



Making the Most of Michigan's Energy Future

**MI Power Grid Phase II
Advanced Planning Resource Diversity
February 9, 2021**

**Primary Lead - Naomi Simpson
Assisted by: Pat Hudson, Roger Doherty, Jesse Harlow**



MPSC

Michigan Public Service Commission

Workgroup Instructions

1. This meeting is being recorded
2. Please be sure to mute your lines
3. There will be opportunities for question/comments after each of the sections identified in the agenda
 - Please type questions into the chat function or use the raise hand function during this time
 - We will open it up to those on the phone after those using the chat function
 - We will be requesting comments after all of the meetings which will be posted to the webpage
4. The presentations for all the meetings are posted to the MI Power Grid webpage.

Agenda Items

1:00 p.m.	Introduction	Jesse Harlow (MPSC)
1:10 p.m.	Overview of Staff's Generation Diversity metrics (recap from 1 st meeting)	Zach Heidemann (MPSC)
1:25 p.m.	MISO's Perspective on the Value of Generation Diversity	Marc Keyser (MISO)
1:40 p.m.	Considering Generation Diversity in Planning	Drew Siebenaler & Erin Buchanan (NSP)
2:00 p.m.	Valuing Generation Diversity and Methodology?	Dr. Michael Milligan (Grid Lab)
2:45 p.m.	Break	
2:50 p.m.	Value of Gen Diversity and Risk Assessment	Tom Eckmann (LBNL)
3:35 p.m.	Valuing Biomass	Gary Melow (Michigan Biomass)
3:55 p.m.	Perspectives on Hydro, Landfill Gas, and Waste-to-Energy	Tim Lundgren (IPPC)
4:15 p.m.	Closing	Jesse Harlow (MPSC)
	Adjourn	

Generation Diversity

- MCL460.6t(8)(a) “....the commission shall consider whether the plan (integrated resource plan) appropriately balances all of the following factors.”
 - Resource adequacy
 - Compliance with environmental regulations
 - Competitive pricing
 - Reliability
 - Commodity price risks
 - **Diversity of generation supply**
 - Peak load reduction and EWR are reasonable and cost effective

Generation Diversity

- Statewide Energy Assessment

- Final report posted Sept. 11, 2019 in Docket # U-20464

“While diversity of supply is one consideration in an IRP, there are not currently any methods to quantify the value of diversity, nor are there goals with respect to the diversity of supply.”

“Understanding the value of resource diversity could also better inform power plant retrofitting and retirement decisions beyond traditional net present value and market price comparisons. **The Commission recommends utilities work with Staff and stakeholders to propose a methodology to quantify the value of generation diversity in integrated resource plans.**”



Making the Most of Michigan's Energy Future

Value of Generation Diversity

Zachary Heidemann

February 9, 2021

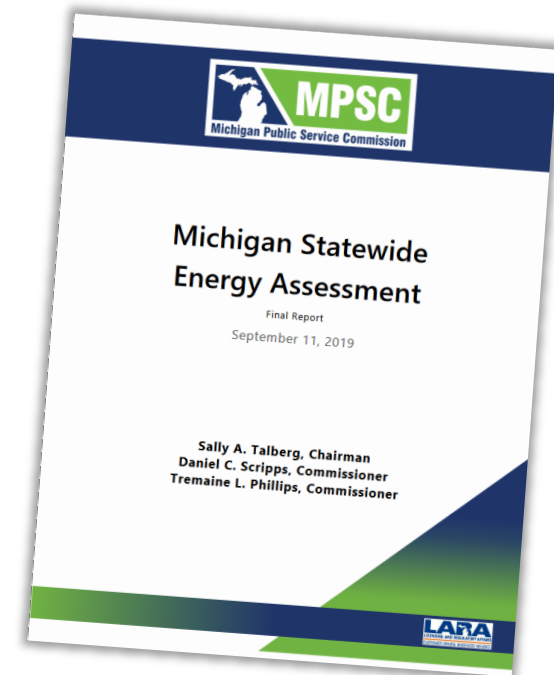


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Case No. U-20633 Order

- Directs the Staff to begin outreach aimed at holding a series of stakeholder sessions, and to research best practices in... Methodologies to quantify and value generation diversity in IRPs.
- The order refers to the Statewide Energy Assessment recommendations



Recommendations from the SEA

The Commission recommends utilities work with Staff and stakeholders to propose a methodology to quantify the value of generation diversity in integrated resource plans.

The changing electric generation fleet in Michigan and the Midwest due to increasing retirements of coal and nuclear plants could lead to reliability and resiliency problems especially if new replacement resources such as energy waste reduction, demand response, and wind and solar energy projects are delayed. Understanding the value of resource diversity could also better inform power plant retrofitting and retirement decisions beyond traditional net present value and market price comparisons.

- The word diversity is used frequently in vernacular
- Is there a more formal analysis that is more conducive to quantification?

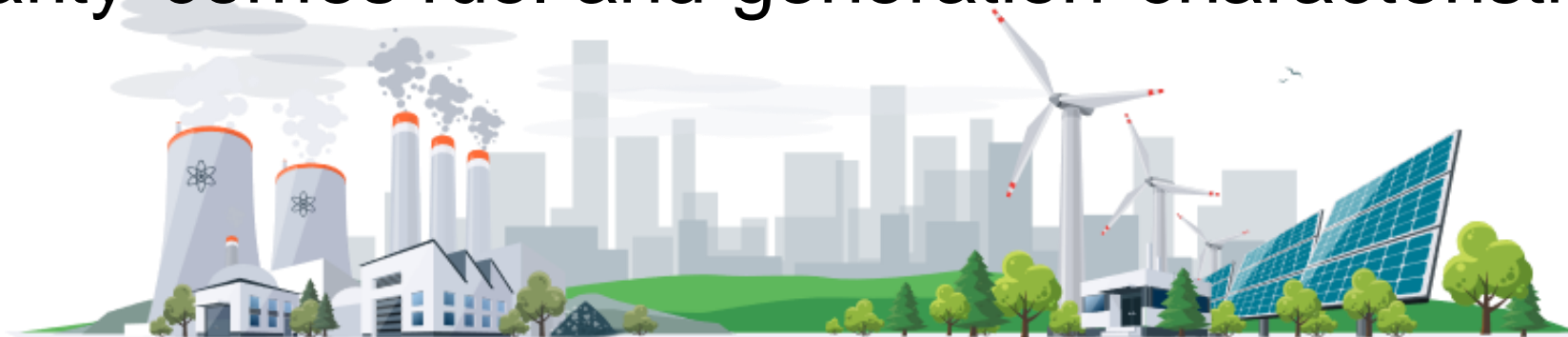
Diversity from an Academic View

- Diversity as a concept appears in many fields
- Diversity has three components⁽¹⁾
 - Variety⁽¹⁾
 - The number of different categories (species, investment type, fuel)
 - Balance⁽¹⁾
 - How evenly spread are the category populations
 - Disparity⁽¹⁾
 - How different are the different categories from one another

Stirling, A. (2007) A General Framework for Analyzing Diversity in Science, Technology and Society. Journal of the Royal Society 707-719.
<https://royalsocietypublishing.org/doi/10.1098/rsif.2007.0213>

Diversity in Generation

- Academic studies usually categorized by fuel
 - Sometimes sub types are considered
- Categorization by fuel allows both the variety and balance of generation to be considered
 - Energy
 - Capacity
- Disparity comes fuel and generation characteristics



Diversity Indices

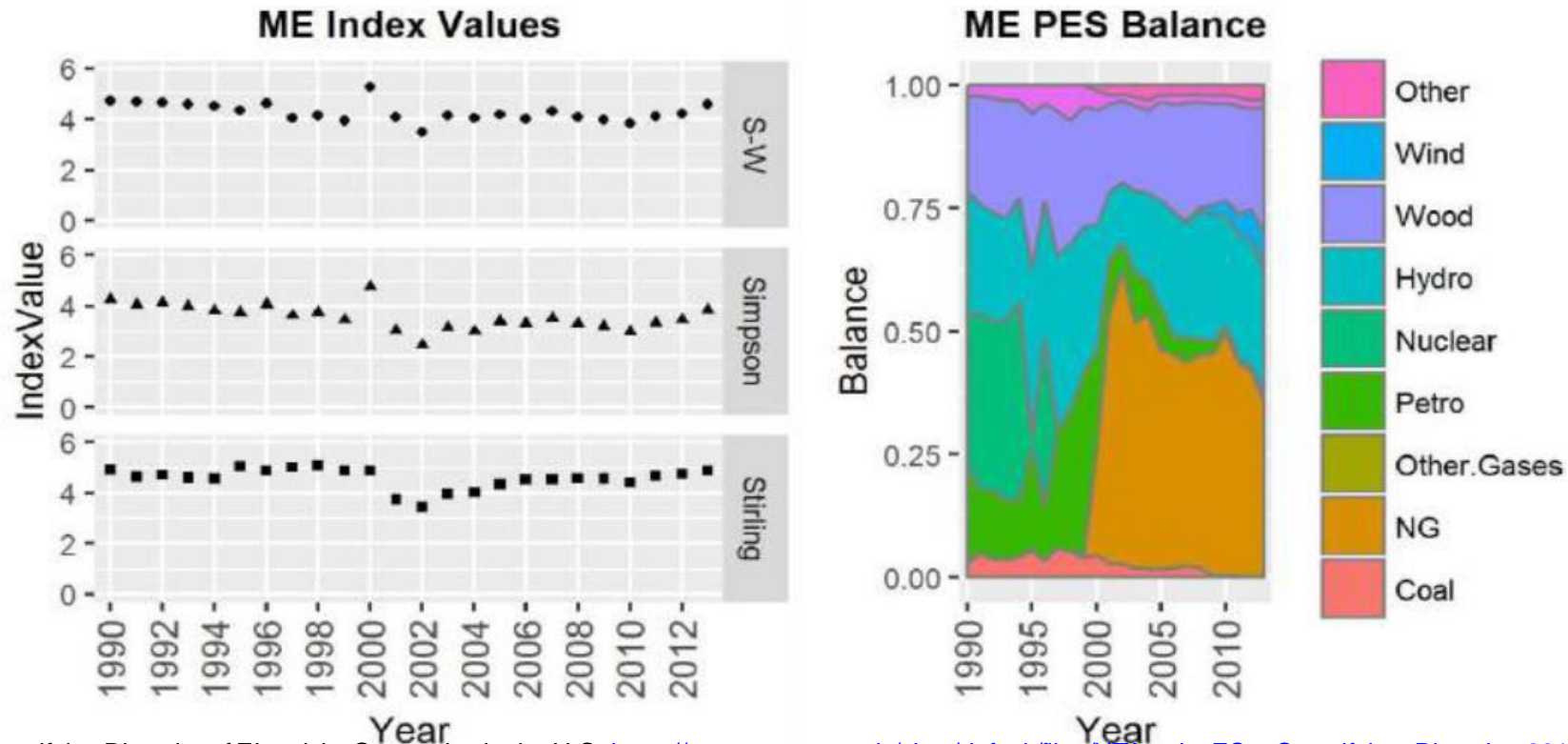
- There are three common indices that are used for electrical generation
- Shannon Wiener Index
 - Considers variety and balance⁽¹⁾
 - Variety more emphasized⁽¹⁾
- Simpson Index
 - Also known as Herfindahl-Hrishman Index (Hhi)
 - Considers variety and balance⁽¹⁾
 - Balance more emphasized⁽¹⁾
- Stirling Index
 - Considers variety, balance and disparity⁽¹⁾
 - More complicated and more open to interoperation⁽¹⁾
- There are other indexes that consider only one component or are more complicated⁽²⁾

(1) Wu T, Rai V. (2017). Quantifying Diversity of Electricity Generation in the U.S. https://energy.utexas.edu/sites/default/files/UTAustin_FCe_Quantifying_Diversity_2018_Feb.pdf

(2) Stirling, A. (2007) A General Framework for Analyzing Diversity in Science, Technology and Society. Journal of the Royal Society 707-719 <https://royalsocietypublishing.org/doi/10.1098/rsif.2007.0213>

The Math Doesn't Care

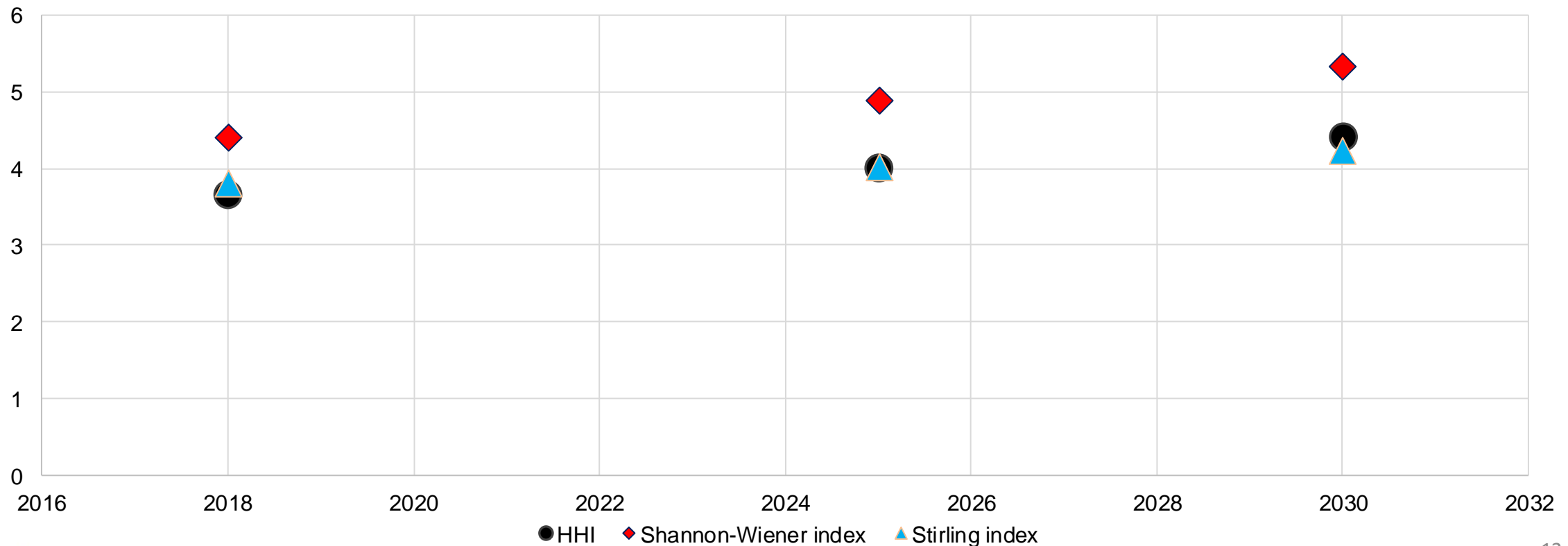
- The diversity indices treats all generation types equally
- Maine is a good example



(1) Wu T, Rai V. (2017). Quantifying Diversity of Electricity Generation in the U.S. https://energy.utexas.edu/sites/default/files/UTAustin_FCe_Quantifying_Diversity_2018_Feb.pdf

Staff's Preliminary Calculations

- Staff applied equations to Michigan as first look
- Using Stirling X30 to have it be of similar scale to other indices⁽¹⁾
- Data taken from IRP's and capacity demonstrations



Diversity \neq Resilience

- For the Sterling index the disparity coefficient (D_{ij}) for utility scale and distributed solar would be small
- They will have different effects on resilience
- Diversity may have effects on resilience
- Resilience has components related to distribution which generation diversity does not contemplate

Considerations in Valuing Diversity

- Diversity reduces risk
 - Diverse ecologies are more robust
- Placing monetary value on associated risk may be difficult
 - Some variables in indices are subjective
 - Options are often prioritized based on desirable traits
 - Coal vs Coal with carbon capture
 - May result in buildout that is not economically optimal
 - May be more societally acceptable



Making the Most of Michigan's Energy Future

Questions?



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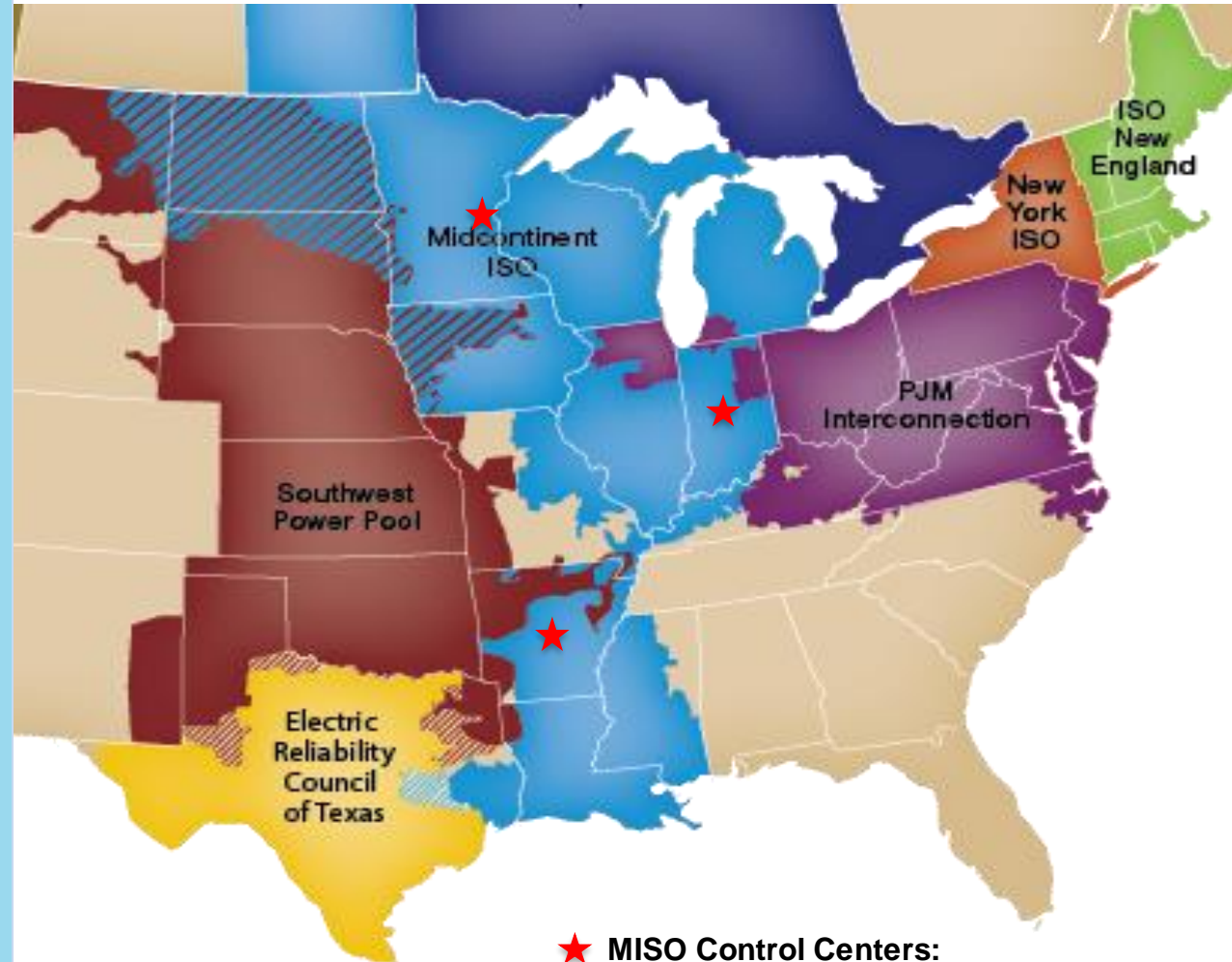
MI Power Grid Advanced Planning

MISO Briefing
February 8th 2021

MISO & neighboring U.S. electric grid operators

MISO

- 15 states + Manitoba
- 42 million customers
- \$30 billion market
- > 6,600 generation units with 175,000 MW capacity
- 68,500 miles of high voltage transmission lines
- > 180 member utilities
- > 460 market participants

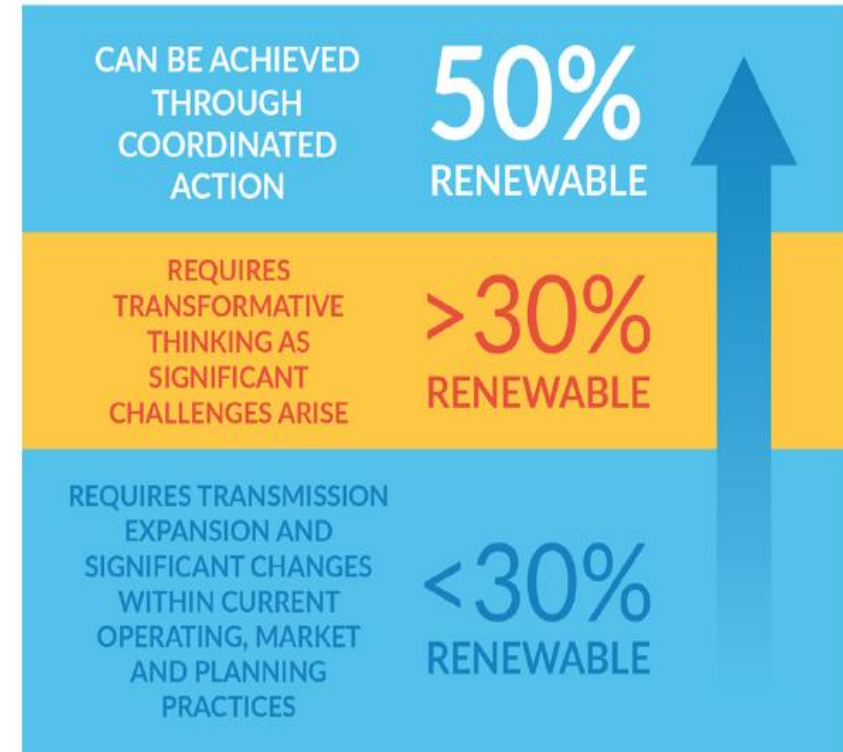


★ MISO Control Centers:
Eagan, Indianapolis (HQ), Little Rock

Growing renewables are driving localized reliability issues now; the Renewable Integration Impact Assessment finds that these challenges will become footprint-wide beyond 30% system-wide renewable penetration

Risk patterns are shifting, and new risks are emerging due to the increasing penetration of wind and solar in the region

- **Stability Risk** requires multiple transmission technologies, operating and market tools to incentivize availability of grid services
- **Shifting periods of grid stress** requires flexibility and innovation in transmission planning processes
- **Shifting periods of energy shortage risk** requires new unit commitment tools, revised resource adequacy mechanisms
- **Shifting flexibility risk** requires market products to incentivize flexible resources
- **Insufficient transmission** requires proactive regional transmission planning

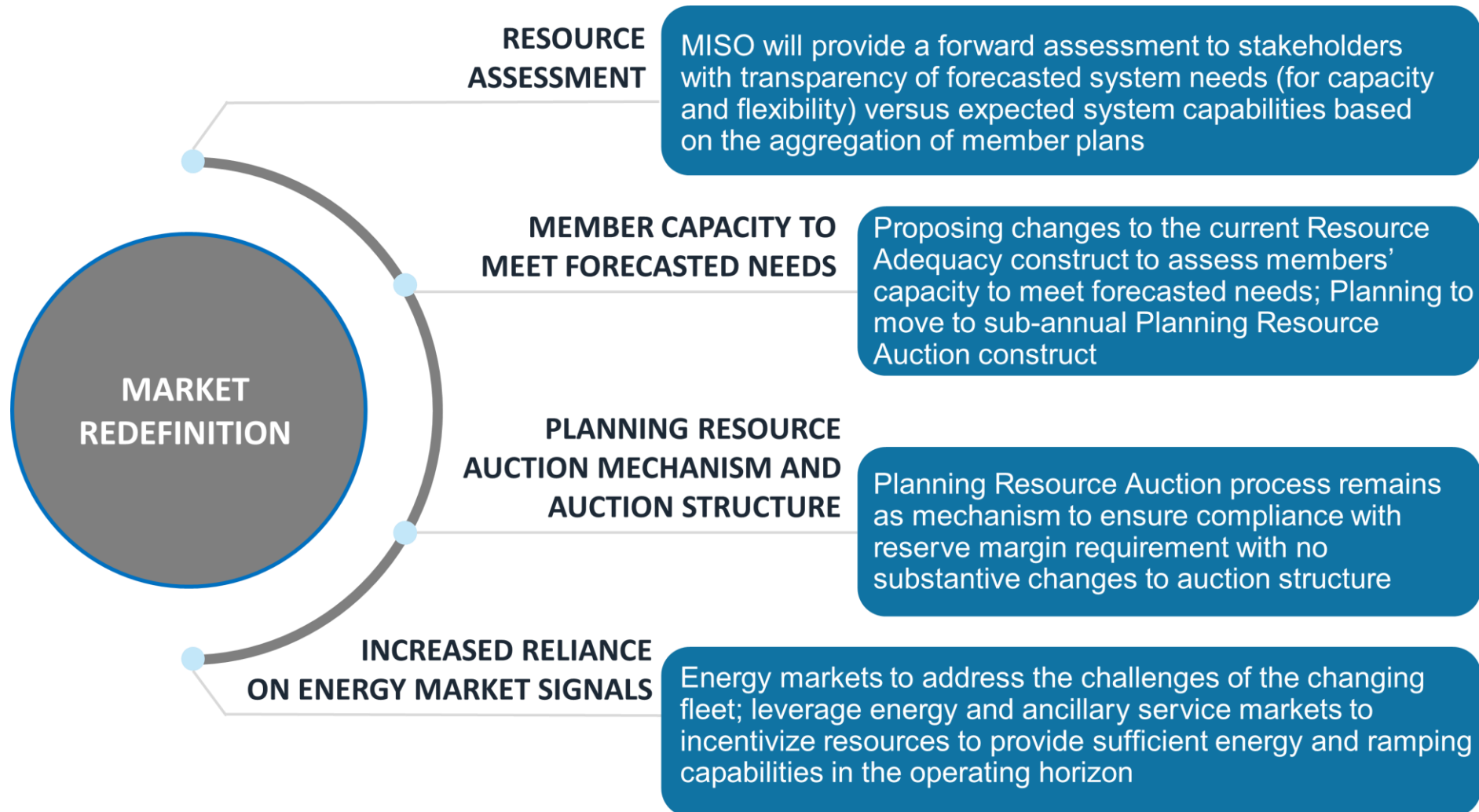


Adaptation within the existing planning, market, and operations constructs will suffice - but only to a point. New and changing risks require new practices to mitigate.

The Reliability Imperative efforts will enable those member / state goals with coordinated enhancements across multiple areas



MISO expects to rely more heavily on increased transparency in the planning horizon coupled with market price signals in the operating horizon to incentivize needed resources





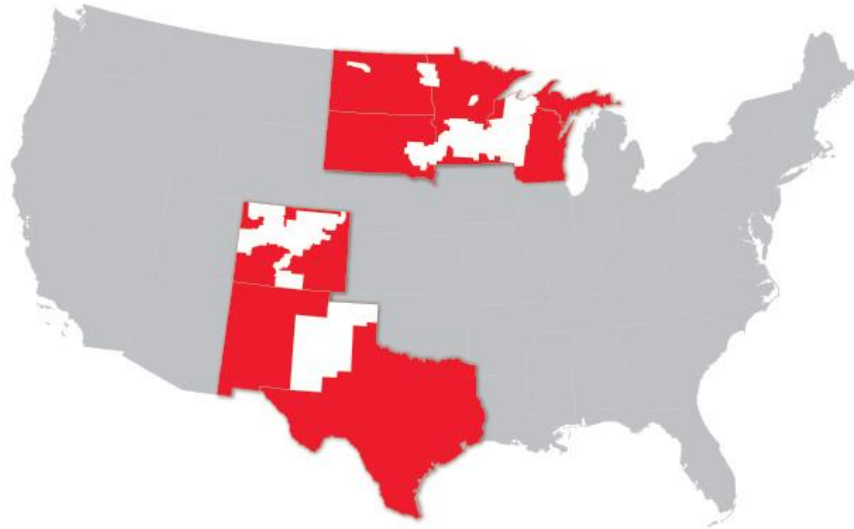
Everything In Moderation: Value of Resource Diversity
Xcel Energy

Presentation to MI Power Grid

February 9, 2021

Intro to Xcel Energy

Xcel Energy serves approximately 3.7 million electric and 2.1 million gas customers in 8 states



- Company-wide commitment to carbon reduction:
 - 80% below 2005 levels by 2030
 - 100% carbon free electricity by 2050

Upper Midwest service area includes ~1.8 million electric customers in five states

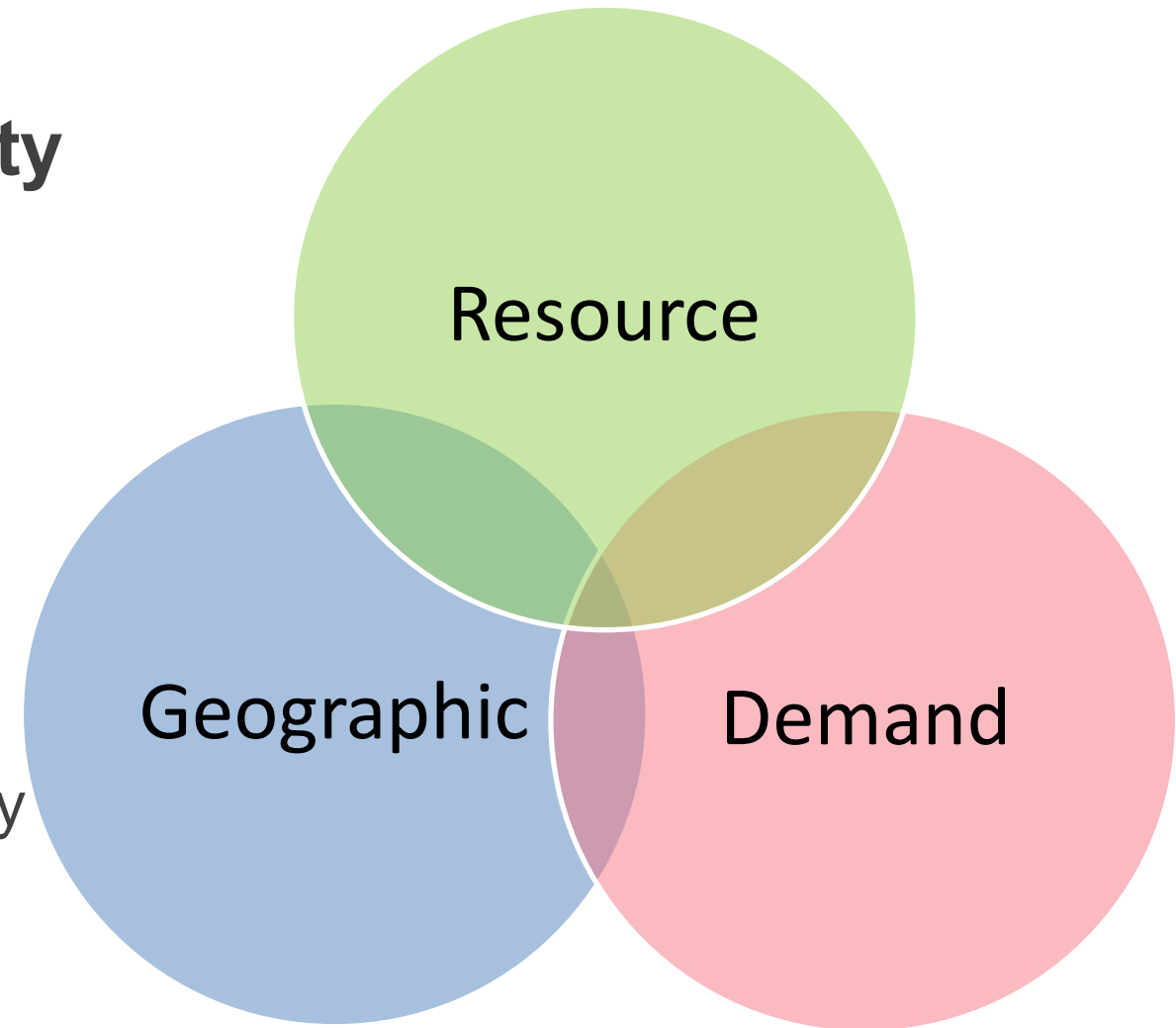


Diversity in Power Systems

Today's Focus: Resource Diversity

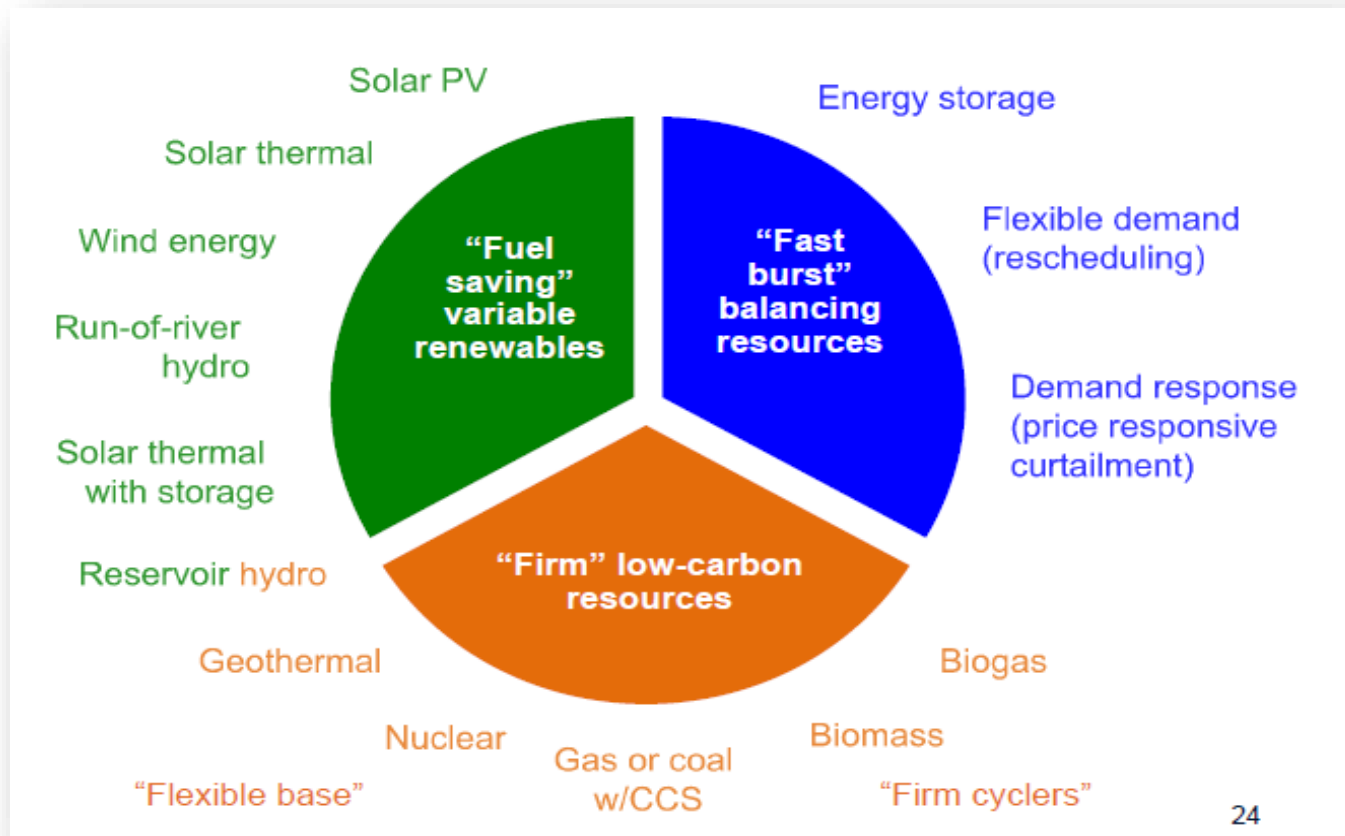
What is the value of a diversified resource fleet?

**Although valuable, diversity in geography and demand will not be covered



Resource Diversity is Key to Ensuring Reliability and to Mitigate Risk

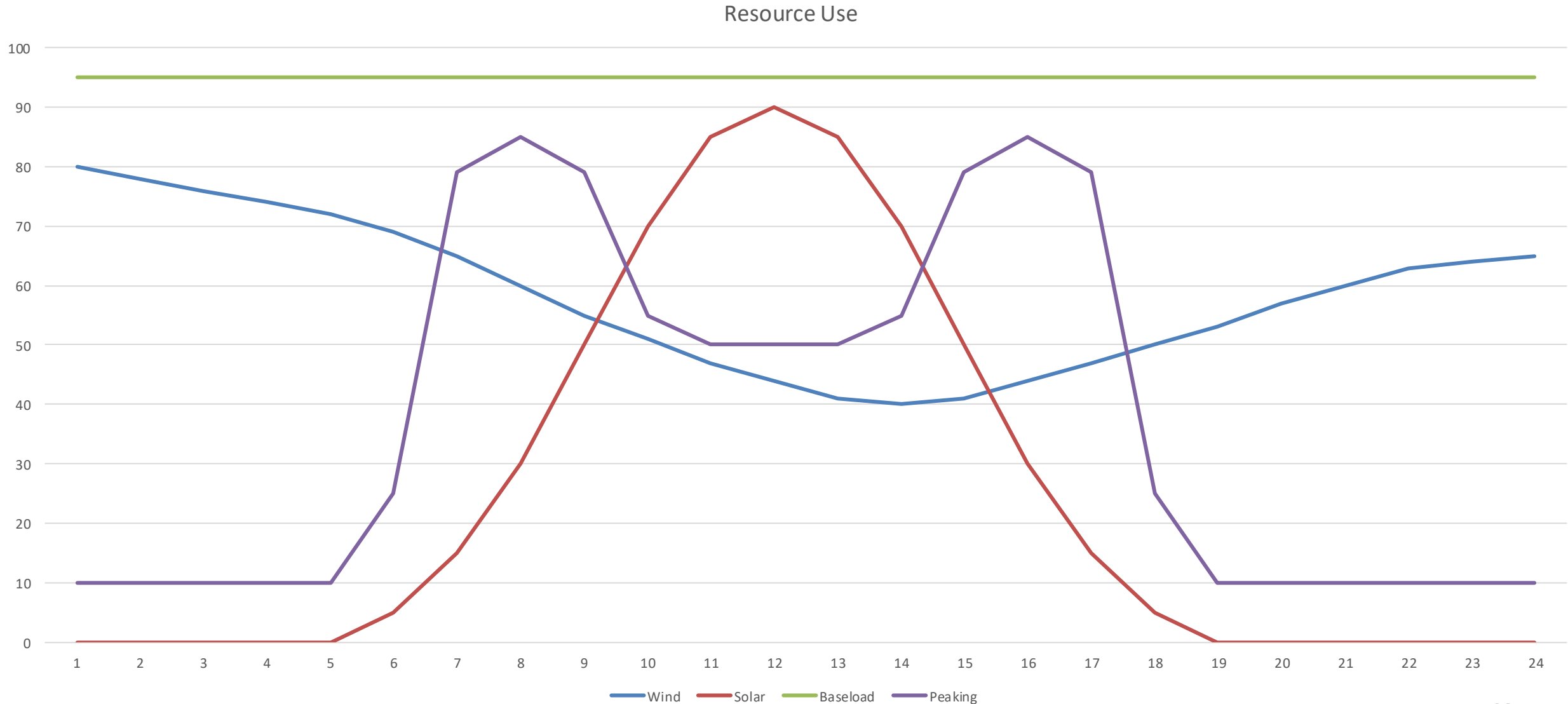
Generation mix building blocks



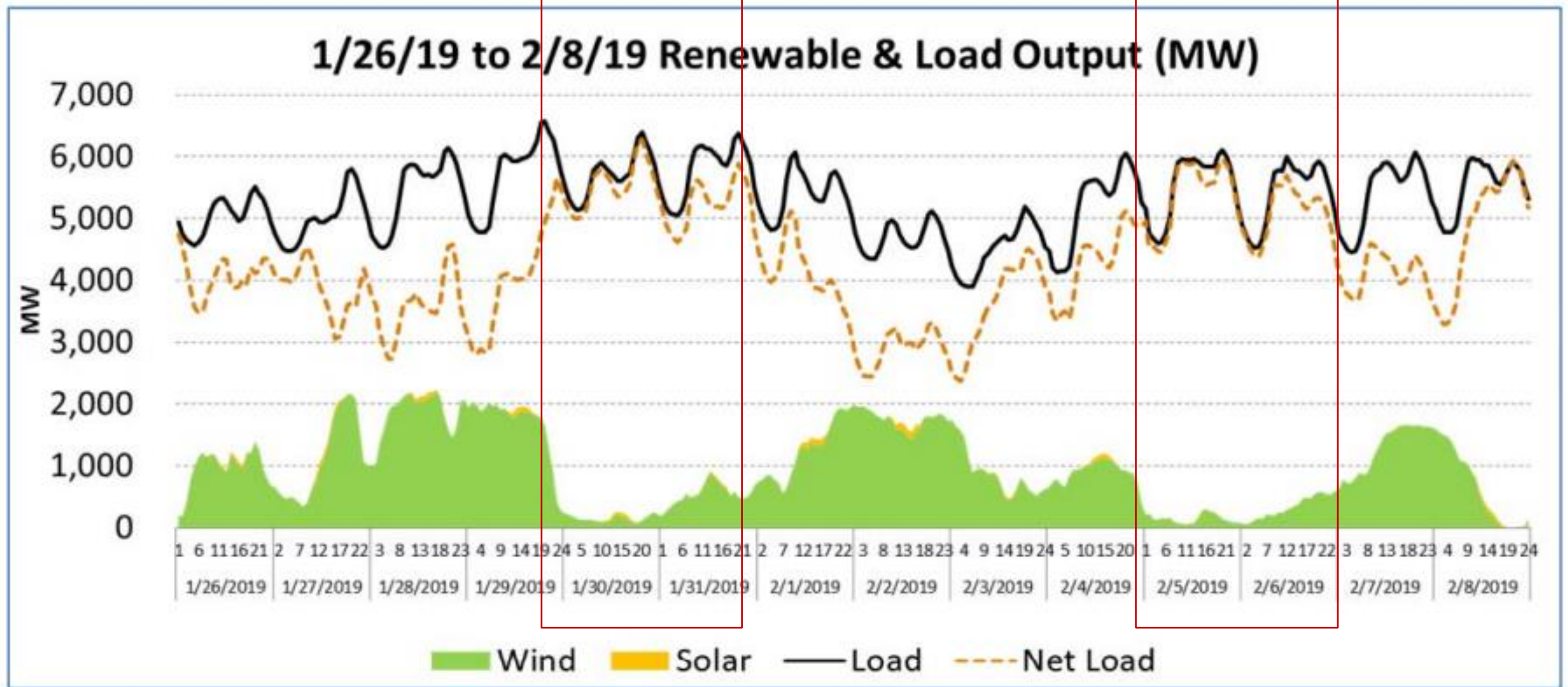
- Our plan **adds significant variable renewables** over the next 15 years
- "Firm" low-carbon resources remain **necessary components** of the electric system for reliability and flexibility

Source: Jenkins, Jesse. "Getting to Zero: Decarbonizing Electric Power." Xcel Stakeholder Workshop, 28 Aug 2018

Typical Resource Profile



Atypical Resource Profile



Additional Testing: Adequacy

- Ensuring ability to supply demand and/or energy requirements for all hours
- How well do these capacity mixes respond to different sets of hourly, chronological modeling conditions?

