Energy+Environmental Economics

The pivotal role of reliable electricity to achieve decarbonization in the NW

July 17 2019

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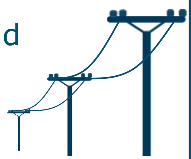
About Us: Energy & Environmental Economics (E3)

E3 is 60+ person energy & environmental economics consulting firm based in SF with five practice areas

DERs & Rates

Analyzes distributed energy resources, emphasizing their costs and benefits now and in the future

Supports rate design and distribution system planning



Clean Energy

Provides market and policy analysis on clean energy technologies and climate change issues

Includes comprehensive and long-term GHG analysis

Asset Valuation

Determines asset values from multiple perspectives

Uses proprietary in-house models and in-depth knowledge of public policy, regulation and market institutions

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Planning

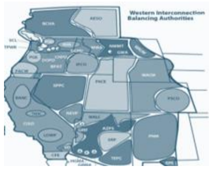
Develops and deploys proprietary tools to aid resource planners

Informs longer-term system planning and forecasting

Market Analysis

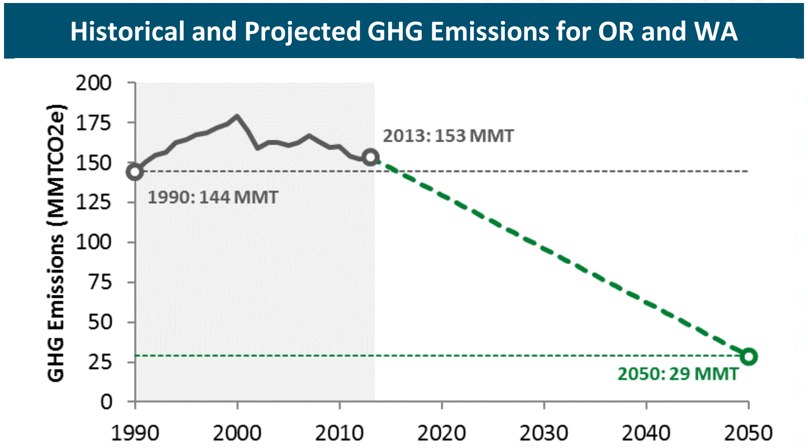
Models wholesale energy markets both in isolation and as part of broader, more regional markets

Key insights to inform system operators and market participants



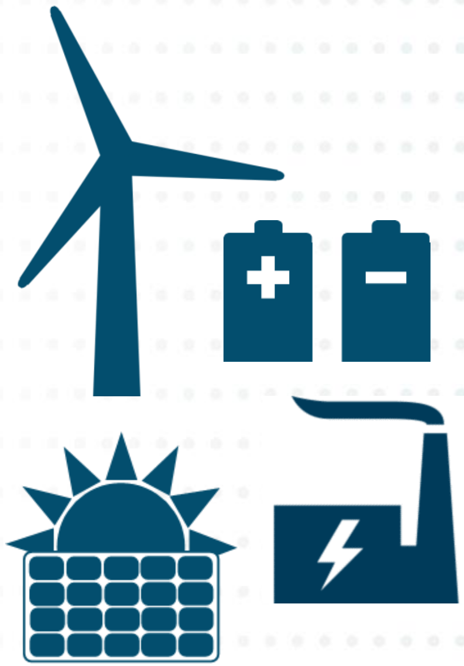
Context for this Presentation: E3's Recent Work in the NW

+ **Over the past three years, E3 has completed a trio of studies* that examine the NW's transition to a low-GHG energy system, these studies identify:**
  1. The pivotal role of electricity in achieving deep decarbonization in the region
  2. Strategies to decarbonize electricity at least-cost



+ **The Pacific Northwest is expected to undergo significant changes to its generation resource mix over the next 20 years due to changing economics and policy goals. These changes include:**
  - Increased penetration of wind and solar generation
  - Retirements of coal generation
  - A shift in the role of natural gas generation

+ **This transition raises questions about the region's ability to serve load reliably as firm generation is replaced with variable resources**



*Note that the geographic scope of these studies varies. More detail is available in the appendix

Agenda

- **The electric sector in the context of economy-wide decarbonization**
- **Ensuring reliability of a very-low emissions electricity system**
  - What is resource adequacy?
  - How resource adequate is the region today?
  - Resource adequacy over the coming decade
  - Resource adequacy in a deeply decarbonized 2050 electricity system

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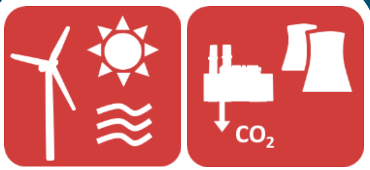
The Electric Sector in the Context of Economy-wide Decarbonization

Four "Pillars" of Decarbonization to Meet Long-Term Goals

Energy efficiency & conservation

Electrification



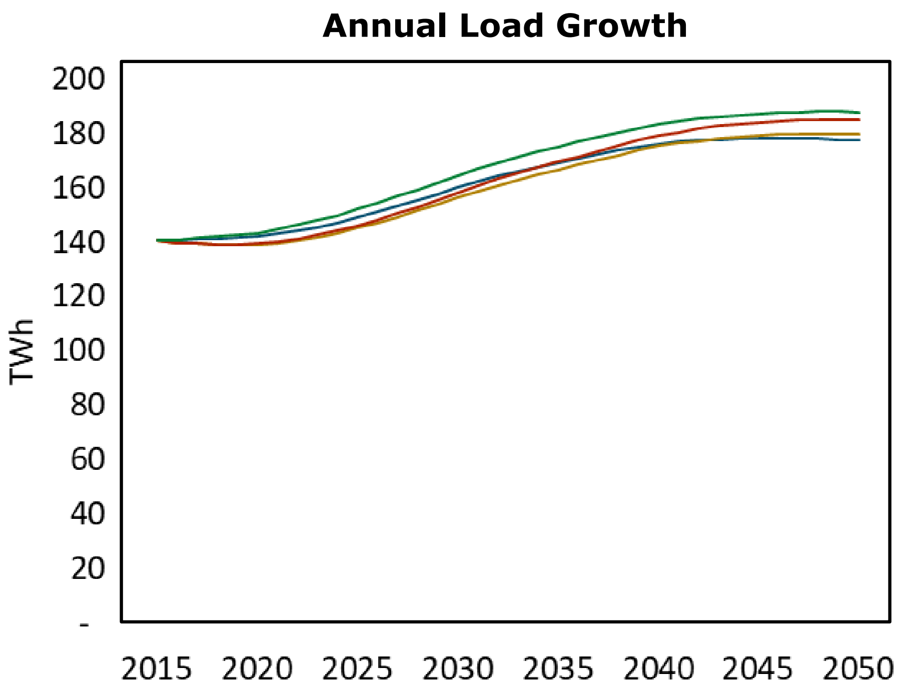
Low carbon electricity

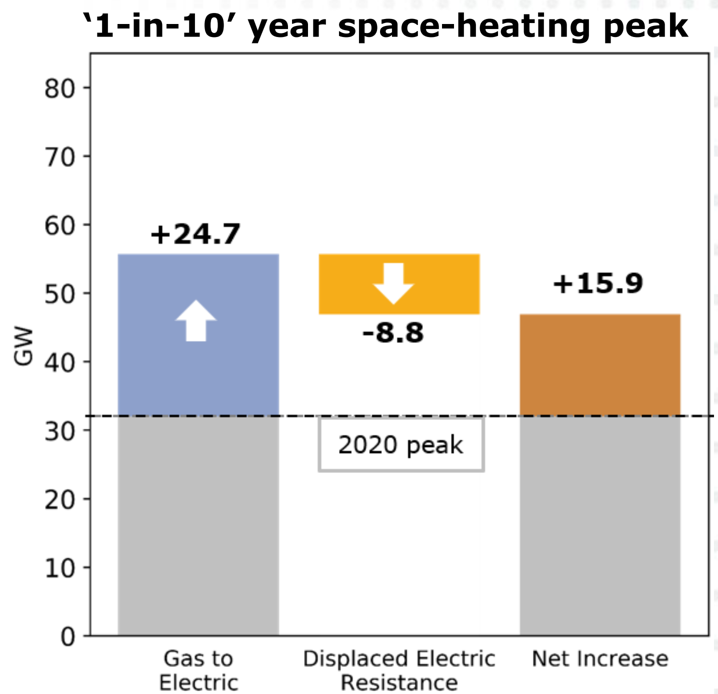
Low carbon fuels

- **Four foundational elements are consistently identified in studies of strategies to meet deep decarbonization goals**
- **Across most decarbonization studies, electric sector plays a central role in meeting goals**
  - Through direct carbon reductions
  - Through electrification of loads to reduce emissions in other sectors

