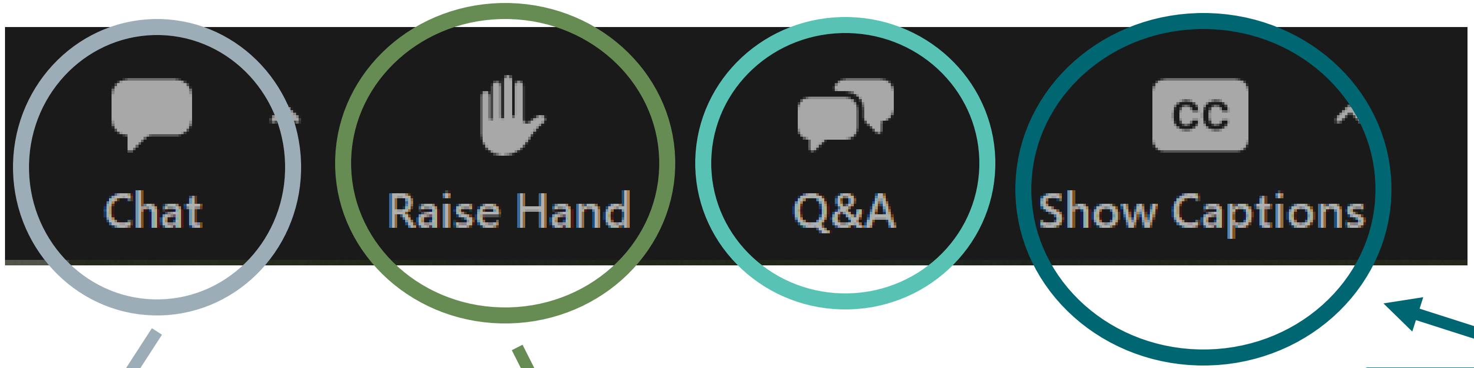
RPAG meeting

2025 Integrated Resource Plan

March 12, 2024

Welcome to the meeting!

The Q&A tool will be turned off during the meeting



RPAG members and PSE staff are welcome to use the chat feature

During the public comment period, raise your hand if you would like to make a verbal comment

Click to see real-time closed captioning

PSE PUGET SOUND ENERGY

Safety moment

March is Eye Wellness Month!

- Wear appropriate eyewear in a hazardous area
- Wear googles or face shields when working with chemicals
- Keep your eye protection in good condition
- Prevent screen-related eye strain with the 20-20-20 rule:
    - Every 20 minutes look away from your screen and look at an object 20 feet away for 20 seconds

PUGET SOUND ENERGY

Facilitator requests

- Engage constructively and courteously towards all participants
- Take space and make space
- Respect the role of the facilitator to guide the group process
- Avoid use of acronyms and explain technical questions
- Use the Feedback Form for additional input to PSE
- Aim to focus on the meeting topic
- Public comments will occur after PSE's presentations

Agenda

Time	Agenda Item	Presenter / Facilitator
12:00 p.m. – 12:05 p.m.	Introduction and agenda review	Sophie Glass, Triangle Associates
12:05 p.m. – 12:15 p.m.	Feedback summary	Phillip Popoff, PSE
12:15 p.m. – 1:30 p.m.	Resource adequacy results	Joe Hooker, E3 Arne Olson, E3
1:30 p.m. – 1:40 p.m.	Break	All
1:40 p.m. – 2:50 p.m.	Social cost of greenhouse gas modeling	Elizabeth Hossner, PSE
2:50 p.m. - 3:00 p.m.	Next steps and public comment opportunity	Sophie Glass, Triangle Associates
3:00 p.m.	Adjourn	All

PUGET SOUND ENERGY

Today’s speakers

Sophie Glass

Facilitator, Triangle Associates

Phillip Popoff

Director, Resource Planning Analytics, PSE

Joe Hooker

Director, Energy + Environmental Economics (E3)

Arne Olson

Senior Partner, E3

Elizabeth Hossner

Manager, Resource Planning and Analysis

Feedback summary

Phillip Popoff, PSE

January 17 RPAG meeting feedback

- Public feedback included:
    - Request to spell out acronyms
    - Public participation in RPAG meetings
    - PSE electric reliability concerns

- RPAG feedback included:
    - Questions from Commission staff about EV forecast and resource adequacy modeling

PUGET SOUND ENERGY

Puget Sound Energy Resource Adequacy

RPAG presentation

March 2024

Arne Olson, Senior Partner
Joe Hooker, Director
Michaela Levine, Managing Consultant
Ruoshui Li, Senior Consultant
Ritvik Jain, Consultant

Energy+Environmental Economics

IAP2 Spectrum

	INFORM	CONSULT	INVOLVE	COLLABORATE	EMPOWER
PUBLIC PARTICIPATION GOAL	To provide the public with balanced and objective information to assist them in understanding the problem, alternatives and/or solutions.	To obtain public feedback on analysis, alternatives and/or decision.	To work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered.	To partner with the public in each aspect of the decision including the development of alternatives and the identification of the preferred solution.	To place final decision-making in the hands of the public.
PROMISE TO THE PUBLIC	We will keep you informed.	We will keep you informed, listen to and acknowledge concerns and aspirations, and provide feedback on how public input influenced the decision.	We will work with you to ensure that your concerns and aspirations are directly reflected in the alternatives developed and provide feedback on how public input influenced the decision.	We will look to you for advice and innovation in formulating solutions and incorporate your advice & recommendations into the decisions to the maximum extent possible.	We will implement what you decide.

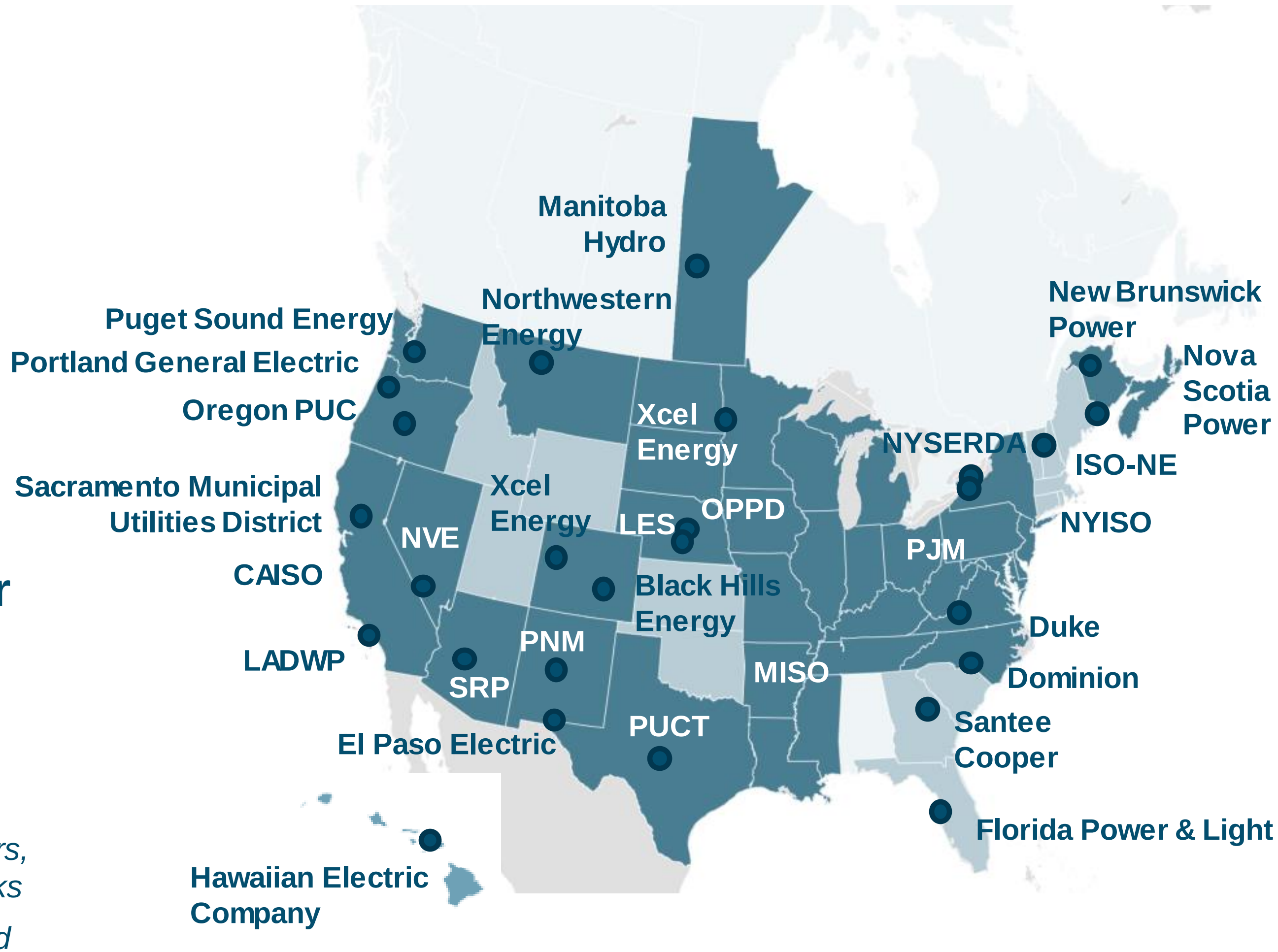
INCREASING IMPACT ON THE DECISION

Agenda

+ Background on resource adequacy
+ Changes in the 2025 Integrated Resource Plan (IRP)
+ Planning reserve margin (PRM) and effective load carrying capability (ELCC) results
+ Comparison of Loss of Load Expectation (LOLE) and Loss of Load Probability (LOLP) results

E3's Experience Performing Resource Adequacy Studies

+ E3 has performed resource adequacy studies and advised entities on resource adequacy across North America
+ E3 has developed a proprietary loss of load probability model, RECAP, to perform resource adequacy studies
+ E3 performed a resource adequacy study for PSE's 2023 Electric Progress Report (EPR)



States where E3 has provided direct support to utilities, market operators, and/or state agencies to perform RA modeling or develop RA frameworks

Areas where E3 has worked with other clients to examine issues related to resource adequacy

Background on Resource Adequacy

Energy+Environmental Economics

Resource Adequacy Inputs to the Portfolio Analysis: PRM and ELCC

Planning Reserve Margin (PRM)

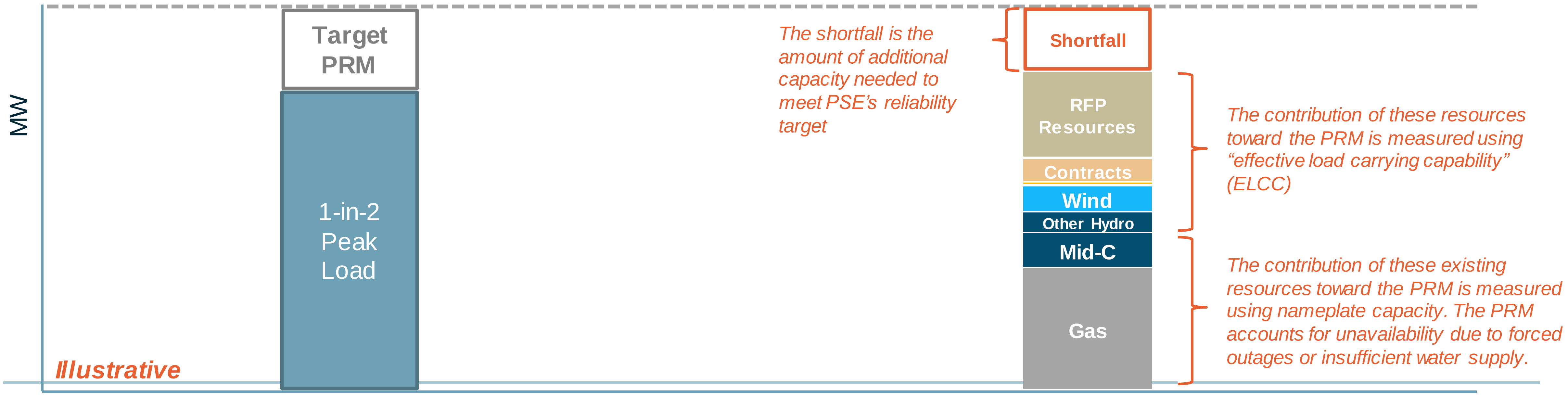
The PRM is the total amount of capacity needed to satisfy the reliability target. (E3 will perform modeling for both 5% LOLP and 0.1 LOLE.)