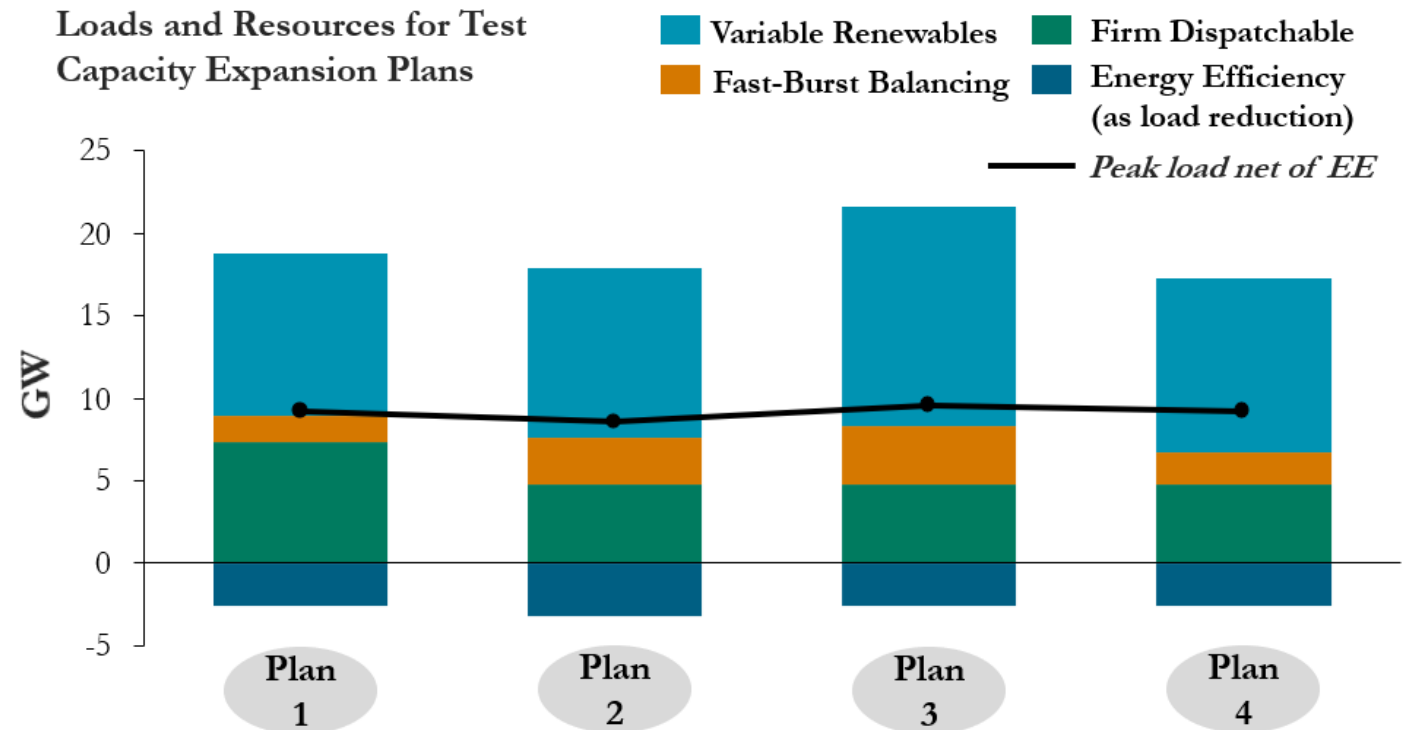
Questions include:

Are there shortfalls?

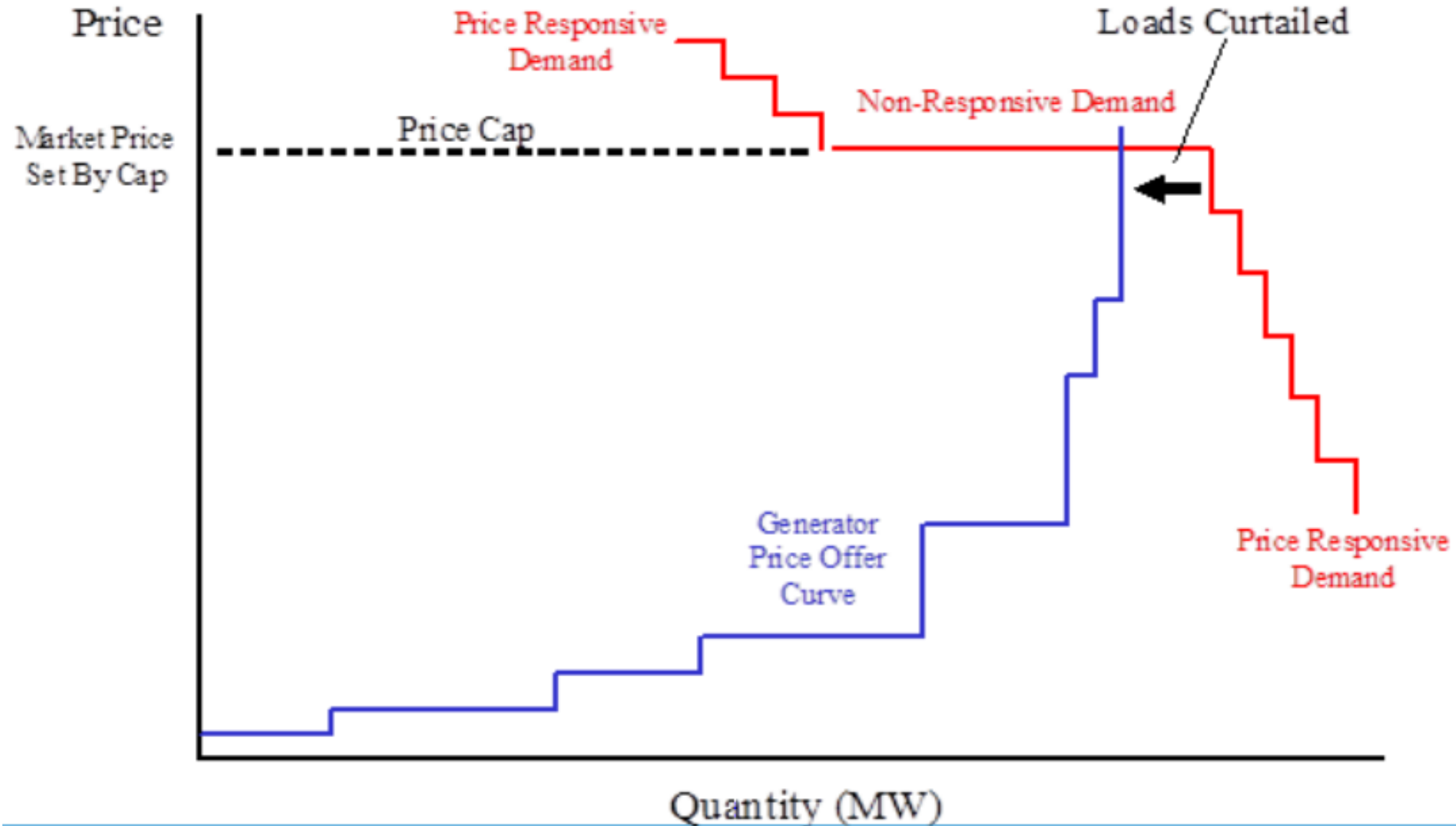
How many hours do they last?

By how many MW are we short?

What are the apparent causes?



So, what's the deal?



Source: MISO Market Subcommittee, Value of Lost Load (VOLL) and Scarcity Pricing Presentation 10-Sept-2020



Questions?



Valuing Diversity and the Evolution of the Grid

Webinar

February 9, 2021

Michael Milligan, Consultant

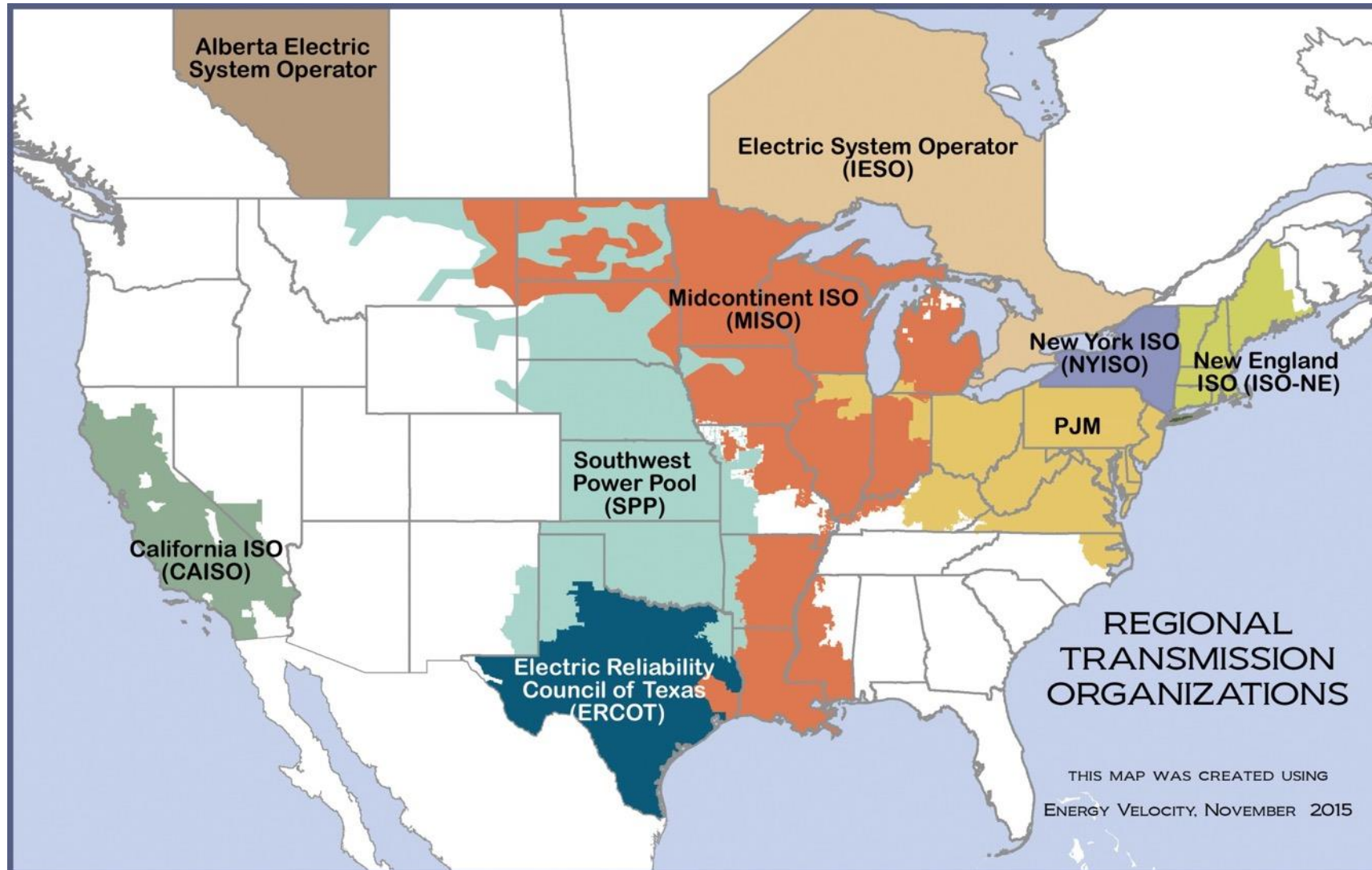
milligangridsolutions@gmail.com

GridLAB

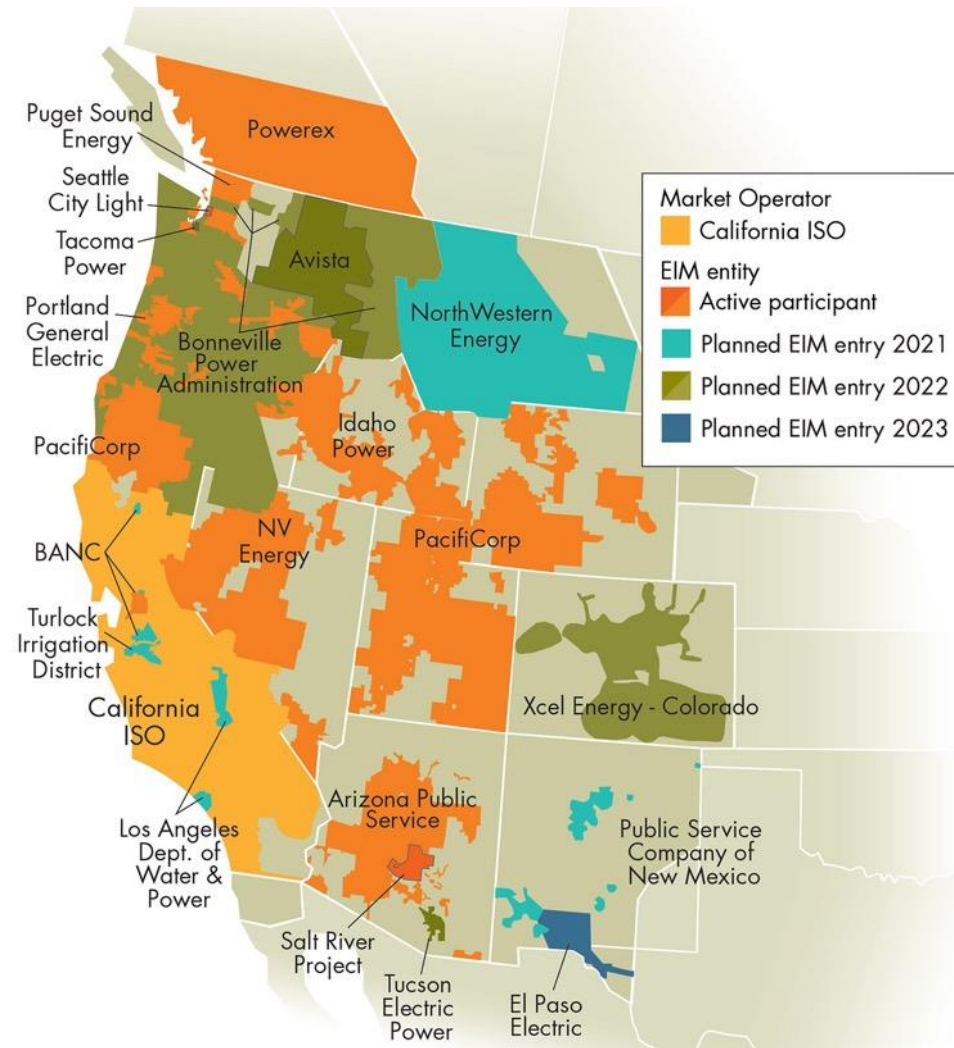
Value of Diversity

- Energy-first planning
- Diversity of renewable energy sources
- Evolving risk assessment
- Transmission can unlock many diversity benefits
- Integration of generation and transmission planning
- Valuing diversity
- Demand response “animation” if time

Evolution of the grid



Evolution of the grid

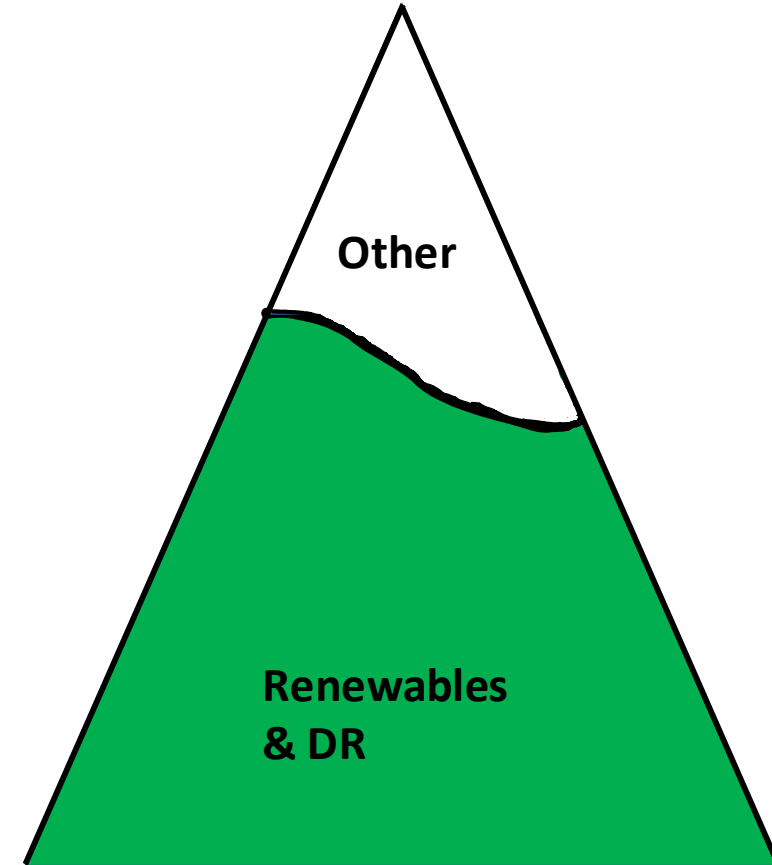


Map boundaries are approximate and for illustrative purposes only.

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Changing power system

- "Energy-first" planning
 - Focus on clean energy first
 - Then "fill in" to achieve RA
- Fill in with
 - Storage
 - DR
 - Quick-start thermal
 - Other

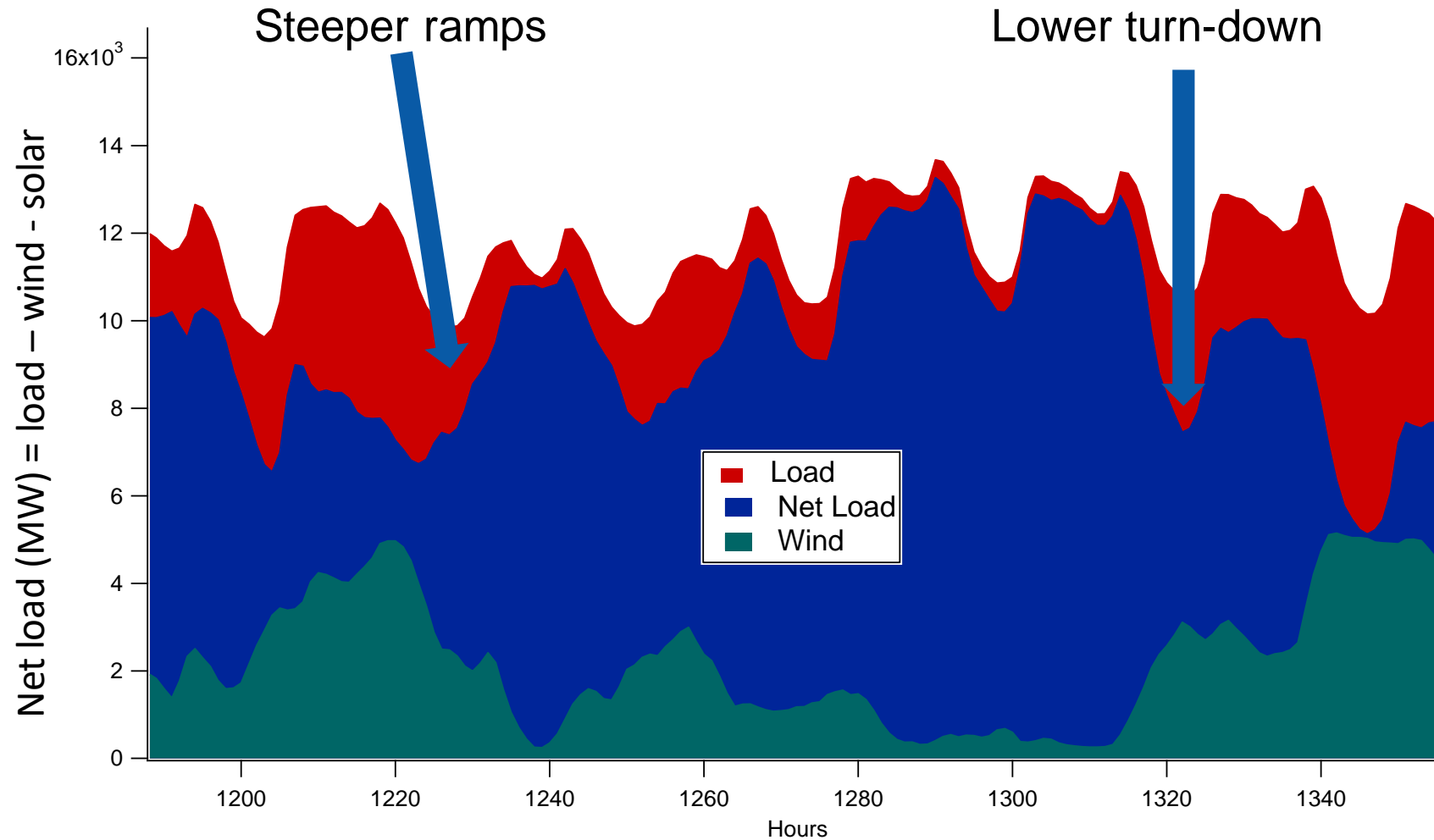


Relevant characteristics of VG

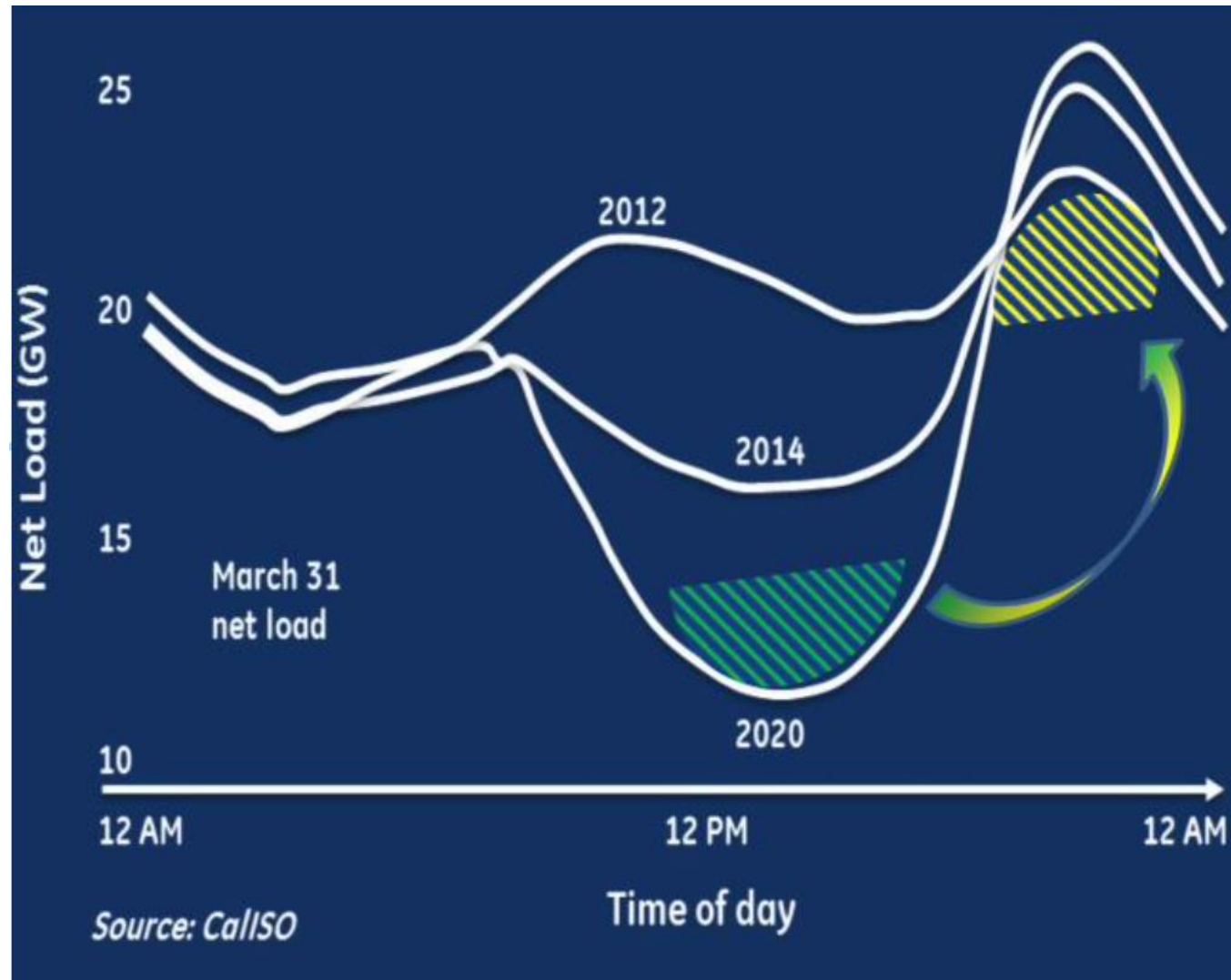
- Variable
- Predictable (up to a point)
- Marginal cost = 0, therefore comes in at the bottom of the dispatch stack
- Modern wind/solar plants can be dispatched up or down (if pre-curtailed; usually an economic decision)
- Increases the flexibility requirement from the remaining power system
- Has some ELCC but generally low relative to its nameplate capacity



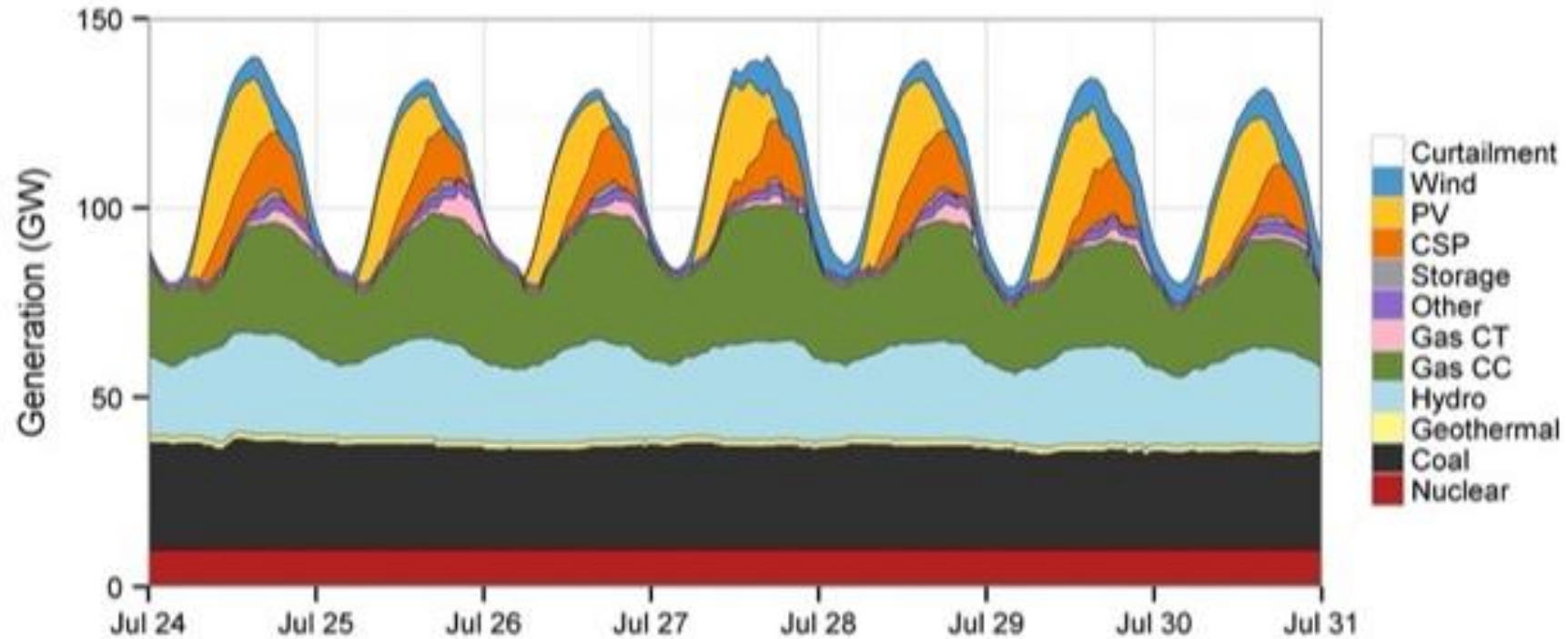
Example 1-week period of demand, wind energy



Example “duck” curve



Wind and solar impact on dispatch

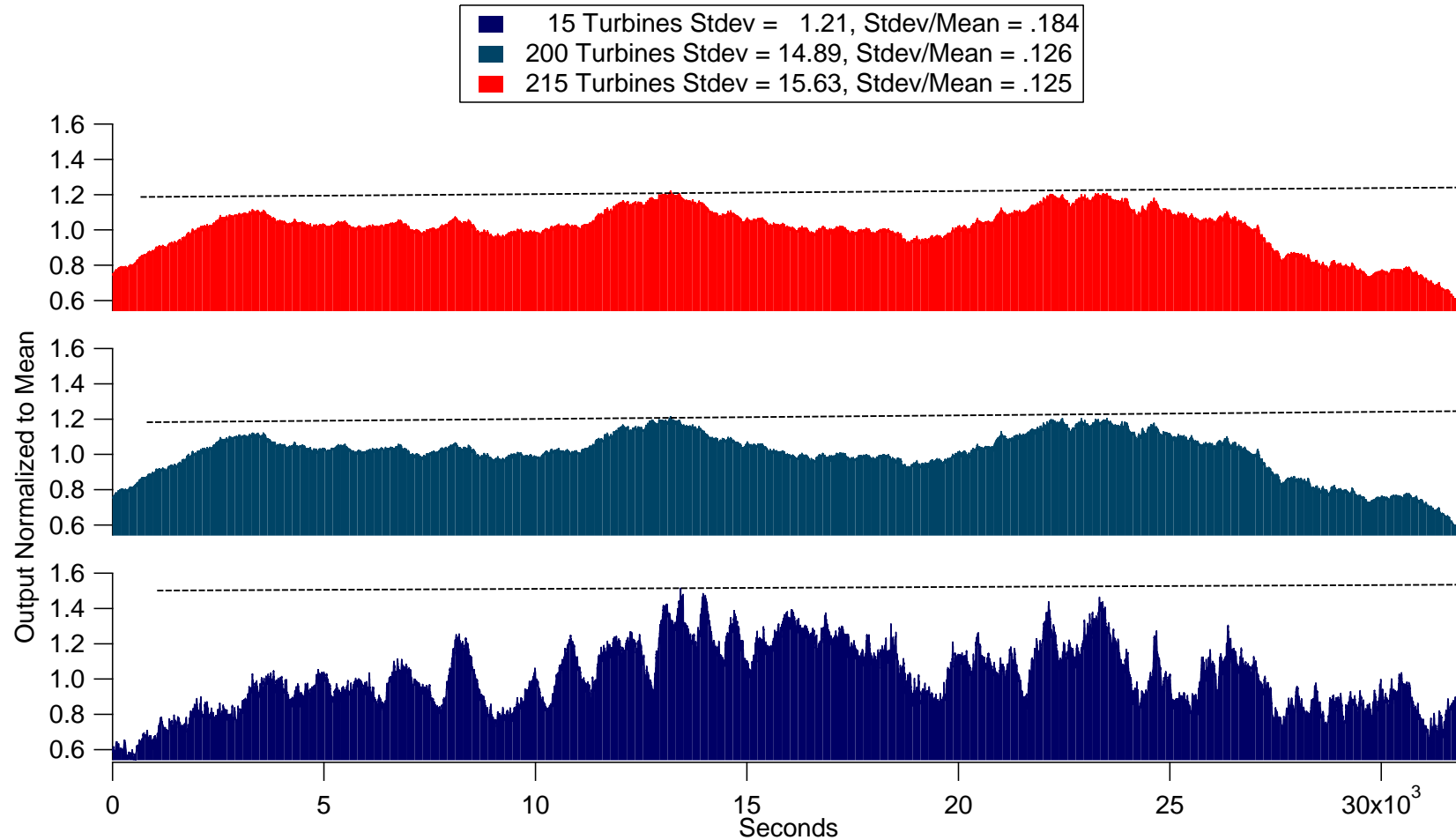


Lew et. al, Western Wind and Solar Integration Study, Phase 2. 2013. NREL.



Diversity provides flexibility in all time scales

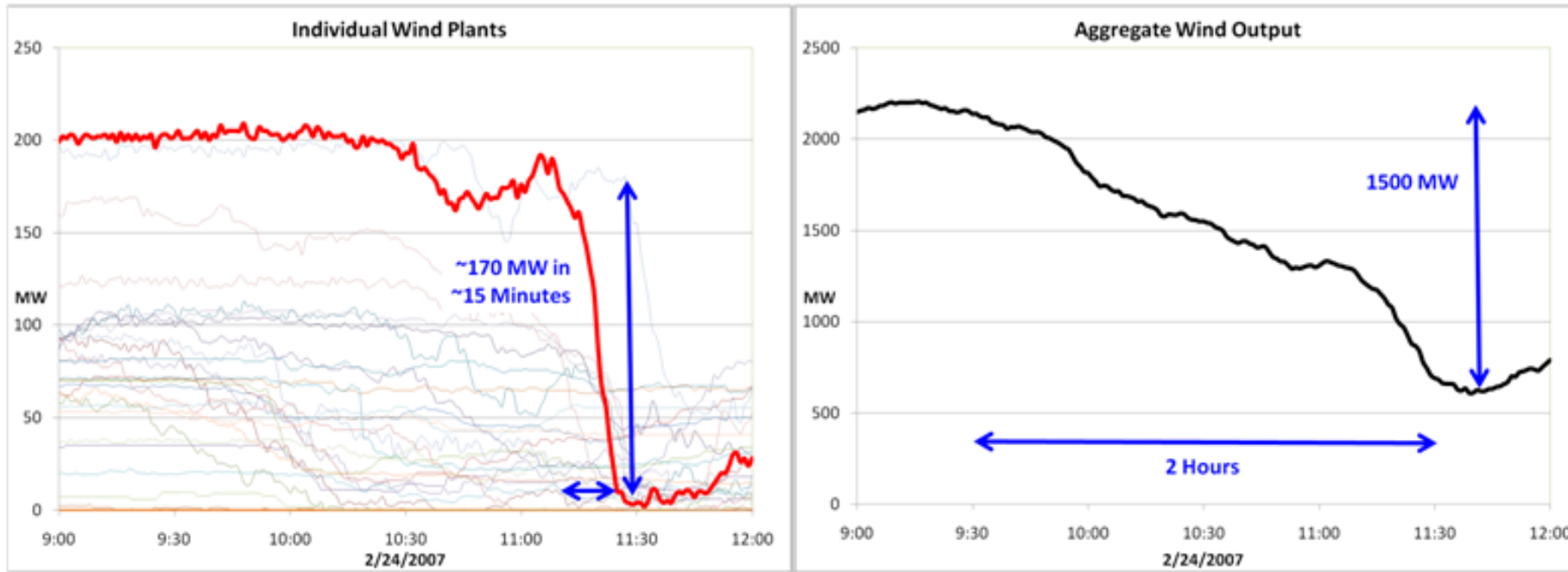
Geographic smoothing within hours, small area



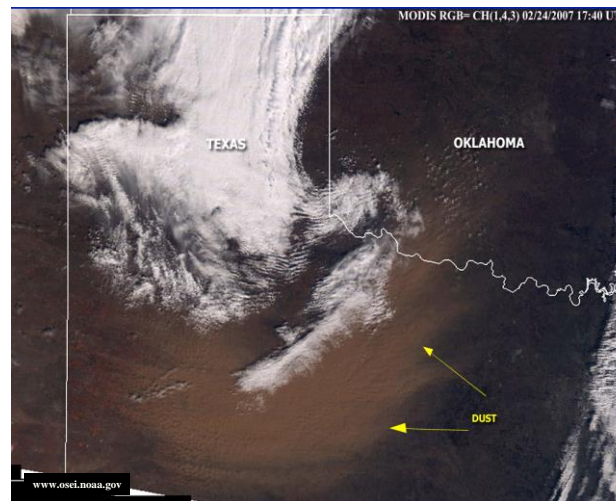
Source: NREL Wind Plant Data

(Approximately 8 hours)

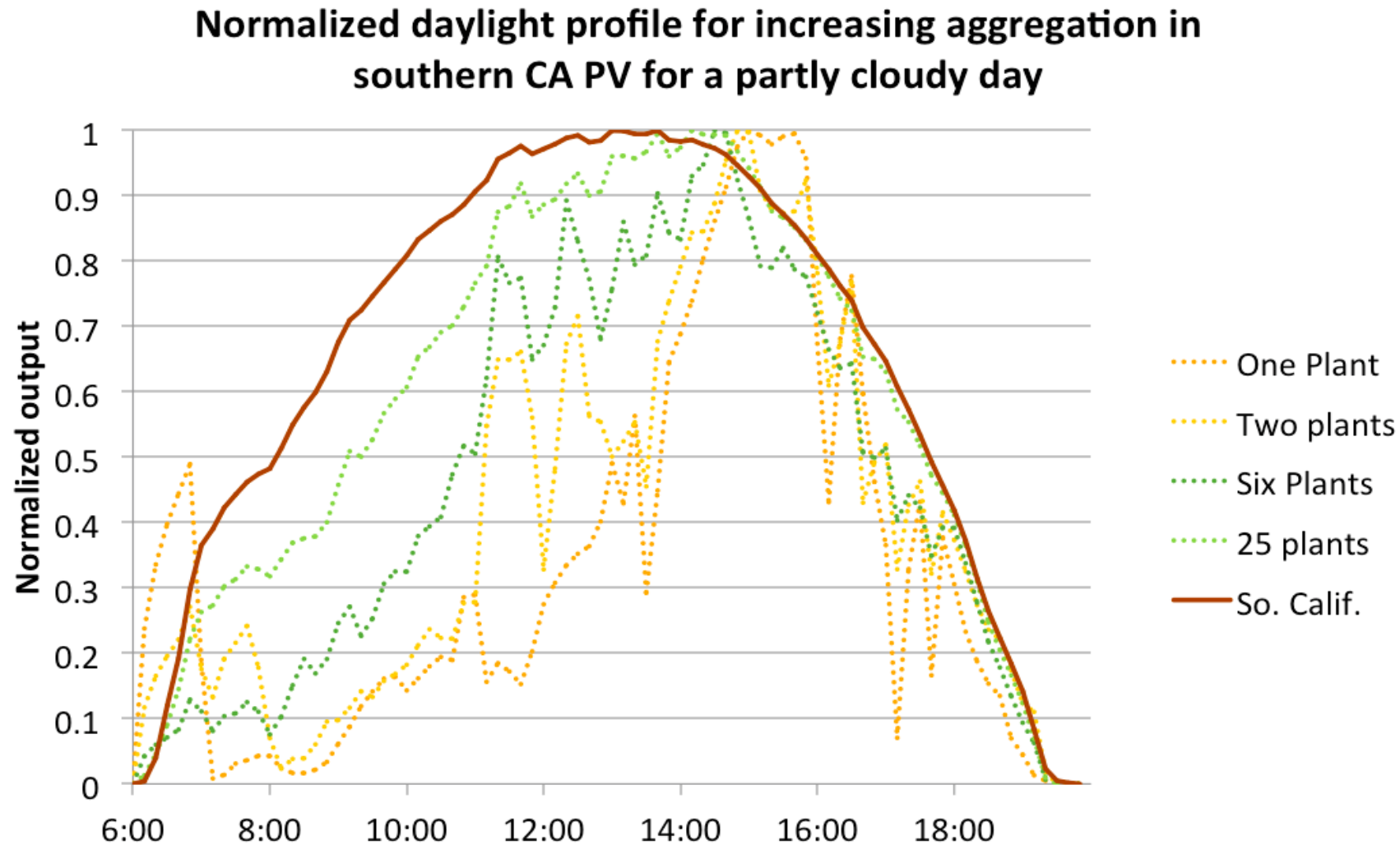
Aggregation is a critical property of wind generation



