National Center for Appropriate Technology

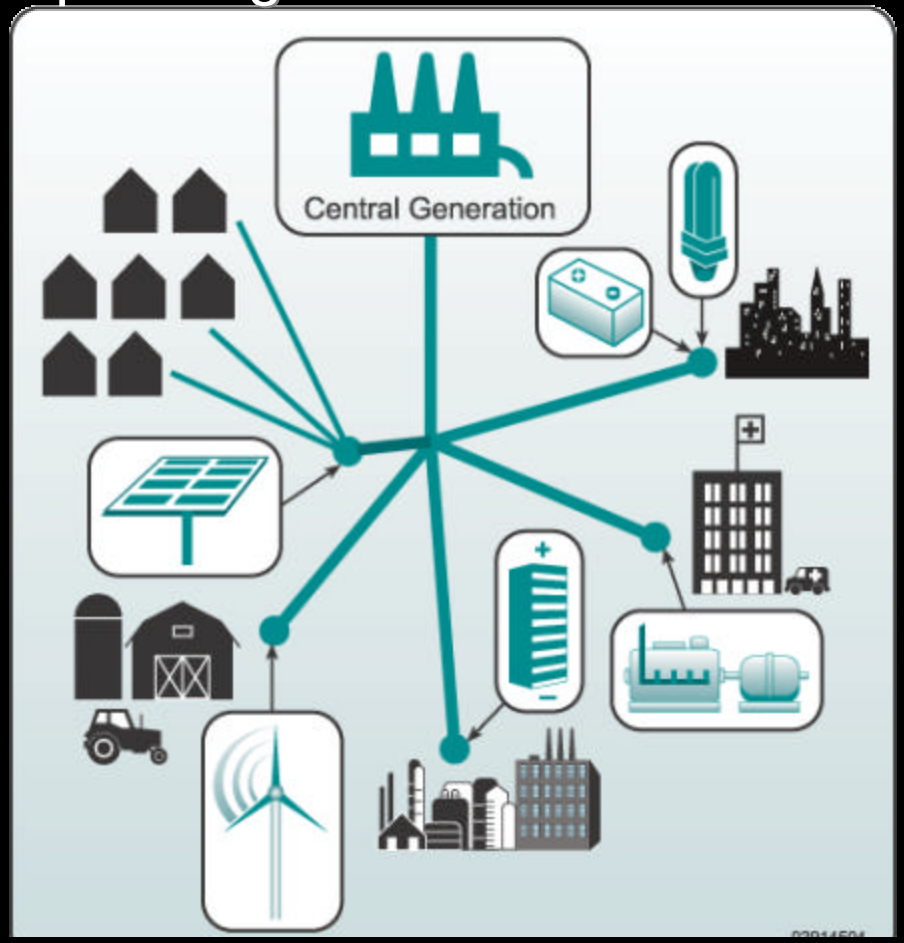
NCAT

Sustainable Energy Program

For 28 years NCAT has been serving people—particularly economically disadvantaged people—and bettering lives by promoting and demonstrating appropriate technologies.

Distributed Generation

-Places power generation sources near loads



- Primarily reciprocating engines, gas turbines, micro-turbines
- Also renewable energy technologies

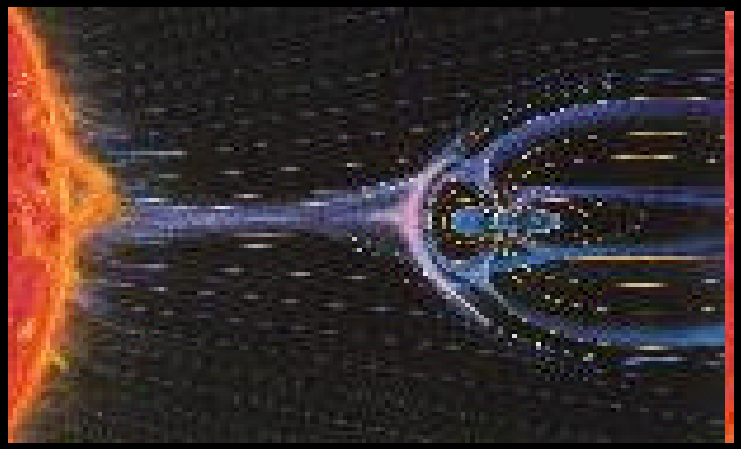
Benefits of Distributed Generation

- Improves the efficiency of the transmission & distribution network
- Improves power quality at the ends of the network
- Reduces pollution
- **Enhances customer choice & adds competition to the energy marketplace**
- **Enhances energy security**

