Electric Utility Integrated Resource Planning Best Practices

Montana Legislature, Select Committee on Energy Resource Planning and Acquisition

September 29, 2023

Energy+Environmental Economics

Arne Olson, Senior Partner

Introductions & Agenda

E3 Overview

Technical & Strategic Consulting for the Clean Energy Transition…

90 full-time consultants | 30 years of deep expertise | Engineering, Economics, Mathematics, Public Policy…


San Francisco


New York


Boston


Calgary

E3 Clients

250 projects per year for a diverse client base

- Utilities
- Investors
- Developers
- Regulators
- Policymakers

E3 Project Examples

santee cooper®

Advisory and bid evaluation services to the State of South Carolina for the potential sale of Santee Cooper (~$9 billion valuation)

Integrated Resource Planning for the CA Public Utilities Commission (CPUC) to achieve state clean energy targets (SB100)

NEW YORK STATE OF OPPORTUNITY. | Department of Public Service | NYSERDA | LIPA Long Island Power Authority | NEW YORK ISO INDEPENDENT SYSTEM OPERATOR | conEdison

Evaluation of gas peaker replacement and/or hybridization with energy storage in New York City and Long Island

GLOBAL INFRASTRUCTURE PARTNERS | Clearway

Price and revenue projections and due diligence for GIP acquisition of NRG renewables portfolio (~$1.4 billion)

ENERGY COMMISSION | CALIFORNIA AIR RESOURCES BOARD | CALPINE®

Multiple studies on costs and feasibility of high renewables integration and low-carbon transition pathways from 2020-2050

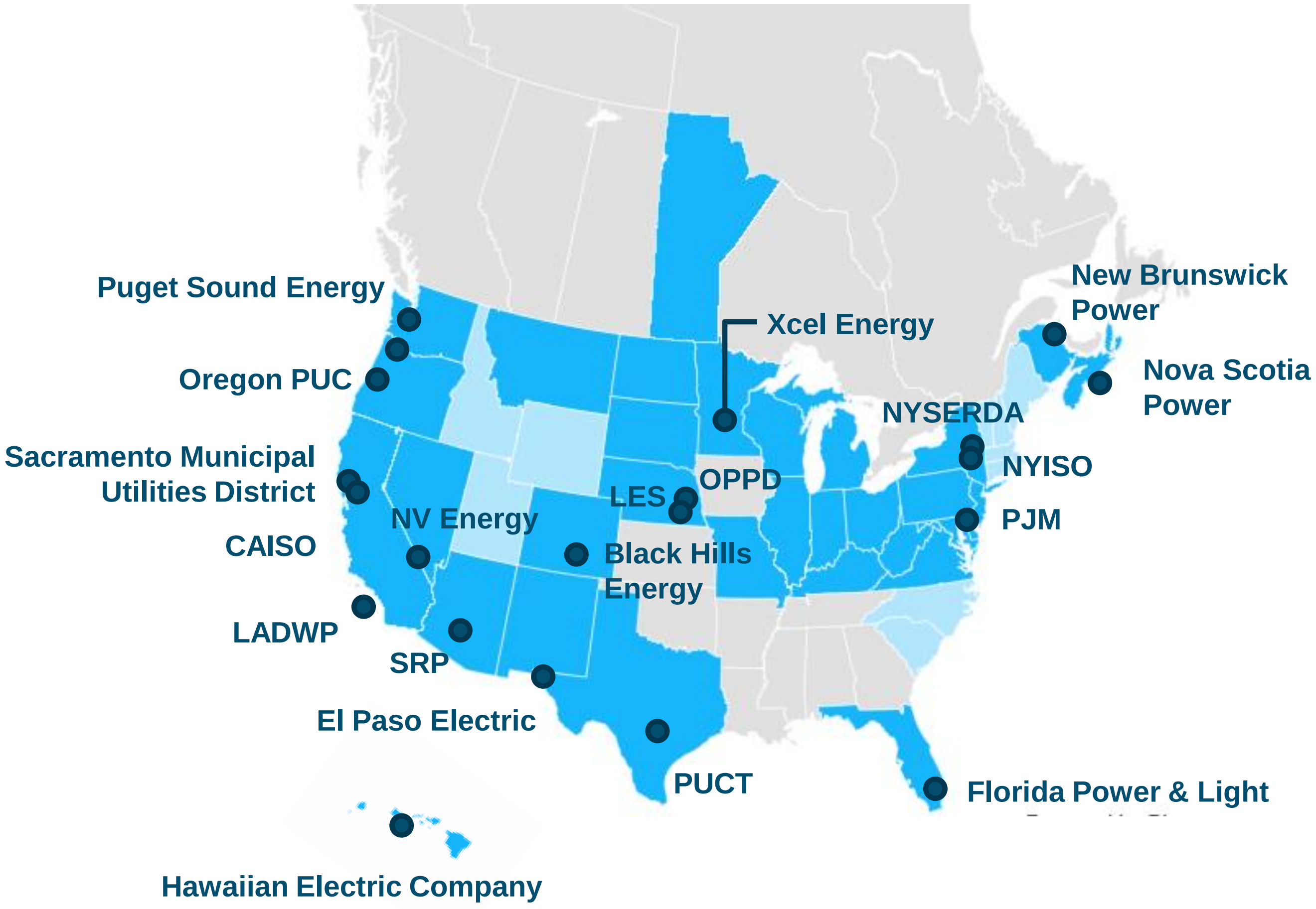
Reliability analysis of closing coastal gas-fired power plants and assessment of alternatives (transmission, storage, etc.)

LA DWP

E3 has extensive experience conducting and assisting with resource plans on behalf of a diverse range of clients

+ **Example projects include:**
  - Leading the development of a first-in-kind Integrated System Plan for the Salt River Project
  - Leading the technical analysis and advising the California Public Utilities Commission in conducting the state's IRP process under SB32
  - Leading analysis of the Sacramento Municipal Utilities District's goal of 100% carbon-free power by 2030
  - Evaluating resource adequacy needs on a changing Pacific Northwest system for a consortium of 13 utilities including NWE
  - Investigating least-cost policies for achieving carbon reductions on behalf of a coalition of independent power producers in PJM
  - Evaluating utility IRPs on behalf of clean energy business interests in the Carolinas

E3 has worked directly with utilities across North America on integrated resource planning



Agenda

+ **IRP in the 21st Century**
  - Emerging challenges for utility planning
+ **Overview of IRP process**
+ **IRP best practices**
  - Engage stakeholders and solicit public input throughout process
  - Use optimization to identify least-cost resource portfolios
  - Consider reliability and resiliency during high impact, low frequency events
  - Operational studies needed to determine operating reserve needs and characteristics
  - Include demand-side resources in planning process
  - Incorporate climate policy and climate change impacts
+ **Conclusion**

IRP in the 21st Century

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Emergence of Integrated Resource Planning

- The concept of Integrated Resource Planning "IRP" emerged in the 1980's, bringing about a new approach to electricity grid planning
- Today, in an ever-changing world, planning for the future is both challenging and critical:
  - A larger suite of generation resources are available
  - Policymakers are setting decarbonization goals that directly impact how the electric system will operate
  - The changing climate requires the grid to be ever-more reliable and resilient

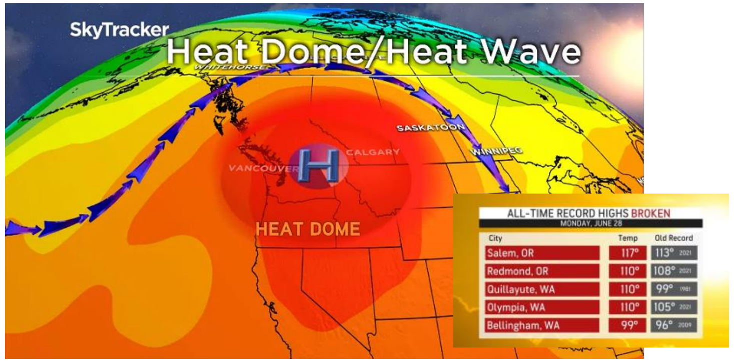
Broad changes are sweeping through society that are increasing the focus and difficulty of integrated resource planning

1. **Technology:** Technological change in data processing, communications and manufacture are making new technologies available and cost-effective

2. **Climate:** Utilities everywhere are updating their planning assumptions to account for more frequent and extreme temperatures and drought conditions

3. **Policy:** Climate change and the need to decarbonize our economy will require the development of massive quantities of low-carbon electricity

4. **Democracy:** Consumers are increasingly wishing to take control of their own destiny, decentralizing the locus of decision-making



Significant Changes are Underway Across All Parts of the System and are Increasingly Interrelated

Bulk Grid Supply	Transmission System	Distribution System	Customer Solutions
Coal Retirements	Traditional Transmission Solutions	Grid Enablement Solutions	Distributed Generation
Renewables	Interregional Transmission	Advanced Metering Infrastructure	Energy Efficiency
Natural Gas Plants	Energy Storage	Traditional Distribution Solutions	Demand Response
Nuclear		Microgrids	Electric Vehicles
Emerging Tech (e.g., H2 storage)		Energy Storage	Pricing Programs
Energy Storage			Energy Storage

Integrated system planning ensures the utility is unified and agile as it carries out these transformations

Increased digitization and onshoring are creating renewed industrial demand growth

MENU Micron

September 12, 2022 at 11:15 AM EDT

Micron Breaks Ground on Leading-Edge Manufacturing Fab in Boise, Idaho

Company celebrates initiation of historic $15 billion investment; construction expected to begin early in 2023, with DRAM production slated for second half of the decade

BOISE, Idaho, Sept. 12, 2022 (GLOBE NEWSWIRE) -- Micron Technology, Inc. (NASDAQ: MU), one of the world's largest semiconductor companies and the only U.S.-based manufacturer of memory, broke ground on its leading-edge memory manufacturing fab in Boise, Idaho. This will be the first new memory manufacturing fab in the United States in 20 years. Micron marked the occasion with a

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JOBS

Intel to add 2 factories to its Chandler campus; $20B investment in Arizona will create thousands of jobs

Russ Wiles
Arizona Republic

Published 3:33 p.m. MT March 23, 2021 | Updated 6:04 p.m. MT March 23, 2021

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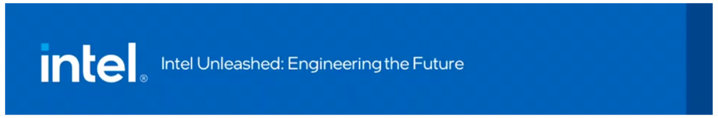


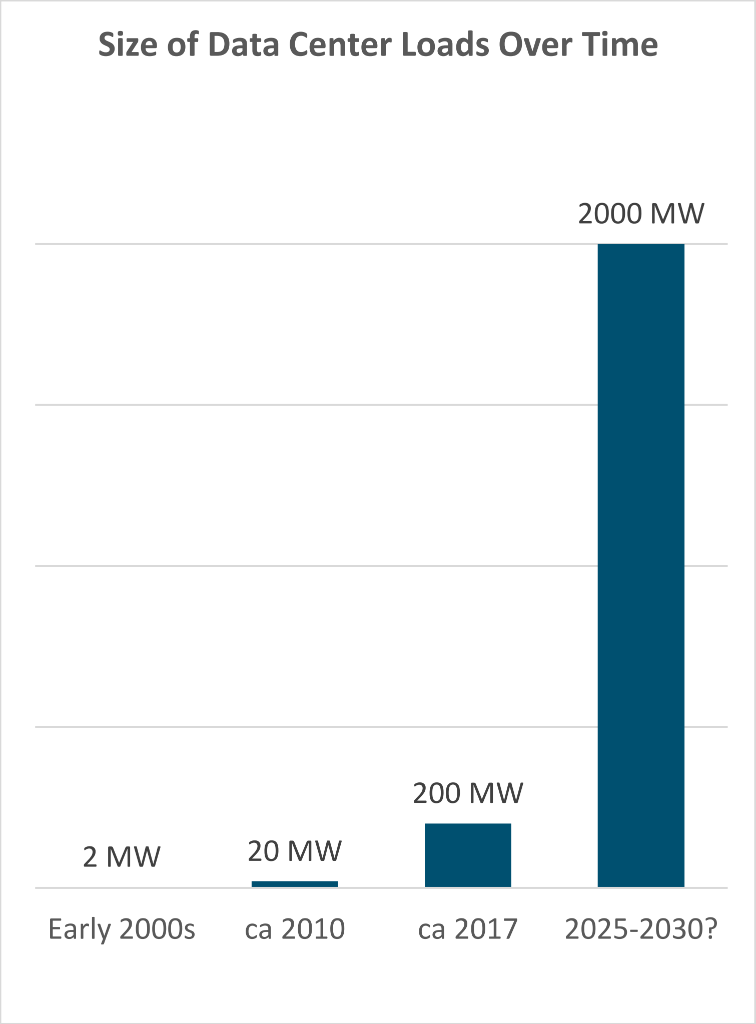
TRANSPO / ELECTRIC CARS / CARS

GM, Hyundai announce EV battery plants for the US

/ GM is teaming up with South Korea's Samsung SDI, while Hyundai said it would create a joint venture with SK On. The new factories are the latest in a rapidly expanding EV manufacturing footprint in the US.