- ***"How many MW needed in total"***
- ***Measured as % above PSE's expected peak load***

Effective Load Carrying Capability (ELCC)

The ELCC is the equivalent "perfect" capacity that a resource provides in meeting PSE's reliability target

- ***"How many MW provided by each resource"***
- ***Measured as % of nameplate capacity***



LOLE = Loss-of-Load Expectation, LOLP = Loss-of-Load Probability

Changes in the 2025 IRP

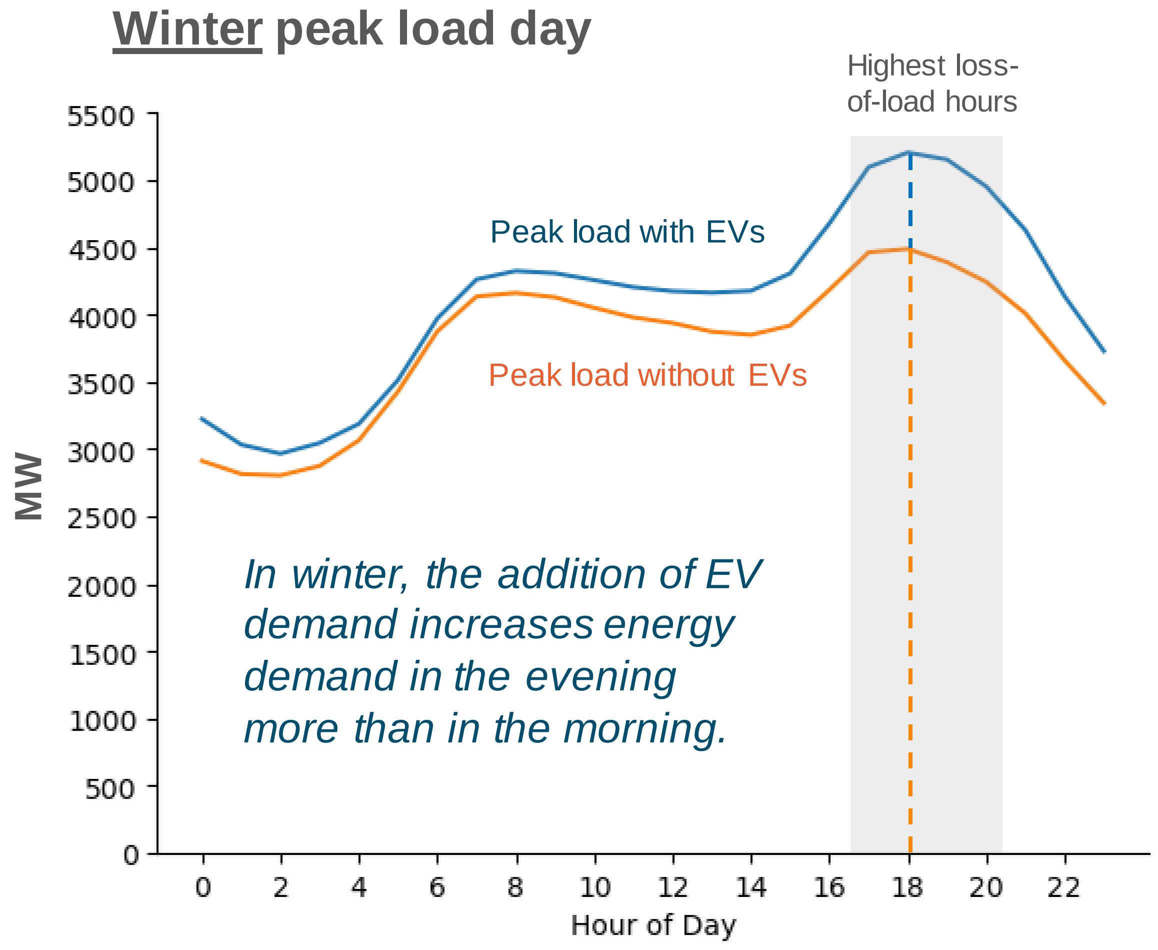
Energy+Environmental Economics

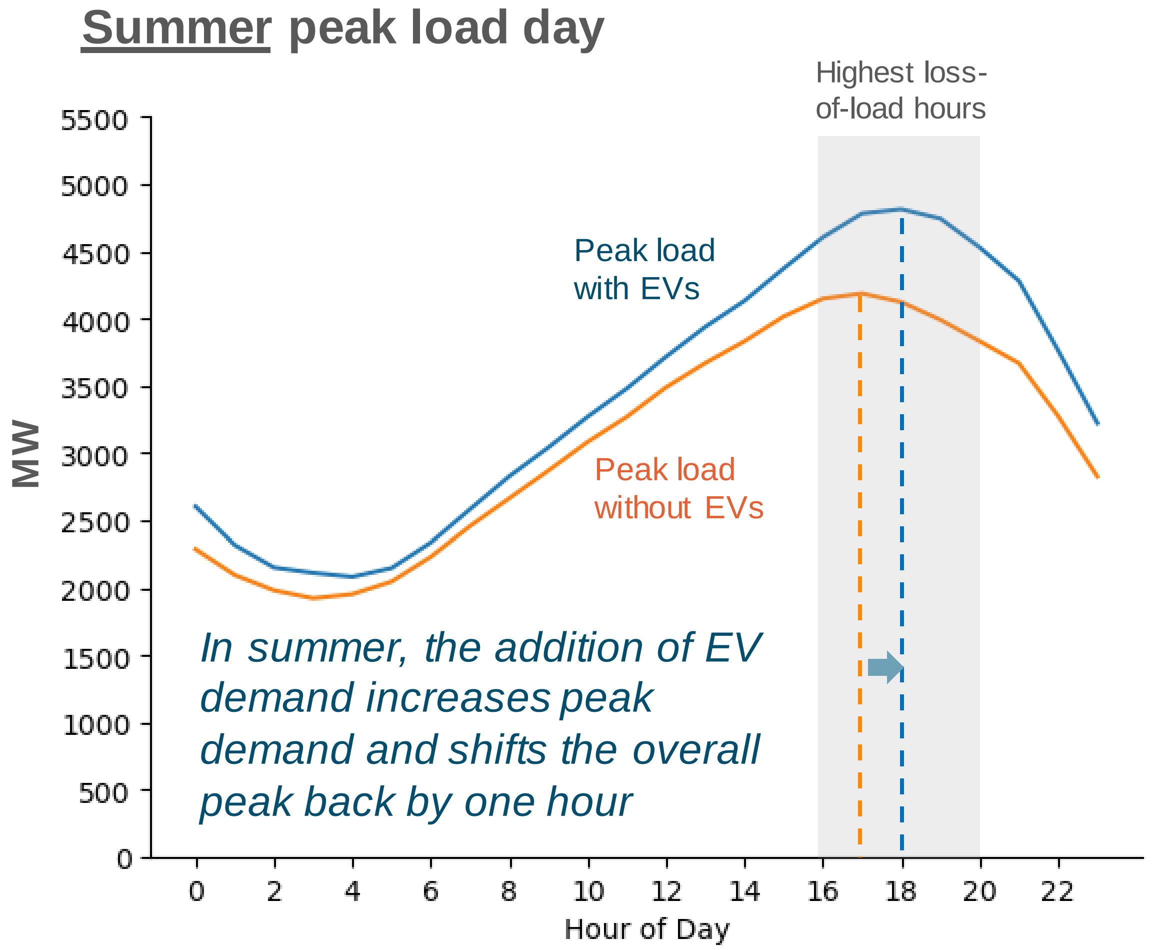
Key Changes in the 2025 IRP Resource Adequacy Analysis

Components	2023 EPR	2025 IRP	Directional Impact on Capacity Short
Load Forecast	No electric vehicle (EV) loads	Includes EV loads	↑ Resource need (large impact)
Operating Reserves	7.7% (includes balancing reserves)	7.1% (excludes balancing reserves)	↓ Resource need (small impact)
PG&E Exchange	300 MW export obligations in summer in exchange for 300 MW imports in winter	PG&E exchange removed	↓ Resource need in summer ↑ Resource need in winter
Market Availability	Market curtailments in summer and winter	All purchase curtailments in summer	Changes the timing of loss of load events
Mid-C Hydro Resources		Increased MW from Douglas PUD and modeled flexibility for two Grant PUD units	↓ Resource need
Demand Response	No demand response in E3 modeled base portfolio	119 MW winter nameplate; 149 MW summer nameplate	↓ Resource need

* Other changes included: modeling line losses for MT, WY, ID resources; slight changes in small contracts; an updated profile for Snoqualmie; updated thermal outage rates. These changes have a relatively minor impact on the resource need relative to the items above.

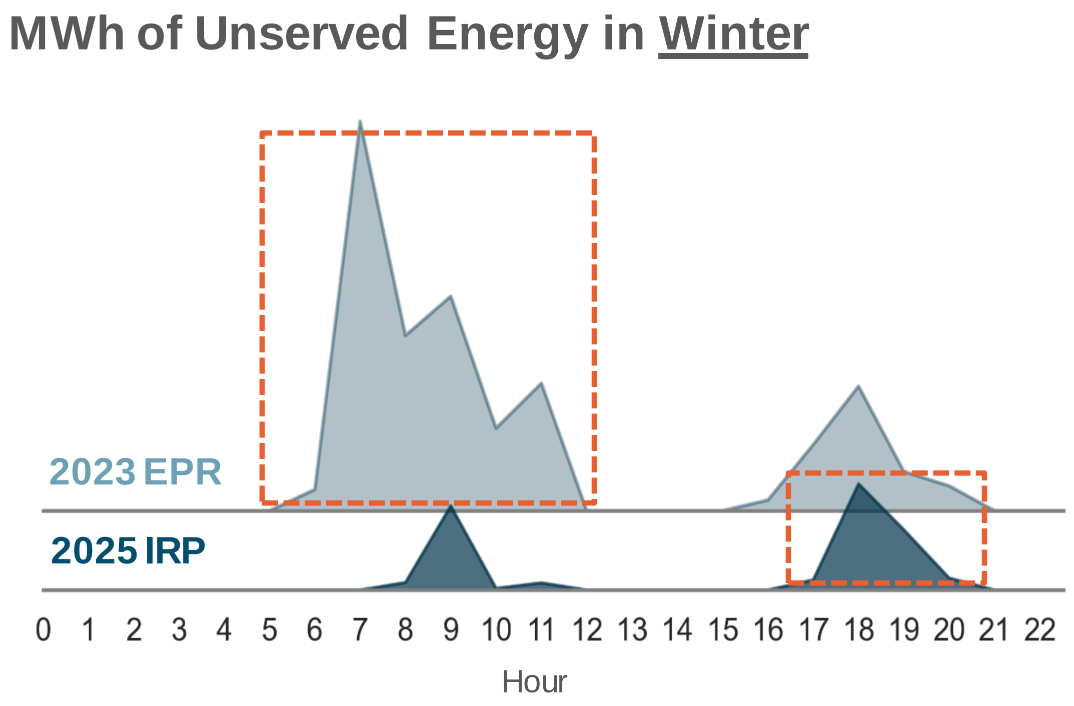
Impact of Electric Vehicles on Peak Energy Demand
Example from Model C





The charts above are an average across 30 load years. Managed charging will be considered in PSE's portfolio analysis.