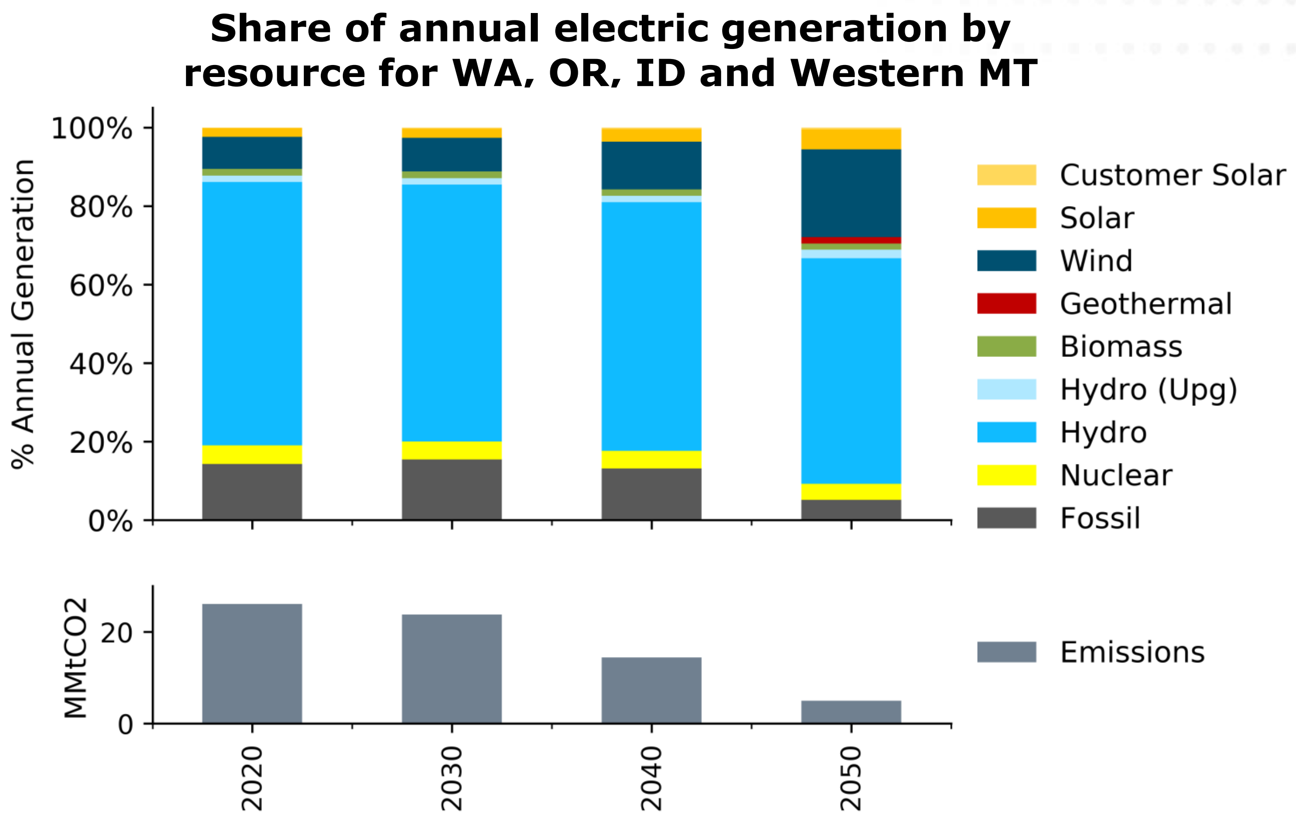
Deep decarbonization scenarios mean both annual and peak load growth

- A low carbon electricity system enables emissions reductions elsewhere in the economy via measures like transportation and building electrification
- However, those measures will increase both the annual and peak loads in the Northwest, even in scenarios that include deep energy efficiency savings



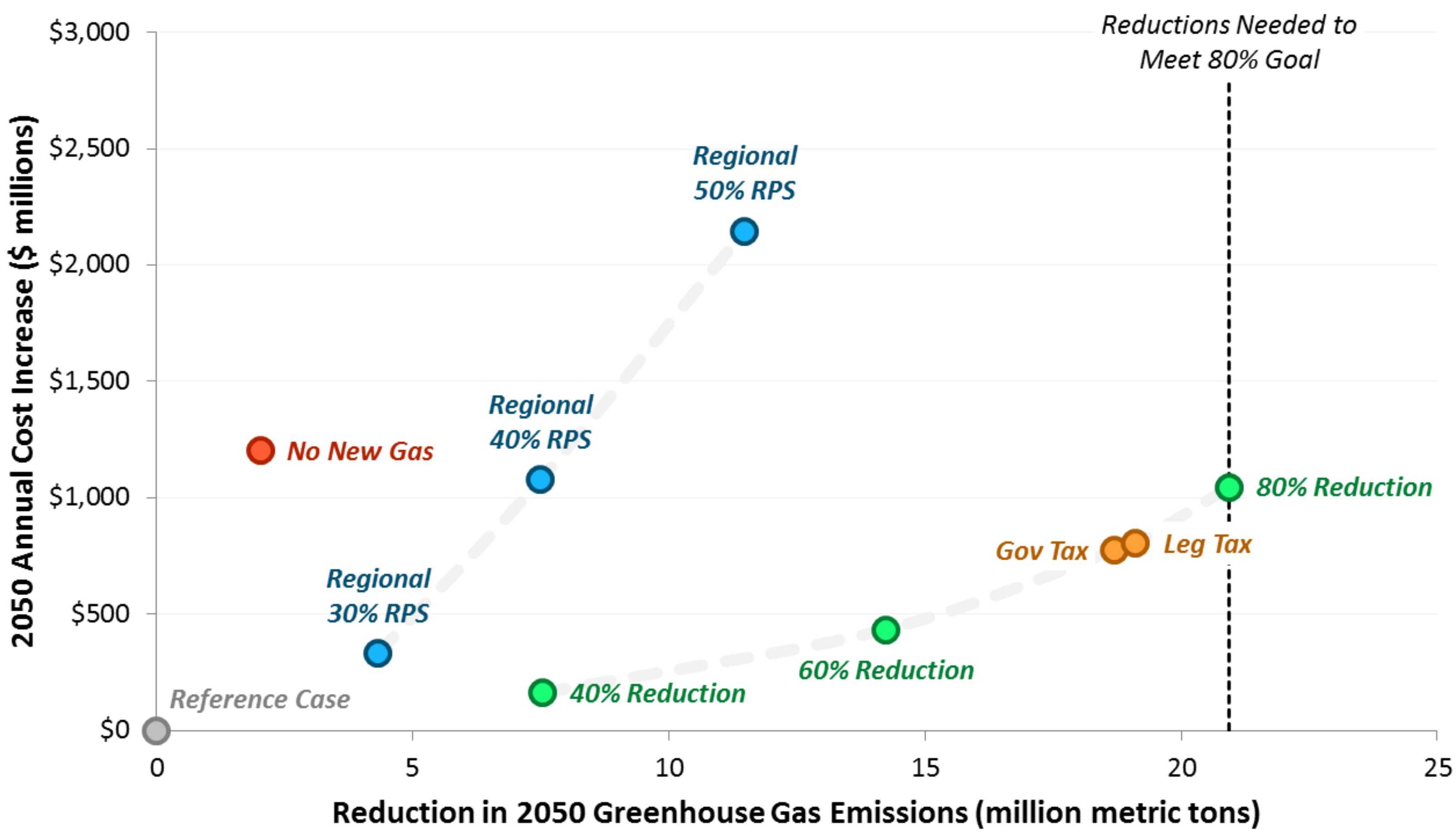


Annual Generation in the Northwest by Resource Type



- Fossil generation emissions decline in the near-term as coal generation is replaced by gas and renewables. The largest source of incremental generation is wind energy.
- This example is consistent with a 90% reduction in electric sector GHG emissions relative to 1990

Some approaches to decarbonize electricity are more effective than others



Note: Reference Case reflects current industry trends and state policies, including Oregon's 50% RPS goal for IOUs and Washington's 15% RPS for large utilities

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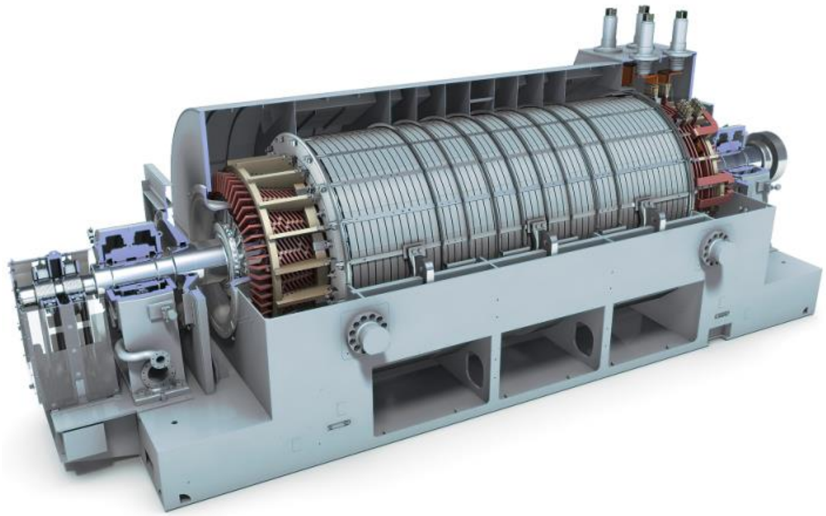
Ensuring Reliability in a Low-Carbon Electricity System