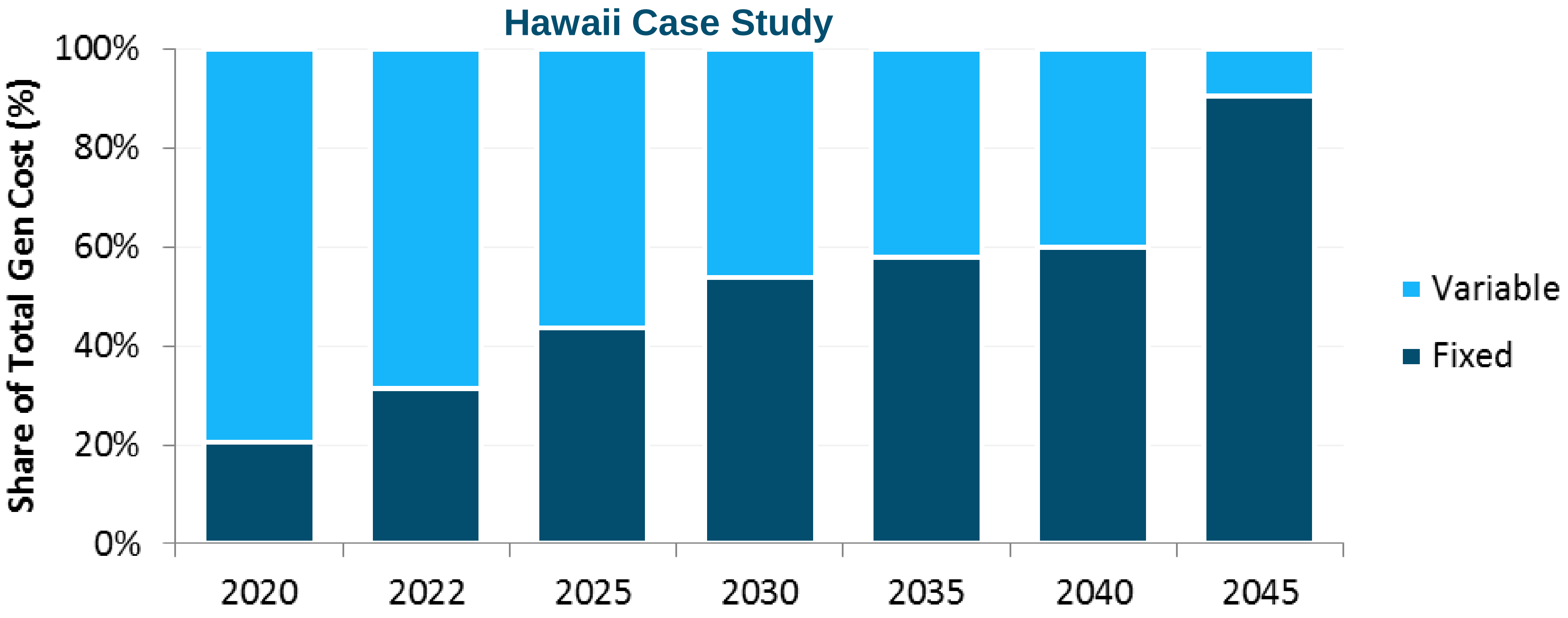
By Andrew J. Hawkins, transportation editor with 10+ years of experience who covers EVs, public transportation, and aviation. His work has appeared in The New York Daily News and City & State.

Apr 25, 2023, 10:04 AM PDT | 4 Comments / 4 New



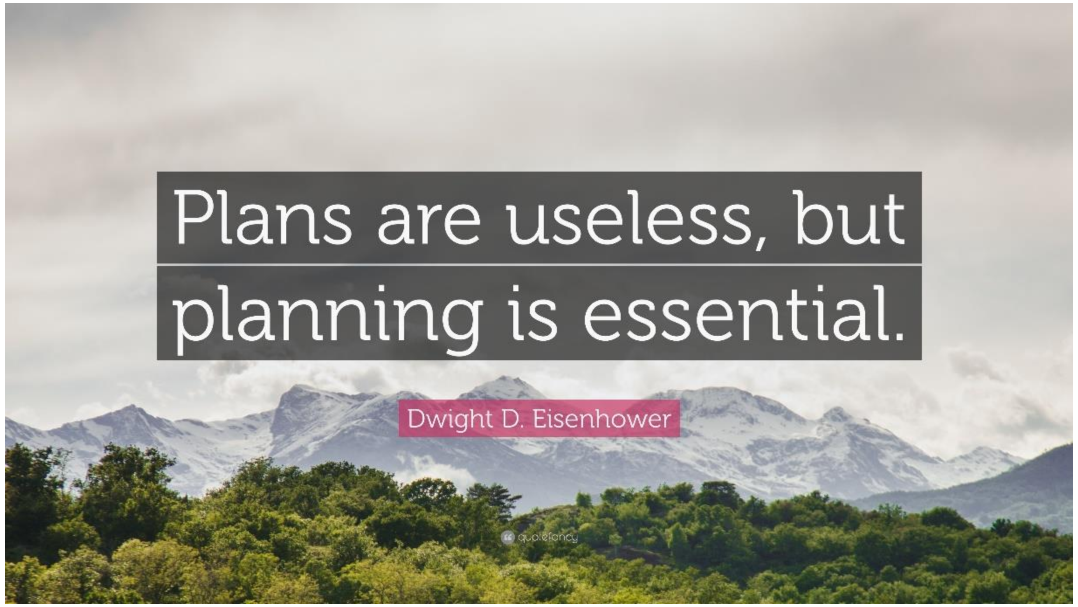
IRP is needed to help ensure efficient allocation of capital

- Power system is transitioning from one with significant fuel costs to one that is consists almost entirely of capital investments
- Utility attention must increasingly shift from managing fuel costs to making wise long-term investments to minimize costs for ratepayers



What is an Integrated Resource Plan?

- **An integrated resource plan:**
  - Identifies supply and demand side resources…
  - Needed to meet a utility's projected demand over time…
  - At the lowest cost…
  - While ensuring reliable electric system operations…
  - Meeting legal and regulatory requirements…
  - And not subjecting customers to undue financial risk
- **An IRP identifies a least-cost resource portfolio that is robust across a wide range of potential futures over long economic lifetimes**
- **An IRP is *not* a prescriptive recipe that the utility must follow for all time**
  - The IRP is done at a particular point in time
  - The plan must be flexible as conditions change



Mid-term of 3-10 years is key focus for IRP Action Plan, but investments must be evaluated over very long economic lifetimes

Mid-term needs shape the utility's "Action Plan" for new investment

1 – 3 years

Near Term

- Portfolio & risk management
- Scheduling maintenance
- Energy trading
- Demand Side Programs

Near-term decisions mostly about optimizing the tools the utility has

3 – 10 years

Mid Term

- Load Growth
- Capacity Needs
- Procurement
- System Change
- Transition

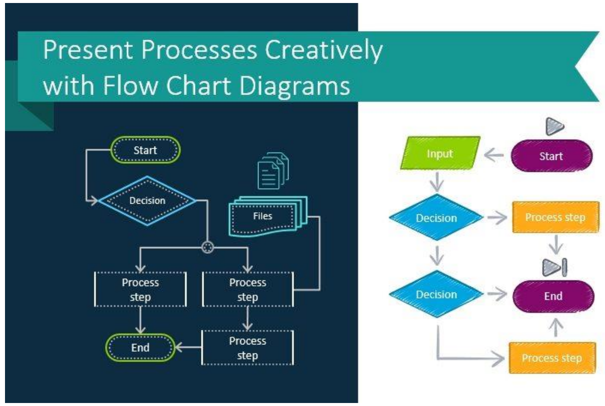
10 – 30 years

Long Term

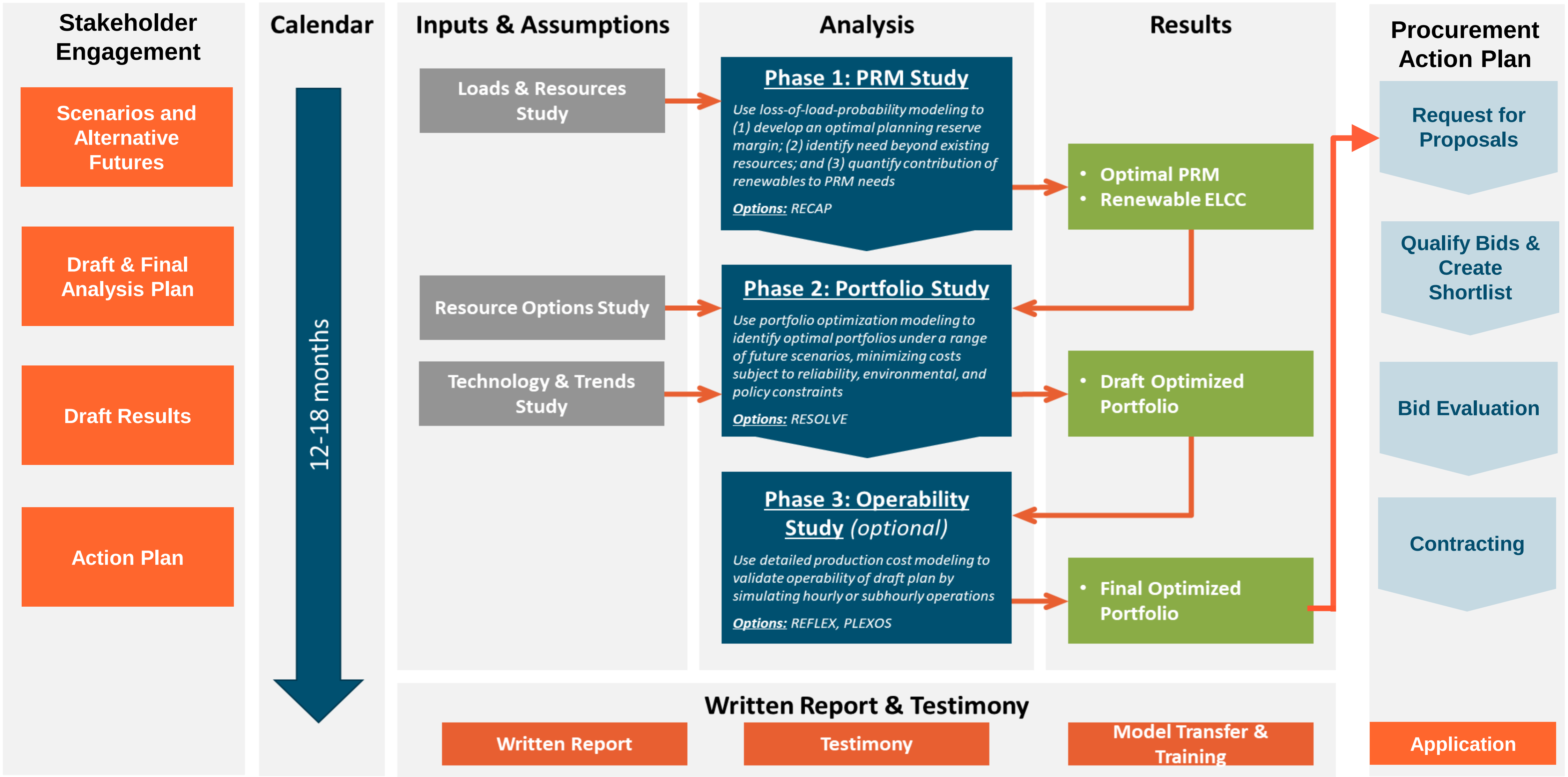
- Future Policy
- Decarbonization
- Climate Change
- Electrification
- Uncertainty

Planned investments evaluated over 20- 40-year economic lifetime

Overview of IRP process



Outline of Integrated Resource Planning Process



Overview of the analytical components of an IRP

1. Load Forecast

What future annual and peak demand can we expect?