Distributed Renewable Energy Sources

- Efficiency
- Wind
- Solar
- Hydroelectric
- Biomass
- Geothermal
- Tidal Power

Wind Energy



- Wind is created by uneven heating of the earth's surface
- Wind Resources are Abundant and Distributed

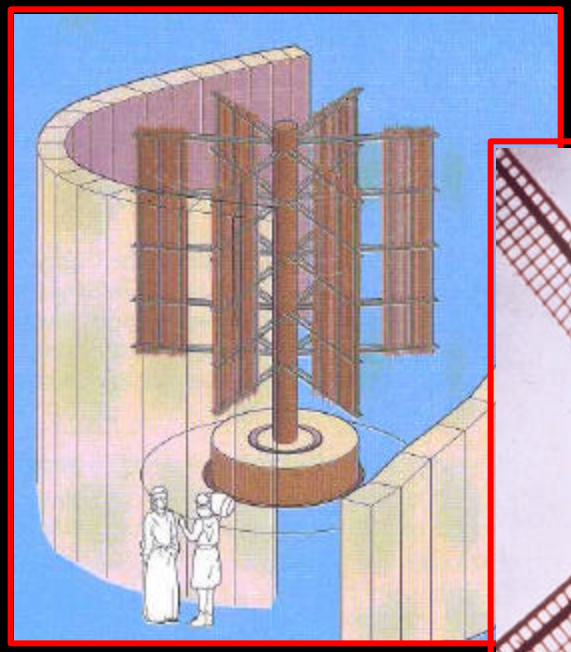
  -Many Areas Have Sufficient Wind for Off-Grid Power Applications
- **$P(W/m^2) = 1/2 \times \rho\ (kg/m^3) \times A\ (m^2) \times V^3\ (m/s)^3$**
- Power in the wind is Proportional to Velocity Cubed ($P \sim V^3$)

  -If Velocity is Doubled, Power Increases by a Factor of Eight

NCAT

Wind Power History

1400 – 1800 years ago, in the Middle East



800 – 900 years ago in Europe

140 years ago, water-pumping wind mills

80 years ago, electric power

NCAT

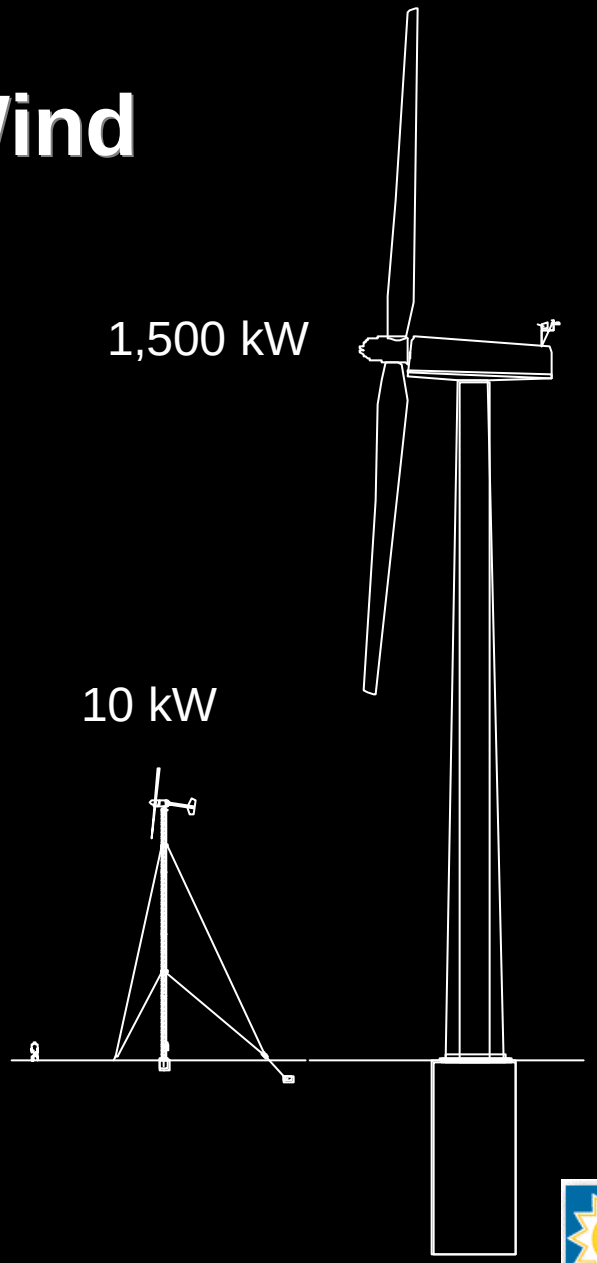
In the 1920’s, 9 out of 10 rural homes were without electric service.