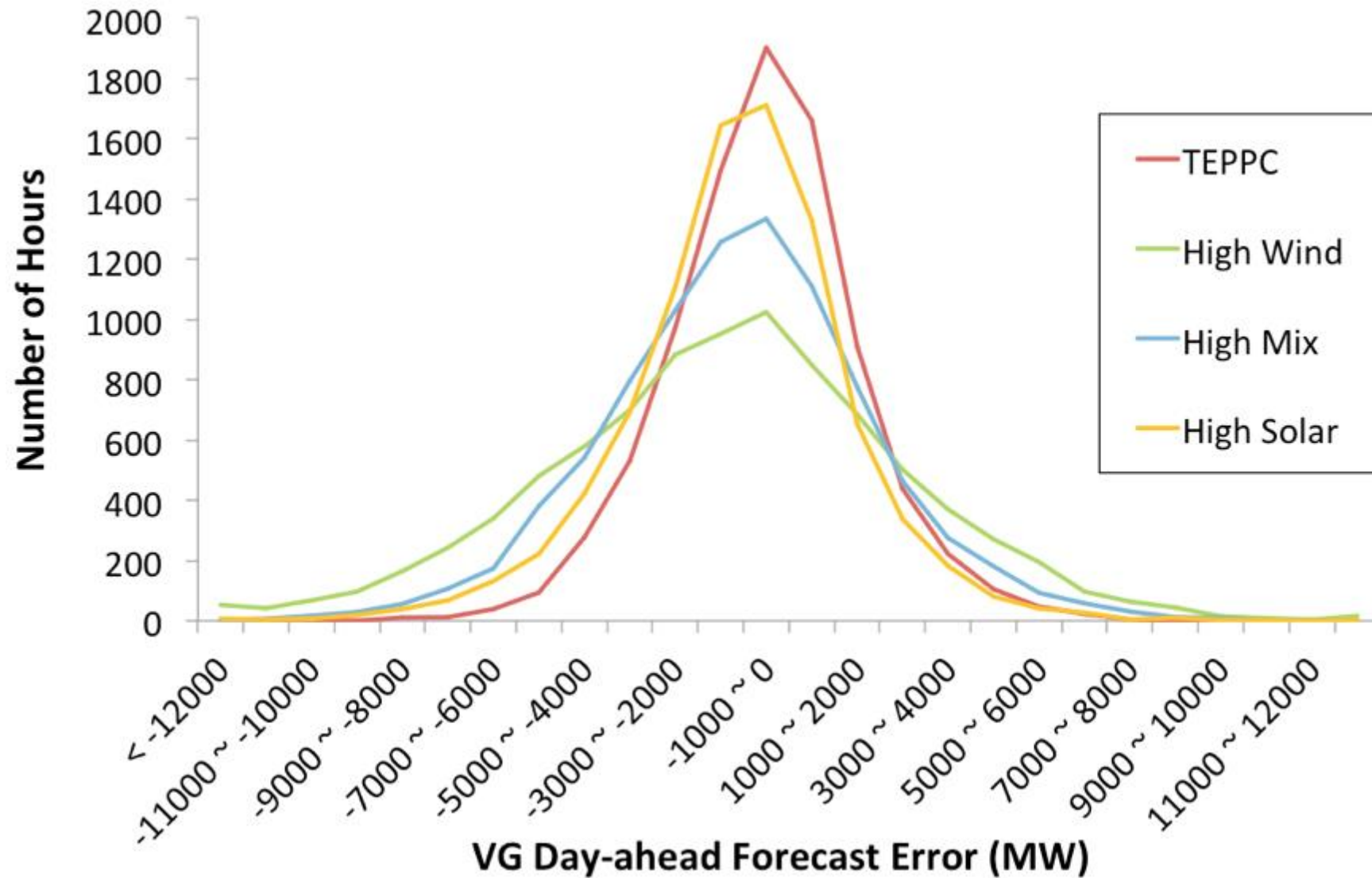
Source: ERCOT, WindLogics



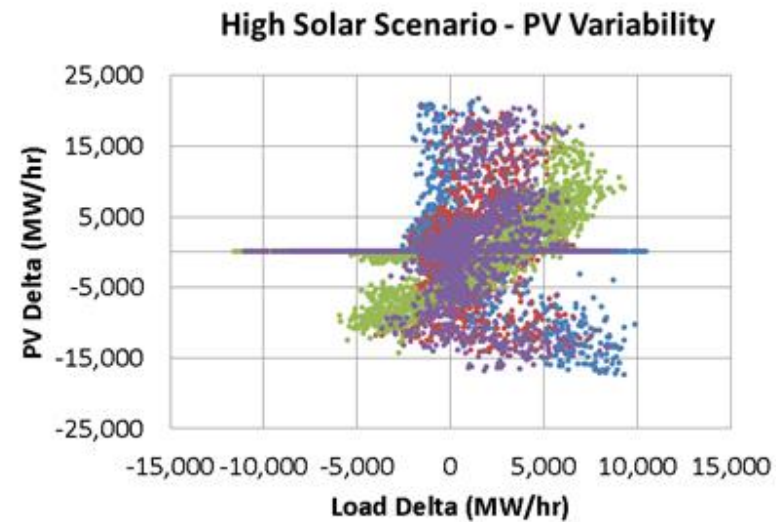
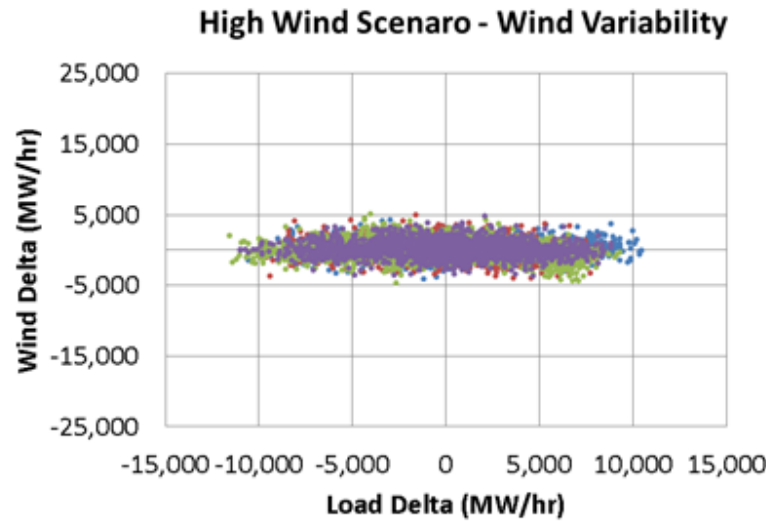
...and aggregation is also a critical property of solar energy



Wind Dominates Uncertainty Extremes

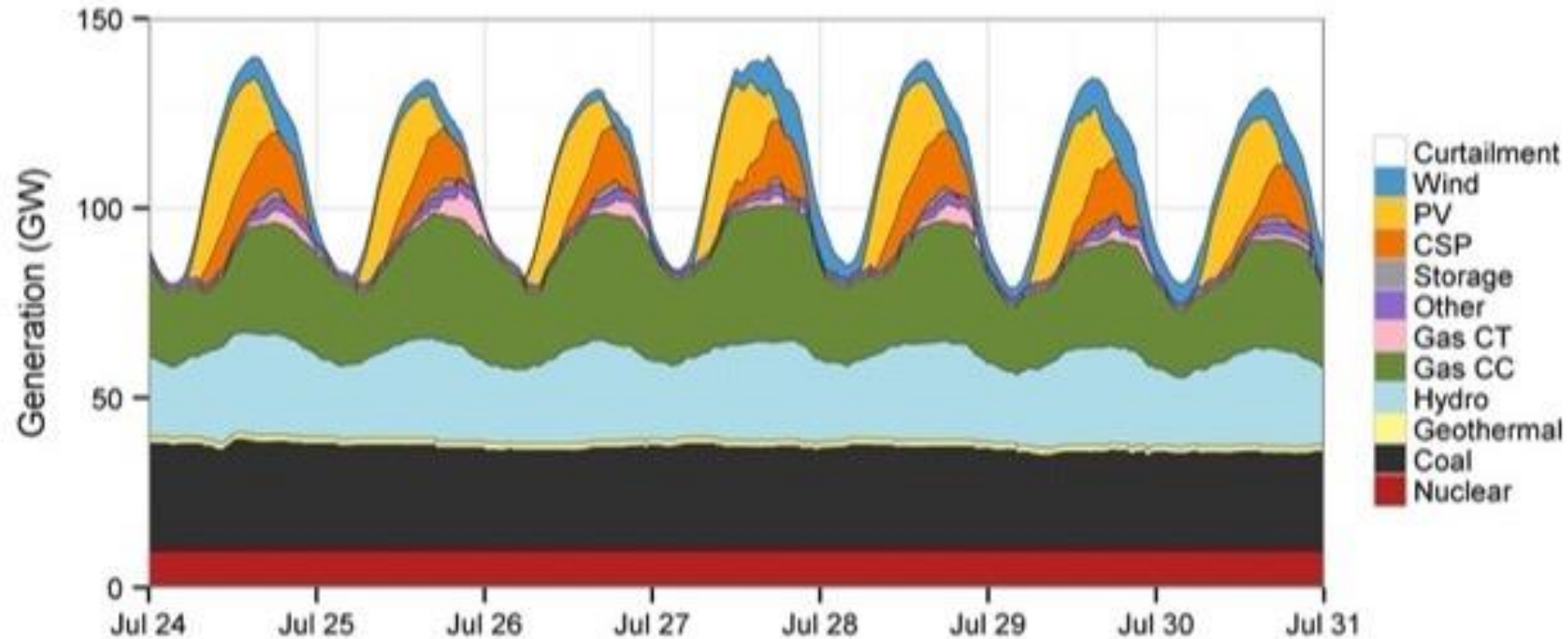


PV Dominates Variability Extremes



- Winter
- Spring
- Summer
- Fall

Diversity in demand, wind, solar, other



Aggregation of demand, wind, solar means that not every change in wind or solar output must be chased by a conventional resource or storage.



Risk assessments are changing too

Resource Adequacy (RA) is a counting problem

- Have we built enough stuff to supply demand at some future date(s)?
- “How adequate” can be turned upside down into “How often do we have a problem?”
- How many problems?
- How long did they last?
- How large was the energy deficit?
- How large was the capacity deficit?



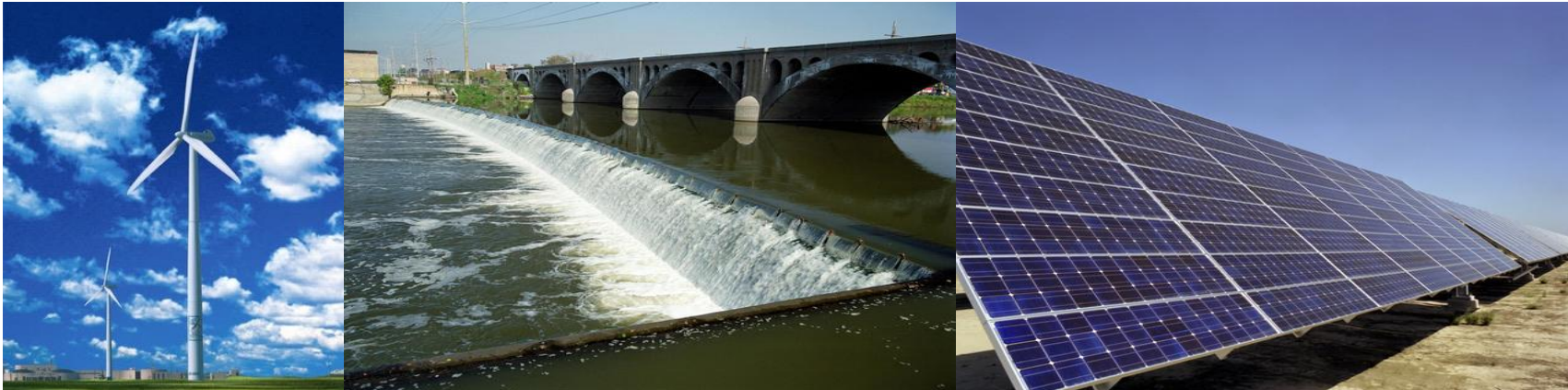
What should be counted?

- Do we want to count only resources (RA)?
- Do we want to include resources plus transmission (system adequacy)?
- Do we want to consider external support from power pool participation or other neighbors who might have the capacity/energy to help during an emergency?



Traditional Approach to RA

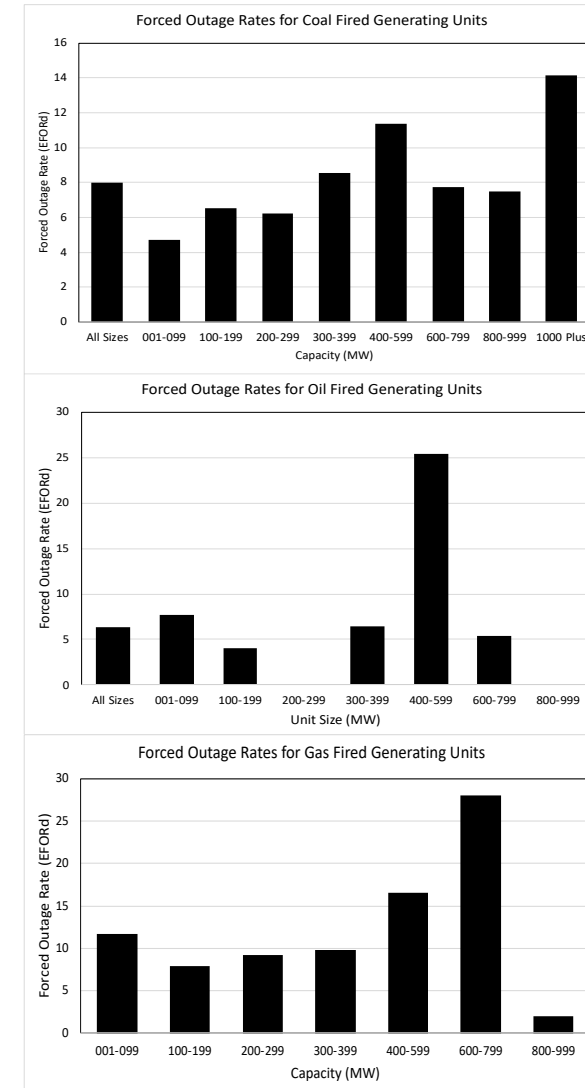
- Often measured based on installed capacity, peak load, and a planning reserve
- A fixed planning reserve margin (PRM), often in a range of 12-15% above forecasted peak demand, was (and is still, unfortunately) common
 - 10,000 MW peak, 11,500 Installed capacity is a 15% PRM.
- However, this isn't a true reliability measure:
 - How often does it fail?
 - How long are failures?
 - Or...how successful are we in keeping the lights on?
- And – it does not work with high levels of renewables



Resource Adequacy: From PRM to LOLP

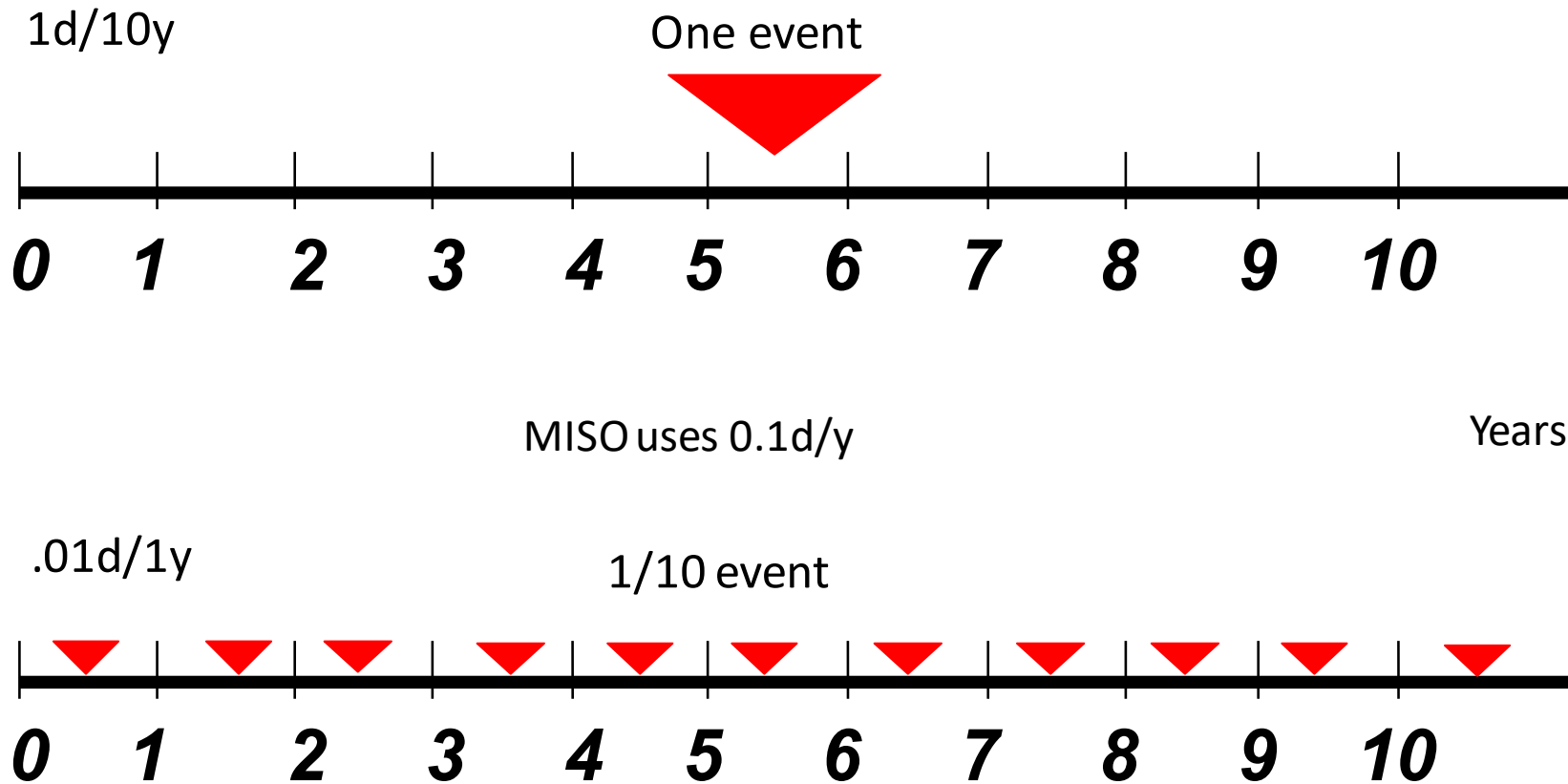
- How *adequate* is *adequate enough*?
- Quantify the number of times system will be inadequate – often measured as hours/year or days/year (1d/10y \approx 99.97%)
- Probability that demand will exceed supply: Loss of load probability (LOLP)
- *The “Loss of load” part of this term should be changed to “probability of emergency import” in interconnected systems*

Forced outage rates source: NERC



Example reliability targets

Note: LOLE of 1d/10y is not the same as 0.1d/10y



Renewables are complicating risk assessment

- Traditional
 - all risk during/near system peak
 - Focus on daily LOLP; ignore hourly data
- With renewables
 - More interest in hourly view
 - More interest in energy metrics
- Fortunately, methods and computational tools exist that can help



See ESIG: Redefining Resource Adequacy: <https://www.esig.energy/resources/redefining-resource-adequacy-for-modern-power-systems-derek-stenclik-december-2020/>

How does weather affect RE?

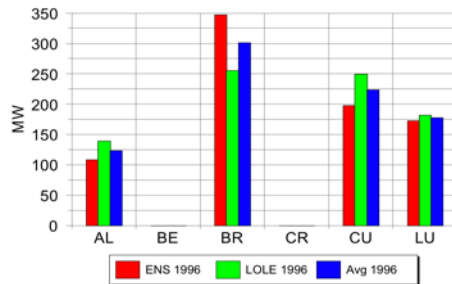
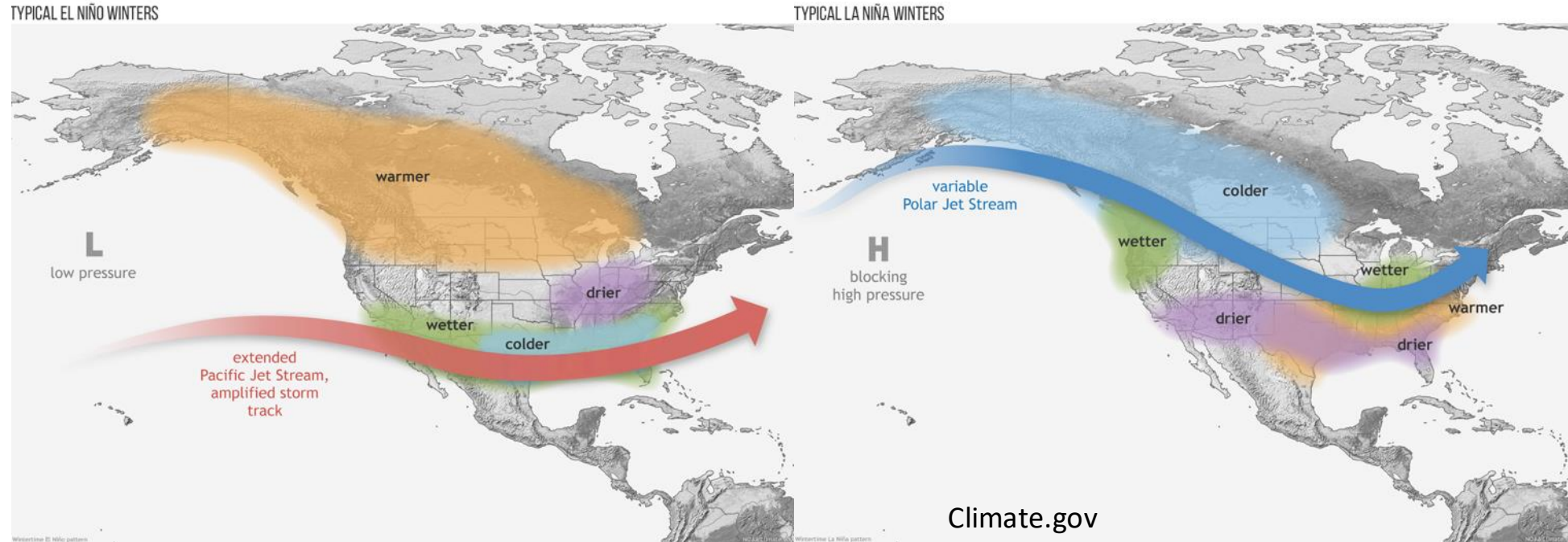


Figure 10. Optimal distribution of wind capacity using 1996 data

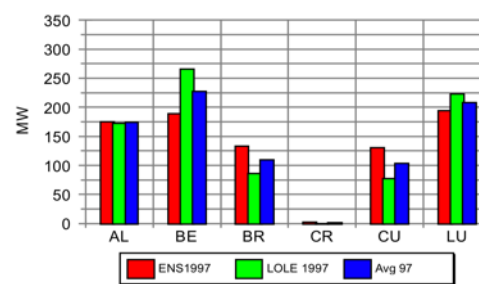
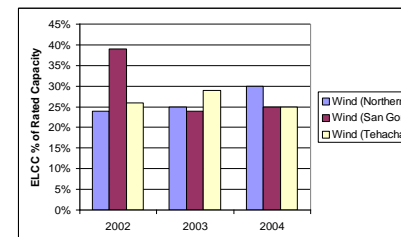
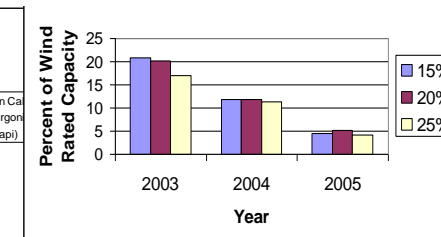


Figure 11. Optimal distribution of wind capacity using 1997 data



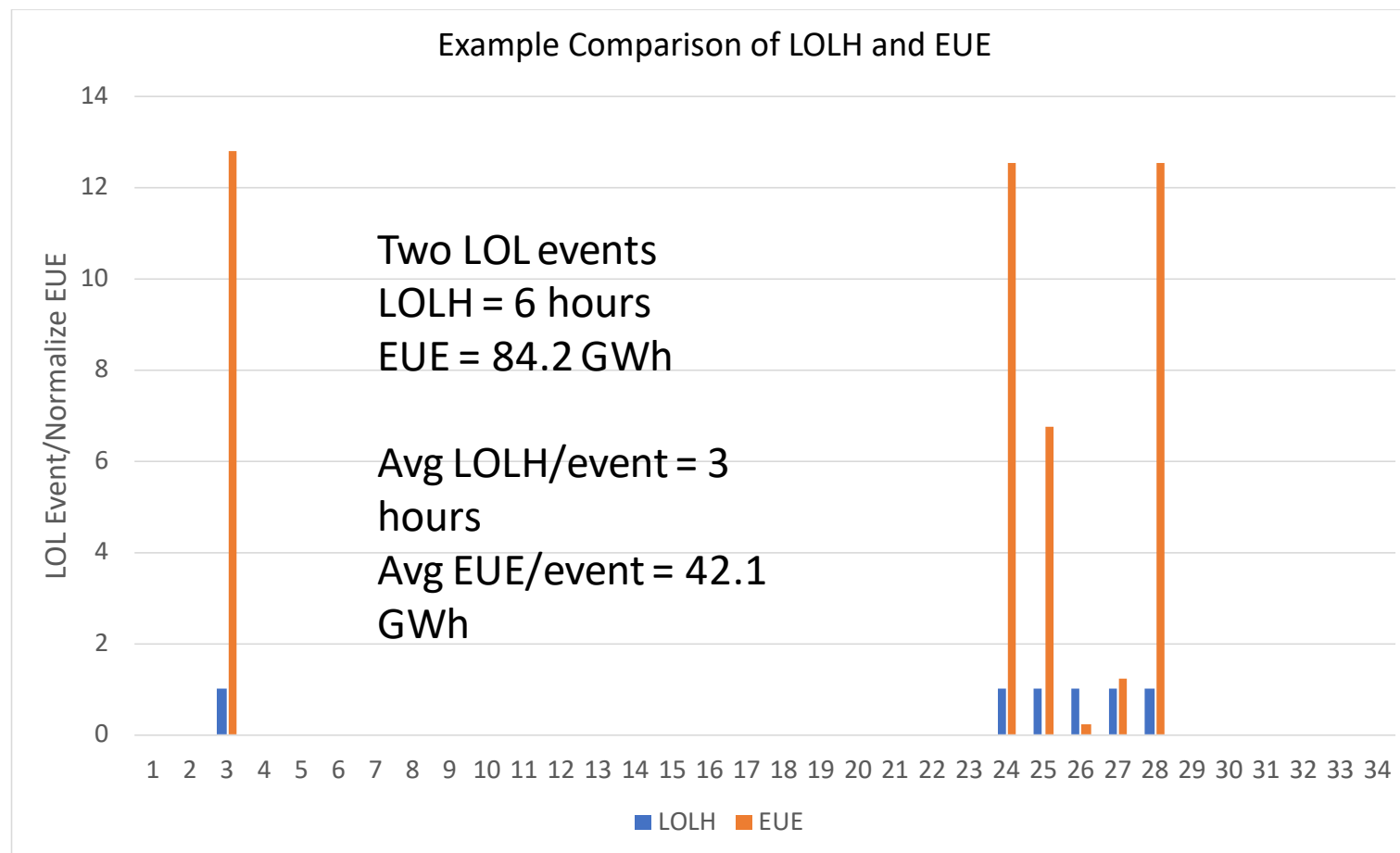
California RPS Integration Study



Minnesota Wind Integration Study

Milligan, M. R.; Artig, R. (1999). Choosing Wind Power Plant Locations and Sizes Based on Electric Reliability Measures Using Multiple-Year Wind Speed Measurements. Prepared for the U.S. Association for Energy Economics Annual Conference, 29 August—1 September 1999, Orlando, Florida; 11 pp.; NREL Report No. CP-500-26724. Available at <http://www.nrel.gov/docs/fy99osti/26724.pdf>

Example: LOLH and EUE

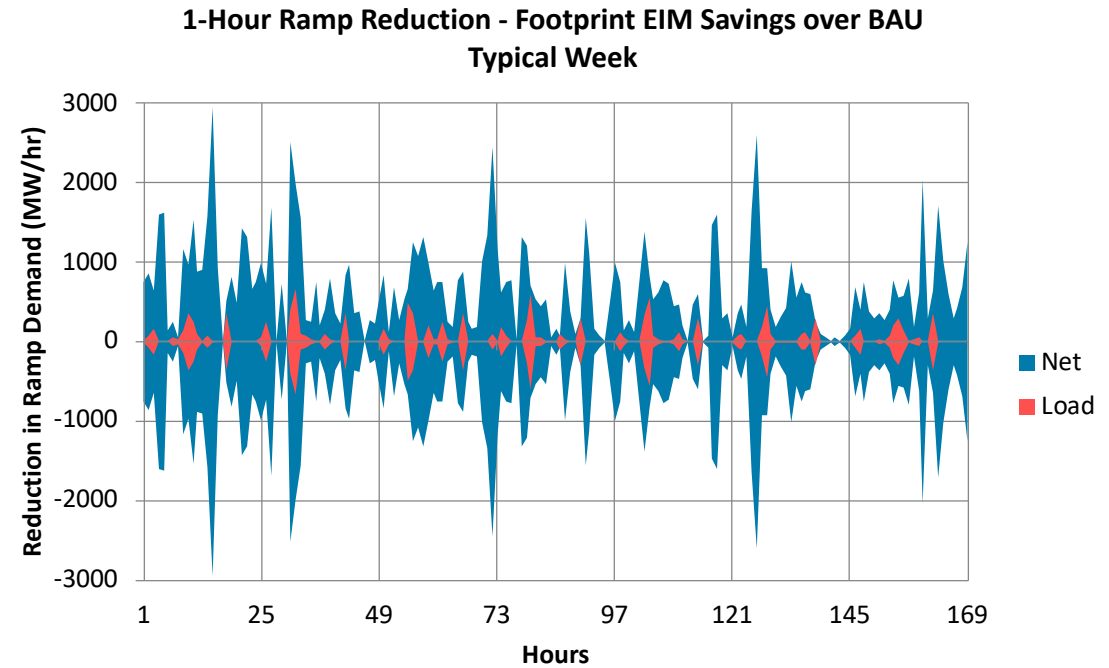
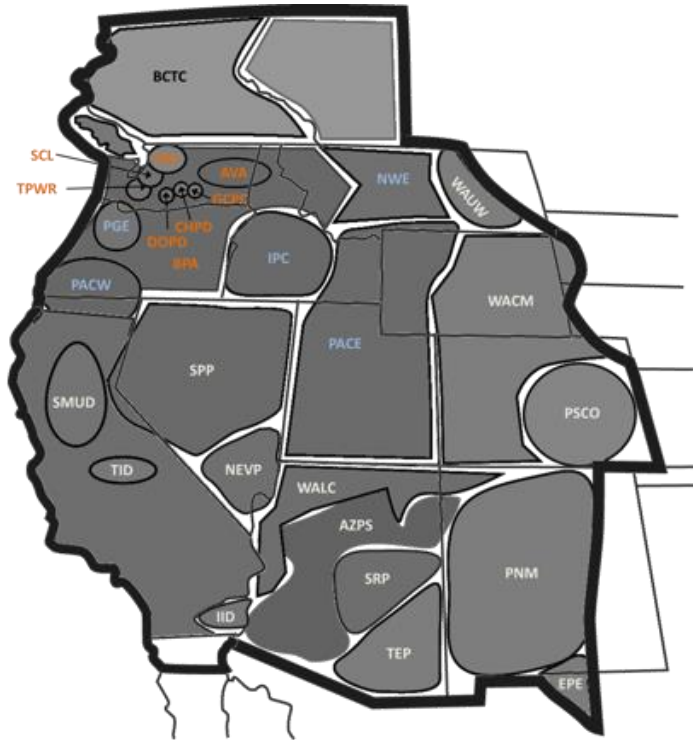


LOLH = loss of load hours (hours of emergency import), number of hours of shortage
EUE = expected unserved energy (emergency import energy)

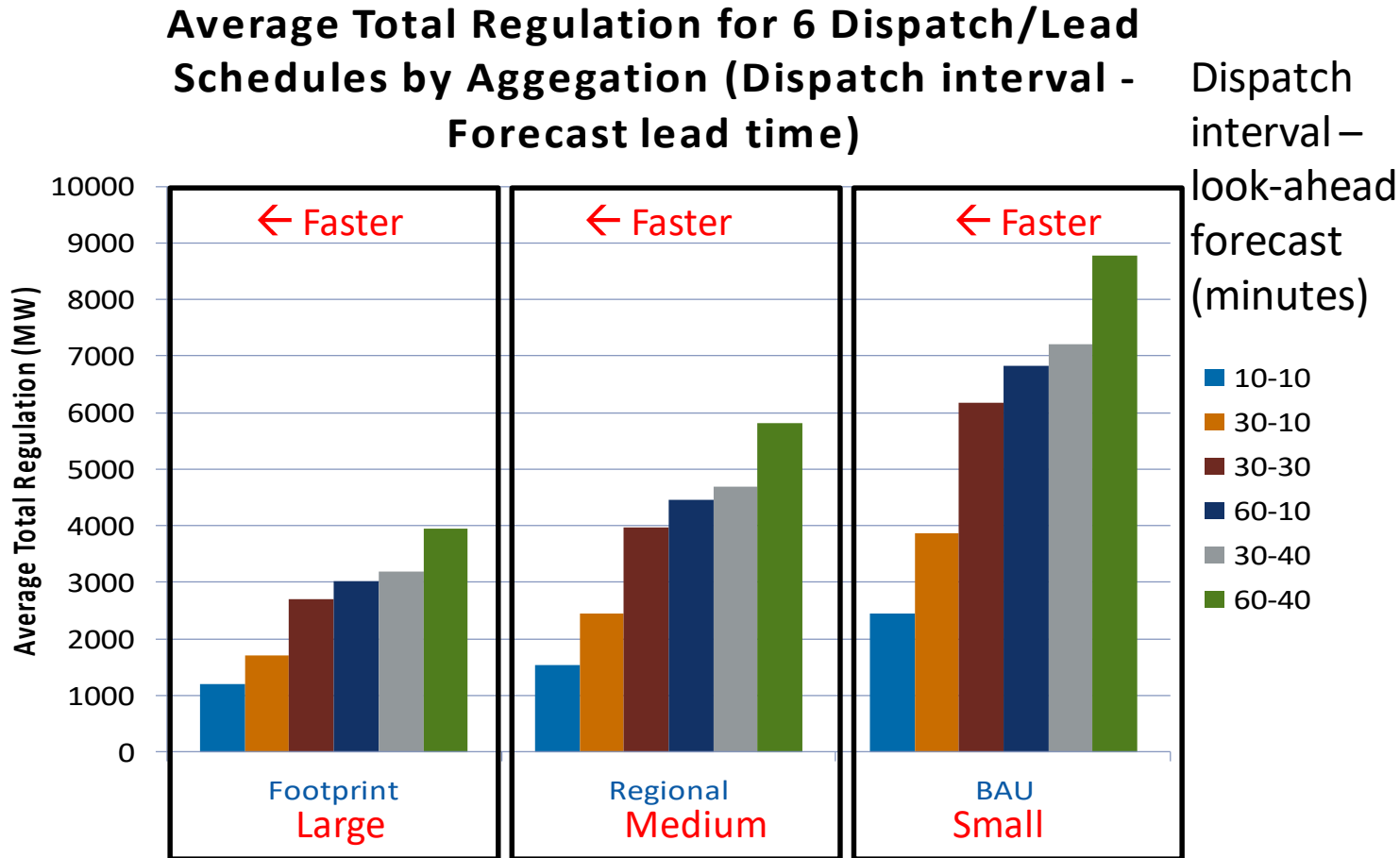


Transmission can increase reliability,
enhance markets, and reduce need to
build resources

Example of ramp reduction in the West



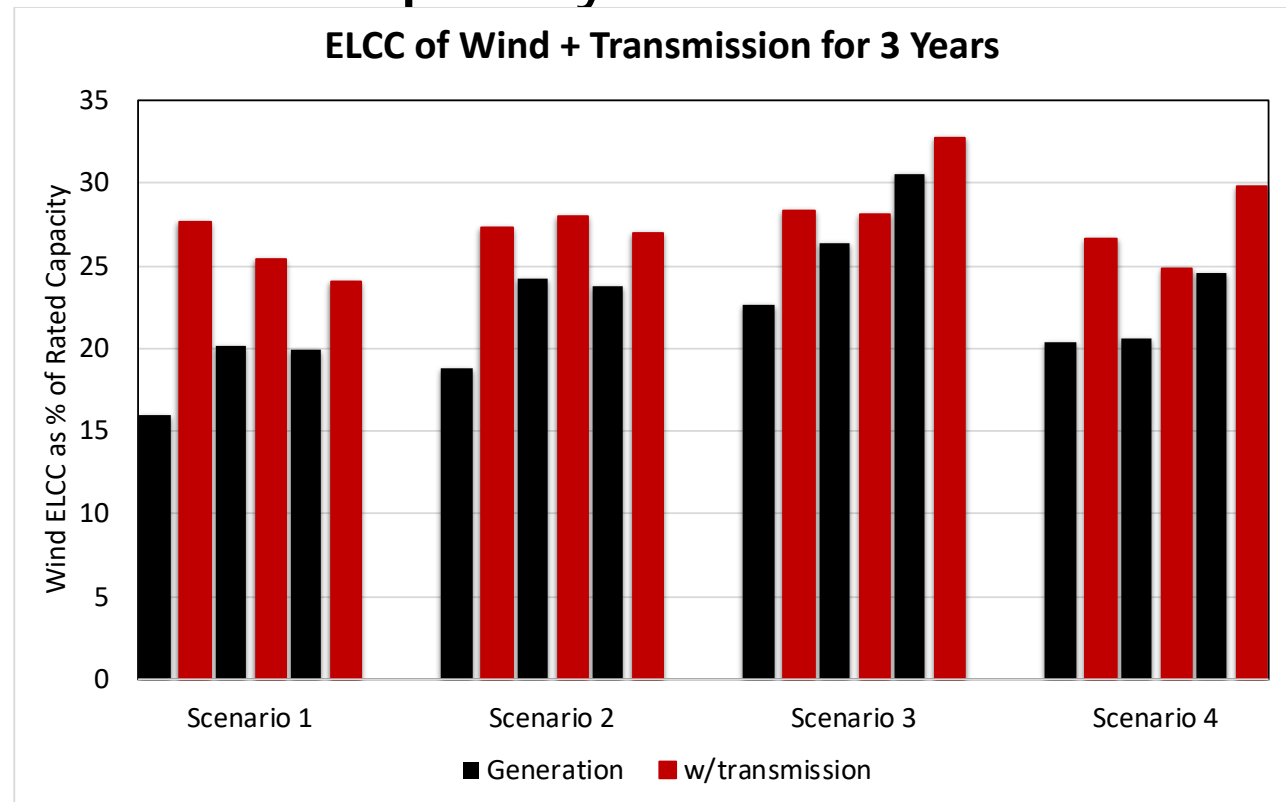
Aggregation in the West: Regulation



Milligan, Kirby, King, Beuning (2011), The Impact of Alternative Dispatch Intervals on Operating Reserve Requirements for Variable Generation. Presented at 10th International Workshop on Large-Scale Integration of Wind (and Solar) Power into Power Systems, Aarhus, Denmark. October

Transmission can play a critical role

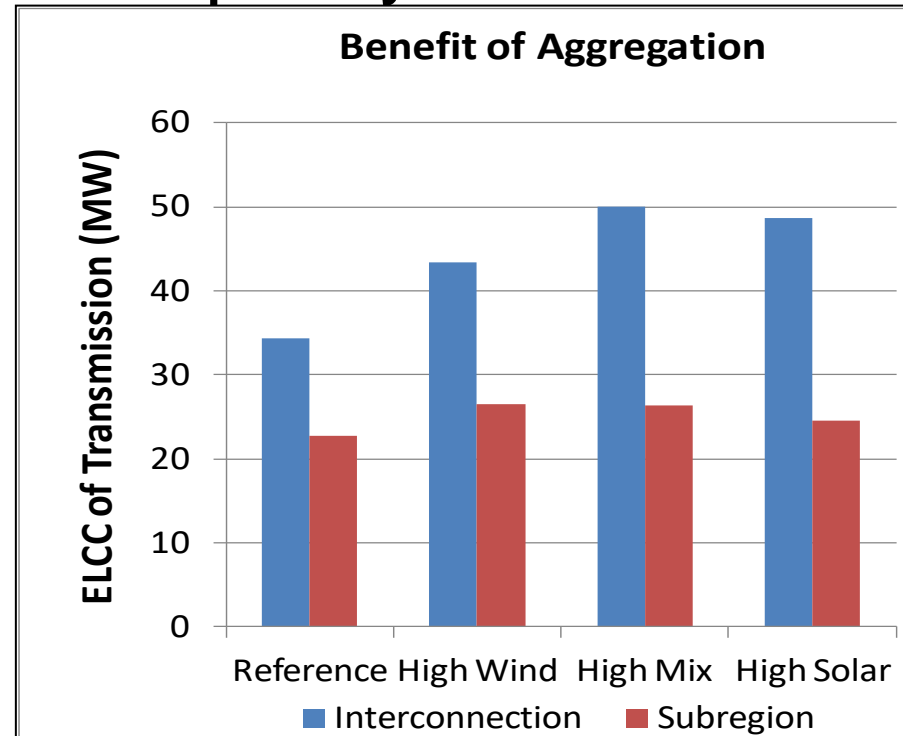
- Increasing transmission links and associated operational coordination can reduce the need for installed capacity



Adapted from Eastern Wind Integration and Transmission Study <https://www.nrel.gov/docs/fy11osti/47078.pdf>

