so it can eventually determine the effects of the consumer information program on consumer choices and driving behavior as well as its benefits. A simple tracking system could be established relatively easily by contacting the primary vehicle dealerships and auto shops of the major Montana cities on an annual basis, and estimates could be gathered from their inventories.

Enforcement: No enforcement actions are necessary initially since this is a voluntary program.

Related Policies/Programs in Place

None.

Estimated GHG Savings and Cost Per Ton

Consumer Information on Vehicle MPG	2010	2020	Units
GHG emission savings	Included in TLU-1 and TLU-2	Included in TLU-1 and TLU-2	$MMtCO_2e$
Net present value (2006–2020)			$ Million
Cumulative emissions reductions (2006–2020)			$MMtCO_2e$
Cost-effectiveness			$\$/MtCO_2e$

$MMtCO_2e$ = million metric tons of carbon dioxide equivalents

Key Uncertainties

None identified.

Additional Benefits and Costs

None identified.

Feasibility Issues

None identified.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None identified.

TLU-4. Financial and Market Incentives for Low GHG Vehicle Ownership and Use

Policy Description

The three components studied and developed under this option would create financial incentives for the purchase and operation of vehicles that emit lower levels of GHGs.

Policy Design

The Climate Change Advisory Committee (CCAC) recommends that Montana further study and develop policy options that create incentives and disincentives for the purchase and operation of vehicles with varying fuel economy. The following are some of the policies to be studied and developed:

1. *Feebates.* A multistate "feebate" program, including the neighboring western states of Arizona, California, and New Mexico. Feebate proposals usually have two parts: 1) a fee on relatively high emissions/lower fuel economy vehicles and 2) a rebate or tax credit on low emissions/higher fuel economy vehicles. Legislation will be needed for this policy option.

2. *Excise Taxes.* A change in new vehicle excise tax that would increase taxes for relatively high-emitting vehicles and reduce taxes for relatively low-emitting vehicles. Overall, excise tax revenue would remain the same.

3. *Labeling.* A consumer labeling program that provides buyers with better information on the GHG emissions of new vehicles.

Together, these incentives could change the vehicle fleet technology mix through a combination of demand- and supply-side changes.

Goal Levels: Prepare a detailed study of options and impacts.

Timing: Complete in 2010.

Parties Involved: Industry, MDEQ, and Montana Department of Revenue.

Implementation Mechanisms

There is an important need for a greater understanding of the potential effects of single-state or multistate feebate programs on the types of vehicles that manufacturers put into the marketplace. Existing analysis shows that 90% of the benefits of feebate programs are likely to arise from the manufacturing (supply side) response rather than the consumer (demand side) response. Because individual states such as Montana have a small share of the national new vehicle market and thus are unlikely to have a significant influence on the supply side by themselves, states in the southwest have been exploring coordinated multistate programs. A consistent set of feebate programs across multiple states may include a large enough share of the U.S. market to have a more significant effect on supply side decisions made by automobile manufacturers.

With that in mind, incentives and disincentives that should be studied and developed include the following:

- **Feebates.** A “Multistate LDV GHG Fee and Rebate Study and Pilot Program” would consider the expected impacts of individual state feebate programs as well as coordinated or consistent multistate programs. Ideally, such a multistate study would include a number of western states in order to assess boundary issues and coordination issues. Initial analysis suggests that the Montana new car market may be too small to have an effect on the types of vehicles that manufacturers put into the marketplace. A consistent set of feebate programs across multiple states may include a large enough share of the U.S. market to have a more significant effect on automobile manufacturers’ supply-side decisions. The study would also identify and assess the actual benefits and costs of a pilot feebate program implemented at the county or metropolitan level in the western United States.

  Economic analyses of these proposals have found that feebate programs would work on two levels. First, the feebates would directly affect consumer choices for vehicle purchases because of financial incentives. Second, the feebates could indirectly affect the types of vehicles that automobile manufacturers choose to put into the marketplace.

- **Excise Taxes.** Examine options similar to Bill 2438 in the 2005 Massachusetts Legislature which directs the Secretary of Taxation and Revenue to set a variable excise tax on new passenger vehicles ranging from 0% to 10%, based on the vehicle’s CO_2 emission rate. The tax would be lowest on the lowest emitting vehicles and highest on the highest emitting vehicles, subject to certain guidelines and constrained by maintaining the current average excise tax of 3% (an annual adjustment of the schedule of taxes would maintain this average). One option would be to link the excise tax structure so that it is set at zero for vehicles that comply with the European Union GHG standards.[1] New Mexico currently has a zero excise tax for hybrid cars.
- **Consumer Labeling.** Examine options similar to an EU program begun in 2001, and a recent proposal by a researcher at Resources for the Future.[2] It would require dealers to place a GHG label on each new vehicle that includes the estimated amount of CO_2 (in pounds) produced annually and places the vehicle into one of five distinct groupings from “best” to “worst.”

Type(s) of GHG Benefit(s)

Reduction in all GHG exhaust emissions through reduced fuel consumption.

Related Policies/Programs in Place

While feebate proposals have been described in academic studies, there has been no implementation of a full feebate program in the United States. While there are individual “gas

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[1] For a discussion of EU standards, see *Pew Center*, “Comparison of Passenger Vehicle Fuel Economy & GHG Emission Standards Around the World,” 12/04, http://www.pewclimate.org/global-warming-in-depth/all_reports/fuel_economy, pp. 11–12.

[2] http://www.rff.org/rff/News/Features/Combating-Global-Warming-One-Car-at-a-Time.cfm

guzzler" taxes and tax incentives for hybrid vehicle purchases, there is not yet any history of an on-the-ground example of a comprehensively implemented feebate program.

States such as Arizona, California, and New Mexico, however, are joining together to form a multistate feebate program.

Estimated GHG Savings and Cost Per Ton

Included in the estimation for TLU-1. Not estimated for this policy option separately from the GHG emissions reductions estimated for TLU-1. Following the study called for under this option, the state could develop quantifiable options that are specific to the policies described in this option.

Data Sources, Methods, and Assumptions

CCS conducted a review of the most relevant research and analysis on feebate proposals. CCS made three findings:

1. There has been significant conceptual development of the feebate idea, especially at the national level;
2. There is a need for a greater understanding of potential benefits and costs of state level and multistate coordinated feebate programs; and
3. There has not been sufficient pilot testing of feebate programs in the United States to provide implementation experience.

CCS assessed recent studies of potential GHG emission reductions from a national feebate program based on modeling work conducted by the U.S. Department of Energy's Oak Ridge National Laboratory (US DOE's ORNL). CCS also reviewed other relevant recent studies and analyses of feebates conducted by the Canadian government, the State of California, and PIRG. The ORNL study and other studies assume a national feebate rate high enough to produce responses from both consumers and manufacturers. ORNL's estimate of the national potential for reduction in carbon dioxide emissions is approximately 11 million metric tons of carbon dioxide equivalents (MMtCO$_2$e) in 2010 and 66 MMtCO$_2$e in 2020.

Some attempts have recently been made to estimate the GHG emissions reduction potential from individual state feebate programs, including programs proposed for the states of Arizona and California. For example, a recent PIRG analysis suggests that a single-state feebate program for Arizona would result in an estimated 0.1 MMtCO$_2$e GHG emissions reductions in 2020. These recent estimates of the potential impacts of individual state programs are contingent upon assumptions and analytical methods that have not undergone thorough peer review. Therefore, the results of these analyses are preliminary and should be interpreted with some caution. Further analysis and study of the potential benefits and costs of individual state and multistate feebate programs would greatly increase confidence in projected results.

Key Uncertainties

Both the US DOE and the Canadian Transport Ministry have studied the potential impacts of national-level feebate programs in recent years. While these studies have informed the debate about the advantages and disadvantages of national feebate programs, there remains considerable uncertainty about the potential benefits and costs of state- or multistate-level feebate programs. There is an important need for a greater understanding of the potential effects of single-state or multistate feebate programs on the types of vehicles that manufacturers put into the marketplace.

Additional Benefits and Costs

None identified.

Feasibility Issues

Requires multistate cooperation.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None identified.

TLU-5. Growth and Development Bundle

Policy Description

This bundle of options encompasses several components intended to reduce GHG emissions through promotion of multimodal transit options and land use practices and policies. These policies contribute to GHG emissions reductions by reducing vehicle trips and VMT.

Potential actions include the following programs and program elements:

1. Infill, densification, and brownfield redevelopment;
2. Mixed-use and transit-oriented development;
3. Smart growth planning, modeling, and tools;
4. Targeted open space protection;
5. Expanded transit infrastructure and service; and
6. Expanded transportation choices.

In general, neighborhood center development and redevelopment options are recommended to reduce VMT resulting from inefficient development patterns and locations. Smart Growth principles should be implemented to manage the location, density, development pattern, infrastructure, and basic human needs of new growth. Options for achieving these principles include:

- Directed Growth—Enable local governments to direct growth to locations that will be most cost-effective to serve and result in lower VMT. This goal can be achieved through a combination of education, partnerships, funding programs, and policy changes at state and local levels.
- Market Incentives—Create market incentives to encourage voluntary adherence to Smart Growth principles. Collaboration between the state and private lending institutions would be required to identify and implement lending policies that create incentives for Smart Growth developments.
- Alternative Revenue Sources—Reduce local governments' reliance on property tax to fund public capital improvements, and operating and maintenance needs, thus eliminating the incentive to expand the jurisdictions' property tax base (sprawl). Provide alternative funding sources to schools and local governments.

Policy Design

Goal Levels: Implement a package of policies and incentives, such as the implementation mechanisms identified below, that will significantly reduce urban VMT below the 2020 baseline. The scientific research literature indicates that VMT reductions of 3% to 11% are possible in urban areas as a result of implementing the recommendations set forth below. How aggressively the package of policies and incentives is implemented will determine the precise extent of the reduction. For this policy option, the CCAC established an urban VMT reduction target, measured against the 2020 baseline, of between 3% and 11%, preferably at the higher end of this range.

Timing:

- State policy changes should be promoted during the 2009 legislative session, but the building of a widespread coalition to provide the necessary political will should begin immediately.
- Actions that do not require legislative changes or securing new funding sources should begin within 3 months after the adoption of this policy.

Parties Involved: MDT, Governor's Office, Montana Association of Counties, Department of Commerce, League of Cities and Towns, Montana Smart Growth Coalition, EPA Smart Growth Division.

Implementation Mechanisms

Access Management and Cooperative Planning

MDT will continue to strengthen its access management program, including the development of corridor access management plans that proactively seek to ensure that the capacity of the existing corridor to transport people and goods is not impaired. The order of priority for this planning should focus on urban and suburban highways in and near Montana's fastest growing areas.

- The state will encourage local governments to use arterial access management as a tool to manage growth while maximizing transportation system performance and safety. This will involve mechanisms to better link local access management policies to land use plans.
- MDT will continue and expand cooperative transportation planning efforts in Montana's communities, in part to help cities and counties develop 20-year multimodal transportation plans that are coordinated with local land use plans.
- MDT will work with local governments to encourage smart growth principles in transportation and land-use planning and ensure multimodal transportation solutions that are consistent with community goals.
- MDT will develop a Smart Growth transportation planning tool kit for local government's use to support multimodal transportation networks.
- MDT will substantially increase, from present levels, the percentage of Surface Transportation Program (STP) discretionary funds that are used for the purpose of creating effective multimodal transportation networks in and around existing cities and towns.
- MDEQ and the Montana Department of Natural Resources and Conservation (DNRC) will initiate a rule-making that examines the agencies' water quality and quantity rules and regulations that relate to land use development. In undertaking this review, the agencies will consider the effect their rules and regulations will have on facilitating the sprawl and will take into account the cumulative impact of the new development on Montana's surface and ground waters.

Directed Growth

- Fund a state-level Community Technical Assistance Program to provide Smart Growth model codes that create location-efficient communities designed to encourage the use of nonmotorized transportation and public transit. The Program would also compile and distribute information on Smart Growth design standards and funding sources.
- Require all elementary schools to be located on sites with good pedestrian and bicycle access.
- Require all state government work centers to be located in the central business district (CBD) or other established core business area of municipalities or, if this is not possible, in a suburban location with good pedestrian and bicycle access.
- Create a Governor's Smart Growth Council consisting of representatives from the Montana Association of Realtors, Montana Building Industry Association, Montana Association of Planners, and other entities to develop and distribute information on the GHG savings and other cost advantages of implementing Smart Growth principles.
- Require local growth policies to include a database of infill properties, including those that qualify as brownfields, and strategies for redevelopment.
- MDT will continue to expand existing transit service and create new transit services, taking advantage of federal funds made available through the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU).

Market Incentives

- Enable and encourage local governments to adopt financial incentives for infill or location-efficient development such as fast-track permitting, reduction of building permit fees, and reduction of system development or impact fees.
- Encourage lending institutions to adopt location efficient mortgage principles, such as recognizing transportation cost savings when calculating a household's borrowing ability.

Alternative Revenue Sources

- Encourage use of local option fuel taxes to help local governments fund transportation infrastructure that supports smart growth, including capital improvements and operation and maintenance. The state could also enable local government to adopt local option sales taxes, which could be used for this purpose.
- Adopt alternative funding sources for schools.
- Encourage the use of developer impact fees. In the long term, such fees could provide significant cost savings to local governments that could be redirected toward the city–county multimodal transportation funding.

Related Policies/Programs in Place

A variety of state and local policies and programs are in place to promote expansion of transportation choices and smart growth land use patterns. MDT has an access management program to ensure that land development does not jeopardize transportation system performance and safety. MDT funds cooperative planning efforts with local governments. MDT also spends approximately $5 million per year on bicycle and pedestrian improvements.

Estimated GHG Savings and Cost Per Ton

Growth and Development Bundle	2010	2020	Units
GHG emission savings	0.00	0.14	$MMtCO_2e$
Net present value (2006–2020)	N/A	<$0	$ Million
Cumulative emissions reductions (2006–2020)	0.00	0.77	$MMtCO_2e$
Cost-effectiveness	N/A	<$0	$/$MtCO_2e$

$MMtCO_2e$ = million metric tons of carbon dioxide equivalents; N/A = not applicable.

Data Sources:

Baseline VMT from Montana Greenhouse Gas Inventory and Reference Case Projections, 1990–2020.

A variety of simulation modeling and empirical studies have attempted to estimate the impacts of smart growth land use policies on VMT. Virtually all of this research focuses on urban areas (either local urban neighborhoods or metropolitan areas). For a summary of relevant literature, see:

- US EPA, *Our Built and Natural Environments: A Technical Review of the Interactions between Land Use, Transportation, and Environmental Quality, 2001.* http://www.epa.gov/dced/built.htm
- Cambridge Systematics, Inc., *Transportation Impacts of Smart Growth and Comprehensive Planning Initiatives: Final Report*, prepared for National Cooperative Highway Research Program, May 2004.
- Federal Highway Administration, Toolbox for Regional Policy Analysis, http://www.fhwa.dot.gov/planning/toolbox/index.htm

Regarding cost impacts, a variety of literature finds that integrated transportation and land use planning produces net savings on the total costs of buildings + land + infrastructure + transportation. However, some components may be higher even though total costs are reduced. The preponderance of literature suggests net savings overall (see US EPA, *Our Built and Natural Environments: A Technical Review of the Interactions between Land Use, Transportation, and Environmental Quality*, 2001). A National Academy of Sciences/Transportation Research Board review found substantial regional and state-level infrastructure cost savings from more compact development (see Robert Burchell, et al., *The Costs of Sprawl—Revisited (TCRP Report 39),* Transportation Research Board, Washington, DC, 1998).

Quantification Methods:

As described below, assume policy bundle results in 7% reduction in urban area VMT.

Calculate impact on total baseline transportation GHG emissions based on 7% reduction in baseline urban area VMT in 2020.

Key Assumptions:

Estimated GHG emissions reductions have been calculated against the mid-range of the possible reduction in VMT at 7%. The 7% estimated reduction is determined as the middle of the range, 3%–11%, which was based on the findings of the scientific research literature. Benefits (VMT and GHG reduction) increases linearly beginning in 2011 up to 2020.

Key Uncertainties

Achieving the target reduction in VMT depends on implementation of the policy initiatives at all levels of government. It is possible that required planning could be done in a way that does not change development patterns and thus does not reduce VMT and emissions. That is, the policy language does not require these outcomes.

External forces can have a significant effect on VMT and land development patterns, which creates additional uncertainty regarding the impacts of this policy option. For example, fuel prices affect vehicle use. A major increase in fuel prices would help to encourage use of alternative travel modes and might increase the benefits of this option. Conversely, a reduction in fuel prices would make it more difficult to reduce VMT through smart growth and multimodal transportation planning efforts. Land development patterns are strongly influenced by regional and state macroeconomic forces. The ability of governments to influence land use patterns depends to some extent on developer demand.

Additional Benefits and Costs

Land use policies such as the densification of developed land, mixing of compatible land uses and other urban design measures have beneficial “spin-offs” for other strategies. Land use-based policies further mode-switching policies because these policies help create an environment that is easier served by transit, biking, and walking.

Benefits include reduced infrastructure costs noted above, avoided health care costs from reduced air pollution and increased walking and biking, and other quality-of-life aspects.

There will be front-end costs of program development and implementation, and a successful program requires dedicated resources.

Feasibility Issues

Land use changes will not have a large impact on transportation systems or CO_2 emissions over the short-term. However, over longer time spans, land use changes aimed at creating denser, mixed-use settlements may offer important opportunities to reduce transportation energy intensity and CO_2 emissions.

Land use-based measures targeting densification and land-use mix will primarily but not exclusively affect only urban areas as they have the characteristics to address densification. The effectiveness of these policies also depends upon the willingness of local governments—largely in urbanized areas—to implement land use policies and regulations. In addition, policies that affect land use and transportation take a long time not only to implement but also a long time to accrue their effects. Typically, transit-oriented development strategies take more than 20 years to implement.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None identified.

TLU-6. Low Carbon Fuels

Policy Description

This policy will seek to increase the use and market penetration of low carbon fuels (LCFs) to offset traditional fossil fuels such as gasoline, diesel, jet fuel, and others derived from crude oil. Additionally, the policy aims to increase production opportunities for LCFs derived from Montana crops and other low carbon transportation alternatives such as hydrogen, natural gas, and electricity. TLU-6 will evaluate the merits of LCFs based on their net carbon impact and will remain consistent with AFW-2, which increases biodiesel production in the state.

Various options or a combination of them to increase low carbon fuel use would include

- Carbon fuel accounting,
- Fuel quality standards,
- Low carbon fuel infrastructure development,
- Low Carbon Fuel Standard (LCFS) and credits for compliance,
- High carbon fuel tax, and
- State government fleet ‘leadership’ programs for adoption of low carbon fuels.

Carbon Reduction Requirements

LCFs demonstrate tangible economic benefits to rural economies. An LCF policy provides for strong, proactive measures to address economic and environmental issues where agricultural concerns yearn for economic sustenance and higher crop prices or new and higher paying industry jobs to sustain the existing economy.

Policy Design

This policy is designed to increase the use of LCFs through a combination of voluntary measures and standards.

Goal Levels: Create an LCF target for transportation fuels sold in Montana and reduce carbon intensity of Montana’s passenger vehicle fuels by at least 10% by 2020. This minimum reduction should be based solely on implementation of LCF programs.

Timing: LCF targets will take place by the end of 2015.

Parties Involved: Fuel and Agriculture Industry, MDEQ, MDT, Montana Department of Revenue, auto dealerships, Montana University System (research).

Implementation Mechanisms

The following options or a combination of the options described below could be implemented to increase LCF use.

Carbon Fuel Accounting. All of these policy options should be evaluated based on fuel life cycle or net accounting that measures the net carbon emission per usable unit of energy delivered. In the case of traditional fuels, this includes carbon emissions of harvesting, mining, processing, transportation, and other energy inputs and carbon outputs from production to consumption. Biofuels should undergo the same net carbon accounting, including fertilizer, fuel used on the farm for seeding and harvesting, processing, and transportation.

Low Carbon Fuel Standard. A benchmark for promotion of LCFs should be based on energy output per volume of GHG generated, allowing policy to promote fuels with a favorable GHG-to-Energy ratio. The LCFS will require all fuel providers in Montana to ensure that the mix of fuel they sell into the Montana market meet, on average, a declining level of GHG emissions measured in grams of CO_2 equivalent per unit of fuel energy sold. The standard will also be measured on a life cycle basis in order to include all emissions from fuel production to consumption.

An LCF Standard is market- and performance-based, allowing averaging, banking, and trading to achieve lowest cost and consumer-responsive solutions. An LCF Standard is also fuel neutral where fuel providers will choose which fuels to sell and in what volumes. This provides flexible options for compliance including blending or selling increasing amounts of LCFs, using previously banked credits, and purchasing credits from fuel providers who earned credits by exceeding the standard.

An Executive Order would initiate this process, followed by a detailed report and regulatory proceedings before implementation. The appropriate state agencies will undertake a study to develop the framework for the LCFS. Once the study is completed, it will be introduced to the State’s legislative proceedings, at which point the appropriate state agency will conduct public hearings on the proposal. The final report is expected to be finalized by 2010 and upon the adoption of this report, an appropriate state agency will initiate a regulatory proceeding, establishing and implementing the LCFS.

Credits for Compliance. Fuel providers, defined as refiners, importers, and blenders of passenger vehicle fuels, would demonstrate on an annual basis that their fuel mixtures provided to the market met the target by using credits previously banked or purchased. Providers that exceed the performance target for the compliance period will be able to generate credits in proportion to the degree of over performance and quantity of fuel provided. These credits can be used for future use or sold to other regulated fuel providers. Penalties for noncompliance will be determined during the implementation process.

High Carbon Fuel Tax. Options encouraging consumer demand shifts may also be required since fuel providers may not be able to shift to lower-carbon options if the market is unresponsive. The high carbon fuel tax will place a percentage tax on each gallon of fuel sold based on that fuel’s GHG emissions measured in grams of CO_2 equivalent per unit of fuel energy sold. The fuel will also be measured on a life cycle basis in order to include all emissions from fuel production to consumption.

This carbon tax provides an economic incentive for both producers and consumers to shift production to fuels with lower carbon content. A tiered system, whereby conventional petroleum is taxed at a high rate and LCFs are taxed at a low rate, if at all, will also generate some revenue for a State Carbon Trust Fund. Revenues collected would finance loans, incentives, and rebates for direct investment in research by Montana institutions, infrastructure for transportation alternatives, and Montana production of LCFs.

While there is much political aversion to a new tax or fee, this policy option provides the strongest option for the greatest market-based reductions in carbon fuel use. A carbon tax would be implemented through a new fuel tax infrastructure whereby the tax would need to be collected at the refinery level (as opposed to the distribution level). Revenues can directly move other goals, favorably shift the market toward LCFs, and assist with funding programs (e.g., in-state crop production and public transportation demonstration projects). A carbon tax tied to road use also provides additional incentives for local production and distribution.

State Government Fleet Lead by Example Programs. State agencies may explore how they can implement the purchasing of LCFs or alternative fuel vehicles into contracts. The award of construction contracts is another area in which the state can immediately have an effect on GHG emissions. After these programs are implemented, the benefits of GHG emission reductions, as well as lower fuel costs should be documented. The appropriate state agencies would publish a report detailing the benefits of the program.

Carbon Reduction Requirements. Reduction in carbon-intensive fuels can also be achieved directly through voluntary or mandated goals. Options include a specific mandate (e.g., 10% of fuel used in Montana markets will be either ethanol or biodiesel by 2025) or flexible mandates (e.g., by 2020, the total amount of GHG emissions from fuel consumption will be 90% of current levels), or a yearly reduction by current producers. Legislative action will put these goals in place. Policy will also be designed to avoid a situation similar to the “flex fuel hoax,” where ethanol-capable vehicles were purchased for compliance, but no ethanol had been used. Any requirement should account for actual fuel use, and punishments for failure to meet these goals will be implemented.

Transportation Alternatives. State agencies would calculate the carbon reduction benefits of alternative transportation vehicles such as hydrogen, natural gas, and electricity, including neighborhood electric vehicles (NEVs) and other specialized transportation. Policy would be created to provide incentives for these vehicles and infrastructure for their use based on the achievable GHG reductions.

Type(s) of GHG Benefit(s)

Reduction in criteria air pollutants.

Related Policies/Programs in Place

California is in the process of finalizing their report for an LCFS, which is expected to be completed by June 30, 2007. Implementation of the LCFS is expected by the end of 2008.

Estimated GHG Savings and Cost Per Ton

Low Carbon Fuels	2010	2020	Units
GHG emission savings	0.00	0.04	$MMtCO_2e$
Net present value (2006–2020)	N/A	N/A	$ Million
Cumulative emissions reductions (2006–2020)	0.00	0.39	$MMtCO_2e$
Cost-effectiveness	N/A	N/A	$\$/MtCO_2e$

$MMtCO_2e$ = million metric tons of carbon dioxide equivalents.

Data Sources:

- CCS, Draft Montana Greenhouse Gas Inventory and Reference Case Projections.
- David Crane and Brian Prusnek. White Paper, "The Role of a Low Carbon Fuel Standard in Reducing Greenhouse Gas Emissions and Protecting Our Economy," January 8, 2007.
- Alexander E. Farrell (UC Berkeley)and Daniel Sperling (C Davis)."A Low-Carbon Fuel Standard for California, Part 1: Technical Analysis," May 30, 2007.

Quantification Methods:

CCS applied a declining value in carbon intensity of 10% (defined in gCO_2e/Btu) in LDV fuels to the reference case for Montana to determine its emissions savings.

Key Assumptions:

Benefits of GHG reductions follow a linear increase beginning in year 2011 up to year 2020. Quantification also assumes that the units of energy per gallon of fuel sold and combustion efficiency remains constant.

Key Uncertainties

None identified.

Additional Benefits and Costs

None identified.

Feasibility Issues

The market penetration of LCFs is dependent on the increasing innovation and/or regulation by the State to ensure that the fuel put on the market by providers meets, on average, a declining level of GHG emissions.

According to MDT, the current fuel tax infrastructure does not support the collection of high carbon fuel taxes at the distribution level. In order to establish a high carbon fuel tax, the state would need to develop a new fuel tax infrastructure, and legislation may be needed.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None identified.

TLU-7. Heavy-Duty Vehicle Emissions Standards and Retrofit Incentives

Policy Description

The State of Montana would seek to work with other states and the U.S. Environmental Protection Agency (US EPA) to advance GHG emissions standards for on-road heavy-duty vehicles (HDVs). In addition, the state would adopt incentive programs to reduce particulate matter (PM) emissions from existing on-road HDVs. Diesel particulate matter includes black carbon aerosols, which are thought to contribute to global warming through positive radiative forcing.

Approaches to diesel engine emission reductions include vehicle scrappage and replacement, re-powering (engine replacement), and retrofit with exhaust after-treatment devices. Two devices commonly used to reduce diesel PM emissions are diesel oxidation catalysts and diesel particulate filters. These devices can be used on certain model year engines of heavy-duty trucks, motor coaches, and transit and school buses.

Policy Design

This policy includes working with other states to set national emissions standards while at the same time initiating voluntary efforts to retrofit equipment, leading by example with initiatives to retrofit the state's own equipment and provide education and technical assistance. An incentive program would be used to encourage retrofits. A voluntary program with information and education would be aimed at target audiences, including impacts on children.

Goal Levels:

- The state would encourage the retrofit of on-road heavy-duty diesel vehicles of model year 2006 or earlier. (Beginning with model year 2007, HDVs must meet stringent new EPA emissions standards and therefore have very low black carbon emissions.)
- The state would develop and implement a diesel retrofit incentive program with a goal of retrofitting 50% of the pre-2007 HDVs registered in the state that would still be in use in 2020. (The vast majority of HDVs in the 2020 fleet will meet the 2007 EPA standards and therefore not require retrofits.)
- The state would lead by example by initiating a retrofit program for the state-owned and state-leased vehicle fleet, with a goal of reaching a minimum of 80% of the pre-2007 vehicles fleet, subject to available funding.

Timing:

- The state could lead by example by seeking to initiate a diesel retrofit program for the state-owned and leased vehicle fleet by 2009 if funding is available.
- By 2009, a voluntary diesel retrofit program will be established by a state agency, focused on private HDVs registered in the state. Information packages would be developed about the health effects of air pollutants on human health, particularly on children. The program would

create incentive options and marketing strategies, track retrofit and research activities, and spearhead the progression of on-road HDV GHG emissions standards with other states and the EPA.

- HDV retrofit incentives will be available for vehicle owners by 2011.

Parties Involved: MDT, MDEQ, local governments, Montana Metropolitan Planning Organizations, relevant industries (e.g., utilities, parcel delivery services), public and private educational institutions and organizations, Department of Health and Human Services, Montana University System.

Implementation Mechanisms

Rebate and Tax Credits: The appropriate state agency would establish a voluntary program to retrofit diesel engines in a rebate program. Users of heavy-duty diesel engines who retrofit with emission controls would also qualify for a credit against Montana income or business taxes (whichever is relevant) to a percentage (such as 25%) of the retrofit costs. Some retrofits reduce emissions of black carbon, which contributes to the greenhouse effect.

Local Ordinances: The state would encourage communities to establish local ordinances requiring retrofitting of HDVs, including garbage and construction trucks. In addition, transit companies contracted by the public school system to transport students, regardless of the purpose (e.g., daily transport, sporting events, educational trips) would also be required to participate in the retrofit programs.

Encourage New Federal Standards: The state would encourage the EPA to initiate the development of new GHG emission standards for HDVs.

Air Pollution Control Measures in Non-Attainment Areas: The state and some counties have the regulatory authority to require air pollution control measures in areas designated by the EPA as “non-attainment” for air pollution under the federal Clean Air Act. Exhaust emissions from engine combustion can be identified through technical studies and targeted by state or county air pollution control measures.

State Lead by Example: Implement a voluntary diesel retrofit program by an appropriate state agency.

Promotion and Marketing:

- Encourage local and county governments to act consistently with and support state actions.
- Encourage federal agencies located within the state to act accordingly with and support state actions.
- The state will develop information packages about the effects of air pollutants in diesel emissions on human health, particularly on children.
- Encourage transit companies contracted with a public school district to act accordingly with and support state actions. Educational information will be provided by a state agency to both the transit companies and the public education system about health effects of air pollutants from diesel emissions on children’s health.

- Assist in the development of on-road HDV GHG standards with other states and the EPA.
- Encourage the Montana University System to conduct research on on-road HDV GHG standards and emission reduction technologies.
- As in TLU-2 and other options discussed below, all state-supported programs would have dedicated detailed Web sites. In addition to information and materials, efforts of the various governmental agencies and businesses would be documented and publicized.

Technical Assistance:

- Contact the manufacturers of the various diesel emission reductions technologies to coordinate objectives and obtain technical support for outreach materials.
- The EPA created the Retrofit Technology Verification Process. This program evaluates the emission reduction performance of retrofit technologies, including their durability, and identifies engine operating criteria and conditions that must exist for these technologies to achieve those reductions.
- The EPA has also developed the Voluntary Diesel Retrofit Program to address pollution from diesel construction equipment and HDVs that are currently on the road. Program information is available to help fleet operators, air quality planners in state and local government, and retrofit manufacturers create effective retrofit projects.

Funding Mechanisms and/or Incentives:

- Funding for retrofit incentives would be proposed through legislative action. The owners of the retrofitted heavy-duty diesel engines would qualify for a credit against Montana income or business taxes (whichever is relevant) to a percentage of the retrofit costs (tax credit). Another option is feebates incurred as part of the engine maintenance costs, which would be based on the age of the engine.
- Funding may be available through the EPA Voluntary Diesel Retrofit Program and/or the EPA funding programs to reduce air toxics at the local level. Also refer to "Related Policies/Programs in Place" for more possible funding avenues.
- The Montana University System can obtain applicable grant funding independently.

Voluntary and/or Negotiated Agreements: Work with regulated entities to promote voluntary compliance assistance through distribution of materials, staff training, and so on. Encourage participation in EPA's National Clean Diesel Campaign.

Codes and Standards: Refer to the information provided in the previous sections.

Pilots and Demonstrations: Coordinate with product developers to help them promote their technologies.

Reporting: The state will develop a tracking system so emissions reductions from the application of heavy-duty diesel replacement technologies can be derived. The state can annually contact the primary shipper companies in the main Montana cities to gather estimates from their inventories.

Enforcement: No enforcement actions are necessary since this is a voluntary program. However, the EPA will penalize any manufacturer who does not comply with their standards.

Related Policies/Programs in Place

Congestion Mitigation and Air Quality Improvement Program: A heavy-duty diesel engine retrofit may be eligible for funds through the federal Congestion Mitigation and Air Quality Improvement (CMAQ) Program, provided that the vehicle operate predominantly within or in close proximity to an EPA-designated air quality nonattainment or maintenance area and primarily benefit those areas. If the truck is privately owned, CMAQ funding would be contingent upon meeting the public–private partnership provisions of the guidance. Funds under the program also may be used for school bus programs in nonattainment and maintenance areas to retrofit or replace engines with the latest technologies that reduce emissions. Several urban areas in Montana are likely to be designated nonattainment under the new fine particulate standard.

Emissions Standards for 2007 and Newer Vehicles: On December 21, 2000, the EPA signed emission standards for model year 2007 and later heavy-duty highway engines. The rule included two components: 1) emission standards and 2) diesel fuel regulation. The rule focused on PM and nitrogen oxides (NO_x). The stringent standard for PM took effect in the 2007 heavy-duty engine model year. The NO_x standard for diesel engines will be phased in between 2007 and 2010. As a result, model year 2007 and new HDVs have very low PM emissions.

Diesel Emissions Reduction Act: A new energy law enacted in August 2005 created a national program to clean up older diesel engines. The legislation, known as the Diesel Emissions Reduction Act (DERA), provides federal funding to help finance voluntary retrofit incentive programs (both grants and loans) at both the national and state level.

EPA Voluntary Diesel Retrofit Program: The EPA has also developed the Voluntary Diesel Retrofit Program with a designated Web site. The program addresses pollution from diesel construction equipment and HDVs that are on the road today. The program Web site is designed to help fleet operators, air quality planners in state and local government and retrofit manufacturers understand this program and obtain the information they need to create effective retrofit projects. Funding will depend on the President’s FY07 budget.

National Clean Diesel Campaign: In addition, the EPA has created the National Clean Diesel Campaign (NCDC). The NCDC will work aggressively to reduce the pollution emitted from diesel engines across the country through the implementation of varied control strategies and the aggressive involvement of national, state, and local partners.

MDEQ No-Idle Zone: MDEQ is working with a few schools to reduce idling by educating and signing areas around schools where large and small vehicles need to shut off engines while waiting to pick up students.

Estimated GHG Savings and Cost or Cost Savings

Heavy-Duty Vehicle Emission Reduction & Retrofit	2010	2020	Units
GHG emission savings	0.00	0.02	$MMtCO_2e$
Net present value (2006–2020)	N/A	$12.8	$ Million
Cumulative emissions reductions (2006–2020)	0.00	0.16	$MMtCO_2e$
Cost-effectiveness	N/A	$79.0	$\$/MtCO_2e$

Data Sources:

- Truck population data (by model year), mileage accrual data, and PM2.5 emission factors from MOBILE6 model.
- Cost of retrofit devices (including installation) from California Air Resources Board, *Evaluation of Port Trucks and Possible Mitigation Strategies*, Preliminary Draft, April 2006.

Quantification Methods:

- Assume HDVs of model year pre-1994 are retrofitted with diesel oxidation catalysts (DOCs) and HDVs of model year 1994–2006 are retrofitted with diesel particulate filters (DPFs).
- DOCs reduce PM emissions by 25%; DPFs reduce PM emissions by 85% (California Air Resources Board technology verification levels).
- Obtain population of pre-2007 HDVs in operation in 2020 from MOBILE6 (by model year and by two weight classes: 14,000–33,000 lbs gross vehicle weight [GVW] and 33,001–80,000 lbs GVW)
- Assume retrofit program begins in 2011 and is completed in 2015.
- Assume program retrofits 50% of the pre-2007 HDVs that would be operating in 2020.
- Calculate PM2.5 emission reductions achieved in each year from 2011 to 2020.
- PM2.5 emissions from HDVs are 75.6% elemental carbon (black carbon), according to MOBILE6. Calculate black carbon emission reduction.
- Assume that a 1-ton reduction in PM2.5 emissions is equivalent to a 2,053-ton reduction in CO_2 equivalent emissions. This is the midpoint of a method suggested in Mark Z. Jacobson, “Correction to ‘Control of fossil-fuel particulate black carbon and organic matter, possibly the most effective method of slowing global warming,’ ” *Journal of Geophysical Research*, 110:D14105, 2005.
- Assume cost for DOC (purchase plus installation) is $1,200 for GVW 14,000–33,000 lbs and $2,000 for GVW 33,000+.
- Assume cost for DPF (purchase plus installation) is $7,000 for GVW 14,000–33,000 lbs and $8,500 for GVW 33,000+.
- Calculate total retrofit costs by year (all retrofits occur from 2011 to 2015).
- Use a 4% discount rate to calculate net present value (NPV).

Key Assumptions: See above.