Marcellus Jacobs produced his first wind machine in 1922, 13 years before the Rural Electrification Administration was created, bringing electricity to Montana farms.

Rural Energy

Small Wind vs Large Wind

- Utility-Scale Wind Power
  600 - 1,800 kW wind turbines
  - Installed on wind farms, 10 – 300 MW
  - Professional maintenance crews
  - 13 mph (6 m/s) average wind speed
- Small Wind Power
  300 W - 100 kW wind turbines
  - Installed at individual homes, farms, businesses, schools, etc.
  - On the “customer side” of the meter, or off the utility grid entirely
  - High reliability, low maintenance
  - 9 mph (4 m/s) average wind speed



NCAT

Will Small Wind Energy Work For Me?

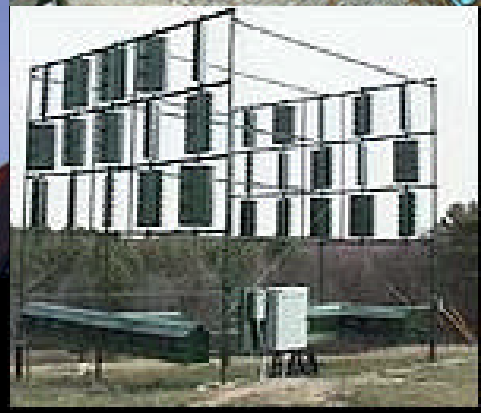
- Good wind resource?
- A desire to be more self-sufficient?
- Concerned about future electricity prices?
- Concerned about energy security?
- Minimum 1/2 to 1 acre of land?
- Comfortable with long-term investments?
- Concerned about the environmental impacts of electric power generation?

Hundreds of Possible Configurations ... Most are Bad

Identification: 1) Performance claims that exceed Betz Limit (59.3%) or the total kinetic energy in the wind; 2) Selling dealerships & distributorships

Bad Configurations Keep Showing-up:

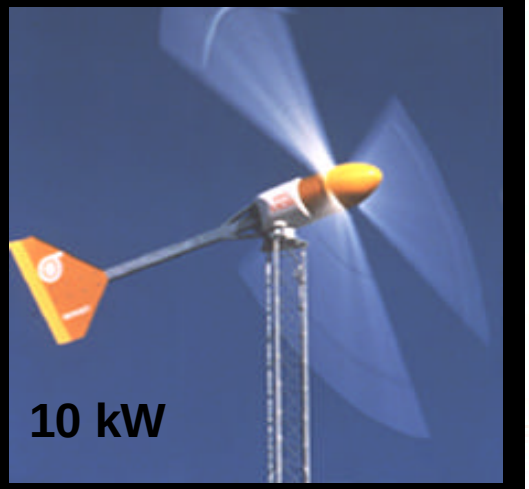
- **Savonius Vertical-Axis Rotor**
- **Darrieus Vertical-Axis Rotors**
- **Cloth-Blade, Sail Wings Rotors**
- **Windmill Rotor with Electrical Generator**
- **High-Speed Mechanical (CWD)**
- **Venturies or Other Flow Concentrators**



NCAT

Modern Small Wind Turbines:

- Aerospace Technology
- Advanced Power Electronics
- Only 2-3 Moving Parts
- Very Low Maintenance Requirements
- **American Companies are the Market and Technology Leaders**