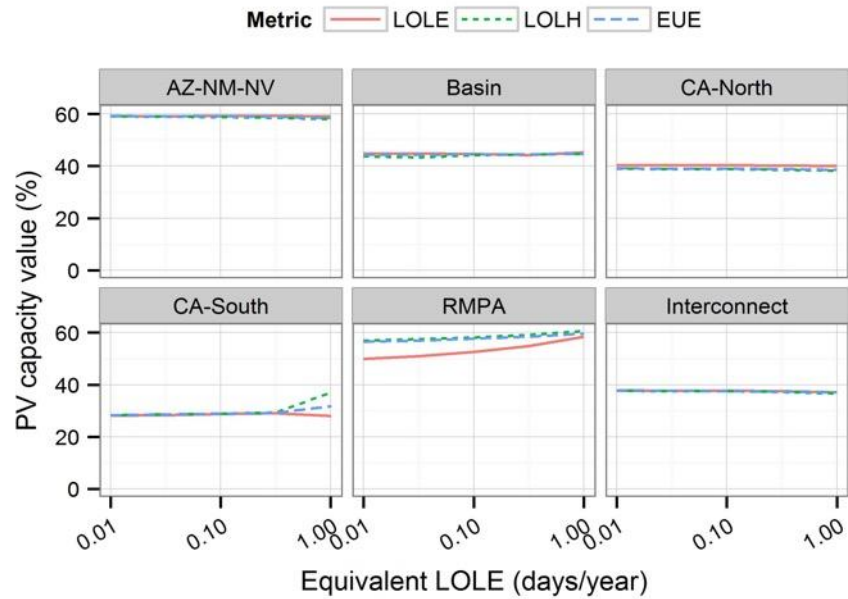
Transmission can play a critical role

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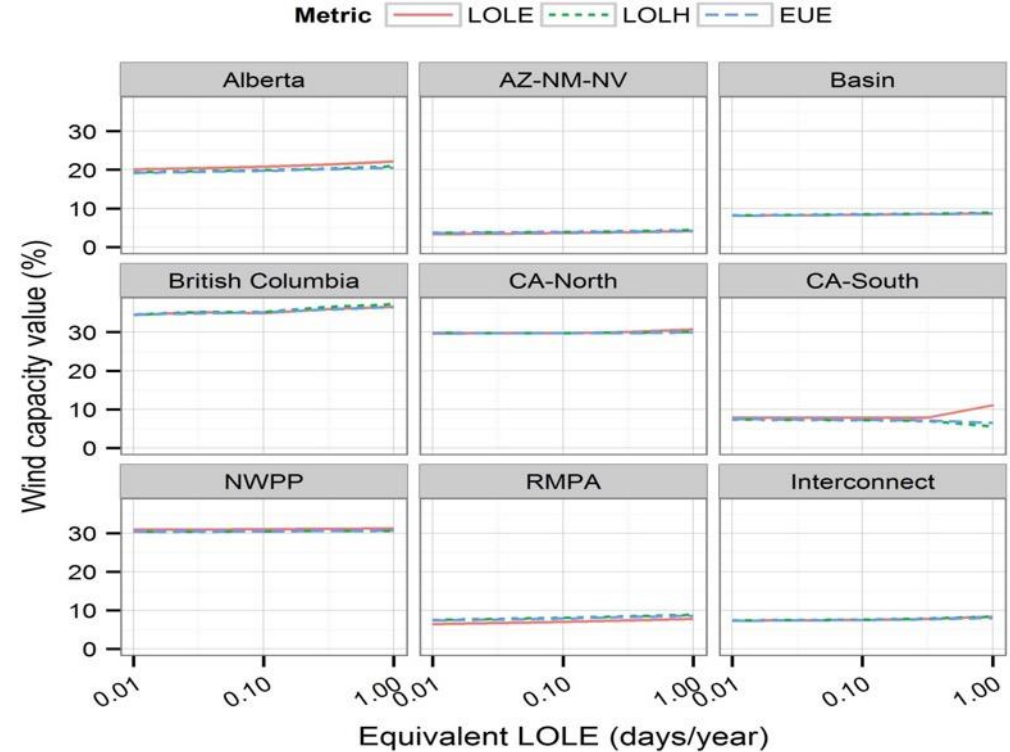


Ibanez and Milligan (2012), "Impact of Transmission on Resource Adequacy in Systems with Wind and Solar Power." IEEE Power and Energy Society General Meeting, Summer 2012. San Diego, and "A Reliability-Based Assessment of Transmission Impacts in Systems with Wind Energy". Available at www.nrel.gov/publications

Example: alternative metrics, targets



PV in the West



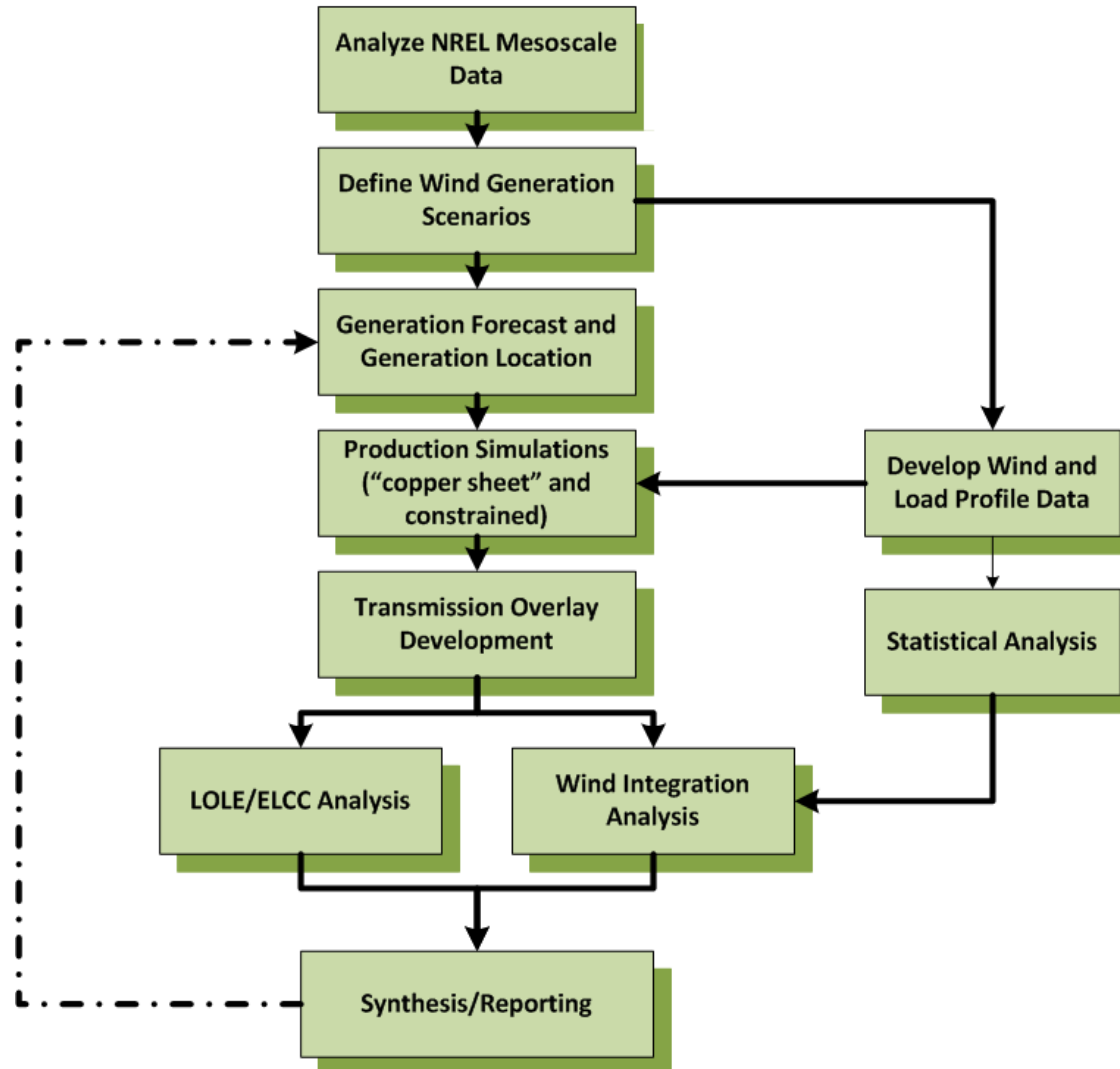
Wind power in the West

Milligan, Michael; Bethany Frew; Ibanez, Eduardo; Kiviluoma, Juha; Holttinen, Hannele; Söder, Lennart, [Capacity Value Assessments for Wind Power: An IEA Task 25 Collaboration](#). Wiley Wires. 2016



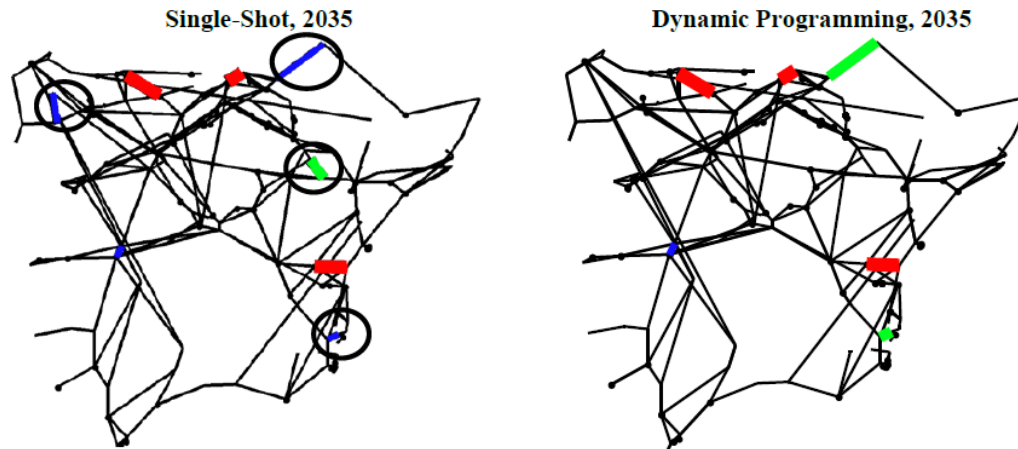
Integrate transmission and resource
planning

MISO/NREL Study Process (EWITS, 2010)



Transmission planning challenges

- Most are well-known...
- Design and build for the short-term, or the long-term?
- Renewable energy siting in advance?



2035	Single-Shot	Dynamic Programming
400 MW	4	1
750 MW	1	2
1500 MW	3	3

Donohoo, P. 2011. *Integrating Dynamics and Generator Location Uncertainty for Robust Electric Transmission Planning*. INFORMS Annual Meeting. Charlotte, North Carolina, USA.

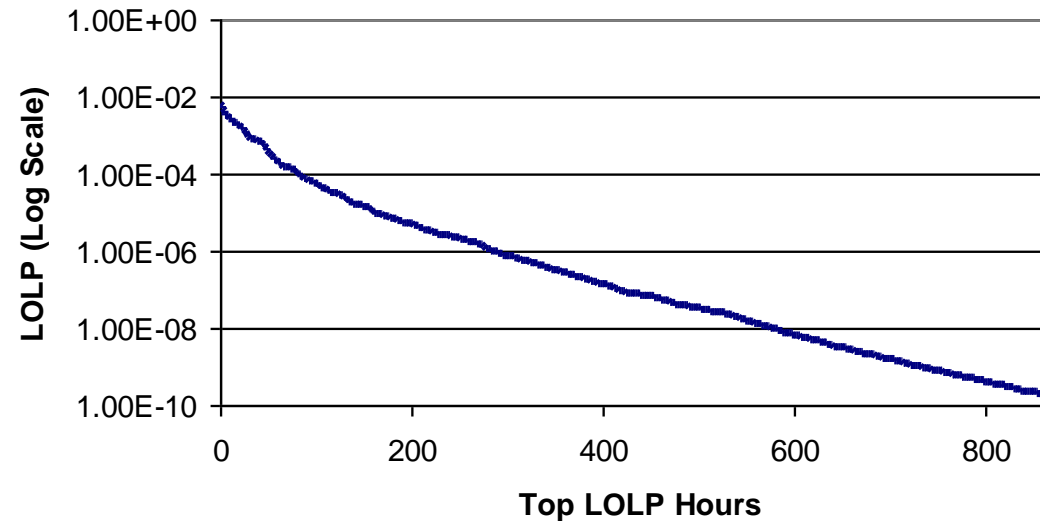
Can DR “fix” times of reliability stress?

- Most days/hours have 0 LOLE
- Few (~300-ish) hours of notable risk

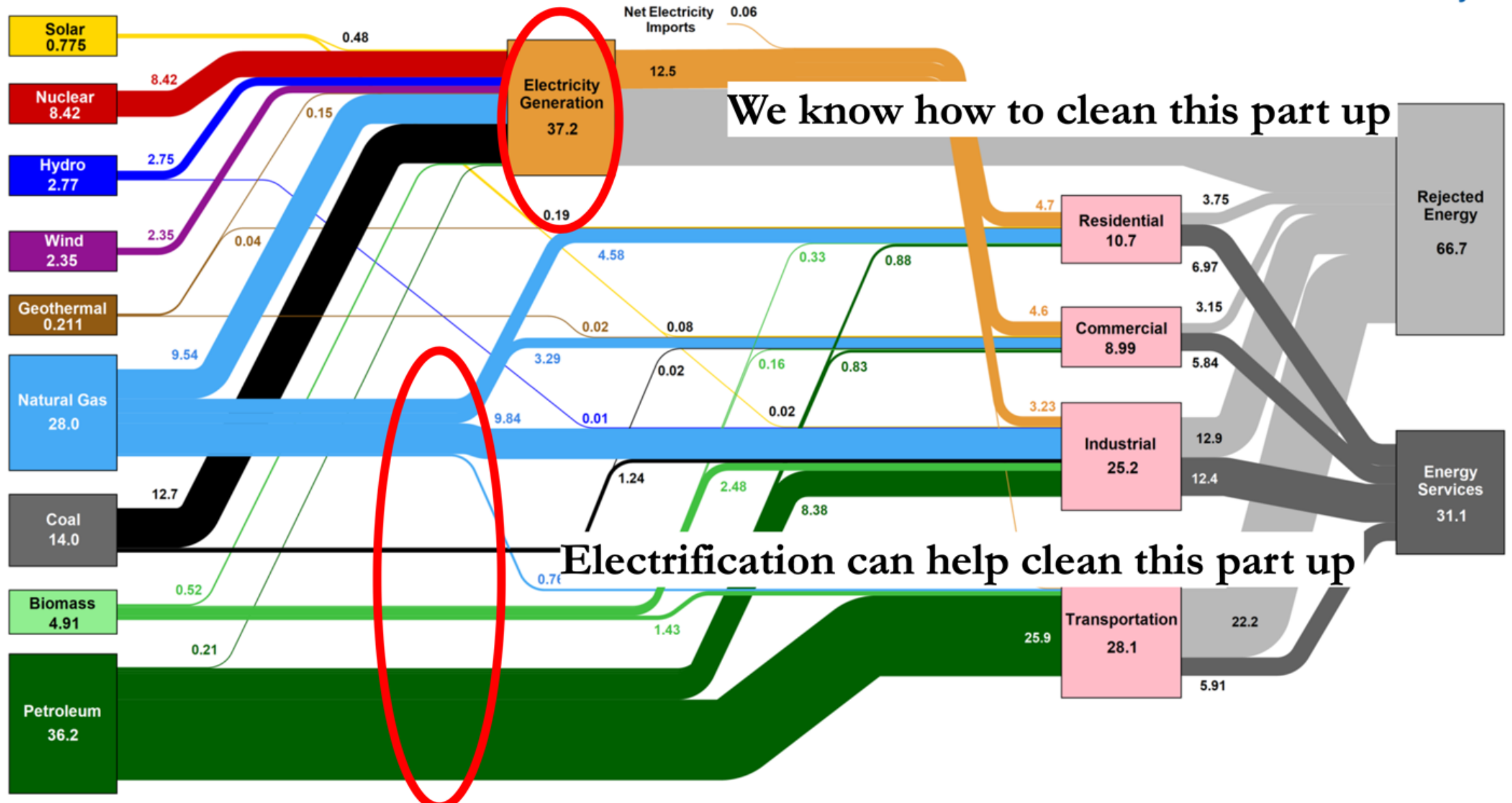


NREL Pix Building
Technologies / 23095.JPG

Sample Hourly LOLP



Estimated U.S. Energy Consumption in 2017: 97.7 Quads





How to value diversity?

Model Transparency

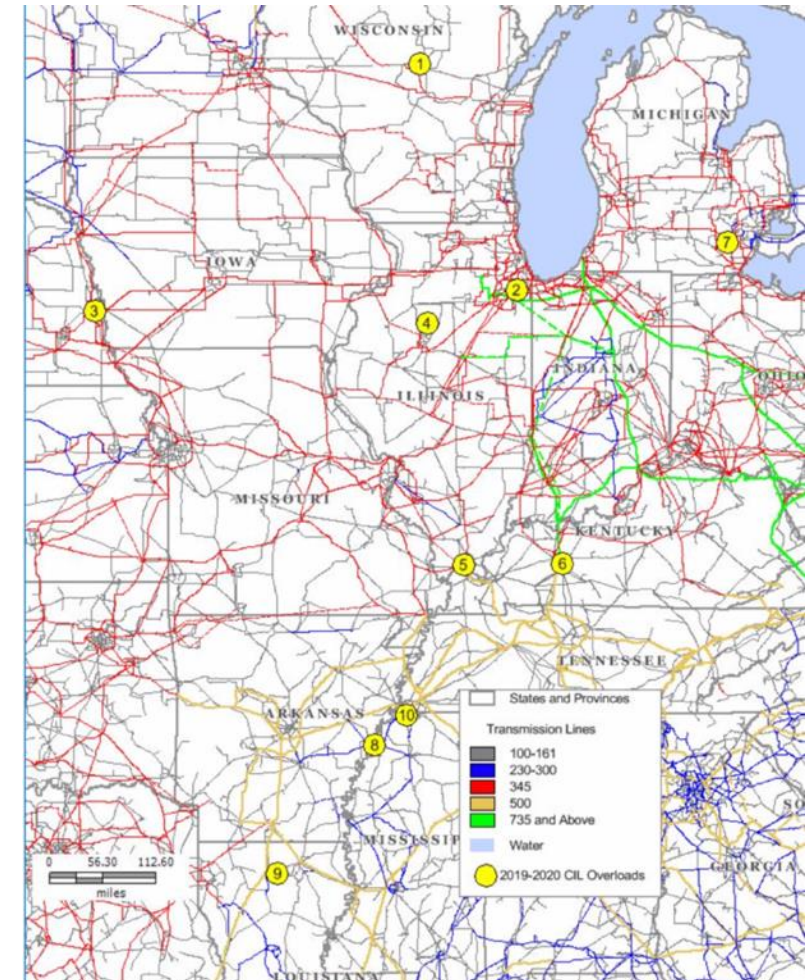
- More open-source models
- Commissions could require specific models (California used to require Elfin; public hearings on algorithms)
- Intervenors in regulatory process could be granted (confidential) access to utility models and data (example, PNM's recent San Juan retirement case)

Valuing diversity

- Many aspects can be evaluated with a production simulation/production cost model
 - Alternative renewable mix, locations
- Can be difficult and time-consuming
- Measure as “delta” from base case
- Some time periods are too short for the model
 - Assess regulation based upon separate analysis
- Transmission benefits are perhaps the most difficult to accurately measure

Transmission benefits

- Reliability benefit
 - Reduction in “lost load” can be economically evaluated
 - Qualitative reliability assessment (see <https://www.caiso.com/Documents/QualitativeAssessment-PotentialReliabilityBenefits-WesternEnergyImbalanceMarket.pdf> for a good example)
- Market benefit
 - Evaluated with production cost model (<https://www.nrel.gov/docs/fy13osti/57115.pdf>)
- Avoided capacity additions
 - Evaluated with LOLP model and/or production cost model (<https://www.nrel.gov/docs/fy12osti/56219.pdf>)



MISO 2019-2020 Planning Import
Constraint Map from LOLEWG Report

Summary

- Diversity is a critical attribute of power systems
- It can sometimes be evaluated directly
- Potential modeling solutions should have diversity as an option
 - Renewable location, technology type, etc.
- Transmission can unlock significant potential





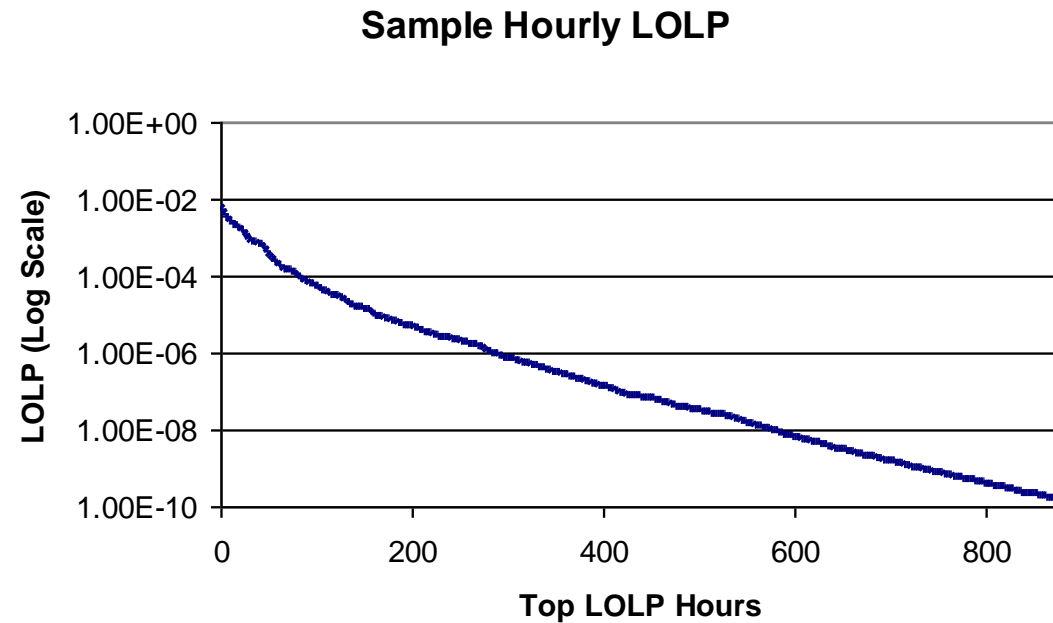
Potential of dispatchable demand
(if time)

Can DR “fix” times of reliability stress?

- Most days/hours have 0 LOLE
- Few (~300-ish) hours of notable risk



NREL Pix Building
Technologies / 23095.JPG



Example of DR providing regulation

- The following example is intended to show the powerful impact of resource diversity – how can many disparate resources be combined to produce the regulation needed by the power system operator
- This type of aggregation may be possible for many other grid services, including balancing
- “Everybody doesn’t have to supply everything.”
- *Scroll thru these slides*