Key Uncertainties

There is a great deal of uncertainty in the global warming impact of aerosol black carbon emissions (such as diesel PM). The Intergovernmental Panel on Climate Change (IPCC) has not assigned a global warming potential to black carbon emissions.

Additional Benefits and Costs

This strategy will reduce diesel PM emissions. Many scientific studies have linked breathing PM to a series of significant health problems, including aggravated asthma, difficult breathing, chronic bronchitis, heart attacks, and premature death. Diesel PM is of specific concern because it is likely to be carcinogenic to humans when inhaled.

Feasibility Issues

None identified.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None identified.

TLU-8. Heavy-Duty Vehicle and Locomotive Idle Reduction

Policy Description

This policy option involves reducing the amount of time that trucks, buses, and locomotives idle. It would involve promoting and expanding the use of technologies that reduce long-term idling, including the use of truck stop electrification. It would also encourage development of local ordinances banning unnecessary idling by HDVs and locomotives in most situations.

Truck stop electrification involves truck plazas that are equipped with electrification systems that allow drivers to shut off their engines and draw electrical power and in some cases, heating, cooling, and communications and entertainment options from a ground source. Different systems may or may not require the purchase of an adaptor to connect to the tractor.

In addition to truck stop electrification, other available technologies that reduce HDV idling include automatic engine shut-down/start-up system controls, auxiliary power units, and direct fired heaters. Technologies to reduce locomotive idling include automatic engine shut-down/start-up system controls and hybrid-electric switcher engines.

The state would encourage local ordinances to ban unnecessary idling by HDVs and locomotives in certain situations. The state would encourage consistency among these ordinances. The ordinances would likely include exceptions for situations when idling is unavoidable, such as cold weather, traffic delays, and other idling that occurs for public health and safety reasons (such as emergency vehicles).

A dedicated state funding stream for enforcement would be identified in order for this measure to be successful in reducing vehicle idling and the resulting reductions in GHG emissions.

Policy Design

This policy uses a combination of voluntary actions, incentives, contractual mechanisms, and standards with eventual enforcement.

Goal Levels:

- Reduce fuel consumption from heavy-duty diesel vehicle idling at rest areas and truck stops in two steps: 40% in Phase I by 2010 and 85% in Phase II by 2020.
- Require that 85% of the transportation services that a public school district has contracts with for transporting students and that uses HDVs must have anti-idling policies and/or in-house electrification systems to reduce fuel consumption and emissions from idling by 2011.
- Reduce locomotive idling in switch yards by 50% by 2020.

Timing: Establishment of local ordinances will be strongly supported by the state, but local governments will need to determine their time schedules.

- Installation of electrification systems at truck stops and rest areas by 2011.

- Attempt to have local ordinances in place by 2011 with relevant documentation available for distribution.
- The two-stage phase-in periods for the reduction in heavy-duty diesel vehicle idling are 2010 (Phase I) and 2020 (Phase II).
- Transportation services that have contracts with a public school district and that use HDVs to transport students must have anti-idling rules and/or electrification systems installed by 2011.

Parties Involved: MDEQ, MDT, local governments, Montana Metropolitan Planning Organizations, relevant public educational parties, truck stop owners and managers, trucking associations, school districts, chartered bus service companies, railroad companies such as Burlington Northern Santa Fe (BNSF) and MontanaRail Link (MRL).

Implementation Mechanisms

Toll Free Technical Assistance: The appropriate state agency would provide the general public, trucking industry, bus companies, and railroads with information (with a phone number to answer questions) indicating when and where (possibly specified by a map) idling is prohibited, and under what circumstances it is permitted. The benefits of reducing idling, including fuel savings, toxic emission reductions, and GHG reductions would be detailed.

Information and Education to Targeted Audiences: Encourage trucking companies and railroads to do their own proctoring. Reach out to busing companies, school districts, and truck stop owners to educate bus and truck drivers about the idling restrictions. Emphasize the fuel savings benefits, reductions in toxic emissions, and reduced engine wear associated with reducing idling. Provide information to fleet carriers, shippers, retailers, bus companies, school districts, and others involved in the diesel fleet industry indicating the economic benefits, as well as the environmental benefits, of applying idle reduction technologies. Identify best practices within the industry and recognize companies with these best practices in place within Montana to encourage companies to select these carriers for their shipments.

Develop outreach materials with cost benefits information and toxic diesel health effects in both indoor (cabin) and outdoor ambient air on both children and adults. Outreach materials should also be geared toward making the general public aware of the GHGs, toxics, and fuel-saving benefits of eliminating unnecessary idling on personal (passenger) vehicles, as well as on trucks and buses. Expand the school bus idling program based upon the pilots currently being conducted.

Promotion and Marketing: The state will develop information packages about the health effects of air pollutants from the idling emissions on human health, particularly the drivers, in and outside the truck cab or bus.

As with other policies, efforts will be supported by the appropriate state agency with a dedicated detailed Web site. Beyond information and materials, those participating in successful idling reduction efforts would have those efforts documented and publicized.

Technical Assistance: Coordinate with the impacted communities to organize workshops/outreach programs to let them know about technological options that provide alternatives to the need for idling including products for cabin comfort, power for other functions (e.g., refrigerated trucks), and engine warm-up.

Funding Mechanisms and/or Incentives: Propose legislation to partially fund idling technology loan grants for truck stop electrification and other idle reduction technologies in the state, focusing grants on high idling areas.

Identify a dedicated funding stream that can be used to fund enforcement of local anti-idling ordinances and fund continued education and outreach. Funding the enforcing agency with an adequate share of the revenue from using the idling reduction facilities would be an option. Federal funds (EPA or DOE) may be available for idle reduction projects. A plan needs to be developed to apply for the funds.

Tax credits may be available for installing electrification through the National Energy Bill. Truck stop owners could offer their own incentives for the use of electrification (e.g., credits for free hours of electrification with the purchase of a specified amount of diesel).

At rest areas, individual meters could measure the amount of energy used by each trucker and the truckers could pay for the energy usages via a currency feed apparatus housed in a safe location from the cost savings derived by the increased fuel efficiency of not idling.

Voluntary and/or Negotiated Agreements: Work with regulated entities to promote voluntary compliance assistance through distribution of materials, staff training, and so on. The state would attempt to establish a Memorandum of Understanding (MOU) with BNSF and MRL regarding switchyard idle reduction. Encourage participation in EPA's SmartWay Transport Partnership (or similar programs). The SmartWay Transport Partnership is a voluntary collaboration between the EPA and the freight industry designed to increase energy efficiency while significantly reducing GHGs and air pollution.

Codes and Standards: Include concise language in local ordinances so that the agency with enforcement responsibilities is clearly delineated and has full authority to enforce the ordinances. The language should also include any exemptions to the idling policy, which can be easily observed. In developing the local anti-idling ordinances, the EPA's recent Model State Idling Law should be reviewed for potential ordinance language.

Pilots and Demonstrations: Coordinate with product developers to help them promote their technologies. Investigate availability of funds for pilot or demonstration projects on idle reduction technologies from EPA, US DOE, and the U.S. Department of Transportation. If funding is available, develop a pilot program to evaluate the effectiveness of various idle reduction technologies, including implementation of truck stop electrification and expanded school bus idling program. Evaluate the effectiveness of the pilot programs before implementing on a broader scale.

Related Policies/Programs in Place

- Lewis and Clark County has Rule 3.101, which applies to both diesel and locomotive engines and limits the amount of idling time when the health department has declared poor air quality (idling is limited to 2 hours within any 12-hour period).

- MDEQ has a voluntary program, *Clean Air Zone Montana*, aimed at reducing school children's exposure to vehicle emissions by discouraging idling of school buses and other vehicles and by helping schools obtain funding for bus maintenance and retrofitting.
- This option also supports progress toward EPA Strategic Plan Goal 1, Clean Air and Global Climate Change, Objective 1.1, Healthier Outdoor Air. The Regional Geographic Initiatives Program enables the Regions to work with states, local governments, and others in specific geographic areas on problems identified as high priorities by the Regions.
- Approximately 16 states and dozens of local counties have laws restricting the time a vehicle can idle its main engine. For a list of state and local anti-idling laws compiled by EPA in April 2006, go to http://www.epa.gov/smartway/documents/420b06004.pdf. EPA has also released a model for a state idling law, based on workshops with trucking industry stakeholders and state environmental agencies (see http://www.epa.gov/smartway/documents/420s06001.pdf)
- The Montana Legislature passed Senate Bill (SB) 449 by Sen. Gillan that requires that state agency vehicles purchased after January 1, 2008, meet or exceed CAFE standards.

Estimated GHG Savings and Cost or Cost Savings

Heavy-Duty Vehicle & Locomotive Idle Reduction	2010	2020	Units
GHG emission savings	0.01	0.02	$MMtCO_2e$
Net present value (2006–2020)	N/A	–$5.6	$ Million
Cumulative emissions reductions (2006–2020)	0.01	0.13	$MMtCO_2e$
Cost-effectiveness	N/A	–$44.0	$/MtCO_2e$

Data Sources:

- Identification and characteristics of truck stops in Montana obtained from www.gocomchek.com
- Information on current truck stop electrification projects in Montana (none) obtained from EPA SmartWay Interactive Activity Map (www.epa.gov/smartway).
- Estimate of truck idling hours per night obtained from Nicholas Lutsey, Christie-Joy Broderick, Daniel Sperling, Carollyn Oglesby. "Heavy-Duty Truck Idling Characteristics—Results from a Nationwide Truck Survey," paper submitted for the 2004 Annual Meeting of the Transportation Research Board, 2004.
- Information on fuel use per engine idle hour obtained from *Fleet Managers Guide to Fuel Economy*, The Maintenance Council, American Trucking Association, 1998.
- Population of school buses from Montana Office of Public Instruction.
- Rail-yard fuel use from MDEQ.

Quantification Methods:

School Buses		
Number of school buses, 2005	2,606	80,000
School days per year	180	6
Trips per bus per day	4	480,000
School bus trips per year	1,876,320	
		50%
Idling time per trip, current (min)	15	
Idling time per trip, w/ regulation (min)	5	240,000
Reduction in idling time per trip (min)	10	
		0.0333
Reduction in idling time per year (hours)	312,720	0.0006
		0.0023
CO_2 emission factor (g/hour)	3,300	
Reduction in CO_2 emissions/year (metric tons)	1,032	
Reduction in CO_2 emissions/year ($MMtCO_2$)	0.0010	
Trucks		
Total truck stops in state with truck parking	36	
Number with TSE	0	
Number without TSE	36	
Average spaces per truck stop	32	
Estimated occupancy per night	80%	
Idling hours per truck per night	5.9	
	Phase I (2010)	Phase II (2020)
Percent of idling reduced by TSE	40%	85%
Fuel/engine idle hour (AC)	1	1
Fuel/engine idle hour (no AC)	0.6	0.6
% of Idling hours with AC	25%	25%
% of Idling hours without AC	75%	75%
Reduction in idling hours/year	793,866	1,686,966
Reduction in fuel use/year	555,706	1,180,876
MMBtu (million)	0.0771	0.1638
MMtC	0.0015	0.0031
$MMtCO_2$	0.0054	0.0115
N_2O ($MMtCO_2e$)	0.000005	0.000011
CH_4 ($MMtCO_2e$)	0.000000	0.000001
Total Reduction ($MMtCO_2e$)	0.005	0.012
Locomotives		
Fuel use per major yard, currently (gal)	80,000	
Major switch yards in Montana	6	
Total Montana yard fuel use, currently (gal)	480,000	

Portion of idling that can be eliminated	50%	
Reduction in fuel use/year (gal)	240,000	
MMBtu (million)	0.0333	
MMtC	0.0006	
$MMtCO_2$	0.0023	

Key Assumptions:

- Benefits of truck idle reduction increase linearly between 2010 and 2020.
- Benefits of school bus and locomotive idle reduction constant from 2011 to 2020.
- School buses currently idle 15 minutes per trip on average; implementation of this policy would reduce idling per trip to 5 minutes.
- Rail-yard fuel use can be reduced by 50%.
- Cost of diesel fuel assumed to be $2.50 per gallon.
- Cost of truck stop electrification service (IdleAire) assumed to be $1.20 per hour.
- Cost savings estimated as difference between fuel cost and IdleAire service.

Key Uncertainties

- Number of overnight truck parking spaces in Montana.
- Utilization of overnight truck parking spaces.
- Extent of school bus idling and effectiveness of policy at reducing bus idling.
- Willingness of railroads to cooperate with locomotive idle reduction efforts.

Additional Benefits and Costs

Reducing idling by HDVs and locomotives would reduce PM emissions. Many scientific studies have linked breathing PM to a series of significant health problems, including aggravated asthma, difficult breathing, chronic bronchitis, heart attacks, and premature death. Diesel PM is of specific concern because it is likely to be carcinogenic to humans when inhaled.

Feasibility Issues

None identified.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None identified.

TLU-9. Procurement of Efficient Fleet Vehicles

Policy Description

Montana state and local government agencies could “lead by example” by enacting procurement policies and/or joining the EPA SmartWay program and utilizing the SmartWay Upgrade Kits that result in adoption of lower emitting vehicle fleets. There are three primary components of the EPA SmartWay program: creating partnerships, reducing all unnecessary engine idling, and increasing the efficiency of LDVs and HDVs, rail, and intermodal operations.

Targets are listed under the Policy Design section and will be based on availability of energy saving technologies and overall efficiency of the life of the vehicle.

This policy option strengthens Montana’s commitment to reduce GHG emissions through fuel efficiency in vehicles owned by the state while also encouraging private and public agency fleets with the potential to develop incentive programs for local governments to help with the initial costs of purchasing such vehicles.

Policy Design

This is an enabling option that would have the state government lead by example, ensuring that its own fleet of vehicles meets or exceeds the targets set for the state as a whole while providing available means for all public and private vehicles to also exceed these standards on a voluntary basis.

Goals: Where the fuel and vehicle-type requirements of TLU-1, TLU-6, TLU-7, and TLU-8 are higher, the state vehicle fleet would conform to the higher requirements.

Timing: By 2020.

- The state will set a goal where at least 70% of all HDVs and at least 90% of all light-duty passenger vehicles are “fuel efficient,” meeting on average, a higher MPG, for the state’s HDV and LDV fleets.

Parties Involved: Montana state and local government agencies, private industries and fleets, trucking industry.

Implementation Mechanisms

Executive Order: This order would establish that the state or appropriate agency will immediately

- Identify barriers to purchasing hybrid vehicles and research and develop solutions to procure hybrid or other lower GHG emitting vehicles in the state,
- Ensure that the overall state of Montana fleet considers EPA fuel efficiency rating calculated over the life cycle of the vehicles purchased for the fleet, and

- Ensure that LCFs are purchased for the state motor pool fleet wherever they are available and if applicable for the vehicle type.

Participation in EPA SmartWay Program

State and local agencies with vehicle fleets could sign on as SmartWay carrier partners. They would then measure their environmental performance with the fleet model and come up with a plan to improve that performance. The partnership provides information and suggested strategies to improve fuel economy and environmental performance of vehicle fleets.

EPA SmartWay Shippers: State or local agencies that buy transportation services or ship goods could sign on as SmartWay shippers. As shipper partners, state agencies would seek to select SmartWay partners when they purchased the services of carriers. One way that the state could help would be to add SmartWay certification to the list of factors that they may consider when selecting carriers. Alternatively, they could encourage the carriers that they do business with to join the partnership. Shippers can also implement direct strategies, for instance, developing no-idle policies for their loading areas.

SmartWay Affiliates: State and local agencies could sign on to SmartWay as affiliates. As affiliates, they would help to distribute information on the program to interested parties. This could be as easy as putting a link on their Web site, or it could involve a more active role.

EPA SmartWay Loan Initiative: Incentives to reduce emissions in the trucking industry are also available through the EPA SmartWay Loan Initiative. The US EPA is partnering with the Small Business Administration (SBA) to make loans available to purchase SmartWay Upgrade Kits. This loan initiative uses SBA Express Loans and partners with Bank of America, Business Loan Express, Superior Financial Group, and other SBA lenders to help small trucking companies finance the purchase of SmartWay Upgrade Kits. Participating lenders will provide quick approval and affordable monthly payments. Small trucking firms can borrow from $5,000 to $25,000 with no collateral, an easy online or telephone application, and flexible loan terms.

SmartWay Upgrade Kits: A variety of fuel- and emissions-saving technologies, typically consisting of engine idle reduction technology, LRR tires, improved aerodynamics, and exhaust after-treatment devices. In tests, these kits can reduce fuel consumption by 10% to 15%, saving more than $8,000 in fuel costs annually. They also reduce pollution: carbon dioxide and nitrogen oxide emissions are cut 10% to15%, and when a kit includes an exhaust after-treatment device, PM emissions are reduced by 25% to 90%.

Related Policies/Programs in Place

Arizona and New Mexico have programs that could be used as models.

Estimated GHG Savings and Cost Per Ton

GHG reductions and costs for this enabling option are incorporated into those reported under TLU-1, TLU-6 through TLU-8, and TLU-11.

Key Uncertainties

None identified.

Additional Benefits and Costs

None identified.

Feasibility Issues

None identified.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None identified.

TLU-10. Transportation System Management

Policy Description

The State of Montana would seek to reduce GHG emissions from the transportation sector through improvements to transportation system management. These efforts would focus on the improvement, management, and operation of the transportation infrastructure, with a focus on the roads and highway systems.

Policy Design

Goals: Promote the development of efficiencies in Montana's transportation system to achieve fuel savings and improved safety.

Timing: Ongoing and continuous.

Parties Involved: MDT, urbanized areas, county road supervisors, Montana transit providers.

Implementation Mechanisms

- Relying on existing sources and employing models such as SIDRA, MDT will evaluate potential locations for roundabout installation. MDT will report on its roundabout evaluation criteria and list all locations evaluated annually for potential roundabout installation, to be no less than 15 intersections or locations annually. MDT will encourage the installation of roundabouts when the installation is based on sound engineering principles. MDT will work cooperatively with local governments seeking information on the principles of roundabout installation. MDT will assist the cities and counties in their analysis of roundabout suitability for intersections under their jurisdiction. MDT will consider roundabout treatment at planned right-angle intersections for new construction and upgrades and when completing routine safety reviews. Roundabouts have safety benefits because crashes generally are of reduced severity. Roundabouts can also reduce traffic queuing and delay, thus saving fuel and reducing GHGs.
- MDT will continue its commitment to providing a multimodal transportation system by continuing to invest in bicycle and pedestrian facilities. MDT spends an average of roughly $5 million annually on these facilities and expects this level of commitment to continue or increase.
- All urban areas (i.e., > 5,000 population) will continue to include consideration of bicycle and pedestrian facilities in their urban transportation plans.
- MDT will complete signal synchronization on all state managed routes (mostly arterials) in urban areas (i.e., > 5,000 population) by 2009. Signal synchronization reduces start/stop traffic on arterial routes because the lights are timed to continuously move traffic forward at the target pace. This strategy also helps reduce traffic queuing thus saving fuel and reducing GHGs.
- MDT will complete conversion of all traffic lights to LED bulbs by 2010 and will work with cities to convert lights under city jurisdiction. LED bulbs conserve energy.

- MDT will continue to expand transit services in Montana communities and seek additional federal funds to support this expansion.
- All urban transportation plans will be updated by 2012 with an emphasis on operations and safety. The operations elements in urban transportation plans will improve traffic flow and reduce conflict points; they can also result in turn lanes, reconfiguration of intersections, or access control. In metropolitan areas, the transportation plans will meet air quality conformity requirements for criteria pollutants.
- Congestion management plans for all high-volume construction projects will be routinely implemented by 2009. These plans implement strategies to keep traffic flowing through construction zones, thus reducing fuel use and reducing GHG emissions.
- Access management will continue to be pursued consistent with State of Montana statutes and Transportation Commission policies. Currently, MDT is implementing access management on US 93 (north and south) and US 212 from Red Lodge to Laurel. MDT is developing access management plans in a number of rapidly developing urban/suburban areas (Bozeman, Billings). In addition, MDT is developing plans for bypass projects in Billings, Kalispell, and Great Falls that will be access controlled. The appropriate goal is to continue and strengthen access management within the state.
- State and local governments should ensure that all new streets are designed to provide a full range of transportation options (i.e., multimodal or encompassing vehicular, bicycle, and pedestrian uses).
- The state should seek to ensure the preservation of railroad rights-of-way for future freight and passenger transportation, including utilizing the option of rail-banking where appropriate.

Related Policies/Programs in Place

None identified.

Estimated GHG Savings and Cost or Cost Savings

Not quantified.

Key Uncertainties

To implement these strategies, continued Federal-Aid Highway Program funding will be needed.

Additional Benefits and Costs

Increased safety and reduced traffic queuing and delay.

Feasibility Issues

None identified.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None identified.

TLU-11. Intermodal Freight Transportation

Policy Description

Transportation of freight by railroad generally results in less fuel use and GHG emissions than transportation by truck. The best candidates for diversion from truck to rail are commodities that can move by intermodal rail transportation, which involves shipping containers or truck trailers placed on rail flatcars. This option would encourage the expansion of intermodal rail service for Montana shippers. In addition, the state would strive to increase the competitiveness of rail rates for all Montana shippers.

With the closure of the intermodal facility in Shelby, intermodal transfers are not currently possible on the BNSF mainline in Montana. MDT has initiated a study to perform logistics and marketing research in support of container on flatcar shuttle train service on the BNSF mainline to the Port of Seattle or Tacoma. It is expected that the results of this study will suggest actions for the state to support reestablishment of intermodal rail service for Montana shippers seeking rail access to markets outside the state.

Policy Design

Continued study of intermodal shuttle train research with recommendations to increase efficiency of transportation in Montana through intermodal transportation is needed. Policies to increase use of intermodal transportation will be an outcome of the research underway.

Goals

- MDT and appropriate partners will complete the Stage I Intermodal Shuttle Train Research Study in 2008.
- State of Montana will pursue competitive rates and access to service for Montana rail shippers.
- Target outcome of these efforts is 1 intermodal unit train to Port of Seattle or Tacoma by 2010 and 4 intermodal unit trains by 2020.

Timing: See goals above.

Parties Involved: MDT, railroads.

Implementation Mechanisms

Implementation mechanisms will be determined in part by the Intermodal Shuttle Train Research Study. They might include the following:

- Montana will implement the strategies coming from this research project starting in 2009.
- State support for improvements to intermodal transfer facilities in the state.
- State identification of potential intermodal shippers.

- State discussions with railroads operating in the state.

Related Policies/Programs in Place

Montana has a Rail Competition Council that seeks to ensure competitive railroad rates for the state's shippers.

MDT is initiating an Intermodal Shuttle Train Research Study, as noted above.

Type(s) of GHG Reductions

By reducing heavy-duty truck travel, this option would primarily reduce CO_2 emissions.

Estimated GHG Savings and Cost per $MtCO_2e$

Intermodal Freight Transportation	2010	2020	Units
GHG emission savings	0.02	0.09	$MMtCO_2e$
Net present value (2006–2020)	N/A	N/A	$ Million
Cumulative emissions reductions (2006–2020)	0.02	0.59	$MMtCO_2e$
Cost-effectiveness	N/A	N/A	$/$MtCO_2e$

Data Sources:

- Railroad distance from Shelby to Tacoma, Washington, from BNSF Web site.
- Railroad fuel efficiency from the Association of American Railroad's Railroad Facts and *Rail vs. Truck Fuel Efficiency: The Relative Fuel Efficiency of Truck Competitive Rail Freight and Truck Operations Compared in a Range of Corridors, Prepared for the Federal Railroad Administration,* prepared by Abacus Technology Corporation, April 1991.

Quantification Methods:

Assume one 100-car double-stack intermodal train begins service in 2010, running from Shelby to the Port of Tacoma, Washington. Train runs 6 days per week. Assume 40-foot containers are drayed from Great Falls to Shelby. Train eliminates truck trips (pulling 53-foot trailers) between Great Falls and Tacoma, WA. Train frequency increases to 2 per week in 2013, 3 per week in 2016, and 4 per week in 2019. See calculations below.

Distances		
Rail: Shelby to Tacoma, WA	757	miles
Truck: Great Falls to Shelby	86	miles
Truck: Great Falls to Tacoma, WA	654	miles
Train length	100	cars
TEUs/train (double-stack)	400	
Cargo weight/TEU	8	tons
Cargo weight/train	3,200	tons
Rail fuel efficiency (double-stack)	400	ton-miles/gal
Rail emission factor (double-stack)	24.6	g CO_2/ton-mile
Train emissions	59,555	kg CO_2

TEUs/dray truck	2	
Dray truck trips/day	200	
Dray truck fuel use/day	2,867	gallons
Dray truck emissions/day	27,897	kg CO_2
TEUs/long-haul truck	2.65	
Long-haul truck trips/day	151	
Long-haul truck fuel use/day	16,453	gallons
Long-haul truck emissions/day	160,113	kg CO_2
Total Annual Emissions		
Rail + dray	27,285	$MtCO_2$
All truck	49,955	$MtCO_2$
Difference	22,670	$MtCO_2$
Emission reduction, 2010	0.023	$MMtCO_2$
Emission reduction, 2020	0.091	$MMtCO_2$

TEUs= trailer equivalent units.

Summary comparison of truck-only vs. intermodal rail

	Truck-Only	Intermodal Rail
Total distance (miles)	654	843
Annual emissions, 2010 ($MtCO_2$)	49,955	27,285
Emissions per ton-mile (g CO_2/ton-mile)	76.5	32.4

Key Assumptions: See above.

Key Uncertainties

The success of this strategy depends on sufficient shipper demand and willingness of the railroads to provide intermodal service. Because MDT has not yet completed the shuttle rail research study, there is significant uncertainty as to the level of shipper demand for such service and the likelihood that the railroads would reestablish intermodal service.

Additional Benefits and Costs

By shifting freight from truck to rail, this option could result in small additional benefits related to highway congestion and highway safety.

Feasibility Issues

As noted above, the success of this strategy depends on sufficient shipper demand and willingness of the railroads to provide intermodal service. These factors are largely outside government control.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None identified.

TLU-12. Off-Road Engines and Vehicles GHG Emissions Reductions

Policy Description

Off-road (also called non-road) engines and vehicles are significant emitters of GHGs and consumers of petroleum-based fuels. Emissions from off-road engines can be reduced by adoption of GHG emissions standards and through retrofit technologies. The efforts would be expected to be consistent with efforts to reduce off-road emissions of other regulated air pollutants. In the State of Montana, these reductions would affect the following equipment categories: airport service, construction, industrial, lawn and garden, agriculture, light commercial, logging, recreational (including snowmobiles and snow coaches), and recreational marine.

Policy Design

This policy would include a combination of state government leadership in retrofitting its own off-road equipment, a voluntary diesel retrofit program encouraging local governments and business, particularly airports to participate, use of existing air quality pollution control authority and setting standards for off-road engines, and eventual tax incentives for retrofits.

Goal Levels: After the appropriate state agency has concurred, the state will adopt CO_2 emissions standards for the various off-road equipment categories based on engine horsepower, within 2 years of when a municipality or another state has established such regulations.

Timing:

- The state would lead by example by initiating a diesel retrofit program for 40% of the state-owned and leased off-road engines and vehicles by 2010.
- The state would set a goal of 30%–40% of lawn and garden equipment by 2015.
- The state will implement a voluntary diesel retrofit program by 2010.
- The state will develop information about the emissions reductions from retrofit technologies on the various off-road engines and vehicles by 2010.

Parties Involved: Relevant industries, airports, general public, MDT, MDEQ, and local, county, and federal governmental agencies.

Implementation Mechanisms

- **Encourage Use of New Technologies:** Emission control technology is now available to retrofit or rebuild existing engines for any kind of off-road diesel engine including marine.
- **Use Existing Regulatory Authority Where it Exists:** The state and some counties have the regulatory authority to require air pollution control measures in areas designated by EPA as “non-attainment” for air pollution under the federal Clean Air Act. Exhaust emissions from engine combustion can be identified through technical studies and targeted by state or county air pollution control measures.

- **Construction Contract Requirements:** Construction contracts funded by the state and local communities would be required to use best available control technology (BACT) and other emissions mitigation measures for all diesel engines.
- **Emissions Standards:** The state will establish CO_2 emissions standards for the various equipment categories based on engine horsepower.
- **State Lead by Example:** The state would initiate a diesel retrofit program for these equipment categories owned or leased by the state.
- **Voluntary Retrofit Program:** Implement a voluntary diesel retrofit program by an appropriate state agency; state tax incentives will be available at a later date corresponding to the new federal emissions standards for particulates and nitrogen oxides.
- **Emissions Standards:** The state will establish CO_2 emissions standards for the various equipment categories based on engine horsepower.

Promotion and Marketing

- Encourage local and county governments to act consistently with and support state actions.
- Encourage federal agencies located within the state to act accordingly with and support state actions.
- Encourage private businesses that use these types of equipment within the state to act accordingly with and support state actions.
- Encourage the airports located in the primary Montana cities to act accordingly with and support state actions.
- The state will develop information about the emissions reductions from retrofit technologies on the various off-road engines and vehicles.
- Implement a voluntary diesel retrofit program by an appropriate state agency; state tax incentives will be available at a later date corresponding to the new federal emissions standards of particulates and nitrogen oxides.
- All state-supported programs should have good information and materials for promoting the program and dedicated detailed Web sites. As discussed in other options, publicity about successful program partners will help spread public awareness.

Technical Assistance:

- Contact the manufacturers of the various off-road emission reductions technologies to coordinate objectives and obtain technical support for outreach materials.
- The EPA has developed the Voluntary Diesel Retrofit Program with a designated Web site. The program will address pollution from diesel construction equipment and HDVs that are currently on the road. The program Web site is designed to help fleet operators, air quality planners in state and local government, and retrofit manufacturers understand this program and obtain the information they need to create effective retrofit projects.

Funding Mechanisms and/or Incentives:

- The appropriate state agency would establish a voluntary program to retrofit diesel engines in a rebate program.
- Users of off-road diesel engines who retrofit with emission controls would qualify for a credit against Montana income or business taxes (whichever is relevant) to a percentage (such as 25%) of the retrofit costs.
- Funding for feebates and/or tax credits for new off-road engines and vehicles would be proposed through legislative action. Owners would qualify for a credit against Montana income or business taxes (whichever is relevant) to a percentage (such as 10%) of the original costs (tax credit). Another option is to impose an additional fee as part of the engine maintenance costs, which would be based on the age of the engine.
- Funding may be available through the EPA Voluntary Diesel Retrofit Program, which will be dependent on the President's FY07 budget.
- Potentially, manufacturers may offer incentives to purchase new off-road engines and vehicles when the new emission standards are in effect (refer to the last section).
- In addition to the above-mentioned standards, the CCAC recommends that the legislature create a "pleasure fuel fee" to apply to fuel used for off-road luxury vehicles.

Codes and Standards: The state will rigorously review and research the CO_2 emissions standards for the various off-road equipment categories as established by another regulatory agency before adoption. The Manufacturers of Emission Controls Association will also be contacted for additional information.

Pilots and Demonstrations: Coordinate with product developers to help them promote their retrofit technologies.

Reporting: A tracking system will be difficult to develop since this is a voluntary program; however, if tax credit programs are initiated, emissions reductions can be estimated from both the installation of off-road retrofit technologies and the acquisition of new off-road engines and vehicles.

Enforcement: No enforcement actions are necessary since this is a voluntary program.

Related Policies/Programs in Place

The EPA promulgated the Clean Air Non-road Diesel Rule in 2004. The new emissions standards apply to diesel engines used in most construction, agricultural, industrial, and airport equipment. The particulate and nitrogen oxides standards will take effect for new engines beginning in 2008, with interim standards in 2010, and fully phased in for most engines by 2014. This comprehensive rule will reduce emissions from off-road diesel engines by integrating engine and fuel controls as a system to gain the greatest emission reductions. Engine manufacturers will produce engines with advanced emission-control technologies similar to those upcoming for highway trucks and buses.

In addition, the EPA limited the fuel sulfur levels in non-road diesel fuel to prevent damage to the emissions control systems starting in 2007. The fuel sulfur levels will be limited to a maximum of 500 parts per million (ppm), the same as for current highway diesel fuel. Starting in 2010, fuel sulfur levels in most non-road diesel fuel will be reduced to 15 ppm.

Type(s) of GHG Reductions

Not quantified.

Estimated GHG Savings and Cost Per Ton

Off-Road Engines & Vehicles GHG Reductions	2010	2020	Units
GHG emission savings	Not quantified	Not quantified	$MMtCO_2e$
Net present value (2006–2020)			$ Million
Cumulative emissions reductions (2006–2020)			$MMtCO_2e$
Cost-effectiveness			$\$/MtCO_2e$

$MMtCO_2e$ = million metric tons of carbon dioxide equivalents.

Key Uncertainties

None identified.

Additional Benefits and Costs

None identified.

Feasibility Issues

None identified.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None identified.

TLU-13. Reduced GHG Emissions From Aviation

Policy Description

The State of Montana would encourage the federal government to take actions reducing GHG emissions from the aviation portion of the transportation sector. Those actions could include promotion and use of existing aircraft technologies and programs to reduce emissions, such as Reduced Vertical Separation Minimums (RVSM), Required Navigation Performance (RNP), System for Assessing Aviation's Global Emissions (SAGE), and Voluntary Airport Low Emissions (VALE) Program.

Since the state and local governments do not have authority over in-air operations of airplanes, the state would work with other states to encourage the United States federal government to take significant actions in this arena.

Working in cooperation with other state governments, the State of Montana would seek to develop and encourage a set of federal policies that would significantly reduce GHG emissions reductions from the in-air operation of airplanes.

Policy Design

This policy recognizes the contribution of aviation sector for GHG emissions and the limited ability of Montana or any individual state to impact this sector. Consequently, the policy is to observe and encourage federal actions.

Goal Levels: Seek development of federal government policies to reduce GHG emissions from aviation.

Timing: Activities to begin immediately.

Parties Involved: Appropriate state government agencies.

Implementation Mechanisms

None cited.

Related Policies/Programs in Place

None cited.

Estimated GHG Savings and Cost Per Ton

Not estimated. GHG emissions reductions would be calculated for the nation as a whole, and would be credited consistent with United Nations Framework Convention on Climate Change (UNFCCC) guidelines on a national basis.

Key Uncertainties

None identified.

Additional Benefits and Costs

None identified.

Feasibility Issues

None identified.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None identified.

Appendix I
Agriculture, Forestry, and Waste Management Policy Recommendations

Summary List of Policy Option Recommendations

	Policy Option	GHG Reductions (MMtCO$_2$e)			Net Present Value 2007–2020 (Million $)	Cost-Effectiveness ($/tCO$_2$e)	Level of Support
		2010	2020	Total 2007–2020			
AFW-1	Agricultural Soil Carbon Management – Conservation/No-Till	0.15	0.37	3.7	0	0	UC
	Agricultural Soil Carbon Management – Organic Farming	*Not quantified*					
AFW-2	Biodiesel Production (Incentives for Feedstocks and Production Plants)	0.02	0.15	0.9	13	14	UC
AFW-3	Ethanol Production	0.02	0.39	2.2	10	4	UC
AFW-4*	Incentives for Enhancing GHG Benefits of Conservation Provisions of Farm Bill Programs	0.5	1.6	15	181	12	UC
AFW-5	Preserve Open Space and Working Lands – Agriculture	0.003	0.02	0.12	5	32	UC
	Preserve Open Space and Working Lands – Forests	0.03	0.1	0.9	3	3	
AFW-6[†]							
AFW-7[‡]	Expanded Use of Biomass Feedstocks for Energy Use	0.04	0.15	1.1	–25	–23	UC
AFW-8	Afforestation/Reforestation Programs – Restocking	0.09	0.5	3.4	41	12	UC
	Afforestation/Reforestation Programs – Urban Trees	0.001	0.006	0.04	–0.1	–3	
AFW-9	Improved Management and Restoration of Existing Stands	0.05	0.2	1.3	159	119	UC
AFW-10	Expanded Use of Wood Products for Building Materials	*Not quantified*					UC
AFW-11	Programs to Promote Local Food and Fiber	0.01	0.02	0.12	0.5	5	UC
AFW-12	Enhanced Solid Waste Recovery and Recycling	0.05	0.55	3.3	58	17	UC
	Sector Total After Adjusting for Overlaps	**0.44**	**2.4**	**17**	**446**	**26**	
	Reductions From Recent Actions	**0**	**0**	**0**	**0**	**0**	
	Sector Total Plus Recent Actions	**0.44**	**2.4**	**17**	**446**	**26**	

GHG = greenhouse gas; MMtCO$_2$e = million metric tons of carbon dioxide equivalents; UC = Unanimous consent.

* The reductions for AFW-4 were not included in the total GHG reductions for this sector. These emissions relate to the protection of agricultural soil carbon and the potential emissions were not included in the GHG forecast for the agricultural sector.

[†] AFW-6 was folded into AFW-7 through AFW-9.

[‡] For AFW-7, these reductions are associated with the use of additional woody biomass not consumed within the renewable energy options in the ES and RCII sectors.