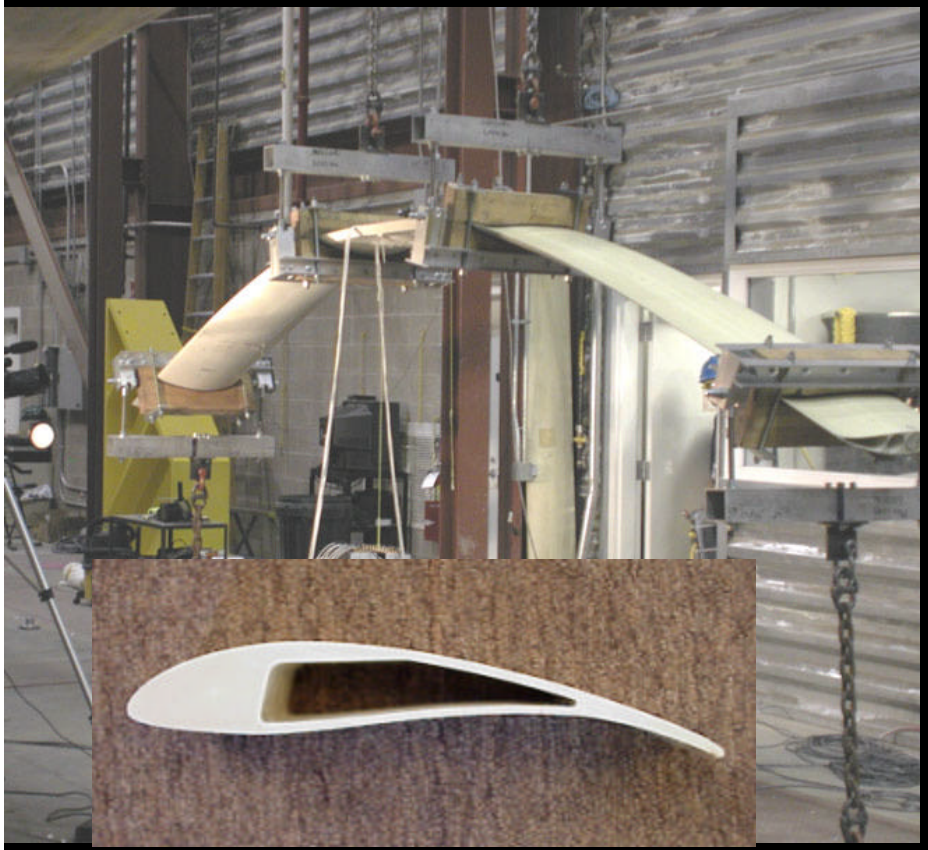


NCAT

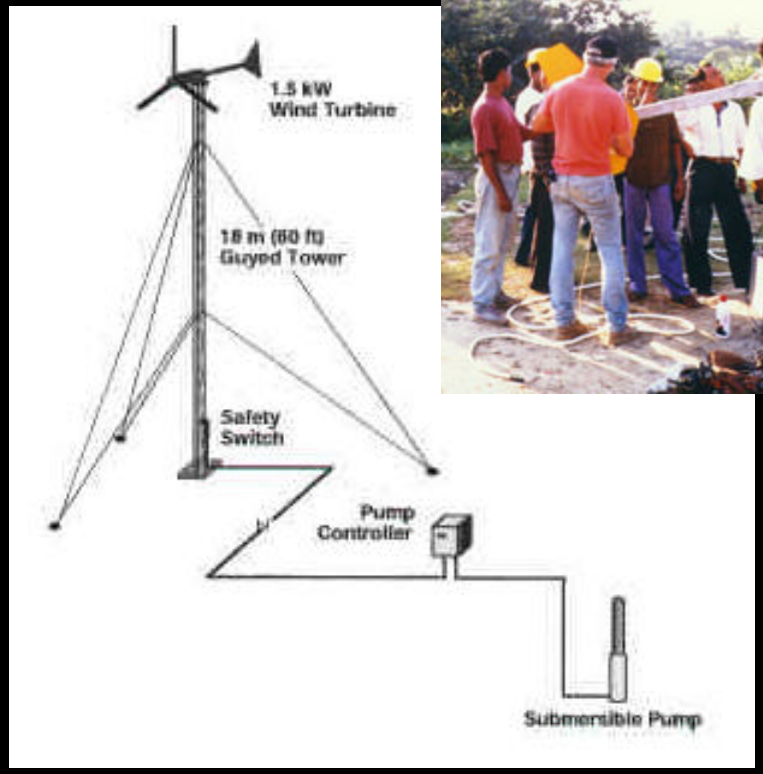
Reliability and Maintenance

- Turbines Operate Unattended and Automatically, Even in Severe Weather
- Reliability and Maintenance Requirements are Design Specific ...
- Best Available Units Require No Scheduled Maintenance and can Operate for 3-6 Years Without Attention
- Typical Design Operating Life is 30 Years (Some Small Turbines Have been Operating for More Than 60 Years!)

Super Strong “Pultruded” Blades



- Blades are the Most Critical Component of a Small Wind Turbine
- 3-Bladed Rotors Run Smoother Than 2-Bladed Rotors
- Fiberglass or Plastic Are Preferred Materials … Avoid Metal (Fatigue) and Wood (Maintenance)
- New Airfoils are Boosting Performance Dramatically



1.5 kW Bergey

Grundfos Pump
11 mph wind site
100 feet of head
4,800 gals/day

1 kW Whispe

Grundfos Pump
11mph Wind Site
100 feet of head
6,800 gals/day

Wind/Electric Water Pumping

NCAT

Rural Residential Wind

TYPICAL HOME SYSTEM

10 kW (21 ft. Rotor Diameter)