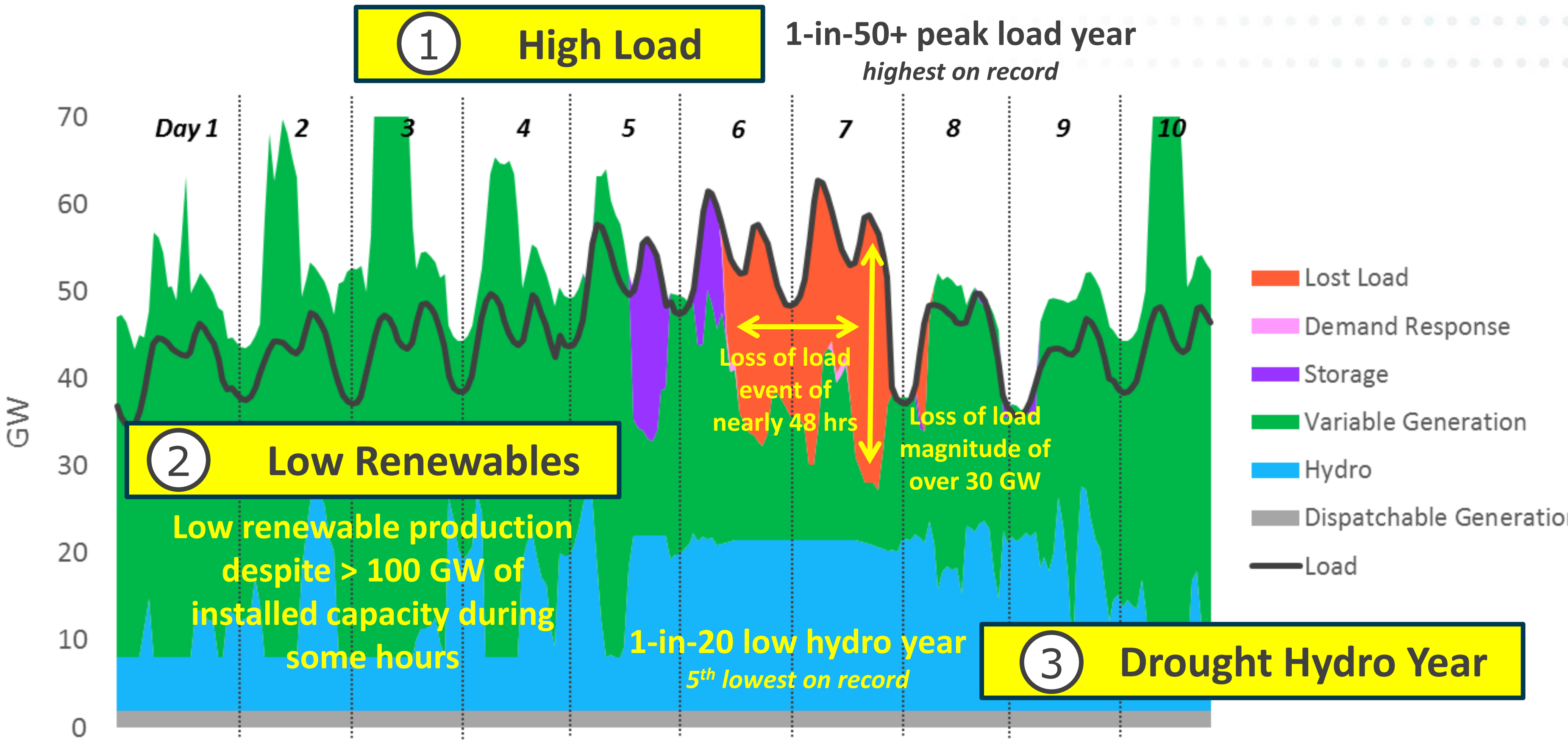
What is "capacity" and why is it important?

- **Capacity is the ability to generate electric energy at any given point in time**
- **Utilities need adequate generation capacity to meet continuously-varying electric loads reliably over a broad range of conditions**
- **The consequence of inadequate capacity is loss of load**
  - Loss of load is inconvenient, expensive, and potentially life-threatening
- **Utilities plan their systems to ensure that loss of load occurs very rarely**



Source: http://www.energy.siemens.com

Resource Adequacy Challenges in a High Renewables System



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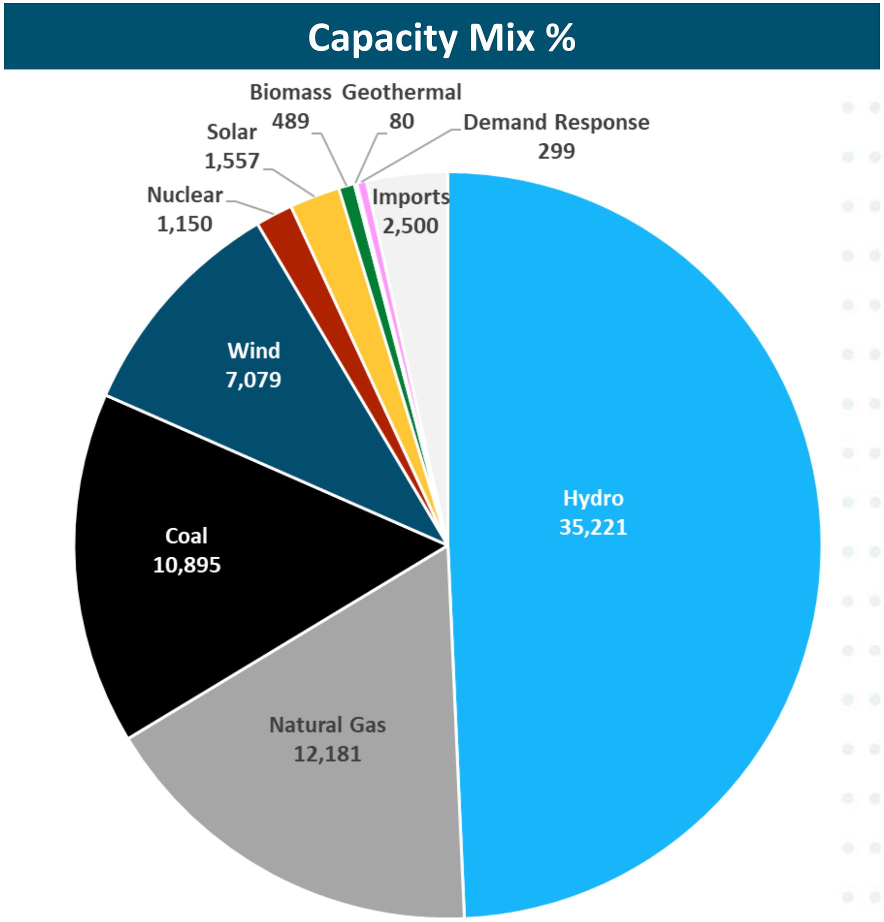
HOW RESOURCE ADEQUATE IS THE NW TODAY?

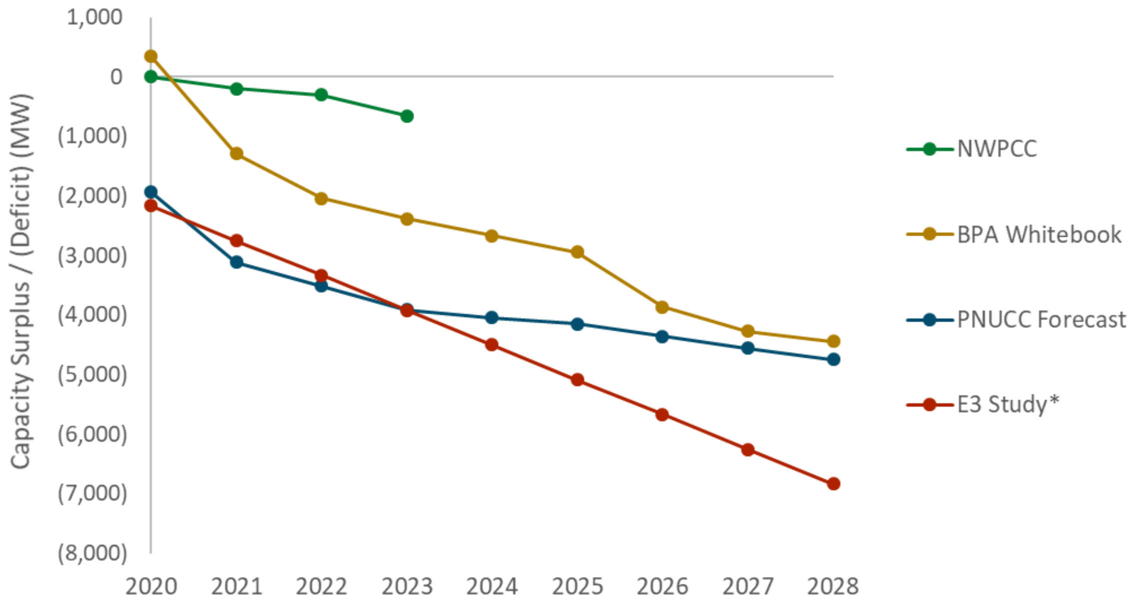
2018 System in the Northwest

Resource	2018 Nameplate MW
Hydro	35,221
Natural Gas	12,181
Coal	10,895
Wind	7,079
Nuclear	1,150
Solar	1,557
Other Hydro	524
Biomass	489
Geothermal	80
Demand Response	299
Imports	2,500