AFW-1. Agricultural Soil Carbon Management Programs – Conservation/No-Till and Organic Farming

Policy Description

Use of conservation tillage/no-till and other soil management practices can increase the level of organic carbon in the soil, which sequesters carbon dioxide (CO_2) from the atmosphere. In addition, some practices lower fossil fuel consumption through less intensive equipment use. Other practices, such as the application of bio-char can also increase the level of soil carbon and improve the soil. Organic farming methods may tend toward an increased use of these soil management practices. This option is designed to increase the acreage using soil management practices that lead to higher soil carbon content for both conventional and organic farming.

Policy Design

Goals: Montana should adopt programs to increase the acres of cropland managed using best management practices, including conservation/no-tillage practices, by 50%. Currently there are approximately 18 million acres of cropland in Montana. Based on 2004 data, 3 million acres were in the Conservation Reserve Program (CRP), 7.9 million acres were in tillage, and the remaining 7.1 million acres were in summer fallow. A total of 5.5 million acres were in no-till (3.6 million acres were cropped and 1.9 million acres were in chemfallow). The acreage that could be used to sequester atmospheric carbon dioxide would be the remaining 9.5 million acres, including the 1.7 million acres currently managed by mulch-till practices that sequester a lesser fraction of carbon from the atmosphere.

An organic farming component is also included in this policy design recognizing that additional assessment and understanding of greenhouse gas (GHG) benefits is needed in the future. Compared to no-tillage systems, organic farming uses higher levels of tillage to manage weeds, to terminate cover crops and, in some cases, organic farming results in lower yields (leading to diminished GHG benefits). However, organic farming also does not use pesticides/herbicides and synthetic fertilizers and might achieve higher soil carbon levels than conservation tillage/no-till practices (leading to increased GHG benefits). Organic farming acreage is increasing at the following projected rates: 126,450 acres in 2005; 215,768 acres in 2010; 305,086 acres in 2015; and 394,404 acres in 2020. The initial goal will be to increase the organic acreage 15% above projected levels in 2015 and to 50% above 2025 levels for practices known to achieve net GHG benefits.

Timing: From 2007 to 2012 achieve a 20% increase in acres of cropland brought into no-till management practices, or an additional 1.1 million acres. By 2020, achieve a 50% increase in acreage for a total increase of 2.8 million acres in no-till/conservation tillage. This seems to be a reasonable goal considering that 1.7 million acres already in mulch-till practice could be brought into the no-till practices with incentives.

This policy also seeks an increase in organic farming acreage of 15% above the projected acreage in 2015 and 50% above the levels currently projected for 2025.

Coverage of Parties: Local Agricultural Extension offices, Montana Conservation District offices, United States Department of Agriculture–Natural Resources Conservation Service (USDA-NRCS) field offices, Montana Salinity Control Program, National Carbon Offset Coalition (NCOC), Montana Chapter of Soil and Water Conservation Society, Montana State University (MSU) Land Resource and Environmental Sciences (LRES) program, certified crop consultants, Montana Grain Growers Association.

Other: Policy goals for soil carbon sequestration on rangelands were not addressed by the Technical Work Group (TWG) under this policy option; however, additional information regarding opportunities for implementing GHG beneficial programs on rangelands is provided under Additional Benefits and Costs below.

Implementation Mechanisms

Conservation Security Program (CSP): Federal funding of the CSP at levels specified in the 2002 Farm Bill would help provide incentives for participation in no-till and other conservation soil management strategies.

Equipment Rebate Programs: Economic incentives to transition to no-till practices might include a program that provides rebates for machinery traded in for no-till machinery (such as a 50% rebate), similar to automobile industry practices for replacing older low-gas mileage vehicles with new more fuel-efficient vehicles.

Educational Outreach: Change the perception of no-till practices among established farmers who a) continue to use historical cultivation practices, b) need technical and financial assistance to become comfortable with and to acquire the new technology needed, c) are concerned that insect control and plant disease management strategies may be impacted, and d) are wary of new practices that are not used by neighbors and that may negatively impact income from the farming enterprise.

Other Incentives: Improve the federal and state general cost-share programs to include no-till, removing some of the special area and conditions restrictions so it can fit under Environmental Quality Incentives Program (EQIP) and CSP.

Related Policies/Programs in Place

Conservation Reserve Program: The CRP rewards farmers financially for removing highly erodible and marginally productive land from production. CRP is currently capped at 25% of Montana cropland per county.

Conservation Security Program (CSP).

Environmental Quality Incentives Program (EQIP).

Note: Both CSP and EQIP are relatively new programs designed to increase and provide cost-share for implementation of best management practices. These practices including, but not limited to, adoption of no-till farming practices.

Montana and USDA programs.

MSU Agriculture Research and Development programs.

Type(s) of GHG Reductions

CO_2: Reducing tillage and soil disturbance slows the breakdown of plant material on the soil surface and in the root zone, accelerating the microbial processes that stabilize carbon and protect carbon from oxidation, inhibiting the release of carbon back into the atmosphere. Depending on how the adoption of conservation tillage and organic production methods affects the overall crop production cycle, additional CO_2 reductions can occur through lower fossil fuel consumption in farm equipment. Note that some studies have shown higher fuel consumption using organic techniques than using conventional production techniques. Organic production methods also reduce GHG emissions associated with the production, transport, and application of pesticides, herbicides, and other chemical treatments.

N_2O: To the extent that fossil fuel consumption is lowered through the cultivation methods implemented under this policy, nitrous oxide (N_2O) emissions from fuel combustion will be lowered. It is important to note that research indicates the potential for higher N_2O emissions as soil organic carbon levels increase.[1]

CH_4: To the extent that fossil fuel consumption is lowered through the cultivation methods implemented under this policy, methane (CH_4) emissions from fuel combustion will be lowered.

Estimated GHG Savings and Costs per $MtCO_2e$

GHG Reduction Potential in 2010, 2020 million metric tons of carbon dioxide equivalents ($MMtCO_2e$): 0.15, 0.37.

The reductions reported above and costs below only cover those associated with the conservation tillage/no-till elements of this policy option. The reductions to be achieved by the organic farming element could not be quantified with available information on the net GHG reduction potential of organic farming methods on Montana crop systems.

Net Cost per $MtCO_2e$: $0.

Data Sources:

Conservation Tillage/No-Till

Agricultural soil carbon accumulation levels are from a 2004 MontGuide Fact Sheet from the MSU Extension Service.[2] This report states that no-till practices result in an increase of soil carbon of 0.045 ton/acre over 10 years.

The reduction in fossil diesel fuel use from the adoption of conservation tillage methods is 3.5 gallons/acre.[3] From the Montana Inventory and Forecast, the fossil diesel GHG emission

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[1] Li et al., "Carbon Sequestration in Arable Soils Is Likely To Increase Nitrous Oxide Emissions, Offsetting Reductions in Climate Radiative Forcing," *Climate Change,* 72:321–338, 2005.

[2] P. Miller, R. Engel, and R. Brinklemyer, *Soil Carbon Sequestration: Farm Management Practices Can Affect Greenhouse Gases*, MontGuide Fact Sheet #200404/Agriculture from the Montana State University Extension Service.

factor is 8.37 $MtCO_2e$/1,000 gallons. Costs for adoption of conservation tillage/no-till practices are estimated to be $0 based on averaging costs from two studies. The first study from North Carolina State University on applying these practices to cotton growing in North Carolina resulted in cost savings ranging from about $3 to $14 per acre per year.[4] The Center for Climate Strategies (CCS) used the low end of the range as a conservative estimate of cost savings. The second study from Iowa found that a subsidy of $3 would be required to get non-adopters to switch to no-till.[5]

Organic Farming

While organic farming practices are known to result in increases to soil organic carbon, the overall net GHG benefits are less certain. A new systematic study of organic farming methods in the United Kingdom[6] showed that with some agricultural systems, organic farming can produce net GHG benefits, while under others, GHG emissions were higher than in the analogous conventional system. The higher GHG emissions from organic systems in some cases are due to the need for additional mechanical cultivation since chemicals are not used (resulting in higher fossil fuel combustion). On the other hand, there is a reduction in chemical usage and the embedded fossil fuels used to produce and transport these products. There is also the potential, in some cases, for differing crop yields between organic and conventional systems (which leads to differing GHG emissions per ton of product).

Given these and other uncertainties, systematic studies are needed for Montana crop systems to determine where organic production methods can yield net GHG benefits. Once these systems are established, the policy calls for promoting those where net GHG benefits occur. This element of this policy proposal therefore remains unquantified.

Quantification Methods:

Conservation Tillage/No-Till

Based on the policy design parameters, the schedule for acres to be put into conservation tillage/no-till cultivation is shown in Table I-1. It was further assumed that the additional carbon would be sequestered in the soil over a period of 10 years (after 10 years, no further carbon is stored). The resulting annual carbon accumulation rate cited above was converted into its CO_2 equivalent yielding 0.15 $MtCO_2$/acre/year.

To estimate carbon stored each year, the annual accumulation rate was multiplied by the number of acres in the policy program each year. After 10 years, the crop acres that entered the program were assumed to not store additional carbon. Results are shown in Table I-1.

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[3] Reduction associated with conservation tillage compared to conventional tillage, at http://www.ctic.purdue.edu/Core4/CT/CRM/Benefits.html, accessed August 2006.

[4] $3–$14/acre savings dependent on comparison of no-till to either strip till or conventional tillage. From "Economic Comparison of Three Cotton Tillage Systems in Three NC Regions," S. Walton and G. Bullen, NCSU, at www.ces.ncsu.edu/depts/agecon/Cotton_Econ/production/Economic_Comparison.ppt, accessed February 2007.

[5] "Costs and Environmental Effects From Conservation Tillage Adoption in Iowa," Lyubov Kurkalova, Catherine Kling, and Jinhua Zhao.

[6] *Environmental Impacts of Food Production and Consumption,* Manchester Business School, prepared for the Department for Environment, Food and Rural Affairs, December 2006, http://www.defra.gov.uk/science/project_data/DocumentLibrary/EV02007/EV02007_4601_FRP.pdf

Additional GHG savings from reduced fossil fuel consumption were estimated by multiplying the fossil diesel emission factor and diesel fuel reduction per acre estimate provided above. Results are shown in Table I-1 along with a total estimated benefit from both carbon sequestration and fossil fuel reductions.

Table I-1. Schedule for acres to be put into conservation tillage/no-till cultivation

Year	Acres in Program	Acres Still Accumulating Carbon	$MMtCO_2e$ Sequestered	Diesel Saved (1,000 gal)	$MMtCO_2e$ From Diesel Avoided	Total $MMtCO_2e$ Saved
2006	0	0	0.00	0	0.00	0.00
2007	0	0	0.00	0	0.00	0.00
2008	275,000	275,000	0.04	963	0.01	0.05
2009	504,167	504,167	0.08	1,765	0.01	0.09
2010	825,000	825,000	0.12	2,888	0.02	0.15
2011	1,054,167	1,054,167	0.16	3,690	0.03	0.19
2012	1,283,333	1,283,333	0.19	4,492	0.04	0.23
2013	1,512,500	1,512,500	0.23	5,294	0.04	0.27
2014	1,741,667	1,741,667	0.26	6,096	0.05	0.31
2015	1,970,833	1,970,833	0.30	6,898	0.06	0.35
2016	2,200,000	2,200,000	0.33	7,700	0.06	0.39
2017	2,429,167	2,429,167	0.36	8,502	0.07	0.43
2018	2,658,333	2,383,333	0.36	9,304	0.08	0.43
2019	2,887,500	2,383,333	0.36	10,106	0.08	0.44
2020	2,750,000	1,925,000	0.29	9,625	0.08	0.37

Key Assumptions:

The assumed carbon sequestration potential is representative across all of the crop systems to which the policy is applied; a 10-year period for accumulating the soil carbon; no additional significant accumulation of soil carbon after 10 years; any potential increase in N_2O emissions is not large enough to significantly affect the estimated benefits; cost savings is a representative average of savings to be achieved across all crop systems.

Key Uncertainties

Most of the conservation tillage considered business as usual (BAU) in this analysis is being done for soil conservation instead of carbon sequestration. These acres may be tilled periodically, since doing so does not significantly harm the soil conservation goal. Only an estimated 15% of the conservation tillage reported is continuous. However, periodic tilling can have a significant negative effect on the carbon sequestration goal, as the emissions in one tilling cycle can destroy several years' worth of no-till carbon sequestration. Incentives to early adopters of conservation tillage may be required to prevent periodic tillage and the resulting soil carbon losses.

Additional Benefits and Costs

These include reduced emissions of criteria and toxic air pollutants from fossil fuel combustion.

No attempt has been made to quantify the potential for carbon sequestration on rangeland in Montana. This brief explanation of the opportunity for rangeland sequestration and the management practices required to obtain the desired sequestration is meant to identify the benefits of such practices and to ensure the recognition of rangeland management to reducing GHGs in any proposed Montana state GHG mitigation initiatives.[7]

The USDA NRCS defines rangeland as "Land on which the historic plant community is principally native grasses, grass-like plants, forbs or shrubs suitable for grazing and browsing. In most cases, range supports native vegetation that is extensively managed through the control of livestock rather than by agronomy practices, such as fertilization, mowing, or irrigation. Rangeland also includes areas that have been seeded to introduced species (e.g., clover or crested wheatgrass) but are managed with the same methods as native range."

Rangeland management practices that increase carbon sequestration in rangeland soils include the following tools:

- Light or moderate stocking rates, and
- Sustainable livestock distribution, which includes rotational grazing and seasonal use.

In Montana, the soil sequestration rates currently established for sustainable grazing systems range from 0.12 $MtCO_2$/acre to 0.40 $MtCO_2$/acre. The sequestration rate depends on the determination of whether the range is in a non-degraded or degraded condition. The NRCS has established indicators of degraded rangeland that are published in the 2005 "Interpreting Indicators of Rangeland Health." NRCS Field Office Technical Guides provide guidelines for managing the controlled harvest of vegetation with grazing animals. Stocking rates and livestock distribution criteria are defined according to county and state in the NRCS "Prescribed Grazing Specification" code.

Feasibility Issues

Because of the high amount of intermittent or periodic no-till cultivation being implemented in the state, the BAU for Montana cropland is any tillage based soil management or conservation tillage system that has been adopted for soil conservation or fuel reduction purposes but not for generating carbon sequestration or offset credits (i.e., including intermittent no-till cultivation). With this understanding of BAU, farmers who adopt continuous no-till practices could be eligible to take part in carbon crediting programs (e.g., Chicago Climate Exchange).

The following are reasons for this definition:

- Currently there are no governmental requirements for continuous no-till (i.e., direct seed) cropping for carbon sequestration. A significant amount of the existing no-till acreage in Montana is therefore potentially subjected to periodic tillage for weed management or seeding with wide-shovel furrow openers. Where this is the case, the soil conservation effects of the practice are maintained, but much if not most of the carbon sequestration impact is lost.

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[7] Information on rangelands provided by T. Dodge, AFW TWG, to S. Roe, CCS, May 2007.

- Moving producers from intermittent tillage to continuous no-till direct seed cropping provides a carbon benefit while at the same time reducing the flexibility to do intermittent tillage, and it may require producers to use different equipment.

Accommodations for early adopters are also needed.

The small percentage of cropland in Montana that is in continuous no-till direct seed cropping will continue to provide CO_2 reductions for 10 to 15 additional years, depending on adoption year. Not allowing these operators to begin to receive credit for their management is to penalize early action when it is in the best interest of the State of Montana to give credit for early action and encourage voluntary reductions for CO_2.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

AFW-2. Biodiesel Production
(Incentives for Feedstocks and Production Plants)

Policy Description

The use of biodiesel offsets the consumption of diesel fuel produced from oil (fossil diesel). Since biodiesel has a lower GHG content than fossil diesel (being derived from biogenic sources), overall GHG emissions are reduced. By producing biodiesel in the state for consumption within the state, the highest benefits can be achieved, since the fuel is transported over shorter distances to the end user (as compared with importing biodiesel to Montana from other states). This option covers incentives needed to increase biodiesel production in Montana.

Note that this policy option is linked with the low-carbon fuels policy in the Transportation and Land Use (TLU) sector. That policy option seeks to achieve greater consumption of lower carbon fuels in the state, while this option seeks to promote lower carbon fuel production in the state (to help meet future demand).

Policy Design

Goals: Produce sufficient biodiesel from Montana feedstocks to meet 2%, 10%, and 20% of 2004 Montana petroleum diesel consumption by 2010, 2015, and 2020, respectively.

Timing: See above.

Parties Involved: Montana Department of Environmental Quality (MDEQ), Montana Department of Agriculture (MDOA), Montana Farmers Union, Resource Conservation and Development, Montana Grain Growers, MSU, Montana Livestock Associations.

Other: According to the Montana Department of Transportation (MDT), the 2004 petroleum diesel consumption in Montana was 372 million gallons (MG). Of this total, 220 MG were used by on-road vehicles and 152 MG were used for off-road equipment (primarily in construction, mining, and locomotive use). Production targets would be 7 million gallons/year (MGY) in 2010, 37 MGY in 2015, and 74 MGY in 2020.

Implementation Mechanisms

Financial Incentives: Financial assistance (e.g., tax breaks, grants, and payments) for oilseed producers.

- Extend the biodiesel production incentive when it expires in 2010.
- Provide payments to growers in the amount of the difference between the highest incomes they could otherwise receive from oil seeds and the cost of growing oil seeds. Examples of the highest income that could be received include the cost of growing oil seeds for human food or the cost of leaving land in CRP.

Research and Development: Research and development of oil-bearing feedstocks (e.g., oilseeds, algae) and production processes for co-products and agricultural uses.

Information and Outreach: Education programs for

- Livestock producers to utilize feed co-products;
- Growers of oil seeds and other feedstocks and professionals who provide technical assistance to these groups;
- Consumers to link demand-side mechanisms under TLU Policy Option 6 (TLU-6) to the benefits associated with fuels produced in-state (e.g., fossil fuel dependence and benefits for in-state agriculture); and
- Industry to increase awareness of biodiesel incentives, including the availability of tax incentives to producers, oil seed crushers, distributors, retailers, and consumers.

Business Development: Recruit biodiesel producers to locate facilities in Montana.

Intergovernmental Coordination: Create an interagency work group to coordinate efforts at the MDOA, MDEQ, Montana Department of Commerce, Montana Department of Labor and Industry, MDT, the Governor's Office of Economic Development, and universities to identify barriers to biodiesel production and use in Montana.

Coordinated Permitting of Facilities: Separate permits are potentially required for air quality, water quality, and waste management at biodiesel production facilities. MDEQ should establish internal procedures to allow for coordinated permitting guidelines from all parts of the department and, when necessary, to convey requirements of other agencies such as the MDT.

Biodiesel Testing Facility: Establish an in-state facility to test biodiesel to ensure that the American Society for Testing and Materials (ASTM) standards are met by new companies starting biodiesel production and as companies grow.

State Lead by Example: Establish a biodiesel fueling system and use biodiesel in the state government fleet. Include requirements for state-hired contractors to use biodiesel.

Related Policies/Programs in Place

Biodiesel Production Incentive: This is a 10-cent-per-gallon tax biodiesel production incentive. For the first year of production, the incentive is for the total gallons produced, and then the incentive is for the additional gallons produced over and above the previous year for up to 3 years. This incentive is paid from the state general fund to produce, refine, or manufacture biodiesel for sale, use, or distribution (15-70-601 Montana Code Annotated [MCA]) and terminates in 2010.

Tax Credit for Investment in Oil Seed Crush Facility: This is a tax credit of 15% of the cost of depreciable equipment invested in property to crush oil seeds for up to $500,000. The credit may be carried forward for up to 7 years (15-32-701 MCA and 2007 Legislature House Bill [HB] 166).

Tax Credit for Investment in Biodiesel Production Facility: This is a tax credit of 15% of the cost for construction and equipment in a facility that produces biodiesel. The tax can be carried forward for up to 7 years (15-32-701 MCA and 2007 Legislature HB 166).

Tax Credit for the Storage and Blending of Biodiesel: This is a tax credit of 15% of the cost of equipment needed to store and blend biodiesel. A distributor can claim up to $52,500 and a motor fuel outlet can claim up to $7,000 (15-32-703 MCA and 2007 Legislature HB 166).

Refund for Biodiesel Taxes Paid: A licensed distributor may claim a refund of 2 cents per gallon for biodiesel sold when the biodiesel is made from Montana products, and retailers can claim 1 cent per gallon sold (15-70-369 MCA).

Property Tax Abatement: The May 2007 Special Session of the Montana Legislature passed a comprehensive tax abatement bill for the development of clean energy in Montana. Biodiesel production and research and demonstration facilities would receive an abatement of property taxes (May 2007 Legislature Special Session HB 3).

Training for Students and Professionals: Montana has received a federal Work Force Innovation and Rural Economic Development (WIRED) grant to assist with the development of biodiesel and ethanol by training students at Montana schools and by educating professionals who will work with biodiesel, thus building the human capital for future GHG reductions through biodiesel production.

CO_2: Life cycle emissions are reduced to the extent that biodiesel is produced with lower embedded fossil-based carbon than conventional (i.e., fossil) diesel fuel. Feedstocks used for producing biodiesel can be made from crops or other biomass, which contain carbon sequestered during photosynthesis (e.g., biogenic or short-term carbon). The primary feedstocks for biodiesel are oils derived from oilseed crops (e.g., soybeans, canola, sunflower camelina, or algal) and alcohols (either methanol or ethanol). From a recent report (Hill et al., 2006),[8] biodiesel from soybeans contains 93% more usable energy than its petroleum equivalent and reduces life cycle GHG emissions by as much as 41%. Higher oil production potential of different feedstocks (e.g., other oil crops, algae) will likely adjust the life cycle GHG emissions further downward as they are developed as biodiesel sources. Local production of biodiesel also decreases the embedded CO_2e of biodiesel compared with importation of out-of-state vegetable oil supplies.

Estimated GHG Savings and Costs per MtCO_2e

GHG Reduction Potential in 2010, 2020 (MMtCO_2e): 0.02, 0.15.

Note: these estimated reductions are incremental to those estimated for low carbon fuels standard under TLU-6 (assumes that lower carbon diesel fuel demand is met primarily through soybean-based biodiesel).

Net Cost per MtCO_2e: $14.

Data Sources: The CO_2e emission factor for fossil diesel combustion used in the Inventory and Forecast is 10.04 Mt/1,000 gallons. The life cycle fossil diesel emission factor is 12.3 Mt/1,000 gallons.[8] The life cycle emission factor includes the emissions from combustion plus the

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[8] Hill et al., 2006, "Environmental, economic, and energetic costs and benefits of biodiesel and ethanol biofuels," *Proceedings of the National Academy of Sciences,* 103:11206–11210, July 25, 2006.

emissions associated with petroleum extraction, processing, and distribution. Information on potential production of crop oil feedstocks in Montana was provided by MDOA.

Quantification Methods:

GHG Reductions

A new study on life cycle GHG benefits for biodiesel production and use was used to estimate the CO_2e reductions for this option.[9] This study covered biodiesel production from soybean production, which is currently the predominant feedstock source for biodiesel production in the United States and is assumed to remain that way for the purposes of this analysis. Life cycle CO_2e reductions (via displacement of fossil diesel with soybean-derived biodiesel) were estimated by Hill et al. to be 41%. This value is being used to estimate the benefit of the biodiesel component of the TLU biofuels option. Hence, this analysis focuses on incremental benefits of in-state feedstocks (i.e., oil) production with the focus on vegetable oils that produce greater volumes of oil per unit of energy input (e.g., canola).

As a result of biodiesel processing, each gallon of vegetable oil will produce slightly less than one gallon of biodiesel. However, for the purposes of this analysis, each gallon is assumed to produce one gallon of biodiesel.

Feedstocks included in this analysis are canola, camelina, sunflower, mustard, and safflower oil. For oil sources other than soybean oil, the benefit for substituting in-state biodiesel for fossil diesel is estimated starting with the life cycle soybean emission factor (7,261 $MtCO_2e$/million gallons [MMgal] from the Hill et al. study).

As shown in Table I-2, by 2020, MDOA estimates that canola can produce 80 gallons of oil per acre compared with soybeans, which produce 46 gallons/acre. Assuming canola production energy inputs are not significantly greater than soy, the life cycle emission rate for canola would be 7,261 × 46/80 or 4,175 $MtCO_2e$/MMgal. Therefore, the incremental benefit of canola over soy is 7,261– 4,175 = 3,086 $MtCO_2e$/MMgal. The other crops shown in Table I-2 also produce greater volumes of oil per acre than soy, except for mustard. Hence, the incremental GHG benefit for obtaining feedstock from mustard versus soy is zero.

The mix of oil feedstocks assumed in this analysis is shown in Table I-2.[10] Biodiesel gallons per acre were derived for 2010 based on 8-year oilseed yields and currently available oil extraction technologies. The 2015 gallon amounts were largely increased by assuming that more efficient extraction and processing technologies will be readily available at that time. The 2020 amounts assumed increases in yield and oil content based on the annual millions of dollars in agronomic research investment as illustrated by more than 20 years of work with safflower.

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[9] Ibid.

[10] Crop share estimates provided by Howard Haines, Montana DEQ.

Table I-2. Estimated seed oil feedstock production and acreage needs

Crop	Crop Share, %	Gallons of Oil per Acre	Biodiesel (MGY)	Estimated Acres (1,000)
2010				
Canola	29.0	58	2.2	37
Camelina	48.0	32	3.5	111
Mustard	12.0	30	0.9	29
Safflower	11.0	40	0.8	20
Sunflower	0	41	0.0	0
Total	**100.0**		**7.4**	**197**
2015				
Canola	25.0	64	9.2	145
Camelina	40.0	60	14.8	244
Mustard	13.9	32	5.2	161
Safflower	20.0	44	7.4	168
Sunflower	1.1	51	0.4	8
Total	**100.0**		**37**	**726**
2020				
Canola	30.0	80	22.2	278
Camelina	42.0	70	31.2	446
Mustard	24.0	42	17.8	425
Safflower	3.5	55	2.5	47
Sunflower	0.5	64	0.3	6
Total	**100.0**		**74**	**1,202**

GHG reductions were estimated by multiplying the production of each oil feedstock by the applicable incremental energy-related benefit (e.g., by oil type). Total reductions in each year were estimated by summing the incremental benefit for each oil type (i.e., incremental benefit over soy).

Costs

Costs were estimated using information from an analysis of biodiesel production costs from the United States Department of Energy (US DOE).[11] Costs of this option are assumed to be equal to the value of incentives needed to encourage meeting the biodiesel production targets. The value of those incentives is assumed to be equivalent to the difference in the costs of producing fossil diesel and soy-based biodiesel ($0.34/gallon). This value is very close to the incentive offered in a State of Missouri incentives program.[12] This program offers production incentives of $0.30/gallon to producers of up to 15 MGY. The incentive grants last for 5 years. This analysis assumed a similar incentive structure in Montana, and that these would cover the costs of all grants or tax incentives associated with this policy (all other implementation mechanisms are assumed to be achieved within existing programs). The cost estimates for this option are based therefore on multiplying the amount of biodiesel produced

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[11] See www.eia.doe.gov/oiaf/analysispaper/biodiesel/index.html, accessed January 2007.

[12] Information on the Missouri Program: www.newrules.org/agri/mobiofuels.html#biodiesel, accessed January 2007.

in each year by the production incentive. This assumes that all production occurs at production facilities of less than 15 MGY. The production incentive runs out after 5 years of production. The existing $0.10/gallon incentive in Montana was factored into the cost-effectiveness estimate. Information on the value of the other biodiesel production incentives was not readily available to factor into this analysis.

Table I-3 summarizes the calculation of the levelized and discounted cost-effectiveness calculated for this policy option, given the incentive payment and the production schedule above. It is calculated by dividing the total discounted costs of the policy option (5% discount rate applied) by the total metric tons of CO_2e reduced by the option. Incentive costs are only incurred for the first 5 years (as mentioned above).

Table I-3. Calculation of discounted and levelized cost-effectiveness

Year	Capacity Needed (1,000 gallons)	Incentive Costs	Discounted Cost	Avoided Emissions ($MMtCO_2e$)	Cost-Effectiveness	Levelized / Discounted CE
2007	0	$0	$0	0.00		
2008	2,480	$595,200	$595,200	0.01	$108	
2009	4,960	$1,190,400	$1,133,714	0.01	$103	
2010	7,440	$1,785,600	$1,619,592	0.02	$98	
2011	13,392	$4,553,280	$3,933,294	0.03	$139	
2012	19,344	$6,576,960	$5,410,881	0.04	$135	
2013	25,296	$0	$0	0.05	—	
2014	31,248	$0	$0	0.06	—	
2015	37,200	$0	$0	0.08	—	
2016	44,640	$0	$0	0.09	—	
2017	52,080	$0	$0	0.11	—	
2018	59,520	$0	$0	0.12	—	
2019	66,960	$0	$0	0.14	—	
2020	74,400	$0	$0	0.15	—	
			$12,692,682	**0.89**		**$14**

Key Assumptions: Life cycle GHG emission factors utilized/derived for this analysis are representative of each feedstock and for fossil diesel. Production incentives offered by this option are sufficient to drive production of GHG-superior feedstocks (i.e., superior to soybeans) and to increase the level of research and development needed for non-crop based feedstocks (e.g., algal biodiesel, Fischer-Tropsch biodiesel).

The inputs into canola and camelina are assumed to be equivalent to soy for this analysis. Soy fixes nitrogen so requires little fertilizer, which may affect the comparison.

Key Uncertainties

Availability of crop acreage to devote to vegetable oil production: the analysis showed a need for 1.2 million acres devoted to vegetable oil production by 2020. There is also the potential for unforeseen impacts on existing animal feed and food crop systems with the level of vegetable oil crop acreage analyzed here. The potential for these impacts, as well as potential impacts to Montana agricultural exports needs further analysis. As mentioned above, the introduction of new and more efficient feedstock sources would lower the amount of acreage required. GHG emissions associated with higher levels of vegetable oil production are assumed to be adequately captured within the life cycle emission factors from recent studies (as described in the Quantification Methods section above).

Oilseed acreage projections do not account for variables in market demand. Global market forces will determine Montana farmers' crop planting decisions, as well as the end-uses of harvested crops. Even if projected oilseed acreages are realized, it is possible that harvested crops will be used for purposes other than biodiesel production.

Additional Benefits and Costs

Increased in-state economic activity, oilseeds as rotational crop, reduced herbicide/pesticide and fertilizer use on traditional crops; increased transportation energy security with shorter transport distances and on-farm use of fuel produced; reduced reliance on imported petroleum.

Feasibility Issues

Sourcing of feedstocks and the size and location of facilities (both crushing and biodiesel production) must be addressed for optimization and planning. Canola may be one of the crops with higher value markets than for biodiesel. Canola oil has very favorable nutritional and culinary qualities. As demand for trans fat–free vegetable oils increases, demand for canola oil and other healthy oils grown in Montana will increase.

There will be interaction with potential ethanol production crops and carbon sequestration, although expanded use of biodiesel will continue to replace/reduce GHG emissions beyond the ability of the land to sequester carbon. There may be an overlap among agricultural options (especially AFW-1 through AFW-4) that should be carefully considered. For example, AFW-1 and AFW-4 seek to increase/maintain crop acreage in no-till production or in conservation management programs. This could be in conflict with the higher levels of crop production proposed in this option.

Some of the crops identified for biodiesel production may have higher value as a food crop. This would limit the amount that could be grown for biodiesel. Camelina is showing promise for oil seed production but has not yet been grown in large quantities, and the long-term results are uncertain.

Global warming may also impact the results since goals in AFW-2 depend on cold climate oilseed production in Montana. Additional warming could favor warmer climate crops such as sunflower and safflower to replace the cold climate crops, but these crops need more water, which may not be available.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

AFW-3. Ethanol Production

Policy Description

Offset fossil fuel use (e.g., gasoline) with production and use of starch-based and cellulosic ethanol. Offsetting gasoline use with ethanol can reduce GHGs to the extent that the ethanol is produced with lower GHG content than gasoline. Provide incentives for the production of ethanol from crops, forest sources, animal waste, and municipal solid waste (MSW). Also encourage cellulosic ethanol production research and development already initiated by the MDOA.

Note that this policy option is linked with the low-carbon fuels policy in the Transportation and Land Use sector. That policy option seeks to achieve greater consumption of lower carbon fuels in the state, while this option seeks to promote lower carbon fuel production in the state (to help meet future demand).

Policy Design

Goals: By 2010, achieve in-state production levels of 50 MGY of starch-based ethanol and 2 MGY of cellulosic production; by 2015, achieve in-state production levels of 110 MGY of starch-based ethanol and 25 MGY of cellulosic production; by 2020, achieve in-state production levels of 250 MGY of starch-based ethanol and 50 MGY of cellulosic production.

Timing: See above.

Parties Involved: MDEQ, MDOA, Montana Farmers Union, Montana Association of Ethanol Producers, Farm Bureau, conservation districts, Montana Extension Service, Montana Stock Growers and Wool Growers Associations, Montana Grain Growers Association and Montana Co-Op Development Center, farmers, Montana Department of Natural Resources and Conservation (DNRC), U.S. Forest Service (USFS), Bureau of Land Management (BLM), MSU Cooperative Extension, University of Montana College of Forestry and Conservation, and the forest products industry.

Other: None.

Implementation Mechanisms

Pilots and Demonstrations: Pilot projects on the use of different forestry and agriculture residues for ethanol production are needed.

Tax Incentives: Provide incentives to reduce the capital costs of ethanol production and transport. Gross receipts exemptions for ethanol production facilities, project construction, and related equipment and materials are also recommended.

Source Reduction: Reduce the amount of open slash pile burning on all land ownerships and/or provide viable alternatives to open burning. Discourage open burning through alternatives to burning provided under the best available control technologies as defined in the Administrative

Rules of Montana, through revised MDEQ air quality permits when permits are needed, and by using local programs to encourage alternatives to burning.

Financial Assistance: Tax breaks or grants for ethanol producers.

Research and Development: Focusing on feedstock supplies (biomass from agricultural residues, MSW, and forestry residue) and production processes (cellulosic processes or starch-based processes achieving similar net GHG benefits).

Information and Education: For target audiences.

- Education programs for livestock producers to utilize feed co-products.
- Education programs for feedstock producers.
- Consumer education programs to link demand-side mechanisms under TLU-6 to the benefits associated with fuels produced in-state (e.g., fossil fuel dependence, benefits for in-state agriculture).

Permitting Process: Streamlined permitting process with coordination between all entities issuing permits for land, water, and air impacts for production facilities.

Business Development: Recruitment of cellulosic/advanced starch-based ethanol producers to locate facilities in Montana.

Related Policies/Programs in Place

The major sections of Montana's laws for ethanol are mostly tax-related and are listed in sections of the MCA.

Tax Credit for Ethanol Production 15-70-522 MCA: This is a tax incentive for the production of alcohol to be blended for gasohol; other laws provide for the proper administration and enforcement of the tax incentive. The incentive on each gallon of alcohol is 20 cents for each gallon that is 100% produced from Montana products to an ethanol producing facility.

Tax Credit for Ethanol Blended Fuels 5-70-204 MCA: This states that gasohol is subject to 85% of the tax imposed in subsection (1)(b), which is 27 cents for each gallon of all other gasoline distributed by the distributor within the state.

Consumer Credit 15-70-221 MCA: This incentive states that a person who purchases and uses any gasoline on which the Montana gasoline license tax has been paid for denatured alcohol to be used in gasohol is eligible for a refund or credit on the gasoline license tax.

Construction Incentive 15-6-220 MCA: This provides that all manufacturing machinery, fixtures, equipment, and tools used for the production of ethanol from grain during the course of the construction of an ethanol manufacturing facility and for 10 years after completion of construction of the manufacturing facility is exempt from property taxation.

Motor Vehicle Conversion Incentive 15-30-164 MCA: This provides a tax credit against taxes for equipment and labor costs incurred to convert a motor vehicle licensed in Montana to operate on alternative fuel. For the purposes of this section, “alternative fuel” includes fuel that is at least 85% methanol, ethanol or other alcohol, ether, or any combination of them.

State Government use of Ethanol 2-17-414 MCA: This states that state government and a state institution of higher education owning or operating a motor vehicle capable of burning ethanol-blended fuel shall take all reasonable steps to ensure that the operators of those vehicles use ethanol-blended fuel (90% gasoline and 10% anhydrous ethanol produced from agricultural products) in the vehicles.

Property Tax Abatement: The May 2007 Special Session of the Montana Legislature passed a comprehensive tax abatement bill for the development of clean energy in Montana. Property tax rate abatement reductions (non-permanent incentives) range from 1.53% to 31.5% and are available for new investments in biodiesel, biomass, biogas, cellulosic ethanol, carbon sequestration equipment, renewable energy manufacturing plants, and research and development equipment for clean coal or renewable energy.

USFS, Northern Region Woody Biomass Utilization Policy: Recently implemented, this policy requires that contractors doing work on federal lands, haul and pile slash at landings to help facilitate removal of biomass during forest operations for utilization.

State Trust Lands Forest Management Program: Recently implemented, the Forest Management Bureau has changed the timber bid sale process for state trust lands to incentivize removal of residues for pulp and biomass by giving priority consideration to bids that include biomass removal.

