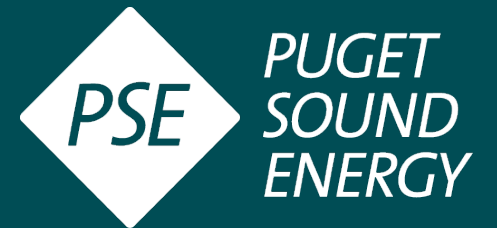


Resource Planning Advisory Group meeting

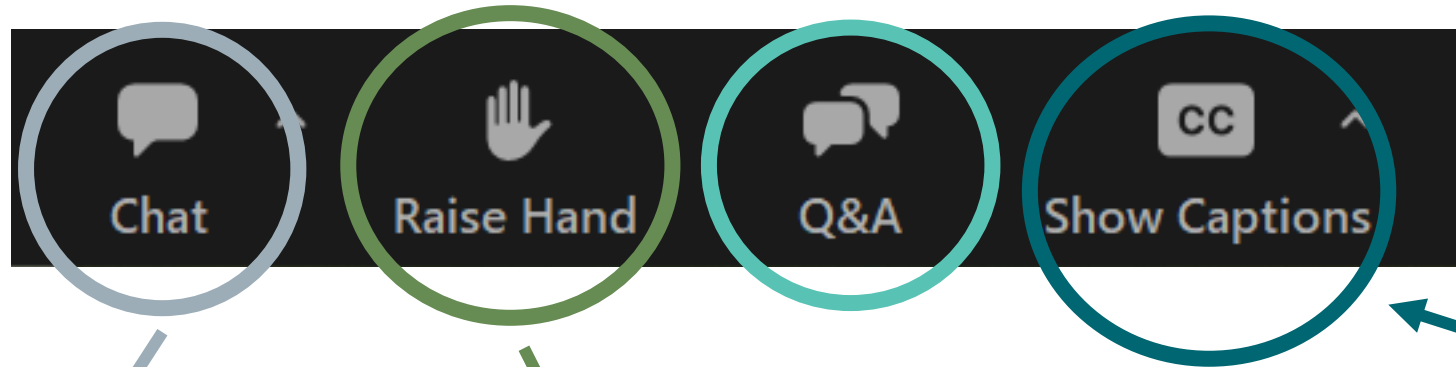
2025 Integrated Resource Plan

May 31, 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

Safety moment

Call before you dig!

- Call 811 2-10 days before any digging or excavating on your property
- 811 will notify all utilities in your area to mark lines
- Find more at DigSafeWa.org

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

Today's speakers

Sophie Glass

Facilitator, Triangle Associates

Phillip Popoff

Director, Resource Planning
Analytics, PSE

Elizabeth Hossner

Manager, Resource Planning
and Analysis, PSE

Jennifer Magat

Consulting Energy Resource
Planning Analyst, PSE

Tyler Tobin

Senior Energy Resource Planning
Analyst, PSE

Nathan Critchfield

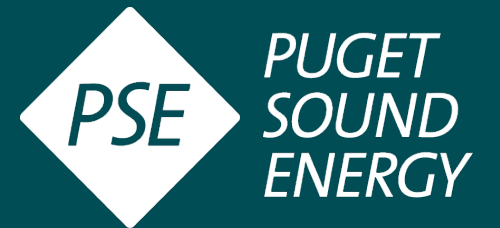
Associate Energy Resource
Planning Analyst, PSE

Agenda

Time	Agenda Item	Presenter / Facilitator
10:00 a.m. – 10:05 a.m.	Introduction and agenda review	Sophie Glass, Triangle Associates
10:05 a.m. – 10:15 a.m.	Feedback summary	Phillip Popoff, PSE
10:15 a.m. – 10:30 a.m.	Electric Analysis Overview	Elizabeth Hossner, PSE
10:30 a.m. – 11:00 a.m.	Electric Price Forecast	Tyler Tobin, PSE
11:00 a.m. – 11:30 a.m.	Electric portfolio model	Jennifer Magat, PSE
11:30 a.m. – 11:40 a.m.	Break	All
11:40 a.m. – 12:10 p.m.	Reference assumptions for new resources	Nathan Critchfield, PSE
12:10 p.m. - 12:50 p.m.	Sensitivity Analysis	Elizabeth Hossner, PSE
12:50 p.m. – 1:00 p.m.	Next steps and public comment opportunity	Sophie Glass, Triangle Associates
1:00 p.m.	Adjourn	All

Feedback summary

Phillip Popoff, PSE



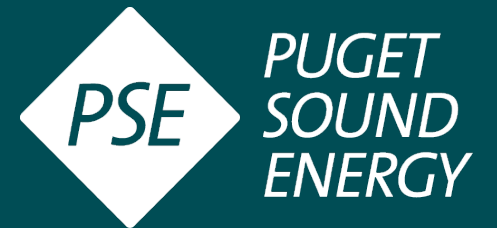
April 23 public webinar feedback summary

Feedback included:

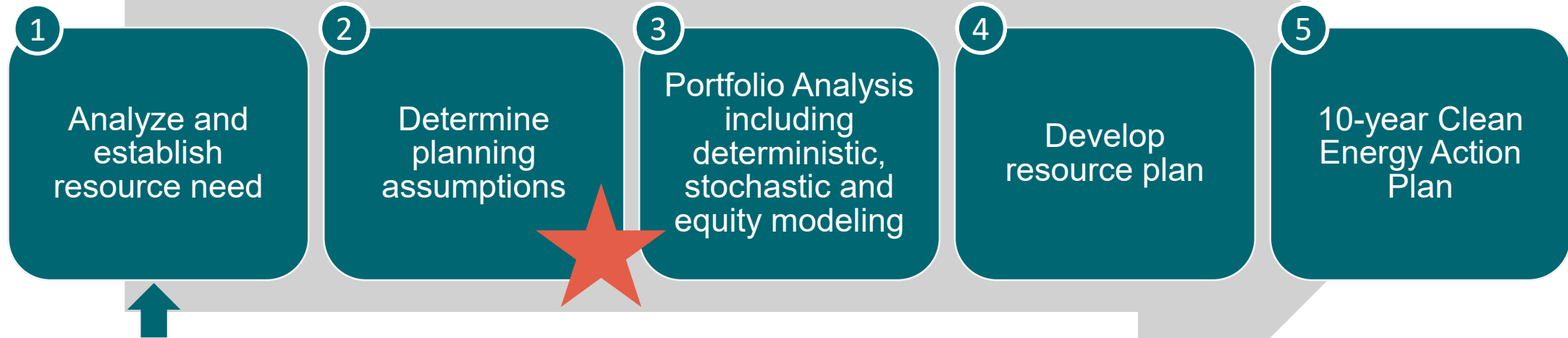
- Support for exploring thermal energy storage technology
- Desire to see more long-term storage technologies modeled
- Interest in iron-air batteries while understanding there are drawbacks to the technology
- Input on energy storage projects and technologies members of the public would like to see PSE consider

Electric analysis overview

Elizabeth Hossner, PSE



2025 IRP planning process



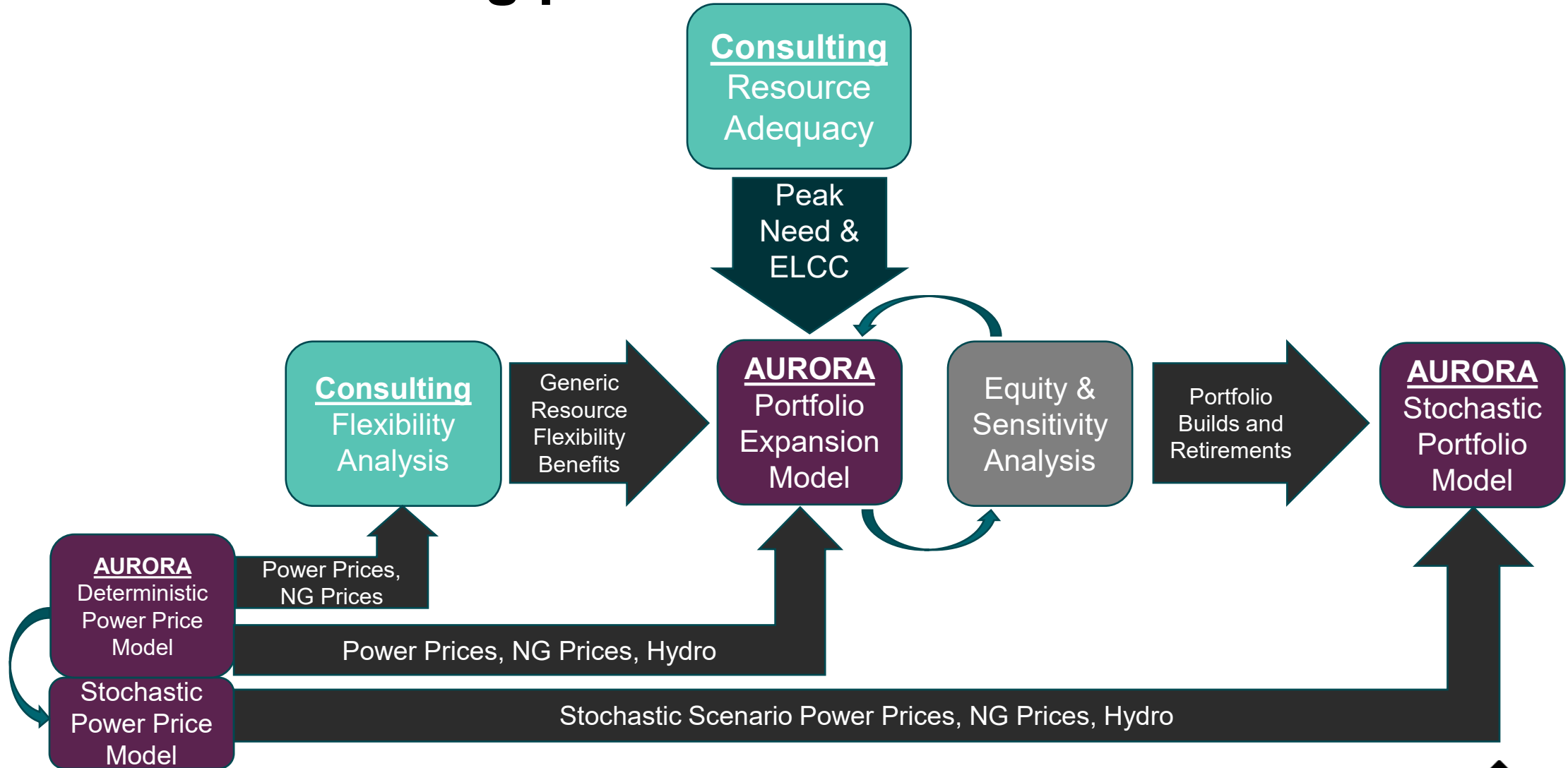
Previous meetings:

1. Demand Forecast
2. Resource Adequacy

Today's focus:

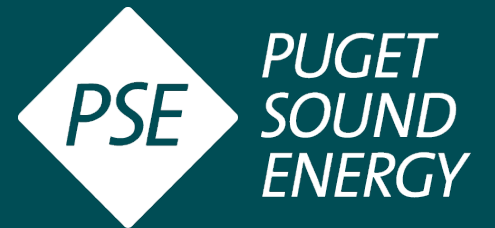
1. Electric Price Forecast
2. Portfolio model
3. Scenarios and sensitivities

Electric modeling process

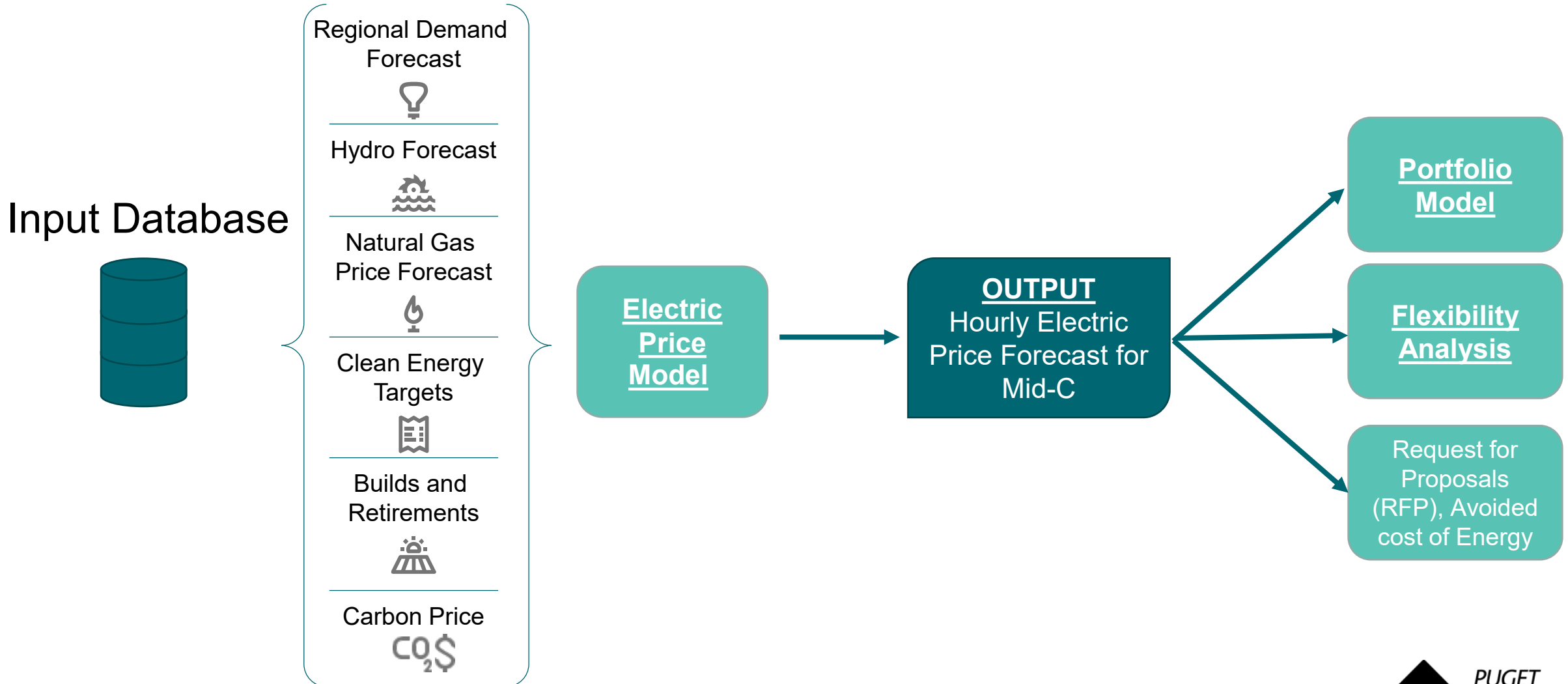


Electric price forecast

Tyler Tobin, PSE

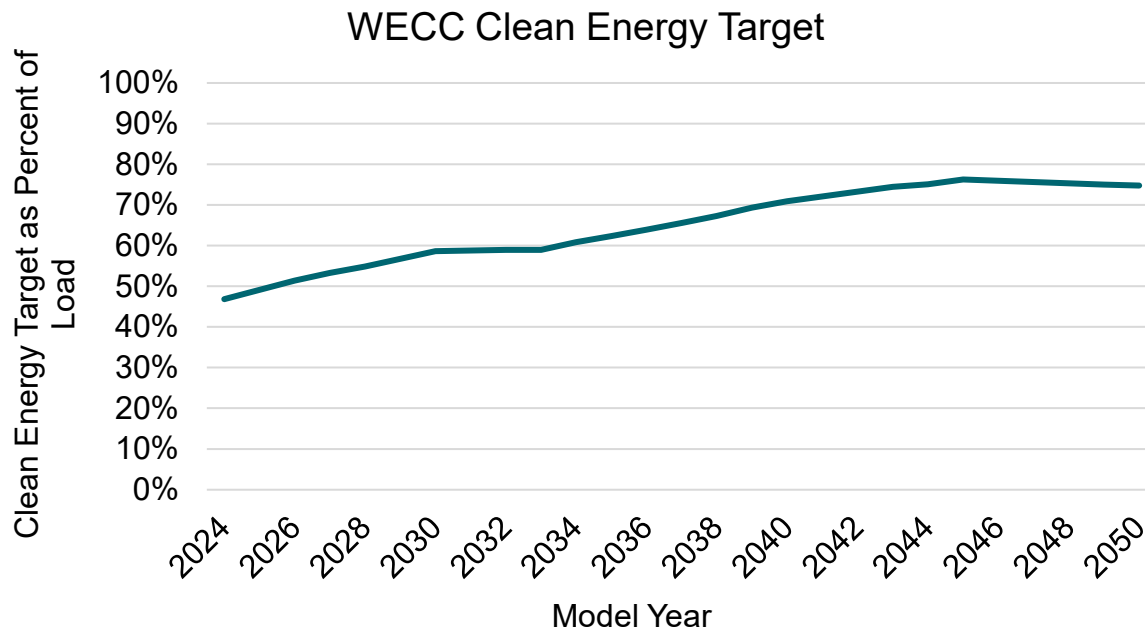


Electric price forecast modeling framework



Updates – clean policies

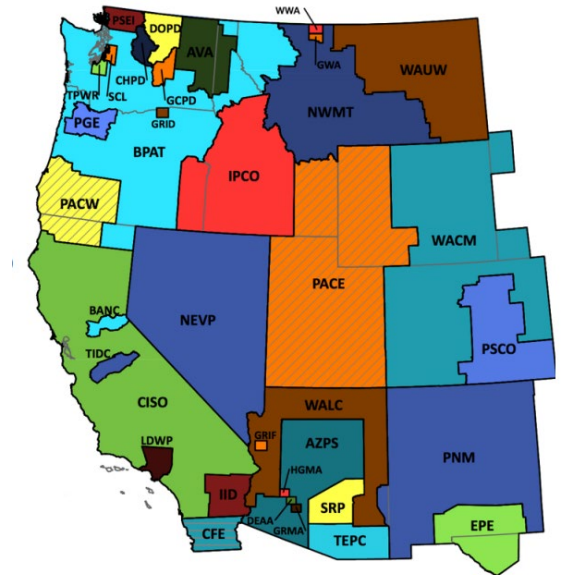
- Based on data aggregated by the NPCC which incorporates:
 - legislative RPS requirements
 - local government clean energy goals
 - utility clean energy policies



Methodology:

LT Energy Minimum – applied at the WECC level to force the capacity expansion to build enough renewable energy across the Western Electricity Coordinating Council (WECC) to meet goals