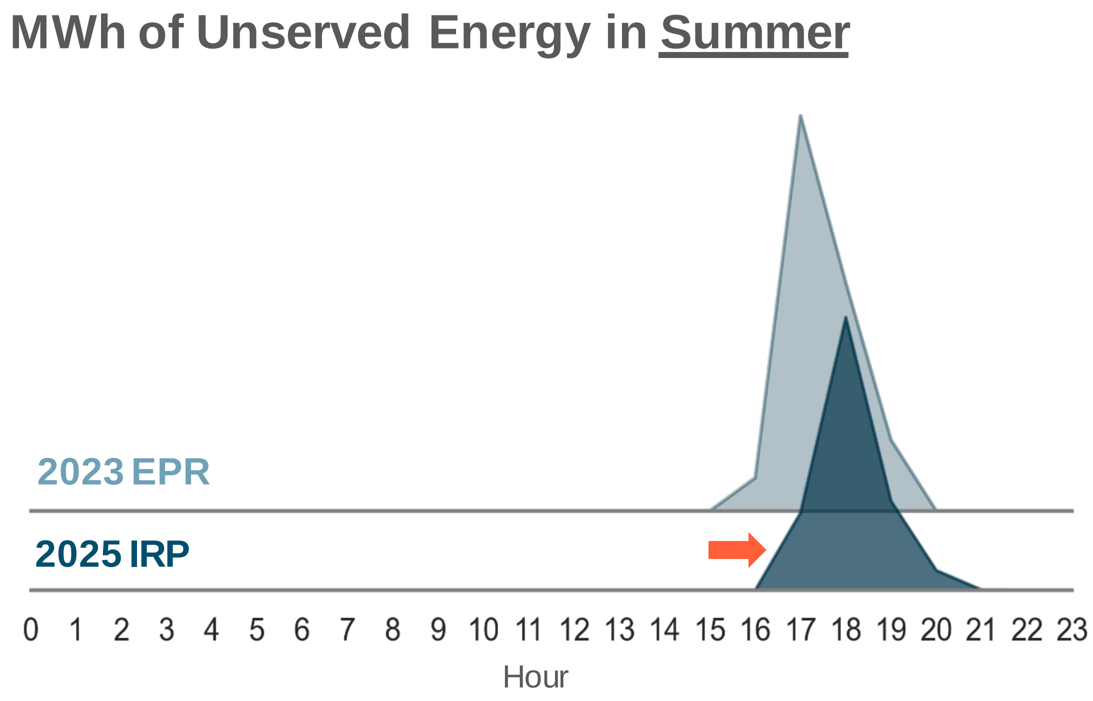
Change in Timing of Loss-of-Load Events
Average of All Models



In the 2025 IRP, winter loss of load events are less concentrated in morning periods for two reasons:

- Addition of electric vehicles → higher evening demand
- Reduction in market purchase curtailments → no longer deep market purchase curtailments in the morning

The length of loss of load events is shorter as a result.



In the 2025 IRP, summer loss of load events shift slightly later due to the addition of electric vehicles.

The length of loss of load events is similar.

2025 IRP Results
(Loss of Load Expectation runs)

Energy+Environmental Economics

Planning Reserve Margin: Comparison between 2025 Integrated Resource Plan (IRP) and 2023 Electric Progress Report (EPR)

	Winter		Summer	
	EPR	IRP	EPR	IRP
Median peak load	5,004	5,323	4,171	4,903
Capacity short vs. target	*1,272*	*1,622*	*1,875*	*1,648*
Capacity short vs. target (without unspecified imports)	2,712	2,973	2,836	2,986
Planning reserve margin	26%	22%	28%	24%

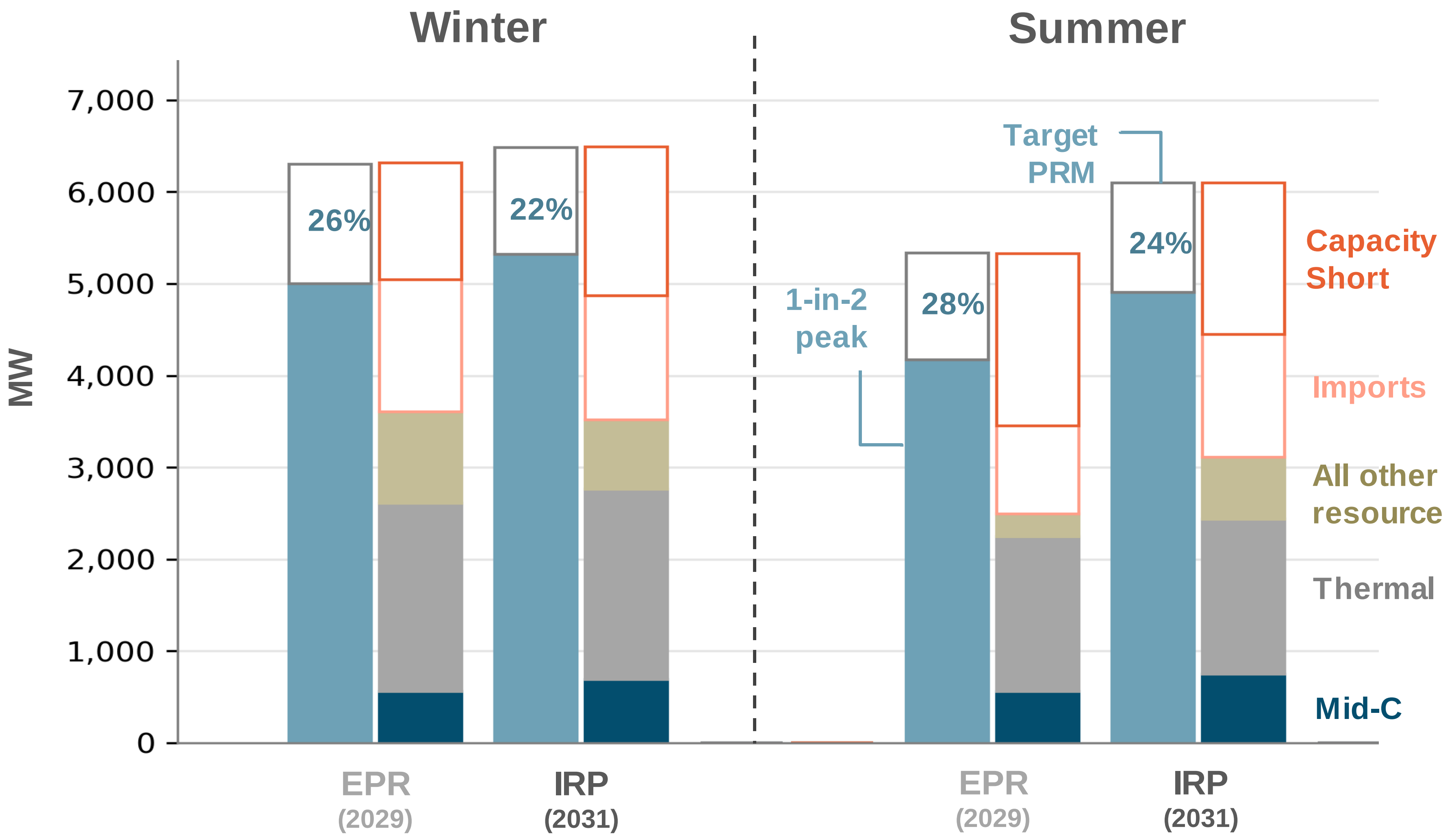
Median peak loads increase (driven primarily by EV load), especially in summer

Winter shortfall increases and summer decreases, due in part to removal of the PG&E exchange

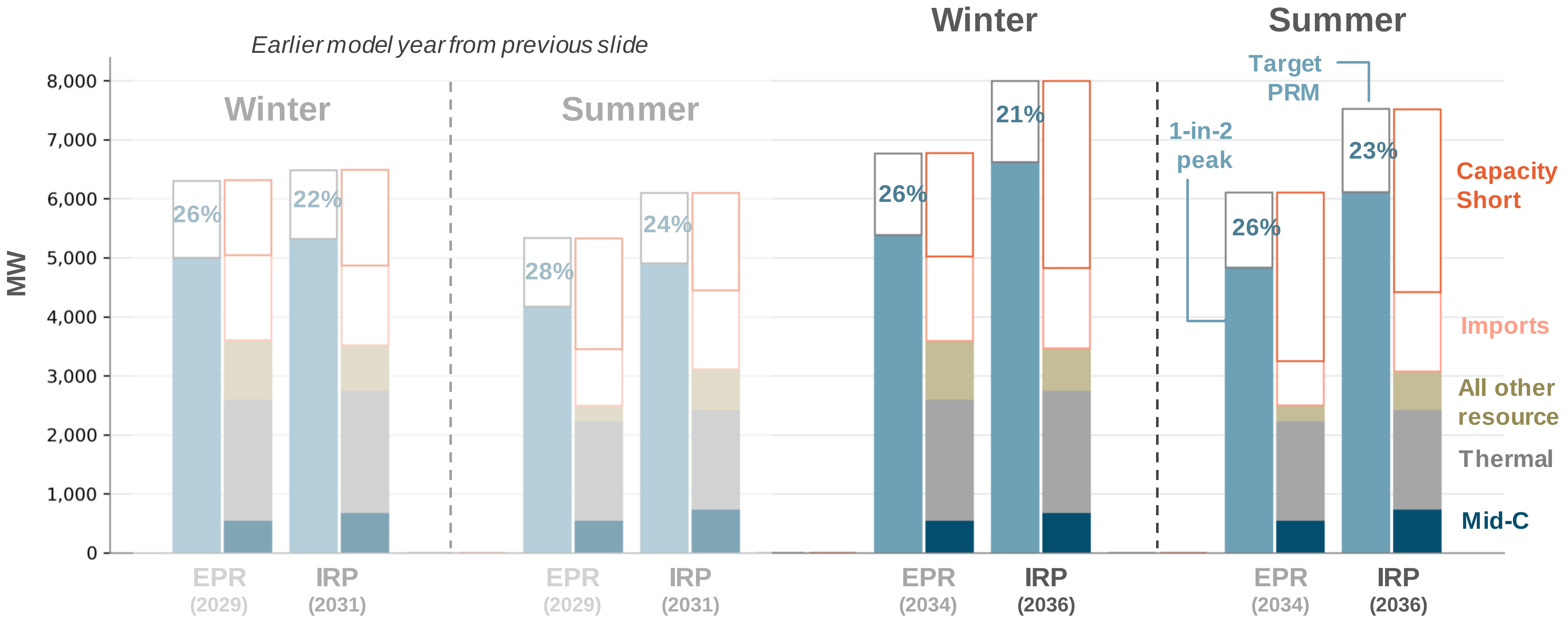
The overall capacity short increases to ~3,000 MW in both seasons

The planning reserve margin target is ~4% lower, due to reduced load variability across weather years and a slightly lower operating reserve requirement