Connected to House Wiring

Produces ~ 18,000 kWh per Year

Offsets ~ 7 Tons of CO_2 per Year

Excess Power delivered to Utility

Net Metered or Very Low Buy-Back Rate

Installed Cost: ~ $35,000

NCAT

JAN 12 2004

3 8:49AM

NCAT

"What the h...??!" Hope you had a Merry Christmas!
Tom & Laurie Gilleon

Merry Christmas
2001
LUV THE ROSSMILLERS
2001

NCAT

Frequently Asked Questions

- Radio/TV Interference: Not a problem with today's fiberglass or wood blades (no metal blades!)
- Noise:
  - Below 30 mph, soft "swoosh" sound
  - Above 30 mph, can get either:

  Loud buzzing from blade "flutter" or "wop/wop" helicopter sound if furled
- Impact on Birds: Bird kills are rare, use common sense in siting turbines
- Lightning: Effectively avoided with proper grounding and use of surge suppressors
- Severe Storms: Can be a problem, some turbines have survived hurricanes and tornados

Market Barriers

- **Economics:**

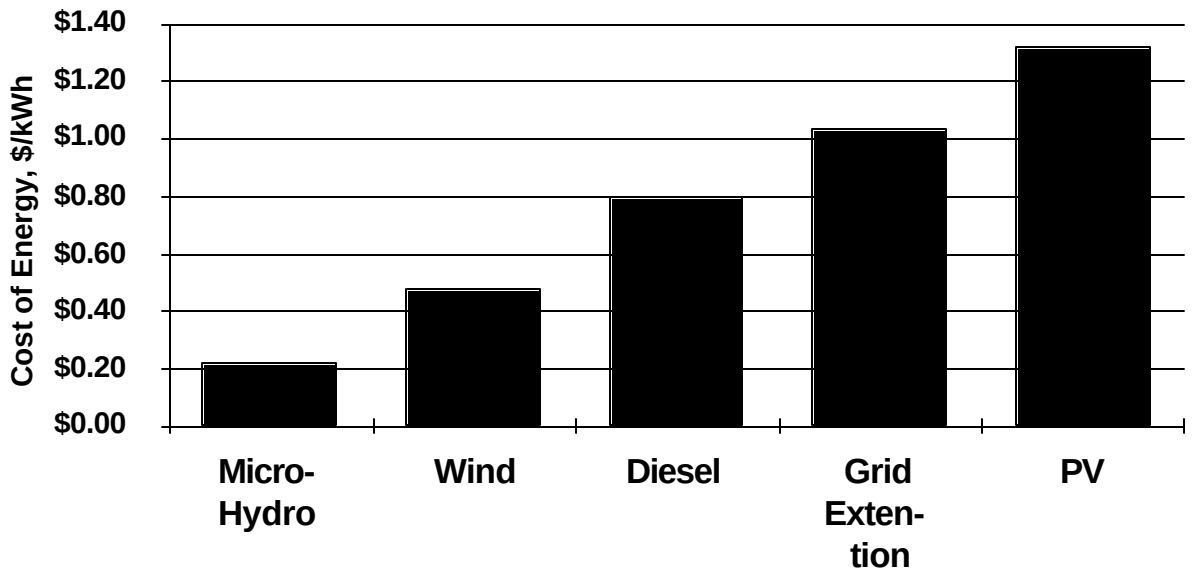
  Low Production Volume & Historical Lack of Subsidies = High Costs

- **No Federal Tax Incentives since 1985**
- **Public Apathy Towards Energy**
- **Zoning: 35’ Height Restrictions**
- **No Effective US-DOE Small Wind Program**

Modern Small Wind Turbines:

A Least-Cost Option for Small Power

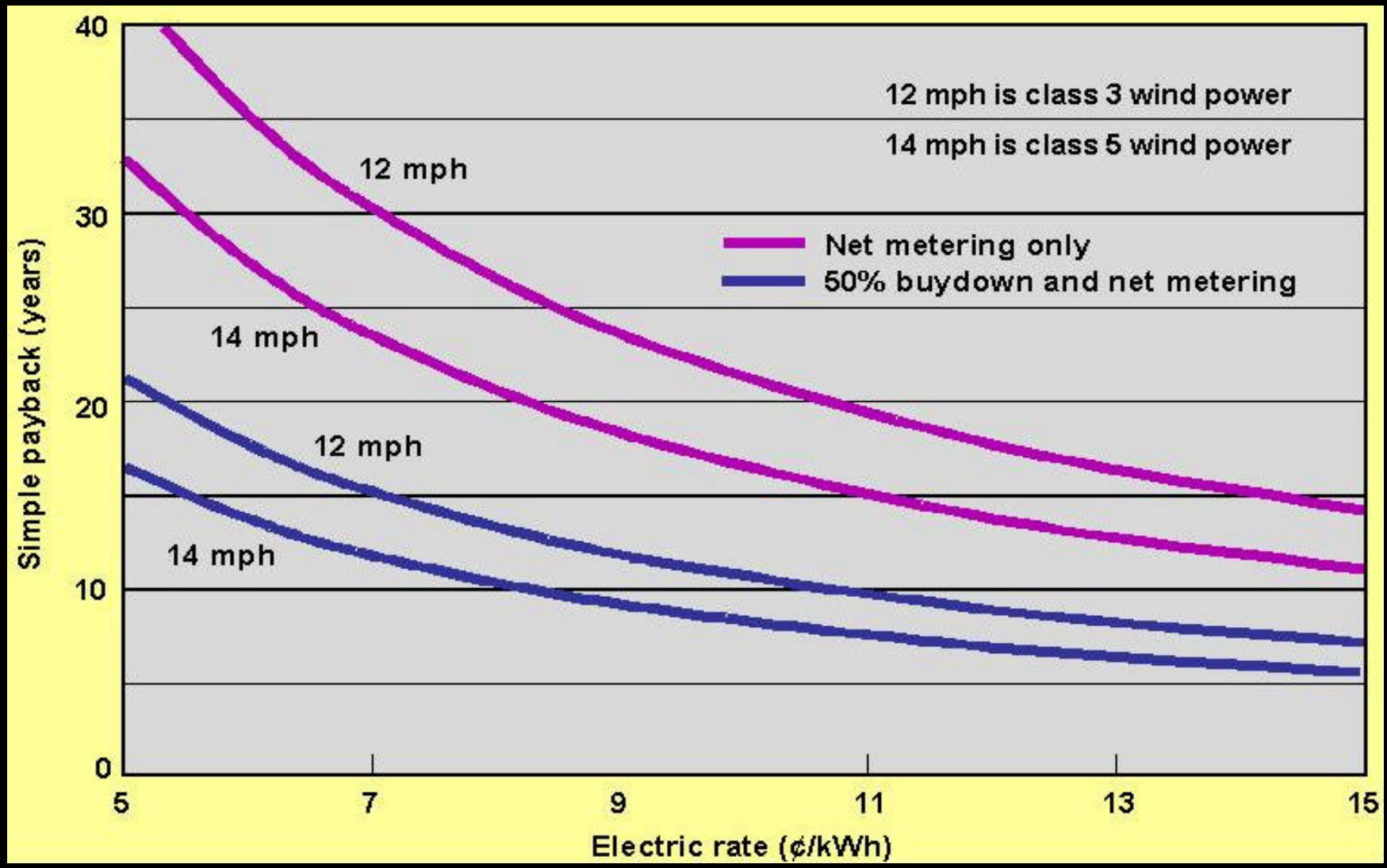
Typical Costs of Energy at 10 kW Capacity



" With reasonable assumptions concerning discount rates, capacity factors, and fuel costs, micro-hydro and wind turbines can have the lowest life cycle costs in locations where the resource is sufficient."

***Fueling Development: Energy Technologies for Developing Countries*, April,1992**
U.S. Office of Technology Assessment

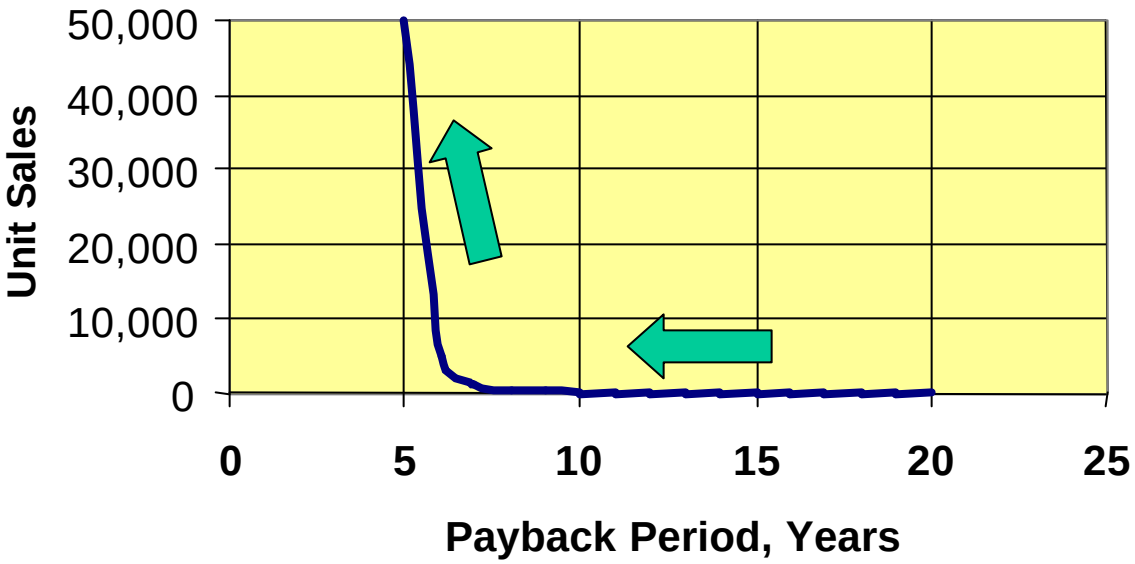
Incentives Make Small Wind Systems More Economical