DR can also provide regulating reserves

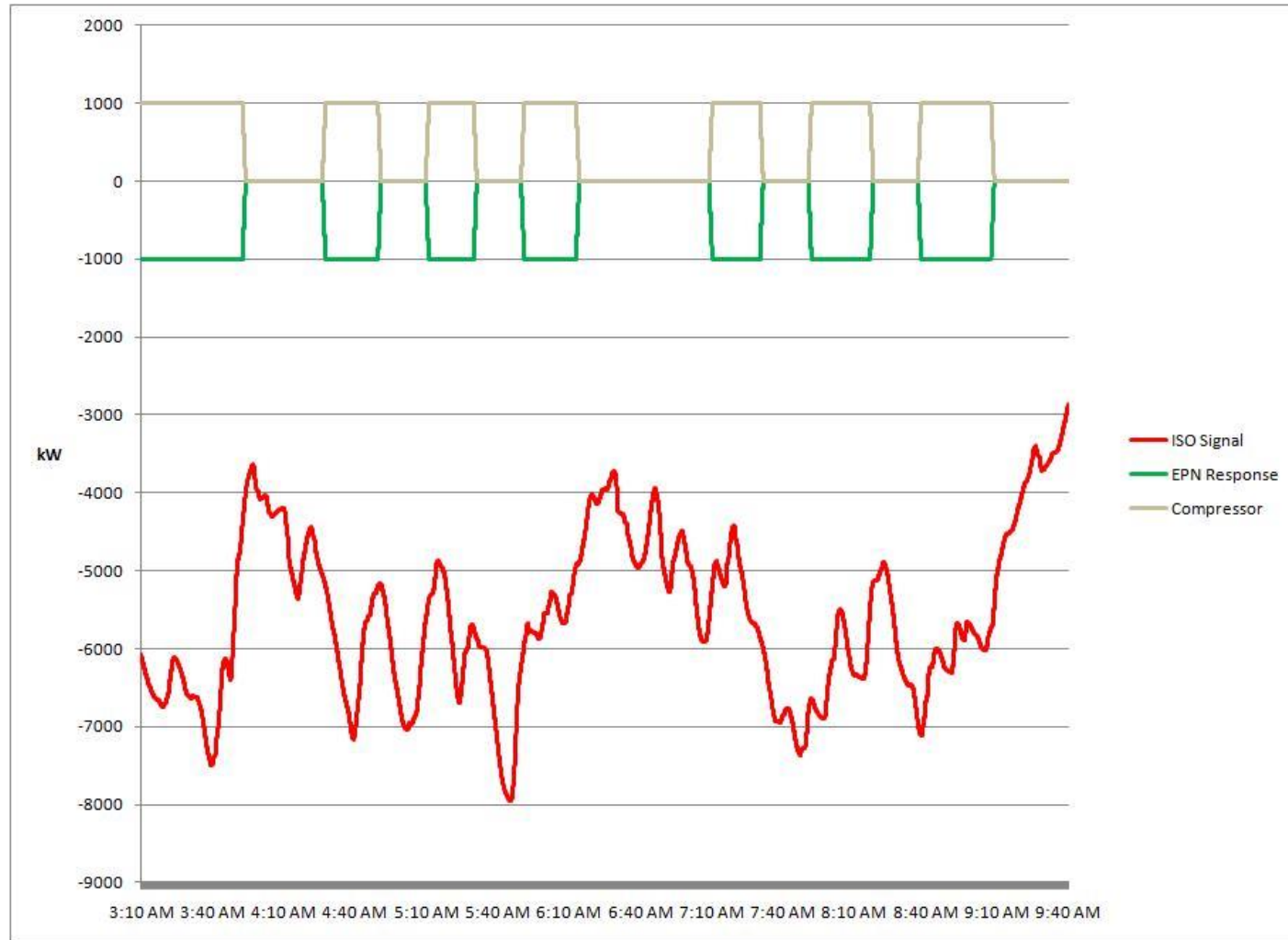


This slide is beginning of simple animation of composite DR response

— ISO Signal
— EPN Response

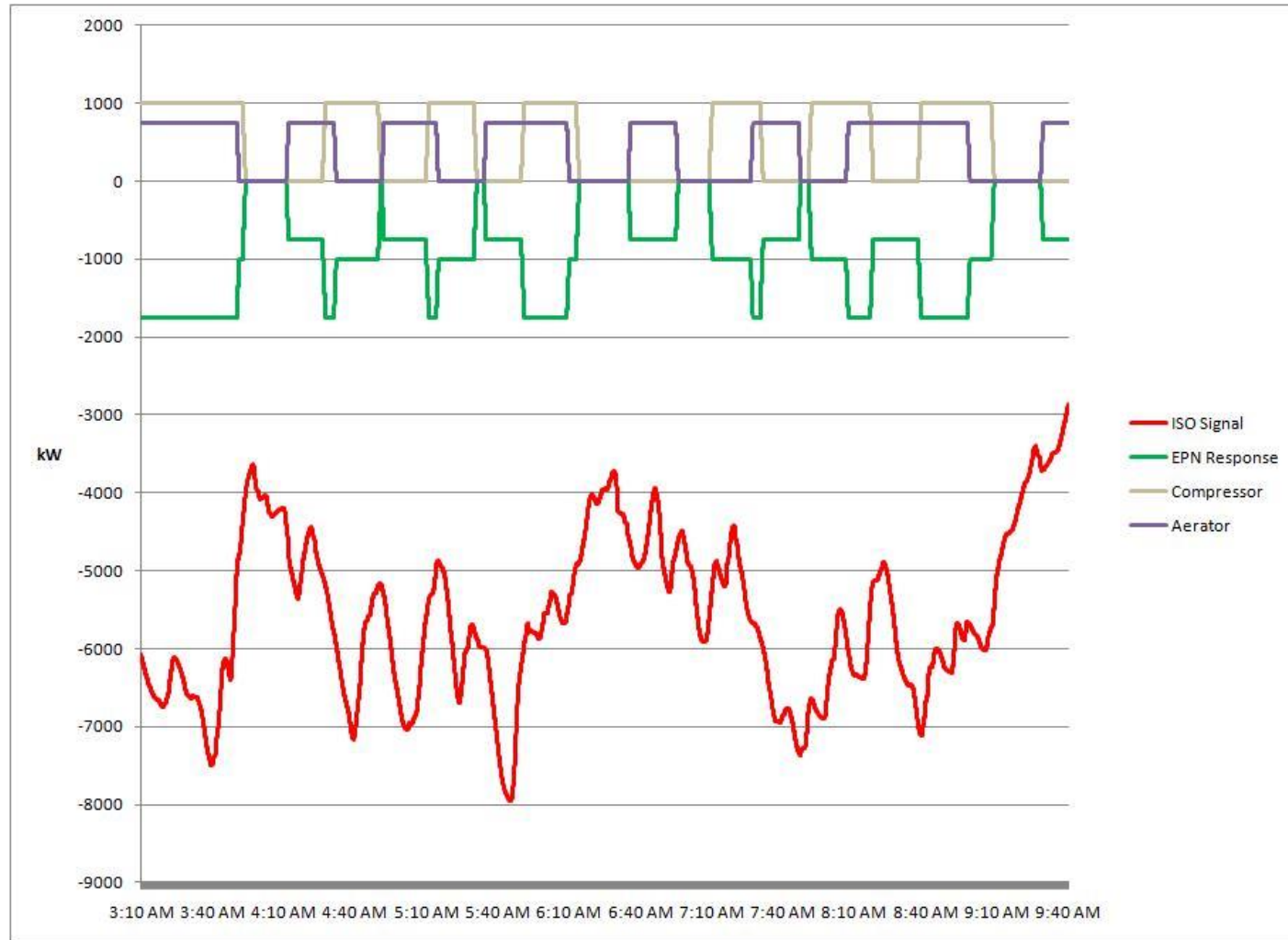
<http://enbala.com/solutions.html>

Resource Response



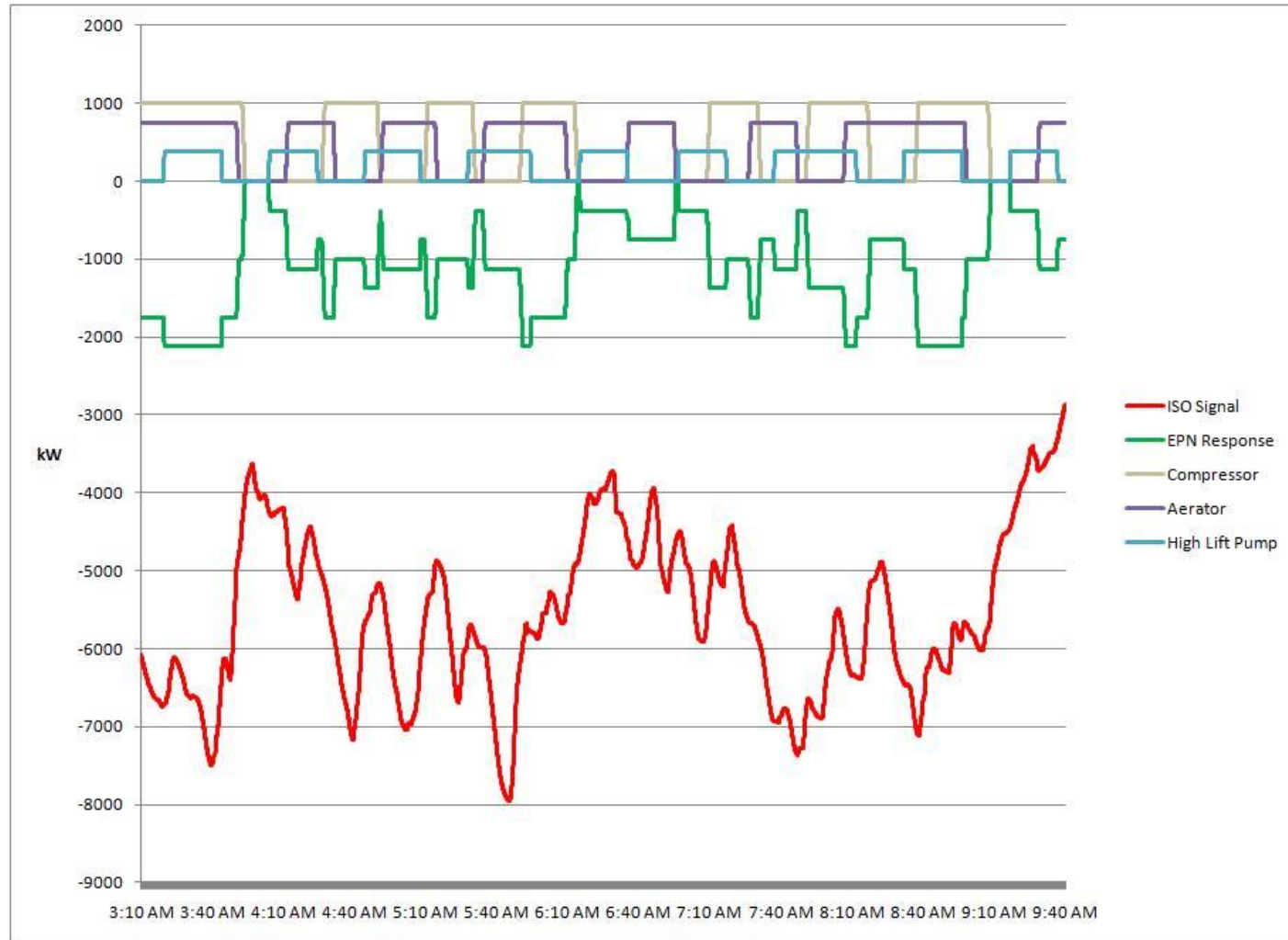
<http://enbala.com/solutions.html>

Resource Response



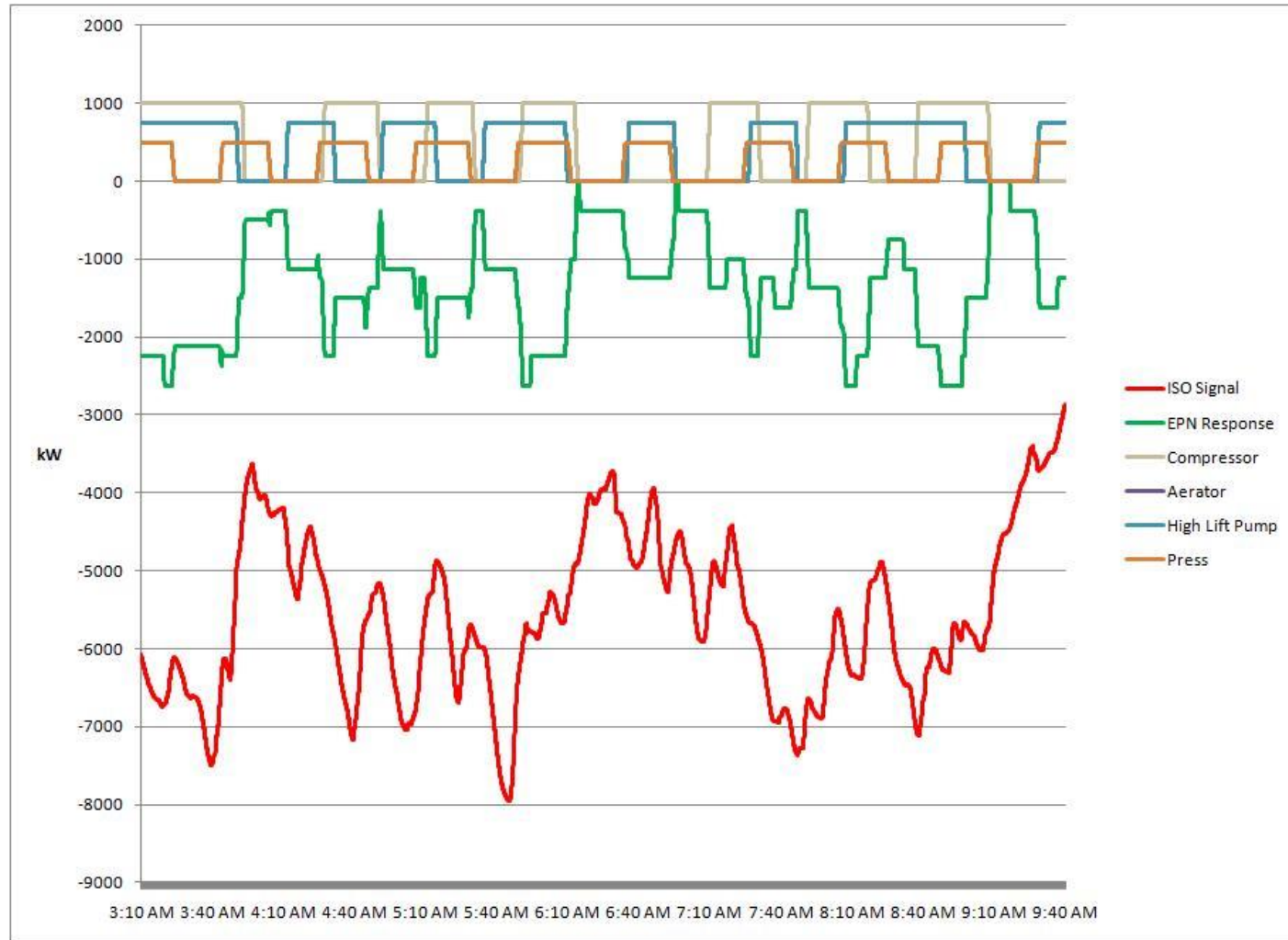
<http://enbala.com/solutions.html>

Resource Response



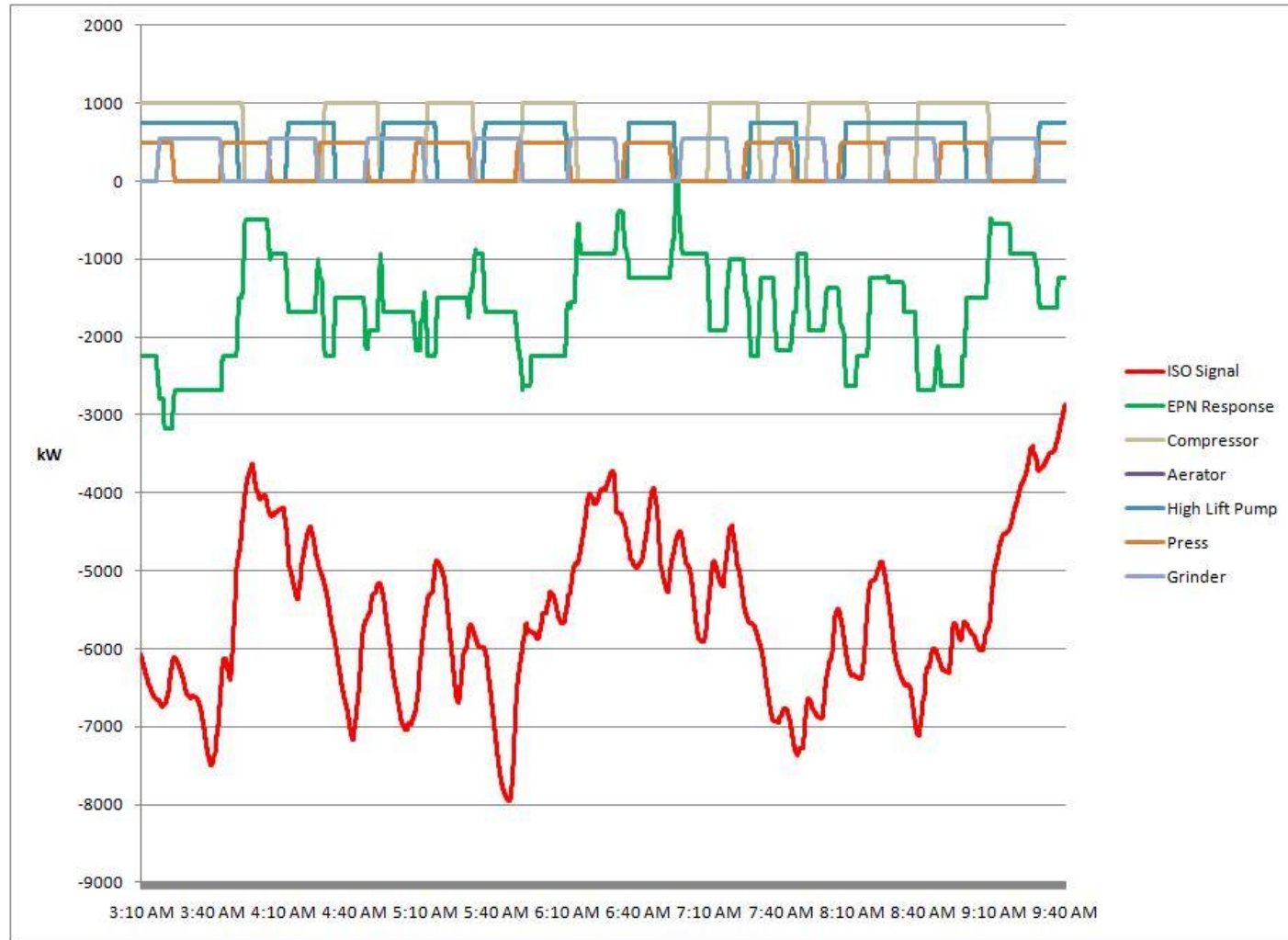
<http://enbala.com/solutions.html>

Resource Response



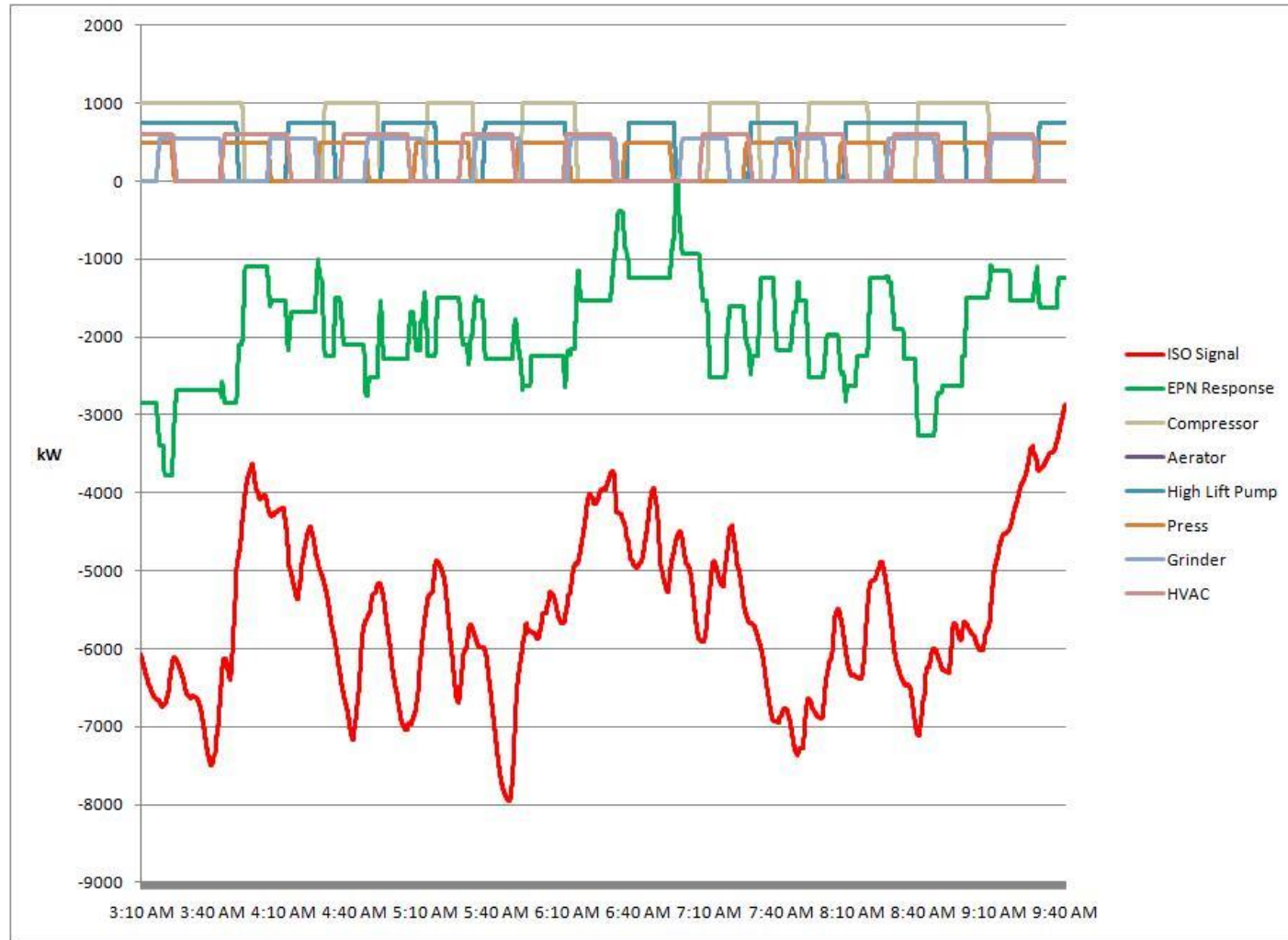
<http://enbala.com/solutions.html>

Resource Response



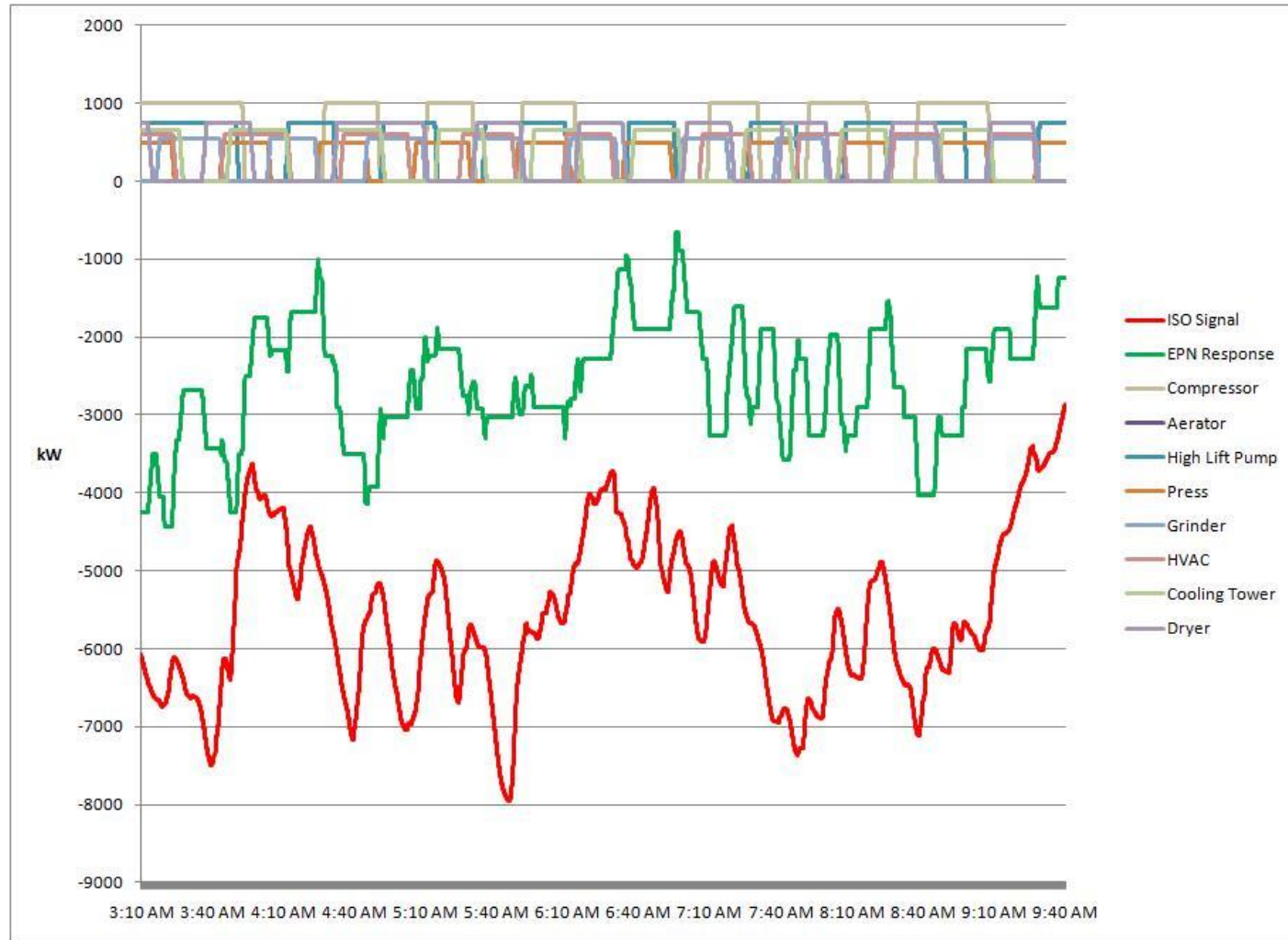
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Resource Response



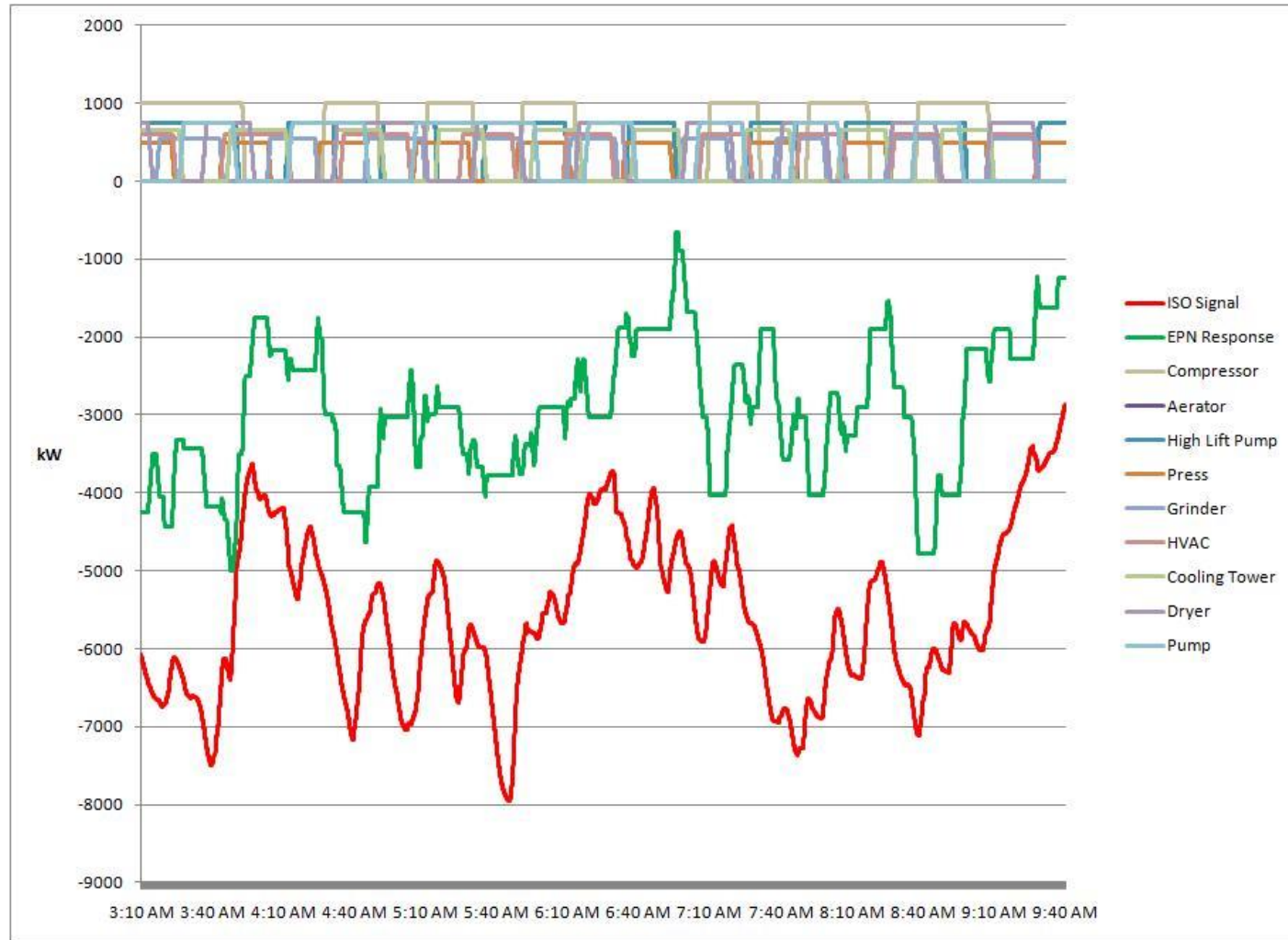
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Resource Response



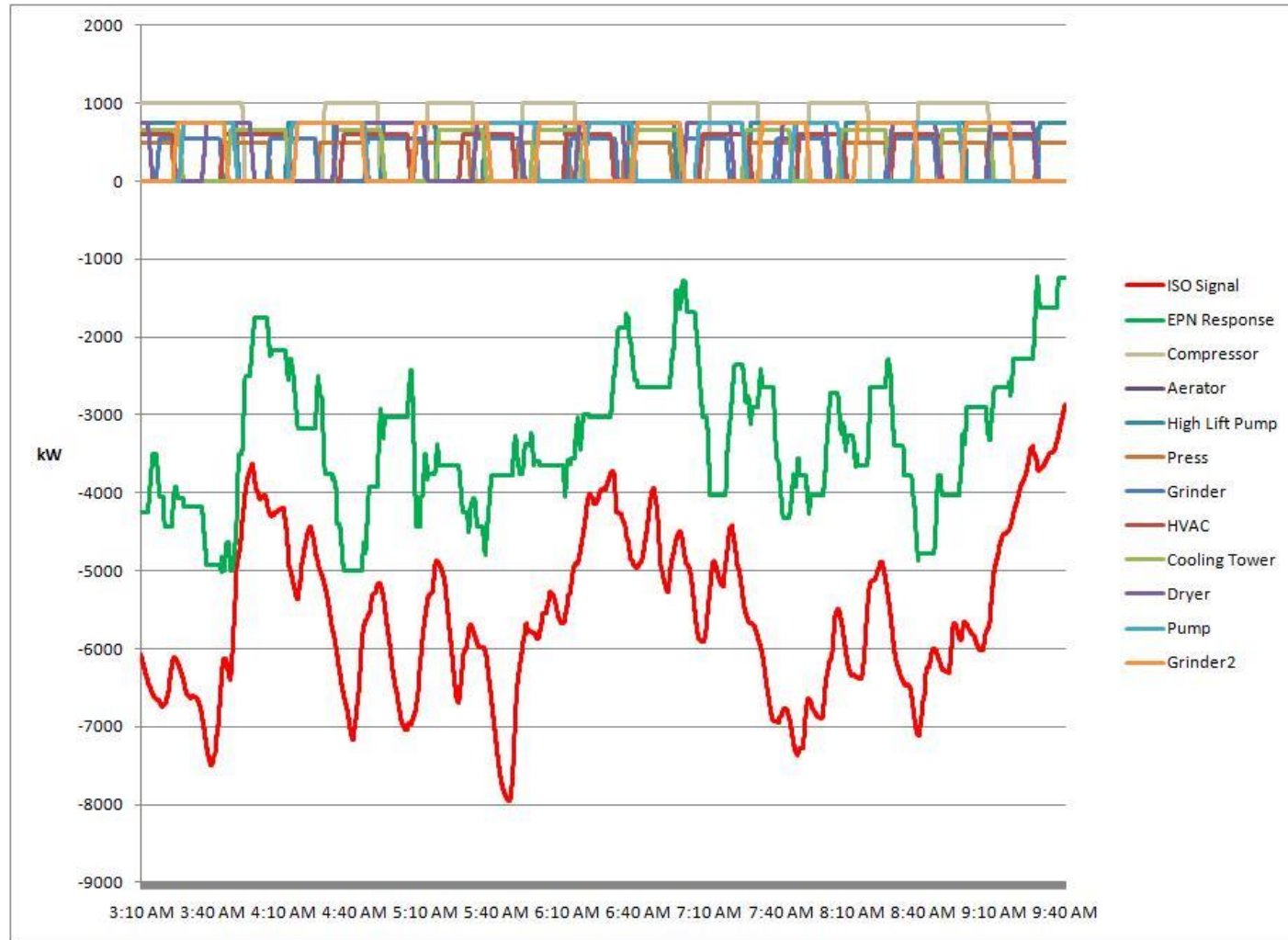
<http://enbala.com/solutions.html>

Resource Response



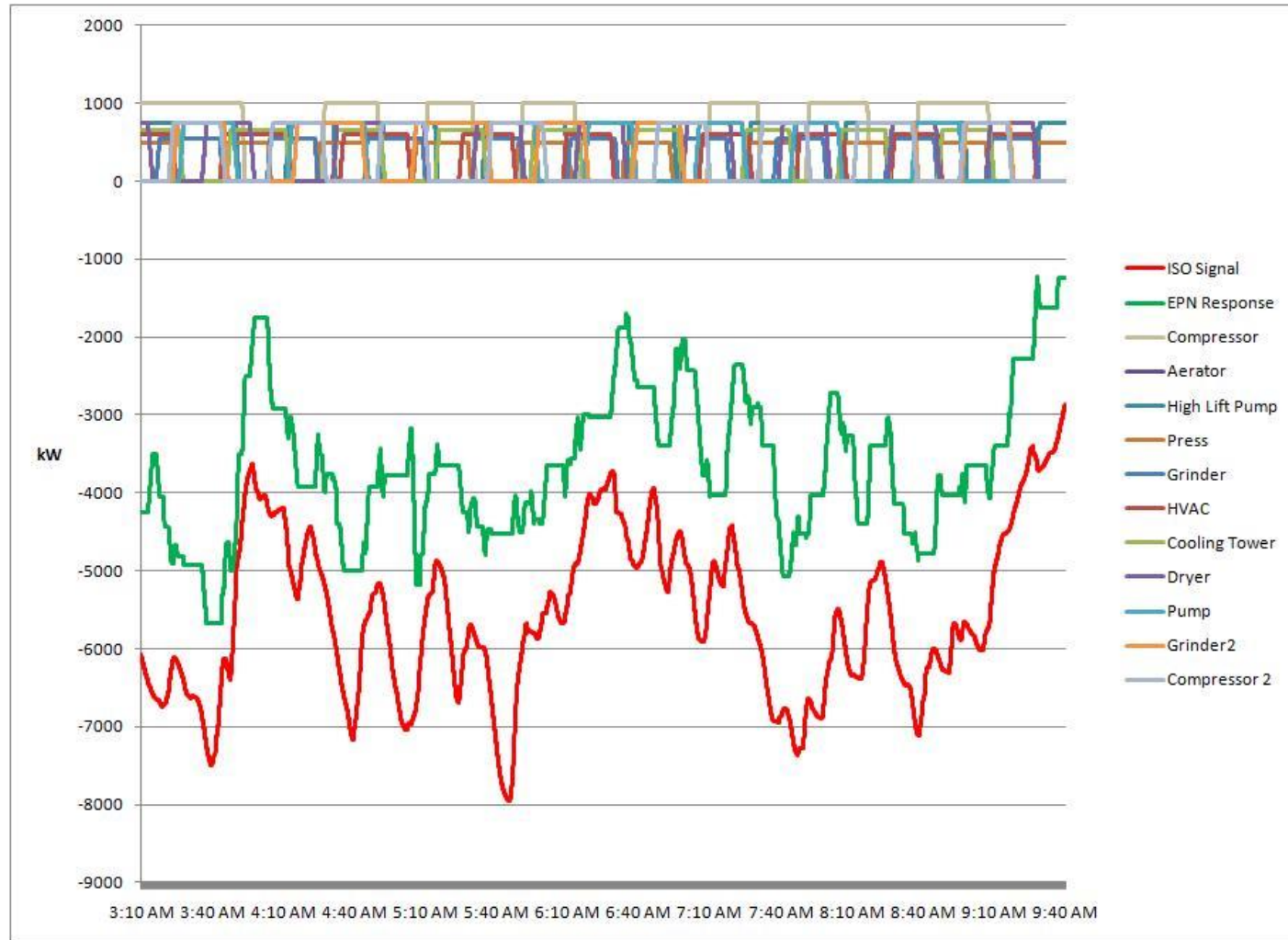
<http://enbala.com/solutions.html>

Resource Response



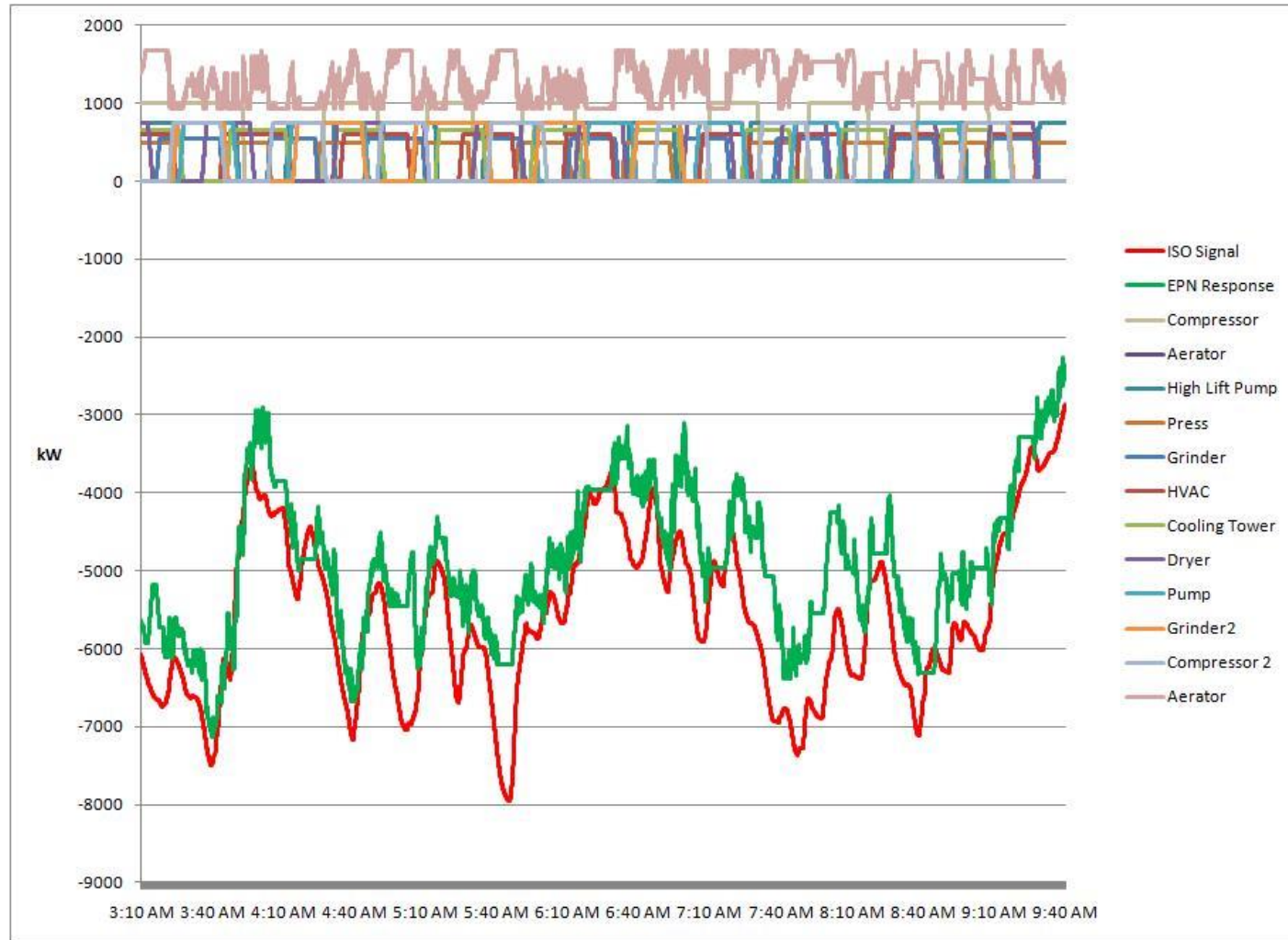
<http://enbala.com/solutions.html>

Resource Response



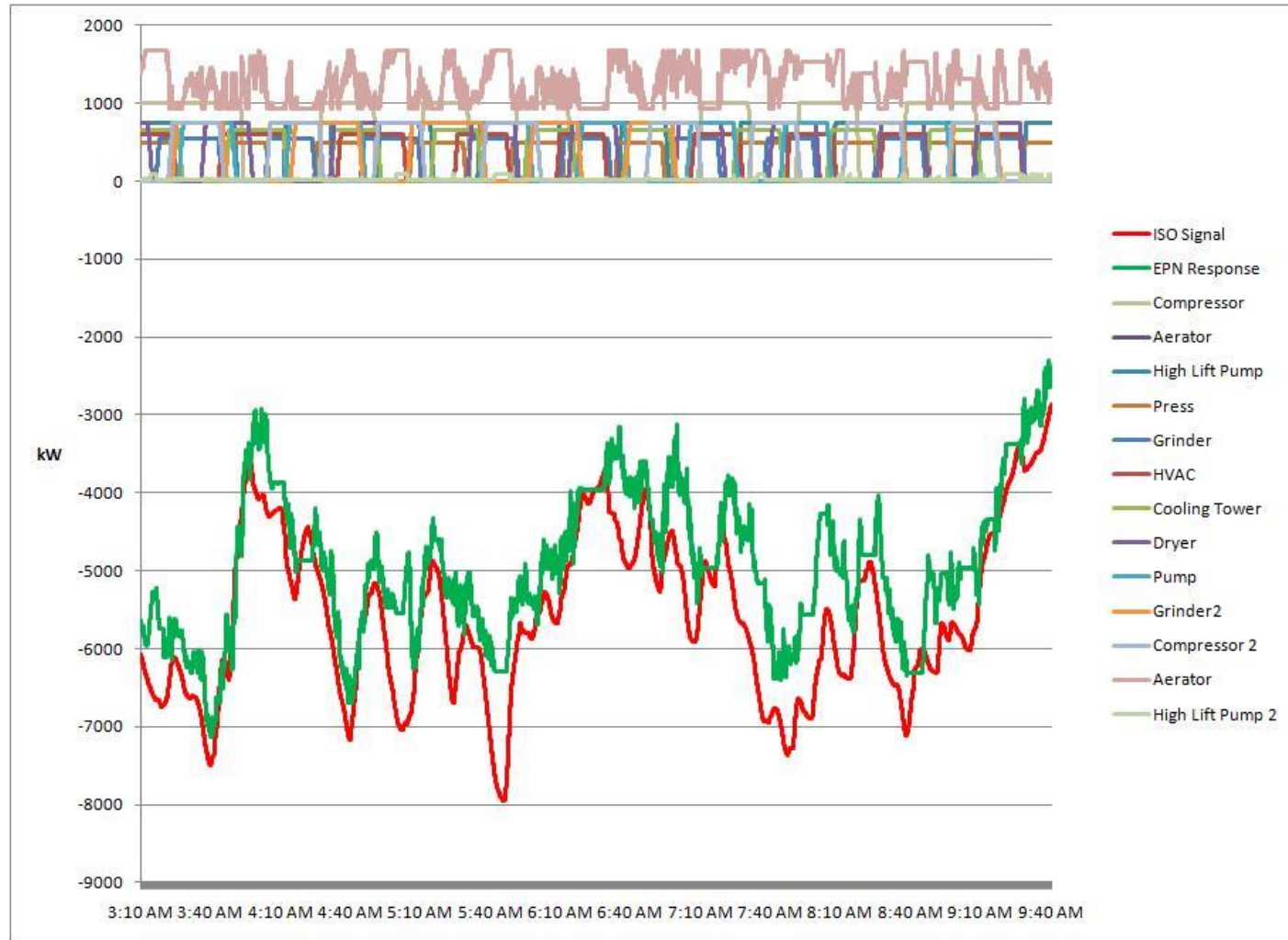
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Resource Response



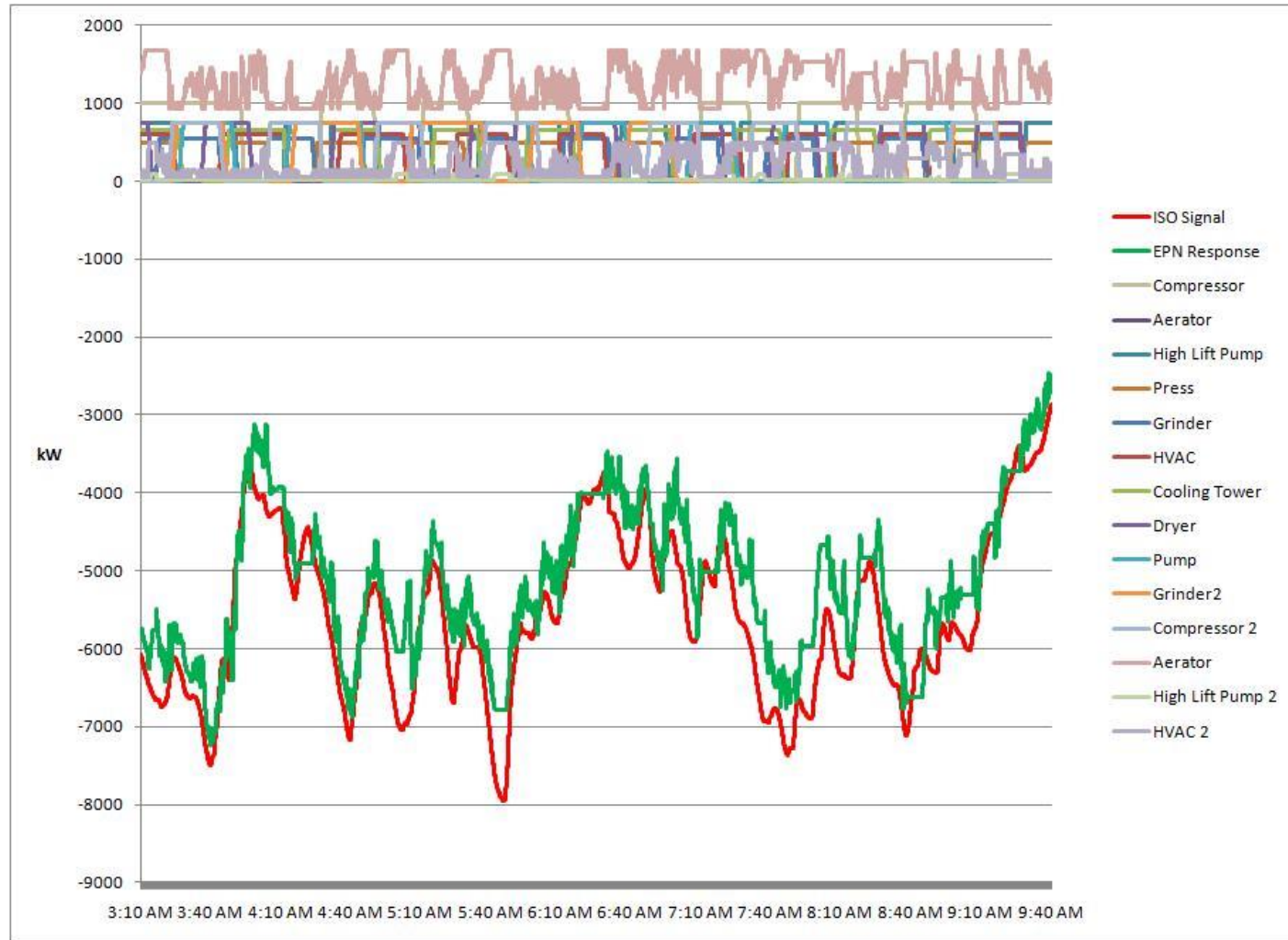
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Resource Response



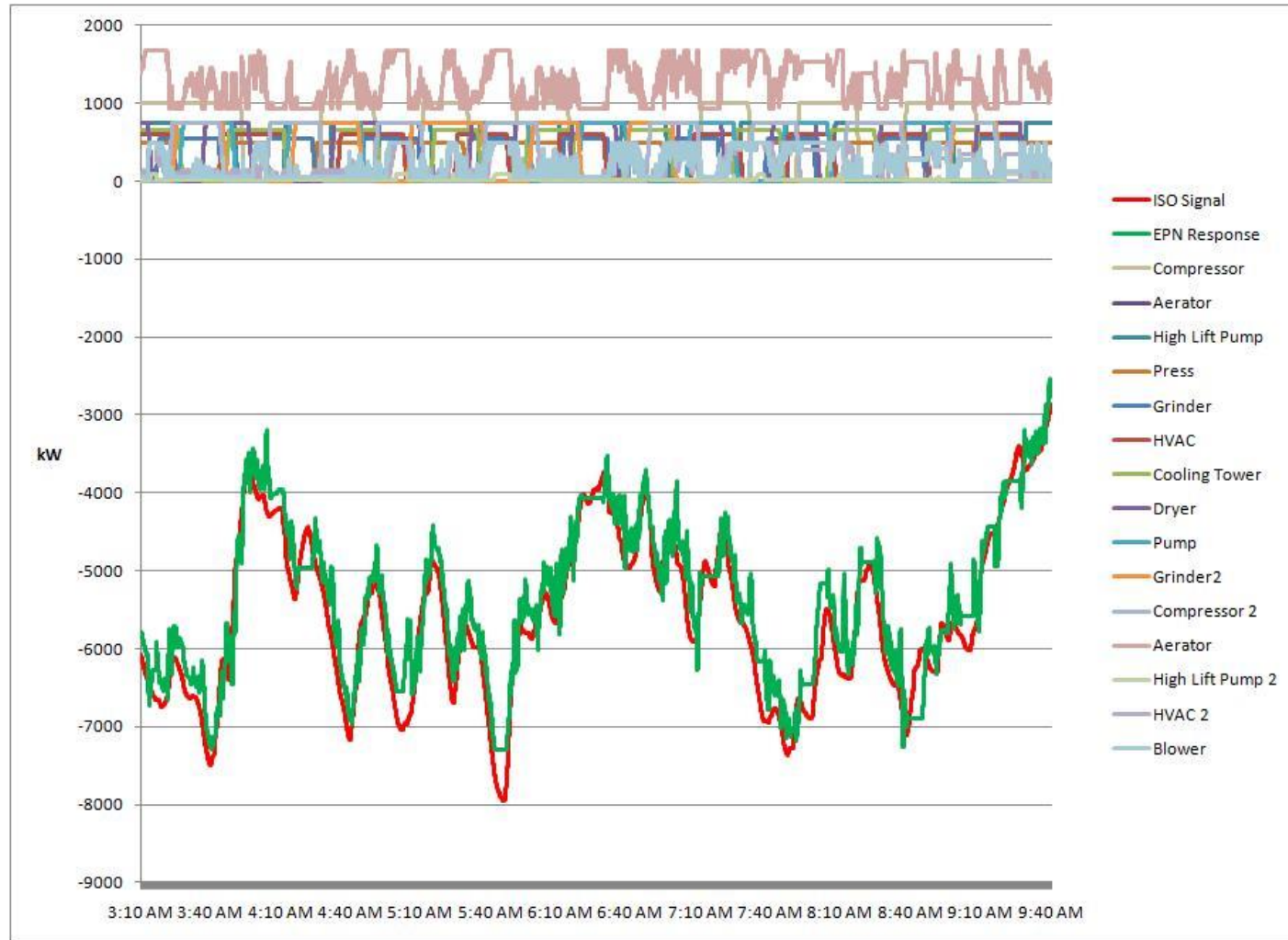
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Resource Response



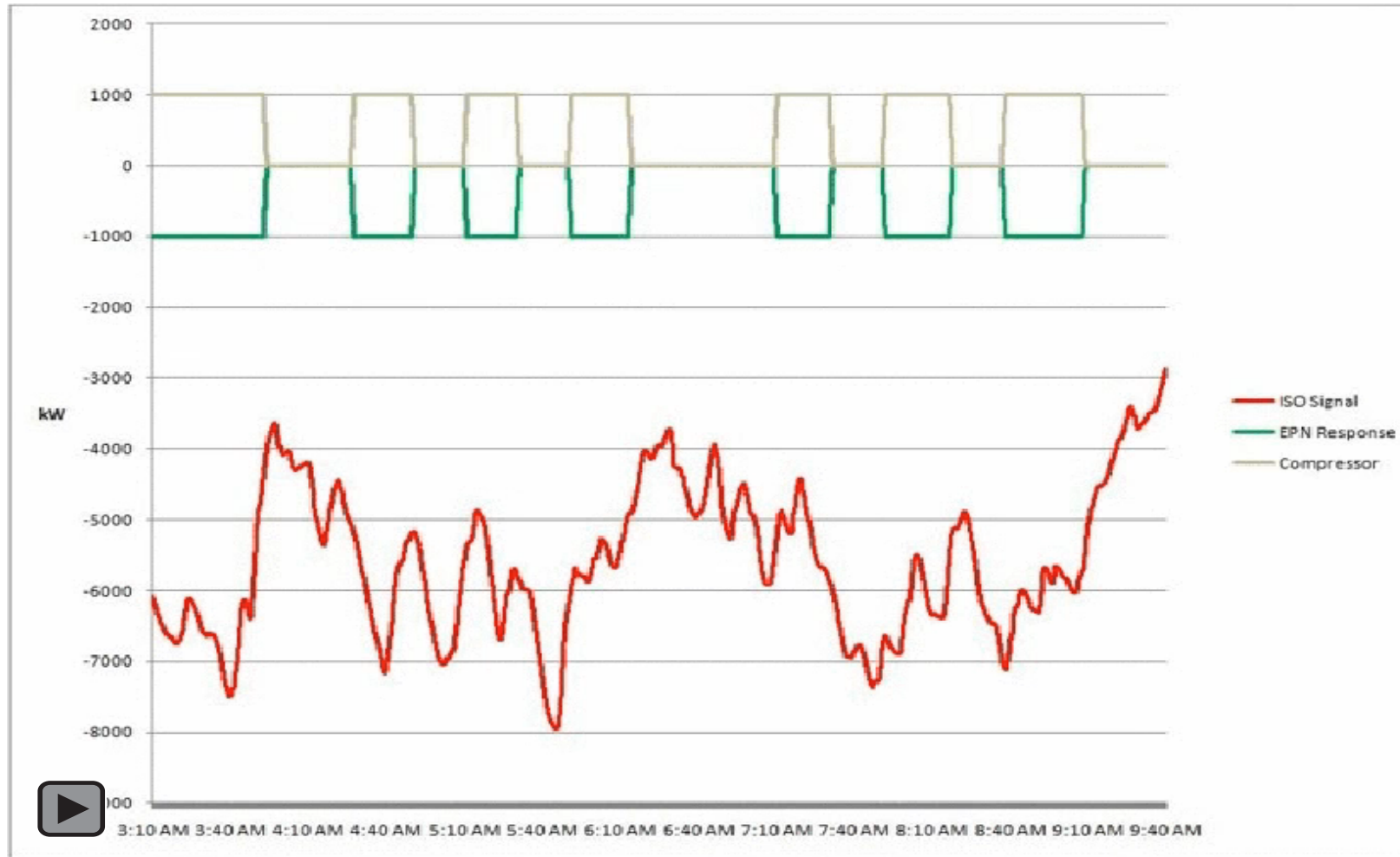
<http://enbala.com/solutions.html>

Resource Response



<http://enbala.com/solutions.html>

Regulation – Resource Response



The aggregate response of each resource in the network is compiled to form the regulation response

<http://enbala.com/solutions.html>

Composition of resources

- The Enbala regulation example is compelling
- How can this be translated to other grid services, and to longer time frames?

Questions?



Michael Milligan
www.milligangridsolutions.com



Making the Most of Michigan's Energy Future

5 Minute Break

Please mute your microphone and turn off your camera during break.



MPSC

Michigan Public Service Commission

Using Portfolio Risk Analysis to Value Resource Diversity

Tom Eckman

Consultant to Berkeley Lab

February 9, 2021

Presented to the 7th Michigan Power Grid Advanced Planning Meeting

This presentation was supported by the U.S. Department of Energy's Office of Electricity under Lawrence Berkeley National Laboratory Contract No. DE-AC02-05CH11231.



Why Resource Diversity?

- Conventional Wisdom:

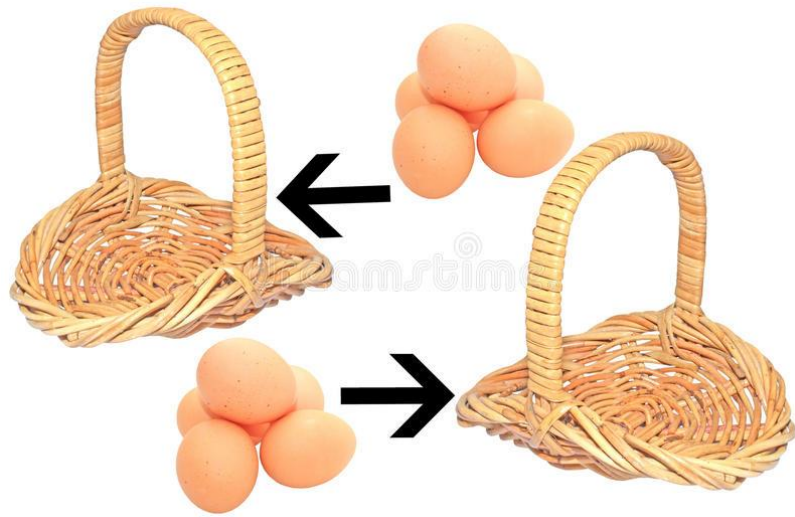
“Don’t put all your eggs in one basket”

Implication: *Diversity* must have some value for *risk mitigation*.

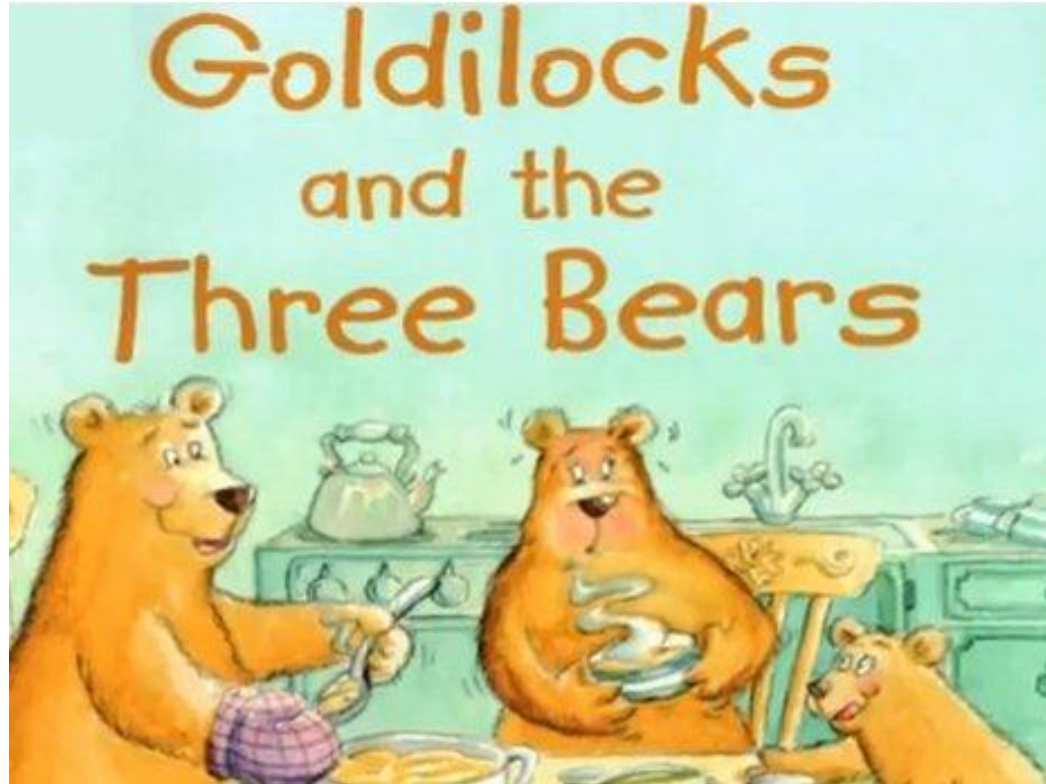
- Rationale from Ecology:

Diverse ecosystems are **resilient** because they contain more species, which means there is a *higher probability* that one of them will have traits that enable them to adapt to a *changing* environment.