The Northwest system is in very tight load-resource balance

Summary of findings from recent reliability studies



- Over the past year, studies from multiple organizations have been released that show an electric sector capacity deficit in the Northwest
- These deficits appear due to a combination of thermal power plant retirements and renewed load growth in the region

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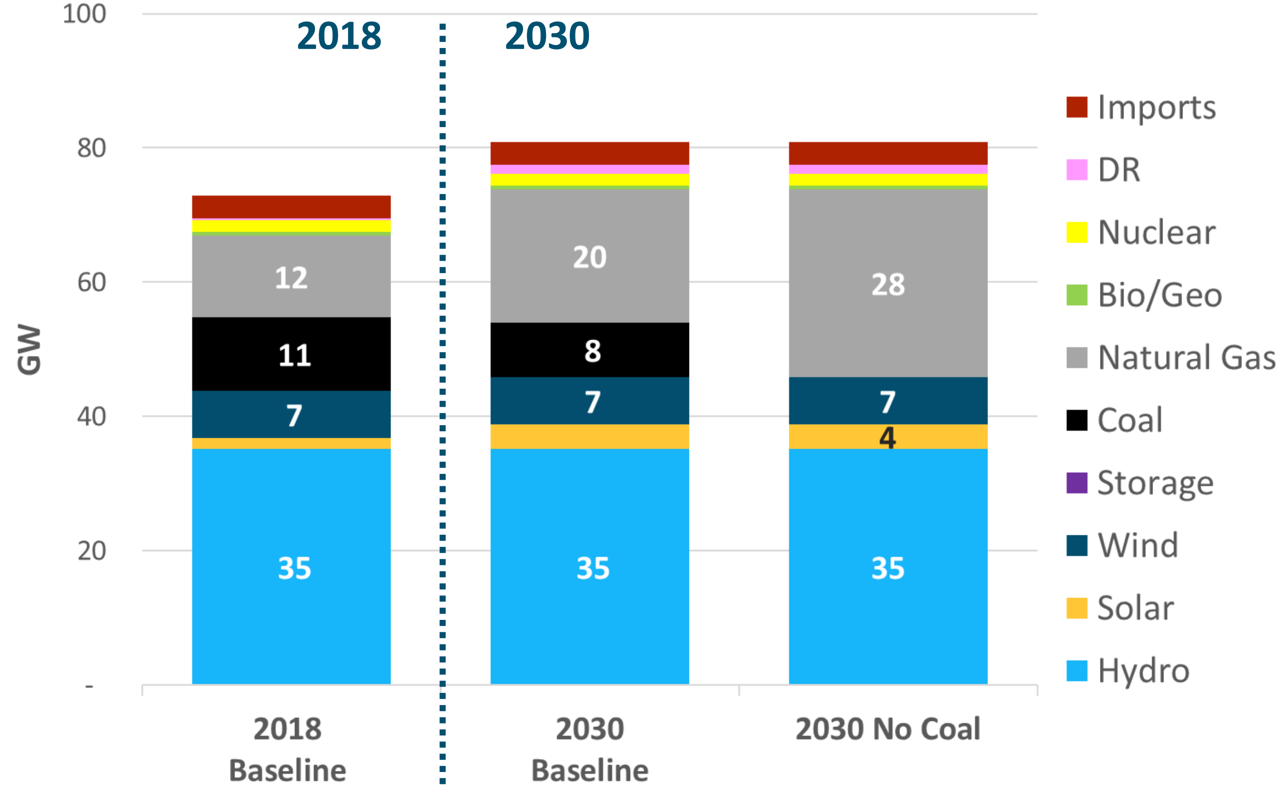
WHAT COULD THE RESOURCE ADEQUACY SITUATION BE IN 2030?

Northwest Electricity Capacity in 2030



GHG Free Generation (%)	61%	61%
Carbon (MMT CO2)	67	42
% GHG Reduction from 1990 Level	-12%*	31%

**Assumes 60% coal capacity factor*

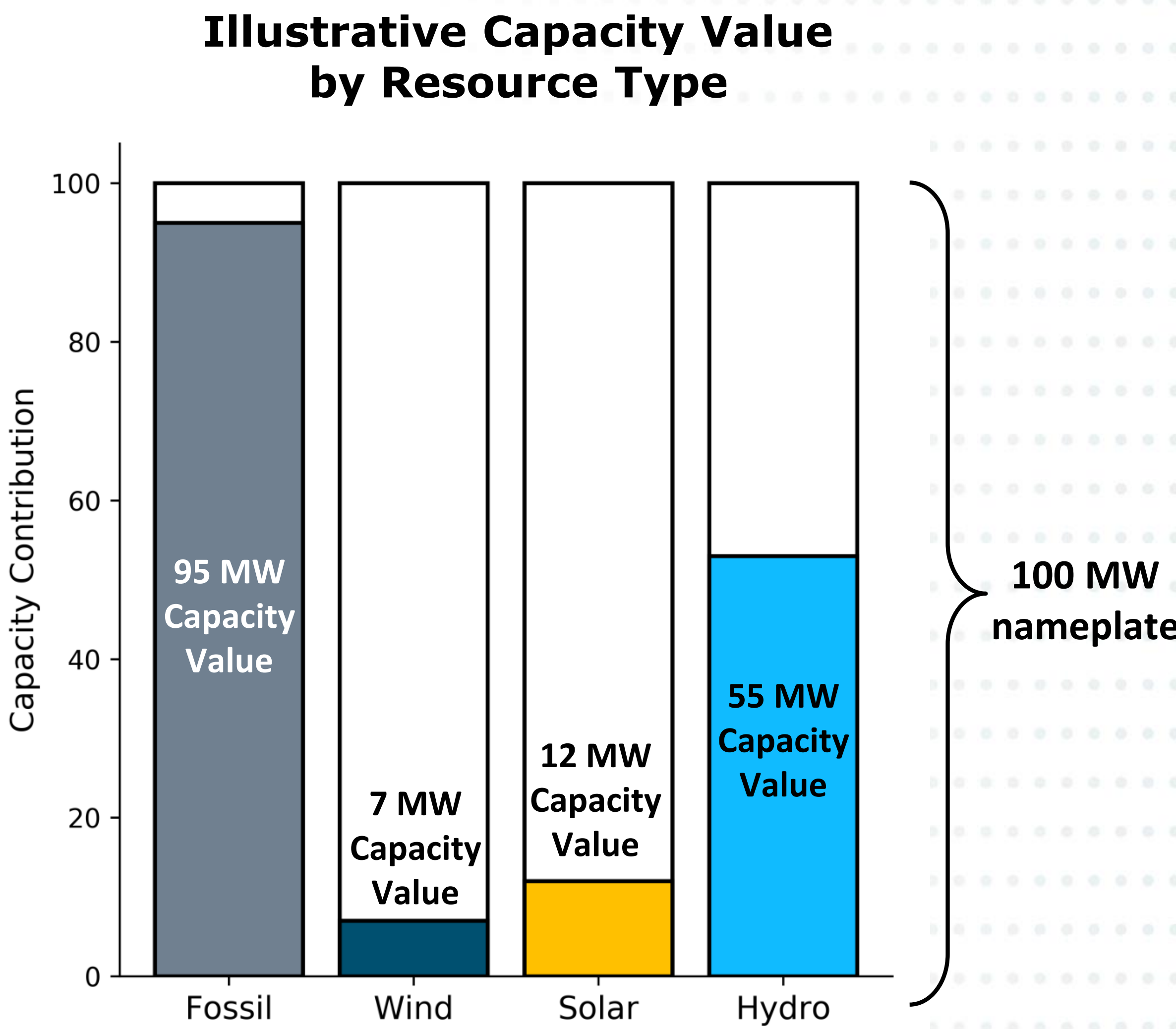
5 GW net new capacity by 2030 is needed for reliability (450 MW/yr)

With planned coal retirements of 3 GW, 8 GW of new capacity by 2030 is needed (730 MW/yr)