One Target for all BAAs →

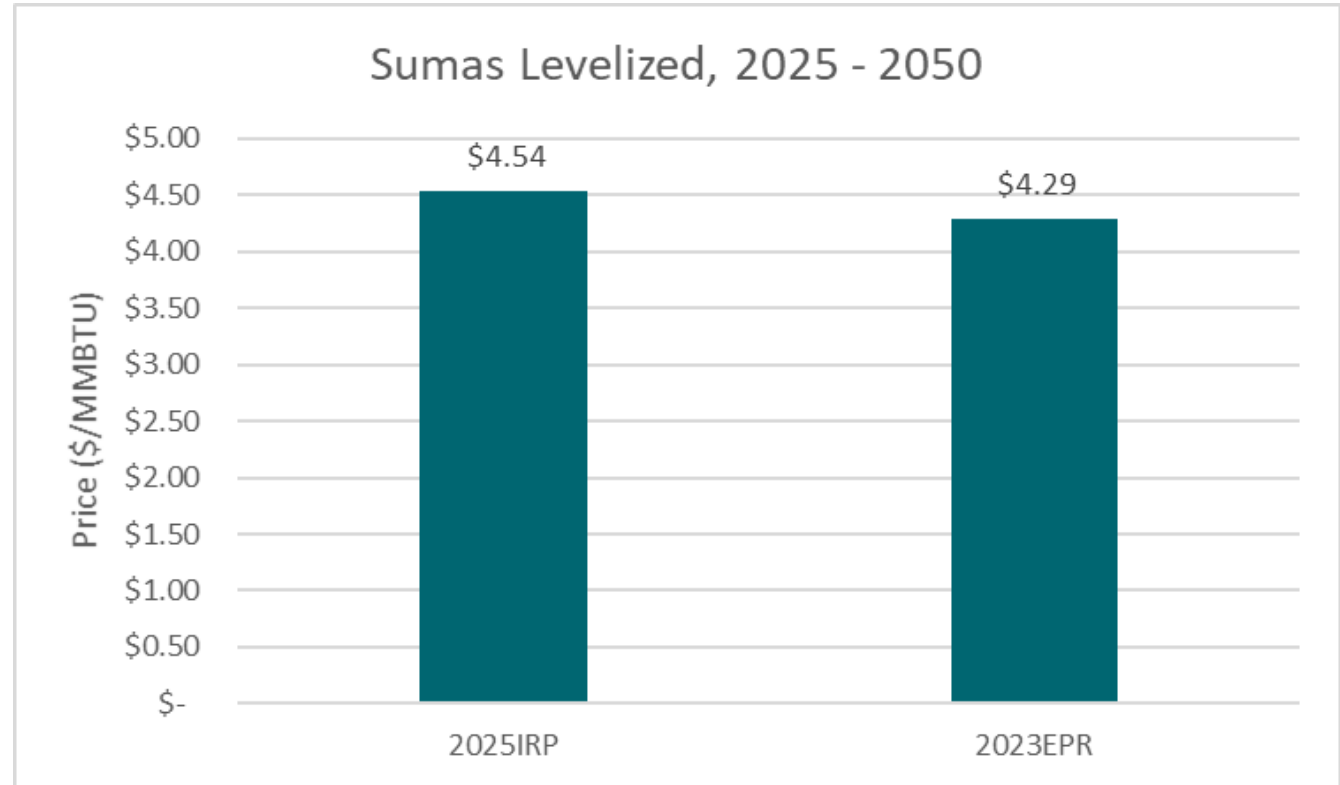


Updates – natural gas prices

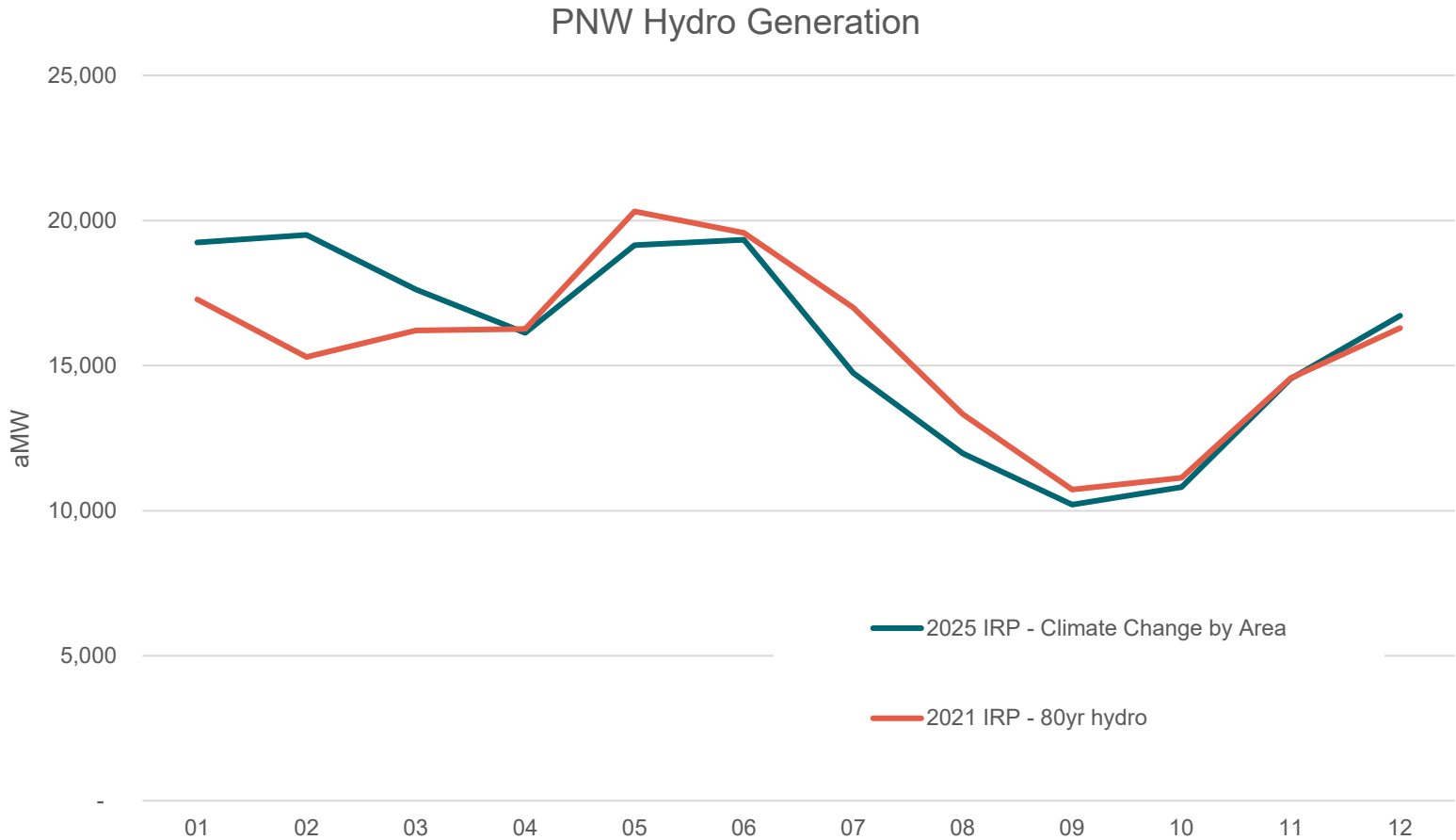
2025 IRP – Wood Mackenzie Fall 2023
2023 EPR – Wood Mackenzie Spring 2022

Ensemble of Forward Marks
and Wood Mackenzie.

- FM: 2024 to 2031
- Transition: 2032 to 2033
- WM: 2034 to 2050



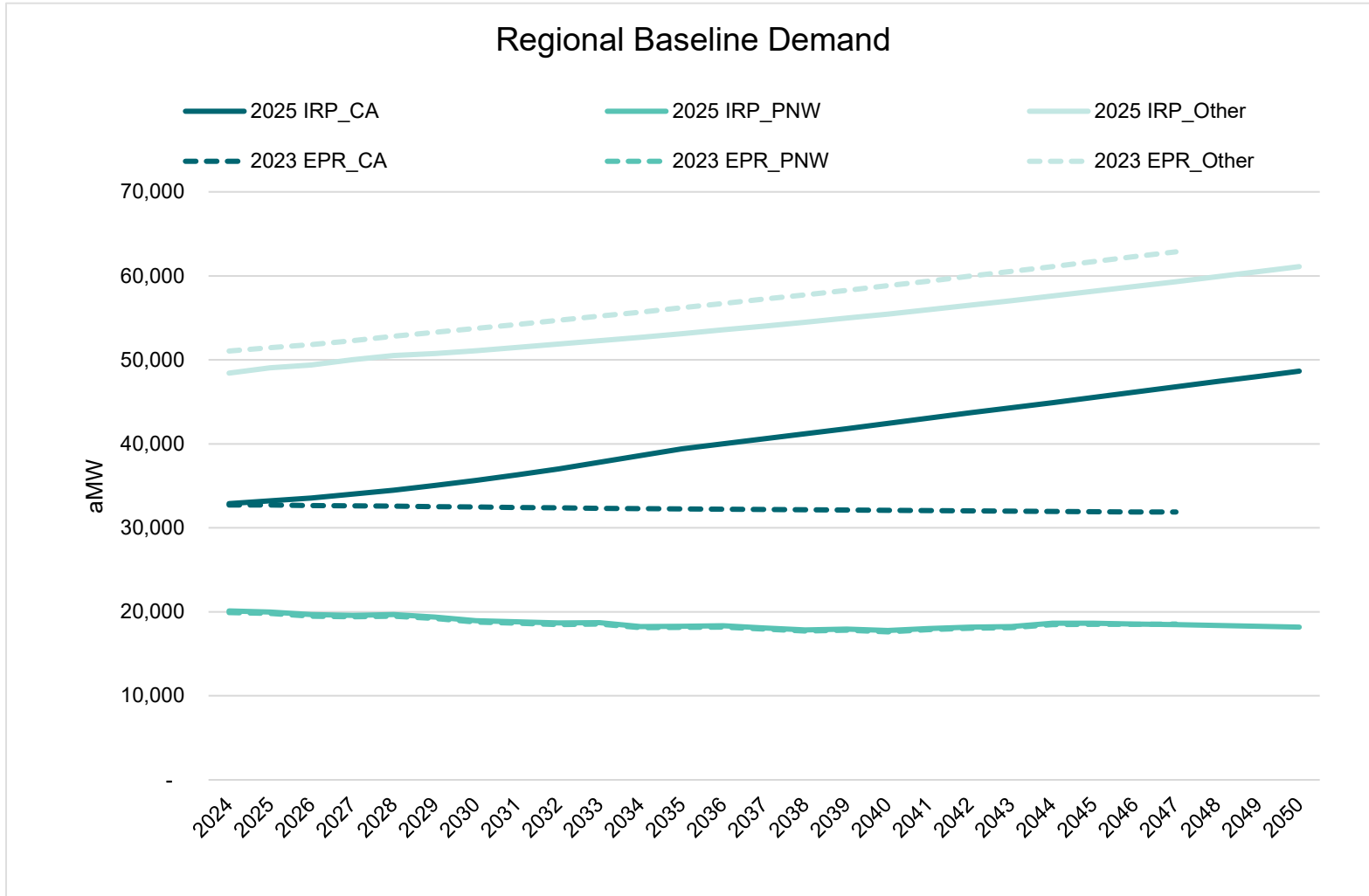
Updates – hydro



Updates for the 2025 IRP:

- A,C,G climate change cases from Northwest Power and Conservation Council
- Used updated GENESYS (classic) output
- **Applied hydro shapes at the “Area” level instead of aggregating for the entire PNW**

Updates – load

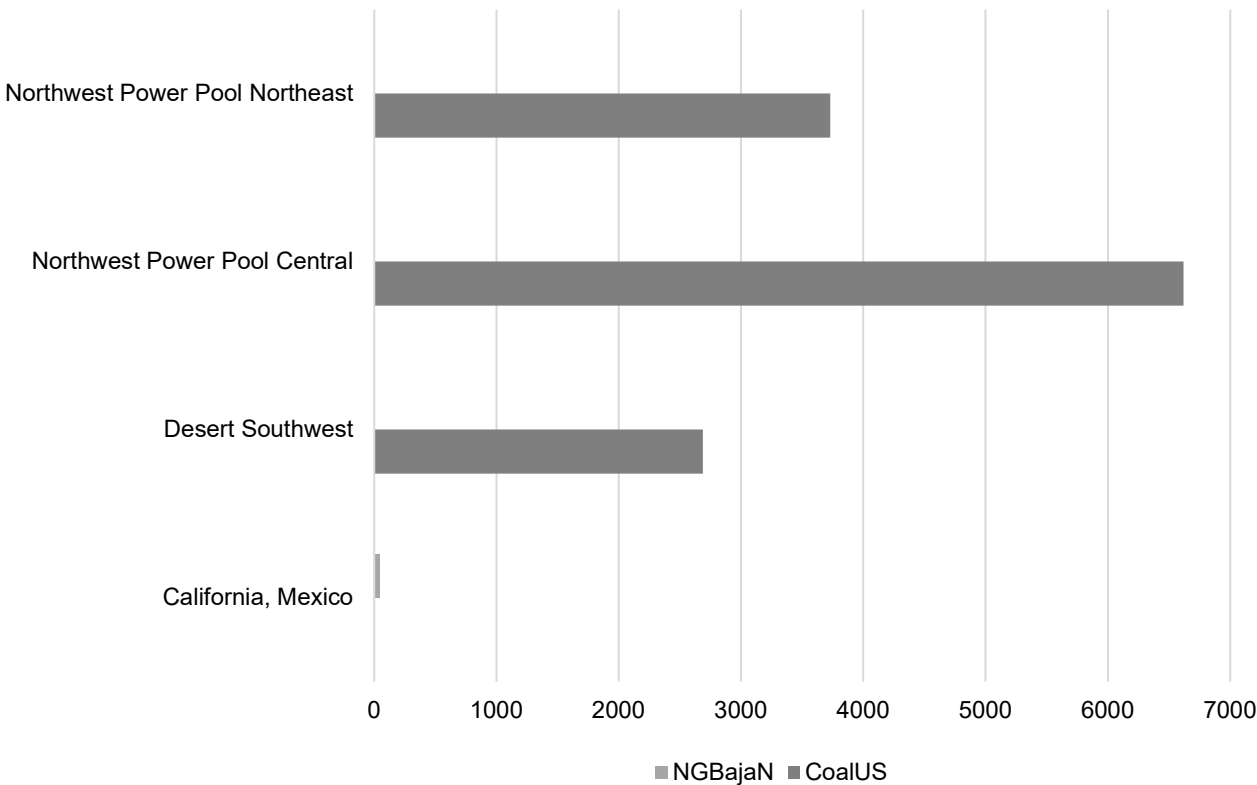


Updates for the 2025 IRP:

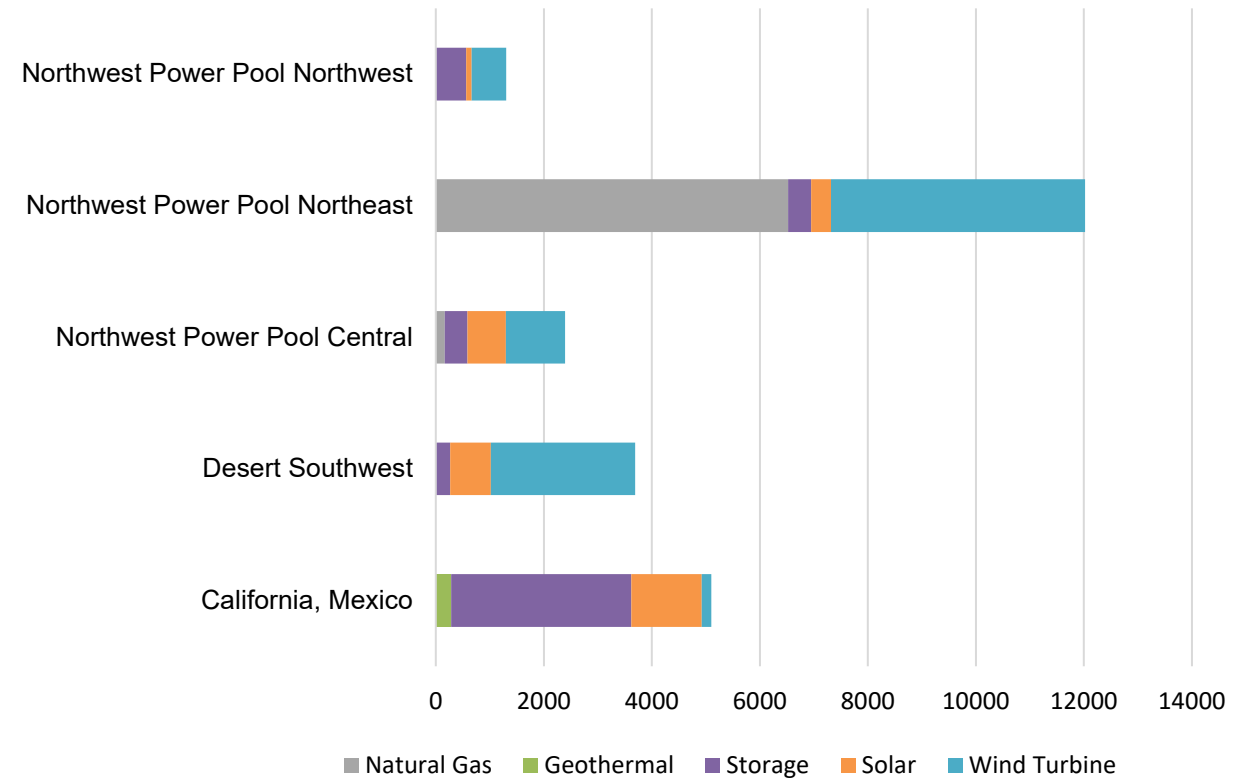
- CA Load – used 2022 CEC IEPR to forecast CA load – includes EV forecast and climate change impacts
- Retained 2021 Power Plan PNW regional load to align with Climate Change assumptions
- Other changes due to updates to the WECC Zonal DB

Updates – resource additions and retirements

Earlier WECC Retirements (2023-2045) than Captured in the Energy Exemplar WECC Database



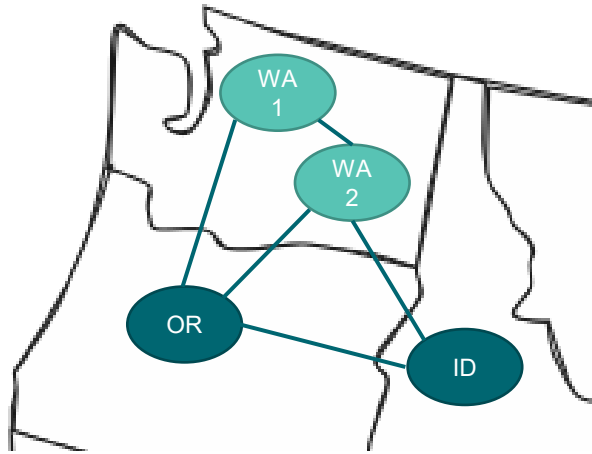
WECC Resource Additions (2022-2045) Missing from Energy Exemplar WECC Database



CCA application in electric price model

BAA – Balancing Authority Area
CCA – Climate Commitment Act
EPR – Electric Progress Report
IRP – Integrated Resource Plan

2023 EPR



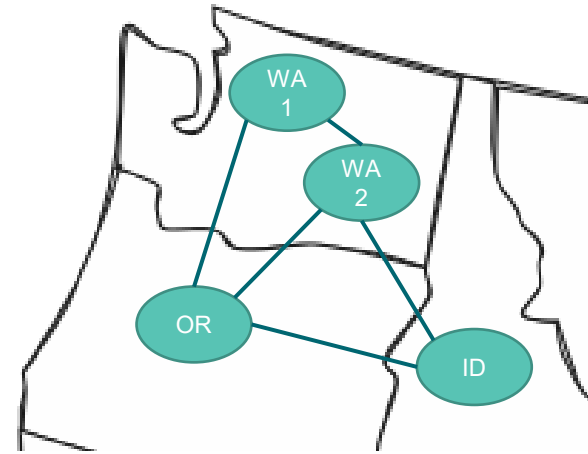
WA BAA:

- Emitting Resource – CCA
- Non-emitting Resource – No CCA

Non-WA BAAs:

- Emitting Resource – No CCA
- Non-emitting Resource – No CCA

2025 IRP



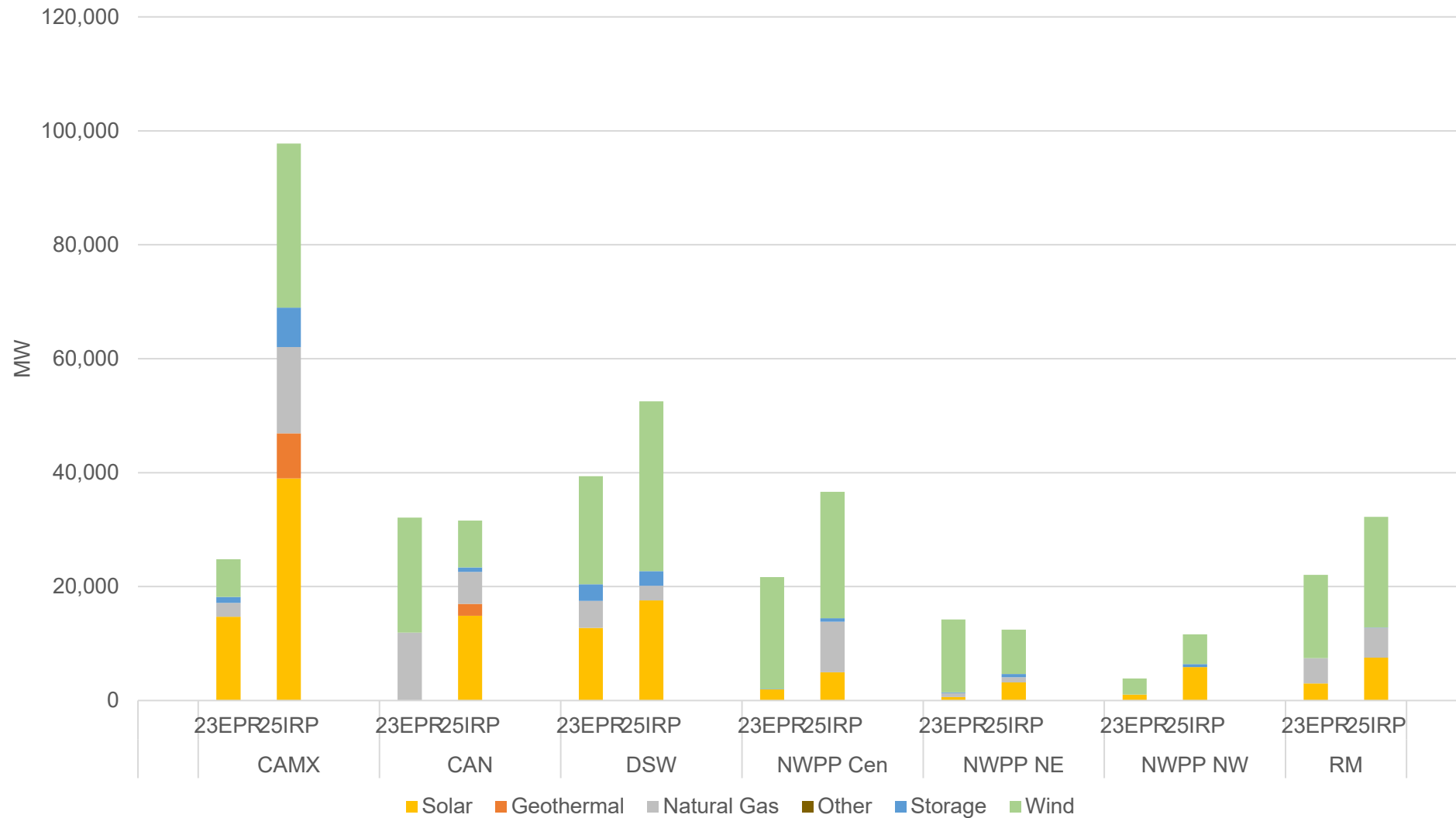
WA BAAs:

- Emitting Resource – CCA
- Non-emitting Resource – No CCA

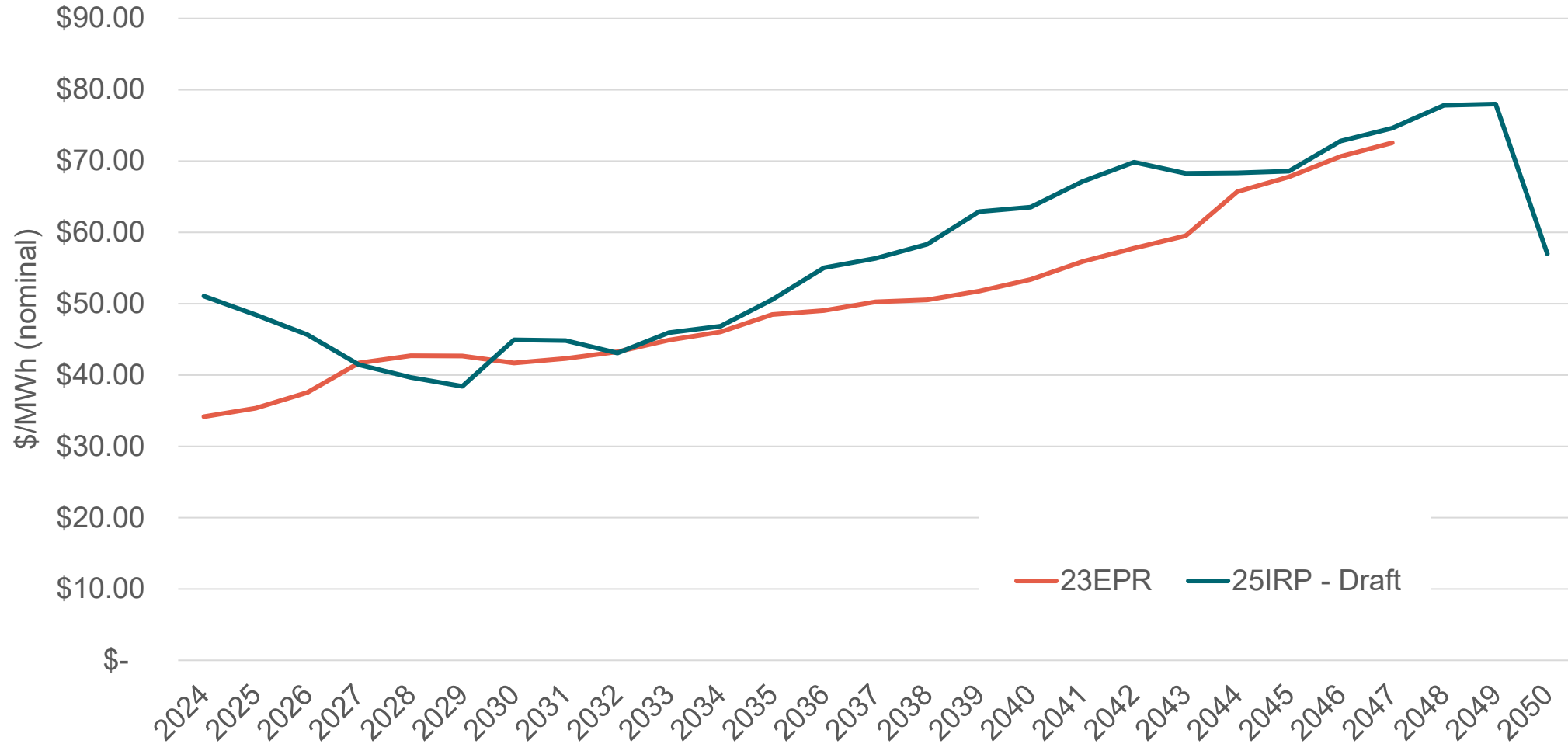
Non-WA BAAs:

- Emitting Resource – CAA
- Non-emitting Resource – No CCA

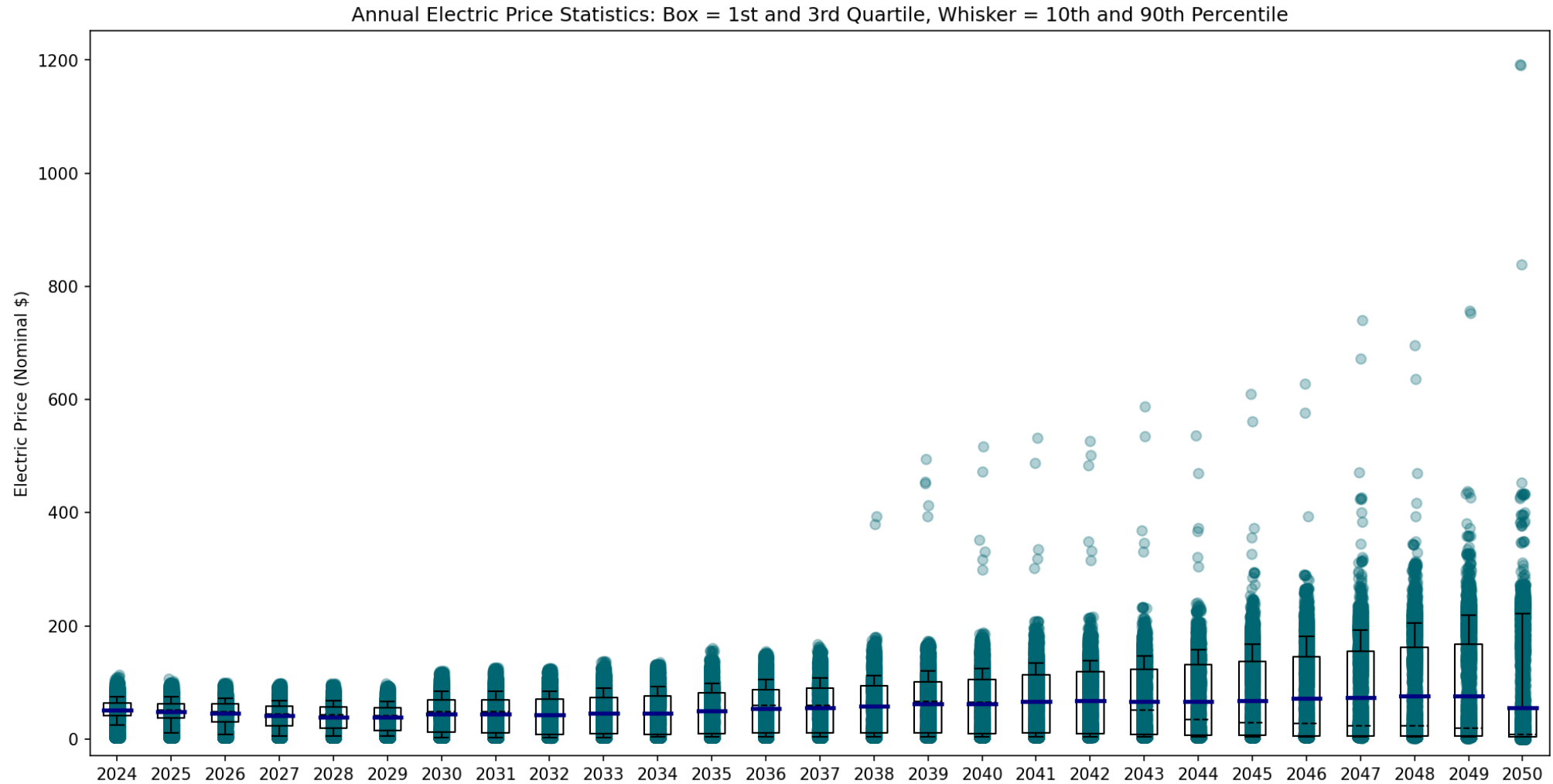
Results – capacity expansion



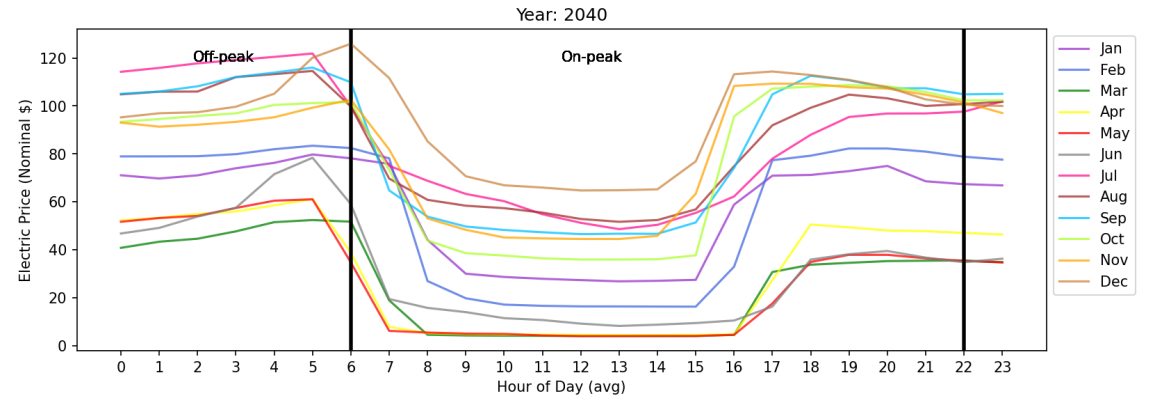
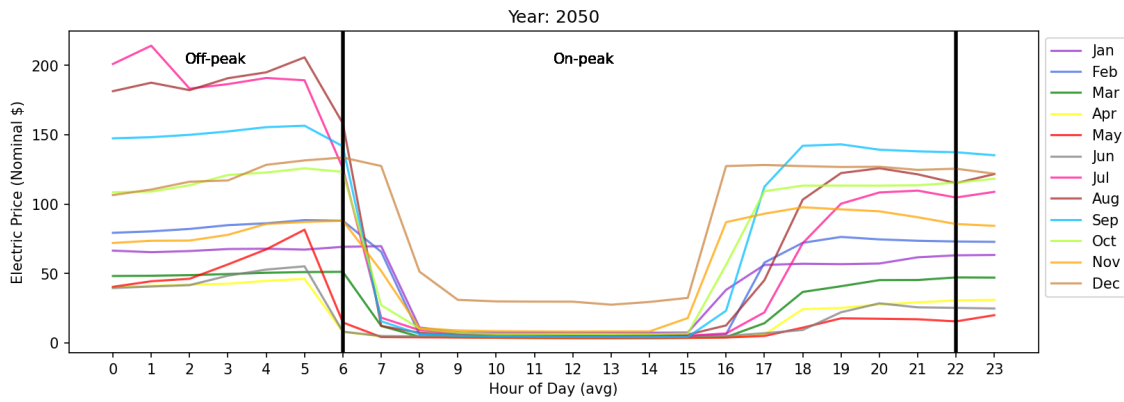
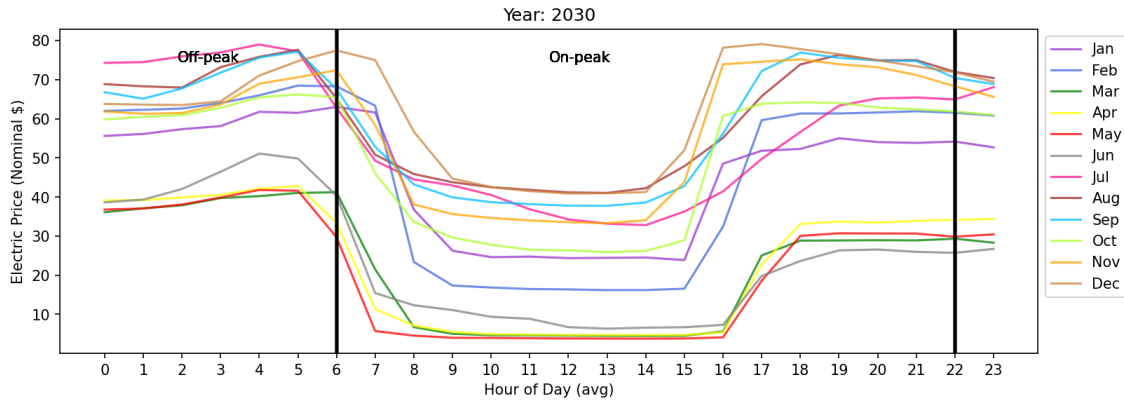
Results – average annual electric price