How Much Diversity Is Enough?



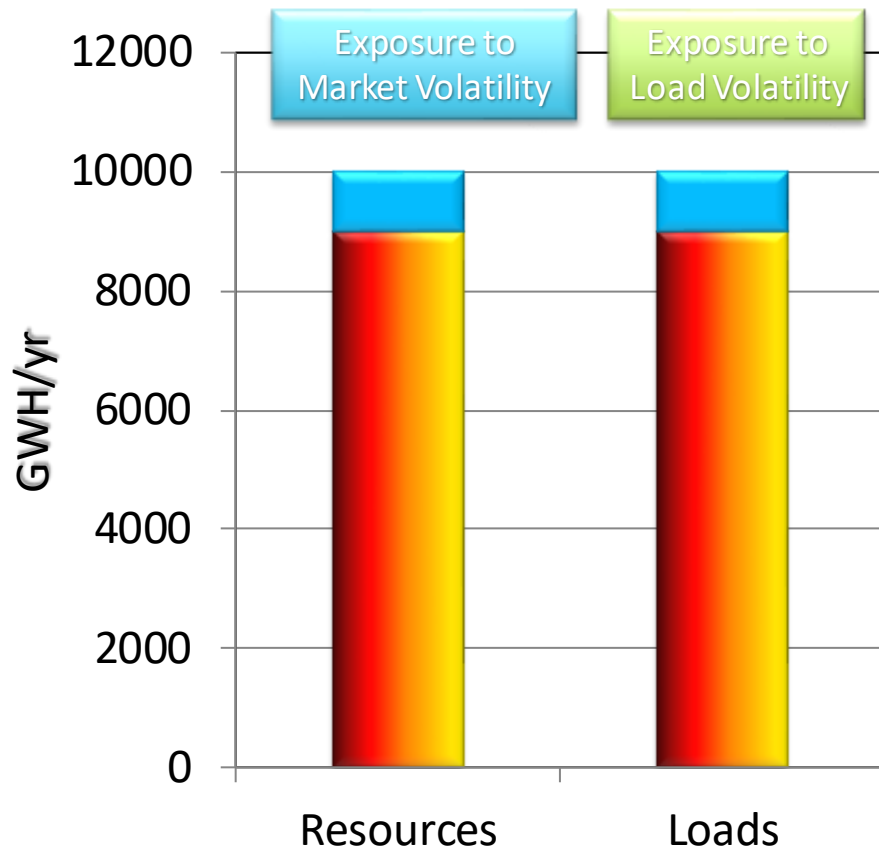
That's a Resource Planner's Problem



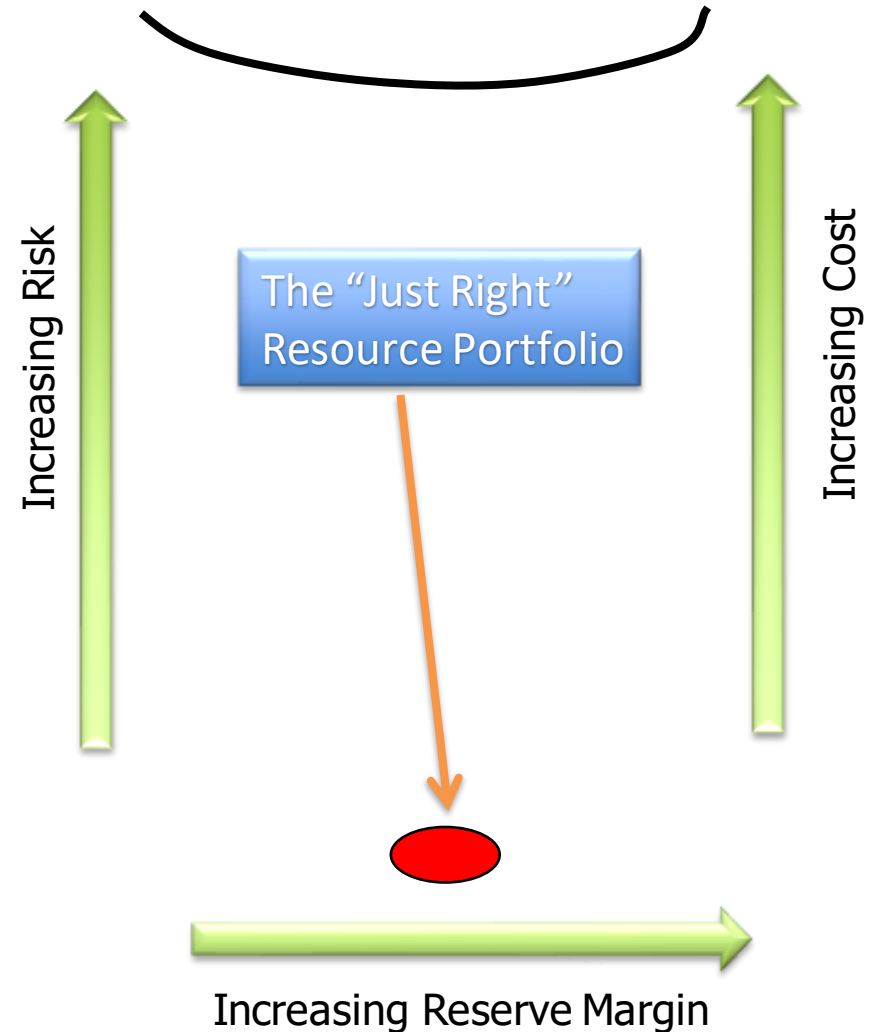
- Don't have too many resources
- Don't have too few resources
- Have “just the right amount” of resources*

**The “right amount” means not only the quantity developed, but the timing of their development and the mix (type) of resources required to provide energy, capacity, flexibility, and other ancillary services for system reliability, including risk management and resilience.*

Solving the “Goldilocks’ Problem” Requires Analysis Comparing **Cost** and *Risk* of Alternative Resource Options



- Market Purchases/New Resources
- Firm Contracts/Existing Resources



This Analysis Must Answer 5 “Simple” Questions.

- 1. When will we need resources?*
- 2. How much will we need?*
- 3. What should we build/buy?*
- 4. How much will it cost?*
- 5. What's the risk?*

Uncertainty and Risk Means Managing the Unknowns

As we know,
There are known knowns.
There are things we know we know.
We also know
There are known unknowns.
That is to say
We know there are some things
We do not know.
But there are also unknown unknowns,
The ones we don't know
We don't know.



*Donald Rumsfeld. Feb. 12, 2002,
Department of Defense news
briefing*

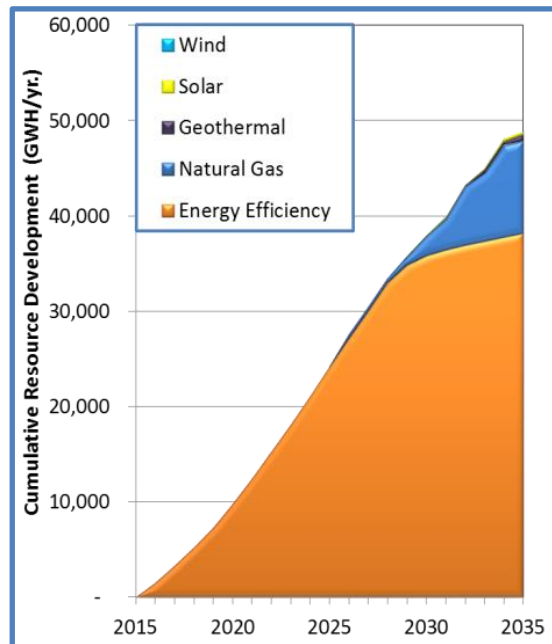
Major Sources of Uncertainty

- **Load Uncertainty**
 - Business cycles (e.g., post-2008 recession, COVID-19)
 - Technology “shifts” (e.g., electrification of transportation, distributed generation)
- **Resource Uncertainty**
 - Output (e.g., prolonged outages due to terrorist action, storms)
 - Cost
 - Construction lead times (e.g., pumped storage, transmission expansion)
 - Technology change (e.g., declining cost of renewables, batteries)
- **Wholesale Electricity Market Price Uncertainty**
- **Regulatory Uncertainty (e.g., required reductions in GHG emissions)**

Answering the *Timing, Amount, Type, Cost* and *Risk* Questions Requires Capacity Expansion Modeling and Risk Analysis

Resource Strategies – actions and policies over which the decision maker *has control* that will affect the outcome of decisions (i.e., “**the knowns**”)

Futures – circumstances over which the decision maker *has no control* that will affect the outcome of decisions (i.e., “**the unknowns**”)



- Load Uncertainty
 - Business cycles (e.g., post-2008 recession, Covid-19)
 - Technology “Shifts” (e.g., electrification of transportation, distributed generation)
- Resource Uncertainty
 - Output (e.g., prolonged outages due to terrorist action, storms)
 - Cost
 - Construction Lead Times (e.g., pumped storage, transmission expansion)
 - Technology Change (e.g., declining cost of renewables, batteries)
- Wholesale Electricity Market Price Uncertainty
- Regulatory Uncertainty (e.g., GHG emissions)



Scenarios – Combinations of *Resource Strategies* and *Futures* used to “stress test” how well what we control performs in a world we don’t control

Capacity Expansion Models – Very High Level Overview

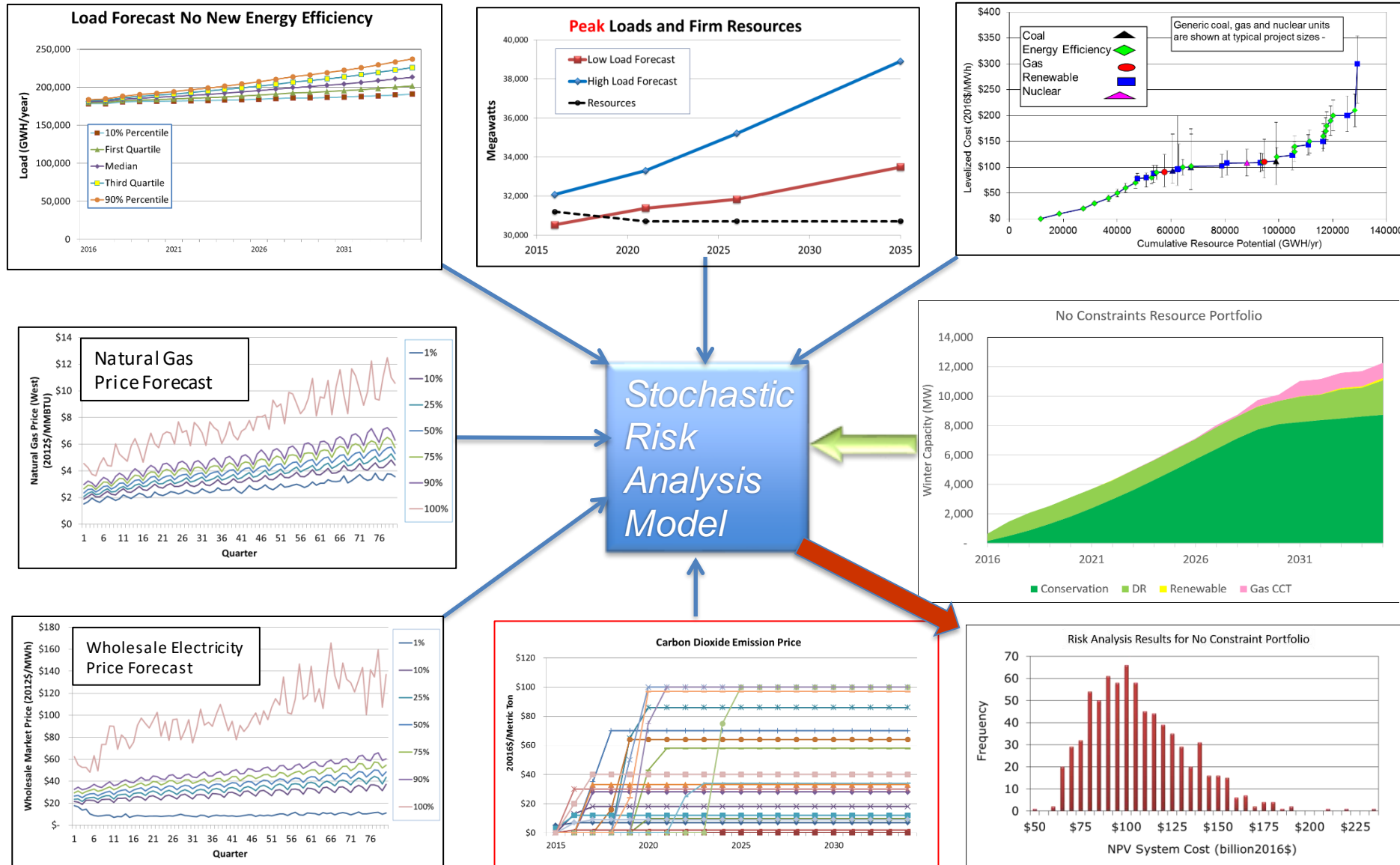
- Evolved from Production Costing/Market Equilibrium models
- Designed to “optimize” the type, amount, and timing of new resource development using assumptions about future load growth, fuel prices, resource characteristics and availability, policies and regulations cy
- Key differences between models
 - Time resolution (e.g., sub-hourly, hourly, daily, weekly)
 - Unit commitment (e.g., chronological or based on load duration curve)
 - Transmission and power flow (pipe flow or DC)
 - Treatment of uncertainty

Resource Portfolio Optimization & Risk Assessment Methods

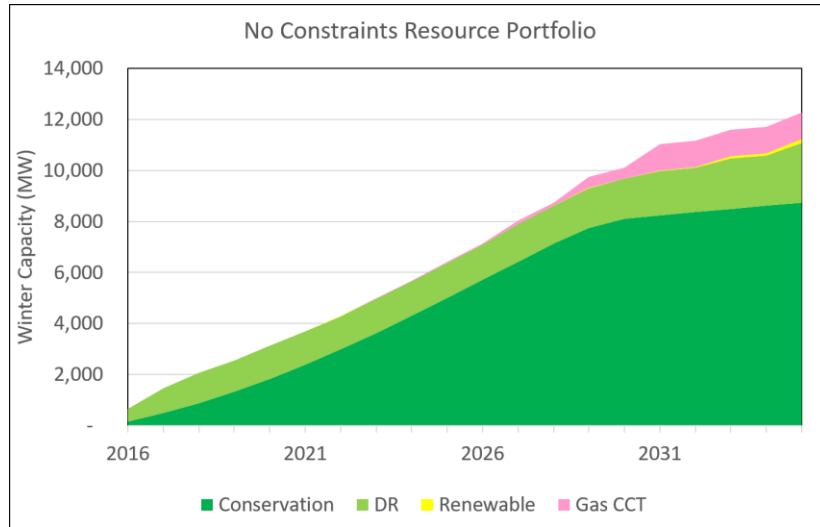
- Users* of Capacity Expansion Models (CEMs) employ different methods to optimize resource development plans and assess risk
 - **Most prevalent** - Deterministic modeling, followed by stochastic risk analysis
 - Optimization is done for a *single* future
 - Optimization produces a “resource portfolio” specifying the type, amount and schedule of resource development over a planning period.
 - Risk is quantified by stress testing the optimized resource portfolio against a wide range of alternative futures.
 - **Less prevalent** – Stochastic optimization (scenario analysis on steroids)
 - Optimization is done across *multiple* (100s) of futures using decision criteria for capacity expansion.
 - Optimization results in a “resource strategy” of options and decision criteria managing the type and schedule of resource development over planning periods as future conditions evolve over a planning period.
 - Risk is quantified based on the cost of “worst outcomes” across all futures tested.

*Commercially available CEMs can be run in “multiple modes.” Users determine which modes are used for optimization and whether other models and analyses are used in conjunction with the CEM to select their preferred resource plan.

Stochastic Risk Analysis of Resource Strategies Optimized for a Single Future



Average of the Inverse \neq Inverse of the Average

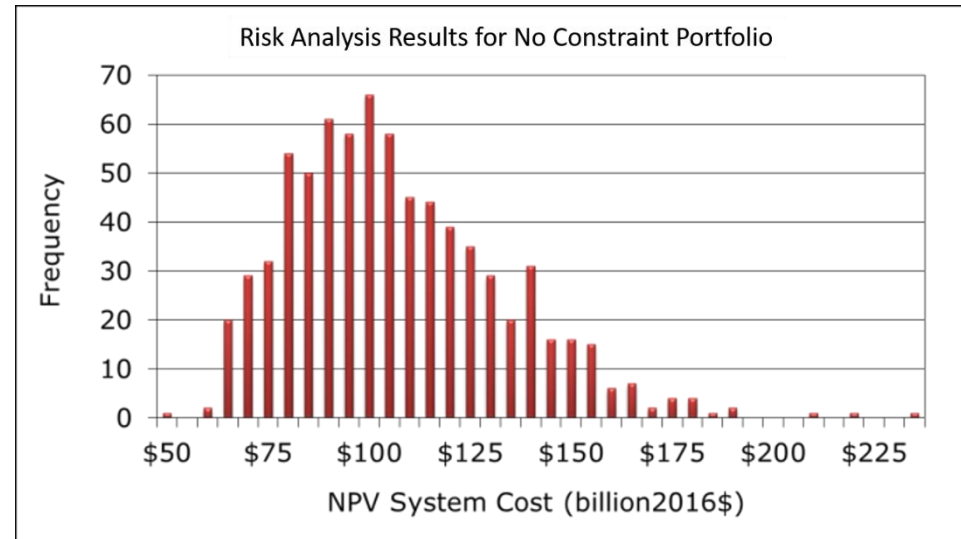


Capacity expansion modeling that optimizes resource portfolios for a *single* future.

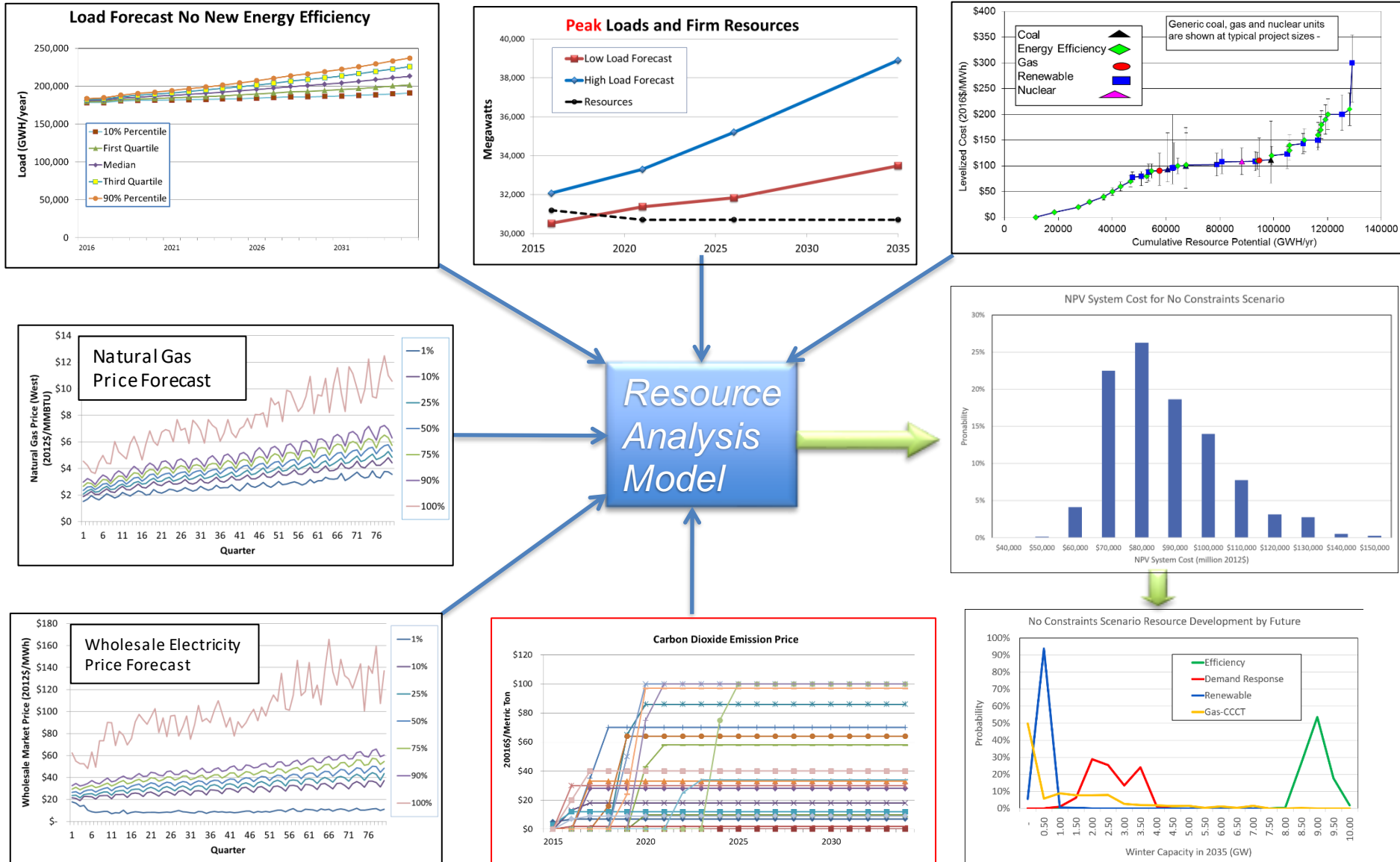
- Assumes control of not only all “known knowns,” but also the “known unknowns” and the “unknown unknowns.”
- This systematically likely *understates* risk, and therefore the value of risk mitigation and resilience.

Adding stochastic risk assessment permits testing resource portfolios optimized for a *single* future against a *wide range of alternative future conditions*.

- Replication is required to compare the risk of resource portfolios optimized for different sets of future conditions.
- This approach likely *overstates* risk, because the resource portfolio is not altered in response to future conditions for which it was *not* optimized.



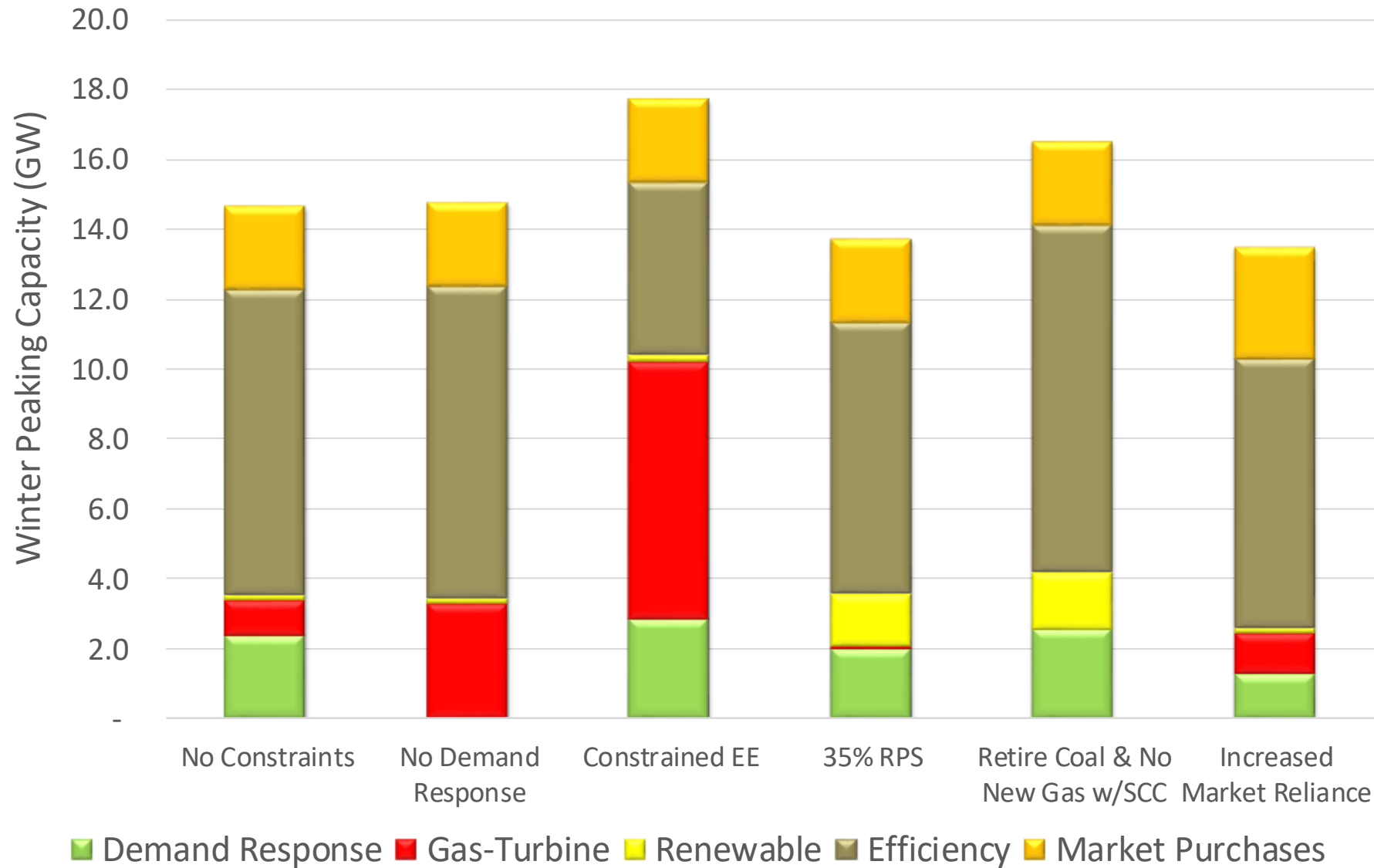
Stochastic Risk Analysis for Resource Strategies Optimized Across A Range of Future Conditions



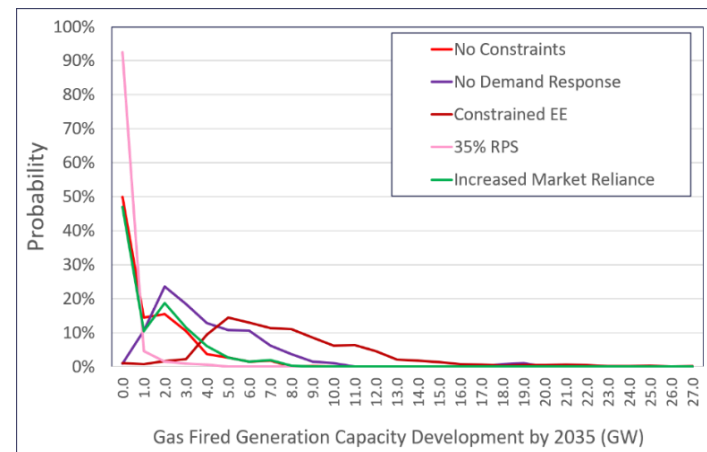
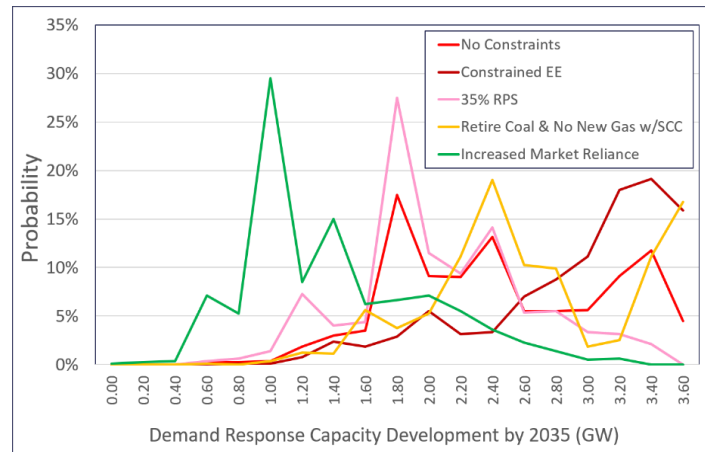
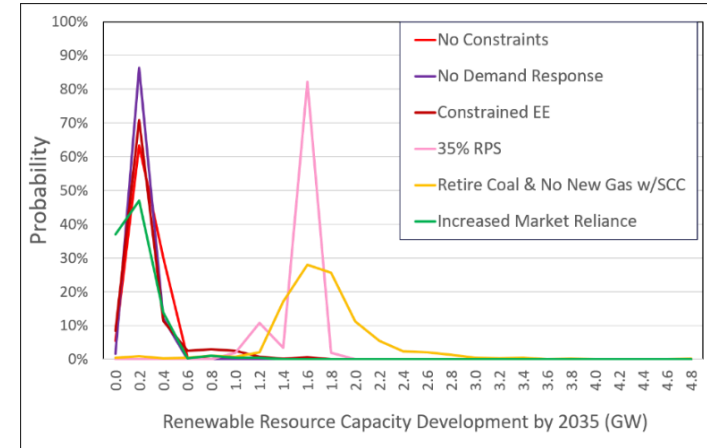
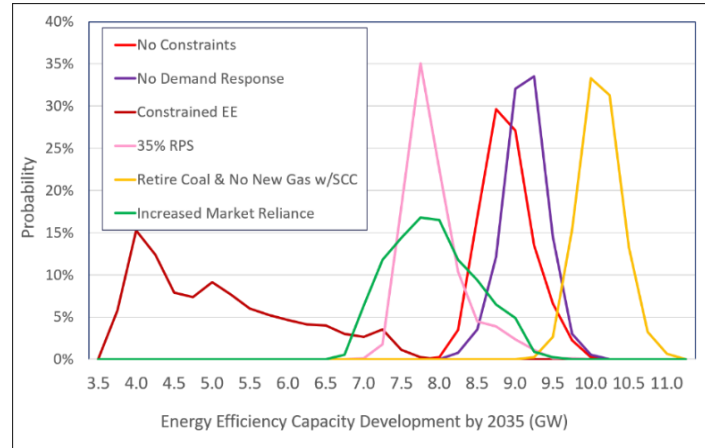
Illustrative Use of Stochastic Risk Analysis to Value Resource Diversity

- Compared five scenarios that varied resource development constraints (i.e., restricted diversity)
 - No resource selection constraints
 - No demand response resources
 - Constrained energy efficiency development by restricting cost-effectiveness to less than 60-month rolling average of market prices
 - Renewable Portfolio Standard at 35% regionwide
 - Retired all coal plants, permit no new gas-fired generation development, imposed GHG gas “tax” equivalent to social cost of carbon
- PLEASE NOTE:
 - Scenarios are from Northwest Power and Conservation Council’s Seventh Regional Power Plan
 - Reflect resource options and policies in PNW circa 2016
 - **YOUR MILEAGE MAY VARY!**

Expected Value Resource Diversity Varied by Scenario

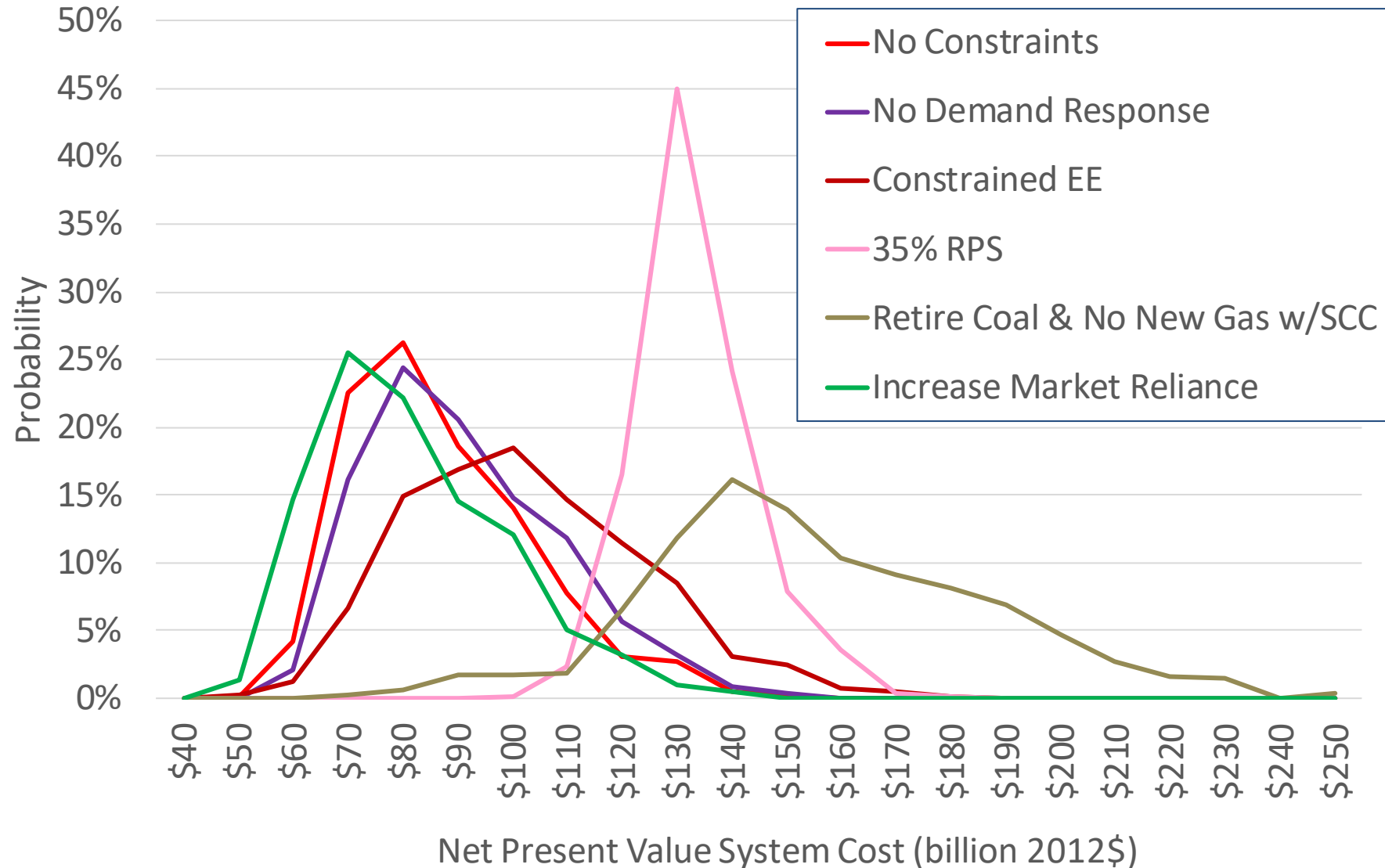


Council Method Optimizes Across Multiple Futures So It Varies Resource Development by Future to Reflect “Adaptive Management”

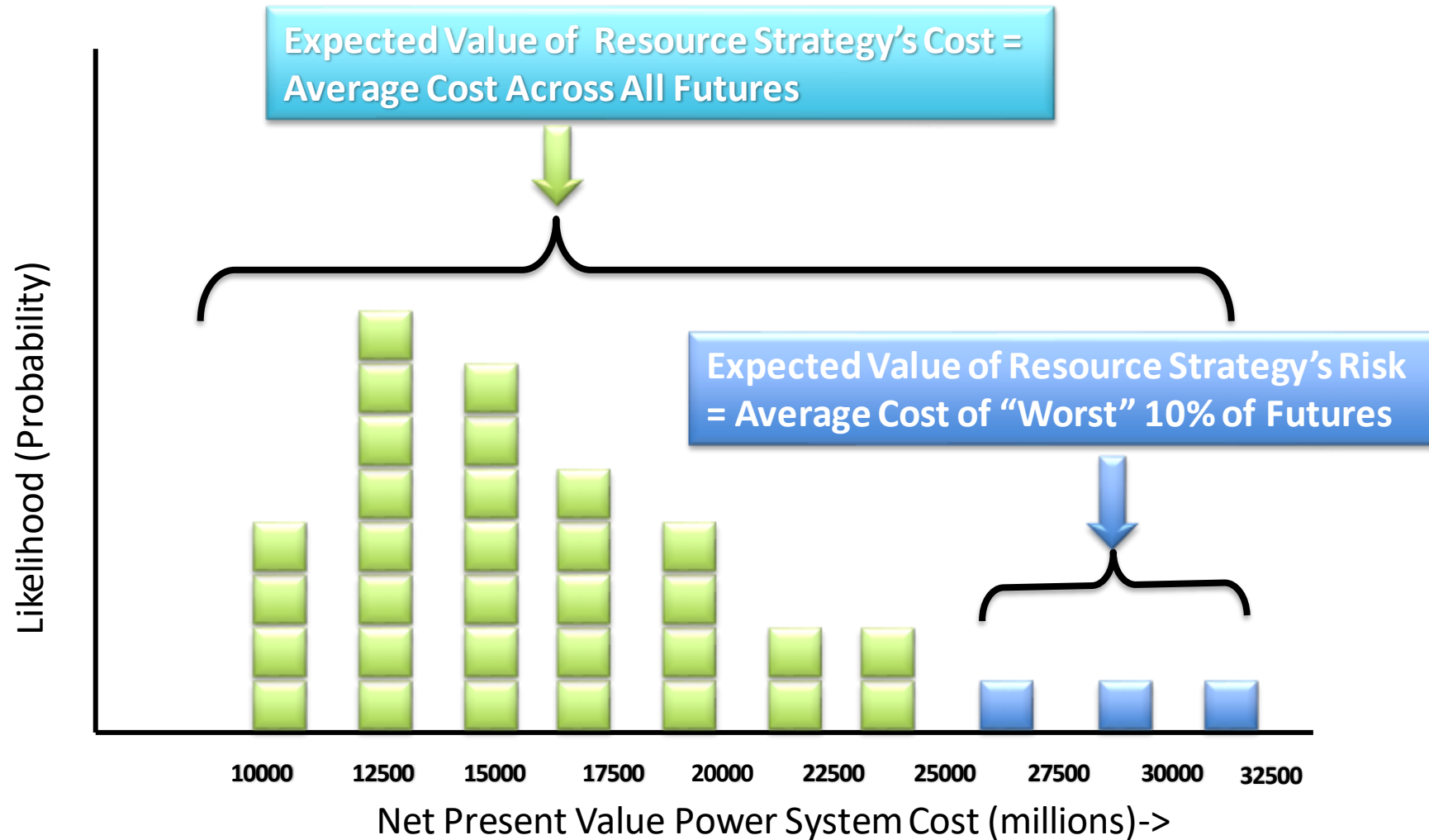


This method of stochastic risk analysis avoids driving into the river when you can see the bridge is out, just so you continue to follow Google Maps’ “Quickest Route”

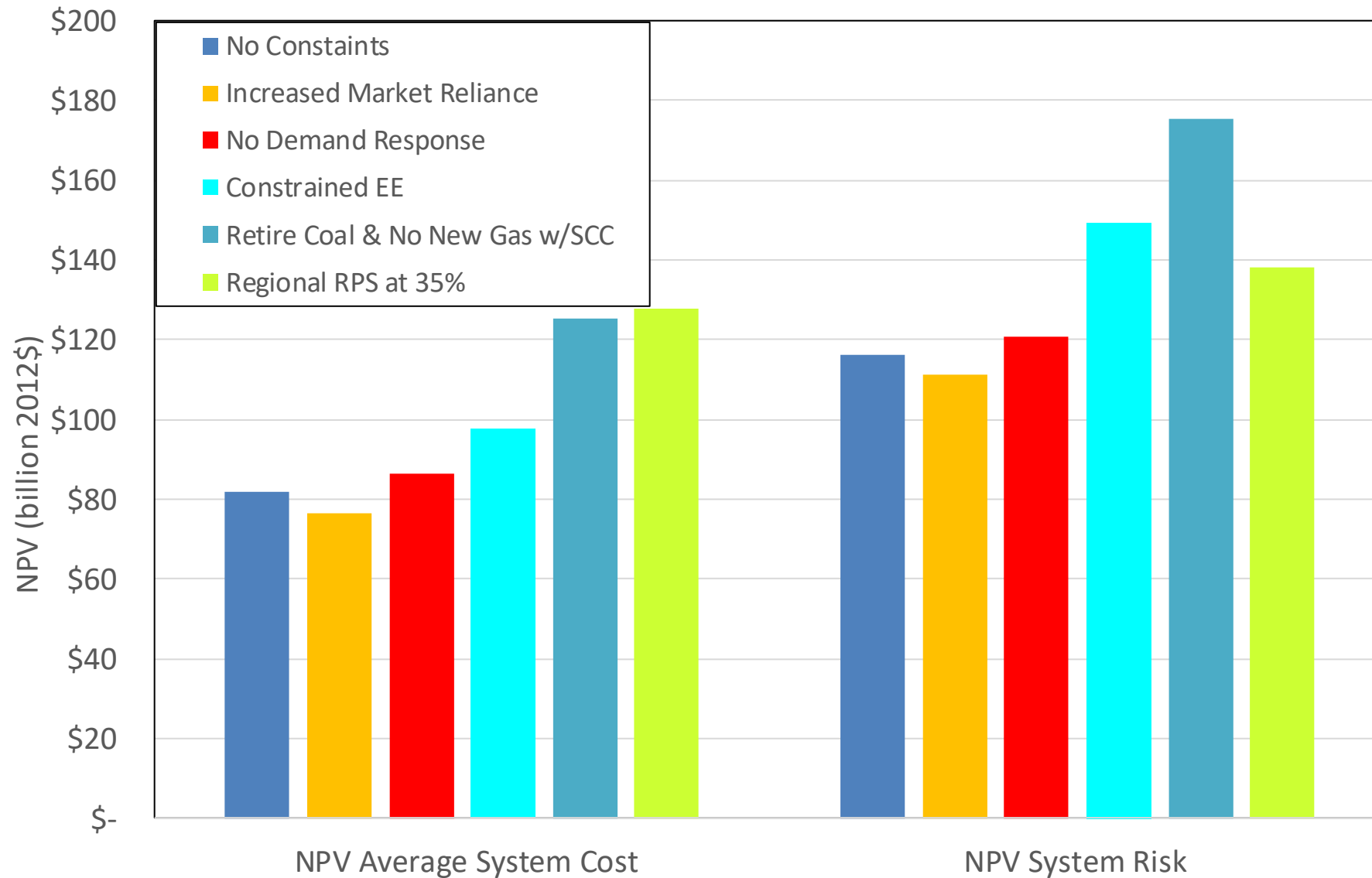
Resource Diversity Impacts the Distribution of Net Present Value System Cost Across Futures



Expected Cost and Risk Metrics Characterize Each Resource Strategy



Resource Diversity Impacts Both System Cost and Risk



Comparison of Cost and Risk of Resource Diversity*

Scenario	NPV Average System Cost (billion 2012\$)	Delta from No Constraint Scenario (billion 2012\$)	NPV System Risk (billion 2012\$)	Delta from No Constraint Scenario (billion 2012\$)
No Constraints	\$82	\$0	\$116	\$0
Increased Market Reliance	\$76	(\$5)	\$111	(\$5)
No Demand Response	\$86	\$4	\$121	\$5
Constrained EE	\$97	\$16	\$149	\$33
Retire Coal & No New Gas w/SCC	\$126	\$44	\$175	\$59
Regional RPS at 35%	\$128	\$46	\$138	\$22

Diversity* includes differences in **type, **amount** and **timing** of resource development

Parting Shot

“The essence of risk management lies in maximizing the areas where we have some control over the outcome while minimizing the areas where we have absolutely no control over the outcome and the linkage between effect and cause is hidden from us.”