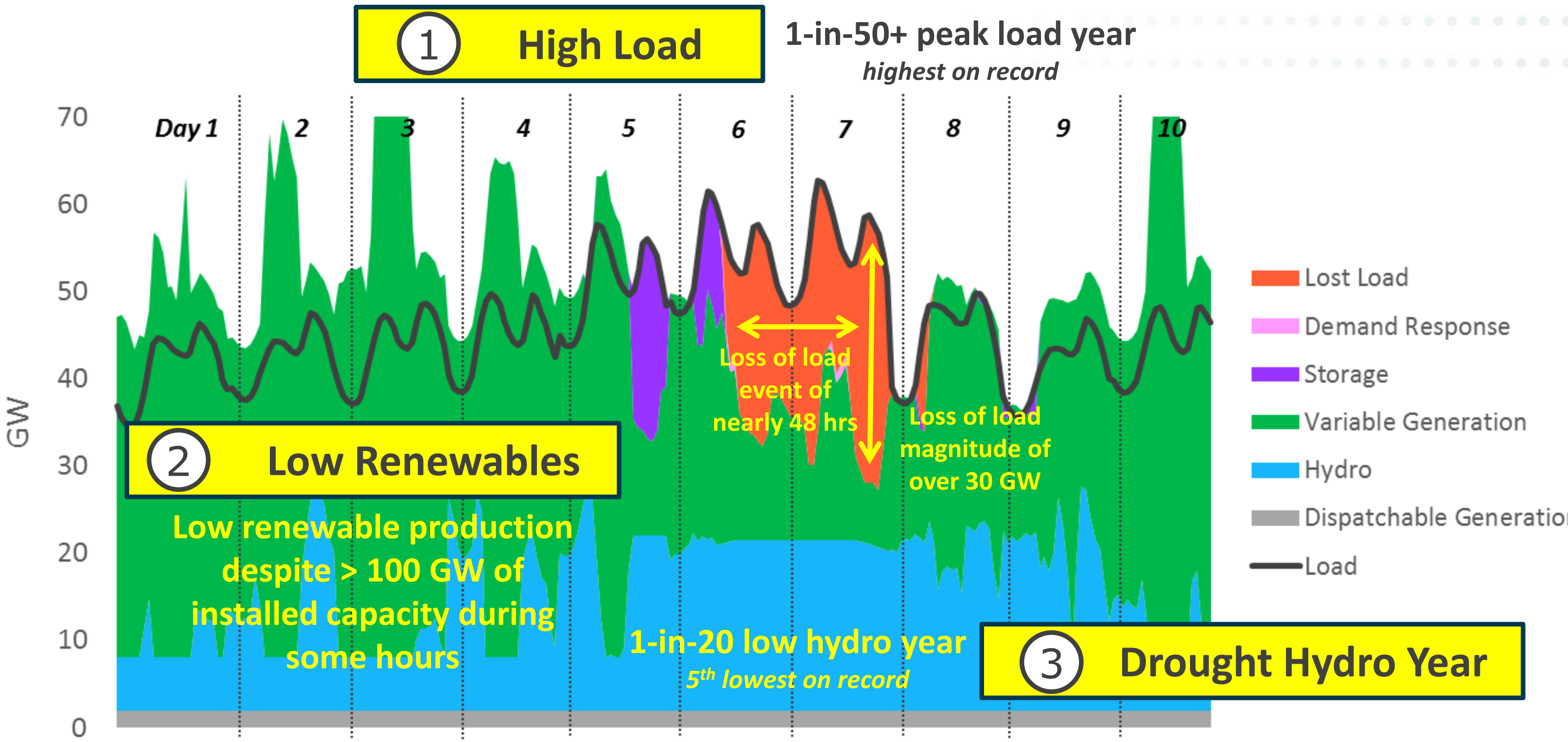
If all coal is retired, then 16 GW new capacity is needed (1450 MW/yr)

Capacity value definition

- A resource's contribution to system reliability
- What portion of a generator's nameplate capacity can you count on during times of system stress?
- In practice, determining capacity values of variable resources is a complicated exercise



Resource Adequacy Challenges in a High Renewables System



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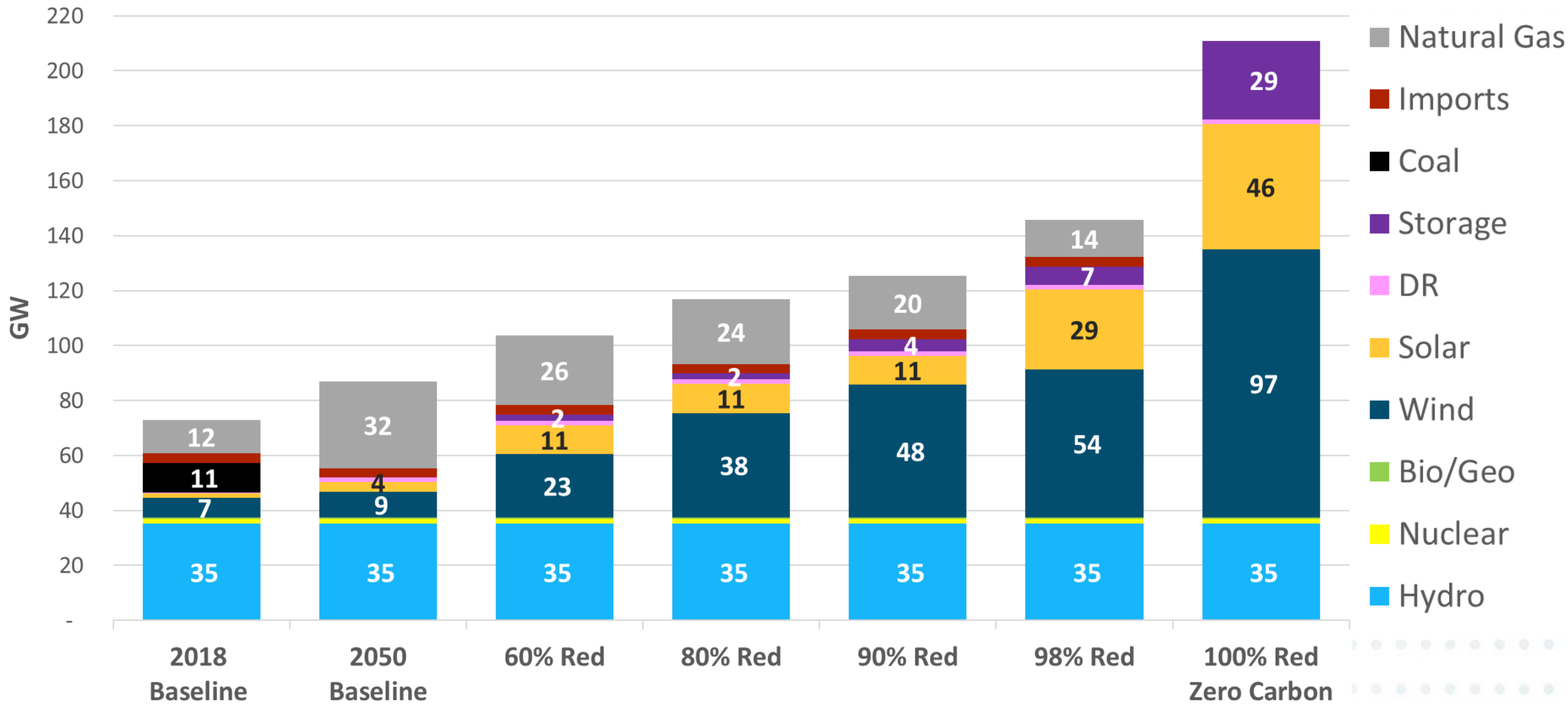
RESOURCE ADEQUACY IN 2050