Results – price volatility

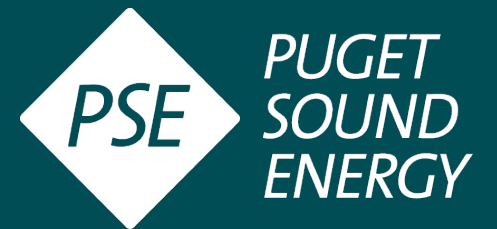


Results – price volatility



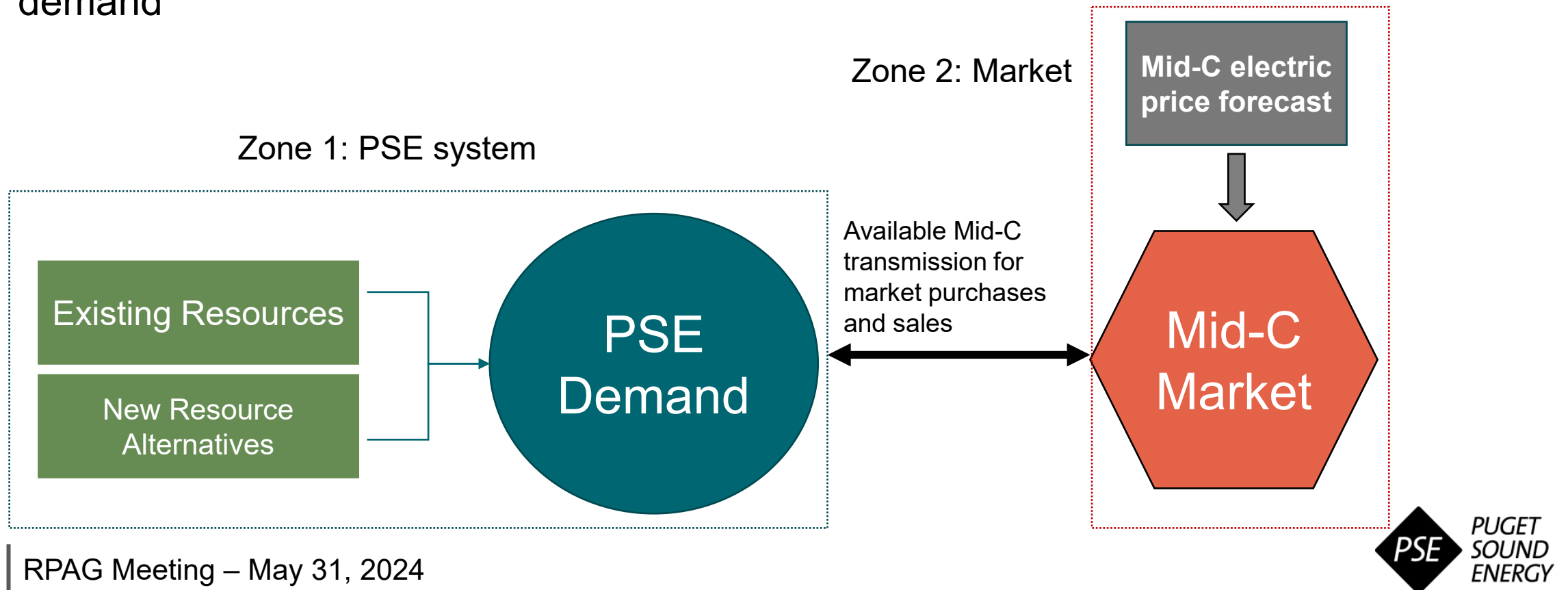
Electric portfolio model

Jennifer Magat, PSE



PSE portfolio model – system diagram

- PSE models a 2-zone system in the AURORA LTCE model
- The 2-zone system allows the limitation of the Mid-C market to available transmission
- All resources are located in the PSE zone to make sure they dispatch to PSE demand



Portfolio modeling framework

Demand Forecast and PRM



CETA Target



Hydro Forecast



Power and Natural Gas Price Forecast



Existing and Generic Resources



Transmission Constraints



Carbon Price



Input Database



Long term capacity expansion (LTCE) for PSE only



OUTPUT
New builds and retirements



Hourly Dispatch for PSE only

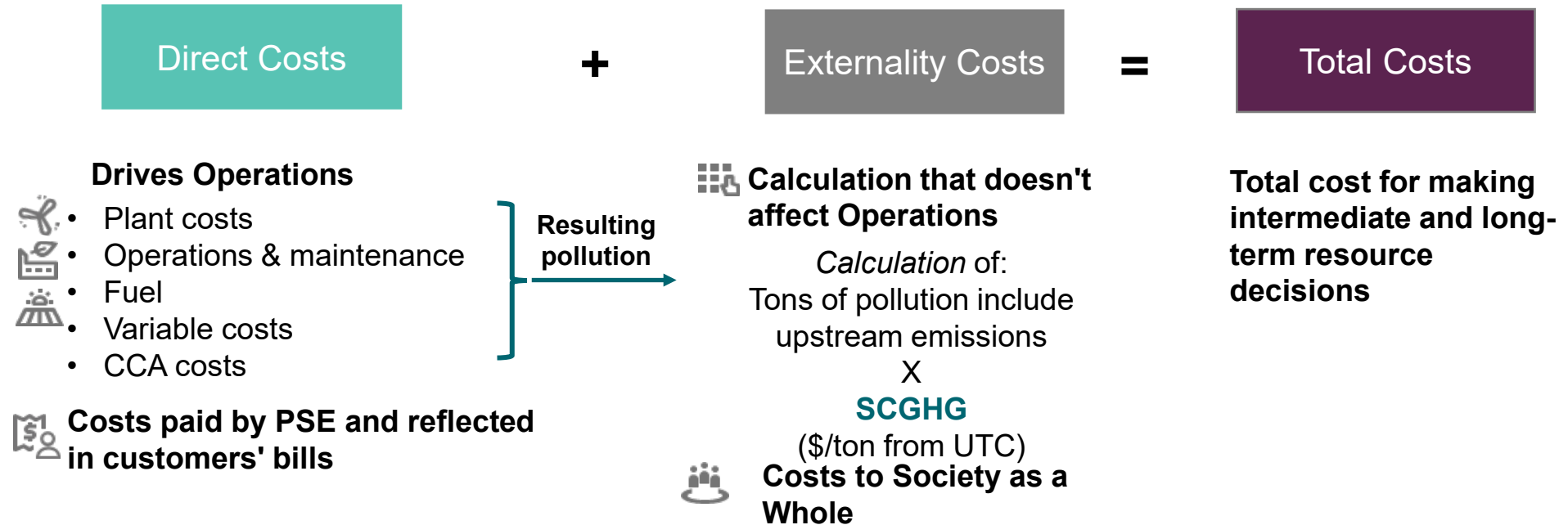


OUTPUT
Portfolio dispatch and costs



Social cost of carbon added to existing and new thermal resources and market purchases as a cost adder

Applying SCGHG to total costs



Based on feedback from interested parties, we will run a sensitivity with the SCGHG included in dispatch cost

Long Term Capacity Expansion Modeling

Modeling Approach: sets mathematical framework

Objective Function: establishes the optimization to be solved, usually to either minimize costs or maximize value

Constraints: limit the solution to the objective function to achieve realistic, achievable results

Mixed Integer Linear Programming problem: uses a mix of continuous linear variables and discrete integer variables

Minimize: the net present value of the total portfolio cost

$$\begin{aligned}
 & \textit{Total Portfolio Cost} = \\
 & \sum_{t=1}^n (\textit{capital cost}_t + \textit{fixed cost}_t + \textit{variable cost}_t + \textit{fuel cost}_t \\
 & + \textit{transmission cost}_t) - \textit{Market Revenue}_t
 \end{aligned}$$

Subject to:

Constraint Type	Purpose
Resource Characteristics	Forces resources to behave as they would in reality
Transmission Limits	Limits Mid-C market purchases based on real conditions
Demand Forecast (Energy need)	Shows the model the demand profile it must meet
Resource Adequacy (Peak Need)	Ensures that the final portfolio meets RA standards
Renewable Requirement	Forces the model to be CETA and RPS compliant

Portfolio modeling



Deterministic Portfolio Analysis

- Shows how different resource alternatives dispatch to market
- Identifies the least-cost integrated portfolio
- Shows how specific input assumptions can impact the least-cost mix of resources

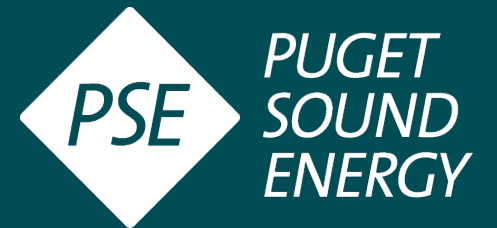


Stochastic Risk Analysis

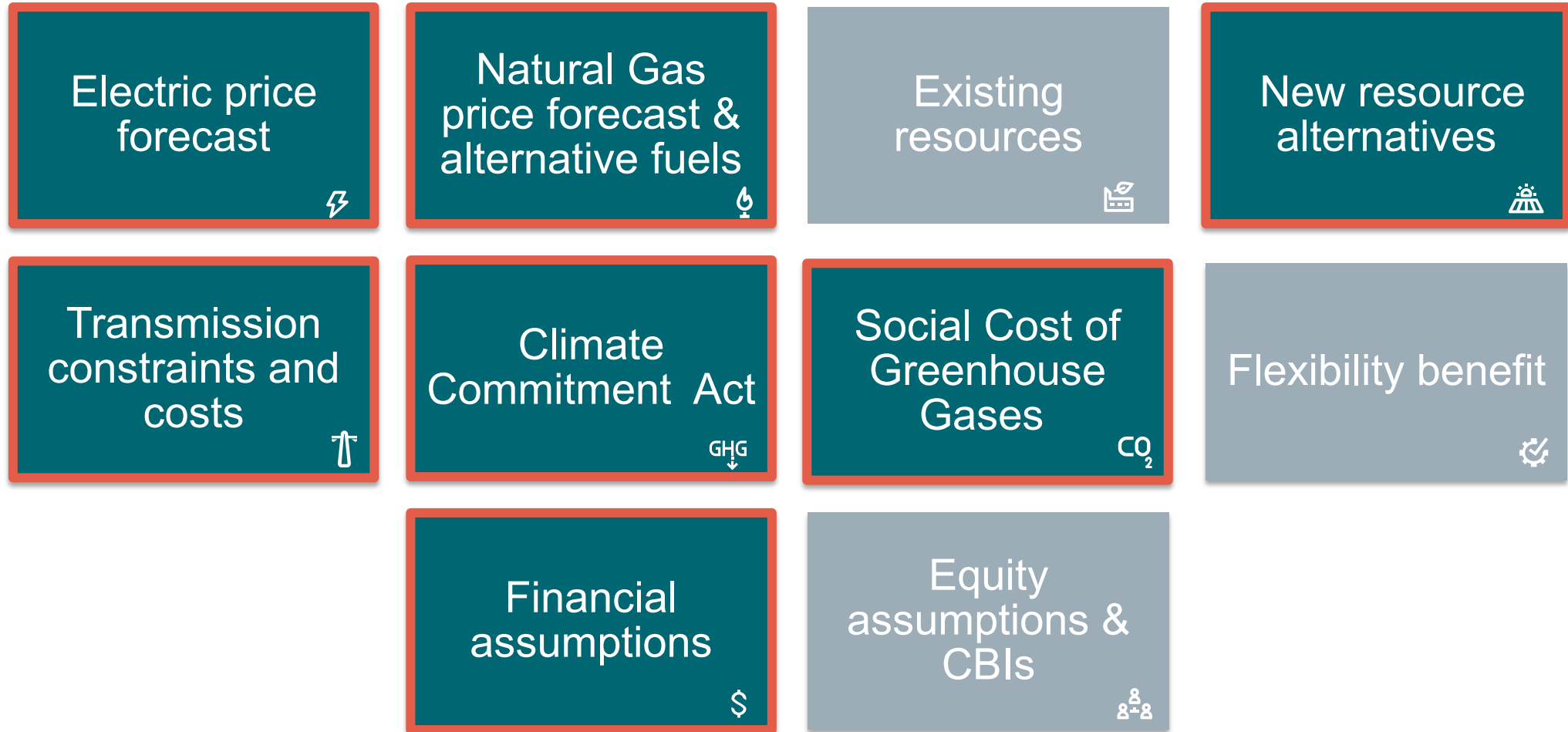
- Tests the robustness of different portfolios
- The goal is to understand the risks of different candidate portfolios
- Runs portfolios from the deterministic analysis through draws