*—Peter L. Bernstein, **Against the Gods, The Remarkable Story of Risk***



Any Questions?

Role of Capacity Expansion/Resource Analysis Models

What They Do Do

- Test alternative resource mixes and development timing (aka, *Resource Strategies*) against a range of future conditions (e.g., load growth, natural gas prices, emissions costs/limits, etc.)
- Identify the “least cost” *Resource Strategy* and may account for “risk”

What They Don't Do

- Determine what is an acceptable level of “cost”
- Determine what is an acceptable level of “risk”
- Decide which *Resource Strategy* is “preferred”

How Does A Stochastic Risk Analysis Model Optimize?

- It test thousands of alternative resource strategies (those things we control)
 - Varying the amount, type and timing of resource development
 - Energy efficiency
 - Demand response
 - Distributed generation (e.g., PV)
 - Storage (thermal, battery, compressed air)
 - Natural gas fired CCCT and SCCT
 - Wind and utility scale solar
 - Varying the amount and timing of market purchases in lieu of resource development
- Against hundreds of different futures (those things we don't control)
 - Fuel price uncertainty
 - Carbon risk uncertainty
 - Load uncertainty
 - Resource uncertainty
 - Technological uncertainty
 - Regulatory uncertainty
 - Wholesale market price uncertainty
- It “sorts” through all of the resource strategies to find those with the lowest cost for each level of risk.

The “Optimization Objective” of Best Practice IRPs: Find the Lowest Cost “Insurance” for the Same Risk Coverage

	LOW DEDUCTIBLE	MIDRANGE DEDUCTIBLE	HIGHER DEDUCTIBLE
Policy year claim is filed	\$250 deductible \$1,000 premium	\$500 deductible \$900 premium	\$1,000 deductible \$800 premium
1	\$1,250	\$1,400	\$1,800

Auto Insurance

INSURER	PRICE	RATING	
Liberty Mutual	300.00	A++	CHOOSE
State Farm	395.00	B	CHOOSE
			CHOOSE
			CHOOSE
			CHOOSE
			CHOOSE

Problem? Report a price as incorrect

Customize >

	My Car Insurance	My Car Insurance Quotes		
2				
3				
4	My Insurance Provider Springfield, CA	Insurance Provider 1 Springfield, CA	Insurance Provider 2 Cupertino, CA	Insurance Provider 3 Modesto, CA
5	Current Auto Insurance Payment: \$154/ mo.	\$132/ mo.	\$154/ mo.	\$180/ mo.
6	Insurance Type: <i>Full Coverage</i>	Insurance Type: <input checked="" type="checkbox"/> <i>Full Coverage</i>	Insurance Type: <input checked="" type="checkbox"/> <i>Full Coverage</i>	Insurance Type: <input checked="" type="checkbox"/> <i>Full Coverage</i>
7	Coverage Type: <i>Standard</i> \$100K/\$300K Injury, \$50K Property	Coverage Type: <input checked="" type="checkbox"/> <i>Standard</i> \$100K/\$300K Injury, \$50K Property	Coverage Type: <input checked="" type="checkbox"/> <i>Basic</i> \$50K/\$150K Injury, \$30K Property	Coverage Type: <input checked="" type="checkbox"/> <i>Liability</i> \$50K/\$150K Injury, \$30K Property
8	Preferred Deductible: \$500.00	Comprehensive Deductible: <input checked="" type="checkbox"/> \$500.00	Comprehensive Deductible: <input checked="" type="checkbox"/> \$1,000.00	Comprehensive Deductible: <input checked="" type="checkbox"/> \$1,000.00
	Preferred Collision Deductible: \$500.00	Collision Deductible: <input checked="" type="checkbox"/> \$500.00	Collision Deductible: <input checked="" type="checkbox"/> \$500.00	Collision Deductible: <input checked="" type="checkbox"/> \$500.00
	Preferred Medical Coverage: \$10,000.00	Medical Coverage: <input checked="" type="checkbox"/> \$10,000.00	Medical Coverage: <input checked="" type="checkbox"/> \$10,000.00	Medical Coverage: <input checked="" type="checkbox"/> \$5,000.00
	Emergency Roadside Assistance: <i>Yes</i>	Emergency Roadside Assistance: <input checked="" type="checkbox"/> <i>Yes</i>	Emergency Roadside Assistance: <input checked="" type="checkbox"/> <i>Yes</i>	Emergency Roadside Assistance: <input checked="" type="checkbox"/> <i>Yes</i>
	Safe Driver Discount: <i>Yes</i>	Safe Driver Discount: <input checked="" type="checkbox"/> <i>Yes</i>	Safe Driver Discount: <input checked="" type="checkbox"/> <i>Yes</i>	Safe Driver Discount: <input checked="" type="checkbox"/> <i>Yes</i>

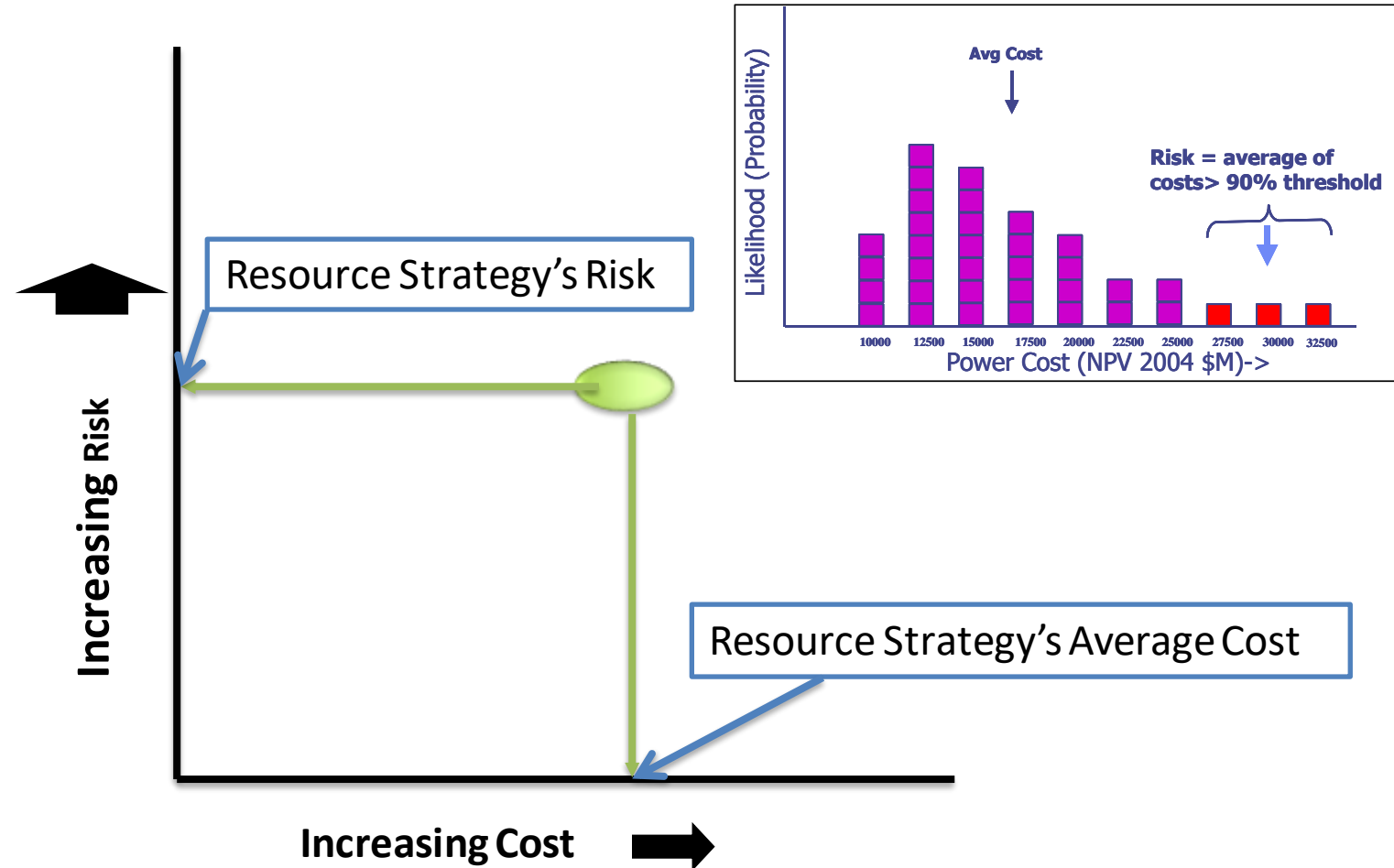
Source: CR Money Lab. Prem

This image is for illustration purposes only, and do not necessarily represent the exact products, services, or ideas in the context they are found in.

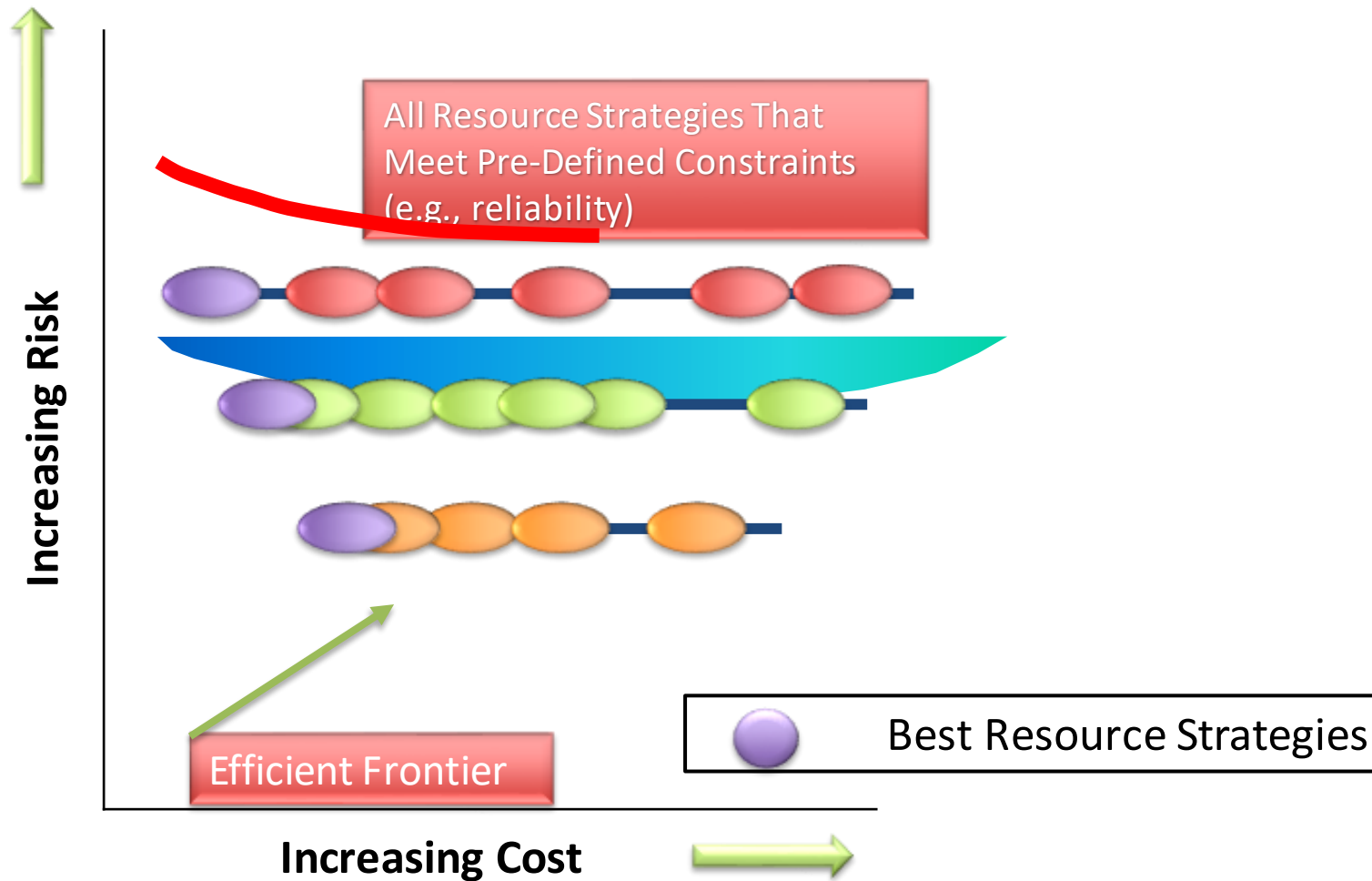
How the Strategic Risk Analysis Approach Differs

- Likelihood analysis that captures *strategic uncertainty*
- *Imperfect foresight* and use of decision criteria for capacity additions
- *Adaptive plans* that respond to futures
- “Scenario analysis on steroids”
 - Hundreds of futures, strategic uncertainty
 - Frequency that corresponds to likelihood

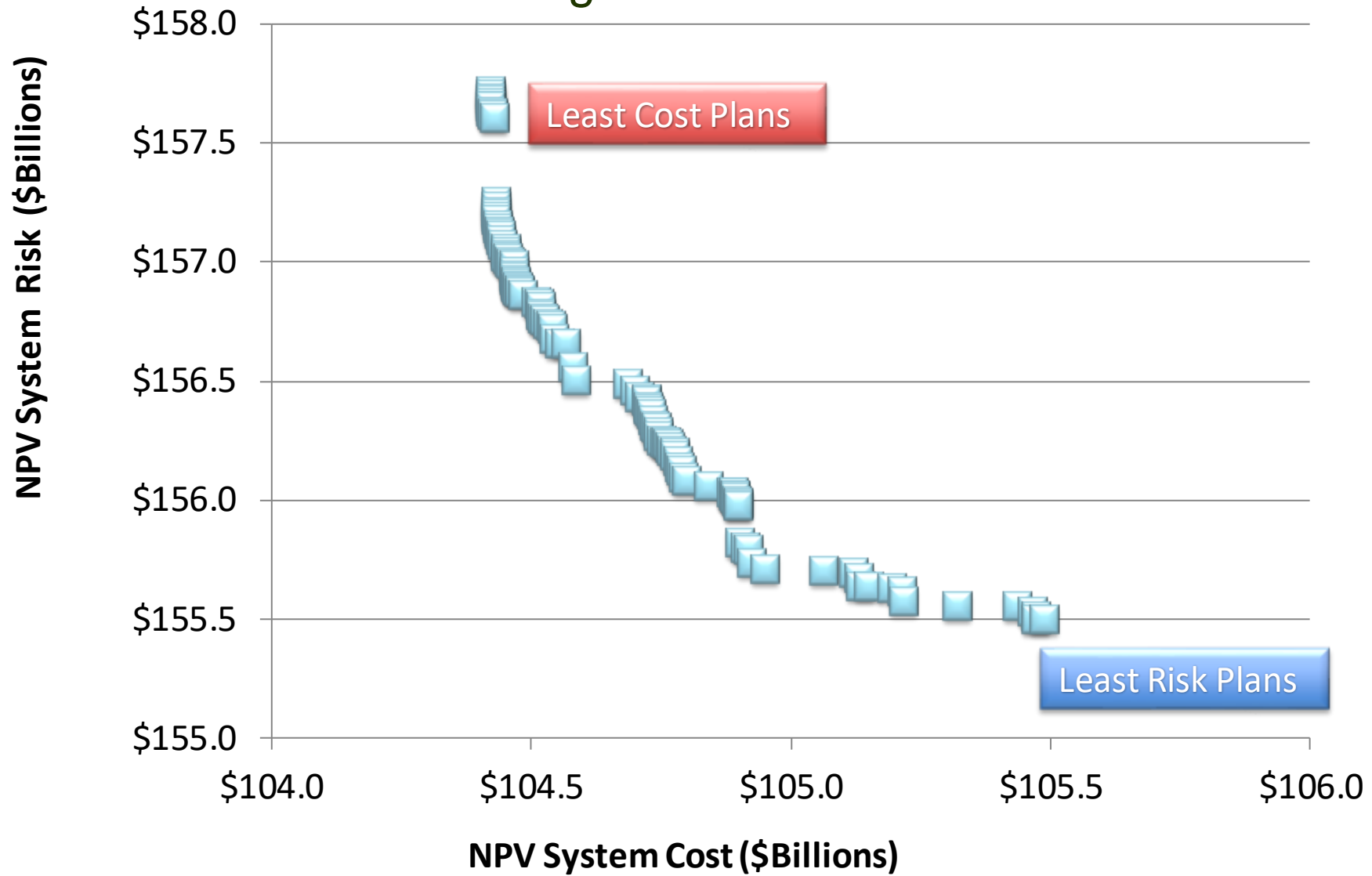
Stochastic Risk Analysis Models Use Two Metrics to Select the Resource Strategies with the Lowest Expected Cost for Varying Levels of Risk



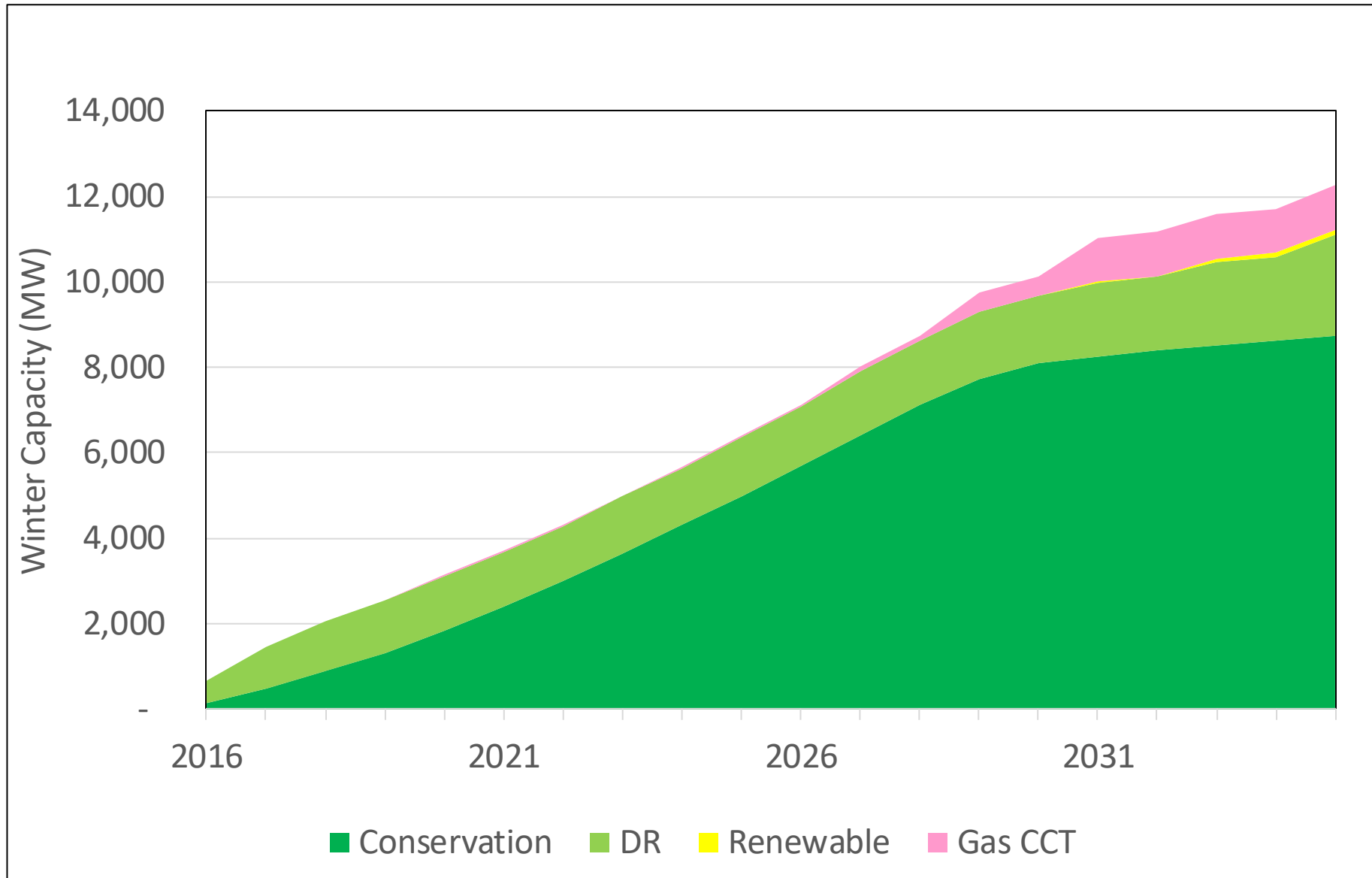
The “Best” (i.e., Lowest Cost) Resource Strategies at Each Risk Level Form the Efficient Frontier



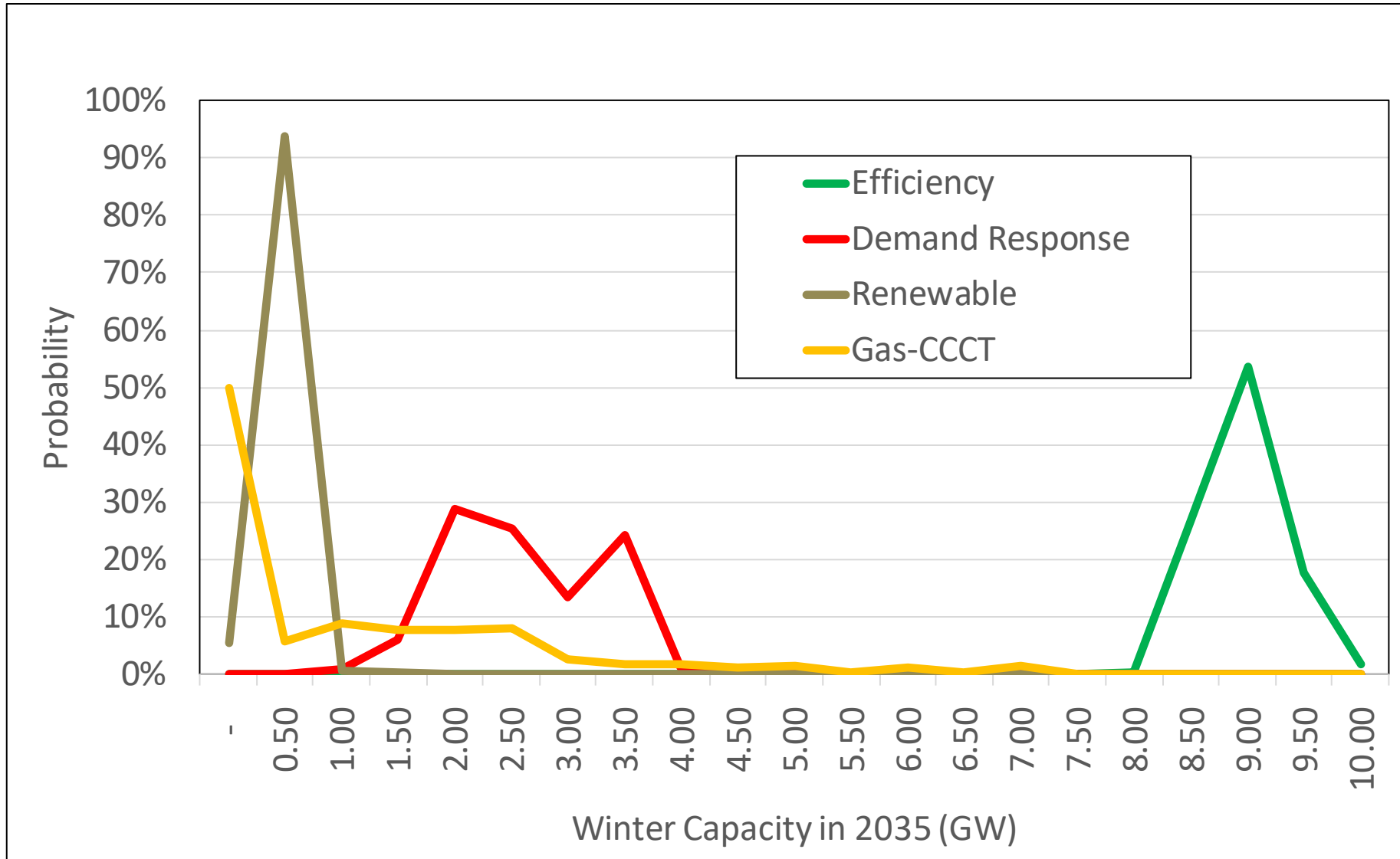
The Efficient Frontier Permits Policy Choices Regarding the Cost of Insuring Against Risk



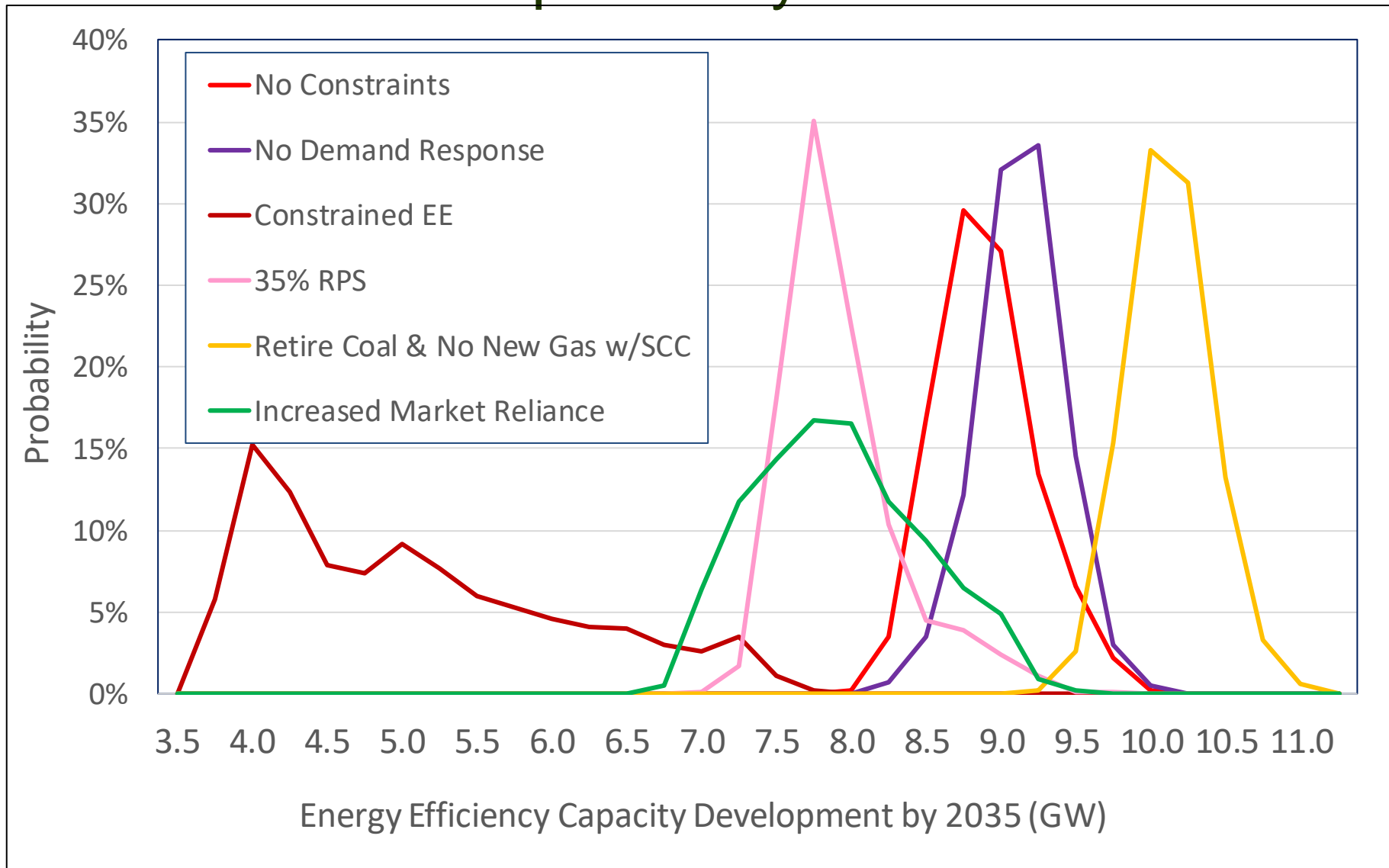
No Constraints Resource Portfolio



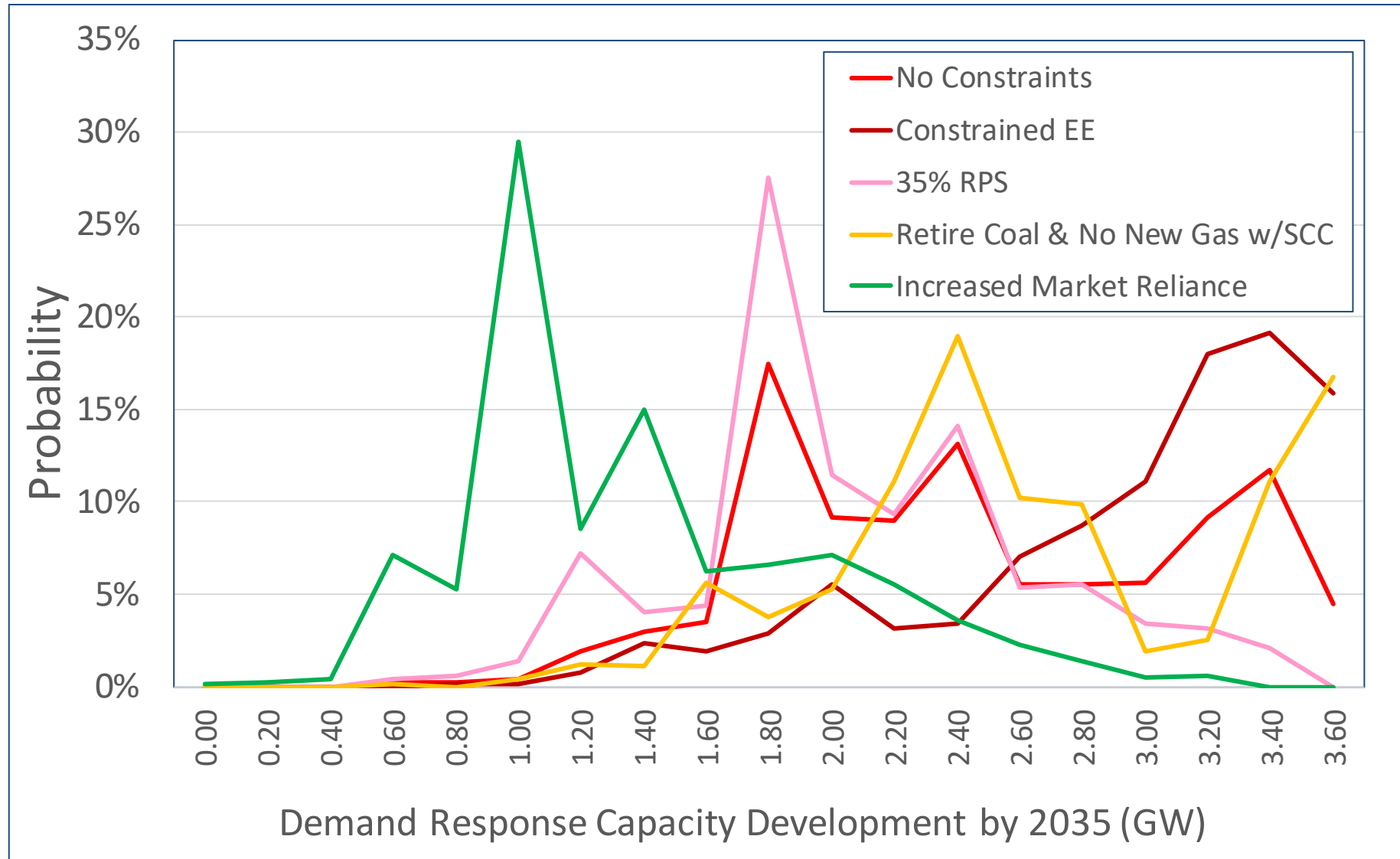
Distribution of Resource Development Across All Futures for No Constraint Scenario



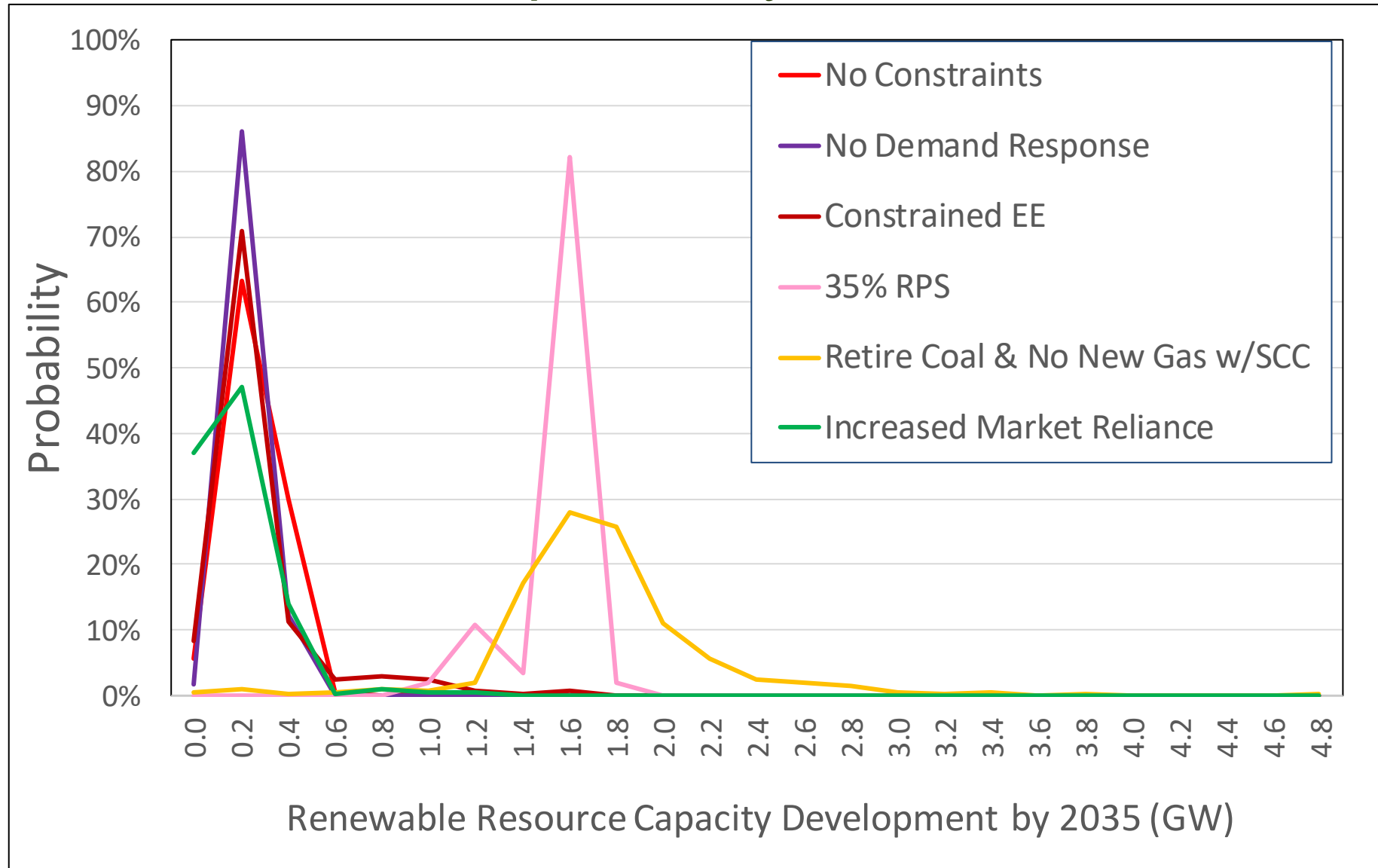
Distribution of Energy Efficiency Resource Development by Scenario



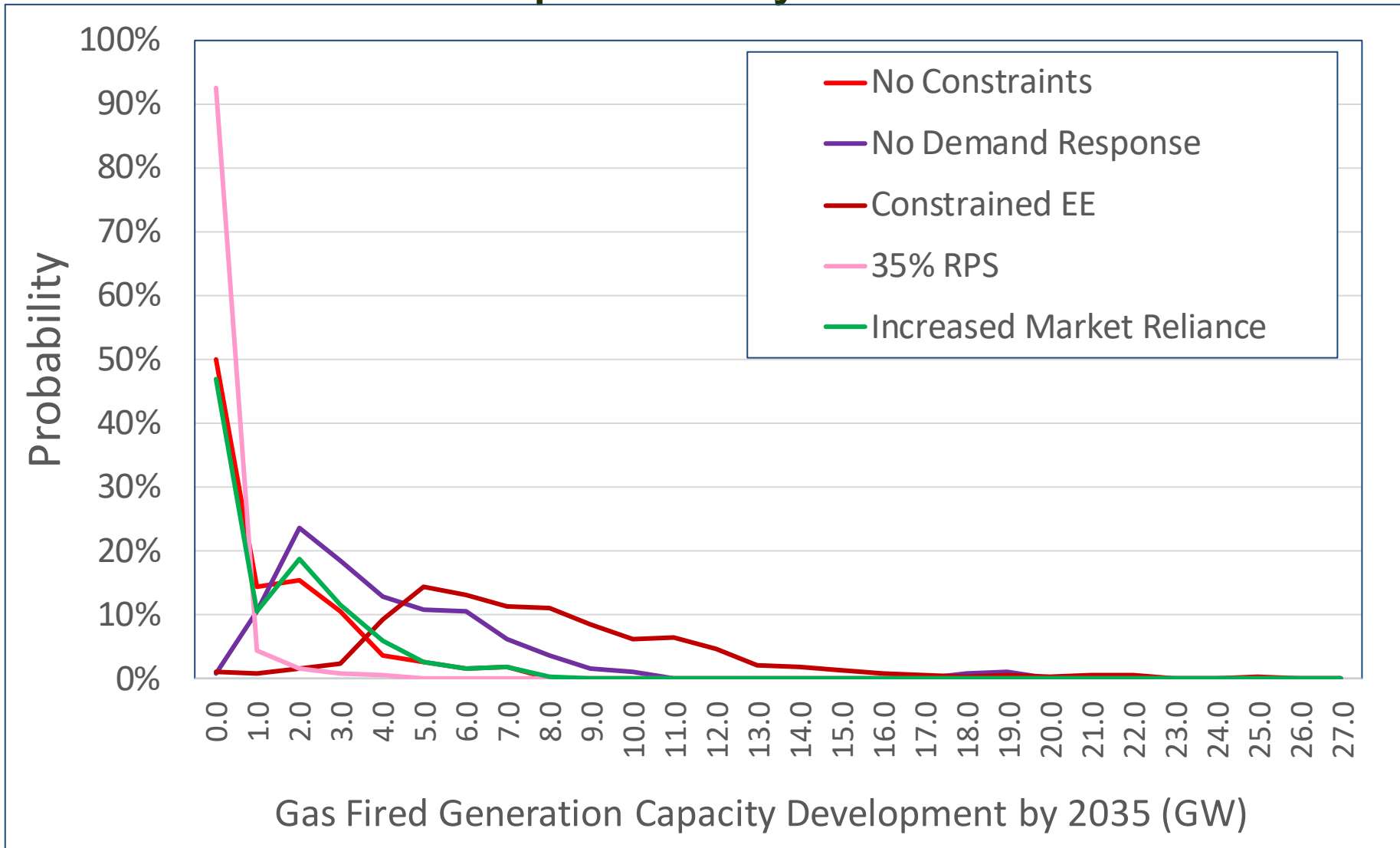
Distribution of Demand Response Resource Development by Scenario