Robust load forecasting to identify resource need

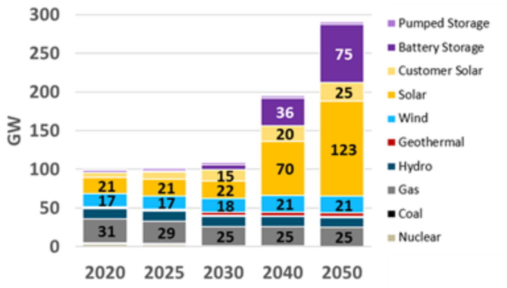
Data needs

- *Historical hourly loads*
- *Customer growth*
- *New device impact*
- *Simulated loads*
- *Policy impacts*

2. Portfolio Optimization

What resources should we procure to meet future needs?

Optimal capacity expansion model for electric systems



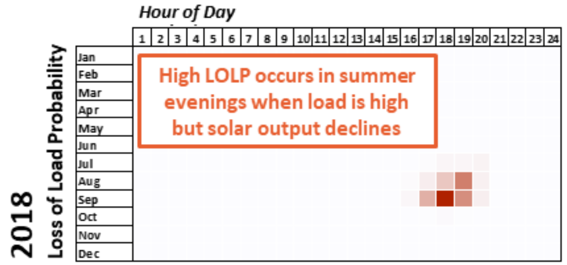
Data needs

- *Resource costs*
- *Resource availability*
- *Future load & peak demand*
- *Policy constraints*

3. Reliability Analysis

Do the future portfolios ensure a reliable system?

Loss of load probability simulation to measure resource adequacy



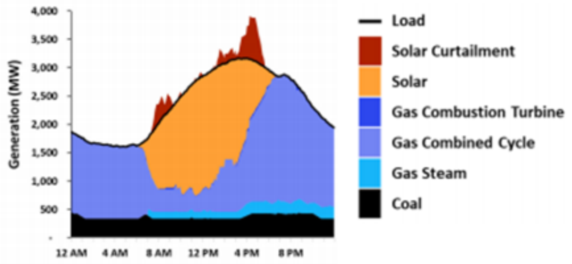
Data needs

- *Hourly loads (historical and simulated via weather)*
- *Simulated hourly renewable production*
- *Historical forced outage rates for thermal units*

4. Production Simulation

How will the system operate and what are the costs?

Detailed operational simulations of system dispatch and flexibility needs



Data needs

- *Thermal dispatch parameters (operational & cost)*
- *Simulated hourly renewable production*
- *Hourly projected loads*

IRP best practices

Six elements of a successful IRP

- Engage stakeholders and solicit public input throughout process
- Operational studies needed to determine operating reserve needs and characteristics
- Use optimization to identify least-cost resource portfolios
- Include demand-side resources in planning process
- Consider reliability and resiliency during high impact, low frequency events
- Incorporate climate policy and climate change impacts

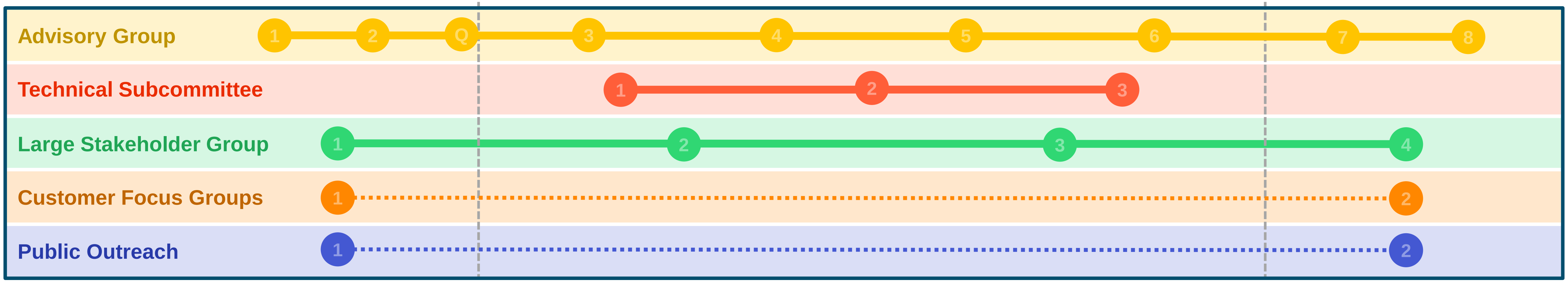
These are generic elements – some of which might differ or be less prescriptive for MT's IRP processes

IRP best practices 1/6:
Engage stakeholders and solicit public input throughout process

IRP stakeholder process is important to educate and seek feedback from key stakeholder groups

Prepare *Phase 1*	Analyze *Phase 2*		Synthesize *Phase 3*
Formulation • IRP Launch • Form Advisory Group **Scenarios & Metrics** • Define scenarios and metrics • Gather data	**Analytical Framework** • Share IRP analytical framework	**Conduct Analysis** • Forecasts • Distribution • Resources • Transmission • System-wide avoided costs	**Results** • Evaluate scenario results • Choose preferred portfolio • Assess impacts to other planning areas

Activities



Goalsetting for the IRP

- It is important for an IRP process to start with clear goals and objectives for the resource portfolios
- Establishment of the goals and objectives helps guide the process for how to evaluate the inevitable tradeoffs

Figure 1. System Planning Objectives

SAFE
- Provide safe electric service throughout the province
- Promote an injury-free workplace where everybody goes home safe every day

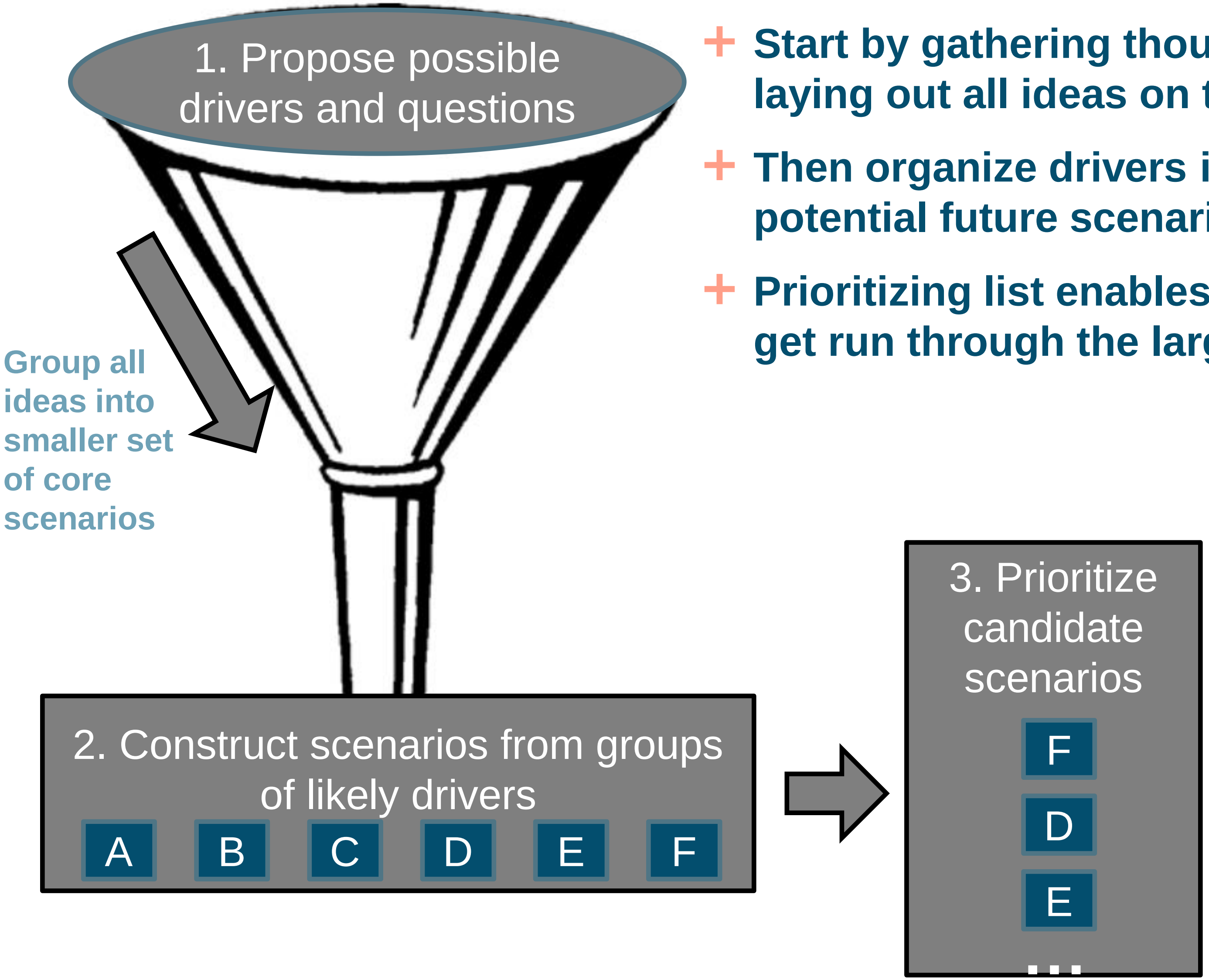
RELIABLE
- Meet reliability requirements for supply adequacy
- Procure essential grid services for system stability and reliability

AFFORDABLE
- Minimize the present value of the long term costs of the power system
- Manage the magnitude and timing of electricity rate impacts

CLEAN
- Reduce greenhouse gas and other emissions
- Support economy-wide decarbonization through long-term planning

ROBUST
- Develop a plan that can withstand realistic potential changes to key assumptions
- Build in flexibility so that future decisions aren't overly constrained

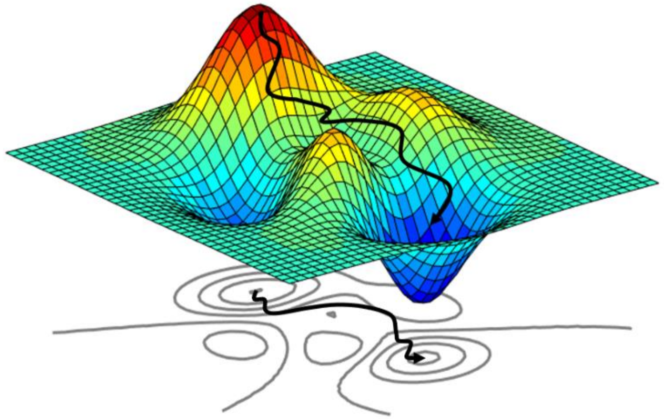
A key role for stakeholders is to help create a tractable set of IRP Scenarios



- **Start by gathering thoughts from stakeholders and laying out all ideas on the table**
- **Then organize drivers into sets that reflect discrete potential future scenarios**
- **Prioritizing list enables most important scenarios get run through the largest number of sensitivities**

IRP best practices 2/6:

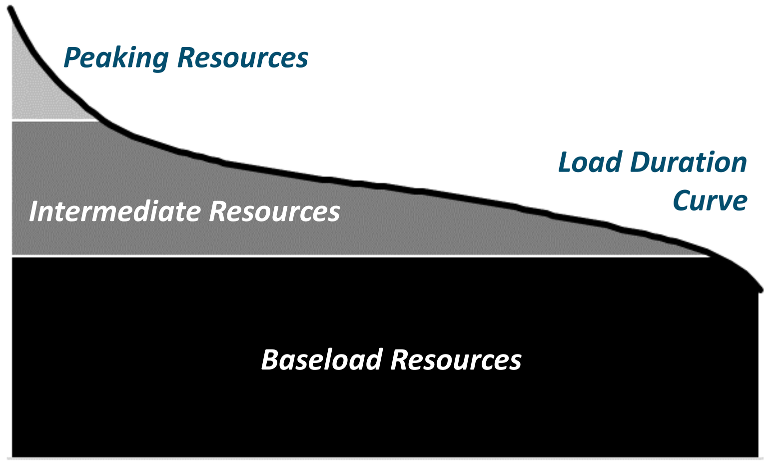
Use optimization to identify least-cost resource portfolios



Generating a cost-optimal resource plan that includes variable renewables and storage requires time-sequential optimization