Electric Capacity in 2050



Removing final 1% of carbon requires additional $100b to $170b of investment

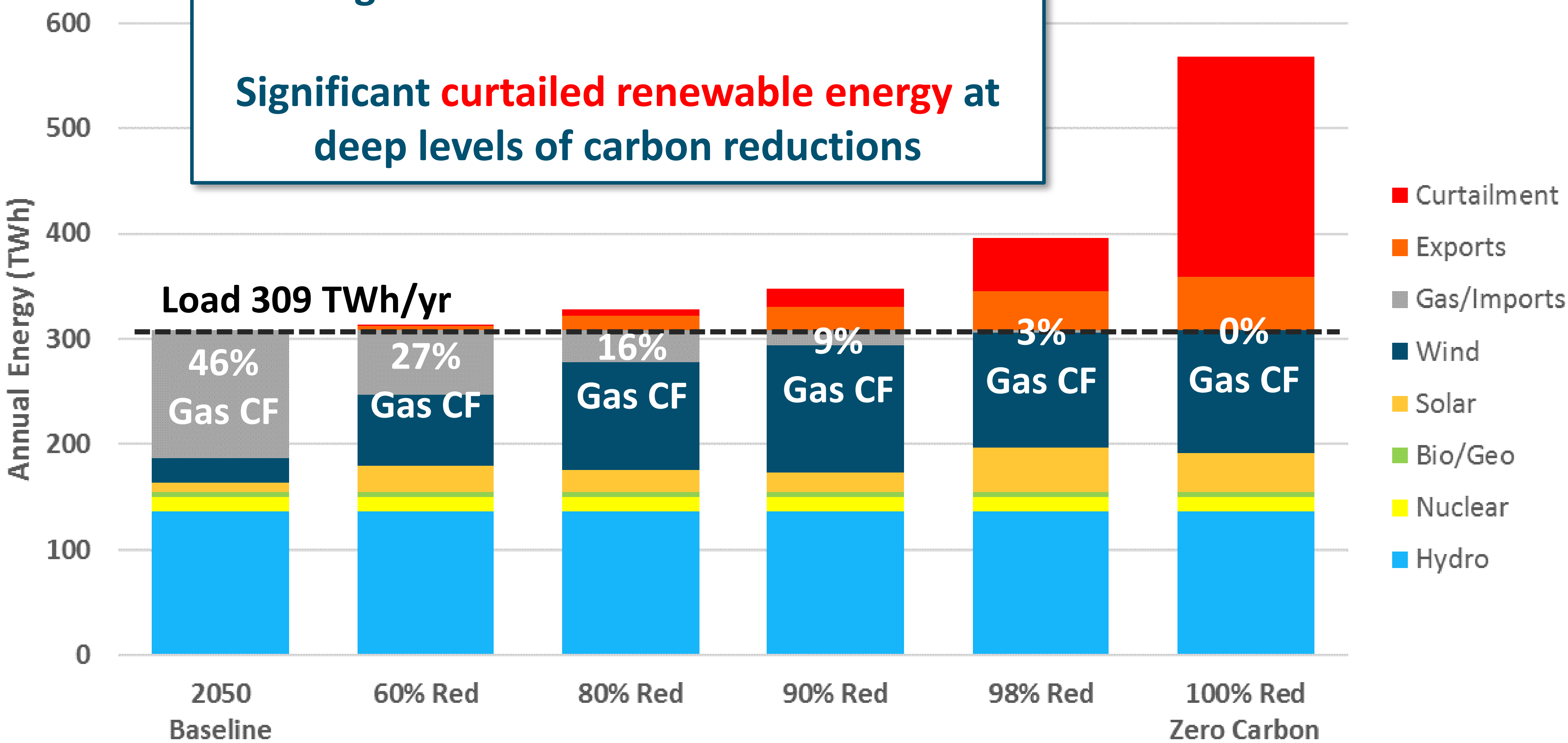
[1]CPS+ % = renewable/hydro/nuclear generation divided by retail electricity sales

[2]GHG-Free Generation % = renewable/hydro/nuclear generation, minus exports, divided by total wholesale load