Distribution of Renewable Resource Development by Scenario



Distribution of Gas-Fired Turbine Resource Development by Scenario



Biomass as a diverse energy resource

Integration Of Resource/Distribution/Transmission Planning
Workgroup

Michigan Public Service Commission

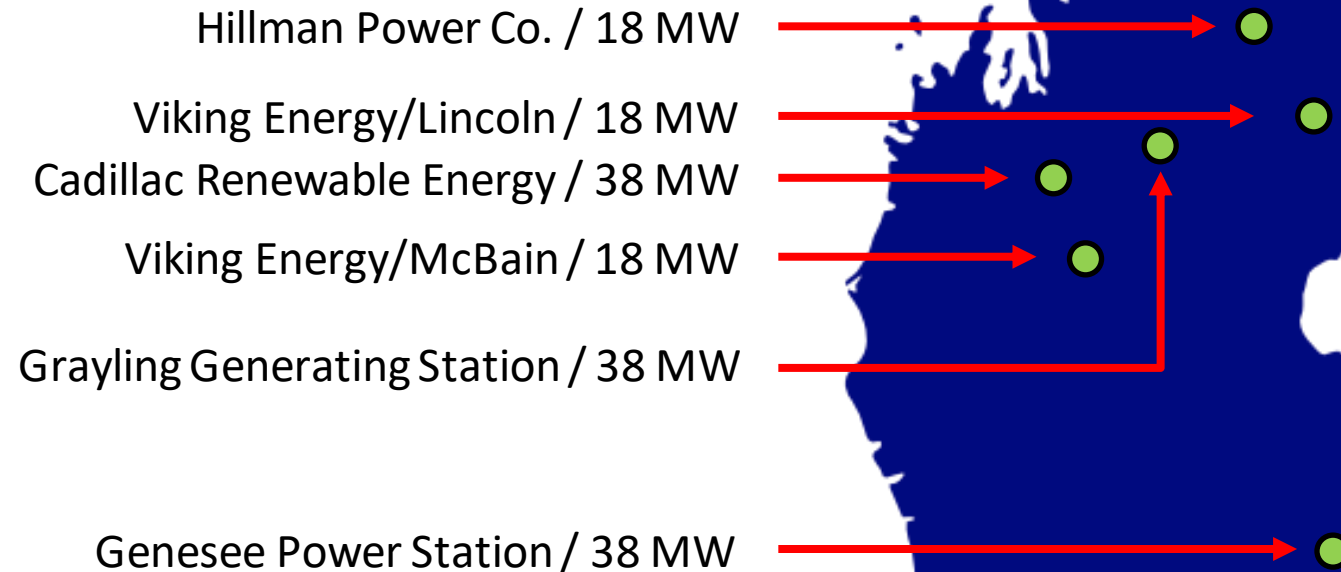
February 9, 2021

Michigan 
Biomass

Home-grown, Michigan-made renewable energy

Biomass in Michigan

168 MW

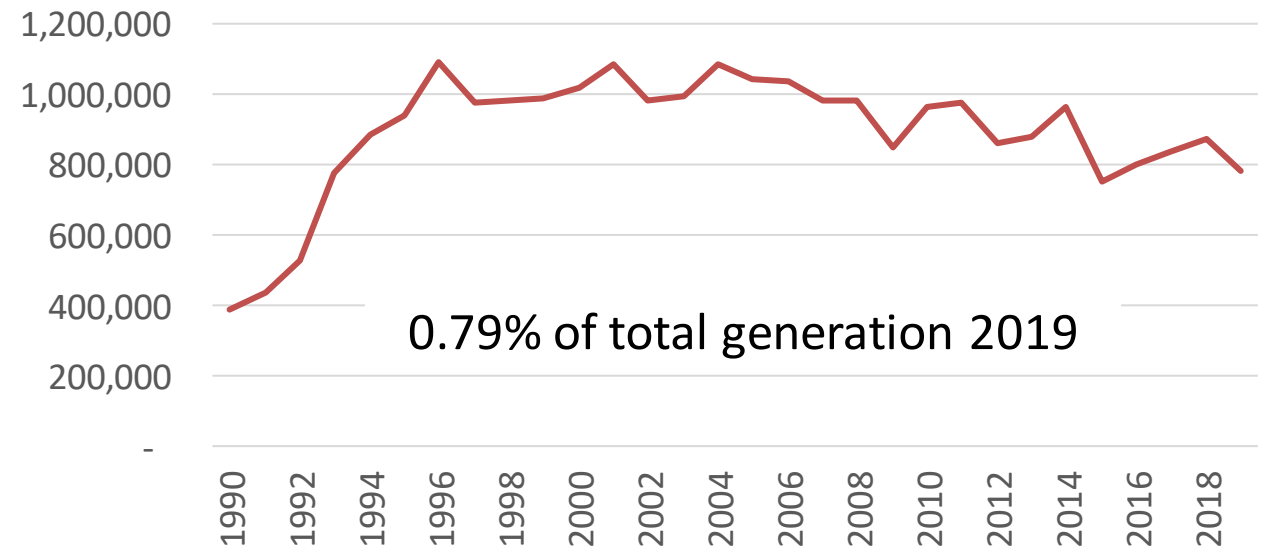


Production

2019 Biomass Power Production

State	Total MWh	Nat'l. Rank
CA	1,667,021	1
NH	866,702	2
MI	781,240	3
GA	625,222	4
ME	601,170	5

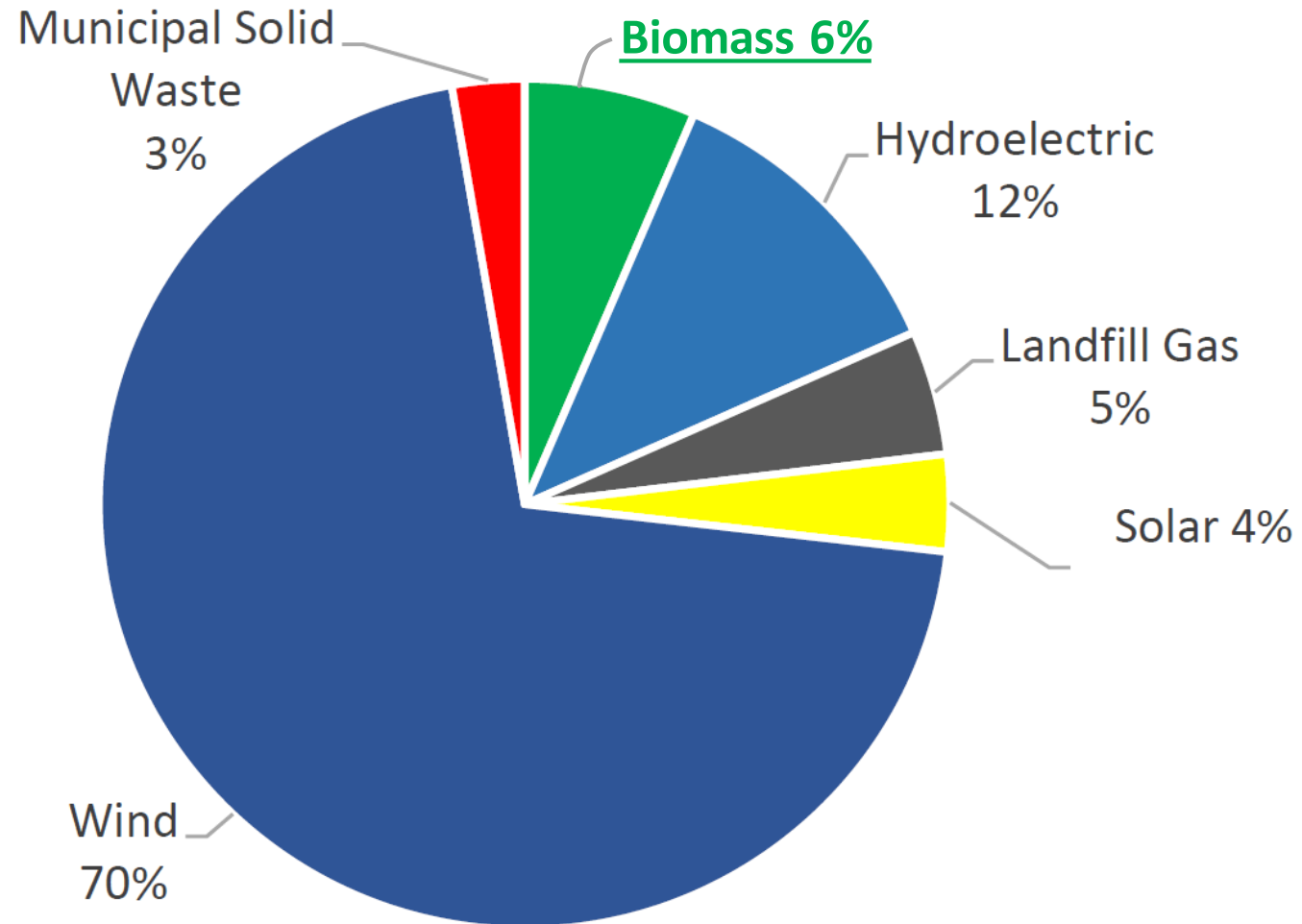
Historical Biomass Power Production



Source: [U.S. Energy Information Administration Net_Generation_1990-2019 Final.xls](#)

Renewable resource

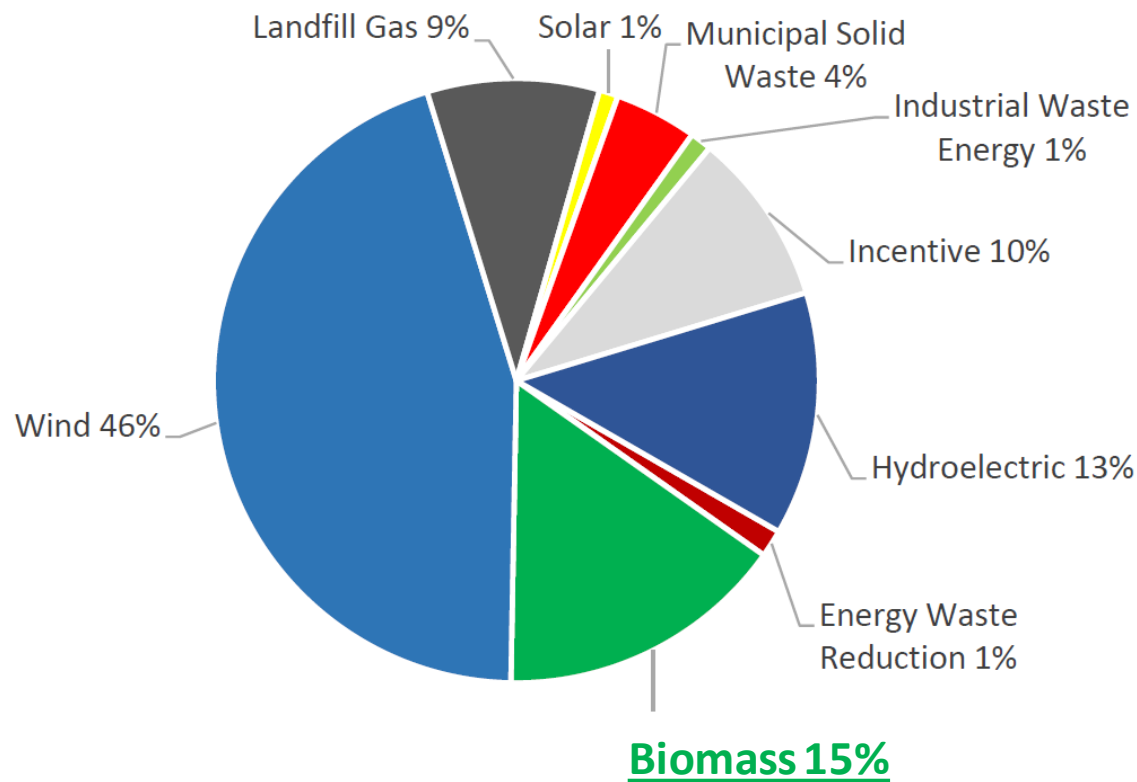
Capacity



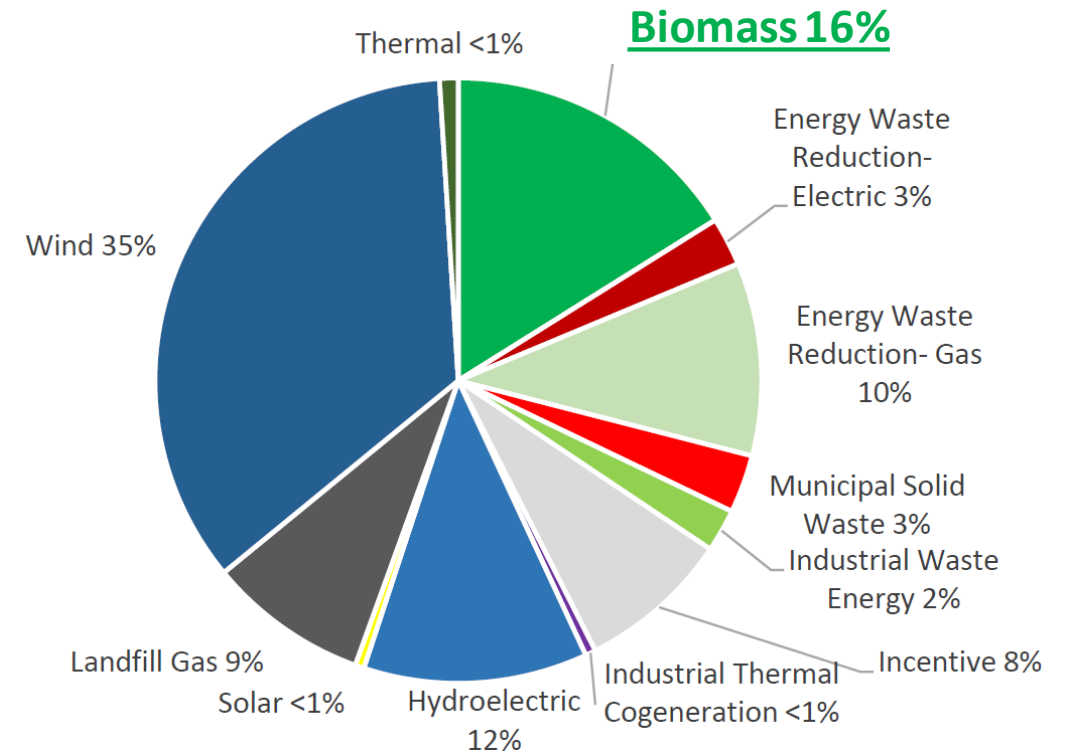
Source: [Report on the Implementation and Cost Effectiveness of the P.A. 295 Renewable Energy Standard](#), MPSC February 2020

Renewable resource

2018 compliance RECs



2009-2019 REC inventory



Source: [Report on the Implementation and Cost Effectiveness of the P.A. 295 Renewable Energy Standard](#), MPSC February 2020

Biomass diversity

Energy values

- Baseload capacity
 - Voltage stabilization
 - VARs
 - Line loss mitigation
 - Dispatchable
- Transmission costs avoided
- High availability
- Cybersecurity
- Thermal application

Fuel values

- Non-commodity fuel
 - Locally sourced
 - Local transportation systems
 - Geopolitically secure
 - Hedge vs. other fuels
 - Pricing
 - Availability

Biomass diversity

Environmental values

- Forest health & stewardship
 - Harvest residuals
 - Precommercial thinning
 - Salvage & sanitation
 - Reduced wildfire risk
- Materials management
 - Mill byproducts
 - Manufacturing byproducts
 - Landfill diversions
 - Crates, pallets
 - Scrap tires
- Offset fossil emissions

Economic values

Energy

- Cost avoidance
 - Infrastructure
 - Offsets “behavioral risks”
- Stable fuel pricing
- Reduced financial risk

Resources

- Lowers cost of...
 - Forest products
 - Forest management
 - Habitat development & maint.

Biomass diversity

Social values

- Jobs, rural economics
 - Non-wind, non-solar
- Stable tax revenues
- Local utilities/infrastructure
- Quality of life

Quantifiable attributes

Baseload optimizes...

- Grid performance
- Resource adequacy
 - Availability

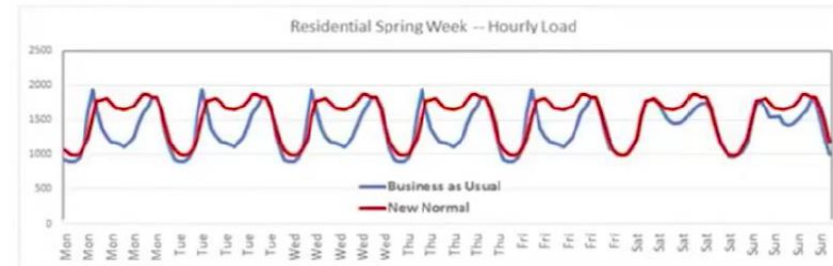
Baseload mitigates...

- Outage frequency & severity
- EWR, DR, other risks
- Forecast/modeling uncertainty
- Costs avoided
 - T&D modernization
 - New capacity, capital outlay
 - Outages & disruptions
- Natural gas baseload reliance

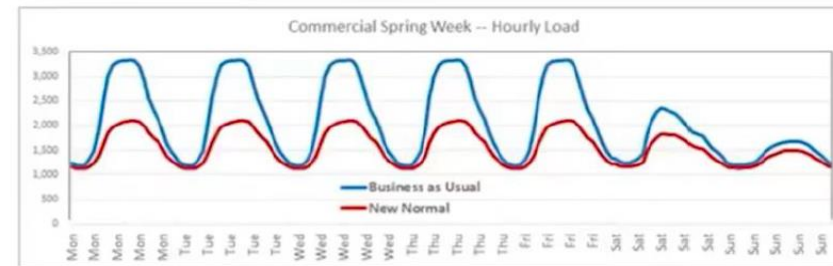
Net carbon benefit

- Methane offsets
- Fossil offsets

COVID-19 Impacts on Load Shapes |



Multiplier	Value
Weekday Impact	1.15
Saturday Impact	1.05
Sunday Impact	1.09
7 Day Impact	1.13



Multiplier	Value
Weekday Impact	0.72
Saturday Impact	0.84
Sunday Impact	0.91
7 Day Impact	0.75

Qualifiable attributes

Resource services

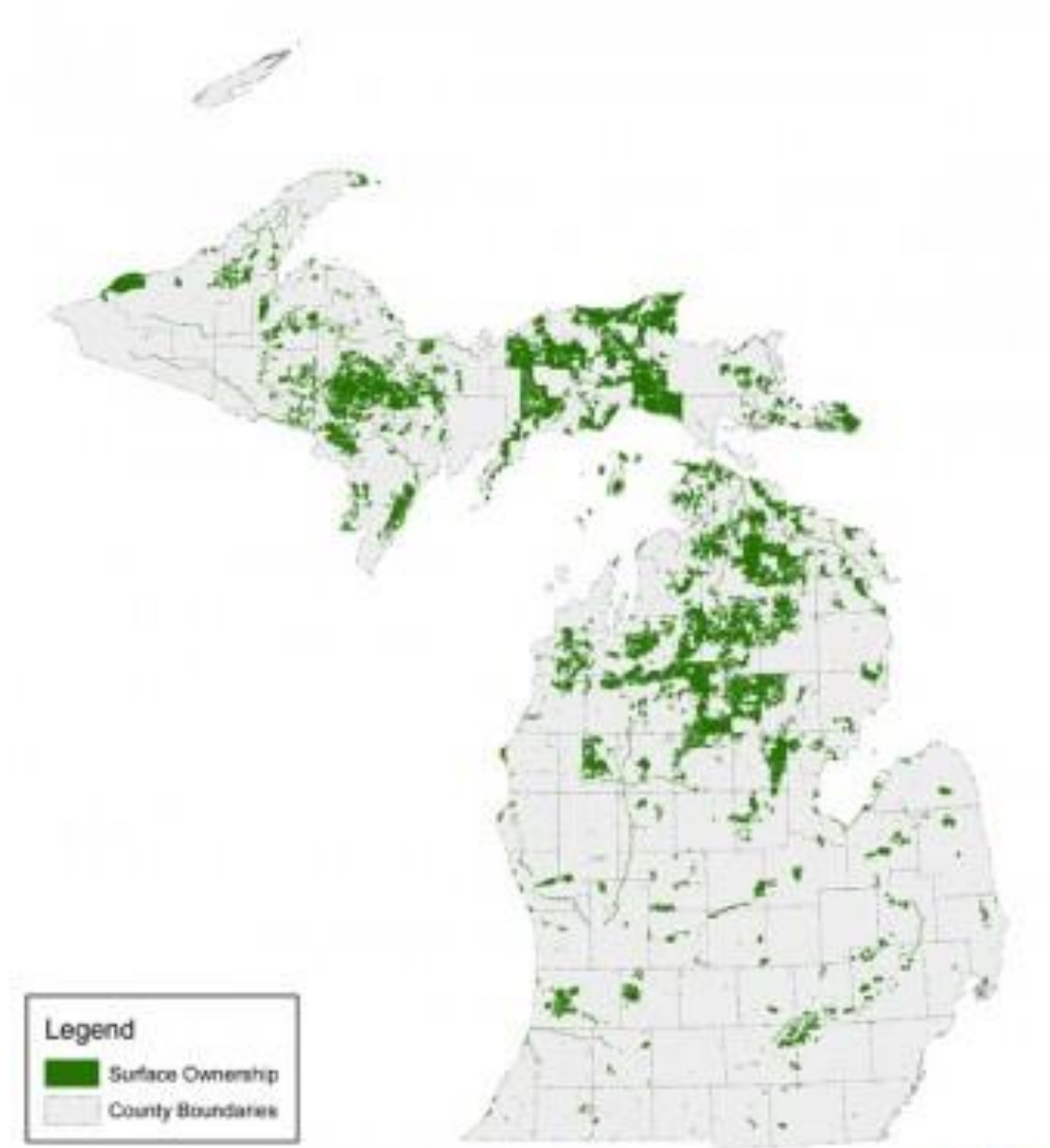
- Sustainable forestry
- Forest carbon sequestration
 - MI Healthy Climate Plan
- Materials management

Fuel diversity

Economic values

- Finland Circular Bioeconomy MOU
- Rural communities

Cost/benefit analysis?



Created: 7/27/2011



It's not the energy we make, but how we make energy that matters

1. Energy diversity
2. Keeps energy dollars in rural Michigan
3. Dispatchable baseload renewable when and where it's needed
4. Supports the grid and makes it more reliable and resilient
5. Beneficial reuse of byproducts
6. Carbon neutral energy
7. Aids forest health, stewardship

Michigan 
Biomass



gary.melow@michiganbiomass.com

Michigan Biomass

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Independent Power Producers Coalition of Michigan

*Tim Lundgren: tjlundgren@varnumlaw.com
616-915-3726*

Michigan Public Service Commission

February 9, 2021

IPPC

Small QFs ($= < 20$ MW)



	Hydro	Alverno Hydro ...	1.2 MW
Elk Rapids Hydro...	0.76 MW	Waste-to Energy	
White's Bridge...	0.75 MW	Kent County...	17 MW
Tower-Kleber...	2.86 MW	Landfill gas	
City of Beaverton...	0.96 MW	EDL...	40+ MW
Michiana (Bellvue) Hydro...	0.7 MW		



IPPC

- Ancillary benefits
- Energy value
- System benefits
- Capital requirements
- QF technologies
 - Hydroelectric
 - Landfill gas
 - Waste to energy

Ancillary benefits

Environmental

- Carbon mitigation
- Emission profiles
- Waste management

Resources

- Forest health & stewardship
- Flood control
- Habitat

Social

- Local jobs, local resource
- Tax base, property value
- Recreation



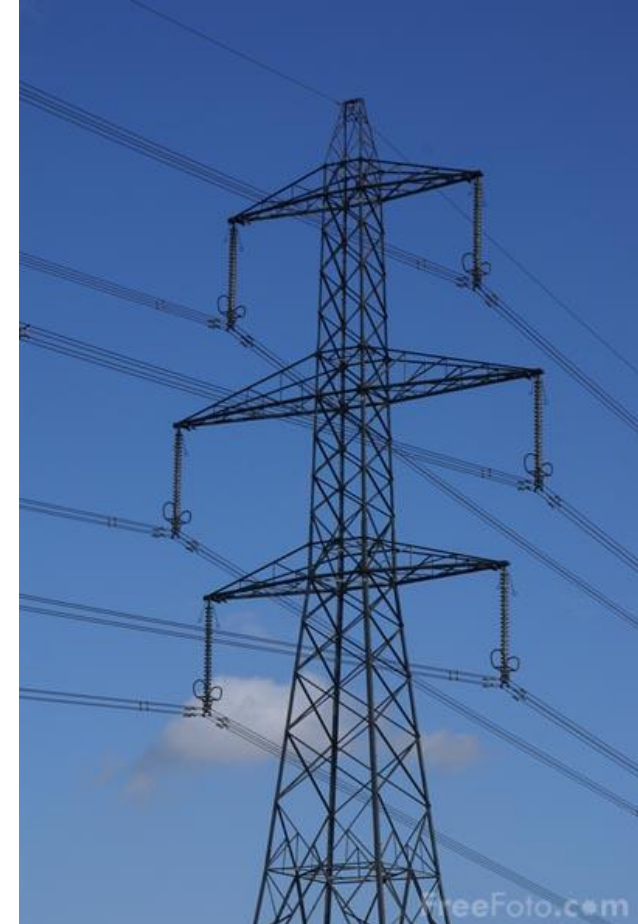
Energy values

- Renewable
 - Clean Power Plan (CPP / Sec. 111(d))
 - Michigan Renewable Portfolio Standards (RPS)
- Fuel diversification
 - MSW
 - Water
 - LFG
- Baseload
 - Capacity factor
 - Availability



System benefits

- Source diversification
 - By fuel
 - By ownership
- Capacity
 - Grid reliability
 - Voltage support
 - VARs
 - \$1 million annual value*
 - Distributed generation
 - Minimize impact of transmission outages
 - Baseload
 - Up to 90%-plus capacity factor
 - Dispatchable



**Source: NEMA.org – based on 100 MW installed capacity*

Capital requirements

- New or existing facilities
 - Both have on-going CapEx, financeability needs
 - Cost recovery over time
- Similar needs as utilities



HYDROELECTRIC POWER



Independent hydro facilities

Entity	Plant	Capacity (kW)	PPA expires	Customer
Boyce Hydro Power, LLC	Edenville	4800	2022	CECo.
Boyce Hydro Power, LLC	Smallwood	1200	2022	CECo.
Boyce Hydro Power, LLC	Sanford	3300	2022	CECo.
Boyce Hydro Power, LLC	Secord	1200	2022	CECo.
Black River Ltd Partnership	Alverno	1100	2016	CECo.
Tower Kleber Ltd. Partnership	Kleber	1200	2016	CECo.
Tower Kleber Ltd. Partnership	Tower	560	2016	CECo.
Commonwealth Power	Irving	600	2018	CECo.
Commonwealth Power	Middleville	350	2018	CECo.
Commonwealth Power	LaBarge	850	2017	CECo.
Northbrook Energy LLC	Fallasburg	900	2016	CECo.
Thornapple River Assn -Northbrook	Ada	1100	2017	CECo.
Northbrook Energy LLC	Morrow	880	2018	CECo.
Cascade Twp - operated by Northbrook	Cascade	1600	2019	CECo.
Elk Rapids Hydroelectric Power	Elk Rapids	700	2019	CECo.
Michiana Hydroelectric	Bellevue Mill Dam	60	2020	CECo.
City of Beaverton	Beaverton	960	2020	CECo.
White's Bridge Hydro	White's Bridge	775	2016	CECo.
Hope Renewable Energy, LLC	Hubbardston	412	2017	CECo.
Renewable World Energies	Belding Dam	280	2016	CECo.
Total capacity		22,827		
Northbrook Energy LLC	French Landing – Belleville	1650		DTE
Ypsilanti Twp	Ford Lake - Rawsonville Rd.	1920		DTE
City of Ann Arbor	Barton Dam	900		DTE
City of Ann Arbor	Superior Dam	500		DTE
Total capacity		4970		

The power of moving water

- Fuel Source Domestic & Secure
 - Water supply not subject to disruption
 - Foreign supply issues
 - Price fluctuations & economics
 - Fuel transportation costs
- Renewable – sustainable, not depleted, natural energy in falling water
- Efficient – 85-90% overall
- Clean
 - No air emissions or toxic byproducts
- Small hydro plant rehabilitations
 - Pioneered renewable energy movement in 1980s
 - Creating or restoring community assets



Bellevue Mill: 45 kW *(20-50 homes)*



Before

Built: 1854
Abandoned: 1955
Pictured: 1975



After

Restored: 1977*
Electrified: 1982
PPA: Consumers
Energy

*On going – see video: <https://youtu.be/tnDWibKuH2E>

Elk Rapids: 700 kW *(400-700 homes)*



Before

Built:	1916
CECo.:	1950
Scrapped:	1965
Pictured:	1984



After

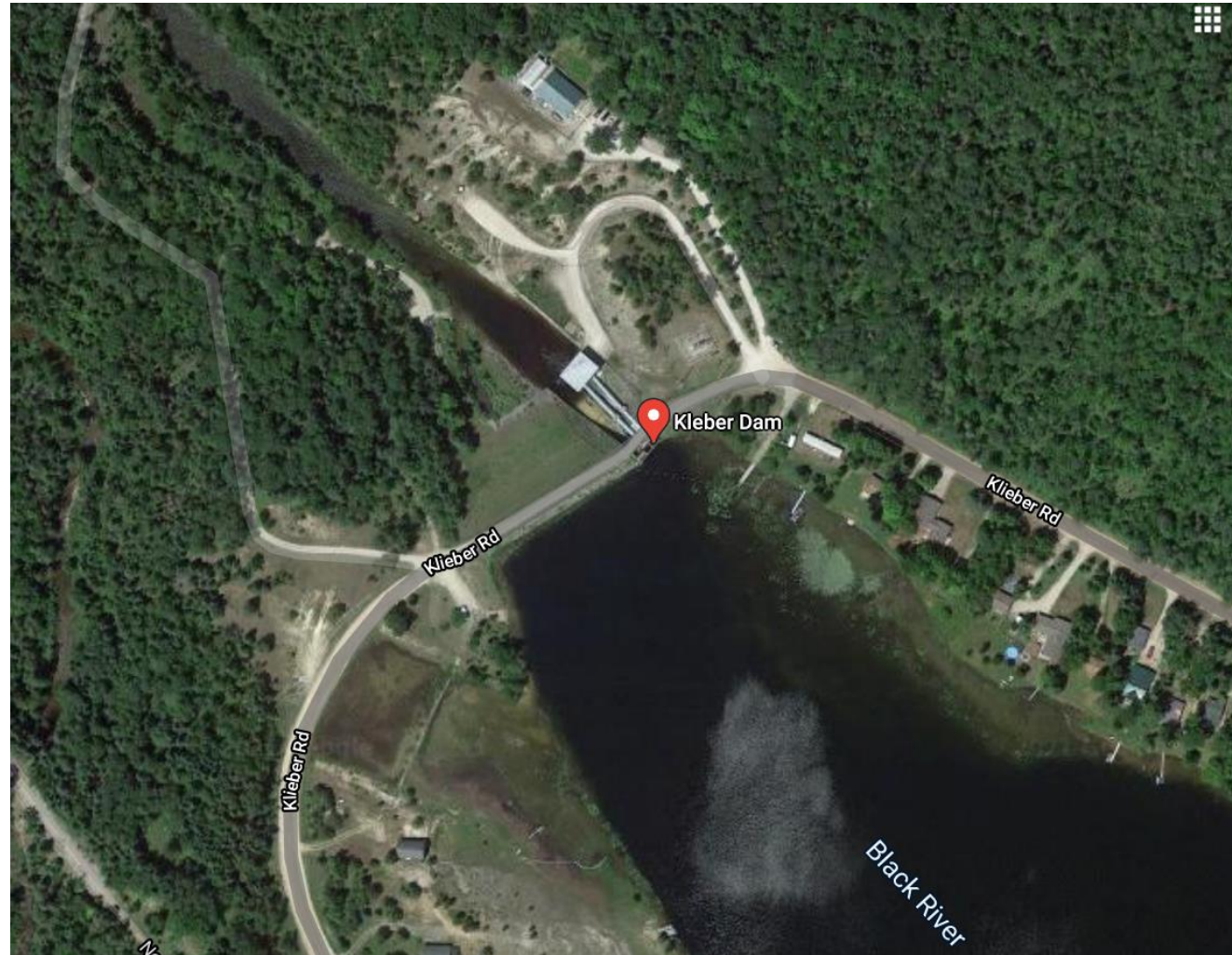
Electrified:	1984
PPA:	CECo.

Elk Rapids water system



Tower and Kleber Hydro Units

DNR & MSU Sturgeon Study: <https://www.sturgeonfortomorrow.org/pdf/sturgeon-research-jon-hegna%20.pdf>



Ancillary benefits

- Waterfowl, fish habitat
- Recreational lakes
- Public access
- Flood control
- Enhanced property value, tax base
- Blocks upstream migration of invasive species
- Employs operators, skilled trades, suppliers and services



Energy value

- Carbon-free = Sec. 111(d) / CPP compliant
- No air emissions
- Not reliant on fuel availability / cost
- Predictable, controllable schedule, continuous

System benefits

- Baseload power
 - Continuous, steady, reliable
- Distributed generation
- Rapid demand response
 - Faster than fossil fuel power plants
- Capacity factors +/-60%
- Black start capability
- Brick-and-mortar capacity, infrastructure
 - Reduces transmission, energy import needs
 - 100+ year life span vs. 30-60 for fossil fuel, nuclear
- Operation not affected by fuel cost/availability

Capital requirements

- Regulatory compliance
 - Environmental
 - Public access, recreation
 - Dam security
 - Dam safety
 - FERC, MDNR, MDEQ

Capital requirements

FERC mandates: Environmental

- Water quality
- Tailrace flow
- Water level monitoring, reporting
- Invasive plant species (impoundments)
- Endangered species monitoring
- Shoreline erosion monitoring, reporting, intervention

Capital requirements

FERC mandates: Public access

- Road access, parking lots
- Fishing platforms
- Portage pathways & facilities
- Boat ramps & docks
- Toilet & trash facilities
- Picnic tables & seating
- Directional signage, warning signals
- Safety barriers & railings
- Handicap accessibility

Capital requirements

FERC mandates: Security

- Physical assessments & evaluations
- Cyber assessments & evaluations

Capital requirements

FERC mandates: Safety

- Letter of Owner's/Licensee's Responsibilities and Obligations
- Annual inspections & reports
 - FERC & owner engineers
- Independent consultant inspection & report (every 5 years)
- Probable Maximum Flood (PMF) analysis
 - High hazard classification dams
 - Construction solutions
- Potential Failure Mode Analysis
- Annual spillway gate tests
- Monthly inspections & reports on internal drainage
- Earthen dam maintenance (annual)
 - Vegetation, drainage systems
- Emergency Action Plans (EAPs) updates
 - Local and state emergency response exercises

KENT COUNTY WASTE TO ENERGY FACILITY

Renewable Energy For Michigan



Integrated solid waste management system

- Energy recovery
- Single stream recycling
- Landfill
- Transfer station
- Curbside and drop off facilities



A 25-year success story

- Commercial operation in February of 1990
- Solid waste management for 600,000 residents
 - Grand Rapids
 - Kentwood
 - East Grand Rapids
 - Wyoming
 - Grandville
 - Walker



Ancillary benefits

- Processes up to 625 tons of municipal waste daily
- Recovers energy from 185,000 tons MSW/year
 - Recovered 140,000 tons of scrap steel over 30 yrs.
 - 25 percent of total Kent Co. volume
 - 90% reduction in volume
- Generates 100,000 MWh annually
- Good paying jobs
 - 40 full-time employees
 - \$4.5 million annual payroll



Benefits

- Electricity generated by WTE under federal and state rules is renewable energy
- 15 MW of renewable, baseload electricity
 - 11,000 Kent County homes
 - Equal to East Grand Rapids and Walker combined
- 90 percent capacity factor
 - Reliable baseload



Capital requirements

- \$65 million investment
 - Today's cost: \$156 million
- \$4 million investment in 1999
 - Emissions reductions retrofit
 - New federal air emission requirements
- Plant refurbishment
 - 2011 – 2018 Actual: \$15,862,072
 - 2019 – 2021 Budgeted: \$12,540,000



LANDFILL GAS



EDL Projects

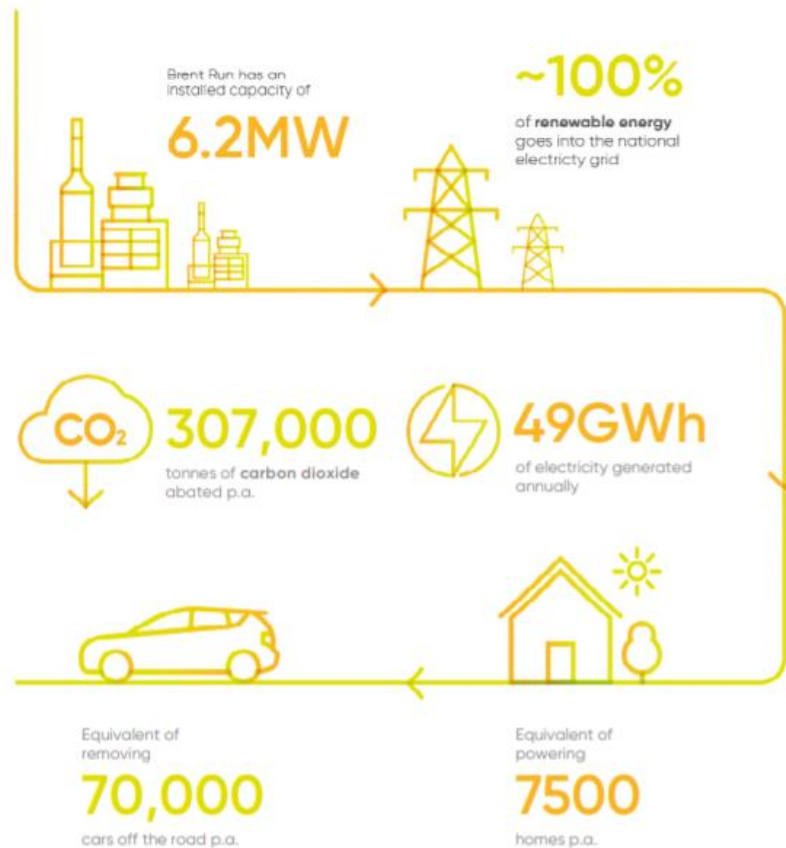
40 MW at:

- Coopersville, Byron Center, Grand Blanc & Pinconning – 15 MW
- Grand Blanc II, Brent Run & Watervliet – 12.6 MW
- Lansing, plant 1 & Lansing plant 2 – 12 MW



Brent Run Generating Station

EDL owns and operates the Brent Run landfill gas power station in Montrose, Michigan, which supplies renewable energy 24 hours a day, 365 days per year.



At a glance

Power station name:
Brent Run

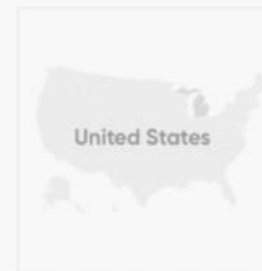
Owner/operator:
EDL

Location:
Montrose, Michigan

Primary fuel:
Landfill gas

Start of operation:
1998

Production:
49GWh p.a.



Ancillary benefits

- Michigan-made energy
 - Built & operated
 - Local fuel resources
 - Local labor
- Energy recovery from waste - captured carbon emissions reduces environmental impact

Energy value

- Michigan RPS qualified
- LFG as capable as combined cycle natural gas
 - Brings “value added” of distributed baseload renewable power
 - Continuous generation
 - High capacity factor
- Baseload

System benefits

- Fuel diversification
- High capacity factor
 - 60% to 95%
- Demand response capabilities
- Dispatchable
- Black start capable
- Distributed generation
 - Supports distribution with VARs
 - Transmission system extensions
 - Voltage stability



Summary

- System benefits
 - Reliable, baseload, dispatchable
 - Diversification, distributed generation
 - Grid support
- Capital requirements
 - New or existing have on-going capital costs
 - Same as utilities, but without similar mechanisms
- Energy value
 - Renewable energy resource (RPS)
- Ancillary benefits
 - Environmental, economic, social



Making the Most of Michigan's Energy Future

Next Steps

Feedback Request Responses Due February 19th

Next Meeting Scheduled for March 2nd **Time TBD**



MPSC

Michigan Public Service Commission

Feedback Requests

1. Should generation diversity be valued through risk assessment in an IRP to assess how different diverse resource portfolios can mitigate various risks? The assumption is that this would allow for a comparison of the costs associated with maintaining diverse resources vs the benefit of mitigating certain risks.
2. Are there other methodologies that stakeholders recommend using to determine the value of generation diversity?
3. Will better alignment of planning processes help to identify the value of generation diversity by identifying benefits across multiple planning processes, such as blackstart capability, grid resiliency, etc.?
4. Should utilities provide a calculation of resource diversity for the proposed course of action assuming a 5-, 10-, and 15-year planning horizon in the IRP filing?

Next Steps

Please send Feedback Requests to:

Danielle Rogers RogersD8@michigan.gov

Please direct general comments or questions to:

Naomi Simpson SimpsonN3@michigan.gov

Presentation materials for today's meeting can be found on the [MI Power Grid website](#).



Making the Most of Michigan's Energy Future

Adjourn



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