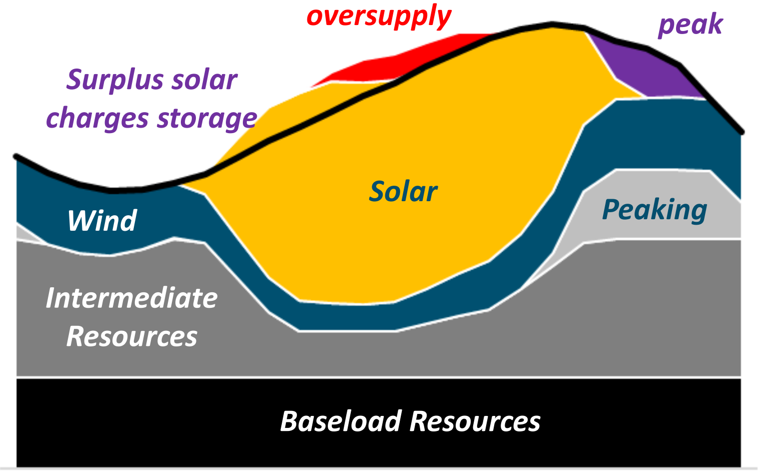
Traditional Planning: Hand-Picked Portfolios

+ **Heuristic approaches provide a reasonable means of evaluating resource needs and investment options**
  - Tradeoff between capital-intensive resources with low operating costs and low capital resources with high operating costs



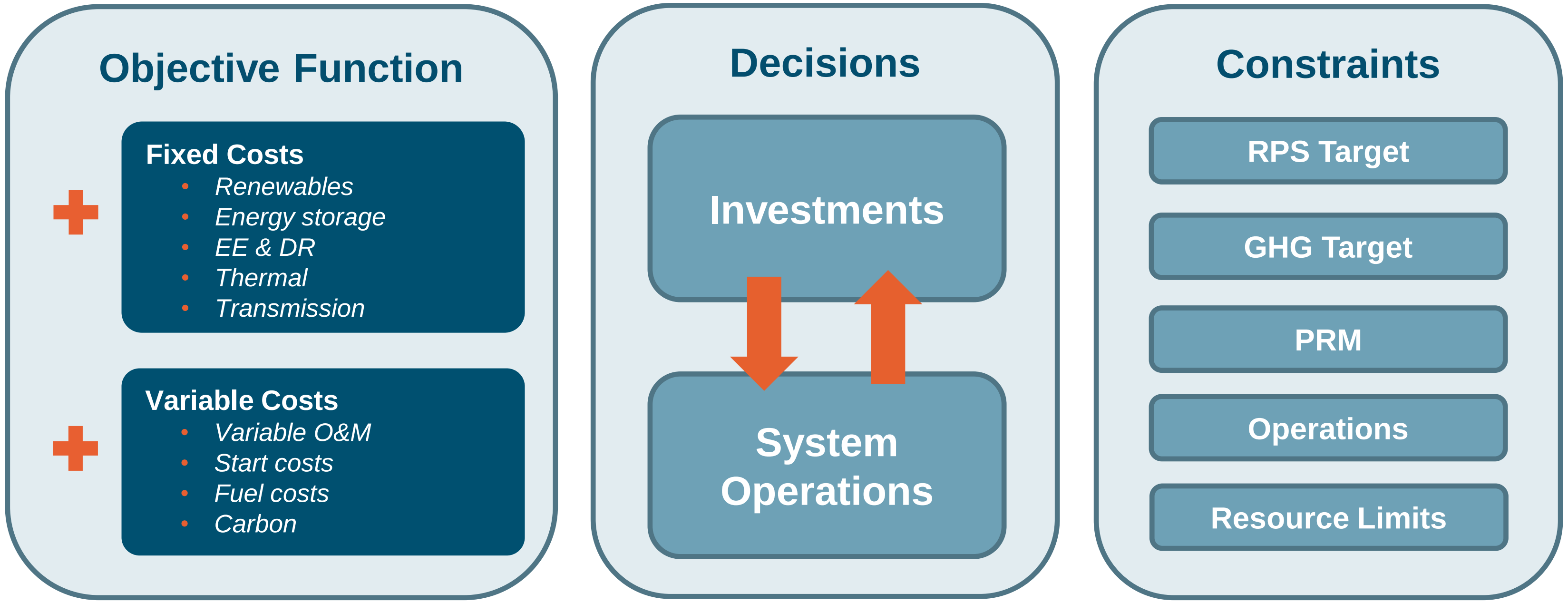
21st Century Planning: Optimized Portfolios

+ **Understanding system dispatch at hourly & sub-hourly timescales becomes necessary to evaluate investments**
  - Chronological simulation needed to capture constraints on operational flexibility

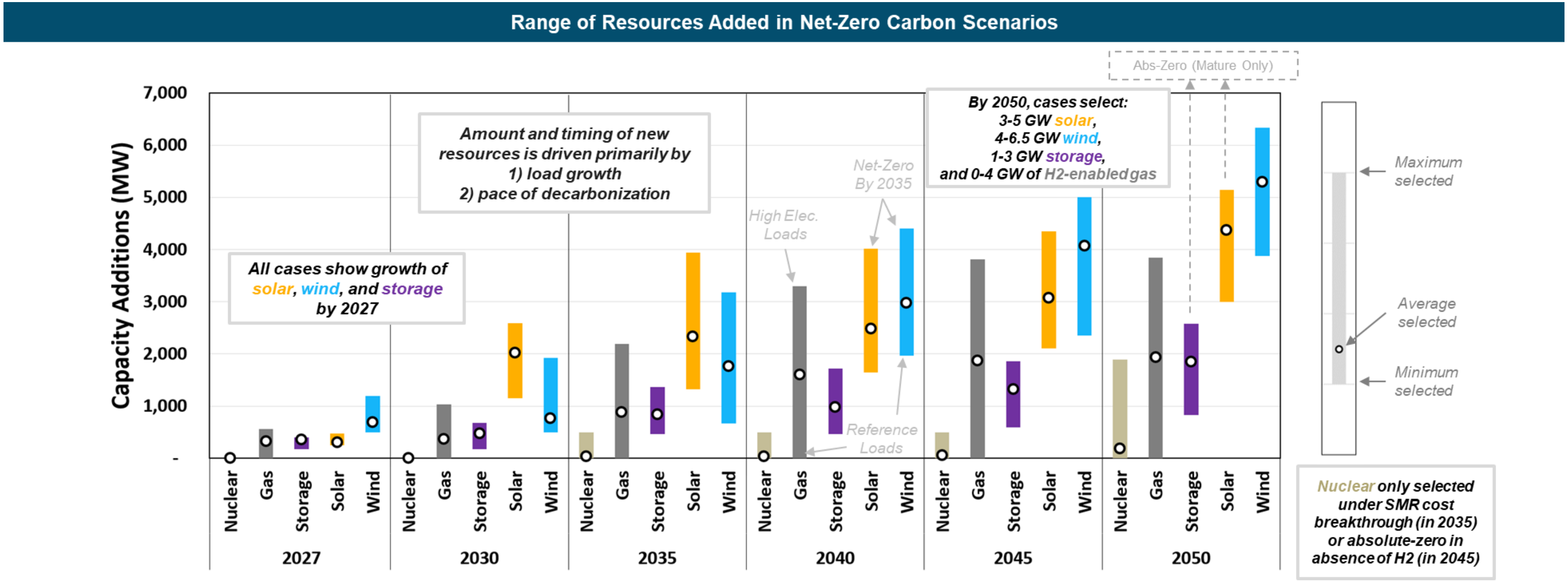


Investment and Operational Decisions in E3's RESOLVE Model

+ **RESOLVE co-optimizes investments and operations to find the portfolio that minimizes electric system costs over time**
  - Detailed simulation of system operations in sample years
  - Model invests in new resources to meet growing load, replace retiring resources, satisfy policy requirements, meet operational needs, and minimize fuel costs



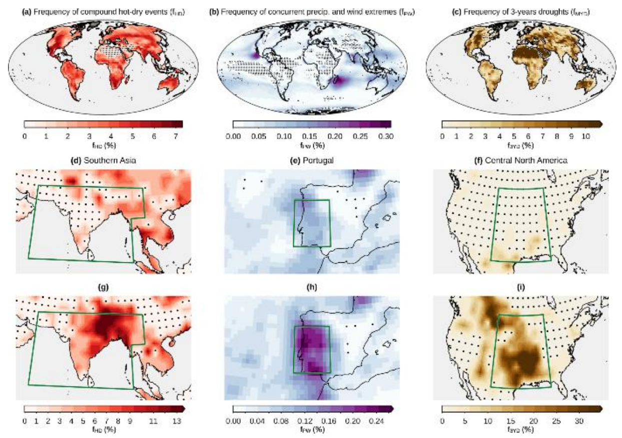
Using a capacity expansion model helps make informed decisions across a range of possible futures



- Capacity expansion modeling is akin to a reliable resource with a high upfront capital cost but low operational expenses
- Once setup for a system, it can be used to conduct many sensitivity runs that can help make “no-regret” decisions accounting for future uncertainty in resource costs, load growth, policies, etc.
- Hand-building and tuning portfolios across many sensitivities will not be feasible

IRP best practices 3/6:

Consider reliability and resiliency during high impact, low frequency events



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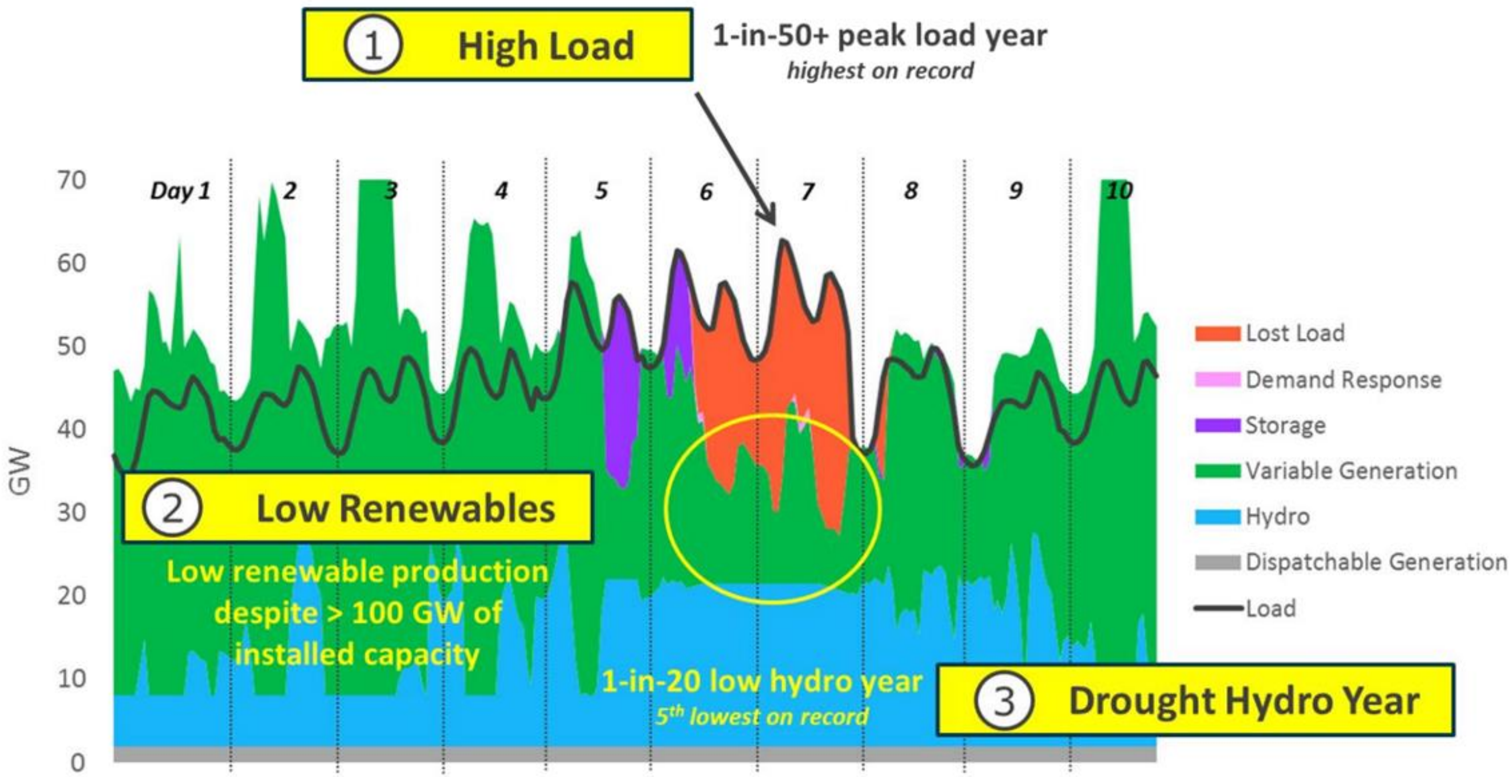
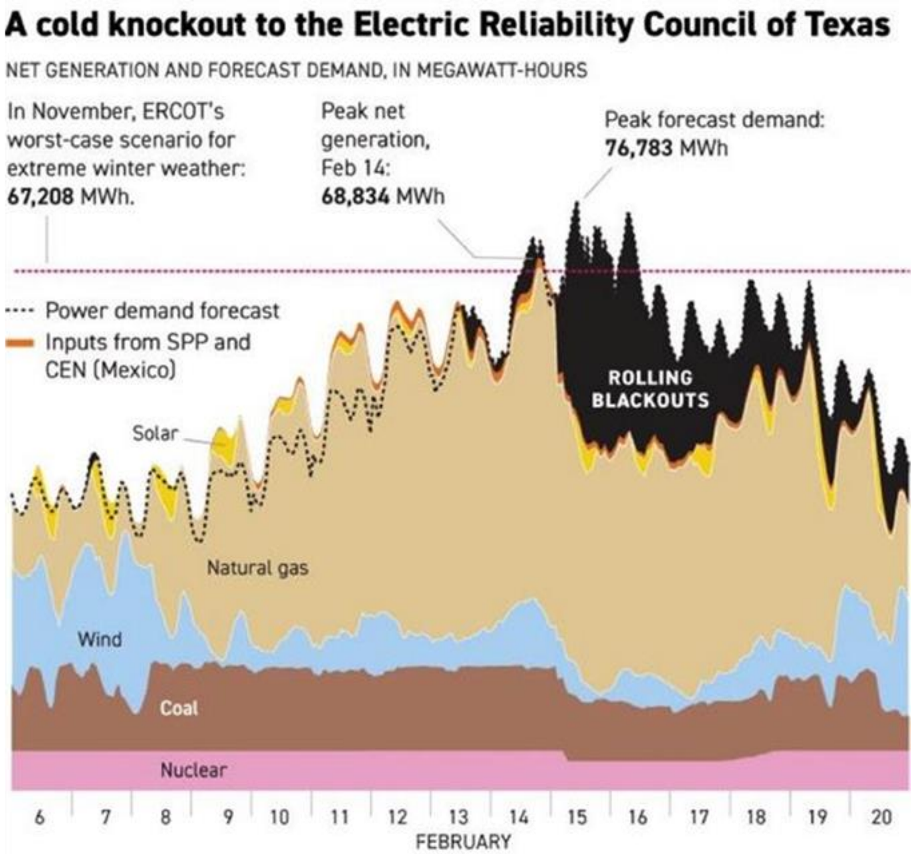
Loss-of-load events are costly and can lead to loss of life

- All resources have challenges with availability during extreme weather events
- A *diverse portfolio* of resources is likely to provide the best performance



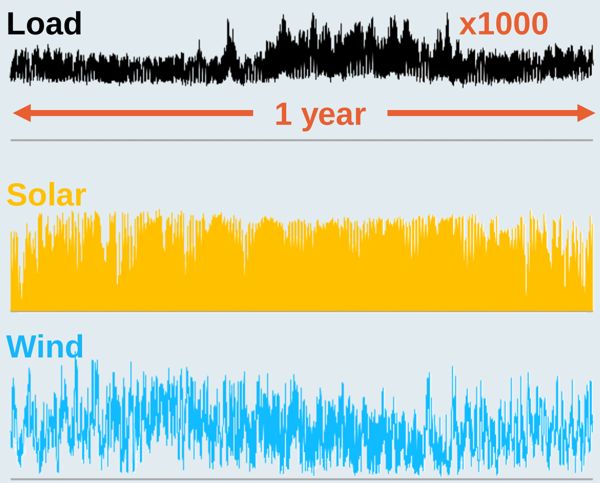


Best practice for determining capacity needs is using Loss-of-Load Probability (LOLP) Modeling

+ LOLP modeling can be thought of as an organized way to analyze the potential for extreme weather and other events to cause a supply shortfall

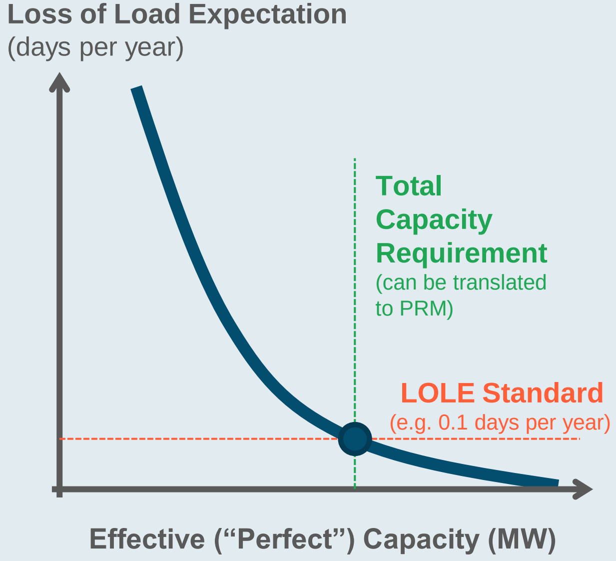
Develop a representation of the loads and resources of an electric system in a loss of load probability model

LOLP modeling allows a utility to evaluate resource adequacy across all hours of the year under a broad range of weather conditions, producing statistical measures of the risk of loss of load



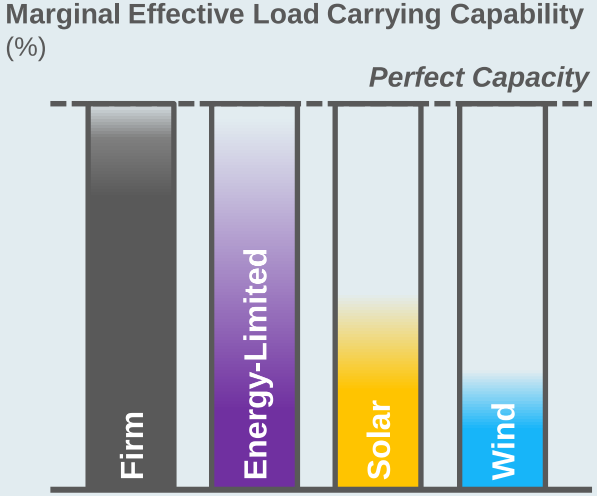
Identify the amount of perfect capacity needed to achieve the desired level of reliability

Factors that impact the amount of perfect capacity needed include load & weather variability, operating reserve needs



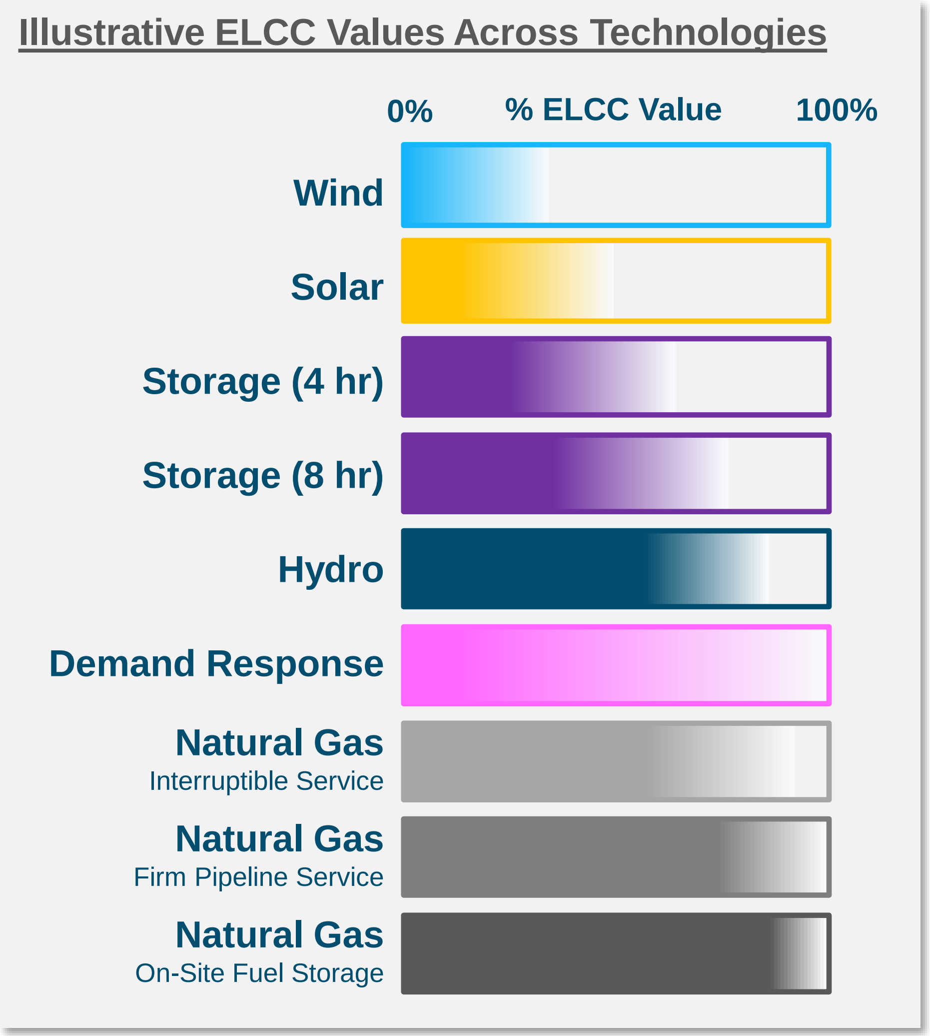
Calculate capacity contributions of different resources using effective load carrying capability

ELCC measures a resource's contribution to the system's needs relative to perfect capacity, accounting for its limitations and constraints

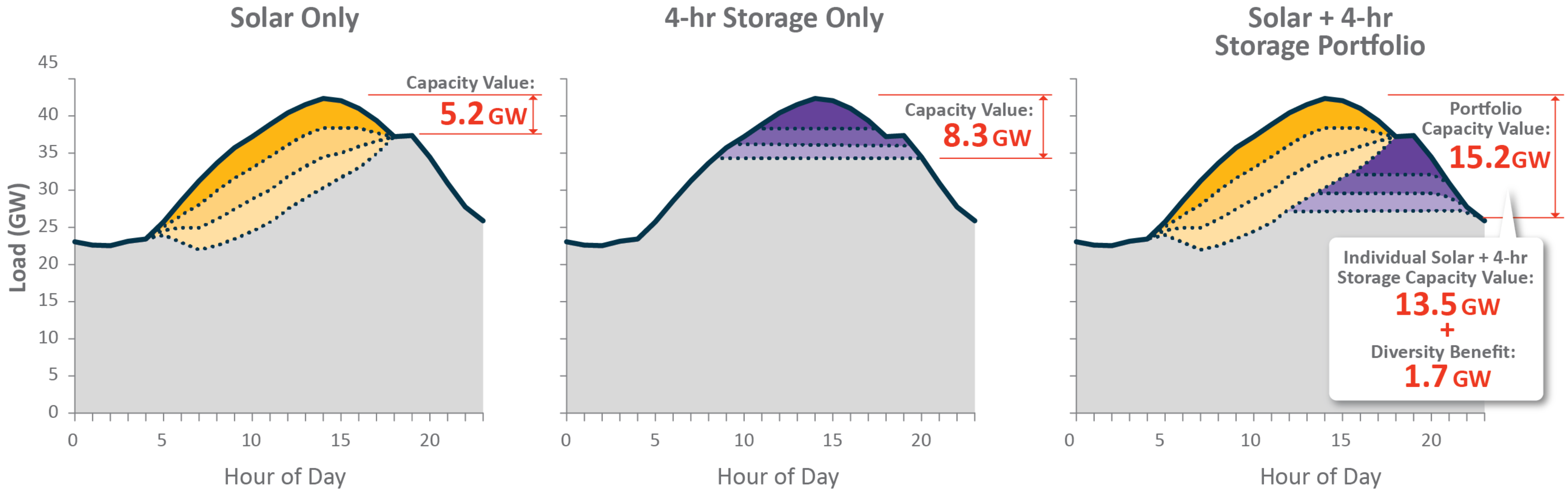


No Resource is "Perfect" – Account for Limitations Across All Technologies on an Apples-to-Apples Basis