Type(s) of GHG Reductions

CO_2: Life cycle emissions are reduced to the extent that ethanol is produced with lower embedded fossil-based carbon than conventional (i.e., fossil) fuel. Feedstocks used for producing ethanol can be made from crops or other biomass that contains carbon sequestered during photosynthesis (e.g., biogenic or short-term carbon). There are two different methods for producing ethanol based on two different feedstocks. Starch-based ethanol is derived from corn or other starch/sugar crops. Cellulosic ethanol is made from the cellulose contained in a wide variety of biomass feedstocks, including agricultural residue (e.g., wheat and barley straw), forestry waste, purpose grown crops (e.g., sweet sorghum, switchgrass), and MSW. Local production of ethanol also decreases the embedded CO_2e of ethanol compared with importation from the current U.S. primary ethanol producing regions. Current research indicates that cellulose-based ethanol production provides a reduction in GHGs of up to 72%–85% compared to gasoline, whereas an 18%–29% reduction is measured from starch-based ethanol production compared with gasoline.

Estimated GHG Savings and Costs per $MtCO_2e$

GHG Reduction Potential in 2010, 2020 ($MMtCO_2e$): 0.02, 0.39.

Note: these estimated reductions are incremental to those estimated for low carbon fuels standard under TLU-6 (only reflects the benefit associated with in-state cellulosic ethanol, since it is assumed that the low-carbon gasoline demand under TLU-6 is met primarily through starch-based ethanol. Although some benefit would be achieved by producing starch-based ethanol in-

state versus transporting it from out of state, these incremental benefits are estimated to be minimal).

Net Cost per MtCO$_2$e: $4.

Note: As with the benefits above, the costs are those associated with incentives for cellulosic ethanol feedstocks and production methods.

Data Sources: The computation of the GHG reduction potential and cost-effectiveness of this option is based upon the following data:

Emission factors for gasoline and ethanol (both starch-based and cellulosic) were taken from a General Motors/Argonne National Laboratory Study.
Research completed by the Energy Information Administration (EIA) provided the cost of production for starch-based and cellulosic ethanol.

Quantification Methods:

GHG Reductions

The benefits for this option are dependent on developing in-state production capacity that achieves benefits above the levels of existing and planned (BAU) starch-based production in the United States. In this analysis, this analysis estimates the incremental benefit of the policy option to that achieved via implementation of TLU-6, which promotes consumption of low-carbon fuels. The primary assumption in this analysis is that the reductions in carbon content of gasoline within the policy period achieved through implementation of TLU-6 will be met primarily through higher consumption of starch-based ethanol. Hence, the benefit for this option is driven by the production of fuels in-state that have lower embedded GHG than starch-based ethanol (e.g., cellulosic ethanol).

Emission factors for reformulated gasoline, starch-based ethanol, and cellulosic ethanol were taken from a General Motors/Argonne National Laboratory study.[13] These emission factors incorporate the GHG emissions during the entire life cycle of fuel production (e.g., for gasoline: extraction, transport, refining, distribution, and consumption; for ethanol: crop production, feedstock transport, processing, distribution, and consumption). These life cycle emission factors are referred to as "well-to-wheels" emission factors:

- Reformulated gasoline: 552 grams CO$_2$e/mi
- Starch-based ethanol: 451 grams CO$_2$e/mi
- Cellulosic ethanol: 154 grams CO$_2$e/mi

Based on the emission factors shown above, the incremental benefit of the production targeted by this policy over conventional starch-based ethanol is 66% (reduction of CO$_2$e by offsetting gasoline consumption). This value was used along with the life cycle emission factor for

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[13] "Well-to-Wheels Analysis of Advanced Fuel/Vehicle Systems—A North American Study of Energy Use, Greenhouse Gas Emissions, and Criteria Pollutant Emissions," General Motors, Argonne National Laboratory, and Air Improvement Resource, Inc., May 2005.

gasoline[14] and the production in each year to estimate GHG reductions. Table I-4 gives the amount of cellulosic ethanol and feedstock needed for each year.

Table I-4. Amount of cellulosic ethanol (EtOH) and feedstock for years 2008–2020

Year	MMGal EtOH Capacity Needed	Cellulosic Feedstock Needed (dry tons)
2008	0.7	9,524
2009	1.3	19,048
2010	2.0	28,571
2011	6.6	94,286
2012	11.2	124,444
2013	15.8	175,556
2014	20.4	226,667
2015	25.0	277,778
2016	30.0	333,333
2017	35.0	388,889
2018	40.0	444,444
2019	45.0	500,000
2020	50.0	500,000

Costs

Costs for the incentives needed by this policy option are based on the difference in estimated production costs between conventional starch-based ethanol and cellulosic ethanol. The US DOE EIA estimated that the cost to produce starch-based ethanol is $1.10/gal compared to $1.29/gal, or a difference of $0.19/gal (in $1998).[15] In 2006 dollars, the difference is $0.23/gal. These incentives are considered necessary in the near term (up to 2015) to help commercialize technologies that produce ethanol from cellulose or produce starch-based ethanol using renewable fuels. The incentives should also help establish the infrastructure to deliver biomass to bio-refineries, since producers will seek the local feedstocks or renewable fuels for their operations.

By 2015, it is assumed that advances in cellulosic ethanol production (e.g., enzyme costs, production processes) will make cellulosic ethanol production cost competitive with starch-based production. Hence, the incentives are discontinued beginning in 2015. Note that there is currently a federal legislative proposal to offer cellulosic production an incentive of $0.765/gal compared with the $0.51/gal currently offered for ethanol production.[16] If enacted, this $0.255/gal premium could cover the additional incentives that are assumed to be needed by the State of Montana. Obviously, the federal incentives do not ensure that production facilities would locate in Montana. These federal incentives have not been factored into the cost estimates for this option.

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[14] In the study mentioned above, the average fuel economy used was 21.3 miles/gallon or 100 miles/4.7 gallons. Multiplying this value by the emission factor of 552 grams/mile yields 11,745 grams/gallon.

[15] DOE EIA analysis can be found at www.eia.doe.gov/oiaf/analysispaper/biomass.html, accessed January 2007.

[16] D. Morris, *Making Cellulosic Ethanol Happen: Good and Not So Good Public Policy*, Institute for Local Self-Reliance, January 2007, at www.newrules.org/agri/cellulosicethanol.pdf, accessed January 2007.

The costs for this option were estimated using the $0.23/gal incentive multiplied by the production needed in each year. By 2015, it is assumed that these incentives will no longer be needed as cellulosic ethanol technologies become fully commercialized. Hence, the costs for this option are targeted toward incentives for cellulosic ethanol production (including research and development, pilot plants, and early commercial production. The costs do not address incentives needed by feedstock producers, including costs to establish feedstock collection and distribution infrastructure. Those are addressed under AFW-7.

Key Assumptions: Starch-based ethanol production using renewable fuels could achieve significant GHG life cycle benefits over conventionally produced starch-based ethanol; however, the analysis above does not assume that any of the starch-based ethanol is produced using GHG-superior methods. For costs, this analysis assumes that existing State incentives are sufficient for promoting additional starch-based production; federal tax incentives do not preclude the need for the additional state incentives assumed for the cost estimate.

Key Uncertainties

Oil market volatility; favorable federal legislation for ethanol.

Federal support for cellulosic research and design.

Ability to harvest and transport biomass cost effectively (see AFW-7).

Forest biomass generated is dependent on logging activity (e.g., logging slash addressed under AFW-7) and assumes that current levels of logging activity will occur into the future. Forest biomass could also come from forest thinning projects, which would then be dependent on the number of forest acres and level of thinning treatment (biomass density reduction). This can be greatly impacted by budget limitations, state and federal forest policies, and forest management litigation or appeals.

Additional Benefits and Costs

Agricultural residue: increase in value added to crop production.

Fossil fuel dependence: dependence on foreign fossil fuels reduced; higher revenues for energy producers within the state.

Feasibility Issues

Impacts on food and animal feed production with increases in starch-based ethanol production; water availability to produce significant quantities of starch-based feedstocks. Cellulosic feedstocks (500,000 dry tons by 2020 needed, as shown above) are expected to come from utilization of crop residue (see AFW-7).

For the agricultural sector, a study by the US DOE National Renewable Energy Laboratory (NREL) estimates the amount of agricultural residue available in Montana to be 1,560,000 dry tons/year.[17] From NREL's assessment, CCS derived an estimate of 546,000 dry tons of residues

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[17] *A Geographic Perspective on the Current Biomass Resource Availability in the United States*. NREL, US DOE, NREL/TP-560-39181, December 2005. All estimates were developed using total grain production by county for

available each year. It is assumed that this biomass will fulfill the requirements for cellulosic feedstock under this option. Significant increases in production above the current goals would likely require additional biomass from other sources (e.g., purpose grown crops, forest biomass, and MSW fiber).

Sufficient biomass appears to be available to meet the levels of cellulosic ethanol production in the goal statement for 2020. There will be unused amounts of agricultural residue available between 2010 and 2020. However, it is assumed that it will take some time for the technology and markets to be available to gather, transport, and use this material effectively. The actual use of agricultural or woody biomass will be dependent on which technologies develop first and also on the location of the facilities, because eastern Montana has more agricultural biomass and western Montana has more wood.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

2002 reported to the USDA. Quantities that must remain on the field for erosion control differ by crop type, soil type, weather conditions, and the tillage system used. It was assumed that 30% residue cover is reasonable for soil protection. Animals seldom consume more than 20%–25% of the stover in grazing, and NREL presumes about 10%–15% of the crop residue is used for other purposes such as bedding and silage. Therefore, it was assumed that about 35% of the total residue could be collected as biomass. CCS used the policy goal of 10% of agricultural residue to adjust the NREL estimate (i.e., NREL estimate of 1,560,000 dry tons/year × 10%/35%).

AFW-4. Incentives for Enhancing GHG Benefits of Conservation Provisions of Farm Bill Programs

Policy Description

Agricultural lands that have been placed into conservation programs such as those established through the 2002 Farm Bill may sequester carbon dioxide by implementing practices that build soil carbon over time. For example, land in the CRP is taken out of production and, in the absence of tillage practices, soil carbon is sequestered over time. This option seeks to extend the GHG benefits of current Farm Bill programs, looking particularly at land that is scheduled to retire from Farm Bill programs and potentially return to production.

Policy Design

Goals: For acreage that is being retired from conservation programs, retain these crop acres in some type of management program that protects the soil carbon.

Timing: Achieve no net conversion of acreage in conservation programs to conventional tillage by 2010. Retain no net conversion through 2020.

Parties Involved: Montana DNRC, MDOA, conservation districts, USDA agencies including the NRCS, the Farm Services Agency, and the USFS.

Other: This strategy would be a low-cost option that would bring to bear the existing federal and state staff and programs in a focused approach unlike any other in the United States.

Implementation Mechanisms

Leverage existing federal and state conservation cost share programs: State agencies would incorporate USDA-approved carbon sequestration planning criteria into program literature, staff training, and technical assistance to landowners desiring to develop a carbon sequestration project for entry into the NCOC portfolio.

The Montana DNRC and the Montana conservation districts would include terrestrial carbon sequestration benefits, emerging carbon market information, and established state or national carbon sequestration planning criteria in their program literature. Conservation district staff would be trained to provide such information and technical assistance to landowners desiring to develop carbon sequestration projects for entry into emerging voluntary or federally mandated carbon markets. Such a program would help Montana landowners and tribal governments use existing federal and state conservation practice standards and cost share programs when entering into private carbon credit trades, thus increasing incentives for conservation and carbon sequestration practices.

Education and training: Implementation of this strategy would include a series of training workshops and print and Web-based materials for inclusion in existing outreach efforts.

Related Policies/Programs in Place

NRCS CRP rewards farmers financially for removing highly erodible and marginally productive land from production. CRP is currently capped at 25% of Montana cropland per county.

Type(s) of GHG Reductions

Net CO_2 is reduced by maintaining agricultural conservation lands in an uncultivated (untilled) condition. When soil carbon is exposed to air following tillage, this carbon is oxidized and lost to the atmosphere as CO_2. Additional reductions through lower fossil fuel consumption than would otherwise be used to actively till land.

Estimated GHG Savings and Costs per $MtCO_2e$

GHG Reduction Potential in 2010, 2020 $MMtCO_2e$): 0.50, 1.61.

Net Cost per $MtCO_2e$: $12.

These GHG reductions were left out of the cumulative totals for the AFW sector in the summary table at the front of this document, since they refer to soil carbon benefits that would occur if the CRP acres were returned to active cultivation using conventional tillage. Since this scenario was not included in the BAU forecast in the Inventory and Forecast, the emission reductions cannot be taken against the existing future emission estimates. Note that this policy option is needed to ensure that soil carbon losses do not occur on retiring CRP acres.

Data Sources: Data on the number of acres expiring from CRP as of 2007 were obtained from a USDA monthly CRP acreage report for May 2007.[18] Estimates of the percentage of expiring acres that were offered extensions or reenrollment were taken from USDA CRP state data tables[19] and a report from Ducks Unlimited.[20] Average annual CRP rental payments were taken from USDA state data tables.

The change in soil carbon due to CRP acres returned to conventional tillage or development was taken from a report from the Food and Agricultural Policy Research Institute. This report shows that the effects of conventional crop production in Montana are in the range of –3.9 to –2.0 tons of carbon (C) per acre and the effects of the CRP in Montana are 1.1 to 5.0 tons C/acre over 10 years. Adding the midpoint of these two ranges results in 6 tons C/acre (20 $MtCO_2e$/acre).

Quantification Methods: The number of acres leaving the CRP program for each year was estimated using the number of acres expiring for 2008–2020 as of 2007. These acreages do not include extensions and reenrollments. Therefore, 91.6% of expiring acres were assumed to be offered extensions or reenrollments with 93.3% accepting the offers (based on USDA data for 2006). For the acres accepting offers, 32.2% are assumed to be reenrollments (10-year contract) and 67.8% are assumed to be extensions (based on data in the Ducks Unlimited report cited

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[18] USDA, Farm Service Agency, Monthly CRP Acreage Report, http://content.fsa.usda.gov/crpstorpt/rmepegg/MEPEGGR1.HTM.

[19] USDA, Farm Service Agency, CRP State Tables, August 2006.

[20] Ducks Unlimited, “Conservation Reserve Program: Critical Waterfowl Nesting Habitat at Risk in the Prairie Pothole Region” http://www.ducks.org/media/Conservation/Farm%20Bill/_documents/CRP_021007.pdf

above). The contract extensions are divided equally between 2-, 3-, 4-, and 5-year extensions. Table I-5 shows the estimated number of acres leaving CRP for 2001–2020. The number of acres leaving CRP was then multiplied by the soil carbon change between conventional crop production and CRP management.

Table I-5. Estimated number of acres leaving CRP for 2001–2005

Year	CRP Acres Set to Expire (2007)	Acres Expiring Including Reenrollments and Extensions	Active Acres Estimate	Acres Leaving Program
2007	618,435	618,435	3,387,546	89,903
2008	190,425	190,425	3,359,863	27,682
2009	307,871	397,457	3,302,084	57,779
2010	409,680	526,851	3,225,495	76,589
2011	493,060	667,806	3,128,414	97,080
2012	645,081	896,147	2,998,140	130,275
2013	362,907	621,124	2,907,846	90,294
2014	235,108	595,556	2,821,268	86,577
2015	115,767	508,615	2,747,330	73,938
2016	40,814	443,614	2,682,841	64,489
2017	332	550,260	2,602,848	79,992
2018	23,234	389,825	2,546,179	56,670
2019	1,778	415,076	2,485,838	60,340
2020	26,312	445,415	2,421,087	64,751
2021	6,646	450,989	2,355,526	65,561
2022	0	507,441	2,281,758	73,768

Costs were estimated by applying the cumulative number of acres leaving CRP by the annual rental payment ($34/acre).

Key Assumptions: No new acres will be enrolled into CRP and the current level of reenrollment and extensions will continue.

Key Uncertainties

It is not certain that all of the acres leaving CRP would return to active production; for those returning to active production, it is also unclear whether it would be to annual or perennial crops (this analysis assumes annual crops that require conventional tillage each year).

Additional Benefits and Costs

None identified.

Feasibility Issues

Implementation of this policy option needs to consider additional programs targeted at production practices that conserve soil carbon and net GHG benefits as alternatives to programs like CRP. CRP programs are sometimes being used for retirement income by older farmers, which creates a disincentive for removing the lands from the CRP program. These acres could be returned to production with conservation practices that would not necessarily need to be plowed;

for example, they could be used for grazing. Use of acres in this manner would allow for economic growth in the agriculture industry, provide an opportunity for young farmers to use the land, and provide for growth of businesses providing support services.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

AFW-5. Preserve Open Space and Working Lands – Agriculture and Forests

Policy Description

Reduce the rate at which existing crop/pasture, rangeland, and forests are converted to developed uses. The carbon sequestered in the soils and aboveground biomass of these open spaces and working lands is often much higher than in developed land uses. Policies that preserve open space and working lands provide additional GHG benefits by reducing the vehicle miles traveled that would otherwise occur from unwise or unplanned development (note relationship to growth and development under TLU-5).

Policy Design

Goals: By 2020, reduce the rate at which forest and agricultural lands are converted to developed use by 50% from current levels.

Timing: By 2015, reduce the rate of conversion by 25%; achieve full 50% by 2020.

Parties Involved: Montana DNRC; Montana Fish, Wildlife, and Parks (FWP); USFS; USDA NRCS; county governments and other political subdivisions of the state; private nonprofit land trusts; nonprofit organizations; Alternative Energy Resources Organization (AERO); Montana Farmers Union; and other farm groups.

Other: NRCS National Resources Inventory (NRI) data (1987–2003) shows that Montana is losing (on average) more than 2,000 acres of forestland and more than 34,000 acres of rangeland on an annual basis. While some of that rangeland is turning into pastureland, more than 13,000 acres a year (on average) is being developed or becoming other rural lands. There is potential for divestiture of more than 1 million acres of industrial forestland and loss of more than 5 million acres of ranchlands, with some proportion of those lands being converted to development. There were more than 14,500 new subdivisions approved by local governments over the past 10 years, resulting in more than 1.1 million acres of new development. Projections are 200,000 more people in the next 20 years, with more than 100,000 additional homes in western Montana by 2025.

Implementation Mechanisms

- Develop a mitigation fund where developers would contribute and funds would be used to offset impacts (e.g., conservation easements).
- Engage local/county planning boards and zoning departments.
- Engage tourism departments and land trusts in the solution.

Related Policies/Programs in Place

State Programs: There are several existing state programs aimed at conserving lands that provide important wildlife habitat. The Habitat Montana program administered by FWP uses hunting license fees to protect threatened wildlife habitats. Montana's FWP Wildlife Mitigation Program aims to replace wildlife and habitat lost during the development of Libby and Hungry Horse Dams. FWP state wildlife grants use federal funding through the Land and Water Conservation Fund for projects involving species of special concern and can potentially be used for land and easement acquisitions. The Natural Resource Damage Program under the Montana Department of Justice (DOJ) uses funds recovered from an environmental lawsuit to fund restoration in the Clark Fork Drainage area. The funds can be used for land and easement acquisitions.

Federal Programs: There are also several federal programs that have been critical for funding land conservation through fee or easement purchases. The Forest Legacy Program provides funding to protect environmentally sensitive forestlands. The Habitat Conservation Plan Land Acquisition Grants Program provides funding for acquisition of vital habitat for threatened and endangered fish, wildlife, and plants. At the county level, Gallatin, Ravalli, and Missoula counties have passed $40 million in bonds to protect open space, particularly agricultural land that is rapidly being converted for subdivisions.

Type(s) of GHG Reductions

CO_2: Avoided emissions from carbon sequestered in biomass and soils that sequester carbon, as long as they are not disturbed by development and conversion to developed uses. The conversion of existing forests and agricultural lands to developed use releases carbon that has previously been sequestered and hinders future sequestration.

Estimated GHG Savings and Costs per $MtCO_2e$

I. Agriculture

GHG Reduction Potential in 2010, 2020 ($MMtCO_2e$): 0.003, 0.02.

Net Cost per $MtCO_2e$: $32.

Note: The reductions and cost per Mt estimated for this option refer only to the direct benefits and costs associated with the estimated loss of soil carbon from agricultural soils due to development. They do not include the indirect benefits that occur as a result of more efficient development patterns that could result from this option (see TLU-5).

Data Sources:

The annual rate of agricultural land conversion in Montana is 7,200 acres per year.[21] The typical level of soil carbon in agricultural soils in estimated by comparing soil carbon and cropland maps from the United States Geological Survey (USGS). These maps show that the areas of Montana with the most agriculture have soil carbon stocks ranging from 0.1 to 4.0 kg C/m^2 in the top 20 cm. About half of the area is in the 0.1 to 2.0 kg C/m^2 range and about half is in the 2.1 to 4.0 kg C/m^2 range. The midpoint of this range—2.0 kg C/m^2—is equivalent to 0.008 MMtC/1,000 acres. The cost of establishing conservation easements on agricultural lands

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[21] NRI data provided by Julie Tesky, State Resource Inventory Coordinator, USDA, NRCS, Montana State Office. Includes agriculture and rangelands.

surrounding developing areas was estimated by dividing the total costs for eight easements preserved through the Montana Agricultural Heritage Program by the total acreage for these easements.[22] The resulting average net policy cost is $730/acre.

Quantification Methods:

GHG Benefits

Studies are lacking on the changes in below- and aboveground carbon stocks when agricultural land is converted to developed uses. For some land use changes, carbon stocks could be higher in the developed use relative to the agricultural use (e.g., parks). In other instances, carbon stocks are likely to be lower (graded and paved surfaces). CCS assumed that the agricultural land would be developed into typical tract-style suburban development. It was further assumed that 50% of the land would be graded and covered with roads, driveways, parking lots, and building pads. The final assumption was that 75% of the soil carbon in the top 8 inches of soil for these graded and covered surfaces would be lost and not replaced. CCS assumed no change in the levels of aboveground carbon stocks.

The benefit in each year was determined by a) determining the amount of land protected in each year by multiplying the annual rate of agricultural land lost by the percent of agricultural land protected; b) multiplying the soil carbon content on the protected land by 50% (representing graded and covered areas) and by 75% (fraction of soil carbon lost); and c) converting the soil carbon lost to CO_2 by multiplying by 44/12.

Costs

To estimate program costs in each year, CCS used multiplied the estimated agricultural acres protected from development by the conservation cost ($730/acre) and an assumed cost share of 50%. This cost share is assumed to be available from the NRCS or other sources (e.g., city or county governments or nongovernment organizations). The resulting cost-effectiveness is $32 per $MtCO_2e$. This estimate accounts for only the direct reductions associated with soil carbon losses estimated above and does not include potentially much larger indirect benefits associated with reductions in vehicle miles traveled (see TLU-5).

Note that the availability of this cost share is a significant assumption for this policy option, since the number of acres to be protected is substantially higher than the average number of acres protected during the 1996–2001 period (about 200 acres/year). Without the cost share, the cost-effectiveness would be twice the value presented here.

Key Assumptions: No change in aboveground carbon stocks; 75% loss of soil carbon on 50% of developed land; 50% cost share available from NRCS, city or local governments, or other sources.

II. Forests

GHG Reduction Potential in 2010, 2020 ($MMtCO_2e$): 0.03, 0.14.

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[22] The Montana Agricultural Heritage Program approved eight landowner grant applications totaling $888,000. This figure is to be matched by an additional $6.36 million from various federal, local, and private sources, including the participating landowners. The corresponding easements preserve 9,923 acres. http://www.westgov.org/wga/publicat/pdr.pdf.

Cumulative GHG Reduction Potential ($MMtCO_2e$, 2007–2010): 0.9.

Net Cost per $MtCO_2e$: $3.

Data Sources:

Forestry—USFS Methods for Calculating Forest Ecosystem and Harvested Carbon with Standards Estimates for Forest Types of the US, General Technical Report NE-343 (also published as part of the US DOE Voluntary GHG Reporting Program). Data on forest conversion to developed uses from NRCS NRI (1987–2003). Data on forest types from the Forest Inventory Analysis (FIA), 2003–2005. T.F. Strong, 1997 “Harvesting Intensity Influences the Carbon Distribution in a Northern Hardwood Ecosystem,” USFS Research Paper NC-329; “The Intersection of Land Use History and Exurban Development: Implications for Carbon Storage in the Northeast” master’s thesis, K. Austin, 2006.

Quantification Methods:

Carbon savings from this option were estimated from two sources: 1) the amount of carbon that would be lost as a result of forest conversion to developed uses (i.e., avoided emissions) and 2) the amount of annual carbon sequestration in protected forest area. The area of forestland protected annually is based on a gradual implementation of the goals outlined above, so that a 25% reduction in forest conversion rates is achieved by 2015 and a 50% reduction by 2020. A current conversion rate of 2,000 acres/year was assumed based on NRI data from 1987 to 2003. The percentages in the goals represent a decrease from the current conversion rate of 500 acres/year in 2015 and 1,000 acres/year in 2020. Table I-6 shows the assumptions about the types of forests protected under this option, based roughly on relative abundances of three common forest types in Montana. Table I-6 also provides values for forest carbon stocks and annual carbon flux used to calculate total carbon savings under this option.

Table I-6. Input data, by forest type

Forest Type	Percent of Protected Acres	Annual C Flux (tC/acre/year)	Biomass Carbon Stocks (tC/acre/year)	Soil Carbon Stocks (tC/acre/year)
Douglas fir	52%	0.573	66.0	15.7
Lodgepole pine	26%	0.388	44.0	15.0
Ponderosa pine	22%	0.368	45.0	13.9

The forest carbon stocks (tC/acre) and annual carbon flux (annual change in tC/acre) data are based on default carbon sequestration values for Douglas fir, lodgepole pine, and ponderosa pine forest types in the northern Rocky Mountain region of the United States (USFS GTR-343, Tables A30, A32, and A33). Values for forest carbon stocks (including biomass and soils) in each of the three forest types represent the average for typical mature forests and are based on coefficients for 65-year-old stands. Annual rates of carbon sequestration (tons carbon sequestered per year) were calculated by subtracting total carbon stocks in forest biomass of 125-year-old stands from total carbon stocks in forest biomass of new stands and dividing by 125. A long-term average was used to implicitly take into account the relatively fast rate of carbon accumulation in young stands and slower rates in older stands. Soil carbon density was assumed constant and is not included in the annual carbon flux calculations because default values for soil carbon density are constant over time in USFS GTR-343.

A. Avoided Emissions

Loss of forests to development results in a large one-time surge of carbon emissions. In this case, it was assumed that 53% of carbon stocks in biomass and 35% of carbon stocks in soils would be lost in the event of forest conversion, with no appreciable carbon sequestration in soils or biomass following development. The biomass loss assumption is based on research that shows heavy levels of individual tree removal results in the harvesting of 53% of carbon in aboveground biomass (Strong, 1997). The soil carbon loss assumption was based on a study that shows about a 35% loss of soil carbon when woodlots are converted to developed uses (Austin, 2006). Therefore, to estimate avoided emissions, the total number of acres protected in a year for each forest type was multiplied by the percent-adjusted carbon stock value for loss of biomass and soil carbon stocks. Results were converted to units of $MMtCO_2e$ and are provided in Table I-7.

Table I-7. Emissions avoided by protecting forestlands in Montana

Year	Acres Protected	Avoided Emissions ($MMtCO_2e$)			
		Douglas Fir	Lodgepole Pine	Ponderosa Pine	Total
2007	56	0.0043	0.0015	0.0013	0.007
2008	111	0.0086	0.0030	0.0026	0.014
2009	167	0.0129	0.0045	0.0039	0.021
2010	222	0.0171	0.0061	0.0051	0.028
2011	278	0.0214	0.0076	0.0064	0.035
2012	333	0.0257	0.0091	0.0077	0.043
2013	389	0.0300	0.0106	0.0090	0.050
2014	444	0.0343	0.0121	0.0103	0.057
2015	500	0.0386	0.0136	0.0116	0.064
2016	600	0.0463	0.0163	0.0139	0.077
2017	700	0.0540	0.0191	0.0162	0.089
2018	800	0.0617	0.0218	0.0185	0.102
2019	900	0.0695	0.0245	0.0208	0.115
2020	1,000	0.0772	0.0272	0.0232	0.128
Total	**6,500**	**0.50**	**0.18**	**0.15**	**0.83**

B. Annual Sequestration in Protected Forests

The results for annual sequestration are given in Table I-8. Forests preserved in one year continue to sequester carbon in subsequent years. Thus, annual sequestration includes benefits from acres preserved cumulatively under the program. It was calculated each year by multiplying the cumulative acres protected by the percentage of each forest type and by the average annual carbon flux for each forest type.

Table I-8. Annual carbon sequestered in protected forestlands

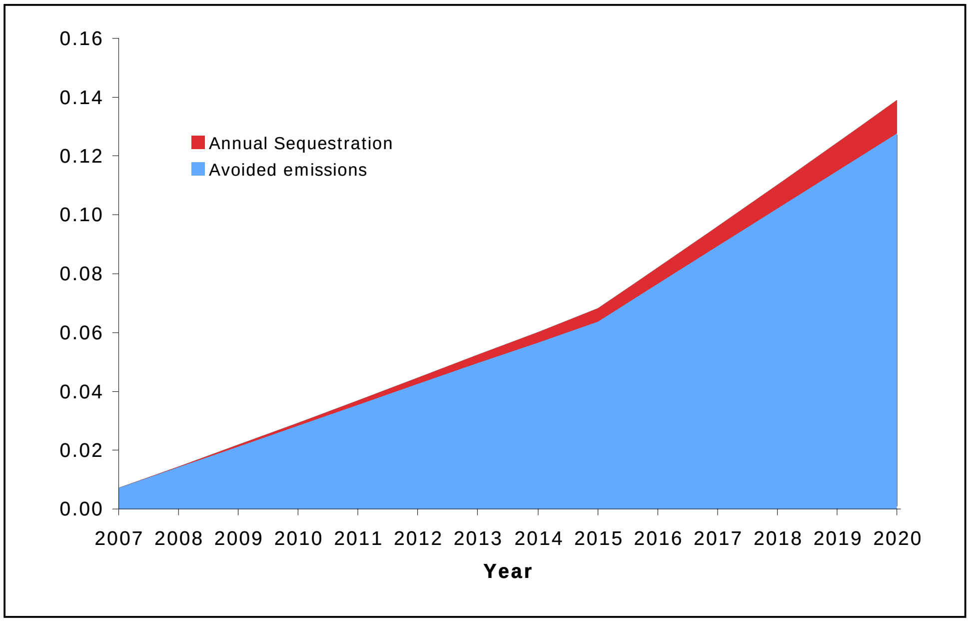
Year	Acres protected	Annual C Sequestered ($MMtCO_2e$) Douglas Fir	Lodgepole Pine	Ponderosa Pine	Total
2007	56	0.0001	0.0000	0.0000	0.0001
2008	167	0.0002	0.0001	0.0000	0.0003
2009	333	0.0004	0.0001	0.0001	0.0006
2010	556	0.0006	0.0002	0.0002	0.0010
2011	833	0.0009	0.0003	0.0002	0.0015
2012	1,167	0.0013	0.0004	0.0003	0.0021
2013	1,556	0.0017	0.0006	0.0005	0.0027
2014	2,000	0.0022	0.0007	0.0006	0.0035
2015	2,500	0.0027	0.0009	0.0007	0.0044
2016	3,100	0.0034	0.0011	0.0009	0.0055
2017	3,800	0.0042	0.0014	0.0011	0.0067
2018	4,600	0.0050	0.0017	0.0014	0.0081
2019	5,500	0.0060	0.0020	0.0016	0.0097
2020	6,500	0.0071	0.0024	0.0019	0.0114
Total	**6,500**	**0.036**	**0.012**	**0.0097**	**0.058**

C. Total Carbon Savings

Total carbon savings achieved by protecting forestlands from development are illustrated in Figure I-1. Figure I-1 shows that the bulk of carbon savings under this option arise from avoiding the emissions generated during conversion of forestlands to other uses.

The cost of protecting forestland was estimated at $635/acre using expert input from the Montana land trust community. This value assumes that 20% of forests under this option will be acquired at $2,500/acre, 10% of forests will be preserved with conservation easements costing $1,000/acre, and 70% of forests will be preserved with donated conservation easements at $50/acre. The analysis does not take into account potential cost savings from forest products revenue on working forestlands that are protected under this policy. Annual costs were estimated by multiplying the number of acres protected by the cost per acre. Annual discounted costs were then estimated using a 5% interest rate. The cumulative cost-effectiveness of the total program was calculated by summing the annual discounted costs and dividing by cumulative carbon sequestration, yielding \$3/$MtCO_2e$. The sum of annual discounted costs also provides an estimate of the net present value (NPV) of this option of $2.7 million.

Figure I-1. Total carbon savings from protecting forestlands



Key Assumptions: Forestry: 53% and 35% of biomass and soil carbon, respectively, is lost when forests are converted to developed uses; no appreciable carbon sequestration occurs post-development. Distribution of forest types protected is assumed based on forest dominance.

Key Uncertainties

Levels of above- and belowground carbon stored in agricultural lands versus developed land uses; costs of both agricultural and forestland protection programs; potential for leakage (working lands protected in one area force a similar level of development in a different area).

Additional Benefits and Costs

Supporting intact rural communities in traditional land uses; maintaining land for recreational opportunity (hunting and fishing), critical wildlife habitat, productive timberland, and water quality.

Potential to enhance smart-growth objectives.

Potential loss of commercial income generating activity.

Feasibility Issues

Lack of funding at federal, state, and local level.

Difficulty in requiring how private property will be used.

Difficulty in determining the total number of acres that need to be protected (total number with the potential for development within the policy period) in order to achieve the policy goals for reducing conversion to developed use. For example, the costs for the agricultural land conversion goal is based on protecting the exact number of acres that have been protected from development, not the total number of acres that need to be protected in order to achieve the conversion goal (50% reduction in conversion by 2020). In order to prevent leakage (the same level of development occurring in another location after reducing conversion in a target area), it is highly likely that a much larger number of acres will need to be protected via conservation easements or acquisition than reported above. Additional study is needed on areas that should be targeted for protection in order to implement this policy and inform policy makers on the potential costs.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

AFW-7. Expanded Use of Biomass Feedstocks for Energy Use

Policy Description

This policy seeks to expand the use of biomass from forests, agriculture, and other sources for energy. Biomass can be used to produce liquid fuels, including cellulosic ethanol, or to produce energy in the form of electricity, heat, or steam. The latter is covered by this option.

Carbon in biomass is considered biogenic under sustainable systems; carbon dioxide emissions from biomass energy combustion are replaced by future carbon sequestration in new biomass. Expanded use of biomass energy in place of fossil fuels results in net emissions reductions by shifting from high- to low-carbon fuels (when sustainably managed), provided the full life cycle of energy requirements for producing fuels does not exceed the energy content of the renewable resource. Expanded use of biomass energy can be promoted through increasing the amount of biomass produced and used for renewable energy and providing incentives for the production and use of renewable energy supplies.

Policy Design

Goals: Increase usage of woody biomass residue for renewable electricity, heat, and steam generation to 450,000 tons/year by 2020. To use 540,000 dry tons of agricultural residues utilized annually by 2020.[23]

Timing: See above.

Parties Involved: Montana DNRC, MDEQ, USFS, BLM, MSU Cooperative Extension Service, University of Montana College of Forestry and Conservation, Montana PSC, industrial and commercial energy providers and consumers, livestock and poultry producers, farmers, private landowners, forest products manufacturers, and logging companies.

Other: The current estimated amount of biomass used in Montana is 2 million dry tons, with 1.95 million derived from primary and secondary mill waste and only 85,000 tons from logging residue. It is estimated that there is 2.76 million dry tons of woody biomass available in Montana (US DOE, NREL), with 704,000 dry tons available annually from logging residue. Therefore, one of the goals will be to increase the utilization of woody biomass from logging residue. That amount would be used under this option to supply fuel for producing electricity, steam, and heat. As the acreage being treated to reduce fire hazards in the state increases, the total amount of available biomass will also increase.

Implementation Mechanisms

State Lead by Example: Require consideration of renewable resource systems (including biomass heat/energy) in all new state building constructions and renovations and provide state

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[23] 540,000 dry tons is one-third of the estimated agricultural residues available from a study by the US DOE NREL. *A Geographic Perspective on the Current Biomass Resource Availability in the United States*, A. Milbrandt, Technical Report, NREL/TP-560-39181, December 2005.

support to the DNRC Biomass Utilization Fuels for Schools Program and Beyond which identifies financially viable biomass heating opportunities and helps facilities secure funding, supply, and installation. State lands should incorporate biomass recovery objectives during program implementation.

Source Reduction: Reduce the amount of open slash pile burning on all lands and/or provide viable alternatives to open burning. Revise MDEQ air quality permits and local ordinances to discourage open burning and continue to encourage alternatives.

Voluntary/Negotiated Agreements: Voluntary, incentive based programs should be used to foster the development of the industry and associated economic markets. Provide landowners and/or corporations with opportunity to enter into agreements to better utilize biomass energy and/or increase the productivity of carbon sequestered on the landscape.

Funding Mechanisms: Provide tax incentives to reduce the capital costs of biomass energy production, including electricity generation and heating of residences and public buildings; establish utility "Buyback Rates" for biomass-derived energy where utilities offer a standard rate for which they purchase biomass-generated energy (electricity and/or heat). Expand or develop renewable energy tax credits to provide new incentives for smaller distributed biomass generation.