Small Wind Could Supply 5% of U.S. Electricity in 2020

- Residential Electricity Consumption Exceeds Either Commercial or Industrial (35% of U.S. Sales in 1998)
- 51 Million Homes have ½ Acre or More
- 4.6 Million Commercial Buildings

U.S. Market Potential: 4-8 Million Units in 2020



Volume Production Can Drive Costs Down by 15 – 30%

NCAT

NCAT Small Wind Program

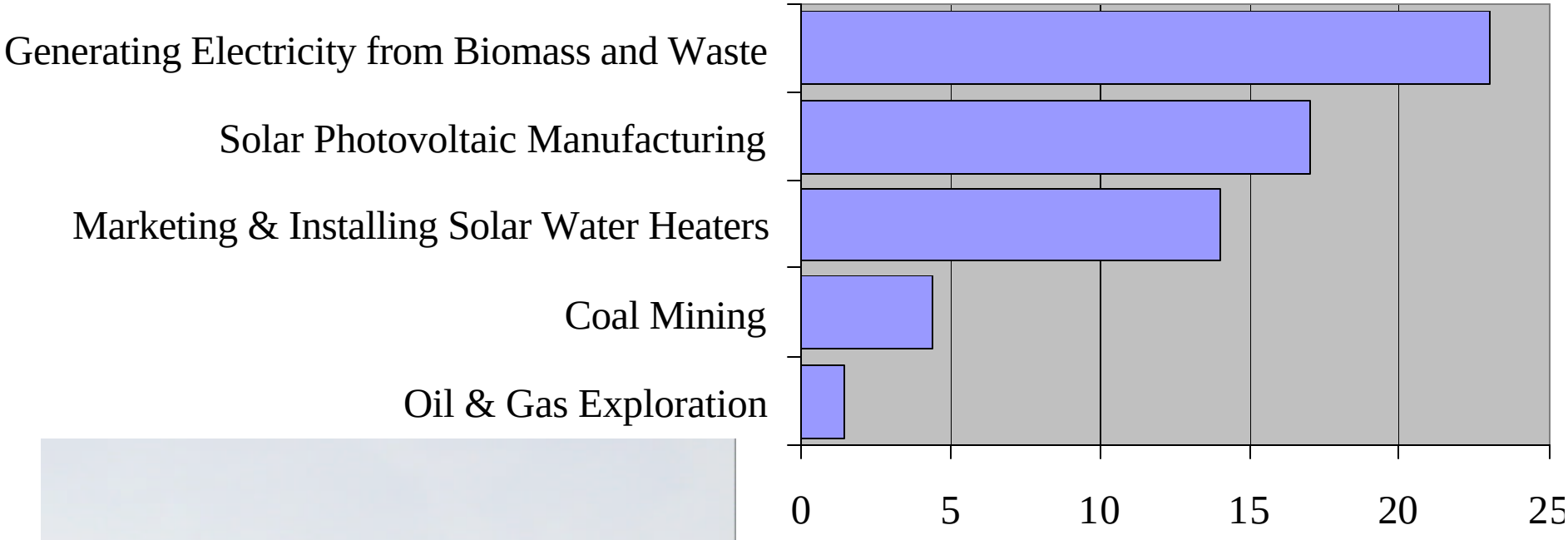
- NorthWestern Energy USB Rebate Program
- Coop Net Metering Demonstration Program
- Small Wind Outreach
- Anemometer Loan
- Coordination with

  -National Renewable Energy Lab

  -North West Sustainable Energy for Economic Development

  -Department of Energy

Jobs Created for every $1 Million spent)



Montana currently has three full time Renewable Energy Contractors /Dealers and numerous part time contractors