- **Availability during loss-of-load hours (marginal ELCC) creates level playing field by measuring all resources against perfect capacity**
- **Can account for all factors that can limit availability:**
  - Hourly variability in output
  - Duration and/or use limitations
  - Seasonal temperature derates
  - Energy availability
  - Fuel availability
  - Temperature-related outage rates
  - Correlated outage risk, *especially under extreme conditions*



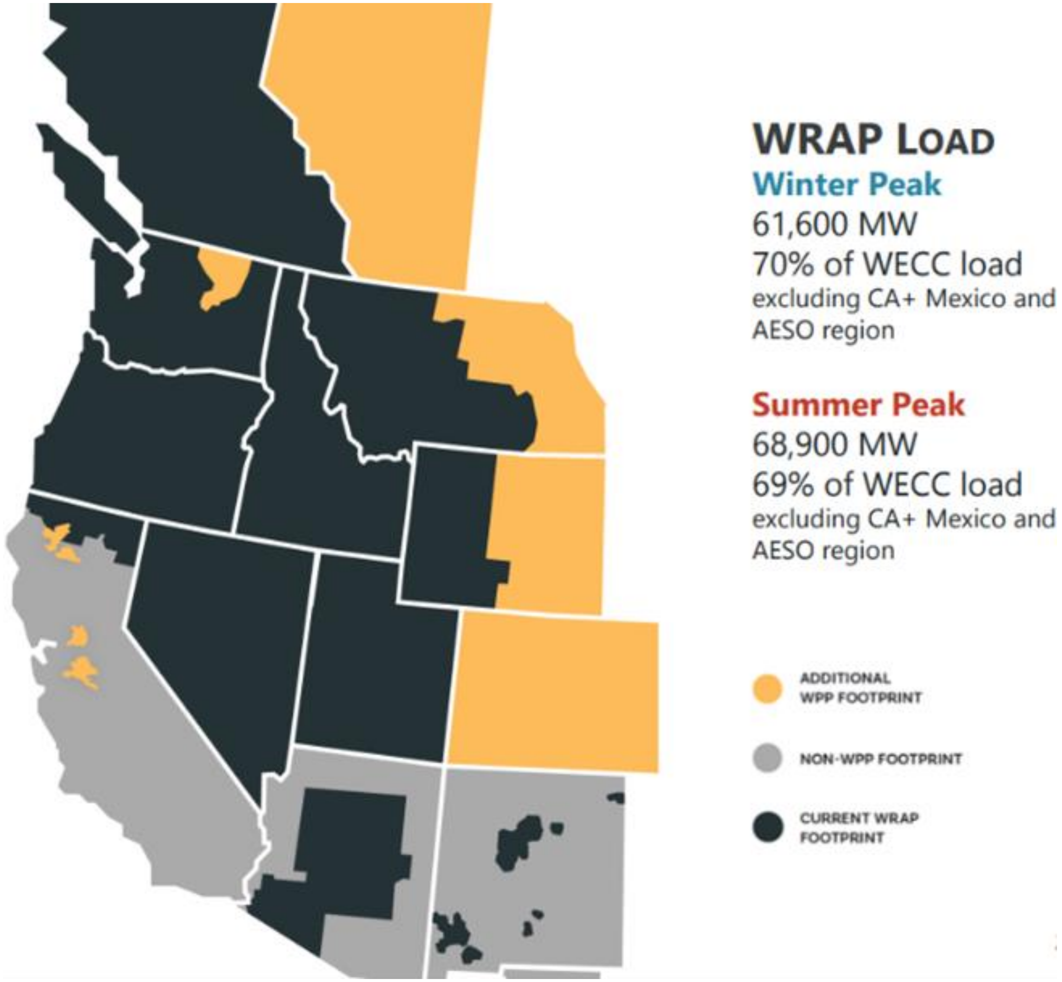
Capacity contributions calculated must account for resource interactions



+ **A resource interacts with itself, which leads to diminishing returns as more of the same resource is added**
+ **Interaction between different resource types can be either positive or negative**
  - For example, solar + storage can bring more value than either can by itself
  - Storage and Demand Response offer similar "energy shifting" services. Less incremental value is gained from the 2nd of the two resources to be added

Western Resource Adequacy Program will establish system need and rules for capacity accreditation

- **WRAP is a regional reliability planning and compliance program**
- **Regionwide planning can help make the most of load and resource diversity of participants and yield more cost-effective outcomes**
- **However, WRAP participants must meet WRAP's requirements**
  - Their reliability standard will need to be at least as stringent as that set by WRAP
  - Sufficient resource capacity will need to be built or contracted with to meet WRAP's forward showing requirements
  - The capacity value of these resources will also be determined by WRAP

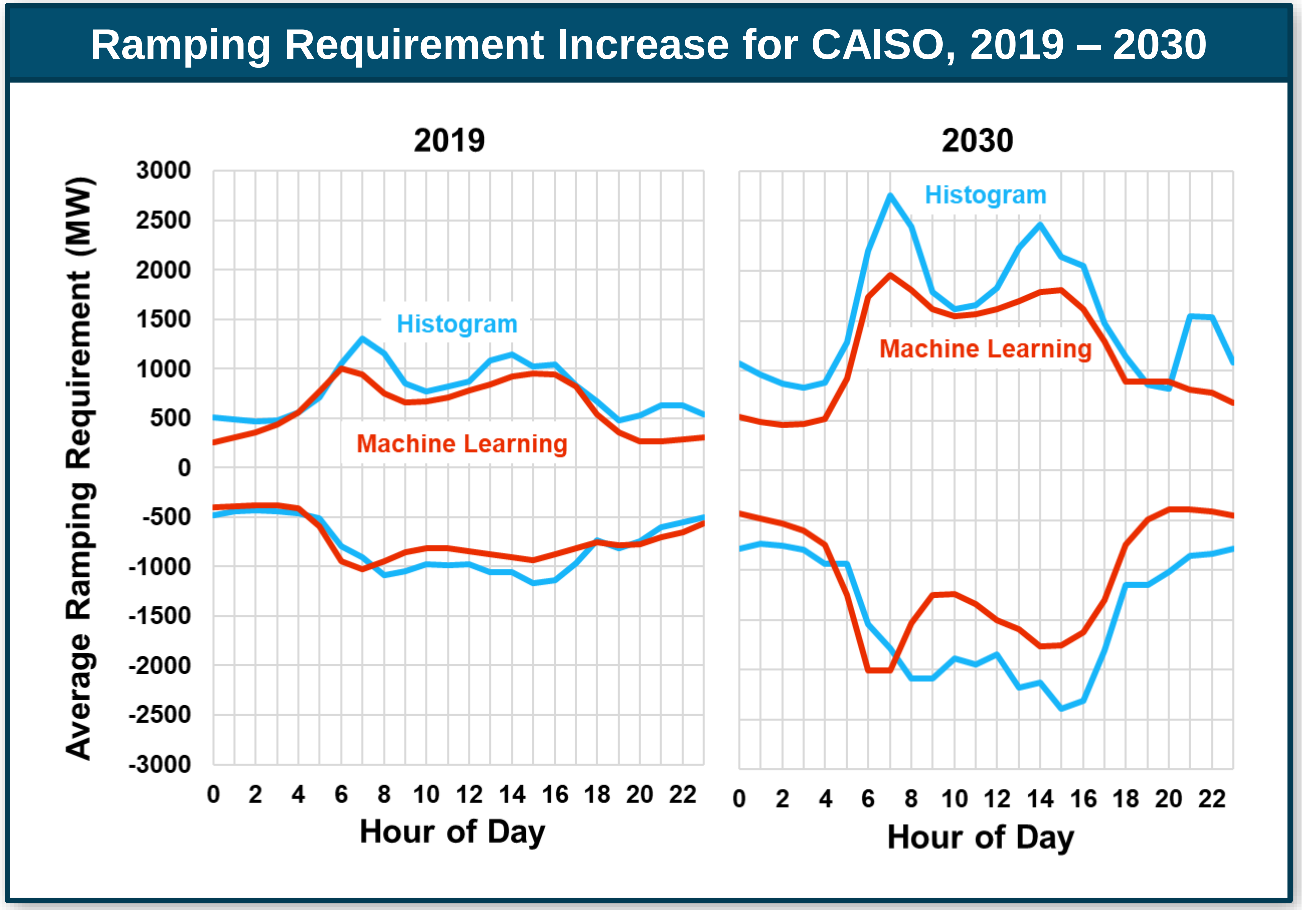


IRP best practices 4/6:

Operational studies needed to determine operating reserve needs and characteristics

Need for grid services will grow with higher penetrations of wind and solar generation

- Grid operators have always balanced variability and uncertainty in demand and supply using ancillary services
- The need for grid services will grow as wind and solar increase due to increased variability and forecast errors
- The need for grid services will also become more dynamic as grid conditions change with the weather



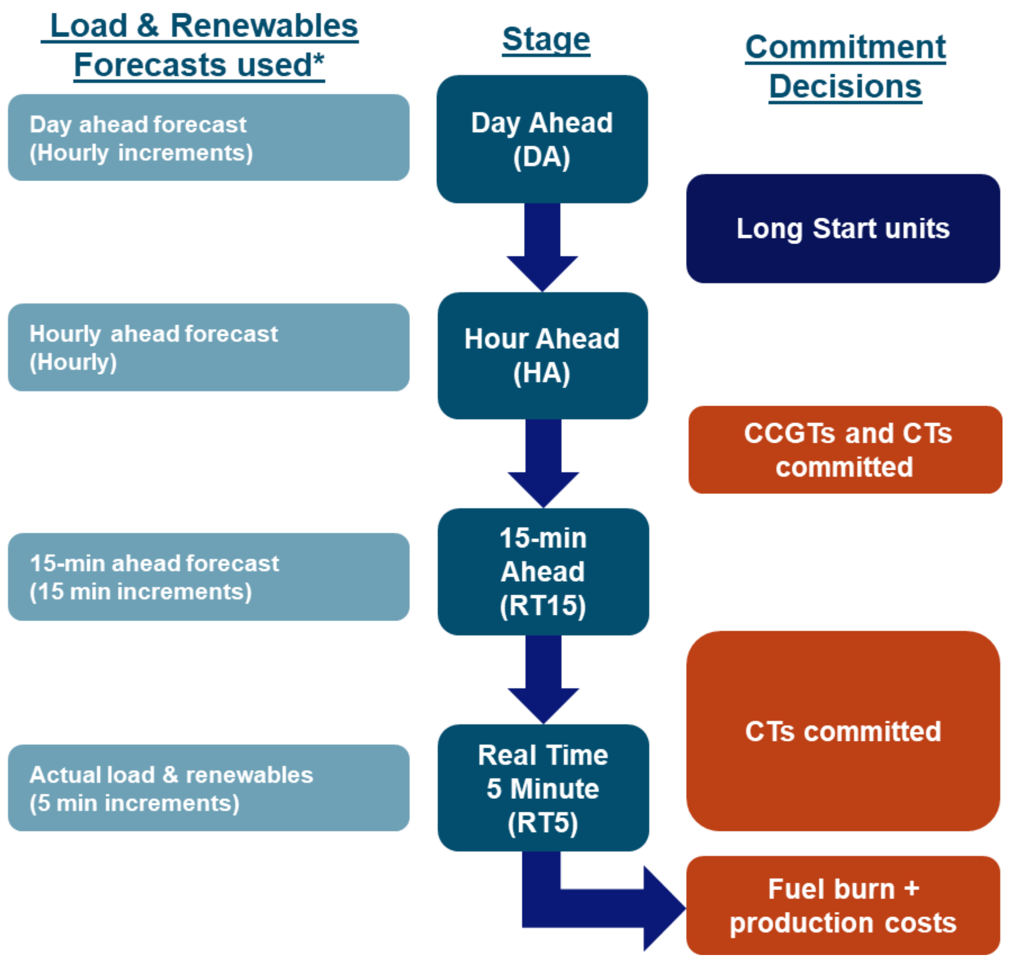
arpa·e CHANGING WHAT'S POSSIBLE

Source: E3, Predicting Reserve Needs Using Machine Learning, project partially funded with grant from ARPA-E