Planning Reserve Margin:
2025 IRP vs. 2023 EPR



Planning Reserve Margin:
2025 IRP vs. 2023 EPR



Renewable Resource ELCCs

2025 IRP vs. 2023 EPR

ELCC of 100 MW Generic Resource Addition (%)

	Resource	Winter		Summer	
		EPR	IRP	EPR	IRP
Wind	Zone 1: British Columbia	34%	39%	13%	15%
	Zone 2: Offshore Wind	32%	35%	41%	38%
	Zone 3: Washington	13%	14%	5%	6%
	Zone 4: Montana	36%	31%	23%	21%
	Zone 5: Idaho	12%	13%	17%	19%
	Zone 6: Wyoming	46%	44%	34%	36%
Solar	Zone 2: Washington West	4%	4%	53%	51%
	Zone 3: Washington East	4%	2%	55%	48%
	Zone 5: Idaho	8%	2%	38%	30%
	Zone 6: Wyoming	11%	2%	28%	22%

Overall, the renewable ELCC results for the 2025 IRP are very similar to those from the 2023 EPR

Storage and Demand Response Resource ELCCs

2025 IRP vs. 2023 EPR

ELCC of 100 MW Generic Resource Addition (%)

Resource	Winter		Summer	
	EPR	IRP	EPR	IRP
Demand Response (3-hour)	69%	82%	95%	71%
Demand Response (4-hour)	73%	84%	99%	70%
Li-ion Battery (4-hour)	96%	98%	95%	98%
Pumped Storage (8-hour)	99%	99%	99%	99%
Iron-Air Battery (100-hour)		97%		97%

Demand response: the ELCC is higher in winter and lower in summer:

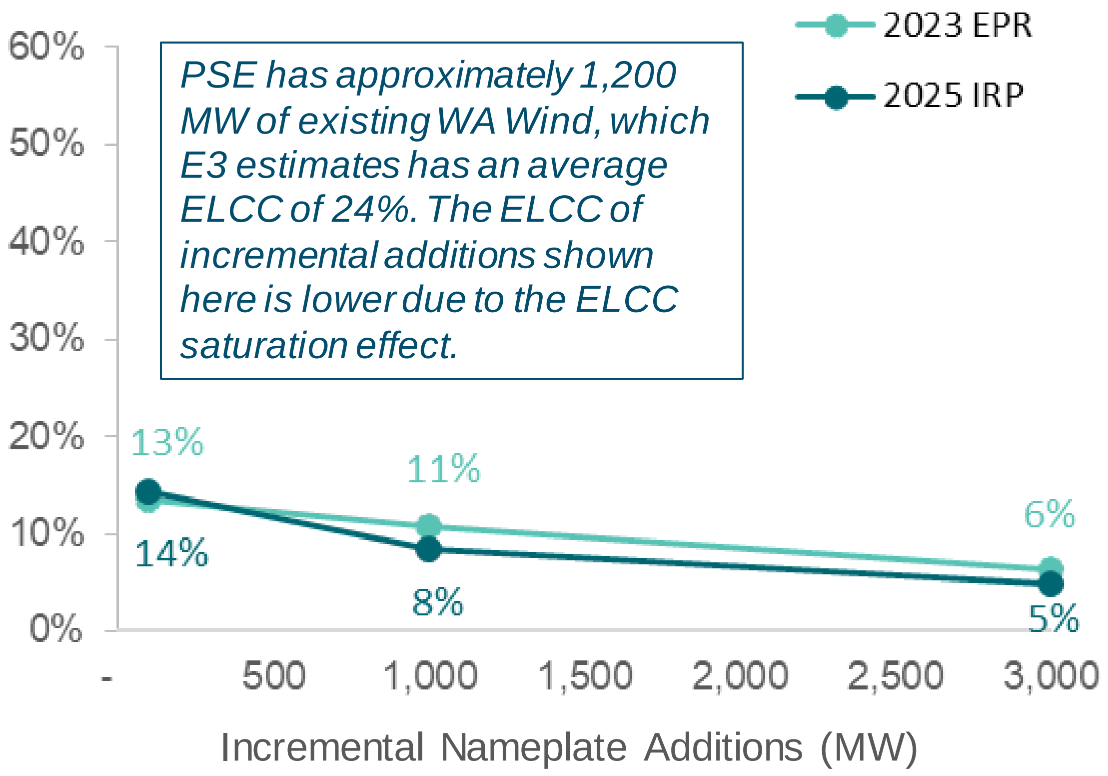
- Winter: shorter loss of load events result in an increase in the ELCC of demand response
- Summer: the addition of demand response in the base portfolio reduces the ELCC for subsequent additions of demand response

Storage: the ELCC results for the 2025 IRP are very similar to those from the 2023 EPR.

Washington Wind and Solar ELCC Comparison

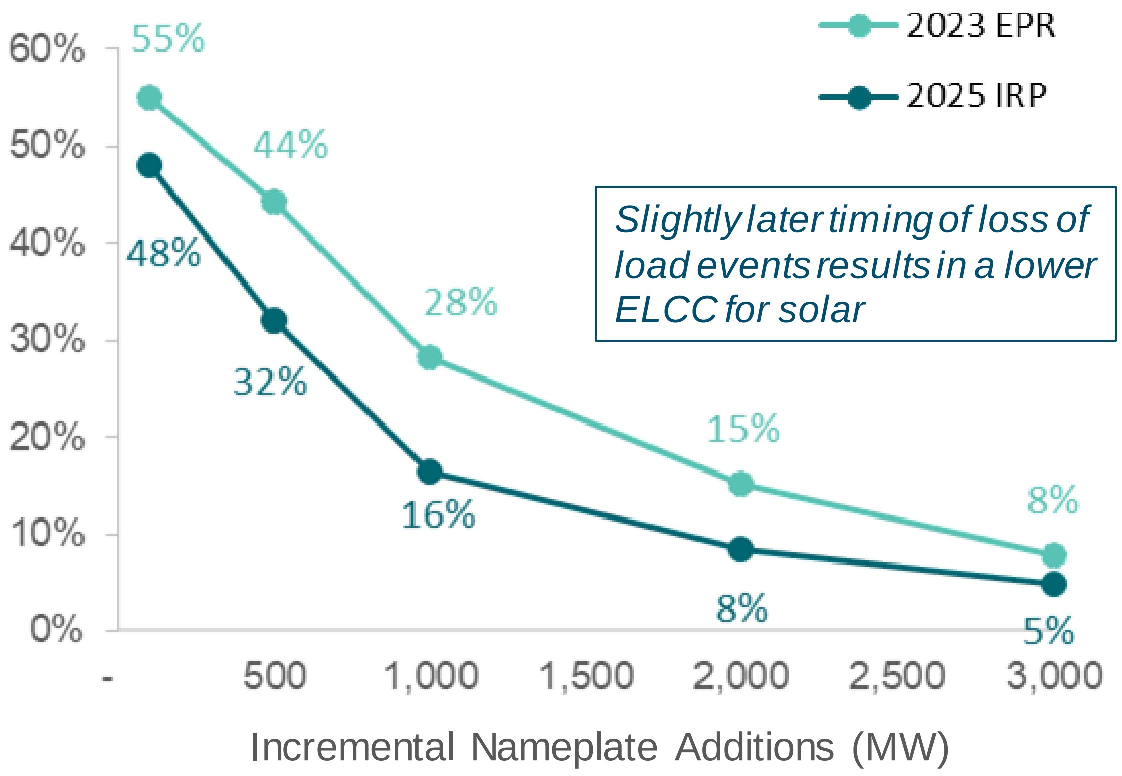
2025 IRP vs. 2023 EPR

Winter ELCC for Washington Wind
(%)



PSE has approximately 1,200 MW of existing WA Wind, which E3 estimates has an average ELCC of 24%. The ELCC of incremental additions shown here is lower due to the ELCC saturation effect.

Summer ELCC for Washington Solar
(%)