Pilots and Demonstrations: Pilot projects on the use of different forestry (e.g., bio-refineries) and agriculture residues (e.g., cellulosic ethanol plants) for energy production are needed, as are pilot projects to demonstrate the transportation, collection, storage, and distribution infrastructure.

Research and Development: Research is needed on techniques for collecting and processing forestry and agriculture residues, as well as market development or expansion for these materials. Research is also needed to characterize emissions from biomass boilers to better characterize impacts on community air pollution and ways to minimize those impacts.

Market-Based Mechanisms: Incentives (e.g., preferential tax rates) may be needed to spur the use of biomass energy.

Provide Tax Incentives: Incentives to reduce the capital costs of biomass energy production and transport for use in liquid fuels production, electricity generation, and heating residences and commercial buildings. This could include gross receipts exemptions for biomass generation facilities, project construction, and related equipment and materials. Additional tax incentives have been put in place as a result of HB 3 in the Special Session of the 2007 Legislature. Analysis of the new incentives and any additional recommendations will be needed.

Establish Utility "Buyback Rates" for "Feed-in-Tariffs": Applicable to biomass-derived energy where utilities offer a standard rate at which they purchase biomass generated energy (electricity and/or heat). Buyback rates for biomass projects in other regions of the country generally range from 6 to 7¢/kWh.

Expand the Montana Renewable Energy Tax Credit: Lower the eligible threshold capacity from 10 MW to 1 MW and expand the classification of corporate taxpayers and include general income taxpayers.

Codes and Standards (State): Expand existing net-metering regulations to enable smaller projects of up to 2 MW to net-meter at retail energy rates. (Net-metering enables customers to use their own generation to offset their consumption over a billing period by allowing their electric meters to turn backwards when they generate electricity in excess of their demand, feeding it back to the grid.)

Codes and Standards (Local): Work with local communities to develop responsible ordinances and continue to evaluate and discuss those that allow the use of US EPA–certified wood/pellet burning equipment (instead of broad burn bans that apply to all wood-burning equipment). Expand existing net-metering regulations to enable projects of up to 2 MW to net-meter at retail energy rates. Work with regional and national efforts to increase efficiency standards for wood-burning equipment (e.g., furnaces, stoves, boilers).

Related Policies/Programs in Place

Renewable Portfolio Standards: Requires public utilities to obtain 15% of their retail electricity sales from eligible renewable resources by 2015.

Renewable Energy Credits: Create market for clean power generated by biomass. Western Governors' Association and California Energy Commission are currently working together to develop Western Renewable Energy Generation Information System (WREGIS), a regional renewable energy tracking and registry system.

Alternative Energy Revolving Loan Program: Provides loans to individuals, small businesses, local government agencies, units of the university systems, and nonprofit organizations to install alternative energy systems that generate energy for their own use. Maximum loan amount is $40,000 with a fixed interest rate, and the loan must be paid back within 10 years.

Montana Electric Cooperatives–Net-Metering: Under the model policy, customers generating their own electricity using (but not limited to) wind, solar, geothermal, hydro, biomass, or fuel cells may participate in net-metering.

Mandatory Green Power Program: NorthWestern Energy (NWE) offers its customers the option of purchasing a product composed of or supporting power from certified environmentally preferred resources generated by renewables including biomass.

DNRC Forestry Assistance Programs: Maintain and improve the health of Montana's forests, forested watersheds, and the communities that depend on them. Tools include information and education, technical assistance, and financial assistance.

Biomass Utilization Fuels for Schools and Beyond Program: Promote the use of forest biomass as an energy source for heating schools and other pubic facilities. Use of biomass energy for heat and energy creates carbon offsets when compared with use of fossil fuels.

USFS Woody Biomass Utilization Policy: Recently implemented, it requires that contractors doing work on federal lands haul and pile slash at landings to help facilitate removal of biomass during forest operations for utilization.

State Trust Lands Forest Management Program: Recently implemented, the Forest Management Bureau has changed the timber bid sale process for state trust lands to encourage removal of residues for pulp and biomass.

Type(s) of GHG Reductions

Avoided fossil fuel emissions (primarily CO_2, but also CH_4 and N_2O) through the use of lower carbon liquid and solid fuels.

Estimated GHG Savings and Costs per $MtCO_2e$

GHG Reduction Potential in 2010, 2020 ($MMtCO_2e$): 0.04, 0.15.

Net Cost per $MtCO_2e$: –$23.

ES and RCII options related to increasing energy generation from renewable energy sources include biomass energy generation. This policy calls for the utilization of 450,000 tons of woody biomass by 2020. GHG reductions from avoided fossil fuel use associated with this AFW option are almost fully accounted for in the quantification of the ES/RCII renewable fuels options. The total inferred biomass tonnage included in the quantification of the relevant ES/RCII options is approximately 161,000 dry tons. This leaves 289,000 dry tons of additional woody biomass per year that could also be used to offset fossil fuel combustion in the ES or RCII sectors. It is assumed that no additional woody biomass from the mill waste is available. Therefore, the additional biomass is assumed to come from logging slash. Subtracting the estimated 85,000 tons of current utilization and assuming that the BAU utilization doesn't change between 2006 and 2020 leaves a total increase in woody biomass of 204,000 dry tons (450,000 dry tons from logging slash minus 161,000 dry tons used by RCII minus 85,000 BAU consumption). The benefit for this additional biomass is quantified here, assuming that the biomass is used to offset natural gas consumption (higher benefits would occur if higher carbon fuels like coal or oil were offset).

The cost analysis for this option is based on the difference in costs between a supply of woody biomass fuel and the assumed fossil fuel that it is replacing (for the purposes of this analysis, natural gas). The cost of natural gas is assumed to be $9.50/MMBtu, which is a nominal cost across residential, commercial, and industrial users based on 2005 data.[24] The cost of supplying biomass is $130/ton (see fuel cost comparison chart, Figure I-2). This value compares to an estimate of $140/ton associated with an 80-mile radius between supply and use and a cost of $108/ton for a 25-mile radius in a recent study on western biomass supply and use.[25]

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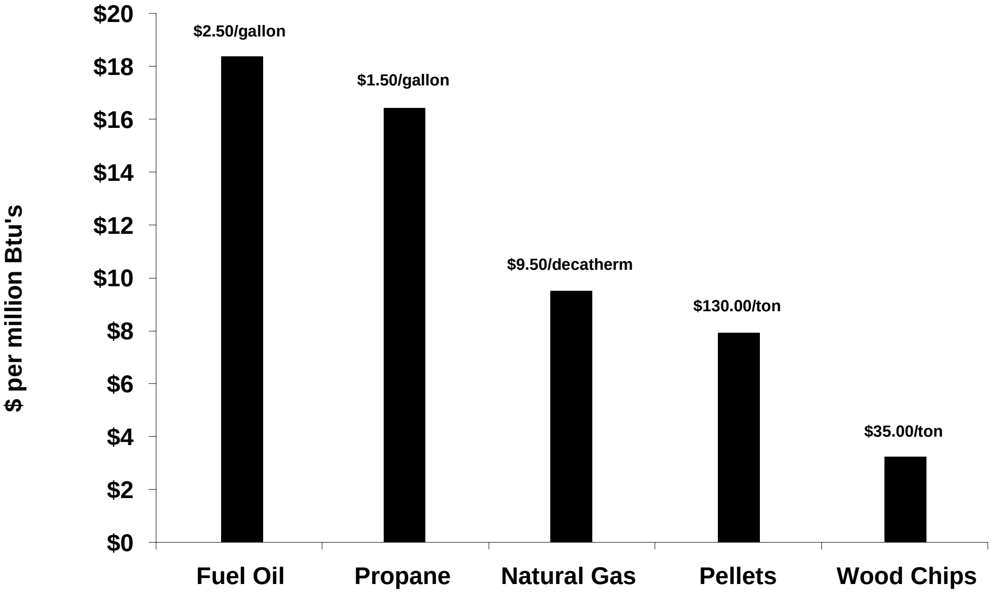
[24] Source MDEQ: http://www.deq.state.mt.us/Energy/HistoricalEnergy/Natural_gas_tables_2006_FINAL.htm. Note that there are about 1,029 Btu per cubic foot of natural gas. Note also that trends in natural gas pricing show substantial increases during the past 5 years.

[25] Based on 80-mile radius, dry ton basis. From McNeil Technologies Report: *Western Regional Biomass Energy Program*, Final Report, Evaluating Biomass Utilization Options for Colorado: Summit and Eagle Counties, 2003.

The cost estimates do not include capital costs for new equipment purchases or retrofits. It is assumed that changes in equipment use occur after the useful life of existing fossil fuel-fired equipment. The up-front cost of a biomass combustion system can be greater than a traditional system; however, the fuel is far less expensive, such that, over time, fuel savings can more than offset up-front costs (as shown below). Net cost savings are more likely in certain circumstances, in particular a) when the price of fossil fuel equipment options are relatively expensive and b) in larger, heat-using facilities whose unit savings on heating fuel costs result in a better payback on the up-front investment. Figure I-2 shows costs relative to heat generation for various fuel sources.

Figure I-2. Fuel cost comparison



Source: Angela Farr, Fuels for Schools Program Coordinator, DNRC.

For costs associated with the establishment of a biomass fuels collection, processing, and distribution industry (e.g., incentive programs), these are assumed to be adequately captured within the cost estimates made for the applicable biomass energy option. For example, the price paid for delivered biomass energy under the ES or RCII options is assumed to be sufficient to drive the establishment of fuel collection, processing, and distribution. Similarly, for the use of biomass to produce liquid fuels, the costs are captured within the costs estimated for AFW-3.

Data Sources: For the quantification of benefits in the other associated biomass consumption options, see ES-1, ES-4/RCII-7, RCII-5/RCII-12, and AFW-3.

Quantification Methods: For the quantification of benefits in the other associated biomass consumption options see ES-1, ES-4/RCII-7, RCII-5/RCII-12, and AFW-3.

Key Assumptions: A key assumption on the costs is that there is no significant increase in capital costs associated with any equipment purchases or retrofits for end-users who switch over from fossil fuel–fired equipment to biomass equipment. Costs for delivering biomass and natural gas are assumed to remain at current estimated levels. The benefits are based on offsetting natural gas consumption. Potentially greater benefits would be gained by offsetting other fossil fuels (coal and oil).

Key Uncertainties

The amount of logging residues generated is dependent on timber harvesting and agricultural crop residues on crop production. Through 2020, timber harvesting and agricultural crop production are assumed to remain at current levels. Additional sources of biomass could be residues from forest thinning projects, purpose-grown crops (e.g., sweet sorghum), or MSW fiber. These additional sources were not considered in this policy analysis.

Additional Benefits and Costs

- Encourage management of forested lands by contributing to economically viable ways to remove hazardous fuels and maintain healthy forests.
- Provide opportunities for local forest-dependent economies to supplement their businesses based on supplying woody biomass to users.
- Reduce risk of severe wildfires and their negative impacts on habitats, homes, communities, and watersheds.
- Improve forest carbon sequestration potential with the thinning treatments of forests.
- Reduce emissions from open-pile slash burning (reductions in particulate matter, CH_4, NO_x, SO_x, CO).
- Displace the emissions associated with the combustion of traditional fossil fuels of natural gas, propane, and fuel oil.
- Reduce dependence on foreign fossil fuels.
- In-state air pollutant and GHG emissions associated with collection and transport of biomass; these offset emissions associated with the production, processing, and transport of fossil fuels to a greater or lesser extent (quantification of net impacts was beyond the scope of this analysis).
- Distribute heat and energy sources for national security.

Feasibility Issues

- Economic and efficient recovery and transportation of forest biomass feedstock.
- Forest management litigation or appeals on state and federal lands.
- Long-term availability of biomass feedstock supplies at low costs.
- Challenges in permitting and/or locating facilities in air quality non-attainment areas.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

AFW-8. Afforestation and Reforestation Programs – Restocking and Urban Trees

Policy Description

Increase carbon stored in forests through expanding the forestland base. Establishing new forests, either on historically non-forested land (“afforestation”) or on land that has not been managed as forestland for some time (“reforestation”) increases the amount of carbon in biomass and soils compared to preexisting conditions. Afforestation and reforestation accomplished with stocking, planting, and other practices (e.g., soil preparation, erosion control) can increase carbon stocks above baseline levels and ensure conditions that support forest growth.

Policy Design

Goals: Ensure restocking on 20% of the accessible forestlands impacted by stand replacement fires since the year 2000 (estimated at 70,000 acres) to stocking rates of 200–400 trees/acre (depending on forest type). For future lands impacted by wildfire, restock forestlands impacted by stand replacement fires (estimated at 20,000 acres/year) within 5 years post-fire.

Plant 42,250 new trees in Montana communities by 2020 through programs such as DNRC’s Urban and Community Forestry (U&CF) Program.

Timing: By 2010, ensure restocking on 15,000 acres of accessible lands impacted by stand replacement fires since the year 2000; by 2020, ensure restocking on the remaining 55,000 acres. As stated in the goal above, for future fires, restock 30% of the high severity burned forestlands within 5 years post-fire. For the urban area goals, achieve them at a pace of 3,521 trees per year.

Parties Involved: Montana DNRC, USFS, UM School of Forestry and Conservation, conservation districts, watershed management groups, BLM, Bureau of Indian Affairs, Confederated Salish and Kootenai Tribe, USDA NRCS; private industry, nonindustrial private landowners.

Other: Since 2000, over 3.3 million acres have burned in Montana. It is roughly estimated that one-third of these have been forested acres, and of the forested acres, about one-third have been high severity burns that require some level of restocking. Some of these areas have been replanted; however there are an estimated 70,000 acres still requiring replanting. In addition, each year there are an estimated 20,000 acres/year of forests burned with high severity (stand replacement fires). Together, there is a need for restocking on about 25,000 acres/year on federal, state, and private lands in Montana between 2007 and 2020 to meet the goals of this policy. Reforestation costs are roughly $180/acre.

A 2007 study (Potter et al.) estimates that there are more than 69 million acres of low-production rangelands in Montana that could be afforested to result in carbon gains. More realistically, only 8.9 million acres are available for afforestation because of precipitation and soil nutrient limitations. The potential results of afforesting 8.9 million acres could be the sequestration of more than 15 million tons of carbon annually.

However, a question remains on the efficacy of afforestation in Montana. The best possible means for afforestation could remain with the development of wind breaks, shelter belts, and riparian areas. As currently written, this policy pertains only to reforestation efforts on high severity burned areas and urban forestry goals.

The Montana DNRC U&CF Program has the goal of planting 3,250 trees (250 trees/year) during 2008–2020. There is the potential for more trees to be planted each year by cities, counties, and local organizations. A rough estimate of this potential was used in combination with the DNRC goal to arrive at the goal level for urban tree planting. Montana has 129 incorporated cities, towns, and county governments and an additional 100 communities receiving some or all of their technical assistance from the Montana U&CF Program to build the necessary infrastructure to achieve Tree City USA designation and sustainable community forestry programs. The goal stated above assumes that each of these 229 communities plant 10 trees per year, leading to roughly 3,000 trees planted per year (that number will range from 0 to more than 100; e.g., The Growing Friends of Helena plants approximately 100 trees/year). This in combination with the DNRC U&CF Program would be 3,250 trees/year or 42,250 trees by 2020.

Implementation Mechanisms

Information and Education: Work through the MSU Extension Forestry program and DNRC's Forest Stewardship Program to educate private forest landowners on the importance and practice of stand regeneration, post-fire reforestation, and restocking.

Technical Assistance: Develop interagency partnerships with then NRCS, USFS State and Private Forestry, conservation districts, and the Montana DNRC to deliver comprehensive private forest landowner assistance and cost-share programs for forest management and post-fire rehabilitation. Develop interagency site-specific reforestation plans post-burn with planting targeted for stand replacement fires.

Market-Based Incentives: Support and engage in private sector markets for carbon sequestration that recognize the carbon benefits of forest management, urban forestry, and afforestation/reforestation (e.g., Chicago Climate Exchange). State participation further enhances state lead by example as an implementation mechanism.

Enhance and Expand Conservation Seedling Nursery: Utilize the DNRC Conservation Seedling Nursery to provide locally adapted and native seedlings for private forest and riparian area reforestation projects. Provide additional support and resources to this program in order increase the capacity for program delivery to state, federal, and tribal landowners and other conservation organizations.

State Lead by Example: On state trust lands, DNRC generally plants 700–1,000 acres per year. In 2007 that level will increase to 1,700 acres due largely to areas impacted by wildland fires.

Forest Pest Management: Provide assistance to nonindustrial forest landowners and others in identifying and managing forest insects and diseases.

Biomass Utilization: Promote the use of forest biomass as an energy source for heating schools and other public facilities.

Forest Stewardship: Promote forest stewardship by helping nonindustrial forest landowners acquire personal knowledge about their forest resources and develop and implement a forest management plan for their property.

Related Policies/Programs in Place

Forestry Best Management Practices: Montana has no regulations that direct landowners to replant stands post-harvest or post-burn. However, forestry best management practices encourage rapid reforestation post-harvest.

Long-Term Maintenance Goals: On state trust lands, there are general rules for maintaining long-term productivity of forestlands but no specific rules aimed at reforestation. However, DNRC has an active reforestation program focused on areas where natural regeneration is not occurring or where there are issues with tree species composition.

DNRC Forestry Assistance Programs: Maintain and improve the health of Montana's forests, forested watersheds, and the communities that depend on them. Tools include information and education, technical assistance and financial assistance.

Type(s) of GHG Reductions

Carbon sequestered in forest biomass.

Carbon sequestered in urban/suburban trees.

Displaced fossil emissions from reduced heating and cooling needs (as a result of increased shade and reduced wind impacts from urban and suburban trees).

Estimated GHG Savings and Costs per MtCO$_2$e

GHG Reduction Potential in 2010, 2020 (MMtCO$_2$e): (A) Restocking: 0.09, 0.51; (B) Urban trees: 0.001, 0.006.

Cumulative GHG Reduction Potential (MMtCO$_2$e, 2007–2020): (A) Restocking 3.4; (B) Urban trees: 0.04.

Net Cost per MtCO$_2$e: (A) Restocking: $12; (B) Urban trees: –$3.

Data Sources: USFS Methods for Calculating Forest Ecosystem and Harvested Carbon with Standards Estimates for Forest Types of the US, General Technical Report NE-343 (also published as part of the US DOE Voluntary GHG Reporting Program); USFS Effects of Urban Forests and their Management on Human Health and Environmental Quality http://www.fs.fed.us/ne/syearacuse/Data/data.htm; Carbon Dioxide Reduction Through Urban Forestry, USFS PSW-GTR-171, McPherson and Sampson, 1999; Northern Mountain and Prairie Community Tree Guide: Benefits, Costs and Strategic Planning, McPherson et al., 2003.

Quantification Methods: Analysis of this option includes two parts: (A) restocking of forests impacted by wildfires and (B) urban tree planting.

Part A: Restocking of Forests Impacted by Wildfires

Goal levels require replanting on 5,000 acres/year from 2008–2010 and 5,500 acres/year from 2011–2020 to restock a total of 70,000 previously burned acres by 2020. In addition, each year there will be an estimated 20,000 acres of forests burned at high severity stand replacement intensities, and this policy aims to restock all of those future burn sites as well. Thus, another 20,000 acres/year of future burns are assumed starting in 2009.

Assumptions used to calculate the carbon benefits achieved through restocking are shown in Table I-9. The proportions of area restocked with each species type are based on the approximate relative distributions of these three forest types in Montana. Carbon sequestration rates of restocked forests are from USFS GTR NE-343 tables B30, B32, and B33, which contain carbon densities on northern Rocky Mountain forests that have been afforested. Carbon sequestration rates were calculated by subtracting carbon stocks in 15-year-old stands from carbon stocks in new stands and dividing by 15. These rates are intended to reflect growth rates in young, recently established stands. It was assumed that in the absence of this restocking program, no carbon sequestration would occur on these sites (i.e., the baseline rate is assumed to be zero).

Table I-9. Restocking assumptions

Forest Types Restocked	Proportion of Area Restocked With This Species	C Sequestration Rate (tC/acre/year)
Douglas fir	50%	0.56
Lodgepole pine	25%	0.32
Ponderosa pine	25%	0.39

Forests restocked in one year continue to sequester carbon in subsequent years. Thus, the calculation of carbon sequestration each year is based on annual benefits from acres restocked cumulatively under the program. Annual carbon sequestration was calculated for each forest type, based on the proportions provided in Table I-9, and summed to achieve the total carbon benefits. Units were converted from tons carbon (tC) to MMtCO$_2$e. Table I-10 shows the acreage treated under goal implementation and resulting carbon sequestration benefits.

Table I-10. Acres restocked and resulting carbon sequestration

Year	Acres Replanted		Carbon Sequestered ($MMtCO_2e$/year)			
	Previous Burns	Future Burns	Douglas Fir	Lodgepole Pine	Ponderosa Pine	Total
2008	5,000		0.0051	0.0015	0.0018	0.0084
2009	5,000	20,000	0.0308	0.0088	0.0106	0.0502
2010	5,000	20,000	0.0565	0.0161	0.0195	0.0921
2011	5,500	20,000	0.0826	0.0236	0.0285	0.1348
2012	5,500	20,000	0.1088	0.0311	0.0376	0.1775
2013	5,500	20,000	0.1350	0.0386	0.0466	0.2202
2014	5,500	20,000	0.1612	0.0461	0.0556	0.2629
2015	5,500	20,000	0.1874	0.0535	0.0647	0.3056
2016	5,500	20,000	0.2135	0.0610	0.0737	0.3483
2017	5,500	20,000	0.2397	0.0685	0.0828	0.3910
2018	5,500	20,000	0.2659	0.0760	0.0918	0.4337
2019	5,500	20,000	0.2921	0.0835	0.1008	0.4764
2020	5,500	20,000	0.3183	0.0909	0.1099	0.5191
Total	**70,000**	**240,000**	**2.10**	**0.60**	**0.72**	**3.42**

Costs were estimated based on a restocking cost of $180/acre (Whitney, DNRC, personal communication). Annual costs were calculated by multiplying the number of acres restocked that year with the cost per acre for restocking. Costs were discounted for future years using a 5% interest rate. A levelized cost-effectiveness (CE) of $12.11/MtC was calculated based on cumulative discounted costs divided by cumulative carbon sequestered through 2020. The total discounted costs from 2007 to 2020 yield an NPV for this option of $41 million.

Part B: Urban Tree Planting

Two types of emissions reductions were calculated separately below for this goal: carbon sequestration in trees and CO_2 savings from reduced heating and cooling costs.

Carbon sequestration in urban trees was calculated at 0.0076 tC/tree/year (0.028 tCO_2e/tree/year), based on the average for Montana in the USFS assessment of urban forests resources (Nowak et al., 2001). Using this value, total annual carbon sequestration from urban tree planting was calculated each year, including sequestration in trees planted that year and in prior years under the program.

A CO_2 savings factor for reduced heating and cooling needs was calculated for Montana using default factors published in USFS PSW-GTR-171. An average factor was calculated from defaults for the northern region of the United States, across three vintages of housing classes (pre-1950, 1950–1980, and post-1980). Separate factors for the shade effects of urban trees on cooling and heating demands and the wind effects on heating demands were calculated and then combined by adding them together for a single composite factor reflecting the net impacts. Default data for medium evergreen trees were used as a proxy for the types of trees planted. Table I-11 shows the default factors by vintage and effects categories as well as the final composite, which indicates that each tree planted will result in CO_2 savings of 0.1125 tCO_2/tree/year.

Table I-11. CO_2 savings factor for shading and wind reduction effects of urban trees

Housing Vintage	Shade-Cooling	Shade-Heating	Wind-Heating	Net effect
pre-1950	0.122	–0.0227	0.1006	0.1999
1950–1980	0.0079	–0.0141	0.0658	0.0596
post-1980	0.0089	–0.0198	0.0889	0.078
Average ($MtCO_2e$)	0.0463	–0.0189	0.0851	0.1125

$MtCO_2e$ = Metric tons carbon dioxide equivalents

Carbon sequestration and CO_2 savings were calculated by multiplying the factors above by the cumulative number of trees planted under the program each year, taking into account that carbon sequestration and energy savings continue every year after a tree is planted. Table I-12 shows the results of this analysis.

Table I-12. Carbon benefits and program costs of urban tree planting

Year	Number of Trees Planted	Cumulative Number of Trees in Program	Carbon Sequestered ($MMtCO_2e$/year)	CO_2 Savings From Shading and Wind Effects ($MMtCO_2e$/year)	Total Carbon Savings ($MMtCO_2e$/year)
2008	3,250	3,250	0.0001	0.0004	0.0005
2009	3,250	6,500	0.0002	0.0007	0.0009
2010	3,250	9,750	0.0003	0.0011	0.0014
2011	3,250	13,000	0.0004	0.0015	0.0018
2012	3,250	16,250	0.0005	0.0018	0.0023
2013	3,250	19,500	0.0005	0.0022	0.0027
2014	3,250	22,750	0.0006	0.0026	0.0032
2015	3,250	26,000	0.0007	0.0029	0.0037
2016	3,250	29,250	0.0008	0.0033	0.0041
2017	3,250	32,500	0.0009	0.0037	0.0046
2018	3,250	35,750	0.0010	0.0040	0.0050
2019	3,250	39,000	0.0011	0.0044	0.0055
2020	3,250	42,250	0.0012	0.0048	0.0059

A cost of $14.56/tree was estimated using a 40-year average for small, medium, and large conifer trees in northern mountain and prairie communities (McPherson et al.). Net cost savings were estimated at $28.26/tree, considering energy conservation, storm water interception, clean air, and higher property values. Taken together, each tree yields a net cost savings of $13.70. Using this value, total cost savings, cost-effectiveness (cost per ton of GHG reduced), and discounted costs (assuming a 5% interest rate) were calculated. Cost-effectiveness (cost per metric ton of carbon) improves through the duration of the time frame as the cumulative number of trees planted continues to accrue carbon sequestration and CO_2 savings without any additional costs. Undiscounted net annual costs are –$44,525/year (negative indicates cost savings), i.e., –$13.70/tree × 3,250 trees. The NPV for this option (sum of the discounted annual costs from 2008 to 2020) is estimated at –$132,880. Overall cost-effectiveness is estimated at –$3/$MtCO_2e$, based on cumulative discounted costs divided by cumulative GHG savings.

Key Assumptions:

(A) Restocking Goal: The carbon sequestration rate in non-restocked forests is zero; forest types burned are proportional to dominant forest types; future annual rate of stand replacement fires of 20,000 acres/year.

(B) Urban Trees Goal: State-wide and regional carbon sequestration and CO_2 savings coefficients are representative of trees planted under the program. Costs and costs savings were based on 40-year averages for conifers.

Key Uncertainties

The number of acres that will burn in the future.

Additional Benefits and Costs

Increased wildlife habitat and ecosystem health.

Erosion control and water quality.

Increasing productive forestland more quickly.

Potential small business growth, e.g., contracting out restocking services.

Feasibility Issues

Nursery Capacity: Consider logistics and funding associated with the existing state nursery capacity and ability to respond to increased seedling demand.

Availability of Seed Source Funding.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

AFW-9. Improved Management and Restoration of Existing Stands

Policy Description

This policy seeks to increase forest carbon stocks through changes in management practices on existing forestland. In contrast to the companion policy AFW-6, this policy is not restricted to working through existing forest health programs to promote new practices that increase tree density, enhance forest growth rates, alter rotation times, or decrease the chances of biomass loss from fires, pests, and disease. In addition, increasing the transfer of biomass to long-term storage in wood products can increase net carbon sequestration, provided a proper balance is maintained where enough biomass remains on site as residues serving as nutrient inputs to the forest. Practices may include management of rotation length, biomass density, biomass energy use, and sustainable use of wood products.

Policy Design

Goals: Initiate programs to increase forest productivity by 20% on 700,000 acres of private and state forestlands by 2020.

Timing: Accelerate private forest landowner education programs by 2010. Implement forest improvement projects on 53,846 acres of state and private forestlands per year.

Parties Involved: Montana DNRC, Montana FWP, UM School of Forestry and Conservation, USFS, USDA NRCS; BLM, Bureau of Indian Affairs and tribal governments, county governments and other political subdivisions of the state, private nonprofit land trusts, nonprofit organizations.

Other: A 2001 study (Fiedler et al.)[26] estimated that 7.5 million acres of Montana's forestlands should be considered for treatment because they are in the moderate or high fire hazard condition in short-term fire-adapted ecosystems. Treating these stands would reduce fire hazard potential, improve forest health and diversity, and restore stand conditions. In 2005, more than 1.2 million acres of Montana's forestlands (all ownerships) were impacted by insects and diseases.

Implementation Mechanisms

Information and Education: Work through the MSU Extension Forestry program and DNRC's Forest Stewardship Program to educate private forest landowners on the forest health and hazardous fuels mitigation benefits of implementing proper forest management and silvicultural practices. In turn, this will increase forest productivity and improve stand health. Use success stories from state trust lands to inform private landowners on the benefits of forest management.

Technical Assistance: Public education and outreach to landowners regarding existing federal and state programs. Continue DNRC Service forester assistance to nonindustrial private forest

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[26] Fiedler et al., A Strategic Assessment of Fire Hazard in Montana, Report to the Joint Fire Science Program http://www.nifc.gov/joint_fire_sci/ummontanarpt.pdf

landowners, targeting stewardship program graduates with current Stewardship Management Plans and private land management efforts such as The Blackfoot Challenge.

Funding Mechanisms and/or Incentives: Use NRCS and USFS state and private forestry cost-share programs to assist private forest landowners. Timber management focused on stagnant, overstocked, overage, or debilitated stands of trees would provide increased carbon sequestration. Incentives for this management would be ecologically improved and more productive forestlands and the sale of the harvested logs earnings enough to, at a minimum, pay for the cost of the work.

Market-Based Incentives: Support and engage in private sector markets for carbon sequestration that recognize the carbon benefits of forest management, urban forestry, and afforestation/reforestation (e.g., Chicago Climate Exchange). State participation further enhances state lead by example as an implementation mechanism.

Enhancement of the Existing Programs: Provide increased guidance and expertise to forestland owners to promote the implementation of proper forest management. DNRC currently has urban, nonindustrial, private forest landowner and forest health programs that provide information, education, technical assistance and, when available, financial assistance to landowners and urban forest managers.

These programs are predominately federally funded through USFS State and Private Forestry and Farm Bill funds. These programs are targeted for significant reduction in the President's 2008 budget proposal. Continuation of these federal programs is likely through state efforts in Washington, DC, and program enhancement through Montana legislative and fiscal support for these programs with a new focus on GHG reduction and carbon sequestration strategies.

Hazard Identification: Identify areas of high hazard within the wildland–urban interface and other high-risk areas (high fire hazard, severe overstocking, insect and disease attacks) to help target accelerated treatments for improving stand conditions, which will also result in improved stand productivity.

Improve Inventory: Collect stand data on 10% of forest stands on state trust lands within 10 years. Educate private nonindustrial landowners to do the same.

Increase Forest Productivity: On state trust lands, increase forest productivity on 12,000 to 15,000 acres per year through active forest management.

Sustained Yield Calculation: Consider statewide coarse filter sustained yield calculation across all land ownerships.

Related Policies/Programs in Place

Fire Risk and Forest Health Initiatives: Current fire risk and forest health initiatives directed toward density reduction include the multiagency National Fire Plan and the Western Governors' Association 10-Year Comprehensive Strategy for Implementation of the National Fire Plan.

Cost-Share Assistance Programs: Cost-share assistance for fuels treatment on private lands is provided through the Community Protection Fuels Mitigation Grant Program and Western Wildland–Urban Interface Grant Program. Use NRCS and USDA State and Private Forestry cost-share programs to assist private forest landowners.

DNRC Forest Management Goals and Objectives: On state trust lands, the DNRC forest management objectives through the State Forest Land Management Plan and the current administrative rules are to move stands toward desired future conditions that are based on historical cover type distributions. More specific goals for state lands include thinning overstocked stands, reducing fire hazard, and managing for forest health and biodiversity.

Department of Environmental Quality (MDEQ) Open Burning Program: The Montana/Idaho State Airshed Group was formed in 1978 for minimizing or preventing the accumulation of smoke from prescribed fire to protect state and federal air quality standards and visibility in federal Class I areas. This is accomplished, in part, through MDEQ's restricting open burning when atmospheric dispersion is not acceptable.

Montana has open burning regulations under Annotated Rules of Montana (ARM) 17.8.601 et. seq. It focuses on large open burners (those emitting more than 500 tons of carbon monoxide or 50 tons of other pollutants per calendar year).

Minor burners contribute emissions to airsheds but pay no fees. Minor open burners are not required by MDEQ to obtain an air quality open burning permit but must follow other best available control technology (BACT) procedures that include calling the smoke management hotline and obtaining a burning permit from their local forestry office.

DNRC Forestry Assistance Programs: Maintain and improve the health of Montana's forests, forested watersheds, and the communities that depend on them. Tools include information and education, technical assistance, and financial assistance. Supporting programs could include the following.

- **Forest Stewardship:** Promote forest stewardship by helping nonindustrial forest landowners acquire knowledge about their forest resources and develop and implement a forest management plan for their property.
- **Urban and Community Forestry:** Provide Montana's urban communities with assistance in establishing and maintaining healthy, productive, and financially beneficial urban forestry programs and urban forests.
- **Forest Pest Management:** Provide help with identifying and managing forest insects and diseases to nonindustrial forest landowners and others.
- **Conservation Seedling Nursery:** Produce and distribute seedlings for conservation plantings to private landowners, state, federal, and tribal landowners, and other conservation organizations.
- **Biomass Utilization:** Promote the use of forest biomass as an energy source for heating schools and other pubic facilities.

Type(s) of GHG Reductions

Carbon stored in forest biomass and soils.

Carbon stored in harvested wood products.

Estimated GHG Savings and Costs per $MtCO_2e$

Forest Carbon GHG Reduction Potential in 2010, 2020 ($MMtCO_2e$): 0.04, 0.2.

Forest Carbon Cumulative GHG Reduction Potential ($MMtCO_2e$, 2007–2020): 1.2.

Harvested Wood Carbon GHG Reduction Potential in 2010, 2020 ($MMtCO_2e$): 0.01, 0.01.

Harvested Wood Cumulative GHG Reduction Potential ($MMtCO_2e$, 2007–2020): 0.14.

Net Cost per $MtCO_2e$: $119.

Data Sources: USFS Methods for Calculating Forest Ecosystem and Harvested Carbon with Standards Estimates for Forest Types of the US, General Technical Report NE-343 (also published as part of the US DOE Voluntary GHG Reporting Program), USFS FIA Program; T.F. Strong, 1997, "Harvesting Intensity Influences the Carbon Distribution in a Northern Hardwood Ecosystem," USFS Research Paper NC-329.

Quantification Methods:

This option aims to increase production in terms of harvest volumes (i.e., cubic feet per acre) by 20% on 700,000 acres of forestland in Montana through stand improvement treatments, including density reduction treatment such as pre-commercial thinning, commercial thinning, intermediate harvests, and selection harvests.

For the purposes of estimating the GHG benefits, it was assumed that three dominant forest types in Montana would be targeted for treatment. Specifically, this analysis assumes that 280,000 acres each of Douglas fir and ponderosa pine and 140,000 acres of lodgepole pine will be treated by 2020, for a total of 700,000 acres (Table I-13).

Table I-13. Total acres targeted by the policy by 2020, by forest type

Forest Type	Acres Treated by 2020
Douglas fir	280,000
Lodgepole pine	140,000
Ponderosa pine	280,000
Total	700,000

Stand improvement treatments are anticipated to impact carbon sequestration in two ways. First, they will enhance forest growth and carbon sequestration in forest biomass by 15%. Second, they will yield a 20% increase in harvest volumes, which will increase the amount of carbon stored in durable wood products. These impacts are quantified separately below in Table I-14. Two points: 1) net forest carbon sequestration is calculated as carbon sequestration due to growth minus carbon losses from removals (harvests) and 2) the amount of carbon stored in durable wood products post-harvest is estimated using regional default coefficients for the use and disposal of wood products and corresponding carbon decay.

Forest Carbon Sequestration

Forest carbon sequestration rates under baseline conditions (no stand improvement treatments) were based on published carbon stocks (tC/acre in forest biomass) for Douglas fir, lodgepole pine, and ponderosa pine stands in the northern Rocky Mountain region (USFS GTR-343). Annual rates of carbon sequestration from forest growth (tons of carbon sequestered per year) were calculated by subtracting total carbon stocks in the forest biomass of 125-year-old stands from total carbon stocks in the forest biomass of new stands and dividing by 125. A long-term average was used to implicitly take into account the relatively fast rate of carbon accumulation in young stands and slower rates in older stands.

It was assumed that improved forest management would increase forest growth and carbon sequestration by 15%, based on expert opinion from Montana DNRC. USFS estimates of soil carbon stocks are constant over time. Therefore, this analysis assumes that no net carbon sequestration in forest soils occurs under the baseline or policy scenarios. Carbon sequestration rates under baseline and policy implementation are shown in Table I-14.