- Independent Power Systems-Bozeman
- Sunelco-Hamilton
- Solar Plexus-Missoula

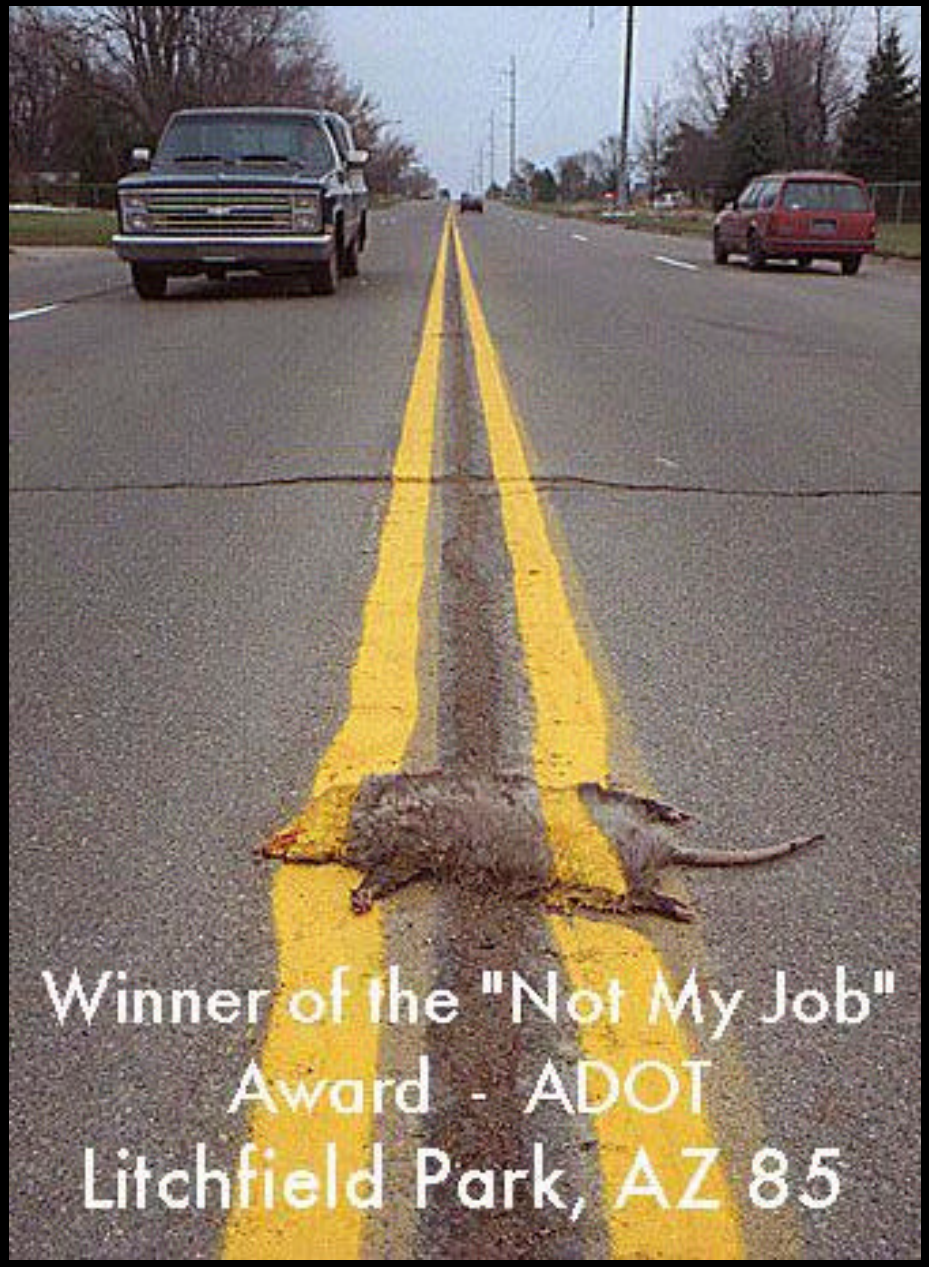
“Let us set as our national goal, in the spirit of Apollo, with the determination of the Manhattan Project, that by the end of this decade we will have developed the potential to meet our own energy needs without depending on any foreign energy source.”

"Let us set as our national goal, in the spirit of Apollo, with the determination of the Manhattan Project, that by the end of this decade we will have developed the potential to meet our own energy needs without depending on any foreign energy source."

1973

Richard Nixon

"Project Independence"


Winner of the "Not My Job"
Award - ADOT
Litchfield Park, AZ 85

National Center for Appropriate Technology

NCAT

Sustainable Energy Program