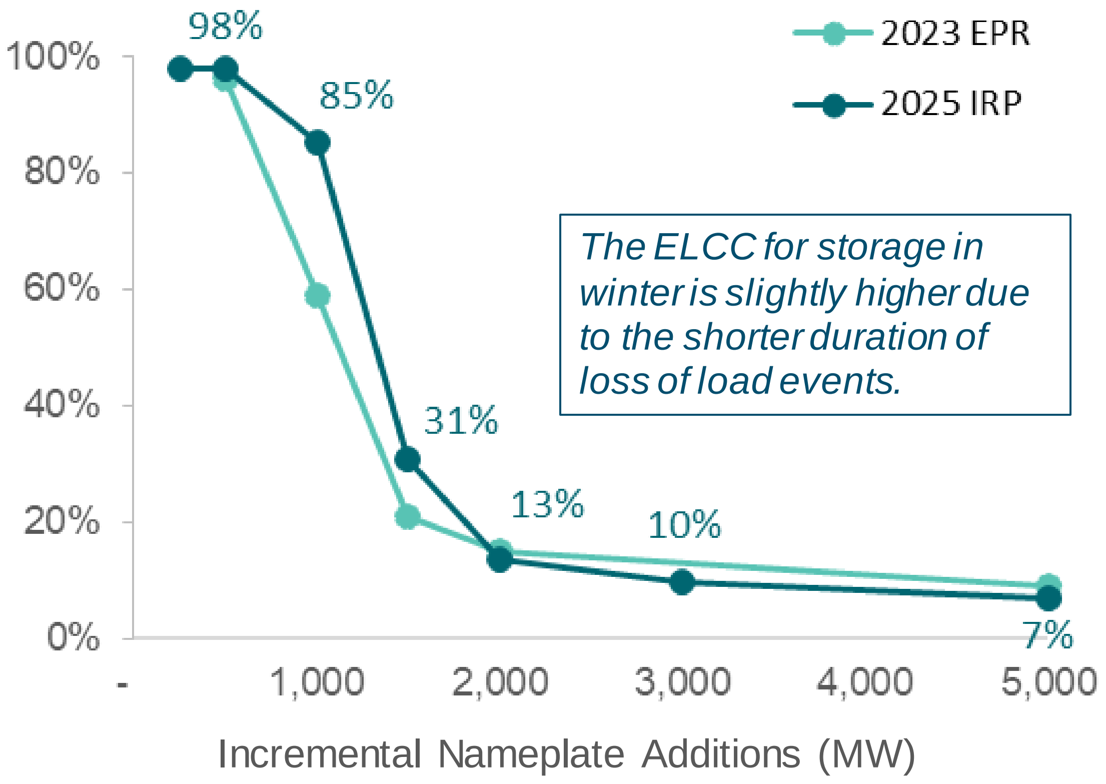


Slightly later timing of loss of load events results in a lower ELCC for solar

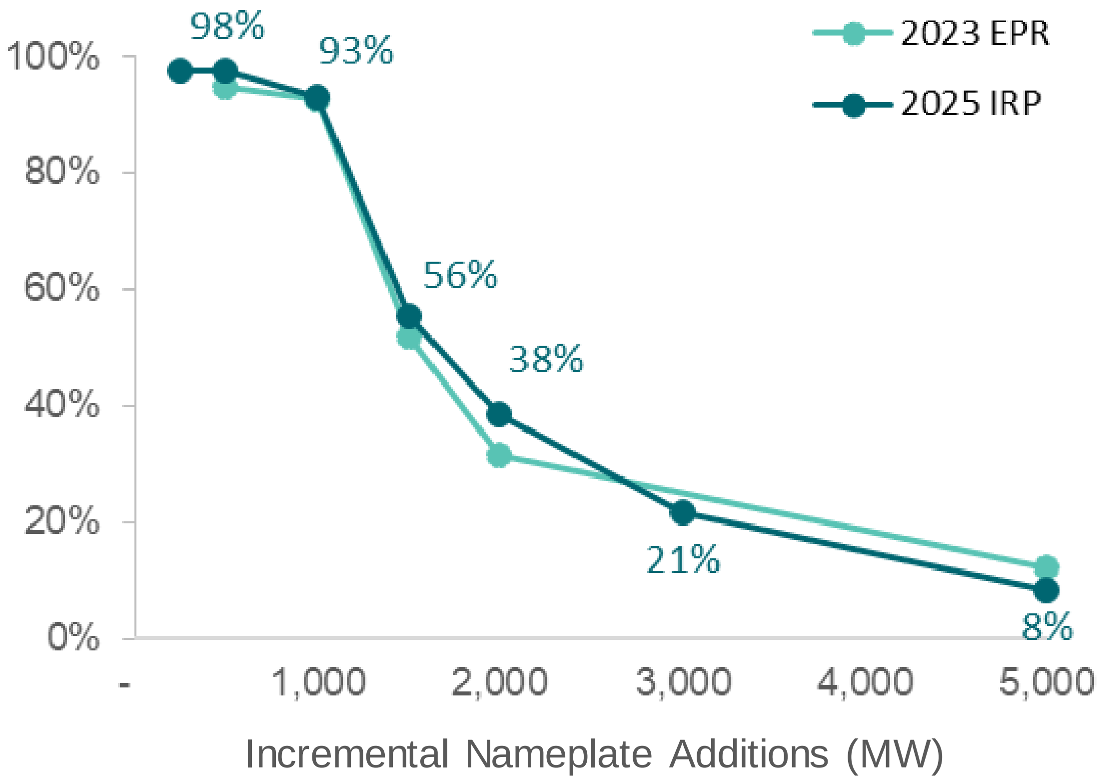
4-hour Li-ion Battery ELCC Comparison

2025 IRP vs. 2023 EPR

Winter ELCC for 4-hour Li-ion Battery
(%)



Summer ELCC for 4-hour Li-ion Battery
(%)

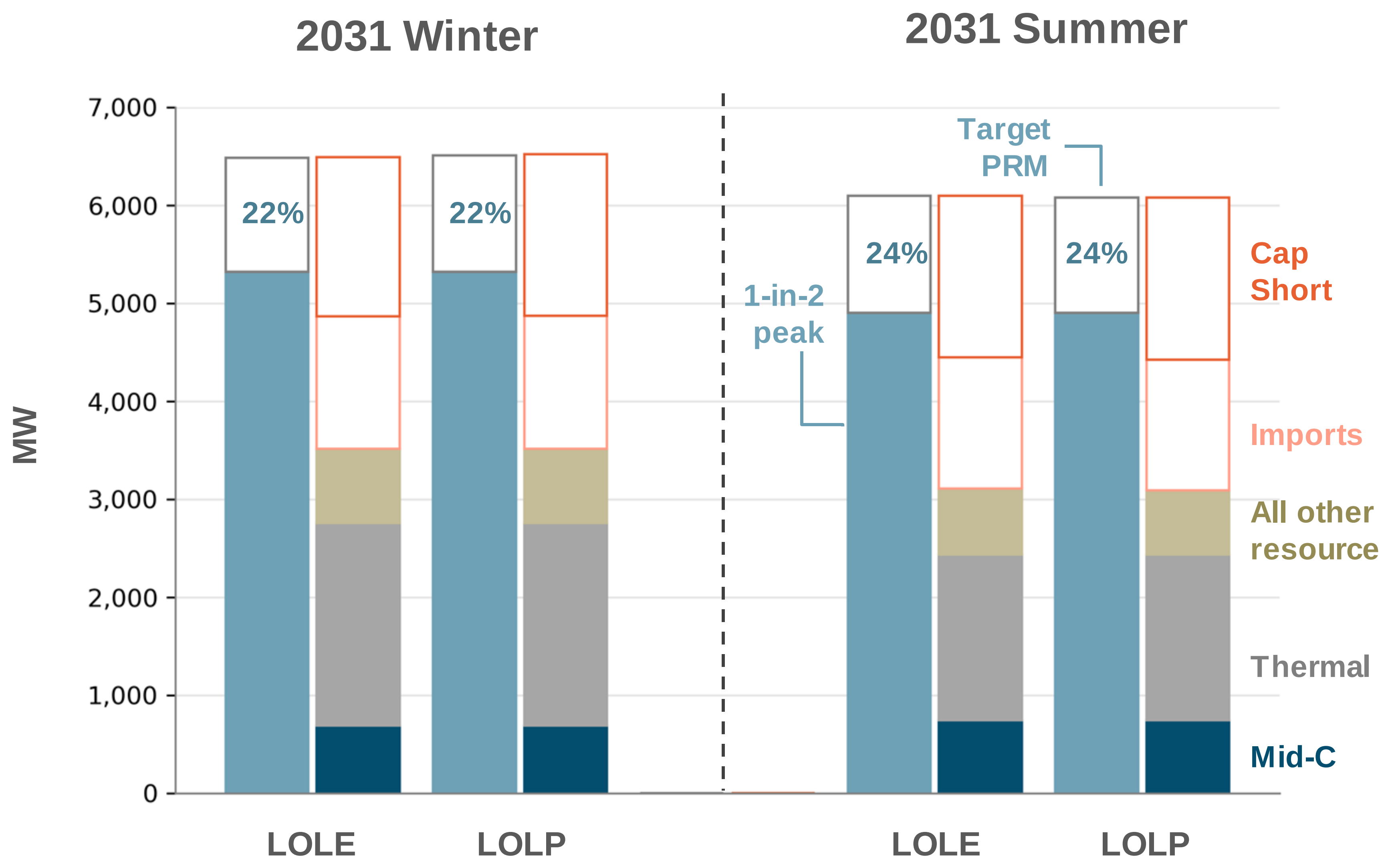


2025 IRP Results

LOLE vs. LOLP

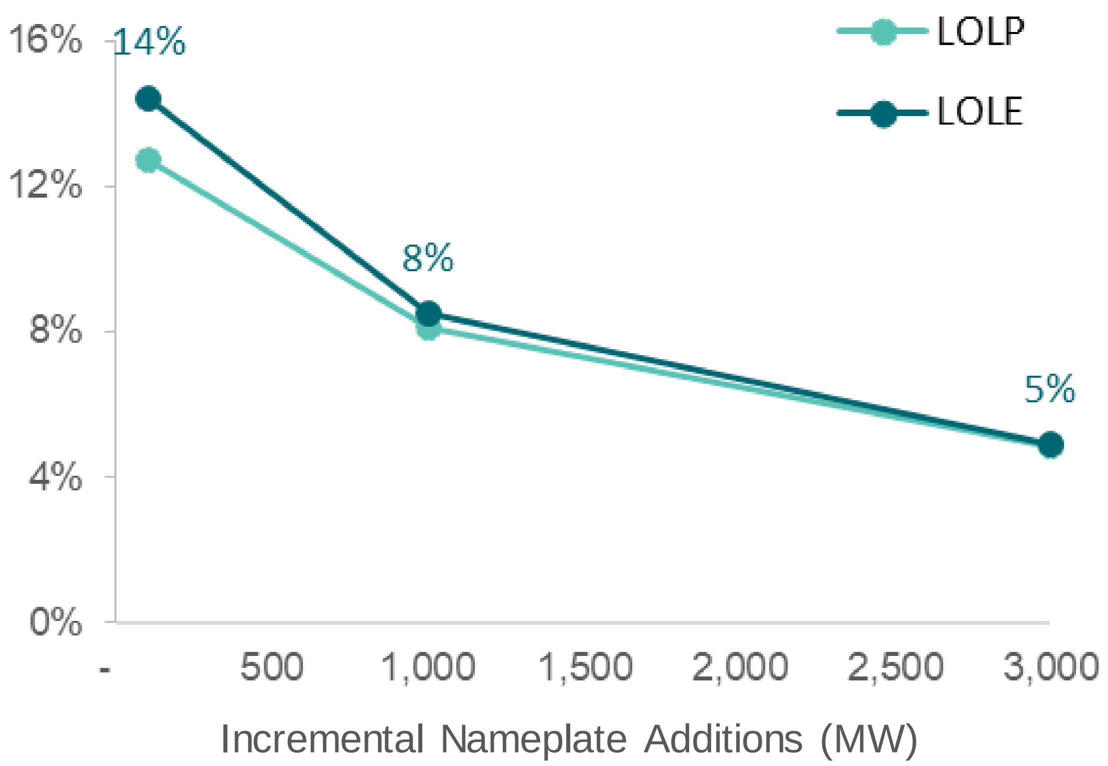
Energy+Environmental Economics

Planning Reserve Margin
LOLE vs. LOLP

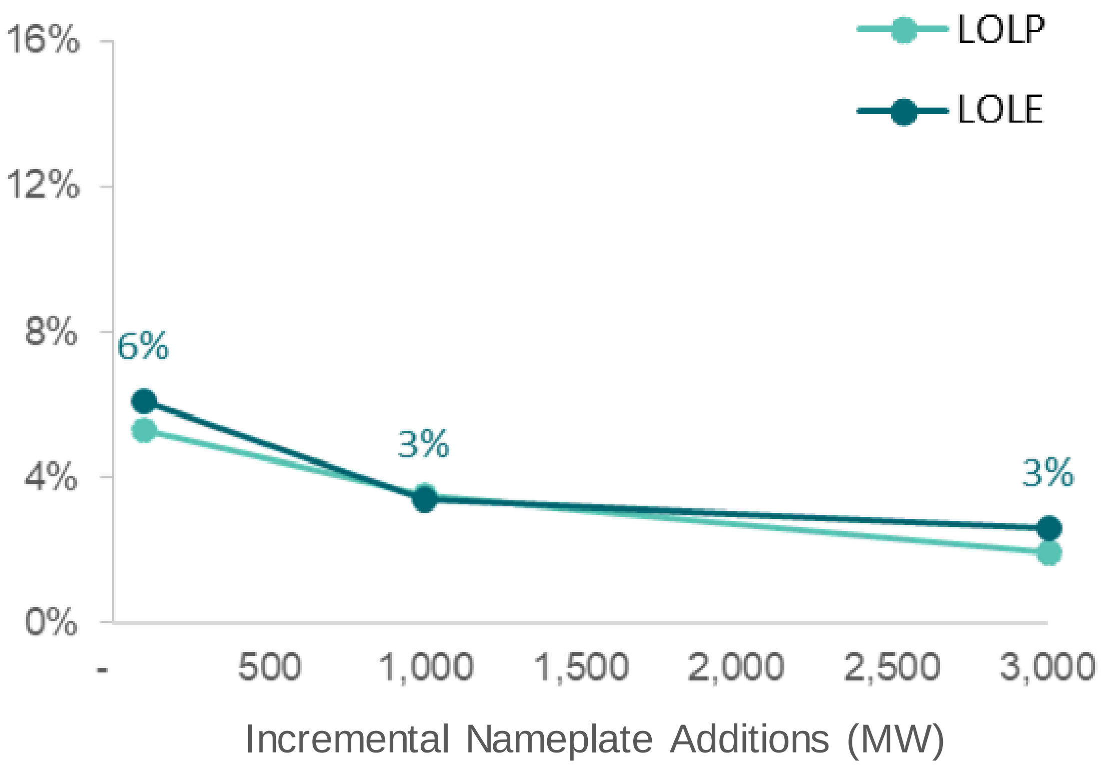


Washington Wind ELCC Comparison
LOLE vs. LOLP

Winter ELCC for Washington Wind
(%)