Table I-14. Forest biomass carbon sequestration rates

	Baseline	With Stand Improvement Treatments
	tons of carbon/acre/year	
Douglas fir	0.57	0.66
Lodgepole pine	0.39	0.45
Ponderosa pine	0.37	0.42

The analysis assumes that approximately 53,846 acres of forests are treated each year, starting in 2008 until 2020, when a total of 700,000 acres will have been treated. Table I-15 shows the cumulative acres treated per year by forest type as modeled in this analysis: starting in 2008, 21,538 acres each of Douglas fir and ponderosa pine and 10,769 acres of lodgepole pine are treated. This same amount of area is treated each year thereafter until the total number of acres treated in 2020 is 280,000 acres each of Douglas fir and ponderosa pine and 140,000 acres of lodgepole pine.

Annual carbon sequestration under policy implementation was calculated by multiplying the cumulative number of acres treated each year by the annual carbon sequestration rate for stand improvement treatments in Table I-14. This accounts for annual carbon sequestration benefits beginning in the first year that an area of forest is treated and continuing through the duration of the time frame of analysis. Annual removals were also calculated assuming a harvest rate of 1.3%/year, i.e., by multiplying the number of acres treated each year by 1.3%, which yields approximately 700 acres/year, and multiplying 700 acres/year by biomass carbon stocks in 65-year-old stands. The biomass carbon stocks were then multiplied by 39% to account for the amount of biomass removed during harvest. Strong (1997) estimates that a light harvest removes approximately 39% of forest carbon. The net change in growth (positive value) and removals (negative value) was calculated to yield a net annual carbon flux (note: removals are shown as negative values to indicate that biomass is lost from the forest). Annual sequestration, removals, and net carbon flux under baseline conditions were calculated using the same area data and applying the baseline annual sequestration and 65-year-old carbon stocks values. The difference in net carbon flux between the policy and baseline cases is the total additional carbon sequestered within forests under this option. Results are shown in Table I-15.

Table I-15. Acres targeted and estimated annual carbon sequestration (Seq.), removals, and net carbon flux under baseline and policy scenarios

Year	Cumulative Acres Treated	Baseline			Policy Scenario			GHG Savings	
		Annual Seq. (A)	Annual Removals (B)	Net Carbon Flux (A+B)	Annual Seq. (D)	Annual Removals (E)	Net Carbon Flux (D+E)	Additional Seq. (D+E) – (A+B)	Additional Carbon Seq.
		tC/year							$MMtCO_2e$
2008	53,846	24,441.8	–14,523.6	9,918.2	28,108.1	–15,249.8	12,858.3	2,940.1	0.011
2009	107,692	48,883.7	–14,523.6	34,360.1	56,216.2	–15,249.8	40,966.5	6,606.4	0.024
2010	161,538	73,325.5	–14,523.6	58,801.9	84,324.4	–15,249.8	69,074.6	10,272.7	0.038
2011	215,385	97,767.4	–14,523.6	83,243.8	112,432.5	–15,249.8	97,182.7	13,938.9	0.051
2012	269,231	122,209.2	–14,523.6	107,685.6	140,540.6	–15,249.8	125,290.8	17,605.2	0.065
2013	323,077	146,651.1	–14,523.6	132,127.5	168,648.7	–15,249.8	153,399.0	21,271.5	0.078
2014	376,923	171,092.9	–14,523.6	156,569.3	196,756.9	–15,249.8	181,507.1	24,937.8	0.091
2015	430,769	195,534.8	–14,523.6	181,011.2	224,865.0	–15,249.8	209,615.2	28,604.0	0.105
2016	484,615	219,976.6	–14,523.6	205,453.0	252,973.1	–15,249.8	237,723.3	32,270.3	0.118
2017	538,462	244,418.5	–14,523.6	229,894.9	281,081.2	–15,249.8	265,831.5	35,936.6	0.132
2018	592,308	268,860.3	–14,523.6	254,336.7	309,189.4	–15,249.8	293,939.6	39,602.9	0.145
2019	646,154	293,302.2	–14,523.6	278,778.6	337,297.5	–15,249.8	322,047.7	43,269.1	0.159
2020	700,000	317,744.0	–14,523.6	303,220.4	365,405.6	–15,249.8	350,155.8	46,935.4	0.172

Carbon Sequestered in Harvested Wood Products

Note: Metric units are used in this portion of the analysis because default coefficients in the USFS methodology for quantifying carbon sequestration in harvested wood products are in metric units.

Stand improvement treatments are expected to enhance the amount of biomass available for harvest. The removal of biomass through harvesting transfers carbon stored in forest biomass to carbon stored in harvested wood products (HWP). Increased levels of production under this option will lead to more carbon transferred into HWP. The analysis below estimates the amount of additional carbon stored in HWP as a result of a 20% increase in productivity on treated forests.

Carbon sequestration in HWP was calculated following guidelines published by the USFS. Details on each step of the analysis can be found in the guidelines, following the methodology referred to as “land-based estimation.” In general, forest productivity is used as a starting point, and regional patterns in the disposition of carbon through various HWP pools are used to model carbon stock changes in HWP over time. The methodology calculates the transfer of carbon through four pools over time: wood in use (i.e., building materials, furniture), wood in landfills (i.e., products that were previously in use and have been discarded), wood burned for energy capture, and wood that has decayed or burned without energy capture. The difference in the amount of carbon entering the “in use” and “landfill” pools at the beginning of a year and the amount remaining one year later equals total net annual carbon flux (i.e., sequestration) in harvested wood products (HWP).

Data from the USFS FIA Program in 2005 were used to estimate current levels of productivity for Douglas fir, lodgepole pine, and ponderosa pine in Montana. Average productivity was calculated separately for each forest type by dividing the total growing stock volume in timberlands by the total area of timberland in 2005. Average productivity in Douglas fir, lodgepole pine, and ponderosa pine stands in Montana was calculated to be 125, 162, and 72 cubic meters per hectare (m^3/ha), respectively. Under implementation of this policy option, productivity is expected to increase by 20%; therefore, productivity on forests with improved forest management was calculated as a 20% increase over current levels (i.e., 150, 194, and 86 m^3/ha on Douglas fir, lodgepole pine, and ponderosa pine, respectively).

Table I-16. Background information on forest production by forest type (FIA, 2005)

Species	Area of Timberlands (ha)	Growing Stock Volume (m^3/year)	Baseline Average Production (m^3/ha/year)	Average Production With Improved Forest Management (m^3/ha/year)
Douglas fir	2,751,891	344,580,115	125.22	150.26
Lodgepole pine	1,439,387	232,661,602	161.64	193.97
Ponderosa Pine	1,189,055	85,327,889	71.76	86.11

There are several steps in the analysis where default coefficients for the northern Rocky Mountain region are applied to the starting point of average productivity. First, for each forest type, average productivity (m^3/ha/year) is apportioned into classes of wood harvested (i.e., softwood sawlog, softwood pulpwood, hardwood sawlog, hardwood pulpwood) and the per-area carbon volumes of each class are calculated. Next, the quantity that is processed into primary wood products is calculated (factoring out carbon in logging residue, fuelwood, and waste), using the following ratios: ratio of industrial roundwood to growing stock volume removed as roundwood; ratio of carbon in bark to carbon in wood; fraction of growing stock volume removed as roundwood; and the ratio of fuelwood to growing stock volume removed as roundwood. The results are approximate per-area carbon stocks (tC/ha) in industrial roundwood, excluding bark and fuelwood. Carbon stocks in industrial roundwood were estimated for the baseline case using current levels of production as the starting point and for the policy scenario using levels of production under improved forest management as the starting point (Table I-17).

Table I-17. Calculated carbon stocks in industrial roundwood

Product Pool	Baseline (tC/ha)	Improved Forest Management (tC/ha)
Softwood saw log carbon in industrial roundwood	43.97	52.76
Softwood pulpwood carbon in industrial roundwood	48.97	58.76
Hardwood saw log carbon in industrial roundwood	0.08	0.10
Hardwood pulpwood carbon in industrial roundwood	0.49	0.59

The average disposition pattern of HWP over time in the northern Rocky Mountain region is provided by the USFS methodology. The disposition pattern is the flow of HPW between four pools over time: carbon in HWP in use, carbon in HWP in landfills, carbon emitted with energy capture, and carbon emitted without energy capture. Because there is not much hardwood in the northern Rocky Mountain region, as reflected in the relatively low carbon stocks for hardwood classes in Table I-17, the disposition patterns include only softwood categories of industrial roundwood. Thus, the remainder of the analysis includes only softwood.

Table I-18 shows the disposition pattern used in this analysis for a single harvest. According to Table I-18, in the year following harvest, 70% of the carbon in softwood goes into use, 21% is emitted with energy capture, 9% is emitted without energy capture, and none is placed in landfills. Over time the amount of carbon in use declines as it is transferred into the categories of carbon in landfills and carbon emitted to the atmosphere, such that by 100 years after harvest, approximately 11% of carbon remains in HWP in use, 26% is in landfills, and 63% has been emitted (note: carbon emissions from HWP are considered biogenic and are not counted as direct emissions).

The disposition over time of carbon stocks was modeled using the carbon stocks in Table I-17 (separately for the baseline and policy cases) and the disposition pattern in Table I-18 (same pattern used in baseline and policy case). This provides per-acre estimates of carbon stocks (tC/ha) remaining in each pool over time starting from a single harvest for both the baseline and policy scenarios. The total amount of carbon stocks and their disposition over time from a single harvest was calculated by multiplying the per-acre carbon stocks mentioned above by an average annual harvested area of 283 ha/year (i.e., 700 acres/year, which is 1.3% of the annual area of treated forest). The net impact of carbon storage in HWP as a result of regular annual harvests over the period of analysis was modeled for the baseline and policy cases. The incremental increase in carbon stocks was calculated as the difference between the two scenarios.

Table I-18. Disposition pattern of carbon in HWP as a fraction of industrial roundwood for the northern Rocky Mountain region of the United States

Year After Harvest	Fraction in Use	Fraction in Landfill	Fraction Emitted With Energy Capture	Fraction Emitted Without Energy Capture
0	0.704	0	0.209	0.087
1	0.664	0.019	0.223	0.094
2	0.628	0.036	0.235	0.101
3	0.595	0.051	0.247	0.107
4	0.567	0.065	0.256	0.112
5	0.541	0.077	0.265	0.118
6	0.517	0.088	0.273	0.122
7	0.495	0.098	0.28	0.127
8	0.474	0.107	0.287	0.131
9	0.455	0.116	0.294	0.135
10	0.438	0.124	0.3	0.139
15	0.373	0.152	0.32	0.154
20	0.33	0.171	0.333	0.165
100	0.112	0.255	0.373	0.26

The results of the analysis are summarized in Table I-19, which shows the amount of carbon stored in landfills and products in use each year above what would have happened in the baseline, spanning the time period 2008–2020. While the amount of additional carbon in landfills and in products from a given harvest decreases each year (as it is emitted through decay or energy capture), additional wood is harvested each year, adding new carbon stocks to the total HWP stream. Thus, for every year in the time series, the carbon stocks in the wood products pool are increasing. This analysis is carried out until 2020 and does not capture the continued disposition of carbon through the wood products pools in time.

The values in Table I-19 are incremental increases in HWP carbon stocks, with annual totals shown at the bottom. Carbon sequestration is calculated as the annual change in carbon stocks (subtracting stocks in year 2 from stocks in year 1). The net sequestration rate (last row) is sensitive to the year of analysis because the transfer of carbon between HWP pools is dynamic over time.

An alternative approach for estimating carbon stored in wood products is to estimate the amount of carbon remaining in products and landfills after 100 years and to apply that value to the year of harvest as an annual sequestration rate (GTR NE-343, 1605b technical guidelines). This approach essentially accounts for emissions occurring during 100 years after a harvest in the year of the harvest and assumes that the carbon remaining after 100 years is stored permanently. This approach was developed to simplify annual reporting of carbon stored in wood products and to account for the long-term dynamics of carbon flows in harvested wood products pools.

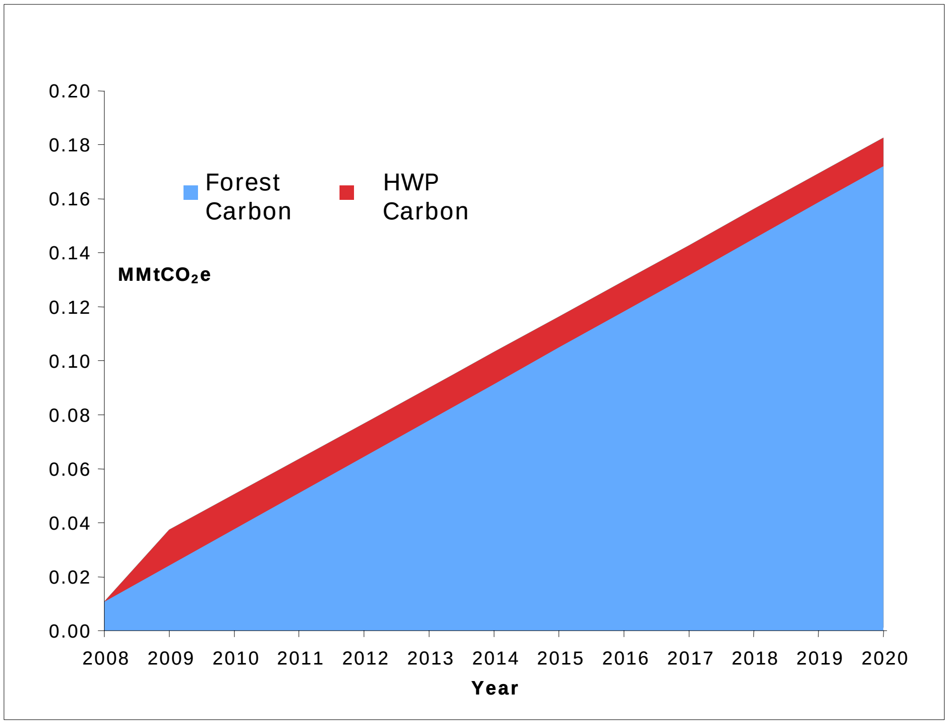
Table I-19. Disposition of carbon in HWP over time, shown by tracking individual annual harvests from 2008 to 2020

Year of Harvest	Carbon in Use or Landfill by the End of This Year												
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
2008	0.014	0.013	0.013	0.012	0.012	0.012	0.012	0.011	0.011	0.011	0.011	0.011	0.011
2009		0.014	0.013	0.013	0.012	0.012	0.012	0.012	0.011	0.011	0.011	0.011	0.011
2010			0.014	0.013	0.013	0.012	0.012	0.012	0.012	0.011	0.011	0.011	0.011
2011				0.014	0.013	0.013	0.012	0.012	0.012	0.012	0.011	0.011	0.011
2012					0.014	0.013	0.013	0.012	0.012	0.012	0.012	0.011	0.011
2013						0.014	0.013	0.013	0.012	0.012	0.012	0.012	0.011
2014							0.014	0.013	0.013	0.012	0.012	0.012	0.012
2015								0.014	0.013	0.013	0.012	0.012	0.012
2016									0.014	0.013	0.013	0.012	0.012
2017										0.014	0.013	0.013	0.012
2018											0.014	0.013	0.013
2019												0.014	0.013
2020													0.014
Total HWP Stocks (MMtCO$_2$e)	0.014	0.027	0.040	0.052	0.064	0.076	0.088	0.099	0.111	0.122	0.132	0.143	0.154
Annual Change in Stocks (MMtCO$_2$e/ year)		0.013	0.013	0.012	0.012	0.012	0.012	0.011	0.011	0.011	0.011	0.011	0.011

For comparison with the analysis shown in Figure I-3, which tracks actual annual stocks and carbon sequestration during 2008–2020, the additional amount of carbon stored permanently above baseline levels 100 years after a single annual harvest is estimated to be 0.007 MMtCO$_2$e. Using the 100-year method, the total amount of incremental carbon permanently stored from harvests during 2008–2020 is 0.09 MMtCO$_2$e. This can be compared with the cumulative amount of carbon sequestration of 0.14 MMtCO$_2$e during 2008–2020, as shown in Table I-19.

Total carbon savings, including forest carbon sequestration and carbon stored in HWP, are shown in Figure I-3. The majority of carbon sequestration occurs from increased forest growth. HWP carbon storage makes a small contribution to the overall benefit.

Figure I-3. Total carbon savings from improved forest management



HWP = harvested wood products; MMtCO$_2$e = million metric tons CO$_2$ equivalents.

Cost Analysis

The costs per acre to implement stand improvement treatments were assumed to be $300/acre based on expert opinion of the TWG. Costs were multiplied by the number of acres treated annually, yielding an annual cost of $16 million per year. Annual discounted costs were then estimated using a 5% interest rate. Cost-effectiveness ($/tCO$_2$e) was calculated by summing the annual discounted costs and dividing by cumulative GHG benefits (including forest and HWP carbon) during 2008–2020. (The annual accounting method for HWP was used in the analysis.) Cost-effectiveness is estimated at $119/MtCO$_2$e. The sum of annual discounted costs also provides an estimate of the NPV of this option of $160 million. This analysis does not take into account the additional revenue generated from enhanced commercial value of treated stands, which would be a cost savings.[27]

Key Assumptions:

Stand improvement treatments increase carbon sequestration by 15% and harvest volumes by 20%; harvest rates are 1.3%/year; regional patterns in the disposition of HWP represent conditions in Montana; stand improvement treatments result in instantaneous increases in growth and volumes harvested.

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[27] This cost analysis does not factor in the commercial value from timber harvests associated with stand improvement treatments, which would increase the cost-effectiveness of implementing this option. Stand improvement treatments range from generating $950/acre to costing $325/acre, depending on the project and forest type. C.E. Fiedler, D.P. Wichman, and S.F. Arno. 1999. “Product and Economic Implications of Ecological Restoration,” *Forest Products Journal,* 49(2):19–23.

Key Uncertainties

Actual forest carbon sequestration will vary by site conditions, species classes, and specific management practices implemented. The analysis uses average values representative of the northern Rocky Mountain region for three common forest types and therefore does not take into account site-specific conditions.

Both HWP accounting approaches involve simplifying assumptions that in one case may overestimate carbon storage (annual accounting with instantaneous benefits) and in the other case may underestimate carbon storage (100-year accounting approach). The real benefits probably lie somewhere in between.

Additional Benefits and Costs

Increased timber yields and revenues.

Reduced pest, disease, and fire risk.

Potential increased public exposure to smoke and increased trace GHG emissions.

Treating these stands would reduce fire hazard potential, improve forest health and diversity, and restore stand conditions.

Feasibility Issues

- Loss of cost-share assistance or state budget cuts.
- Loss of forest industry.
- Litigation/appeals for state projects.
- Poor timber product markets will reduce financial incentives for management on non-industrial private lands.
- Loss of productive forestland.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

AFW-10. Expanded Use of Wood Products for Building Materials

Policy Description

This policy seeks to enhance the use and lifetime of durable wood products. Durable products made from wood prolong the length of time forest carbon is stored and not emitted to the atmosphere. Following their useful life (which could last for decades), wood products disposed of in landfills may store carbon for long periods under conditions that minimize decomposition. Additional GHG benefits can be achieved when methane gas is captured from landfills and used as an energy source (carbon originally stored in wood products becomes methane during decomposition). Increasing carbon stored in the wood products pool increases carbon sequestration from forests. This can be achieved through improvements in production efficiency, product substitution, expanded product lifetimes, and other practices. In addition, increasing the efficiency of the manufacturing life cycle for wood products enhances GHG benefits.

Policy Design

Goals: The Climate Change Advisory Committee (CCAC) recommends that Montana adopt programs to expand the use of wood products by 5% over current baseline rates.

Timing: Increase usage by 2% by 2010 and 5% by 2020, above current trends.

Parties Involved: Building material suppliers, wood product industries, recycled building materials sellers, and others, UM School of Forestry and Conservation, all state agencies lead through example.

Other: Not applicable.

Implementation Mechanisms

State Adopted Policies: The state should adopt policies that require wood products in the construction and maintenance of all state buildings when those products are feasible and relatively close in price (within 5%) to the alternative.

Product Substitution: Promote using wood products whenever and wherever feasible, instead of metal or synthetic building materials. Also promote replacing petroleum thinners and solvents with those derived from wood and tree sap/pitch (i.e., naval stores).

Tax Incentives: Give state tax incentives or low-cost loans for the development and production of new wood products and derivatives. Consider state tax credits for the use of wood products above existing normal levels in building energy efficient homes.

Expanded Product Lifetimes: Research, develop, and demonstrate new products that expand lifetimes through preservatives; these can also be derived from wood.

New Products: Develop new and expanded uses of wood, including filler for organic composting or bedding for livestock. Provide grants or support for research and development of new products. The Montana University System would be an excellent vehicle for such research and development.

Education/Outreach: Develop information and education programs to promote product substitution (using wood products whenever and wherever feasible, instead of metal or synthetic building materials) and the benefits gained through carbon sequestration.

Research and Development: An inventory of needs and opportunities for durable wood product utilization in Montana should be conducted and should consider opportunities to increase the use of small-diameter wood in construction as well as use of wood instead of non-wood products. Ways to engage consumers in choosing to use wood should be considered as well as ways to promote the GHG benefits and local economic benefits.

MDEQ and utility companies offer programs that promote energy conservation and the use of renewable energy. Similar programs could be developed or expanded to promote the use of wood products (e.g., “good sense” homes.)

Related Policies/Programs in Place

State Hazard Reduction Regulations: State forest hazard reduction laws and administrative rules require the reduction of timber slash during harvest projects. Although not required, the current laws and rules structure makes burning slash the most feasible method of reducing the hazard.

Forest Service: USFS has recently implemented a policy that requires contractors to haul and pile slash as landings to help facilitate removal of biomass during harvest operations.

DNRC Logging Contracts: Slash treatment requirements are currently part of all DNRC logging contracts.

State Trust Land Forest Management Program: DNRC has recently changed the timber bid sale process for state trust lands to encourage removal of residues for pulp and biomass.

Type(s) of GHG Reductions

Displacement of life cycle emissions associated with production and use of industrial building materials (e.g., steel and concrete)

Estimated GHG Savings and Costs per $MtCO_2e$

Estimated GHG Savings in 2010 and 2020: Not quantified.

Cost-Effectiveness: Not quantified.

Data Sources: CCS reviewed available data sources including the Consortium for Research on Renewable Industrial Materials (CORRIM, Inc.) Phase I Research Report. This study provided the GHG reduction potential for substituting steel frames for wood frames in residential structures, as well as physical characteristics in wood typically used in the West region.[28] Data were available through MDEQ on the number of residential structures per year that will be built in Montana, as well as population projections from the Montana GHG Inventory and Forecast. Data and GHG reduction estimates for industrial and commercial structures, as well as long-lived consumer products were not available at the time of this analysis. The available data sources did not allow for the development of methods to estimate GHG reductions from this option, since the envisioned implementation covers increased use of wood products in a broad array of building products and other materials. The available information captured only the potential increases in use in residential framing (a very small segment of the wood uses covered by this option). Hence, no estimates were made of GHG reductions or costs.

Quantification Methods: Not applicable; see Data Sources above.

Key Assumptions: Not applicable; see Data Sources above.

Key Uncertainties

There is a lack of data and established methodologies to assess GHG reductions and costs for offsetting high-GHG-embedded building materials in the commercial and industrial sectors and in long-lived consumer products. For the residential sector, the estimated GHG reductions are also unclear whether significant increases can be made in offsetting high-embedded GHG products. Opportunities could exist in other building/finished wood products (e.g., siding, trim, flooring, cabinetry) in place of higher GHG-embedded materials.

Cost information for making substitutions of wood for high-GHG-embedded building materials was not identified for this analysis. The costs for implementing the programs described above for this option could not be estimated.

Additional Benefits and Costs

Potential for greater in-state job creation and retention in forests products and building and finished wood products (e.g., trim, siding, cabinetry, furniture) sectors.

Feasibility Issues

Cost-effectiveness of non-wood alternatives.

Availability of wood products to substitute for non-wood alternatives.

Quality and durability of wood versus the alternatives.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

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[28] J. Bowyer, D. Briggs, B. Lippke, J. Perez-Garcia, J. Wilson. Life Cycle Environmental Performance of Renewable Materials in the Context of Residential Building Construction. Prepared for CORRIM, Inc. http://www.corrim.org/reports/2006/final_phase_1/index.htm

Barriers to Consensus

None.

AFW-11. Programs to Promote Local Food and Fiber

Policy Description

Programs that promote the production, distribution, and consumption of locally grown food and fiber products reduce transportation and manufacturing emissions by offsetting the consumption of products with higher embedded energy. Food and fiber products consumed in the United States can travel thousands of miles before reaching a grocery or clothing store in the form of a final product (on average a typical food product travels 1,500 miles and changes hands 33 times). Increasing the percentage of locally grown food and fiber consumed in Montana will significantly reduce fossil fuel use and its associated GHG emissions.

Policy Design

Goals: 30% of food consumed in Montana is grown, harvested, and processed in Montana.

Timing: By 2010, 20%; by 2020, 30%**.**

Parties Involved: Promotion by MDOA (tracking of in-state product consumption), Farm Bureau, stock growers, Montana Cattlemen's Association, Grow Montana, AERO, National Center for Appropriate Technology (NCAT), sheep producers, wool growers, and grain growers.

Other: Montana-based food systems are a realistic vision. In 1950, 70% of the food Montanans ate was grown in Montana. Today, MDEQ estimates that it is 15%. Through the 1930s, food processing was Montana's number one employer. In the spring of 2003, the University of Montana-Missoula responded to student demand by launching the Farm to College Program, purchasing safflower oil, beef, bread, dairy products, and fruits and vegetables from Montana producers. In the past 2 years, the program bought more than $500,000 from in-state sources. In the same period, the University's overall food costs—as a percentage of its food service budget—decreased.

Implementation Mechanisms

Buy Local Campaigns: Encourage institutions that purchase large quantities of food to buy local. Some of the cost barriers to local purchasing were removed by the 2007 Legislature when Senate Bill 238 (SB 238) passed. This allows institutions to purchase Montana grown or processed food even when it costs a little more. Inform institutions at meetings and conferences about purchasing for state and local government and school districts.

Made in Montana Food and Fiber Products: Focus attention on "Made in Montana" food and fiber products through the MDOA program.

Information and Education: Include information on the benefits of buying local food and fiber as part of energy conservation programs that provide information through the popular Energize Montana Web site and frequently participate in fairs and home shows.

Working together to further define, develop, implement, and promote all local foods production, storage, processing, and consumption will require several strategies.

Related Policies/Programs in Place

Grow Montana Program: Its goal is strengthening Montana's food and agricultural economy. Grow Montana (http://growmontana.ncat.org/) is a broad-based coalition whose common purpose is to promote community economic development policies that support sustainable Montana-owned food production, processing, and distribution and that improve all Montana's citizens access to Montana foods.

Other Initiatives

Mobile Meat Slaughter: The 2005 Montana Legislature authorized the Montana Department of Livestock to inspect mobile meat slaughter units. By harvesting animals on-farm in an inspected mobile unit, farmers and ranchers can sell meat at any Montana retail, restaurant, or direct market. Bill text is available at http://growmontana.ncat.org/docs/hb484final.doc

Local Food for Government Agencies: The 2007 State Legislature changed procurement regulations to allow governmental bodies to purchase food from local sources even if the cost was higher as long as the higher bid was reasonable and capable of being paid from existing budgets with no additional appropriation needed (18-4-132 MCA).

The UM Farm to College Program: University Dining Services and four UM graduate students teamed up in the spring of 2003 to create the UM Farm to College Program, dedicated to buying more food locally and regionally to feed the campus community. See http://ordway.umt.edu/SA/UDS/index.cfm/page/917

Farmers Markets: Agriculture Marketing and Business Development Bureau, MDOA promotes local Farmers Markets. See http://agr.mt.gov/business/farmersMkts07.pdf

Abundant Montana: The AERO's Directory to Sustainably Grown Montana Food. More than 80 sustainable farms, ranches, and retailers are listed by region and by farm name, in the 5th edition of *Abundant Montana*, published in 2005. Products include fruits and vegetables, processed foods, meat products, and grains. The directory gives consumers who value sustainability and community the means to express their values through their food purchases while supporting the growers, processors, and retailers who share their values. See http://www.aeromt.org/publications.php.

Type(s) of GHG Reductions

CO_2: Reduction in CO_2 emissions due to a reduction in ton-miles required to bring out-of-state agriculture products to markets in Montana.

Estimated GHG Savings and Costs per $MtCO_2e$

GHG Reduction Potential in 2010, 2020 ($MMtCO_2e$): 0.005, 0.02.

Net Cost per $MtCO_2e$: $5.

Data Sources: United States per capita food consumption was taken from the USDA Economic Research Service (ERS) Food Availability (Per Capita) Data System. Per capita consumption of each food type is shown in Table I-20. The average travel distance of imported food was taken from an Iowa study of food miles.[29]

Table I-20. Per capita consumption, by food type

Food Category	U.S. Per Capita Consumption (lbs)
Red meat	116
Chicken	86
Turkey	17
Fish	12
Eggs	33
All dairy	601
Fats and oils	87
Peanuts	7
Tree nuts	3
Coconut	1
Fresh fruit	122
Canned fruit	15
Dried fruit	2
Frozen fruit	5
Fruit juice	72
Fresh vegetables	184
Canned vegetables	108
Frozen vegetables	75
Legumes	6
Dehydrated vegetables	14
Potatoes for chips, shoestrings	16
Grains	192
Coffee, tea, cocoa	20
Spices	3
Beverages	116
Total	**1,911**

Quantification Methods: Total consumption of food was estimated for each year by multiplying projected population by the per capita consumption data referenced above. Table I-21 shows the estimated food consumption and the amount of food imported from out-of-state sources. The BAU percentage of out-of-state food was estimated by assuming that existing programs (UM Farm to College Program) targeting institutional food, which accounts for about 10% of Montana's total consumption, achieves 30% consumption of in-state food by 2020. Hence, 90% of Montana food consumption has a 15% in-state content, while 10% of Montana consumption has a 30% in-state content.

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[29] R. Pirog, "Checking the food odometer: Comparing food miles for local versus conventional produce sales to Iowa institutions." Leopold Center for Sustainable Agriculture, 2003, http://www.leopold.iastate.edu/pubs/staff/files/food_travel072103.pdf

Table I-21. Estimated food consumption and amount of food imported

Year	Montana Food Consumption (tons)	% Locally Purchased Food	BAU % Locally Purchased Food	Food From Out-of-State (tons)	BAU Food From Out-of-State (tons)
2007	905,345	15%	15%	769,543	769,543
2008	912,073	17%	15%	760,061	774,209
2009	918,801	18%	15%	750,354	778,861
2010	925,529	20%	15%	740,423	783,496
2011	930,702	21%	15%	735,255	786,801
2012	935,875	22%	16%	729,983	790,095
2013	941,048	23%	16%	724,607	793,376
2014	946,221	24%	16%	719,128	796,645
2015	951,394	25%	16%	713,546	799,903
2016	956,567	26%	16%	707,860	803,149
2017	961,740	27%	16%	702,070	806,382
2018	966,913	28%	16%	696,177	809,604
2019	972,086	29%	16%	690,181	812,814
2020	977,259	30%	17%	684,081	816,011

The reduction of food miles was estimated by taking the difference between the BAU food from out-of-state and the food from out-of-state under this policy and multiplying by average difference in miles traveled by in-state and out-of-state food. The average miles by out-of-state food was assumed to be 1,500 miles plus an additional 25% to account for trucks returning to their points of origin empty (1,825 miles). Since Montana is a relatively large and sparsely populated state, in-state food was assumed to travel 200 miles plus 25% (250 miles), for a difference of 1,575 miles between in-state and out-of-state food. The food transport emission factor (0.162 lb CO_2/ton-mile) was estimated by assuming 23-ton payload trucks, 6 truck-miles/gal diesel, and 22.4 lb CO_2/gal diesel.

Cost

The development of a local food advocacy program is expected to help reach the 2020 target that requires 30% of food consumed in Montana to be grown, harvested, and processed in-state. The cost of such a program is expected to equal the cost of one half of a full-time senior-level program development employee. The full-time equivalent (FTE) of such an employee is assumed to be $75k per year. The cost of the implementation program is therefore $37,500 in the first year, increasing by 5% per year through the end of the target period. The resulting NPV (in $2007) is $0.5 million, and the levelized cost-effectiveness is $5/MtCO$_2$e.

Key Assumptions:

The assumption that 25% of out-of-state trucks return from their delivery point empty is a standard assumption. Although the low density of food processors and markets may increase the probability that these trucks return empty, there is an absence of sufficient data that would support amending this assumption.

It is assumed that all private costs associated with the implementation of this option will be recovered through market mechanisms. Therefore, no subsidies for locally produced food products are necessary to include in the cost analysis of this option. These would include the costs associated with additional production, processing, storage, and distribution infrastructure. The only costs that have been captured are the modest costs to the state for additional staffing to implement programs to achieve the policy goals.

Key Uncertainties

The largest source of uncertainty is whether the region can supply the variety of agricultural products needed to supply 30% of Montana consumption. Significant work will be needed to identify and promote products that can be regionally produced to meet the goals of this policy. Another significant uncertainty is whether the programs needed to achieve the policy goal can be implemented without incentives for enhancing the state's production, processing, storage, and distribution infrastructure.

Additional Benefits and Costs

An increase in Montana jobs for farmers, food processors, and associated industries.

Feasibility Issues

See key uncertainties above.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

AFW-12. Enhanced Solid Waste Recovery and Recycling

Policy Description

Programs are needed to increase the quantity of materials recovered for recycling with specific attention given to materials with the greatest ability to reduce energy consumption during the manufacturing process and to materials that may be used as a fuel source (e.g., clean wood waste). Reducing the quantity of materials being landfilled reduces future landfill methane emissions potential, while recycling reduces emissions associated with the manufacturing of products from raw materials.

Policy Design

Goals: Increase Montana solid waste recycling rates to 17% by 2008, 22% by 2011, 25% by 2015, and 28% by 2020 using a variety of methods, including source reduction, reuse, recycling, and composting.

Timing: See above.

Parties Involved: MDEQ, Montana Association of Counties (MACo), MSU Extension, local governments, other landfill operators (private), and recycling firms.

Other: Based on MDEQ estimates, the current recycling rate overall was 14.3% in 2005. Total diversion was 18.7%, which includes composted material.[30]

MDEQ is responsible for implementing the Integrated Solid Waste Management Act (75-10-803 MCA). Under this act, MDEQ convenes a group of interested parties to review and recommend goals to increase recycling in the state and reduce waste and to develop an Integrated Waste Management Plan. Recommendations for policy implementation come largely from this Plan. Recycling and composting goals are set in the Integrated Solid Waste Management Act. They are 17% by 2008, 19% by 2011, and 22% by 2015. This policy option sets goals higher than the Integrated Waste Management Plan and will require additional effort.

Implementation Mechanisms

Educational Outreach: Educate consumers and businesses on the benefits of recycling and local opportunities to recycle. Because the opportunity to recycle specific goods changes frequently, and because people move in and out of communities, it is necessary to provide a consistent educational effort.

Develop Local Markets for Recycled Materials: Recycling through traditional markets in major metropolitan areas is difficult because of the high cost of transportation from Montana communities to these markets. The cost of transportation is more than the value of the materials shipped except for metals, cardboard, and some paper. Local uses for materials need to be developed and incentives need to be provided to help develop these markets.

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[30] MDEQ 2005 Recycling Summary, http://deq.mt.gov/Recycle/2005Recy_Summary_01-11.htm

Encourage Inter-County Cooperation Using the Headwaters Recycling Model: Headwaters Recycling is a group of counties in southwest Montana that have joined together with Yellowstone National Park to collect recycled materials from rural areas. While no county could provide the services by itself, Headwaters provides equipment and staff that are shared by all. This model needs to be replicated in eastern and northwestern Montana.

Increase Recycling of Construction and Demolition Wastes: The amount of construction and demolition waste entering landfills in the high-growth areas of western Montana may be as much as 30% of the total waste. This waste, particularly wood products, needs to be diverted from landfills. Wood can be diverted for composting and possibly biomass energy production. Metals and cardboard can be recycled.

Encourage Integration of Waste-to-Energy in Sewage Treatment Plant Upgrades: MDEQ has provided limited technical assistance to local governments exploring the option of using biogas to generate electricity. MDEQ should encourage this option and set clear requirements for permitting these upgrades that will allow for complete and timely review.

Encourage the Composting of Biosolids Over Landfilling: MDEQ has knowledge of how biosolids are being managed and where they end up from their review of permits for sewage treatment plants and septic system pumper operations. MDEQ should discourage biosolids from being disposed of in landfills and encourage the composting of biosolids.

Encourage Montana Landfills To Participate in the EPA Methane Outreach Program: At least four Montana landfills are large enough to produce enough methane to have the potential for use. MDEQ should encourage the use of this methane when landfills come in for permitting and present plans for how to control the environmental quality at the landfill.