Reference assumptions for new resources

Nathan Critchfield, PSE



Planning assumptions



Supply-side resource alternatives for the 2025 IRP



Energy Storage

- Short duration (Lithium-Ion 4 hour)
- **Medium duration (CAES 8-hour) - Emerging**
- **Long duration (Iron-Air 100-hour) - Emerging**



Wind

- Onshore wind
- **Offshore wind - Emerging**
- Hybrid and co-located with energy storage and solar



Solar Photovoltaic (PV)

- Utility scale
- Hybrid and co-located with energy storage and wind



Baseload

- **Small Modular Reactor (SMR) - Emerging**



Combustion Turbine (peaker)

- Natural Gas with R99 backup
- **Hydrogen/NG blend with R99 backup - Emerging**
- R99



Distributed Energy Resources

- Solar
- Energy storage

Supply-side resource alternatives

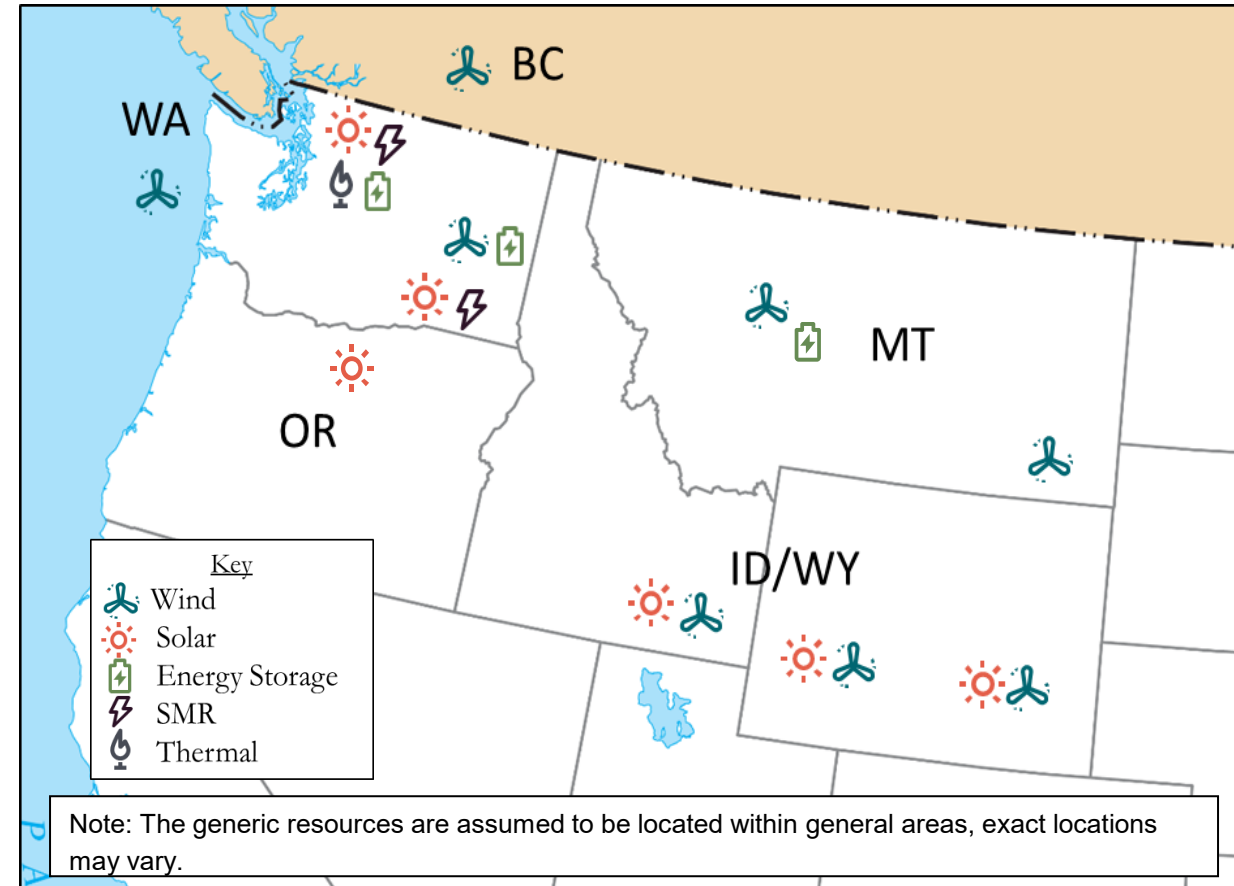
Generic Resources	Resource Group Region							
	PSE Territory	Eastern WA	Western WA	Southern OR	Montana	Wyoming	Idaho	BC
Wind		x			x	x	x	x
Solar	x	x		x		x	x	
Peaker (multiple fuels)	x		x					
Offshore Wind			x					
Nuclear		x	x					
DER Solar/Storage	x							
Storage Short Duration	x	x			x			
Storage Mid Duration	x	x						
Storage Long Duration	x	x						

Annual Average Capacity Factor (%)	
Washington Wind	37.2
Montana-East Wind	47.7
Montana-Central wind	41.3
Wyoming-East Wind	46.4
Wyoming-West Wind	36.1
Idaho Wind	15.0
Offshore Wind	42.1
Washington-West Distributed Solar	17
Washington-East Utility Solar	25.0
Wyoming-East Solar	28.9
Wyoming-West Solar	30.0
Idaho Solar	27.3

*These are the same renewable shapes and capacity factors used in the 2023 Electric Progress Report. More information can be found in [Appendix D: Generic Resource Alternatives](#).

Transmission constraints

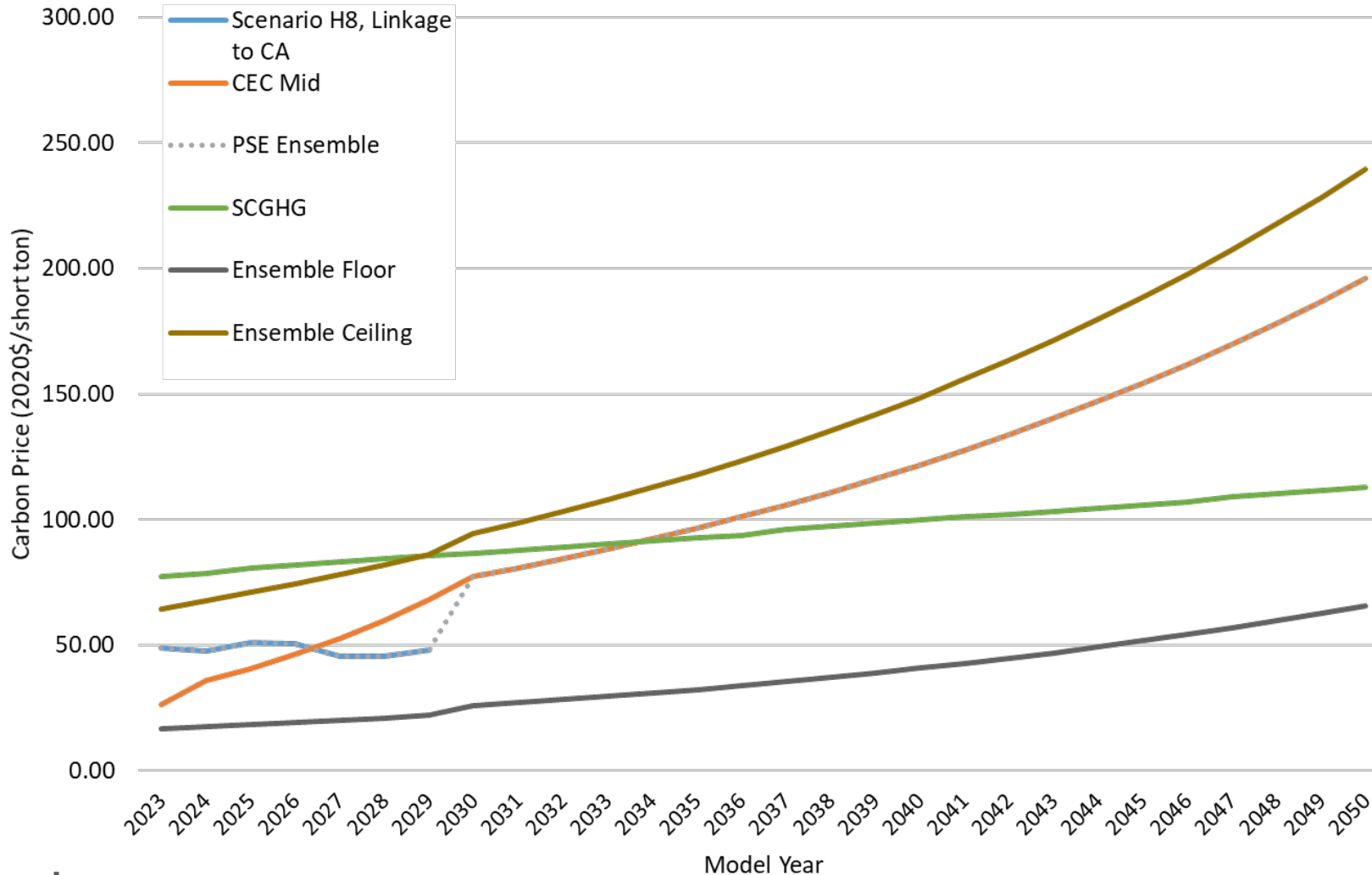
Location	2030	2035	2040
Southeast WA	350	350	350
Central WA	1,150	1,400	1,400
Southern WA/Gorge	375	375	375
Oregon	300	300	300
	2,175	2,425	2,425
Western WA	100	100	100
British Columbia	310	310	310
Montana	48	48	48
Idaho/Wyoming	0	150	150
Total	2,633	3,033	3,033



- Transmission capacity is shown as a cumulative nameplate capacity (MW)
- Numbers shown are modeled as resource build limits
- This table shows the range of plausible transmission limits

Carbon price - SCGHG & CCA

Carbon Pricing in Aurora Portfolio Model



SCGHG represented as the two and one-half percent discount rate, listed in table 2, technical support document: Technical update of the social cost of carbon for regulatory impact analysis under Executive Order No. 12866, published by the interagency working group on social cost of greenhouse gases of the United States government, August 2016

Inflation factor provided by the Washington Utilities and Transportation Commission (UTC) [Social Cost of Carbon \(wa.gov\)](https://www.wa.gov/social-cost-of-carbon)

Upstream emissions

The upstream emission rate represents the carbon dioxide, methane, and nitrous oxide releases associated with natural gas extraction, processing, and transport along the supply chain.