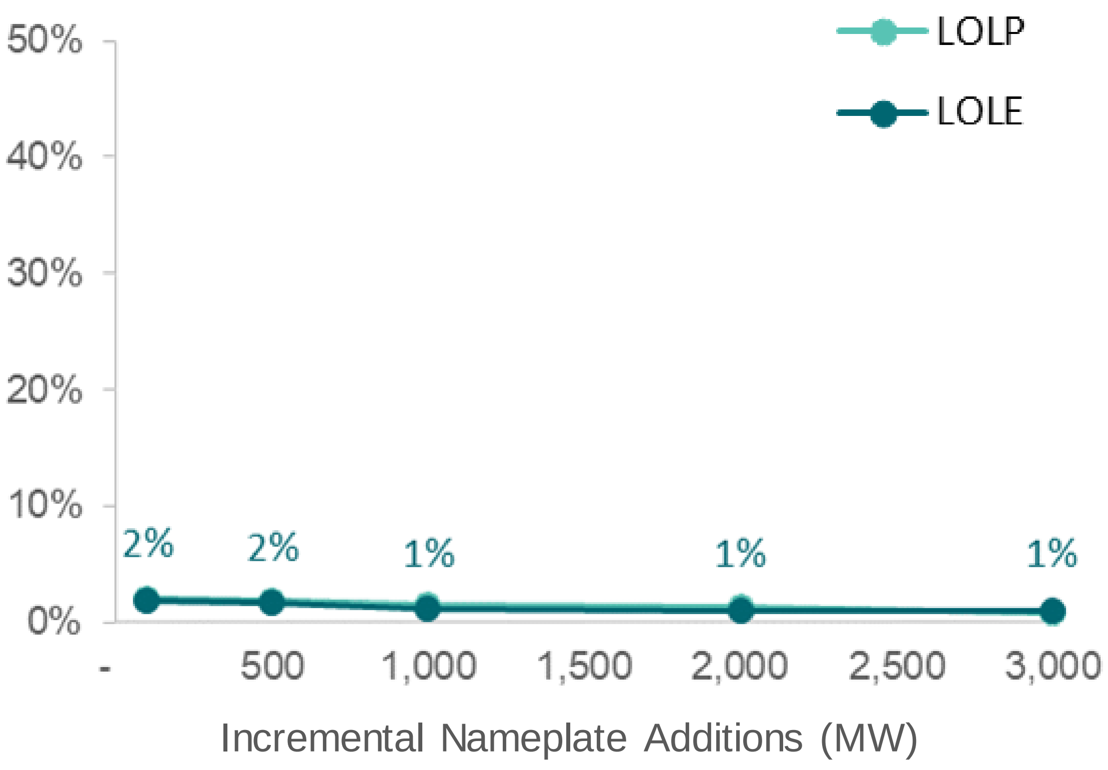


Summer ELCC for Washington Wind
(%)

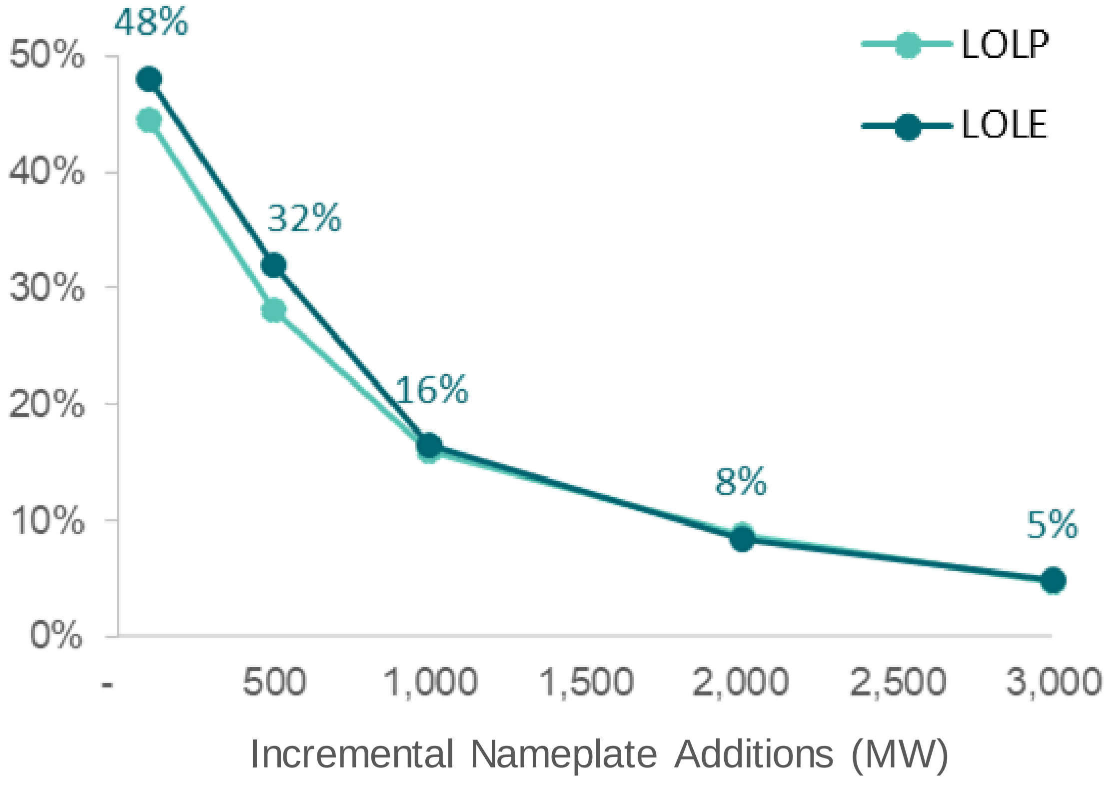


Washington East Solar ELCC Comparison
LOLE vs. LOLP

Winter ELCC for East Washington Solar (%)



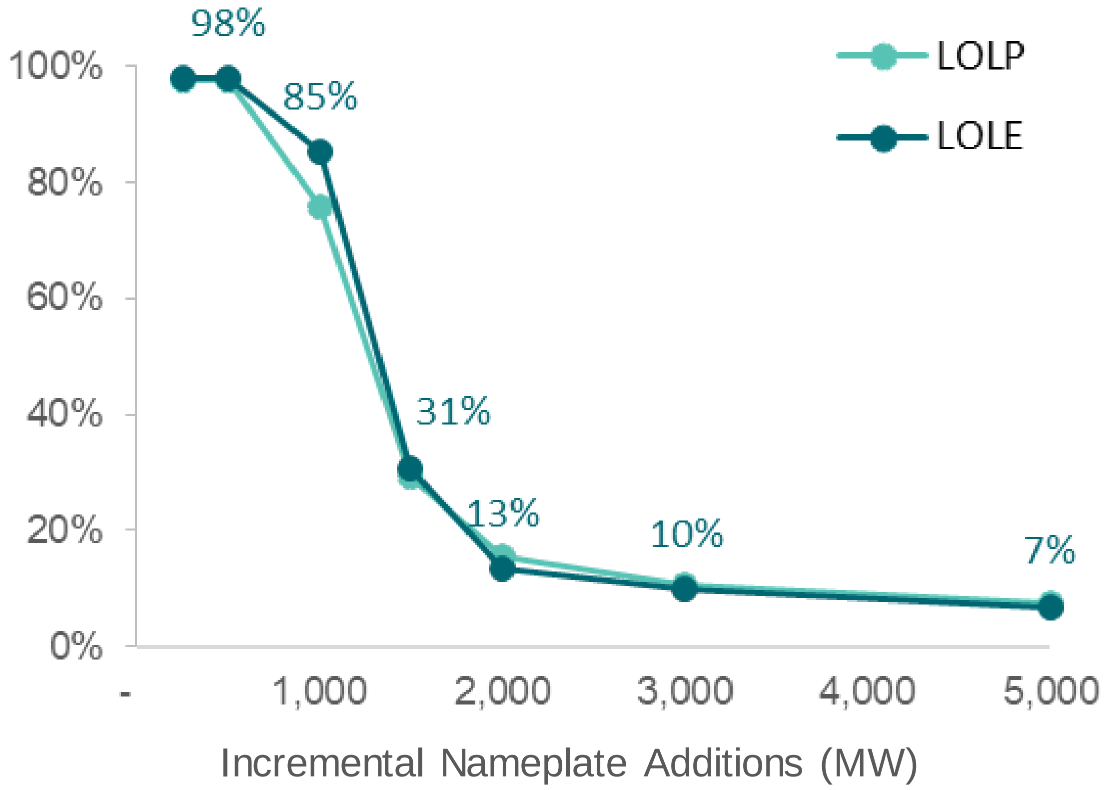
Summer ELCC for East Washington Solar (%)



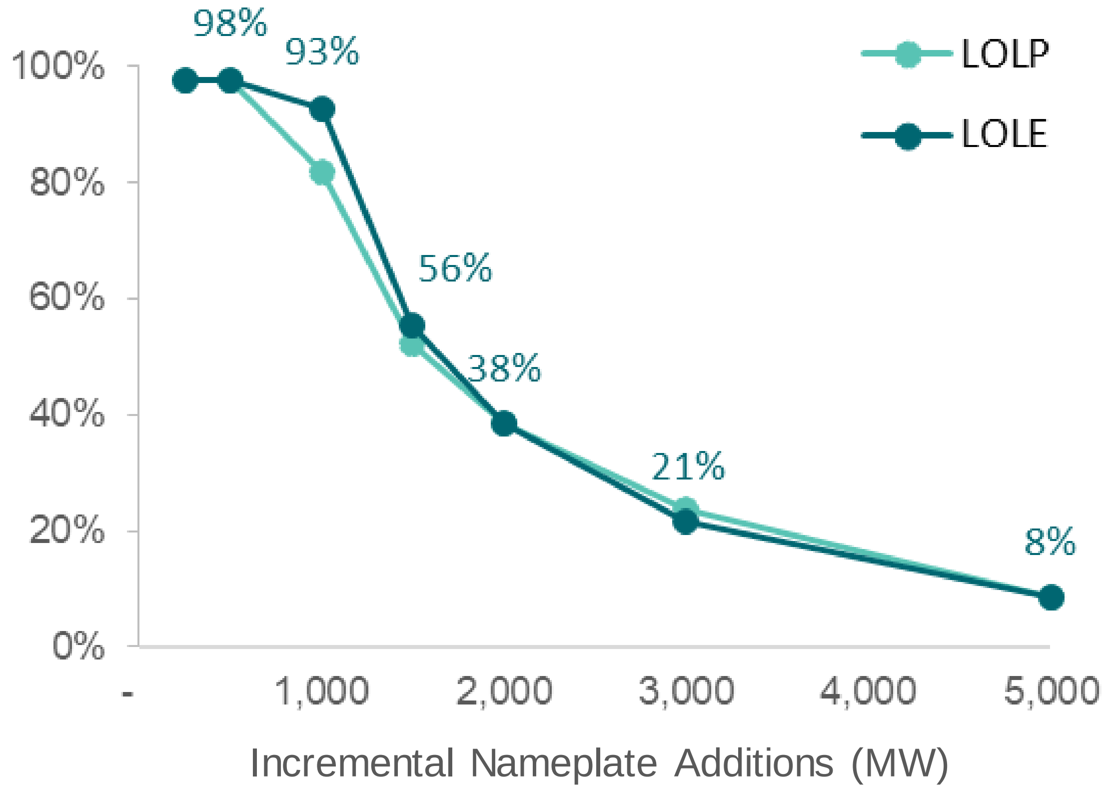
4-hr Li-ion Battery ELCC Comparison

LOLE vs. LOLP

Winter ELCC for 4-hour Li-ion Battery (%)