Variable resources such as wind and solar create operational challenges that must be understood and addressed

+ **Detailed operational reliability studies can evaluate the cost of variability and uncertainty as well as the value of various solutions**
    - Detailed characterization of system reserve and flexibility needs as well as resource operational characteristics
+ **Solutions to flexibility challenges should also be evaluated**
    - Battery storage
    - Flexible natural gas generation
    - Wind and solar dispatch

Multi-stage production simulation model



*Subject to data availability

Interaction of capacity expansion and operability and reliability models

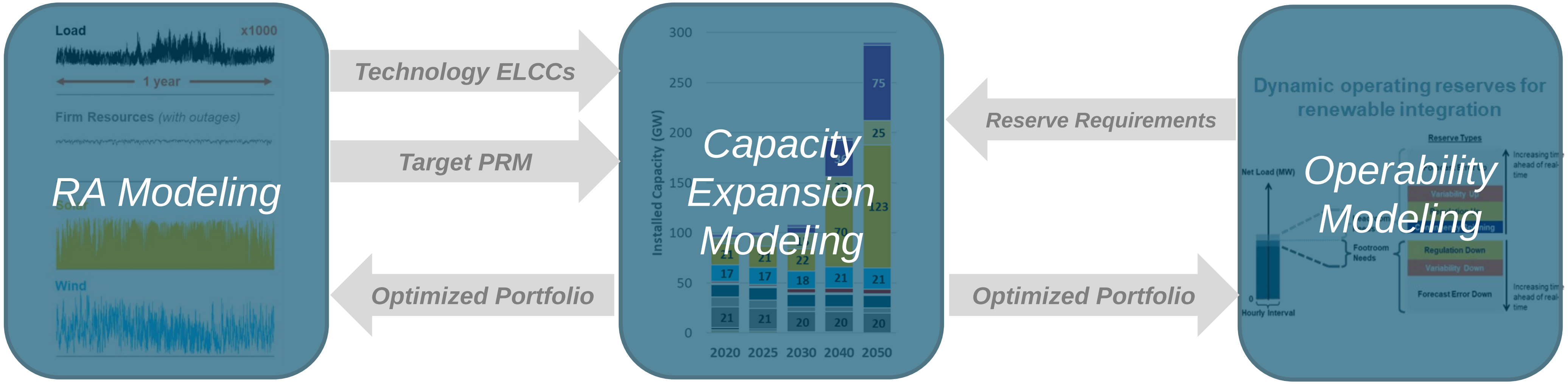
+ Operational and reliability constraints can be setup in a capacity expansion model. These constraints are-

- Parameterized using outputs from separate operability and reliability studies
- Ensure that the capacity expansion problem can stay tractable while still ensuring that the resource portfolio selected is flexible and reliable

1 Use RA model to quantify effective capacity need and contribution from resources by simulating many weather years

3 Use capacity expansion to optimize future portfolios to meet RA, operability and clean energy goals while minimizing cost

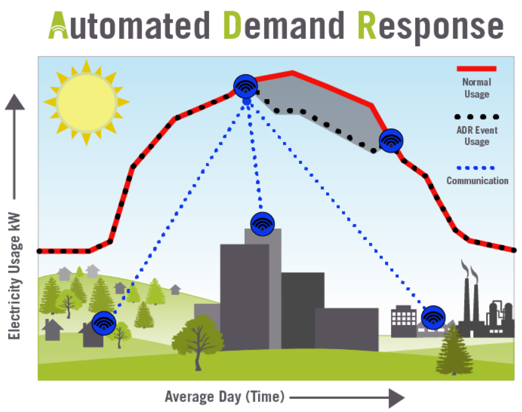
2 Use operability study to identify reserve requirements and parameterize other operational constraints



4a Use RA model to simulate resulting portfolios across wide range of conditions, validating resource adequacy

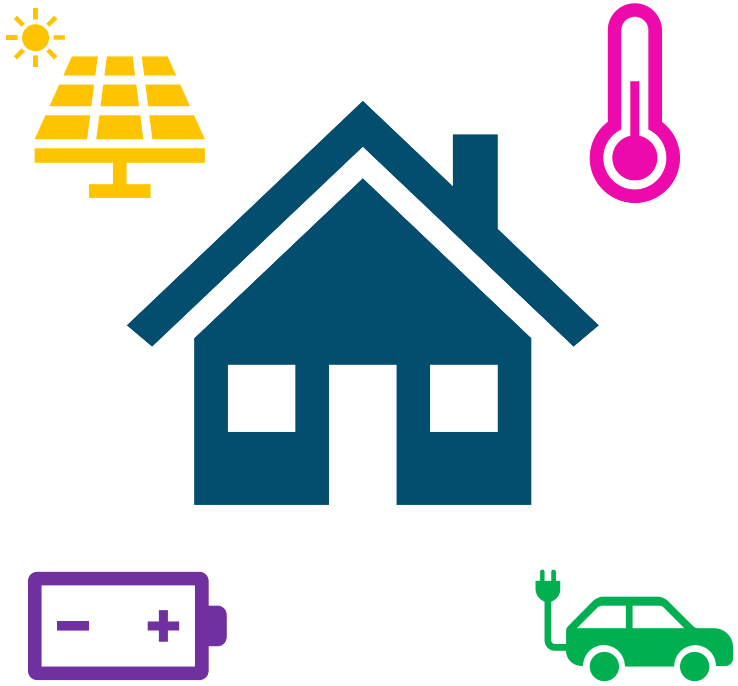
4b Use model to simulate resulting portfolios, validating operability

IRP best practices 5/6:
Include demand-side resources in planning process

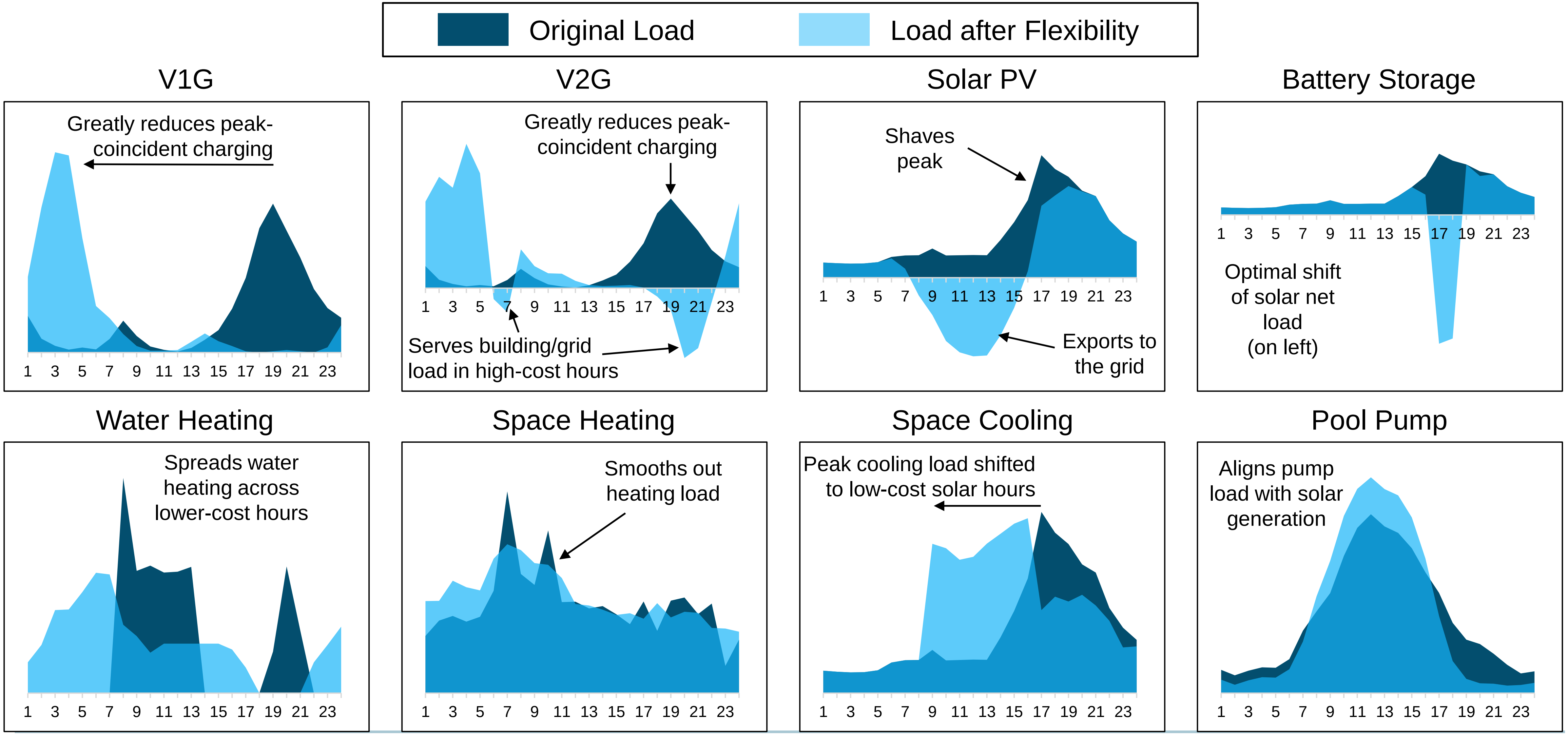


Overview

+ **Historically, demand has been assumed to be passive and something to be satisfied with "supply-side" resources**
+ **Technology advancement is enhancing the role demand-side resources may play in the future resource mix**
+ **Examples of demand side resources include:**
  - Energy efficient appliances
  - Insulation and building shell measures can increase comfort
  - Distributed resources such as solar and battery storage
  - Demand response from smart EV charging and thermostats, etc.
+ **Optimal portfolio will include a mix of both supply and demand side resources**
  - Be mindful of cost shifting among customers when developing compensation mechanisms for demand side measures

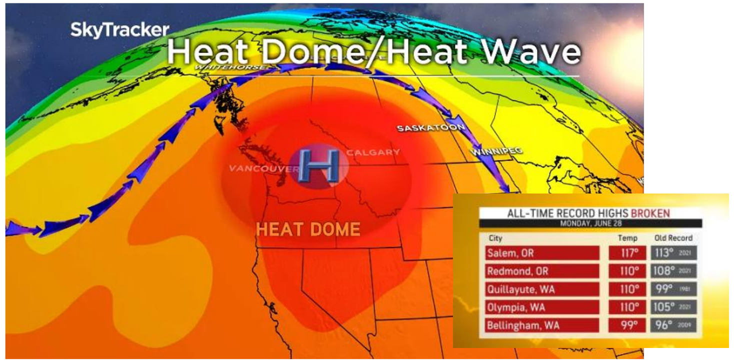


Load flexibility can help maintain reliability and reduce need for peaking capacity



Example load shapes before and after flexibility (subject to system signals & device constraints)

IRP best practices 6/6:
Incorporate climate policy and climate change impacts

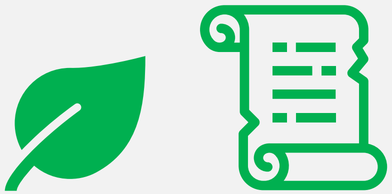


Climate change adds physical risk. Impact of climate policies also adds risks that both need to be anticipated and planned for

Physical Risks

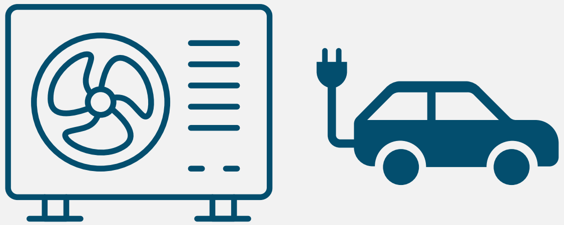
- IRPs should explicitly consider climate-induced changes in hourly load shapes, particularly during extreme hot or cold weather events
- IRPs should also consider other physical risks such as higher forced outage rates and damage to assets due to high winds during storms, wildfires, sea level rise, etc.