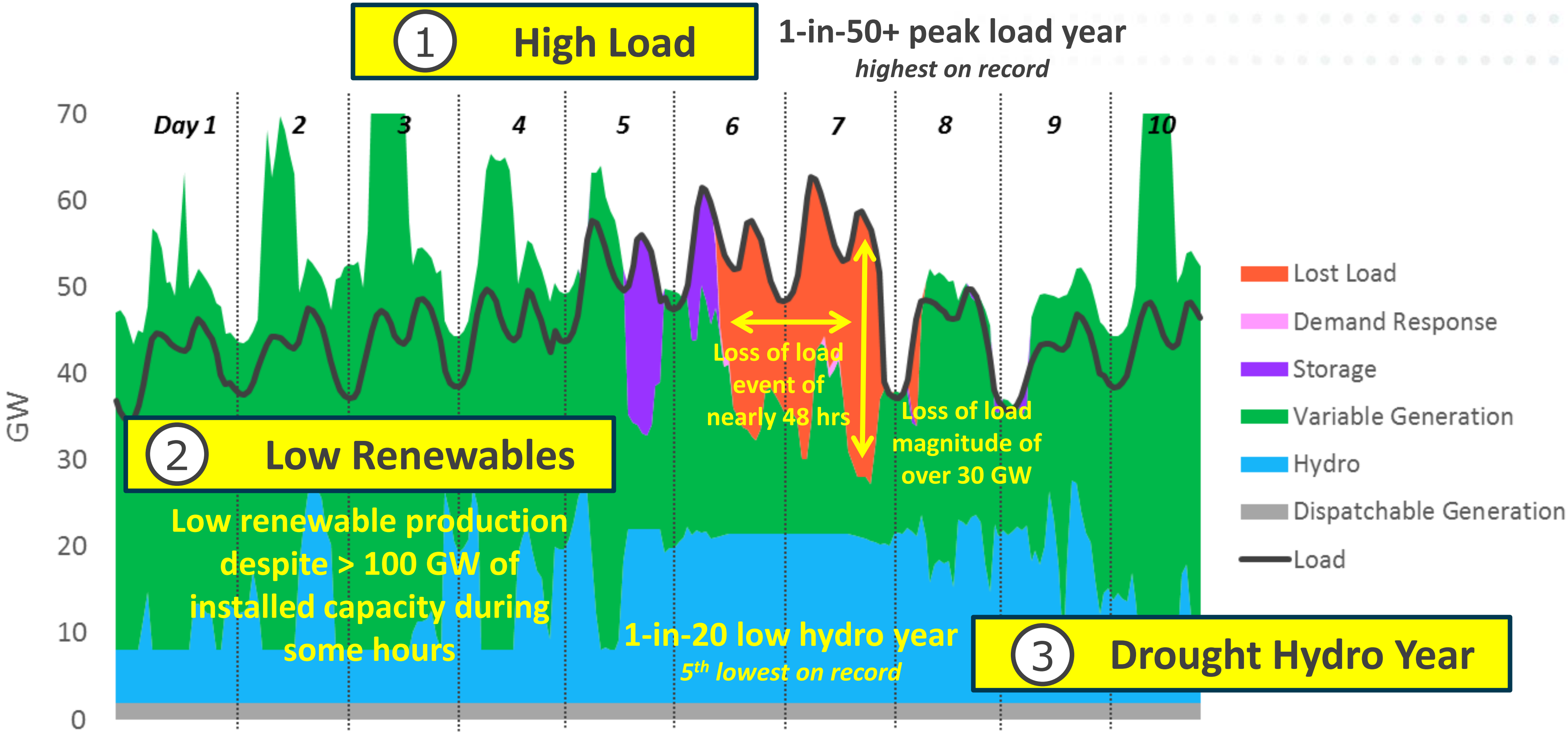
2050 Annual Energy Balance

Gas capacity factor declines significantly at higher levels of decarbonization

Significant curtailed renewable energy at deep levels of carbon reductions

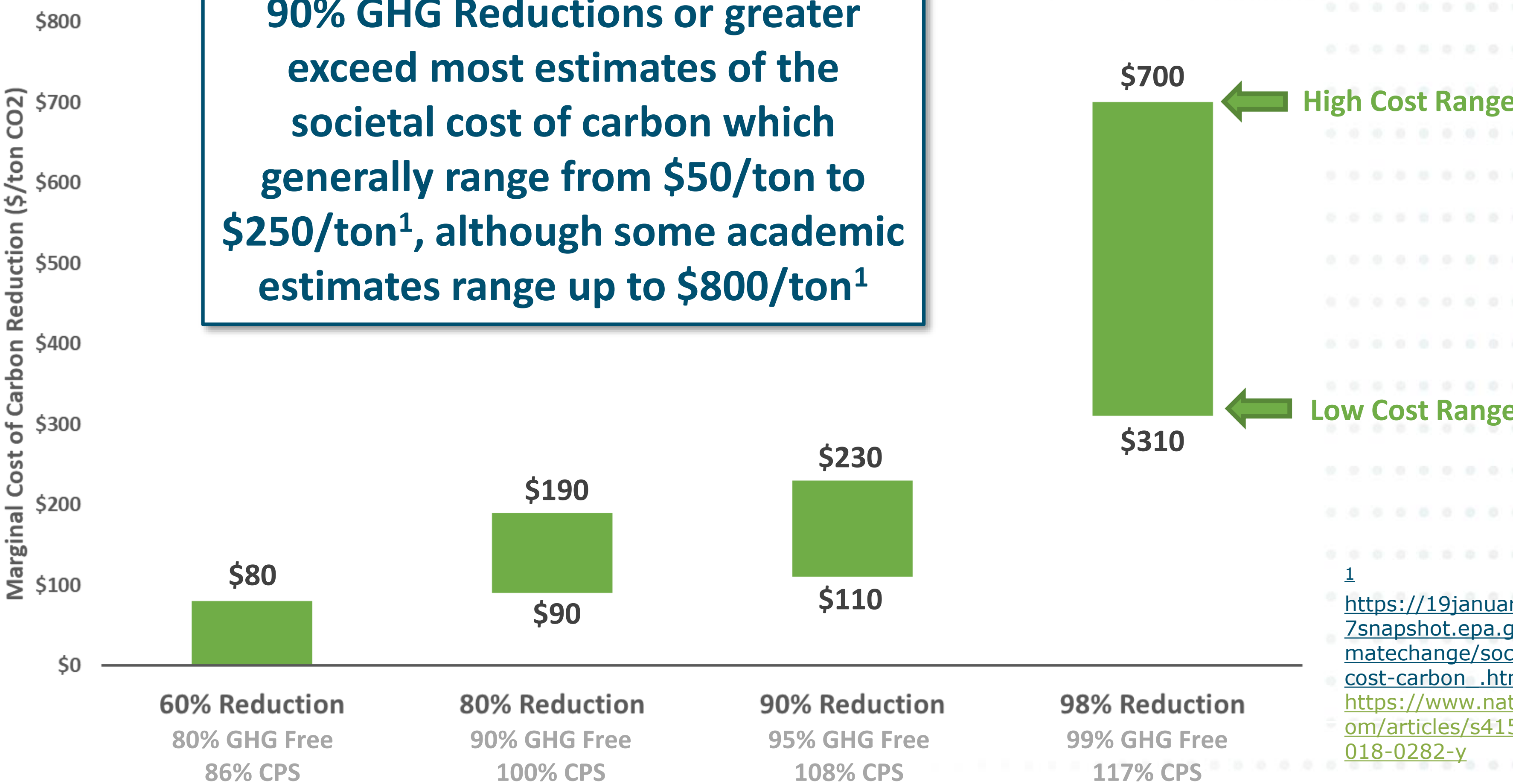


Resource Adequacy Challenges in a High Renewables System



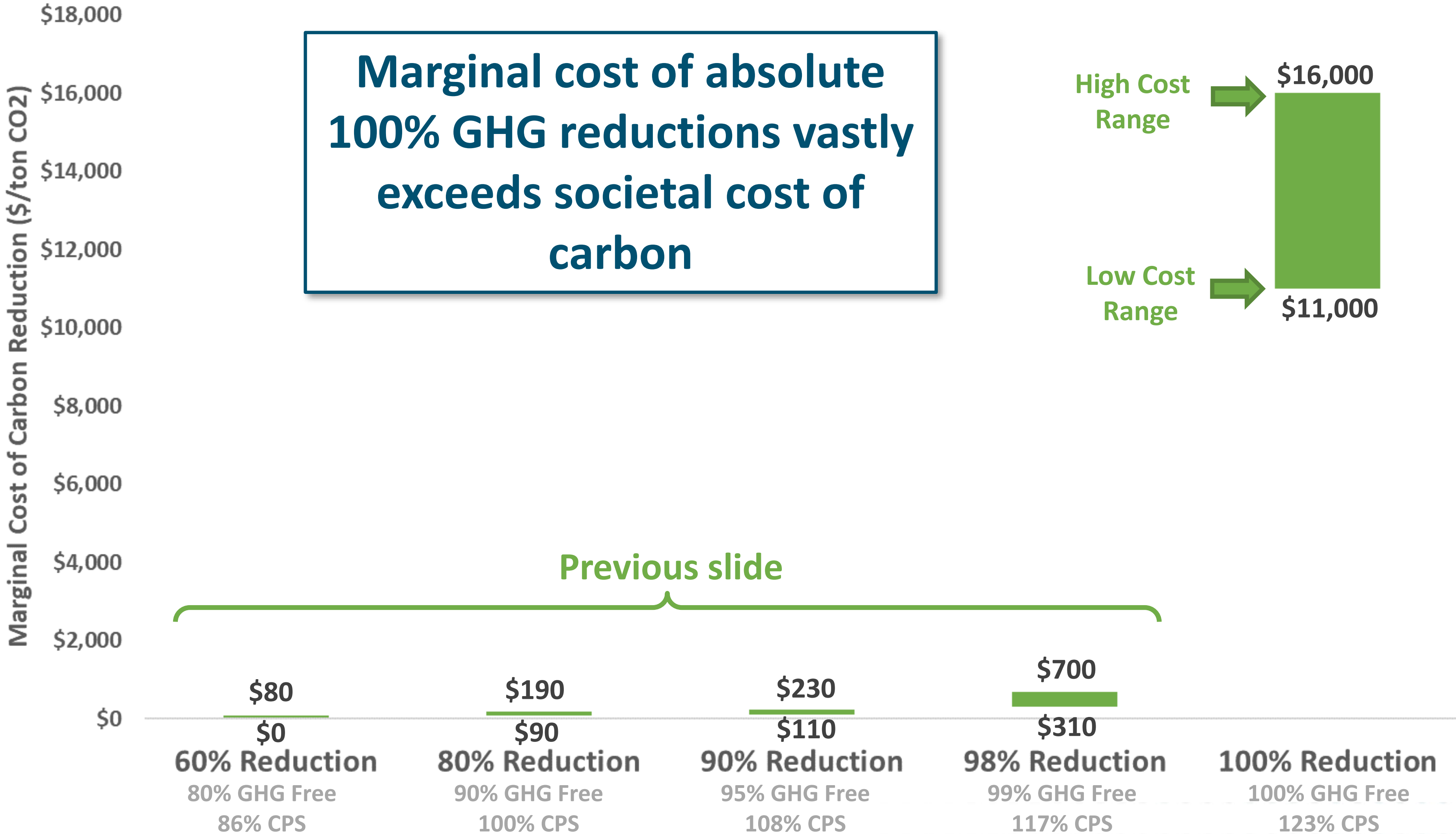
Marginal Cost of GHG Reduction

Marginal cost of CO2 reductions at 90% GHG Reductions or greater exceed most estimates of the societal cost of carbon which generally range from \$50/ton to \$250/ton[1], although some academic estimates range up to \$800/ton[1]



1 https://19january2017snapshot.epa.gov/climatechange/social-cost-carbon_.html; https://www.nature.com/articles/s41558-018-0282-y

Marginal Cost of GHG Reduction



Key takeaways

- The electric sector is a key driver of economy-wide decarbonization. Low-GHG electricity enables decarbonization throughout the economy
- Given the pivotal role of electricity, reliability is key. However, the region faces both near- and long-term reliability issues without firm capacity
- Natural gas power plants have a key role to play in maintaining reliability, but those plants usage decreases rapidly over time
- Potential resources that could supplant natural gas as a key reliability resource are not commercially available

Thank You!

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E3 studies cited in this presentation

Pacific Northwest Low-Carbon Scenario Analysis (2017)

- https://www.ethree.com/wp-content/uploads/2017/11/E3_NW_LowCarbonStudy_FinalResults_2017-11-08.L.pdf
- Geography: WA, OR, ID, Western MT

Pacific Northwest Pathways to 2050 (2018)

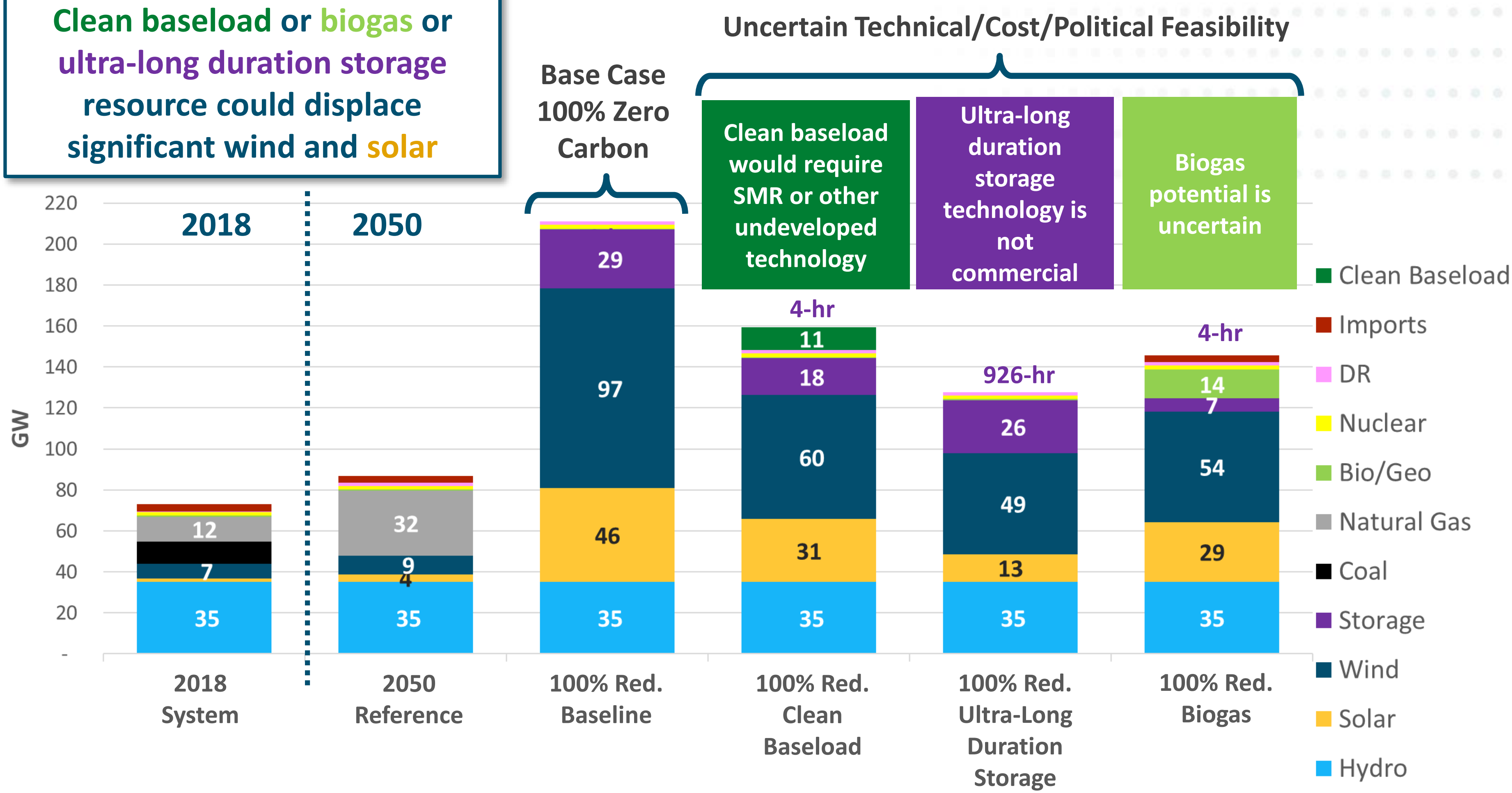
- https://www.ethree.com/wp-content/uploads/2018/11/E3_Pacific_Northwest_Pathways_to_2050.pdf
- Geography: WA, OR