Summer ELCC for 4-hour Li-ion Battery (%)



Summary

1. **The planning reserve margin is 21-24%, depending on the year and season.**
2. **In 2031, PSE needs ~3,000 MW of additional perfect capacity in both seasons.**
   - The addition of electric vehicles in the load forecast and the removal of the PG&E exchange are the two biggest changes.
   - PSE will consider managed charging of electric vehicles as a resource in its portfolio analysis.
3. **Compared with the 2023 Electric Progress Report, loss of load events are more concentrated in the evening in winter and shift back ~1 hour in summer.**
   - The addition of electric vehicles in the load forecast and the switch to a reliable Pacific Northwest system are the two biggest factors.
4. **The ELCC of renewable resources are similar to those quantified for the 2023 Electric Progress Report**
   - The change in timing of loss of load events slightly reduces the ELCC of solar resources, while the directional impacts for wind resources differ based on their locational profiles but overall aren't large
5. **The ELCC of storage and demand response resources increase in winter vs. the 2023 Electric Progress Report**
   - Shorter duration loss of load events in winter improve the ELCC for energy-limited resources like storage and demand response
6. **The 0.1 Loss of Load Expectation (LOLE) and 5% Loss of Load Probability (LOLP) reliability targets do not result in large differences in PRM or ELCC values for PSE's system**

Thank You

arne@ethree.com

joe.hooker@ethree.com

michaela.levine@ethree.com

ruoshui.li@ethree.com

ritvik.jain@ethree.com

Energy+Environmental Economics

Social cost of greenhouse gas modeling

Elizabeth Hossner, PSE

IAP2 Spectrum

	INFORM	CONSULT	INVOLVE	COLLABORATE	EMPOWER
PUBLIC PARTICIPATION GOAL	To provide the public with balanced and objective information to assist them in understanding the problem, alternatives and/or solutions.	To obtain public feedback on analysis, alternatives and/or decision.	To work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered.	To partner with the public in each aspect of the decision including the development of alternatives and the identification of the preferred solution.	To place final decision-making in the hands of the public.
PROMISE TO THE PUBLIC	We will keep you informed.	We will keep you informed, listen to and acknowledge concerns and aspirations, and provide feedback on how public input influenced the decision.	We will work with you to ensure that your concerns and aspirations are directly reflected in the alternatives developed and provide feedback on how public input influenced the decision.	We will look to you for advice and innovation in formulating solutions and incorporate your advice & recommendations into the decisions to the maximum extent possible.	We will implement what you decide.

INCREASING IMPACT ON THE DECISION

PUGET SOUND ENERGY

Social cost of greenhouse gases (SCGHG) methodology

- SCGHG is currently applied as an externality cost but interested parties have suggested it be considered in dispatch
- PSE recommends it remain as an externality so to not inappropriately influence dispatch
- PSE has run scenarios with SCGHG in dispatch and the results are broadly similar with the selection of capacity resources changing

Today's goal: Agree on one approach moving forward to maintain consistency and improve efficiency

PUGET SOUND ENERGY

SCGHG as a cost adder

- The cost adder provides an economic disincentive for building thermal plants without artificially increasing the price of electricity for ratepayers.

- Applying the SCGHG as a cost adder
    - *For thermal plants*:
        - SCGHG costs are included in the value reporting for resources Long Term Capacity Expansion model run but the emissions costs are not included in Dispatch
    - *Unspecified market purchases*
        - SCGHG ($/ton) * emission rate (ton/MWh) = adder ($/MWh)
        - PSE is using the 0.437 metric tons CO_2/MWh for unspecified market purchases from Section 7 of E2SSB 5116, paragraph 2.

- The SCGHG is accounted for post-economic dispatch to evaluate competing resource portfolios as they would function in the real world.

Applying SCGHG to total costs

Direct Costs + **Externality Costs** = **Total Costs**

Drives Operations

- Plant costs
- Operations & maintenance
- Fuel
- Variable costs

Resulting pollution →

Costs paid by PSE and reflected in customers' bills

Calculation that doesn't affect Operations

Calculation of:
Tons of pollution include upstream emissions
X
SCGHG
($/ton from UTC)

Costs to Society as a Whole

Total cost for making intermediate and long-term resource decisions

Why is SCGHG not included in the dispatch cost?
SCGHG is not a binding policy or a cost charged to customers like a carbon tax, so including it in dispatch will risk making decisions on resources that do not reflect real life operations.

Alternative methodology: applying SCGHG in dispatch

We received feedback that the SCGHG should be included in dispatch costs for the long-term capacity expansion when making resource decisions

Direct Costs = Total Costs

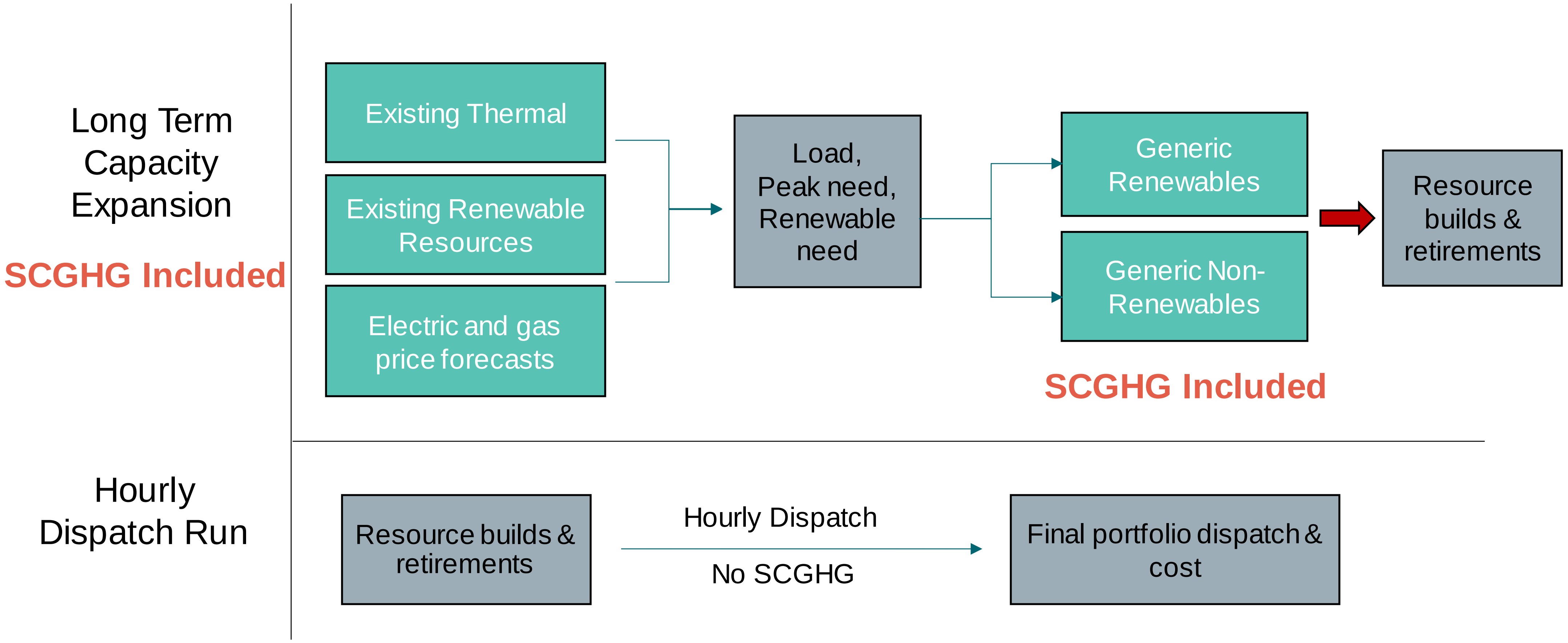
Drives Operations

- Plant costs
- Operations & maintenance
- Fuel
- Variable costs
- **SCGHG** carbon price

SCGHG included in dispatch costs and changes operations of the resource

Total cost for making intermediate and long-term resource decisions

How SCGHG is applied in the portfolio model



SCGHG = (resulting emissions from model run) x ($/ton)

Levelized costs

- Levelized cost of capacity decreases with SCGHG in dispatch, resulting in a model that will favor peakers over DR, BESS, etc.
- Levelized cost of energy increases for peakers, but these resources are added for their capacity value, not their energy production
- Adding SCGHG as a dispatch cost makes the plant look more expensive to dispatch then it is and can result in suboptimal decision making

2021 IRP

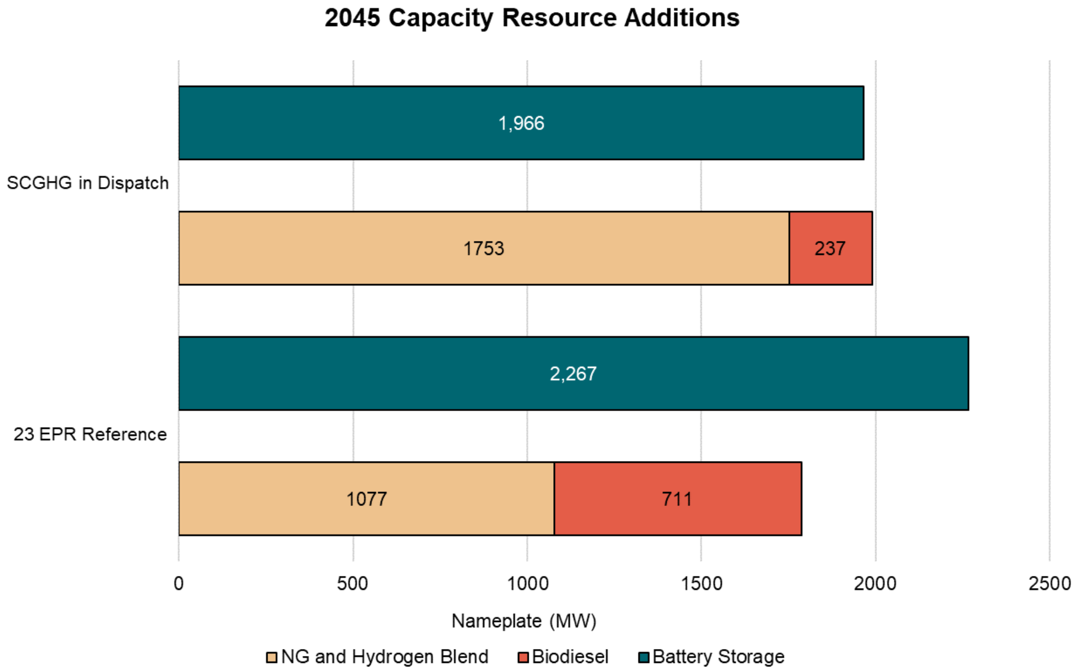
Cost of Capacity Levelized $/kw-yr	SCGHG as Externality Cost	SCGHG as Dispatch Cost
Frame Peaker	$148	$104
Recip Peaker	$308	$234
CCCT + DF	$441	$259

PSE PUGET SOUND ENERGY

Results – externality vs. dispatch

Overall differences:

- SCGHG as dispatch: More peakers with majority using NG/H2 blend with less batteries and demand response
- SCGHG as externality: Less peakers with majority using biodiesel with more batteries and demand response
- Renewable resource selections are largely unchanged – both portfolios meet CETA requirements
- Higher portfolio cost with SCGHG as dispatch cost, but similar total cost with SCGHG as externality



NPV Portfolio Cost, 2024-2045 ($ Billions)

Portfolio – 23 Progress Report	Portfolio Cost	SCGHG	Total Cost
23 EPR Reference	$17.6	$3.2	$20.8
23 EPR SCGHG in Dispatch	$18.3	$2.5	$20.8

PUGET SOUND ENERGY

Facilitated discussion – preferred methodology

- Help us determine which methodology to use

- Which methodology do you prefer to use in the 2025 IRP and why?
  - ➢ SCGHG as an externality cost adder
  - ➢ SCGHG in dispatch cost for the long-term capacity expansion

PUGET SOUND ENERGY

Next steps

Sophie Glass, Triangle Associates

PUGET SOUND ENERGY

Upcoming activities

Date	Activity
March 19, 2024	Feedback form for March 12 RPAG meeting closes
March 25, 2024	RPAG meeting: Gas and electric resource alternatives (supply-side) and scenarios and sensitivities

Email us at irp@pse.com

Register for email updates

Visit our website at pse.com/irp

Leave a voice message at 425-818-2051

PUGET SOUND ENERGY

Public comment opportunity

Please raise your “hand” if you would like to provide comment.