Promote "Cradle to Cradle Responsibility" That Requires Manufacturers To Take Products They Produce Back for Recycling at the End of Their Useful Life: Through the MDEQ, Montana is the first rural state that is working with EPA on initiatives to get manufacturers to take back electronics they produced. Montana does not have enough population or market share to drive a program that requires manufacturers to take back products. However, by joining together with other states and working for national policies and legislation, Montana can influence manufacturers to take back their products. MDEQ should continue to work with national and regional efforts and support policies and legislation for "Cradle to Cradle Responsibility."

Lead by Example: Montana state government needs to lead by example by increasing its recycling rate and by implementing policies that will result in less waste that needs to be recycled. MDEQ and the Department of Administration have responsibility under the Integrated Waste Management Act (75-10-805 MCA) to develop a waste reduction program for state government. This authority needs to be used to establish aggressive recycling and source reduction program for all state agencies.

Related Policies/Programs in Place

Montana Integrated Waste Management Act and Plan: The Montana Integrated Waste Management Act sets recycling targets of 17% by 1998, 19% by 2011, and 22% by 2015 and requires that a plan be put in place to achieve these targets. MDEQ must develop the plan in consultation with interested local governments, recycling businesses, solid waste businesses, and environmental organizations. The goals were updated by the 2005 Legislature and the Plan was updated in 2006. It will be updated again in 2011.

State Government Waste Reduction and Recycling Program: This program was established as part of the Integrated Waste Management Act. It requires MDEQ to work with state agencies to reduce waste and increase recycling.

State Government Procurement of Recycled Supplies and Materials: Part of the Montana Integrated Waste Management Act (75-10-806 MCA) requires that the Department of Administration develop specifications for purchasing materials and supplies that have recycled content. The Department of Administration belongs to the Responsible Purchasing Network.

Licensing of Recycling and Composting Businesses: MDEQ provides licenses for recycling and composting businesses at no cost. Licenses allow MDEQ to track individual events and ongoing business and to ensure that environmental laws are followed.

Tax Credit for the Purchase of Recycling Equipment: An individual, corporation, partnership, or small business corporation may receive a tax credit for investments in depreciable property used primarily to collect or process reclaimable material or to manufacture a product from reclaimed material according to the following schedule:

- 25% of the cost of the property on the first $250,000 invested,
- 15% of the cost of the property on the next $250,000 invested, and
- 5% of the cost of the property on the next $500,000 invested.

This credit through15-32-601 MCA (terminates December 31, 2011).

Purchase of Recycled Materials Deduction: Taxpayers who purchase recycled material as a business-related expense can deduct 10% of the expense of these products from federal adjusted gross income in arriving at Montana adjusted gross income (15-32-609 MCA terminates December 31, 2011).

Deduction for Purchase of Montana Produced Organic Fertilizer: Taxpayers may deduct expenditures for organic fertilizer, such as compost, that is produced in Montana and used in Montana (15-32-303 MCA).

Credit Against Air Permitting Fees for Certain Uses of Post-Consumer Glass: A person with beneficial interest in a business may receive a credit against the fees imposed in 75-2-220 (Air Quality) for using post-consumer glass in recycled material if qualified under HB 499 Section 3.

Type(s) of GHG Reductions

CO_2: Upstream energy use reductions—The energy and GHG intensity of manufacturing a product is generally less using recycled feedstocks than from using virgin feedstocks.

Methane: Diverting organic wastes from landfills will result in a decrease in methane gas releases from landfills.

Estimated GHG Savings and Costs per $MtCO_2e$

Estimated GHG Savings in 2010 and 2020: 0.05, 0.55.

Cost-effectiveness: \$17/$MtCO_2e$.

Data Sources: These include information from MDEQ's 2005 Recycling Summary cited above and EPA's WAste Reduction Model (WArm). 2005 MDEQ recycling data are shown in Table I-22.[31]

Table I-22. MDEQ recycling data, in tons

Recycled Material	2005 Tons
Aluminum cans	549
Steel cans	285
Glass	262
HDPE (plastic)	97
PET (plastic)	170
Corrugated cardboard	38,870
Magazines/third-class mail	1,056
Newspaper	10,938
Office paper	1,326
Phone books	8,265
Mixed paper	135
Mixed metals	99,798
Mixed recyclables	103,979
Computers/electronics	1
Total	**257,545**

In addition, there was a total of 64,524 tons of material composted.

Quantification Methods: GHG Reductions.

Non-organics Recycling

WArm was used to estimate GHG reductions achieved via recycling.[32] The wastes in Table I-22 were aggregated into the applicable WArm material categories (initial estimates based on mixed recyclables): mixed paper waste (fibers in Table I-22), mixed metals (scrap metals in Table I-22), and mixed recyclables (containers and miscellaneous in Table I-22). A baseline estimate of waste recycling and associated GHG reductions for 2005 (representing a 14% MSW diversion rate) was established by inputting the diverted quantities for each waste material.

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[31] L. Moore, MDEQ, personal communication with S. Roe, CCS, August 2007.

[32] The WArm model and associated documentation can be downloaded from http://yosemite.epa.gov/oar/globalwarming.nsf/WARM?OpenForm. Note that CCS excluded organic materials diverted for composting from the recycled amounts in this analysis (they are handled separately).

The incremental benefit for 2010 and 2020 was then determined by inputting the additional quantities of waste that would be recycled in each year (21% in 2010 and 28% in 2020). These additional quantities of recycled materials excluded organic materials (addressed below). CCS assumed that the fractions of materials diverted remained the same as in 2005 (initial estimates based on mixed recyclables): mixed paper (0.56); mixed metals (0.23); and mixed recyclables (0.21). CCS also determined the waste generation in each future year using the same 0.6%/year population growth as in the GHG Inventory and Forecast. Finally, the volume of organic material composted is assumed to rise at the same rate as recycled materials. Table I-23 shows the resulting waste recycling amounts and rates in each year.

Table I-23. Waste diversion rates

	Year			
	2005	2010	2015	2020
MSW landfilled	1,184,198	1,220,153	1,257,199	1,295,371
MSW recycled (minus organics)	257,545	307,823	399,196	478,930
Organics composted	64,524	69,142	83,572	102,343
Recycle rate (excludes organics)	17.1%	17.6%	19.9%	22.6%
Diversion rate (includes organics)	21.4%	22.0%	24.9%	28.3%

For the incremental tons recycled, WArm provided the results shown in Table I-24.

Table I-24. WArm results, in tons

Scenario	$MtCO_2e$
2005 baseline recycling WArm GHG reduction	1,142,012
2010 incremental WArm GHG reduction	1,187,692
2020 incremental WArm GHG reduction	1,676,208

Hence, in 2010, the incremental GHG benefit for additional recycling is 45,680 $MtCO_2e$/year. In 2020, the incremental benefit is 534,196 $MtCO_2e$/year.

Composting of Organic Material

By composting organic material, the CH_4 emissions that would have been generated via anaerobic decomposition in a landfill are avoided. Landfill methane avoided for the baseline (2005) organics material diversion was estimated using an estimate of the degradable organic carbon (DOC) content from the United Nations Framework Convention on Climate Change (UNFCC).[33]

For this assessment, landfill gas (LFG) generated at the applicable landfills in Montana is assumed to be collected and controlled. The EPA default methane collection efficiency of 75% is applied. Also, the default assumption of 10% oxidation of CH_4 as it diffuses through the landfill

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[33] UNFCC, CDM–Executive Board, "Approved baseline and monitoring methodology AM0039," September 29, 2006. The average DOC content for lawn and garden, food, and wood/straw waste is 21%. Default CH_4 content of landfill gas is 50%. 16/12 is the ratio of molecular weights of carbon and methane. 21 is the global warming potential of methane.

soil cover is applied. The 2010 baseline landfill methane avoided is calculated as follows (see footnote for additional details):

$$\text{Baseline 2010 CH}_4 = (64{,}524 \text{ ton organics}) \times (0.21) \times (0.50) \times (0.907 \text{ Mt/ton} \times (16/12) \times 21 \times (1 - 0.75) \times (1 - 0.10) = 39{,}888 \text{ MtCO}_2\text{e}$$

The same method was used to calculate the methane avoided for the higher levels of organics to be recycled in 2010 (69,142) and in 2020 (102,343), as shown in Table I-23. The incremental benefit of increased organic material composting was then estimated as the difference between the baseline recycling level and the policy recycling levels in each year. For 2010, the incremental benefit is 1,595 $MtCO_2e$ and 17,949 $MtCO_2e$ in 2020.

Because GHG emissions also occur as a result of composting, these emissions need to be factored in to obtain a net GHG benefit for organics recycling. CCS used an average CH_4 emission factor of 1.12 lb/ton material from tests conducted by the South Coast Air Quality Management District in California.[34] CH_4 emissions from incremental composting are estimated to be 28 $MtCO_2e$ in 2010 and 339 $MtCO_2e$ in 2020. Nitrous oxide emissions were estimated from tests done on composting of cattle manure[35] (no data on MSW organic materials were identified). The average N_2O emission factor was 0.94 lb/ton of manure. Applying this emission factor to the incremental organic materials composted in 2010 and 2020 yielded 352 $MtCO_2e$ and 4,198 $MtCO_2e$, respectively. The net GHG benefits for the incremental organics composting are shown in Table I-25.

Table I-25. Net estimated GHG benefits for organic composting

Estimate	2010 $MtCO_2e$	2020 $MtCO_2e$
Landfill methane avoided	1,595	17,949
Composting methane	28	339
Composting nitrous oxide	352	4,198
Net GHG benefit	**1,215**	**13,412**

Therefore, the overall emission reductions for the policy option are 46,895 $MtCO_2e$ in 2010 and 547,608 $MtCO_2e$ in 2020.

Costs

Non-organics recycling. CCS assumed that the policy would be applied to households in the three Montana counties with the highest population density: Yellowstone County (52,084 households, 49.09 people/mi^2), Silver Bow County (14,432 households, 48.18 people/mi^2), and Missoula County (38,439 households, 36.88 people/mi^2).[36,37] Single-stream recycling service

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[34] Average of three facilities conducting composting of a variety of organic materials—digested biosolids, manure, wood waste, rice hulls, and green waste. Documented in Roe et al., 2004, *Estimating Ammonia Emissions from Anthropogenic Nonagricultural Sources*, Final Report, prepared for US EPA, Emission Inventory Improvement Program, April 2004.

[35] X. Hao, C. Chang, F.J. Larney, and G.R. Travis, "Greenhouse Gas Emissions During Cattle Feedlot Manure Composting," *Journal of Environmental Quality*, 30:376–386, 2001.

[36] Montana County Population; Population Density 2000. Accessed on June 20, 2007 at http://ceic.commerce.state.mt.us/graphics/Data_Maps/Densitymap.pdf

would cost $3.50 per pick-up with pick-ups occurring every 2 weeks. Further, it is assumed that households would fill a 96-gallon container with mixed recyclables, which result in an annual average cost per household of $91. The total annual cost for all households would be $9.6 million.

There is also societal cost savings associated with this option in that landfill tipping fees are avoided for the waste that is diverted. Tipping fees in Montana are $25.38 per ton. Using an EPA estimate of waste density (0.05 ton/yd^3), the volume of the recycle container, the number of pick-ups per year, and the number of households, the maximum amount of total waste to be diverted was estimated to be 754,809 tons/year, assuming that all collection containers are full. Using the mid-point of the range in tipping fees and 25% of the maximum waste avoided, the avoided landfill cost is $4.8 million/year. The net cost for the non-organics recycling is $5.1 million/year. Using the GHG reduction estimates derived above, the cost-effectiveness in 2020 is $7.86/MtCO$_2$e.

Organics Composting

The cost of organics composting is based on the total quantity of organic material composted under the BAU scenario, less the total quantity of organics composted after the adoption of the targets imposed by this action. The per-ton cost was largely derived from capital and operation and maintenance (O&M) cost estimates provided via personal communication.[38] The cost estimates used in this analysis are provided in Table I-26.

Table I-26. Cost estimates for organics composting

Annual Volume (tons)	Capital Cost ($ in thousands)	Operating Cost ($/ton)
<1,500	75	25
1,500–10,000	200	50
10,000–30,000	2,000	40
30,000–60,000+	8,000	30

The capital costs were annualized using the cost recovery factor method. This method takes the product of the total annual capital cost and a factor that includes assumptions of a 15-year project life and a 5% interest rate. The annualized capital cost is added to the annual O&M cost and the tipping fee is subtracted to determine the total annualized composting costs. This value does not take into account any revenue raised from the sale of compost.

As reported above, the current average tipping fee in Montana is $25 per ton. Therefore, since the total annual cost-per-ton is greater than the tipping fee, composting projects are expected to have a net cost. The NPV of costs related to composting—assuming a constant $25 tipping fee—is $4.82 million.

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[37] U.S. Census Bureau; Montana State and County Quickfacts. Accessed on June 20, 2007 at http://quickfacts.census.gov/qfd/states/30000.html

[38] P. Calabrese, Cassella Waste Management, personal communication with S. Roe, CCS, June 5, 2007. Transmitted via e-mail to B. Strode by S. Roe.

Key Assumptions:

Assumptions used in the EPA WArm modeling include the use of the “current mix” of recycled and virgin material inputs to production (i.e., new products are not produced with 100% virgin materials); LFG is flared; 75% collection efficiency for LFG; distance to the landfill and recycling facilities (50 miles). Another key assumption is how representative the N_2O composting emission factor is in representing emissions from composting MSW organic materials.

Key Uncertainties

See Key Assumptions above.

Additional Benefits and Costs

Lower emissions of LFG for the decomposable waste that would be landfilled without this policy option. In addition to methane, LFG contains other air pollutants, such as volatile organic compounds and toxic air pollutants.

Feasibility Issues

Challenges for implementing this option include a current lack of post-consumer recycling markets (much of the waste currently recycled is sent out of state). Significant effort will be needed to identify new recycling opportunities in Montana. For post-consumer mixed organic waste diversion, increasing the amount and the range of wastes composted might not be feasible at small-scale facilities due to equipment requirements, higher capital costs, and lack of markets for compost residue (whereas the end product from organic composting may be sold as fertilizer).

Co-operating a landfill with an organic composting operation could necessitate additional equipment for odor control. The capital costs of odor control equipment vary, depending on the size of the operation and the available buffer zone between the landfill sites and surrounding communities. For some wastes–particularly heavy nitrogenous or wet wastes–bulking agents are necessary to properly manage the composting operation. These bulking agents are major factors in operations and maintenance costs of composting facilities.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

Appendix J
Cross-Cutting Issues
Policy Recommendations

Summary List of Policy Option Recommendations

	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2007–2020 (Million $)	Cost-Effectiveness ($/tCO_2e$)	Status of Option
		2010	2020	Total 2007–2020			
CC-1	GHG Inventories and Forecasts	*Not quantified*					UC
CC-2	State GHG Reporting	*Not quantified*					UC
CC-3	State GHG Registry	*Not quantified*					UC
CC-4	State Climate Public Education and Outreach	*Not quantified*					UC
CC-5*							
CC-6	Options for State GHG Goals or Targets	*Not quantified*					2020 Goal: UC 2050 Goal: Super-majority
CC-7	The State's Own GHG Emissions	*Not quantified*					UC

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalents; UC = unanimous consent.

* There is no policy option CC-5 (Adaptation), because this option, listed in the catalog of state policy options, was determined not to be a priority for analysis by the CCAC.

CC-1. GHG Inventories and Forecasts

Policy Description

Greenhouse gas (GHG) emissions inventories and forecasts are essential to understanding the magnitude of all emission sources and sinks (both natural and those resulting from human endeavors), the relative contribution of various types of emission sources and sinks to total emissions, and the factors that affect trends over time. The initial use for inventories and forecasts will be to inform state leaders and the public on statewide trends, opportunities for mitigating emissions or enhancing sinks, and verifying GHG reductions associated with implementation of Montana's Climate Action Plan. However, it is expected that other uses of the data will be identified as the program evolves. The responsibility for preparing GHG inventories and sinks should reside with Montana's Department of Environmental Quality (DEQ) which has the expertise needed to systematically compile information on GHG sources and sinks using established methods and data sources. Other state agencies as well as private facilities (sources) will need to provide data to DEQ on a periodic basis. This program should be integrated with existing DEQ inventory and forecast functions as seamlessly as possible. Whenever possible, data from existing reporting systems will be used. Development of GHG emissions inventory and forecasting systems for Montana should take advantage of the substantial related expertise found in the state's colleges and universities. Opportunities for public participation by voluntary self-reporting of individual and community GHG reductions (with appropriate privacy protection) should be made available, even where the data are qualitative. The inventory and forecast will be an ongoing effort that will be improved over time, based on improvements to the accuracy and completeness of data needed to support this effort.

Policy Design

The Cross-Cutting Issues Technical Work Group (CC TWG) recommends that Montana develop its capacity for statewide emissions inventories and forecasts. Key elements are noted below. Additional information regarding important program characteristics is included in the Annex to Appendix J, GHG Inventories and Forecasts Design Options Matrix.

Goals:

- Develop a periodic, consistent, and complete inventory of emission sources and sinks on a continuing basis with forecasts. The time period for forecasts should cover a 20-year planning horizon to be consistent with other state planning efforts. The inventory and forecast should be updated once every 2 years and include the decennial years (e.g., 2010, 2020, and 2030).
- Perform inventory of all natural and man-made emissions generated within the boundaries of the state (i.e., production-based inventory approach) as well as emissions associated with energy imported and consumed in the state (i.e., consumption-based inventory approach).
- Provide a projection of the emissions from the same source categories and on the same basis for a realistic forecast of what the emissions will be in future years, reflecting expected growth and application of scheduled and expected mitigation options.

- Provide a basis for documenting reductions and credits from year to year.

Timing: The program should be implemented as soon as possible, as allowed by funding. The process should be updated to reflect significant reductions or increases, beginning with every year for major point (Title V) sources and every 2 years for other sources.

Parties Involved: All emission sources and sinks (both natural and those resulting from human endeavors) should be included.

Other: Provide user-friendly options for estimating GHG emissions reductions by individuals, families, and communities. Methods will be recommended for voluntary use and self-reporting. The data will parallel other, more scientifically rigorous reporting. The intent is to encourage awareness, understanding, and broad participation in reducing state GHG emissions by citizens and communities.

Implementation Mechanisms

The Montana DEQ, assisted by other state agencies and state colleges and universities, and integrated with DEQ's existing inventory and forecasting functions.

Related Policies/Programs in Place

DEQ emissions inventory for criteria pollutants.

Type(s) of GHG Reductions

Establishing a GHG inventory and forecasting function within state government is an enabling policy to encourage tracking, management, and ultimately reduction of GHG emissions. It does not reduce GHG emissions itself per se. Public disclosure of GHG emissions may encourage sources to reduce emissions.

Estimated GHG Savings and Costs per $MtCO_2e$

This option could be considered an administrative and enabling function of the Climate Action Plan (including enabling any future cap-and-trade options) and will incur overhead costs but not directly reduce emissions per se except where these data motivate reductions for public relations by individual companies or sources.

Data Sources: Many.

Quantification Methods: Several—they will be designed to follow standard, comparative, and accepted approaches that allow exchange/sale of emissions credits should this become a need in Montana.

Key Assumptions: Reporting will establish a baseline for GHG emissions and provide a monitoring tool for assessing the efficacy of the Climate Action Plan. Adjustments will be made in the Plan as certain techniques prove more or less beneficial than projected. Downward trends will allow for further incentives to be developed for sectors that show continuous improvement. Effective emission sinks can be identified and augmented. Public participation will inform and involve citizens in the overall goal of GHG emission reductions. Forecasting will allow state officials to plan for, implement, and monitor necessary additional emission sources or sinks to the emission cycle.

Key Uncertainties

- Adequacy of ongoing funding for a statewide GHG inventory and forecasting function.
- Quality and quantity of existing data that will be useful and can be effectively integrated into a uniform reporting system.
- Quality and timeliness of emission sink quantification and inclusion of all potential sinks.
- Most effective frequency of reporting.

Additional Benefits and Costs

- The preparation of periodic inventories and forecasts at the level of effort conducted for the Climate Change Advisory Committee (CCAC) process is likely to require additional assistance and/or resources for the Montana DEQ.

Feasibility Issues

- Incorporating the reporting and forecasting efforts into the existing workload demands within the Montana DEQ.
- Gathering the required data in a timely and consistent manner.
- Where self-reporting is the best method of obtaining data, overcoming reticence to report accurately for fear of retribution or financial disincentives.
- Maintaining the skills and expertise to accurately forecast based on trends, particularly in the early years of reporting.

Status of Group Approval

Complete.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

CC-2. State GHG Reporting

Policy Description

A GHG reporting system is designed to provide for the measurement and then reporting of emissions. GHG reporting can help sources identify emission reduction opportunities and manage risks associated with possible future GHG mandates by moving up the learning curve. GHG reporting is typically a precursor for sources to participate in GHG reduction programs and a GHG emission reduction registry. Moreover, a reporting system (coupled with an associated registry) would enable sources to secure "baseline protection" to allow reductions to be credited under a future emission reduction program.

Tracking and reporting of GHG emissions would also help in the construction of periodic state GHG inventories. Reporting and the related inventory function will also provide valuable information for assessing the efficacy of measures implemented to reduce GHGs.

Tracking GHG emission performance will make it easier for sources to receive recognition and goodwill for successful emission reduction efforts.

To encourage awareness, understanding, and broad participation on the part of the pubic, self-reporting by individuals and communities should be allowed although self-reporting by individuals and communities would not be subject to the same standards necessary to ensure accuracy as reporting of GHG emissions by sources for inclusion in a registry. (This is considered further in CC-4, State Climate Public Education and Outreach.)

Finally, developing a GHG reporting program could enable the state to influence the development of GHG reporting practices throughout the region and nation and build consistency with other state or regional GHG reporting programs.

Policy Design

The CC TWG recommends that Montana develop GHG reporting requirements and opportunities for its sources and citizens. Key elements are noted below. Additional information regarding important program characteristics is included in the Annex to Appendix J, GHG Reporting Design Options Matrix.

- Subject to consistently rigorous quantification, GHG reporting should not be constrained to particular sectors, sources, or approaches, in order to encourage GHG mitigation activities from all quarters.
- Mandatory GHG reporting should be phased in by sectors as rigorous, standardized quantification protocols, base data, and tools become available, and as responsible parties become clear. Entities should be encouraged to report GHG emissions voluntarily before mandatory reporting applies to them; and the state, municipalities, and other jurisdictions should be encouraged to report emissions associated with their own activities and any programs they may implement.

- Mandatory reporting of direct emissions[1] should be required for stationary sources with an existing reporting requirement under Montana DEQ regulations—Annotated Rules of Montana (ARM) 17.8.1701 through 17.8.1705. Reporting of emissions associated with purchased power and heat[2] should be phased in, and voluntary reporting of other indirect emissions[3] should be allowed. Provisions should also be made for voluntary self-reporting by individuals and communities as considered further in CC-4, State Climate Public Education and Outreach.
- Reporting should be applicable to all sources (e.g., combustion, processes, vehicles) but using common sense regarding de minimis emissions.
- The goal should be reporting of GHG emissions on an organization-wide basis within Montana but with greatest possible detail by facility, to facilitate baseline protection.
- Project-based emissions reporting should be allowed, when properly identified as such and quantified with equally rigorous consistency.
- Reporting should occur annually on a calendar-year basis for all six traditional GHGs and, to the extent possible, for black carbon.
- Every effort should be made to maximize consistency with federal, regional, and other states' GHG reporting programs.
- Development of GHG emissions inventory and forecasting systems for Montana should take advantage of the substantial related expertise found in the state's colleges and universities.
- GHG emissions reports should be verified through self-certification and Montana DEQ spot-checks; to qualify for future registry purposes, reports should undergo third-party verification.
- The reporting program should provide for appropriate public transparency of reported emissions.

Goals: Implementation of a Montana GHG Reporting Program as early as possible.

Timing: As soon as possible, preferably by 2008.

Parties Involved: Initially, mandatory for stationary sources with air quality permit; voluntary for other direct and indirect sources.

Implementation Mechanisms

Utilization of existing Montana DEQ regulations, which require all entities with an air quality permit to report emissions of regulated pollutants on an annual basis. Reporting protocols and

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[1] Defined as "Scope 1" emissions in the *GHG Protocol: Designing a Customized Greenhouse Gas Calculation Tool*, World Resources Institute and World Business Council for Sustainable Development, See: http://pdf.wri.org/GHGProtocol-Tools.pdf

[2] Defined as "Scope 2" emissions in the *GHG Protocol*.

[3] Defined as "Scope 3" emissions in the *GHG Protocol*.

opportunities for parties not subject to existing reporting requirements will need to be developed, probably by the Montana DEQ.

Related Policies/Programs in Place

Many sources in Montana report criteria pollutant emissions in order to comply with various federal and state regulatory programs. Most electricity generating units are also required to report carbon dioxide (CO_2) emissions to the Energy Information Administration (EIA). Some sources may report GHG emissions on a voluntary basis to federal, state, or privately run programs. Otherwise, there is no broad, statewide GHG reporting program in Montana.

Type(s) of GHG Reductions

GHG reporting is an enabling policy to encourage management and, ultimately, reduction of GHG emissions. GHG reporting does not reduce GHG emissions itself.

Estimated GHG Savings and Costs per $MtCO_2e$

The reporting components of this policy option would help position Montana entities for participation in an emissions trading program should one develop in the future, leading to cost savings. Although establishment of a credible reporting program is essential for participating in a trading program, these elements themselves do not reduce GHG emissions.

Key Uncertainties

Uncertainties exist with respect to quantification of some GHG emissions from some sources, but standard quantification protocols are being developed rapidly and accepted widely. There remain significant uncertainties with respect to how various state, regional, and/or federal GHG reporting programs may develop.

Additional Benefits and Costs

Not applicable.

Feasibility Issues

None cited.

Status of Group Approval

Complete.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

CC-3. State GHG Registry

Policy Description

A GHG registry enables measurement and recording of GHG emissions reductions at a macro- or micro-scale level in a central repository with a "transaction ledger" capacity to support tracking, management, and "ownership" of emission reductions as well as to encourage GHG reductions. It also assists with baseline protection and/or the crediting of actions by implementing programs and parties in relation to possible emissions reduction goals. It will also provide a mechanism for regional, multistate, and cross-border cooperation. Subject to appropriately rigorous quantification, participation in a GHG registry should not be constrained to particular sectors, sources, or approaches so as to encourage GHG mitigation activities from all quarters. In particular, a GHG registry should be able to incorporate activities associated with all of the options that the CCAC approves, whether reflective of reductions in emissions of GHGs or increases in biological or geological sequestration of carbon.

Policy Design

The CC TWG notes that the State of Montana has joined more than 39 other states in the effort to develop a national GHG registry through *The Climate Registry*. Being a charter state in this effort should help ensure that Montana's needs and priorities are addressed in the course of *The Climate Registry*'s development. To the extent that Montana's needs may not be fully met by *The Climate Registry*, the state should consider developing supplemental or ancillary registry capacity or opportunity.

Goals: Montana's participation in creating *The Climate Registry*, and its development of any ancillary registry capacity that may be required, may include or cover all of the activities associated with all options that the CCAC recommends and the Governor accepts. A mechanism should be provided whereby Montana sources and stakeholders can keep abreast of—and provide input to—state and national registry efforts as they evolve. Recommendations for key registry design characteristics build off the GHG Reporting policy option (CC-2). Key elements are noted below. Additional information regarding important program characteristics is included in the Annex to Appendix J, GHG Registry Design Options Matrix.

- Geographic applicability at least at the statewide level and as broadly (i.e., regionally or nationally) as possible.
- Allowing sources to start as far back chronologically as good data exist, as affirmed by third-party verification, and allowing registration of project-based reductions or "offsets" that are equally rigorously quantified.
- Incorporating adequate safeguards to ensure that reductions are not double-counted by a single participant or multiple registry participants, and providing appropriate transparency.
- Striving for maximum consistency with other state, regional, and/or national efforts; providing greatest flexibility as GHG mitigation approaches evolve; and providing guidance to assist participants.

- Allowing the state to register reductions associated with its programs, direct activities, or efforts, including ownership of emission reductions associated with the properties (stationary and mobile) it owns or leases, and participate in emission trading. The revenue associated with the sale of any emission reduction credits generated by the state could be used to support the GHG emission inventory, forecasting, and reporting functions within state government (but of course could no longer be claimed as reductions owned or achieved by the state).

Timing: As soon as possible after a GHG reporting program is operating.

Parties Involved: Coverage should include all entities that can verify ownership of GHG emission reductions.

Implementation Mechanisms

The program should be overseen by the Montana DEQ. Incremental staffing and resource requirements are expected to be minimal if Montana joins a regional or national GHG registry (i.e., able to be addressed by existing staff up to perhaps an additional one-quarter full-time equivalent [FTE] staff person); they could be significant otherwise. Ongoing operating costs are expected to be borne or shared by participants benefiting from the registry.

Related Policies/Programs in Place

None cited.

Type(s) of GHG Reductions

Typically, all GHGs would be eligible.

Estimated GHG Savings and Costs per MtCO$_2$e

Not applicable.

Key Uncertainties

There remain significant uncertainties with respect to how various state, regional, and/or federal GHG registry programs may develop. Involvement in early registry implementation—as issues are deliberated among states—will give Montana an advantage in its ultimate outcome.

Additional Benefits and Costs

None cited.

Feasibility Issues

None cited.

Status of Group Approval

Complete.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

CC-4. State Climate Public Education and Outreach

Policy Description

Explicitly articulated public education and outreach can support GHG emissions reduction efforts at all levels in the context of emissions reduction programs, policies, or goals. Public education and outreach is vital to fostering a broad awareness of climate change issues and effects (including co-benefits, such as clean air and public health) among the state's citizens. Such awareness is necessary to engage citizens in actions to reduce GHG emissions. Public education and outreach efforts should integrate with and build upon existing outreach efforts involving climate change and related issues in the state. Ultimately, public education and outreach will be the foundation for the long-term success of all the policy actions proposed by the CCAC as well as those which may evolve in the future.

Policy Design

The TWG recommends that the state lead by example in its own education and outreach activities by establishing a proactive public education and outreach capability and using it to target education and outreach activities to five specific audiences:

1. Policymakers (legislators, regulators, executive branch, and agencies)—because implementation of climate actions hinges on policy makers' approval.

2. Younger generations—by integrating climate change into educational curricula, post-secondary degree programs, and professional licensing programs.

3. Community leaders and community-based organizations (e.g., institutions, municipalities, service clubs, social and affinity groups, and nongovernmental organizations)—in order to recognize leadership, share success stories, publicize role models, and expand climate involvement and participation within civic society.

4. General public—to increase awareness and engage citizens in climate-stabilizing actions in their personal and professional lives.

5. Industrial and economic sectors—in order to recognize leadership, share success stories, publicize role models, and expand climate involvement and participation within the business community.

Additional specific public education and outreach suggestions are provided in the Annex to Appendix J, GHG Education Design Options Matrix.

Goals: The overarching goal is a wholesale shift in public consciousness away from uninformed consumerism to commitment to choices that enhance personal, community, and statewide health and contribute to productive, thriving natural systems. To support monitoring of this goal, it is recommended that the state conduct a voluntary survey of a cross-section of Montana residents' lifestyles to elucidate the level of awareness of sources of individual GHG emissions and steps currently being taken to reduce them. The survey will provide a baseline for a parallel, more qualitative report that will accompany the more technical reporting by non-residential sectors. An initial thought piece on the approach for such a survey is provided as an attachment to this policy option.

Timing: Public education and outreach efforts should commence as rapidly as possible and continue evolving and spreading over time; these efforts need to be institutionalized and made permanent.

Parties Involved: Public education and outreach should involve and apply to all parties, levels, and sectors.

Implementation Mechanisms

Montana's state climate education and outreach efforts should initially be overseen largely by the Montana DEQ, with support from other state agencies and Montana colleges and universities as available but should involve many parties; over time, responsibility should expand to all sectors. Incremental staffing and resource requirements are recommended, reflective of the state's major commitment to climate action. This should include at least two additional FTEs, one dedicated to planning, coordination, and the measurement of progress in the implementation of the overall CCAC recommendations and plan, and a second dedicated to public education and outreach efforts, maintaining a strong Internet-based presence, and coordinating with related volunteer, community, and other groups.

The Internet-based application would provide a method for communities and individuals to network and share information. It would serve as an educational tool by including information on the science of climate change in different forms (e.g., FAQs, articles, and links). It would serve as an organizing tool by providing information about Montana-specific problems and solutions, successes and failures, information about activities and groups in each region, and funding opportunities.

Outreach to those who do not have Internet access on a regular basis will need to be accomplished through Public Service Announcements, newspapers, posters, speakers for senior groups, and organizations that serve lower income people. Individuals at the local level would be trained to provide hands-on training in using the Internet-based application for those who are less familiar with the technology, by using computers at libraries, senior centers, and schools.

Those parts of the final plan that are adopted administratively or referred to the legislature will be summarized in an informal style in a brief, inexpensive publication to inform the general public. The reading level should be that of a general circulation newspaper, with enough specificity that citizens can understand what they can expect from governments and corporations, what they can contribute to the effort, and how they might benefit from personal and societal efforts at GHG reductions. The publication will be distributed through varied and cost-effective means, as newspaper inserts and in government offices, libraries, schools and colleges, and on business premises that agree to participate.

Related Policies/Programs in Place

None cited.

Type(s) of GHG Reductions

Not applicable.

Estimated GHG Savings and Costs per $MtCO_2e$

Not applicable.

Key Uncertainties

None cited.

Additional Benefits and Costs

None cited.

Feasibility Issues

None cited.

Status of Group Approval

Complete.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

ATTACHMENT

CC-4. STATE CLIMATE PUBLIC EDUCATION AND OUTREACH

Living in Montana Survey

The "Living in Montana Survey" will be designed to obtain inputs from state residents regarding designs, participation levels, and effects of Montana's GHG management actions. The survey will be used to measure the extent to which state residents take actions to personally reduce GHG emissions, the kinds of actions they are taking and not taking, and their satisfaction with GHG management outcomes. The survey also will develop citizen input regarding the public's support for (or opposition to) and willingness to participate in future GHG initiatives.

The Living in Montana survey instrument and sample will be scientifically designed to allow for measurements of behaviors and attitudes in Montana overall. The Living in Montana Survey is expected to be administered using a mail-out instrument. The survey instrument will be four pages long, using mainly close-ended questions. A major focus of survey questions will be to identify and quantify of sources of Montana's home area and personal transportation–related GHG emissions. Other survey emphases will be to learn about Montana citizens' participation in GHG management activities and the potential for recruiting state residents to take on new GHG management activities. The survey form should take respondents about 10–15 minutes to complete.

The Living in Montana Survey will be administered to a large sample population. Initially, it would be seeking about 3,120 respondents; this assumes a 60% response rate to 5,200 mailed-out surveys. The use of large sample size will allow for more accurate statistical analyses of overall survey results. The large survey sample also will allow better analyses of attitudes and behavior patterns for Montana's subpopulations and geographic sub-areas. Greater understanding of locations, socioeconomic characteristics, and motivations of people who are likely to implement GHG management will help improve the effectiveness of public and private GHG policies.

The Living in Montana Survey process will culminate with preparation of the "Living in Montana Report." This report will provide clear, nonpolitical summaries of question results. The Living in Montana Report will provide users with summary tabulations for each survey question. Where appropriate, survey outcomes will be presented using graphics and explanatory text.

It is hoped that results of the Living in Montana Survey will be highly publicized. The Living in Montana Report will be distributed to the Montana media. Newspapers and television and radio stations will be encouraged to run features. Access to survey information will allow Montanans to self-evaluate their responses to the state's global warming issues.

An important survey task will be to identify GHG policies that are most and least productive. Survey results will be diagnosed to identify differences in behaviors and opinions of key sub-groups. Survey results will provide Montana with useful feedback about successes and values of GHG controlling actions and will allow Montanans to learn from each other—knowledge through their successes. Survey results also will provide GHG program administrators with better knowledge about factors that most influence GHG actions by Montanans.

Many Montana residents are likely to seek their own personal copies of the Living in Montana Report, and/or access to Living in Montana Survey data. Access to survey results is likely to be sought by Montana household members, students, business operators, elected officials, government and utility officials, and others.

GHG survey results will be made available to Montana residents via the state's Greenhouse Gas Web site where they can also download a copy of the Living in Montana Report. Distributing the Living in Montana Report via the Internet will save the Montana DEQ thousands of dollars in publication and mailing costs.

The Montana Greenhouse Gas Web site will also allow citizens to access more detailed tables and graphics of the survey results. Reviewers will be able to review and download data for key sub-tabulations of survey results. As proposed, the Living in Montana Survey will be repeated over time. Reviewers also will be able to compare survey responses in 2-year cycles. Trends in Montana's GHG management will be identified by comparing responses within one survey cycle to responses to similar questions posed in the survey 2 years later.

During the initial years of Montana's Greenhouse Gas initiative, the Living in Montana Survey will be repeated on a 2-year cycle. The survey's cycle is likely to extend to 4 or 5 years as Montana's GHG program matures.