Direct Carbon Policy Risks



- Climate policy will increasingly favor lower-emitting generators such as wind, solar, or nuclear relative to higher emitting resources such as coal or natural gas
- Every utility that owns or plans to own fossil resources faces significant regulatory risk related to GHG emissions that must be considered through an IRP process

Higher Electric Loads

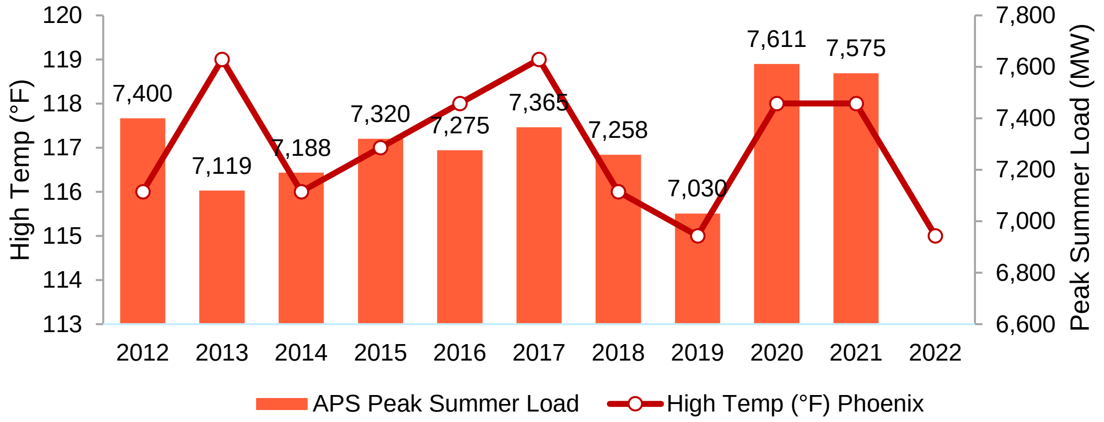


- Climate policy is already resulting in changes in electric load due to proliferation of electric vehicles, heat pumps, and other electrified technologies in many jurisdictions
- Utility IRPs should include an assessment of the potential size, likelihood and timing of new sources of electric load

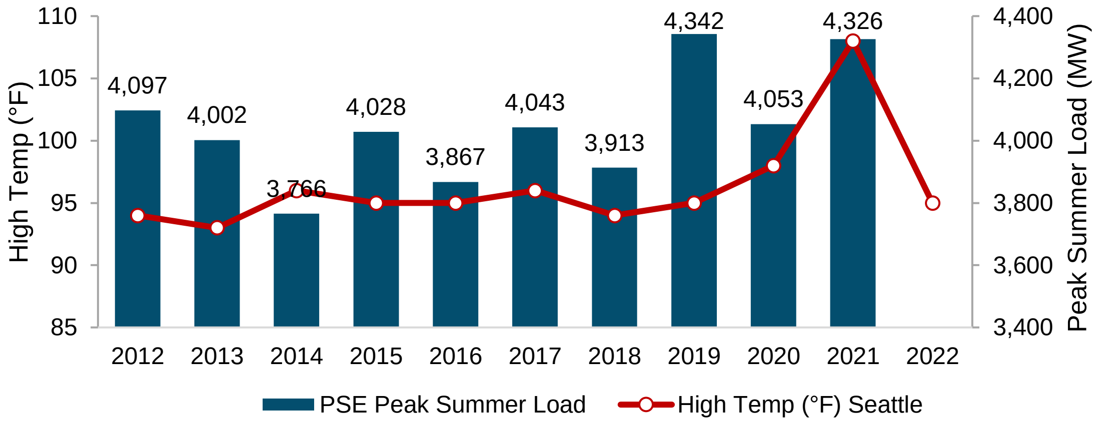
Summer High Temp and Peak Load by Service Territory

Selected WECC Utilities

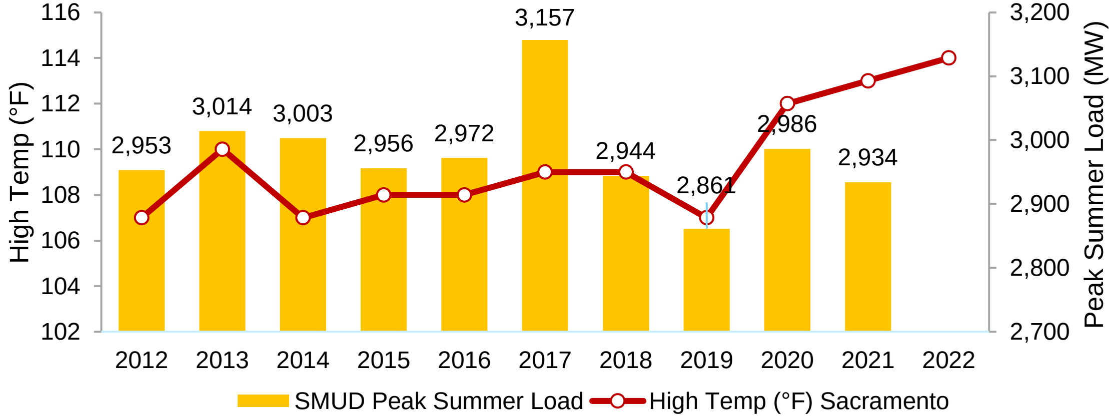
Phoenix (Arizona Public Service)



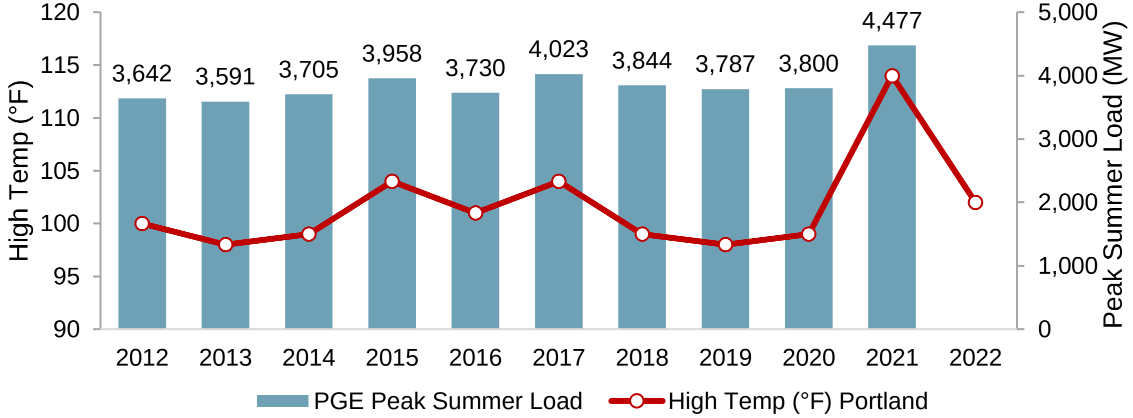
Seattle (Puget Sound Energy)



Sacramento (SMUD)



Portland (Portland General Electric)

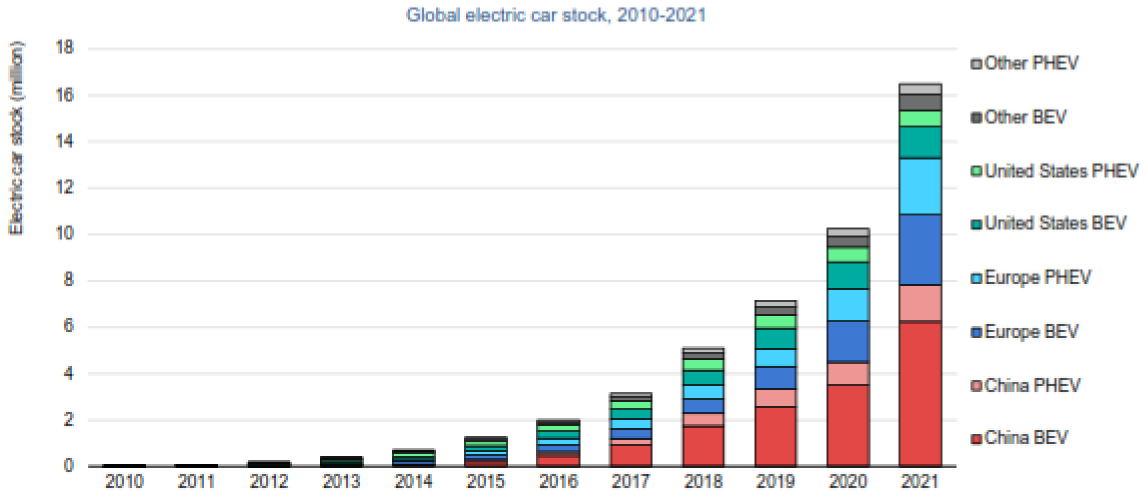


Source: Temperature data: NOAA. Peak load: SNL (S&P Market Intelligence).

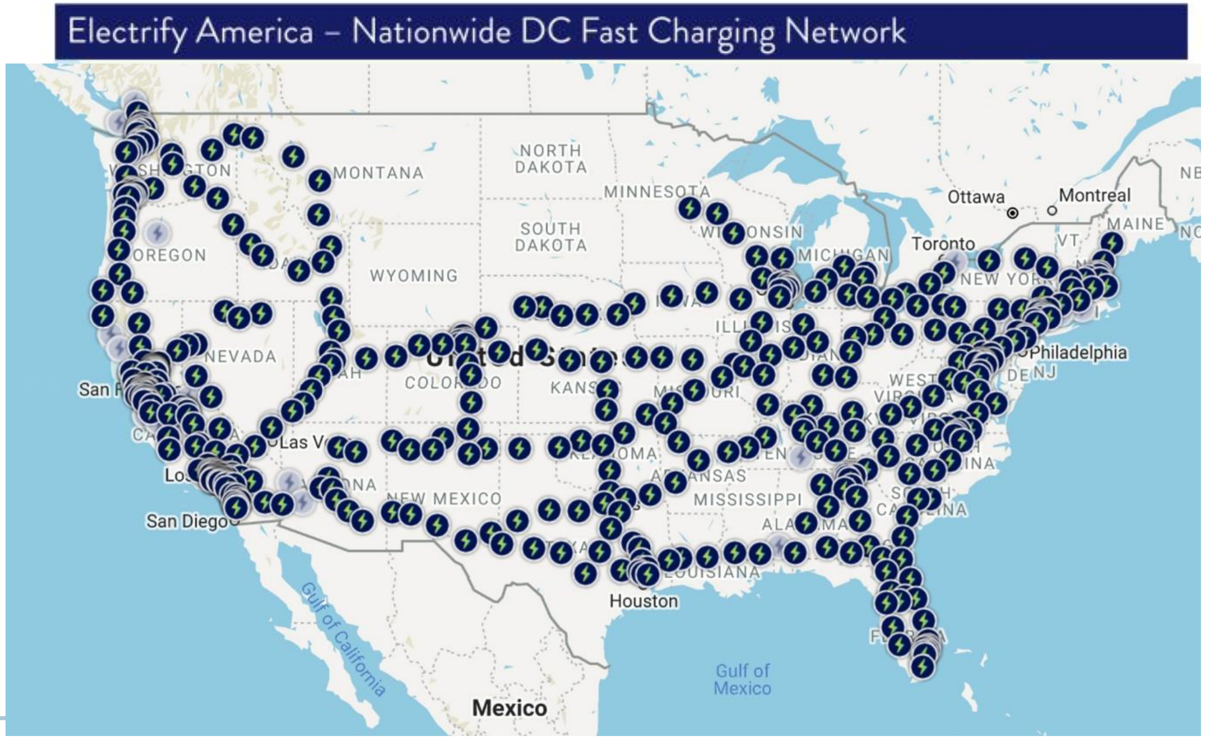
Adoption of light duty electric vehicles is accelerating rapidly

- Vehicle charging load will be become noticeable in the ***NEXT FEW YEARS***
- Initial adoption likely to be concentrated in certain locations creating ***DISTRIBUTION CHALLENGES***
- Utilities will need to be ready for ***SMART CHARGING*** rates, panel installations, charging stations, etc.

Over 16.5 million electric cars were on the road in 2021, a tripling in just three years



Notes: BEV = battery electric vehicle; PHEV = plug-in hybrid electric vehicle. Electric car stock in this figure refers to passenger light-duty vehicles. "Other" includes Australia, Brazil, Canada, Chile, India, Japan, Korea, Malaysia, Mexico, New Zealand, South Africa and Thailand. Europe in this figure includes the EU27, Norway, Iceland, Switzerland and United Kingdom.
Sources: IEA analysis based on country submissions, complemented by ACEA; CAAM; EAFO; EV Volumes; Marklines.



Conclusion

Thank you!

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Energy+Environmental Economics