PUGET SOUND ENERGY

Thanks for joining us!

PUGET SOUND ENERGY

Acronyms

Acronym	Meaning
CCA	Climate Commitment Act
CETA	Clean Energy Transformation Act
CEIP	Clean Energy Implementation Plan
E3	Energy and Environmental Economics
ELCC	Effective load carrying capability
EPR	2023 Electric Progress Report
EV	Electric vehicle
IAP2	International Association of Public Participation
IRP	Integrated Resource Plan
LOLE	Loss of load expectation
LOLP	Loss of load probability
MW	Megawatt
PG&E	Pacific Gas and Electric
PRM	Planning reserve margin
PUD	Public utility district
RA	Resource adequacy
RPAG	Resource Planning Advisory Group
SCGHG	Social cost of greenhouse gas

Appendix

Energy+Environmental Economics

Energy + Environmental Economics (E3)

Technical and Strategic Consulting for the Clean Energy Transition

~90 consultants across 4 offices with expertise in energy economics, policy, modeling

San Francisco

New York

Boston

Calgary

250+ projects per year across diverse topic areas

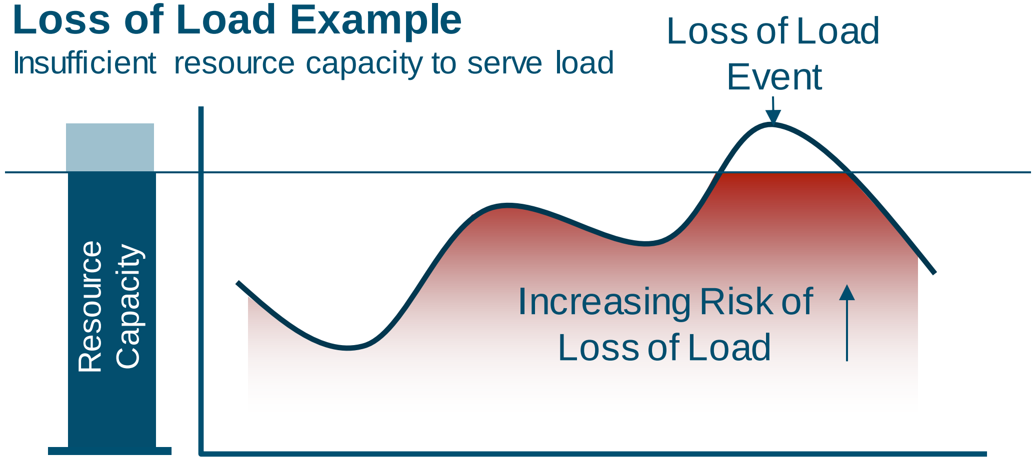
Recent Projects

- Resource Adequacy in the Desert Southwest - E3 conducted a study to examine reliability in the Southwest and identify best practices for resource adequacy that will provide a durable foundation for utilities' planning efforts to preserve reliability in the region
- Lower Snake River Dams Power Replacement Study – E3 evaluated options for replacing power from the Lower Snake River dams across a wide range of scenarios. E3 developed alternative resource portfolios and estimated costs across these scenarios
- NorthWestern Energy Capacity Contribution Accreditation – E3 supported NWE's 2019 Resource Procurement Plan by calculating ELCCs to use for capacity accreditation

What is resource adequacy?

- **Resource adequacy is a measure of the ability of a portfolio of generation resources to meet load across a wide range of system conditions, accounting for supply & demand variability**
- **No system is planned to achieve a perfect level of adequacy**
  - The most common standard used throughout North America is a "one-day-in-ten-year" standard
  - For the PSE's 2025 IRP, E3 performed modeling for both a 5% LOLP standard (up to 1 year with loss of load every 20 years) and 0.1 LOLE standard (up to 1 loss of load event every 10 years)

Loss of Load Example
Insufficient resource capacity to serve load



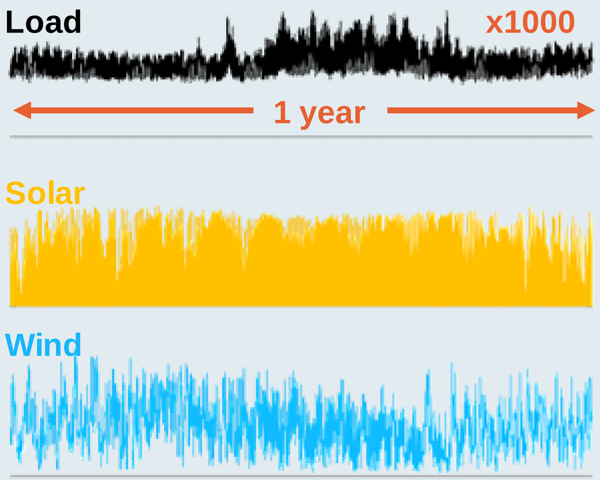
NERC Definition of Resource Adequacy:
"The ability of supply-side and demand-side resources to meet the aggregate electrical demand (including losses)"

Source: NERC Glossary of Terms

Planners are increasingly using LOLP models to support enhancements to resource adequacy

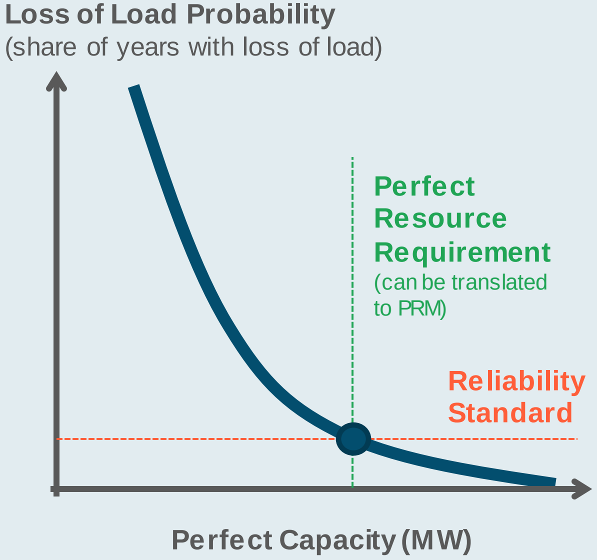
Develop a representation of the loads and resources of an electric system in a loss of load probability model

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

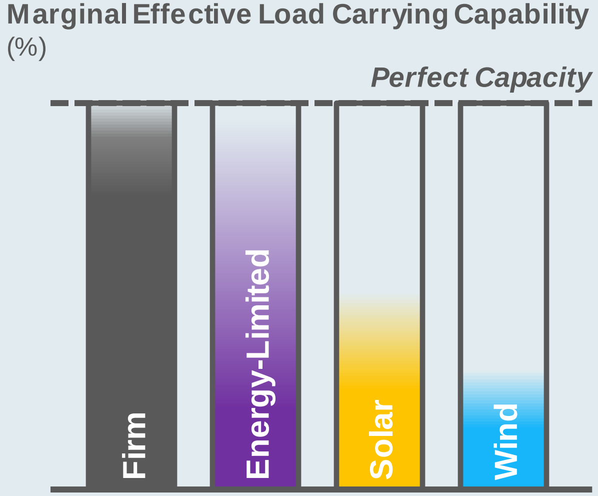


Outputs:

- Total Resource Need (TRN), in MW
- Planning Reserve Margin (PRM) = (TRN ÷ 1-in-2 peak load) - 1

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

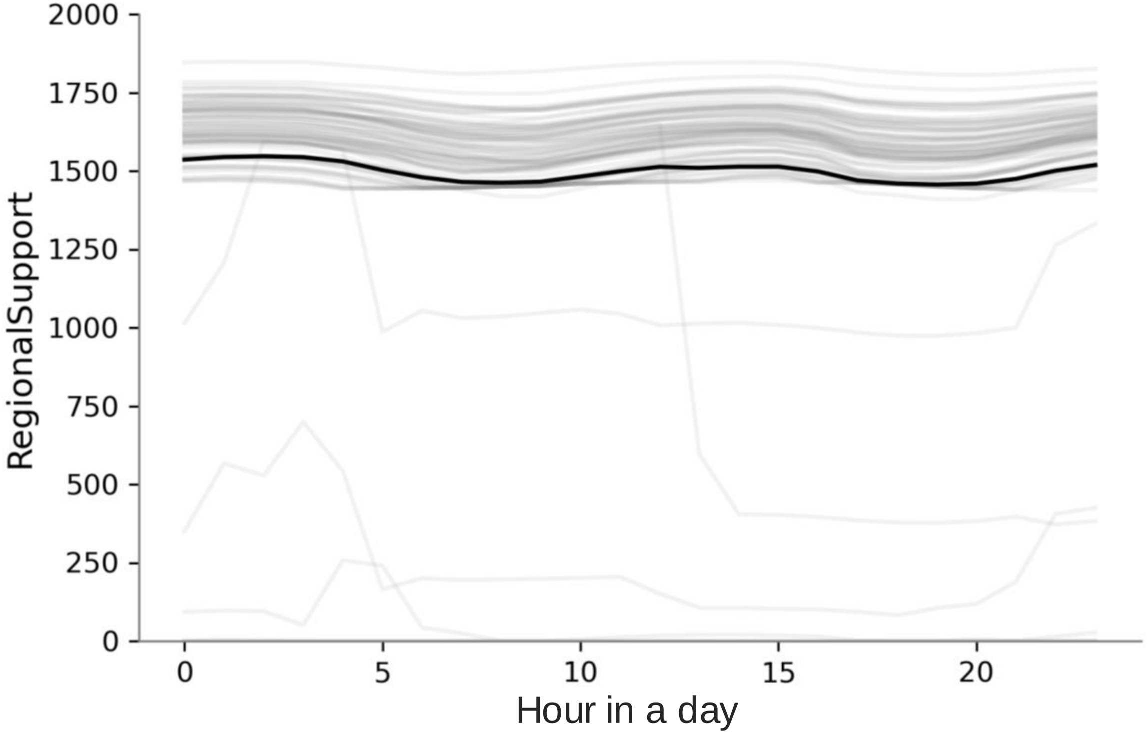


Outputs:

- Individual resource Effective Load-Carrying Capacity (ELCC), in MW and % of nameplate

Impact of PNW Capacity Balance on PSE Imports Availability (Model G example)

Average Market Availability in Loss-of-Load Days,
2023 EPR (2029) G Winter
(MW)



Model G has substantial amount of market purchase curtailment in winter when PNW is not modeled at 5% LOLP, making winter mornings a risky period in PSE system

Average Market Availability in Loss-of-Load Days,
2025 IRP (2031) G Winter
(MW)