An evolving idea will encourage Montanans using the DEQ Web site to review the Living in Montana Survey data to develop similar information about GHG emissions from their own housing area and personal transportation. While still logged to the GHG Survey Web site, interested citizens would be afforded an opportunity to fill out similar survey questions (not identical) describing characteristics of their own housing area and transportation emissions. Respondents could submit the completed survey over the Internet. It may be possible to provide participants with instantaneous feedback on their household and transportation emission patterns. Respondents and Montana DEQ staff would be afforded opportunities to work further toward GHG reductions.

Alternative
Another Web site approach will provide user-friendly calculators so people can evaluate how their current choices in energy use and product purchases contribute to GHG levels in the state. Use of the calculators is voluntary and private. Submittal of personal household and transportation information would be voluntary.

CC-6. Options for Statewide GHG Goals or Targets

Policy Description

The CCAC is to recommend actions that can be taken in Montana to reduce the state's contribution to climate change. Consistent with this charge, the establishment of a statewide goal or target can provide vision and direction, a framework within which implementation of CCAC policy recommendations can proceed effectively, and a basis of comparison for regular periodic assessments of progress. In pursuit of similar climate progress, at least 16 other states have established GHG reduction goals or targets.

Policy Design

The CCAC recommends that Montana establish a statewide, economy-wide GHG reduction goal to reduce gross GHG emissions to 1990 levels by 2020, for both consumption-based and production-based emissions, and further, to reduce emissions to 80% below 1990 levels by 2050. In lieu of establishing a specific target sooner than 2020, the CCAC also strongly recommends the early and aggressive implementation of the CCAC's comprehensive recommendations, along with a corresponding set of incentives to promote early adoption.

Goals: As noted above.

Timing: As noted above.

Parties Involved: All parties statewide.

Implementation Mechanisms

Statewide GHG reduction goals or targets can be adopted through executive order, legislation, and/or similar public policy vehicles.

Related Policies/Programs in Place

No statewide programs or policies cited.

Type(s) of GHG Reductions

Not applicable.

Estimated GHG Savings and Costs per MtCO$_2$e

Not applicable.

Key Uncertainties

Not applicable.

Additional Benefits and Costs

To the extent that statewide GHG reduction goals or targets can help motivate additional and/or more rapid emission reductions, co-benefits associated with GHG reductions will also occur in parallel.

Feasibility Issues

None cited.

Status of Group Approval

Complete.

Level of Group Support

- 2020 Goal—Unanimous consent.
- 2050 Goal—Super-majority (one objection).

Barriers to Consensus

None.

CC-7. The State's Own GHG Emissions

CC-7.1. Establish a Target for Reducing the State's Own GHG Emissions

Policy Description

State government is responsible for providing a multitude of services for the public that are delivered through very diverse operations and result in wide-ranging GHG emission activities. State government can take the lead in demonstrating that reductions in GHG emissions can be achieved through analysis of current operations, identification of significant GHG sources, and implementation of changes in technology, procedures, behavior, operations, and services provided. The state can also encourage local governments, school districts, universities, and other entities in implementing similar GHG reduction strategies by partnering with them.

The establishment of broad-ranging goals for GHG reductions for state government will be helpful for setting an example and building expectations, but actual reductions must be realized at the agency level. Disaggregating the state's own GHG emissions to the agency level and requiring annual agency-specific reports on GHG reduction progress would be an effective way to measure and manage the state's emissions. A multiagency group should oversee the ongoing climate efforts of state agencies, providing direction, guidance, resources, shared approaches, and recognition to agencies and employees working to reduce the state's GHG emissions.

Policy Design

The state should establish GHG reduction targets for its own GHG emissions. State agencies first need to develop agency-specific GHG emissions inventory data. This will become the baseline data for ongoing emission reduction activities and measurements which will be summarized in annual reports by each agency. Agency reports will be aggregated into a summary report reflecting state GHG emissions.

Goals: Reduce GHG emissions from Montana's state operations to 1990 levels by 2018 (2 years earlier than the statewide goal), and 5% below 1990 levels by 2020 (5% lower than the statewide goal for 2020).

Timing: The first annual report by agencies will reflect agency-level inventories. The second annual report should reflect initial progress in reducing GHG emissions as agencies begin to plan and implement operational changes. Future annual reports should show further progress in reducing agency GHG reductions.

Parties Involved: Coverage should include all operations of all state agencies.

Implementation Mechanisms

Several possible implementation opportunities exist. Assuming adequate support from management in each agency and sufficient funding, efforts should focus on fleshing out GHG reduction baselines, and plans and could include memorandums of understanding (MOUs), green procurement policies, training programs for agency facility managers, agency recognition and awards programs, and performance evaluations.

A Kickoff Campaign could start the Lead-by-Example effort and include educational and promotional activities and materials to explain personal and institutional responsibilities for changing behaviors and operations to achieve reductions in GHG emissions. The Governor's Office or the Montana DEQ could be responsible for developing and coordinating the Kickoff Campaign and ongoing Lead-by-Example efforts. The campaign should be started after completion of agency-specific GHG inventories and at the start of the first significant state-wide efforts at changing operations and policies to achieve GHG reductions.

Related Policies/Programs in Place

The Lead-by-Example Sustainable Government Committee is a multiagency body of government leaders and representatives from industry, environmental, and public interest groups. This Committee is a joint responsibility of the Montana DEQ and the Department of Administration. The Committee is responsible for providing direction, guidance, resources, and recognition to agencies and employees working on waste reduction, recycling, and sustainable operations in state government. This Committee's work and goals complement the work on GHG reduction and could absorb the responsibility for overseeing ongoing state climate efforts.

Type(s) of GHG Reductions

Steps to reduce energy demand would reduce all GHGs related to energy production. Support for renewable energy and cleaner energy will also help lower all GHGs associated with energy production. Improving existing recycling efforts would result in an associated reduction in GHG emissions from processing new materials. Transportation and fleet management could lower vehicle emissions, as would converting fleets to run on alternative fuels (e.g., biofuels).

Estimated GHG Savings and Costs per $MtCO_2e$

Not quantified.

Key Uncertainties

Agency participation.

Additional funding will likely be needed to accomplish this task effectively.

Additional Benefits and Costs

Education, recognition, and possibly lower operating costs.

Feasibility Issues

Same as uncertainties.

Status of Group Approval

Complete.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

CC-7.2. Climate-Neutral Bonding

Policy Description

At the request of the CC TWG, the Residential, Commercial, Institutional, and Industrial (RCII) TWG incorporated climate-neutral bonding into the design and quantification of policy option RCII-12 (State Lead by Example).

CC-7.3. Require Evaluation of GHG Emissions in Environmental Studies

Policy Description

Environmental Assessment (EAs) and Environmental Impact Statements (EISs) are written analyses of the potential impacts of state actions on the quality of the human environment. An EA is prepared to determine whether an EIS is required. An EIS is a detailed statement of the environmental impacts of a proposed action and alternatives to that proposal. It is prepared when there is a potential for significant impacts on the quality of the human environment. Requiring that consideration of GHG emissions be included as part of EA and EIS processes and documents would provide data for comparing reference case GHG emissions to estimates of future GHG emissions under each proposed development option. Such information could be helpful in targeting development decisions that minimize GHG emissions or pointing out the need for authority to regulate GHG emissions.

Policy Design

The CC TWG recommends that agencies be instructed to include data regarding reference case and estimated future GHG emissions in EA and EIS documents. This information will guide officials and developers in choosing technologies and activities that result in development which protects the environment and reduces additional contributions of GHGs.

When acting as a co-lead or cooperating agency in the preparation of federal EAs and EISs, the state will encourage the federal agency to include GHG emissions as an issue of concern in the analyses of proposed actions.

Goals: To make informed decisions encouraging development that produces the least GHG emissions.

Timing: Implementation may begin immediately with statewide department directives.

Parties Involved: State agencies, development proponents, and the public.

Implementation Mechanisms

Agency personnel who complete environmental studies would be given training and resources to help them understand and develop protocols for establishing GHG emission baselines and estimating emissions from proposed future development activities and alternatives.

Related Policies/Programs in Place

Air quality/permitting personnel at Montana DEQ already look at various air emissions for proposed projects that require EAs and EISs. DEQ personnel have air emissions databases already in place that could be slightly modified to look at GHG emissions.

Type(s) of GHG Reductions

All six pollutants of concern could be reduced, depending on the future projects analyzed in EAs and EISs and the state's regulatory authority. The amount that would be reduced is unknown.

Estimated GHG Savings and Costs per MtCO$_2$e

Not applicable.

Key Uncertainties

Some activities may not have currently inventoried GHG emissions or ways to accurately assess future emissions. Projections and analyses may depend on estimates based on similar activities. No known effective mitigation measures may exist for reducing emissions from certain activities. The state might not have the authority to require reductions in emissions.

Additional Benefits and Costs

This recommendation would add approximately 1 to 2 days to applicable analyses, depending on availability of data. Current personnel have sufficient expertise to develop or find the data. Decision makers can make better informed decisions that could contribute to the overall GHG reduction goals of this document. The pubic will be better informed and be better able to contribute substantive input in the planning process.

Feasibility Issues

Implementation does not require legislative action, additional personnel, or additional funding.

Status of Group Approval

Complete.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

CC-7.4. Join WCI and Consider Joining CCX

Policy Description

State government is responsible for providing a multitude of services for the public that are delivered through very diverse operations and result in wide-ranging GHG emissions. Montana can take the lead in achieving GHG emissions reductions—by the state itself and more broadly throughout its economy—and may be able to influence the national debate over appropriate responses to climate change by joining the Western Climate Initiative (WCI),[4] which is a regional cap-and-trade effort, and by considering whether to join the Chicago Climate Exchange (CCX), which is a voluntary carbon reduction and trading program.

WCI is a joint effort by the states of Washington, Oregon, California, Arizona, and New Mexico (since joined by the state of Utah and the Canadian provinces of British Columbia and Manitoba) to develop a regional GHG reduction goal, identify market-based mechanisms by which it can be achieved, and participate in a multistate GHG registry. Among such mechanisms, it is widely believed that a cap-and-trade program will eventually be adopted by the federal government as the preferred vehicle for achieving widespread reductions in GHG emissions. In addition to jump-starting necessary GHG reductions across several states and in critical sectors of the economy, WCI is also seen as a precursor to a national market-based system for GHG reductions and may serve as a model for a national program.

By joining WCI, Montana would commit to more broadly applicable GHG reductions—both geographically and among economic sectors—and participate in the development of mechanisms for achieving these goals. One part of the overall strategy will likely be the utilization of offsets, which often include terrestrial sequestration actions to increase the absorption of carbon dioxide as a result of land management activities. Joining WCI will give Montana the opportunity to help define the nature and quality of terrestrial offsets over a large region of the country, helping to ensure that terrestrial offsets play an appropriate role in achieving the GHG reduction goals established by WCI and, subsequently, under a national regime.

CCX is also a market-based effort. Its membership is broad and extensive and includes three other states along with many U.S. cities and dozens of corporations. Joining CCX would require a reduction in Montana's own GHG emissions of 6% (from 1998–2001 levels) by 2010. As a condition for joining CCX, Montana would likely seek eligibility for a portion of its required reductions to be achieved from state trust lands through offsets from agricultural and forestland sequestration projects. Thus, joining CCX could provide potential revenue for the state through GHG reductions achieved on state-owned grazing and forest trust lands. By developing and utilizing such offsets and ensuring that these do, in fact, constitute actual reductions in emissions, Montana could get early experience on this learning curve, allowing it to become a ground floor player in terrestrial CO_2 offset markets during the period that WCI's offset policies are being developed. Ultimately, joining CCX could encourage more CO_2 reductions to be made in Montana and could provide additional revenues to the state as well as to private and tribal landowners. Note that the state would lose its claim to any carbon reductions associated with carbon credits that it sells.

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[4] This effort was originally launched as the Western Regional Climate Action Initiative (WRCAI).

However, CCX is a private entity; thus its activities are not subject to the same degree of transparency and stakeholder involvement as a public program. In addition, concerns have been raised over elements of CCX's program, which is perhaps not surprising, given the complexity of the effort and its relative newness, including its treatment of offsets.

Policy Design

The CCAC recommends that the State of Montana join WCI and consider whether to take advantage of the trading platform provided by CCX. The aspirations and reach of the WCI, coupled with the techniques developed and applied by the CCX, may produce more effective, less costly outcomes than either entity would produce alone.

Goals: Join WCI (with respect to Montana's economy-wide GHG emissions) and consider joining CCX (with respect to state government GHG emissions) and, in either case, commit to meeting their respective GHG emission reduction obligations.

Timing: As expeditiously as possible, Montana should join WCI and decide whether to join CCX.

Coverage of parties: For WCI, coverage should include all sectors ultimately agreed to by the participating states; for CCX, coverage should include all operations of all state agencies.

Implementation Mechanisms

Initial implementation should probably be accomplished through executive order. Involvement in the WCI will likely require participation by the Governor's office or its designee. Ongoing Montana DEQ involvement is likely to be required to develop and update GHG emissions inventories and for further development of potential GHG reduction activities. The Montana Department of Natural Resources and Conservation (DNRC) should undertake and help with the development of terrestrial carbon offsets, particularly as they may apply on state grazing and forest trust lands.

Related Polices/Programs in Place

None cited beyond those above.

Type(s) of GHG Reductions

Principally CO_2.

Estimated GHG Savings and Costs per $MtCO_2e$

None cited.

Key Uncertainties

None cited beyond those above.

Additional Benefits and Costs

None cited.

Feasibility Issues

None cited.

Status of Group Approval

Complete.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

Cross-Cutting Issues Technical Work Group
GHG Inventories and Forecasts Design Characteristics Matrix

Annex to Appendix J, Cross-Cutting Issues—Policy Recommendations

Note: The following matrix provides complementary reference material
to the CCAC Policy Option Description for CC-1 (GHG Inventories and Forecasts).

Purpose and Goals of Inventories and Forecasts:

1. Tracking GHG emissions trends
2. Identifying opportunities and areas for action
3. Others?

#	Design Element	Options	Design Considerations
1.	**Responsibility for Preparing Periodic Inventories and Forecasts**	• Sole responsibility with MT DEQ. • Shared responsibility between DEQ and other state agencies.	• Purpose is to develop consistent, systematic inventories and forecasts from one year to the next. • Subject matter expertise is evolving rapidly.
2.	**Inventory Frequency**	• Annual. • Other.	• Inventory reflects historical emissions. • Different sized sources currently required to report emissions on different schedules (e.g., major sources annually; minor sources every 5 years). • Must be consistent with any MT GHG Reporting Program, and should strive for consistency with other inventory and forecasting programs.
3.	**Forecast Frequency and Periods**	• Annual. • Intervals. • Other.	• Forecasts reflect estimates of future emissions. • Define future years for which emissions inventory is prepared (i.e., frequency and overall forecast period). • Define intervals for future year forecasts (e.g., annual, 5-year intervals relative to a base historical year). • Limitations exist on availability of activity data for projecting emissions (e.g., current Energy Information Administration (EIA) projections of fuel consumption only go to 2030). • Should strive for consistency with other inventory and forecasting programs.
4.	**Greenhouse Gases Included**	• Six “Kyoto gases” (CO_2, HFCs, CH_4, N_2O, PFCs, SF_6). • Black Carbon.	• Must be consistent with any MT GHG Reporting Program, and should strive for consistency with other inventory and forecasting programs. • Broader array promotes inventory building, public information, identification of GHG strategies, etc.

#	Design Element	Options	Design Considerations
5.	**Basis for Calculating and Reporting Emissions**	• Production based. • Consumption based.	• Production refers to emissions generated by sources in-state (e.g., emissions from power generated in-state whether consumed in-state or exported). • Consumption refers to "Production" based emissions plus imports and minus exports, at least for the energy sector.
6.	**Emissions Quantification**	• Calculation methods & tools. • Federal 1605(b) program details quantification of black carbon emissions.	• Apply current best practice methods (e.g., GHG Protocol and calculation tools). • Strive for consistency with other reporting and quantification programs. • Some "other" or "home grown" approaches may be necessary (e.g., Flashing emissions; IPIECA1 and API's2 SANGEATM GHG Emissions Software).
7.	**Public Access & Reports**	• Internet access and/or online reports. • Paper reports. • Both.	
8.	**Funding**	• State-funded. • Emission-based fees (would require legislative approval). • Some combination? • Other?	• Inventories and forecasts can only be accomplished if adequate DEQ resources exist, so creative funding sources should be investigated (e.g., transaction fees, GHG credit sales, etc.).

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[1] IPIECA is the International Petroleum Industry Environmental Conservation Association.
[2] API is the American Petroleum Institute.

#	Design Element	Options	Design Considerations
9.	**Periodic Reassessment of Inventory and Forecast Approach**	• Authority. • Purpose. • Frequency.	• DEQ and involved agencies should have the ability to periodically reassess and revise (if necessary) designs element of the inventory and forecasting program.
10.	**Other?**	• None Cited.	• None Cited.

Cross-Cutting Issues Technical Work Group
GHG Inventories and Forecasts Design Characteristics Matrix

Annex to Appendix J, Cross-Cutting Issues—Policy Recommendations

Note: The following matrix provides complementary reference material to the CCAC Policy Option Description for CC-2 (State GHG Reporting).

Principles for GHG accounting and reporting

The GHG Protocol:[3]

1. Relevance.
2. Completeness.
3. Consistency.
4. Transparency.
5. Accuracy.
6. Enable other goals.

Other Concepts:[4]

1. Additionality and Leakage.
2. Measurement, Monitoring, and Verification.
3. Permanence.
4. Allocation of Risk.
5. Carbon Value.

Potential Goals of GHG Reporting:

1. Identifying reduction opportunities.
2. Reducing risks (e.g., start learning curve).
3. Tracking GHG emissions, assisting the state in constructing annual inventories.
4. Participating in voluntary programs.
5. Participating in – or preparing for – mandatory programs.
6. Precursor for registry participation.
7. Opportunities for recognition.
8. Public reporting.
9. Consistency with other programs.
10. Others?

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[3] The GHG Protocol was pioneered by a collaborative effort of the World Resources Institute and the World Business Council for Sustainable Development.

[4] From Bricklemyer, R., P. Miller, and R. Lawrence, Precision Agriculture Research Association, PowerPoint Presentation titled "Carbon Sequestration: What can it mean for Montana agriculture?," January 30, 2004.

#	Design Element	Characteristics	Design Considerations
1.	**Type of Program**	• Voluntary. • Mandatory.	• May need or want to constrain mandatory applicability to certain sectors and/or sources pending availability of accepted quantification protocols. • Mandatory reporting is in place in some states for permitted sources (ME, CT, etc.); anticipated soon for several others in Northeast and far West. • The Climate Registry and multi-state efforts such as the Regional Greenhouse Gas Initiative and the Western Climate Initiative will likely impact GHG reporting and registry practices.
2.	**Sectors**	• All sectors eligible. • Limited to certain sectors.	• Participation may be limited by availability of quantification methods; may need to "stage" sector participation. • WRI calculation protocols: Stationary combustion, mobile, electric power, cement, iron & steel, aluminum, pulp & paper, wood products, lime, ammonia, purchased heat or power, others.
3.	**Sources**	• All. • Stationary combustion emissions. • Mobile combustion emissions. • Process emissions. • Fugitive emissions.	• Could limit sources even within sectors, (e.g., via types, size thresholds, etc.). • Broader array promotes inventory building, public information, identification of GHG strategies, etc.

#	Design Element	Characteristics	Design Considerations
4.	**Organiz-ational Boundary**	• Entity-wide (e.g., corporation-wide). • Facility. • Emissions unit or source point. • Other (?).	• Clear definitions needed to avoid double counting where shared ownership exists. • Should strive to have design be consistent with possible future directions (e.g., mandatory reporting would not be enforceable above the facility level). • Combinations are possible (e.g., finer resolution aggregated to a greater whole).
5.	**Reporting Period**	• Annual. – Calendar. – Fiscal. • Other.	• Should strive for consistency with other reporting programs.
6.	**Greenhouse Gases Included**	• Six "Kyoto gases" (CO_2, HFCs, CH_4, N_2O, PFCs, SF_6) • Black Carbon • Other	• Should strive for consistency with other reporting programs. • Broader array promotes inventory building, public information, identification of GHG strategies, etc.
7.	**Scope of Emissions Covered**	• Direct. - "Scope 1." • Indirect. - "Scope 2" - Indirect from purchased Heat & Electricity. - "Scope 3" - other indirect (e.g., outsourced activities, employee travel, etc.). • Both.	• May need or want to "stage" coverage (e.g., start small & expand). • Direct emissions most like current reporting requirements, but may omit GHG reduction opportunities or encourage direct-indirect trade-offs. • For many entities, most GHG emissions are from indirect emissions sources.

#	Design Element	Characteristics	Design Considerations
8.	**Emissions Quantification & Monitoring**	• Calculation methods & tools. • Direct measurement (e.g., continuous emissions monitors (CEMs), stack testing).	• Should strive to use current best practice methods, such as GHG Protocol calculation tools, and to have consistency with other reporting programs. • Some "other" or "home grown" approaches may be necessary (e.g., Flashing emissions; IPIECA5 and API's6 SANGEATM GHG Emissions Software).
9.	**Verification**	• State verification. • 3rd party verification. • Self-certification.	• If mandatory, the state may be able to use current verification procedures for criteria pollutants. • Montana DEQ does 3rd party verification?
10.	**Public Access & Reports**	• Internet access and/or online reports. • Paper reports. • Both.	• "Confidential Business Information" (CBI) concerns.
11.	**Project Level Reporting or "Offsets"**	• Yes/No. • Constrain.	• WRI: Raises quantification, baseline, "additionality," secondary effects, reversibility, and double-counting issues. • Location of co-benefits achieved. • May be most useful when there is an externally-imposed constraint (e.g., a "Cap").
12.	**Funding**	• State-funded. • Mandated requirement. • Emission-based fees (would require legislative approval). • Other? A combination?	• Reporting is a necessary cornerstone for a GHG registry, so it may be appropriate to have registry participants share support costs.

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[5] IPIECA is the International Petroleum Industry Environmental Conservation Association.

[6] API is the American Petroleum Association.

#	Design Element	Characteristics	Design Considerations
13.	**Others?**	• None Cited.	• None Cited.

Cross-Cutting Issues Technical Work Group
GHG Inventories and Forecasts Design Characteristics Matrix

Annex to Appendix J, Cross-Cutting Issues—Policy Recommendations

Note: The following matrix provides complementary reference material to the CCAC Policy Option Description for CC-3 (State GHG Registry).

Notes:

- Builds upon GHG Reporting Design Characteristics Matrix.
- Some Reporting preferences could be outweighed by Registry preferences (e.g., if a regional registry has different specs).

Potential Goals of GHG Registry:

1. Recording of GHG reductions (vs. emissions).
2. A central, independent repository for credible info about emissions activities.
3. A "transaction ledger" – providing data management & accounting critical for trading (with or without a cap).
4. "Baseline protection" – encouraging early GHG reductions by ensuring that sources get credit for such actions.
5. An incentive to track & manage emissions, seek productivity and energy efficiency gains, accelerate learning curve regarding competitiveness & carbon markets.
6. Enhance public recognition and demonstrate corporate citizenship.
7. Possible vehicle for regional, multi-state, & cross-border cooperation.
8. Others?

#	Design Element	Characteristics	Design Considerations
1.	**Key Design Criteria** *(beyond those in the GHG Reporting Design Characteristics Matrix*)		
1.1	Define geographical boundaries	• State-only. • Regional (or broader).	• Span of control. • Cost, economies of scale, & broader = better?
1.2	Verification	• State verification. • Third-party verification.	• See GHG Reporting Design Characteristics Matrix.
1.3	Base Year	• Single specified year. • Single entity-chosen year. • Average of multiple years. • Adjustment rules?	• Flexibility vs. Simplicity. • Must have good data for Base Year.
1.4	Project-level submittals	• Yes / No / Constrain	• Against what baseline? • Additionality issues (what would have happened anyway)?
1.5	"Offsets"	• Yes / Some / No	• Co-benefits location? • Nature / character?
1.6	Start Date		• Establish a "to-be-in-operation" date?
1.7	Ownership		• Risk of double-counting.
1.8	Transparency		
1.9	Others?	• None Cited.	• None Cited.
2.	**Technical Issues**		
2.1	Treatment of minority ownership		• *GHG Protocol.*
2.2	Merger & acquisition issues		• *GHG Protocol.*

#	Design Element	Characteristics	Design Considerations
2.3	Quality Assurance; Uncertainty Analysis		• *GHG Protocol.*
2.4	Regulatory guidance (Protocols, guidance documents, etc.)		
2.5	Data flow; filing methods, etc.		• Confidential business information (CBI), legal authority, etc.
2.6	Others?		
3.	**Ancillary, Administrative, & Operational Issues**		
3.1	Location (Agency)	• MT DEQ? • Other?	• Regional potential.
3.2	Software; Web Interface, etc.	• State-specific. • Other implementations, e.g., The Climate Registry, California Climate Action Registry, Chicago Climate Exchange, Environmental Resources Trust, Emissions Allowance Tracking System, etc. • Other?	• Multiple needs (emissions inventory, allowances, mandatory, voluntary, etc.). • Rapidly changing "state of the art."
3.3	Cost	• Transaction fee. • Publicly supported? • Other?	• Development costs. • Ongoing operating costs.
3.4	Oversight & Management	• MT DEQ. • Publicly appointed board. • Other?	

#	Design Element	Characteristics	Design Considerations
3.5	Reporting of Results; Recognition		
3.6	Others?	• None Cited.	• None Cited.

Cross-Cutting Issues Technical Work Group
GHG Inventories and Forecasts Design Characteristics Matrix

Annex to Appendix J, Cross-Cutting Issues—Policy Recommendations

Note: The following matrix provides complementary reference material to the CCAC Policy Option Description for CC-4 (State Climate Public Education and Outreach).

Goals of Public Education & Outreach:

1. Overarching goal: Promote awareness among citizens about the impacts of climate change, solutions, and co-benefits of action.
2. Education provides a foundation essential for all climate action.
3. Provide access to information, products and processes that assist in improving quality of life and quality of the environment to all Montanans.

General Approach:

1. Target the key general audiences and efforts below:
    a. "Walking the Talk" in terms of the State's own efforts and outreach activities.
    b. Policymakers (legislators, executive, agencies, regulators, etc.).
    c. Younger Generations.
    d. Community Leaders and Organizations.
    e. Business and Industry.
    f. The General Public.
2. Ensure long-term sustenance of education and outreach efforts regarding climate change.

#	Measures & Strategies	Tasks & Examples	Notes & Elaborations
1.	**State Government Actions** The State should lead by example (i.e., “walk the talk”) regarding education and outreach.		
1.1	Create a multi-agency body to oversee on-going state climate efforts, starting with the implementation of CCAC policies adopted by the Governor; report progress to the public annually.	• Assemble annual progress reports & make them publicly available.	• Staff the effort adequately; should have one or more “outreach coordinators” specifically tasked with outreach and coordination among agencies and organizations.
1.2	Establish an Education & Outreach Subcommittee of the body established in §1.1 to educate audiences regarding CCAC policies, and to oversee those relating to education.	• Lead implementation of education & outreach measures. • First task: Identify already existing resources & programs. • Identify additional needs and potential funding sources. • Conduct/review polling to identify public attitudes and points of access/resistance to change.	• Staffed by a State Outreach Coordinator. • Identify diverse and efficient ways to disseminate the information collected, especially existing programs and resources.
1.3	Include state public education and higher education officials in the bodies established in §1.1 & §1.2.		• A “two-way street”: education officials bring research & info to the body, act as outreach arm for reaching students and others.
1.4	Educate state employees across-the-board, and assign “point persons” to do so on an on-going basis.		

#	Measures & Strategies	Tasks & Examples	Notes & Elaborations
1.5	Disaggregate the State's GHG emissions to the agency level and require annual agency-specific reports on GHG reduction progress.		• Make agency-specific reports public as part of the report in §1.1.
1.6	Issue regular press releases conveying climate change news, developments, events, etc.		• Internal releases should be frequent; external releases should be either monthly or quarterly.
1.7	Act in the role of a clearinghouse to help smaller government entities be aware of and take advantage of federal opportunities.		• Example: District 2 School Board is taking advantage of federal CREBS funding for renewables.
2.	**Target Audience: Policymakers (legislators, regulators, executive branch, agencies, county commissions, city councils, school boards, etc.)** Implementation of climate actions hinges on policymakers' understanding and approval.		
2.1	Educate policy makers on climate change & CCAC policies in order to promote acceptance and implementation.	• Conduct regular legislative briefings. • Identify & offer agency-specific information on climate issues & opportunities. • Involve town, city and county officials, school boards	• Use input derived from policy maker interactions to develop new mitigation measures going forward.
2.2	Provide continuing outreach & assistance to Governor's office, legislature, and implementing agencies on a regular basis.	• Educate press liaisons from agencies, etc. • Provide regular press releases or updates on reductions, events, etc. • Require/request baseline and progress reports.	• Provide research and background information necessary to craft effective policy and legislation.

#	Measures & Strategies	Tasks & Examples	Notes & Elaborations
3.	**Target Audience: Younger Generations** Integrate climate change into educational curricula, post-secondary degree programs, and professional licensing.		
3.1	Organize groups of educators to identify, assemble, and employ climate change curricula appropriate to age groups.	• Pending.	• Check out British Petroleum's www.aplusforenergy.org
3.2	Public Education Department: include climate change in science and social studies performance standards; identify (a) gaps in climate change education, and (b) curriculum to fill any gaps.	• In addition to specific curricula, incorporate climate change concepts as examples in reading, art, culture, geography, drivers education, etc.	
3.3	Integrate "best practices" into public school design & construction to educate student (and parent's) first-hand in their communities & colleges (i.e., walk the talk). For example: - Institute climate-neutral bonding: upgrade existing buildings to offset new construction. - Reduce GHG emissions in school transportation.	• Investigate whether Montana could provide bonding for school districts to fund energy efficient construction, or take advantage of federal financing opportunities (e.g., CREBS) • Include in-building signage & displays to explicitly point out efficiency aspects built in to public buildings. • Involve students and faculty in understanding and evaluating operations and maintenance of facilities.	
3.4	Promote research into climate change and solutions at state universities; offer curricula and/or degrees in climate friendly technologies and practices.		

#	Measures & Strategies	Tasks & Examples	Notes & Elaborations
3.5	Integrate climate change into existing and/or new educational competition programs (e.g., Envirothon, science fairs, CC questions in academic competitions, a debating team topic, etc.).	• Climate change topics as specific categories.	
3.6	Work with science centers, zoos, and museums, and other non-profits to include a climate science focus appropriate to their core mission.	• A key area for an Outreach Coordinator to focus on.	• Examples exist in other regions (e.g., Clean Air-Cool Planet science center initiative). • Could provide speaking opportunities for teachers; have college professors host forums for high school students on weekend, etc.
3.7	Introduce core competencies on climate change into professional licensing programs (e.g., energy efficiency in building design and construction, use of recycled materials, etc.).	• Look at all licenses for professions and facilities, for potential for education and outreach, plus examine their operations for savings potential, perhaps as part of licensing requirements where appropriate (e.g., hospitals, professional firms).	
4.	**Target Audience: Community Leaders & Community-Based Organizations** (Institutions, municipalities, service clubs, social & affinity groups, NGOs, etc.) Recognize leadership; share success stories & role models; expand involvement and participation; within civic society.		
4.1	Identify individual community leaders who are acting effectively on climate change; showcase and share their successes.	• Enlist/encourage them to be a de facto Speakers' Bureau. • Host discussion forums featuring them. • Bring in speakers from other communities to public venues to share successes.	• Include all walks of work & life (retail, services, manufacturing, healthcare, auto, facilities, etc.). • Put examples, guidance, links, contacts, etc. up on the web clearinghouse.

#	Measures & Strategies	Tasks & Examples	Notes & Elaborations
4.2	Identify “late bloomer” individuals and target a special effort to include, educate, and prod them to act.		
4.3	Engage associations and participate in their meetings periodically to educate them about climate change and sector-specific mitigation actions.	• Set up competitions and challenges between organizations and/or communities to achieve broader participation and effective solutions to GHG emissions.	
4.4	Develop statewide recognition program(s) for community leaders and entities.	• Small incentive grants/awards for individual, community, and non-profit successes.	
4.5	Organize & host outreach events that focus on leading by example, sharing how-to, co-benefits, illuminating financial risks and opportunities, etc.	• Assist organizations and localities in self assessment, opportunities, risks.	
4.6	Identify, assist, and leverage community-based organizations with expertise or interest in climate-related issues.	• Faith community. • Service clubs; sportsmen; recreational/hobbyist groups. • Metropolitan planning organizations. • Environmental, social, & civic advocacy organizations. • Non-profits. • If they’re not already interested, give them reasons to be, based on their raison d’etre.	• Include the health and human services sector. • Libraries play a key role in information dissemination. All publicly funded libraries should provide a prominent section with resources on ameliorating climate change.

#	Measures & Strategies	Tasks & Examples	Notes & Elaborations
4.7	Work with community-based organizations to identify & build upon climate issues related to their core mission.	• Public health vs. new disease vectors? • Low-income vs. additional stressors? • Help them move from mission statement to seeing how climate change might be relevant. • For those that organize their members to affect policy, facilitate their development of lobbying campaigns.	
4.8	Support and facilitate outreach and education within community-based organization regarding climate change issues and actions.	• Provide content for websites, newsletters, listservs? • Coach & assist Community Outreach coordinators?	
4.9	Develop & coordinate a network of community-based organizations acting on climate change so they can link up, organize joint events, etc.	• Community Outreach coordinators, assisted by state climate outreach function(s) noted above. • Assistance in organizing.	
4.10	Encourage cities to join ICLEI's[7] Cities for Climate Protection program.		
4.11	Encourage cities to join the U.S. Mayors Climate Protection Agreement.[8]		

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[7] International Council of Local Environmental Initiatives. See www.iclei.org.

[8] See http://www.ci.seattle.wa.us/mayor/climate/.

#	Measures & Strategies	Tasks & Examples	Notes & Elaborations
5.	**Target Audience: Business and Industry** Promote best practices, recognize leadership; share success stories & role models; expand involvement and participation.		
5.1	Extend training programs for RCI building and facility operators.		
5.2	Promote economic development in the energy technology sector.		
5.3	Promote climate change related R&D and demonstration projects for economic development.		
5.4	Educate business and industry sectors regarding combined heat and power (CHP) in order expand its use and technological penetration.		• Some utility and/or environmental regulatory changes could also facilitate greater penetration of CHP.
5.5	Inform sources of the advantages of registering GHG emission reductions.		
5.6	Develop and provide concrete information on co-benefits to entities in order to boost their climate efforts.		
5.7	Publicize and provide incentives, funding avenues and recognition for those businesses and industries reducing climate impacts..		

#	Measures & Strategies	Tasks & Examples	Notes & Elaborations
5.8	Provide opportunities for business to share successes and problem solving.	• Sponsor business "brown bag lunch" meetings. • Provide easy access to other resources and entities that can assist businesses in achieving emission reductions.	
6.	**Target Audience: General Public** Increase awareness and engage in climate actions in personal and professional lives.		
6.1	Educate broadcasters, reporters, editorial boards, etc. about climate change, the risks it imposes, and solutions.	• Provide access to information and success stories. • Provide photos, B-roll (background video), and media packages of background information.	
6.2	Work with state broadcasters and print media associations to develop & run climate change public service announcements.		
6.3	Conduct public polling to benchmark strength and depth of climate understanding; track over time to measure progress and better tailor outreach efforts.	• (There's an insert above that repeats this, but it may be worth repeating.) • Life in Montana Survey • Montana Greenhouse Gas Website tools	
6.4	Keep a high profile on climate change issues and actions through regular public mention by Governor and other public leaders.		
6.5	Develop and use a state-based "brand" on climate awareness and action.		

#	Measures & Strategies	Tasks & Examples	Notes & Elaborations
6.6	Develop and maintain a state climate change website for the public; establish and maintain a web-based clearinghouse for climate change information and education resources.	• Link to scientific developments, What you can do, How you can help, What the state is doing, etc. • Measuring individual efforts	
6.7	Build recognition of the sources (causes) of GHG emissions.	• Create a hierarchy checklist, from easiest/cheapest to progressively more difficult, of things individual can do, with benefits for each.	• Include agriculture, food production, etc. to make it as personal as possible.
6.8	Work with existing company outreach efforts to customers (e.g., utilities) to enhance awareness of climate change issues & actions.	• Retail advertising and/or "bill stuffers". • Environmental disclosure of electricity fuel mix/emissions; recycled content, etc. • Product messages on labels and attached flyers.	
6.9	Promote local farm produce and products, including biofuels and biopower.		
6.10	Promote clean fuel technologies, especially local ones.		• Locally produced fuels could include, for example, combustion of wood chips for electric power generation, production of ethanol from local cellulosic feedstocks, biodiesel from locally produced feedstocks, etc.

#	Measures & Strategies	Tasks & Examples	Notes & Elaborations
6.11	Promote green power in order to expand subscription.	• Make green power purchase options available to all electricity consumers. • Enhance marketing and promotion of green power where this purchase option is available to consumers.	
6.12	Require environmental disclosure on utility bills.		
6.13	Add GHG to air quality awareness efforts.		
6.14	Provide access to other sources of information	• Website links. • Local organizations. • Library resources (e.g., through displays on-site and on websites). • Universities.	