Resource Adequacy in the Pacific Northwest (2019)

- https://www.ethree.com/wp-content/uploads/2019/03/E3_Resource_Adequacy_in_the_Pacific-Northwest_March_2019.pdf
- Geography: WA, OR, ID, Western MT, Western WY, UT

100% Reduction Portfolio Alternatives in 2050

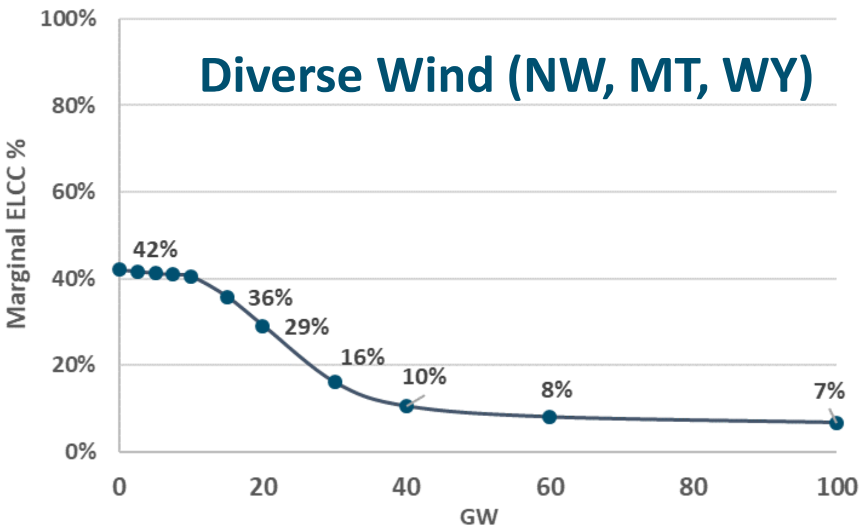
Clean baseload or biogas or ultra-long duration storage resource could displace significant wind and solar

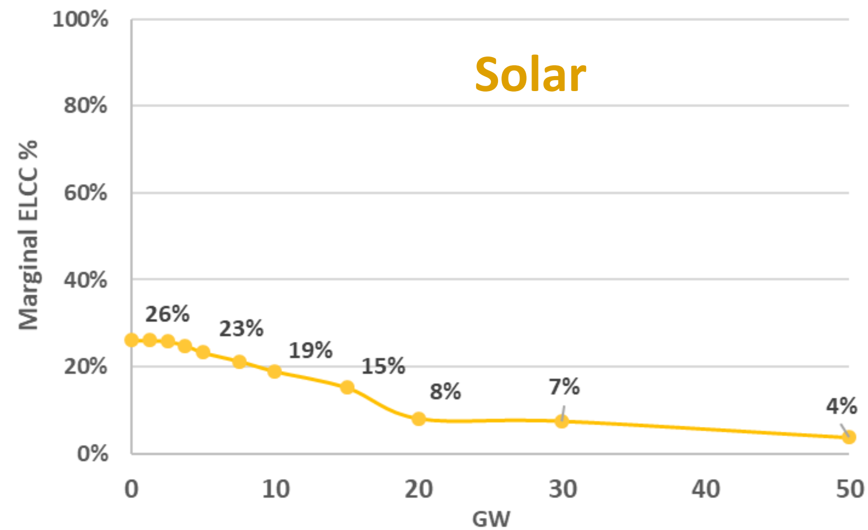


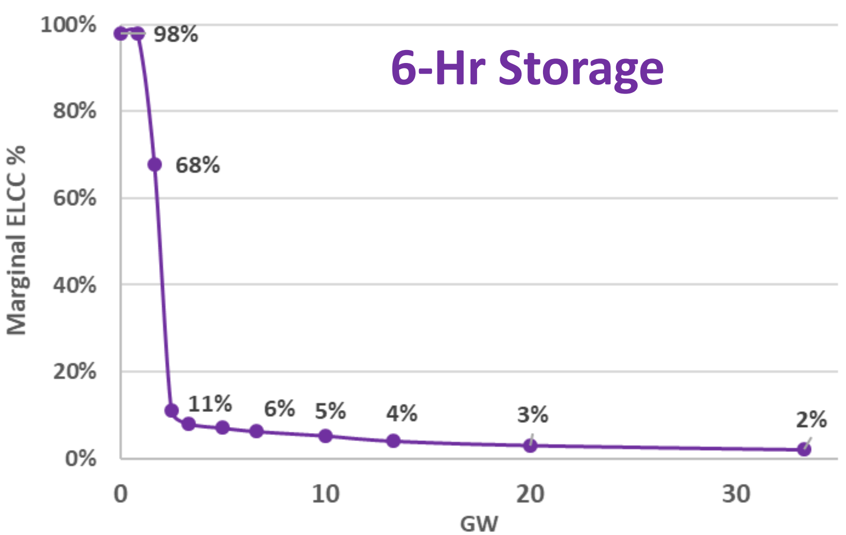
Carbon (MMT CO2)	50	0	0	0	0
Annual Cost Delta ($B)	Base	$16- $28	$14-$21	$550-$990	$4 - $9
Additional Cost ($/MWh)	Base	$52-$89	$46-$69	$1,800-$3,200	$14 - $30

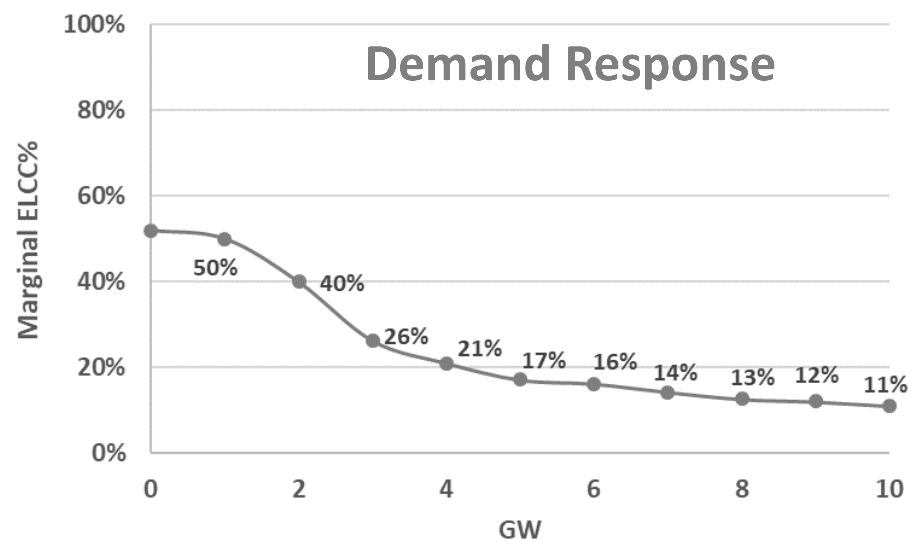
Effective Capacity by Resource

Effective capacity from wind, solar, storage, and demand response is limited due to saturation effects









ELCC = Effective Load Carrying Capability = firm contribution to system peak load