The upstream segment of 10,803 g/MMBtu is converted to 23 lb/MMBtu and then applied to the emission rate of natural gas plants for the SCGHG emissions.

Example:

New NG plant emission rate: 117 lbs/MMBtu

Upstream emission rate: 23 lbs/MMBtu

Total emission rate: 140 lbs/MMBtu

*This is the same assumption as the 2023 Electric Progress Report. Further discussion can be found in [Chapter 5: Key Analytical Assumptions](#), page 6 of the report.

Financial assumptions

Time Horizon

- 2026 through 2050

Inflation

- 2.5% per year
- Short term spikes in inflation, but long-term levels off at 2.5%

Unspecified Market

- Section 7 of E2SB 5116, paragraph 2 states to use 0.437 metric tons CO₂/MWh for unspecified market purchases

Inflation Reduction Act

- PTC at 100% for planning horizon
- ITC at 30% for planning horizon
- Include ITC on stand-alone energy storage
- PTC for new technologies which include small modular nuclear
- There are additional PTC and ITC bonus incentives in the IRA that are not captured in this IRP.

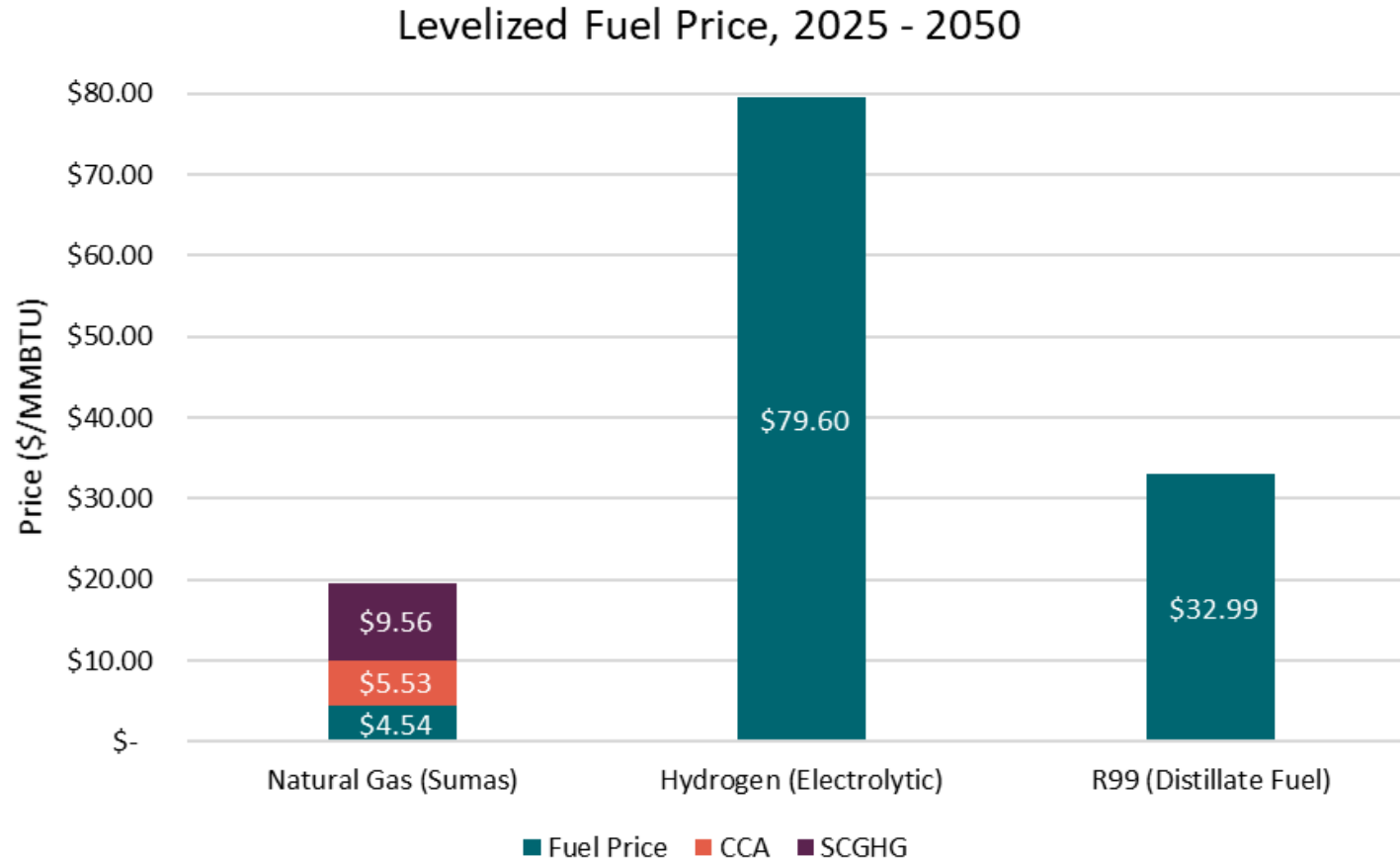
Alternative Compliance

- CETA requires 100% greenhouse gas (GHG) neutrality by 2030
- Minimum of 80% of energy delivered from renewables, remaining can be met with other options
- PSE will estimate the remaining as the LCOE of the most cost-effective renewable

Discount Rate

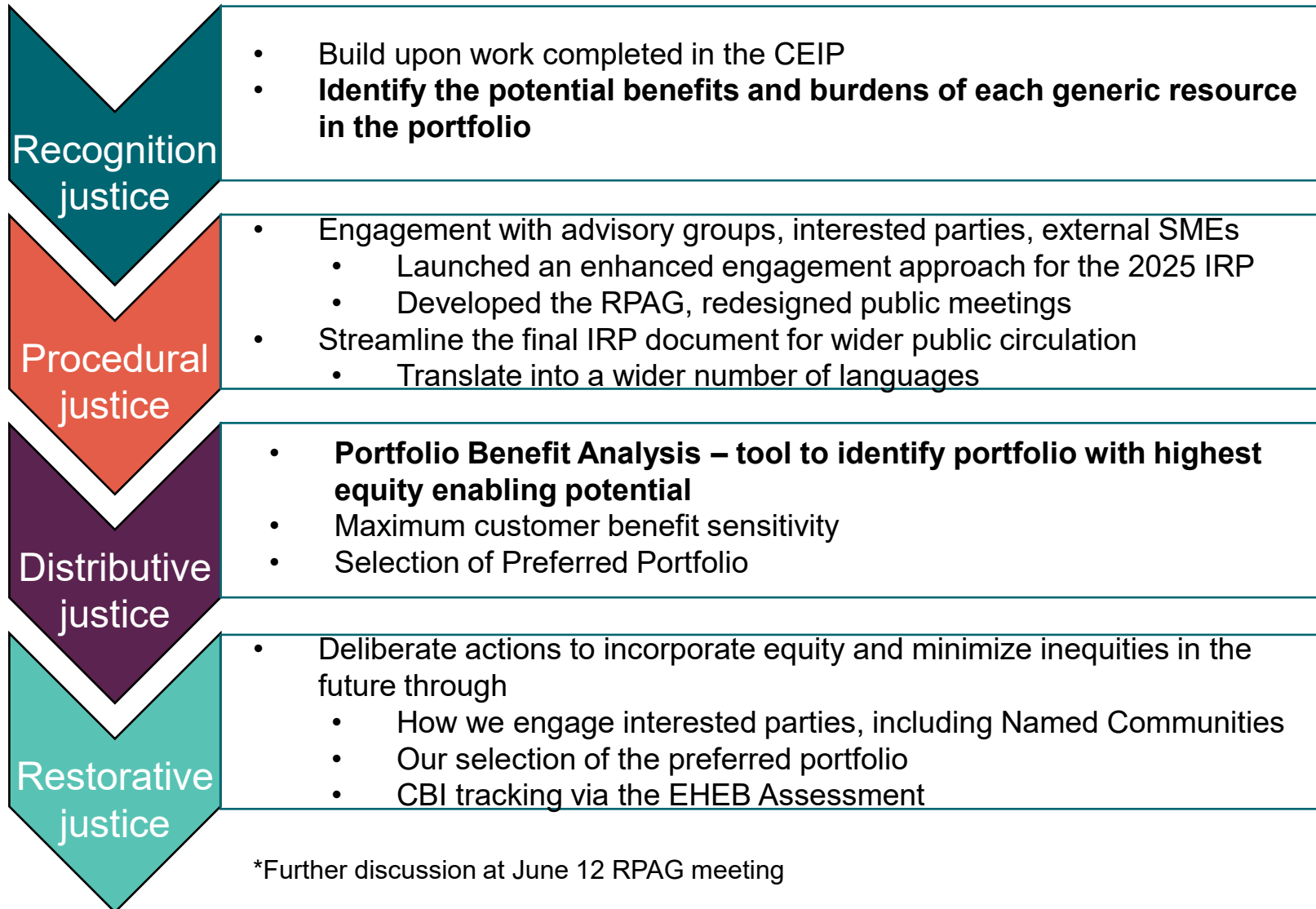
- 6.62% after tax WACC (weighted average cost of capital)

Alternative fuels



- R99 price is represented by distillate diesel forecast from the 2023 EIA Annual Energy Outlook (AEO) as PSE expects the R99 price to mirror diesel in the long-term
- Gas consists of Forward Marks price from 2024-2031 and then Wood Mackenzie's Fall 2023 release long term forecast from 2031-2050.
- Hydrogen price is the result of PSE's internal analysis

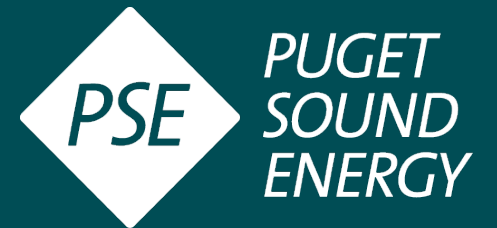
2025 IRP Energy Justice Core Tenets



*Further discussion at June 12 RPAG meeting

Sensitivity analysis

Elizabeth Hossner, PSE



Keep in mind

The sensitivities will be prioritized for work.

What to keep in mind:

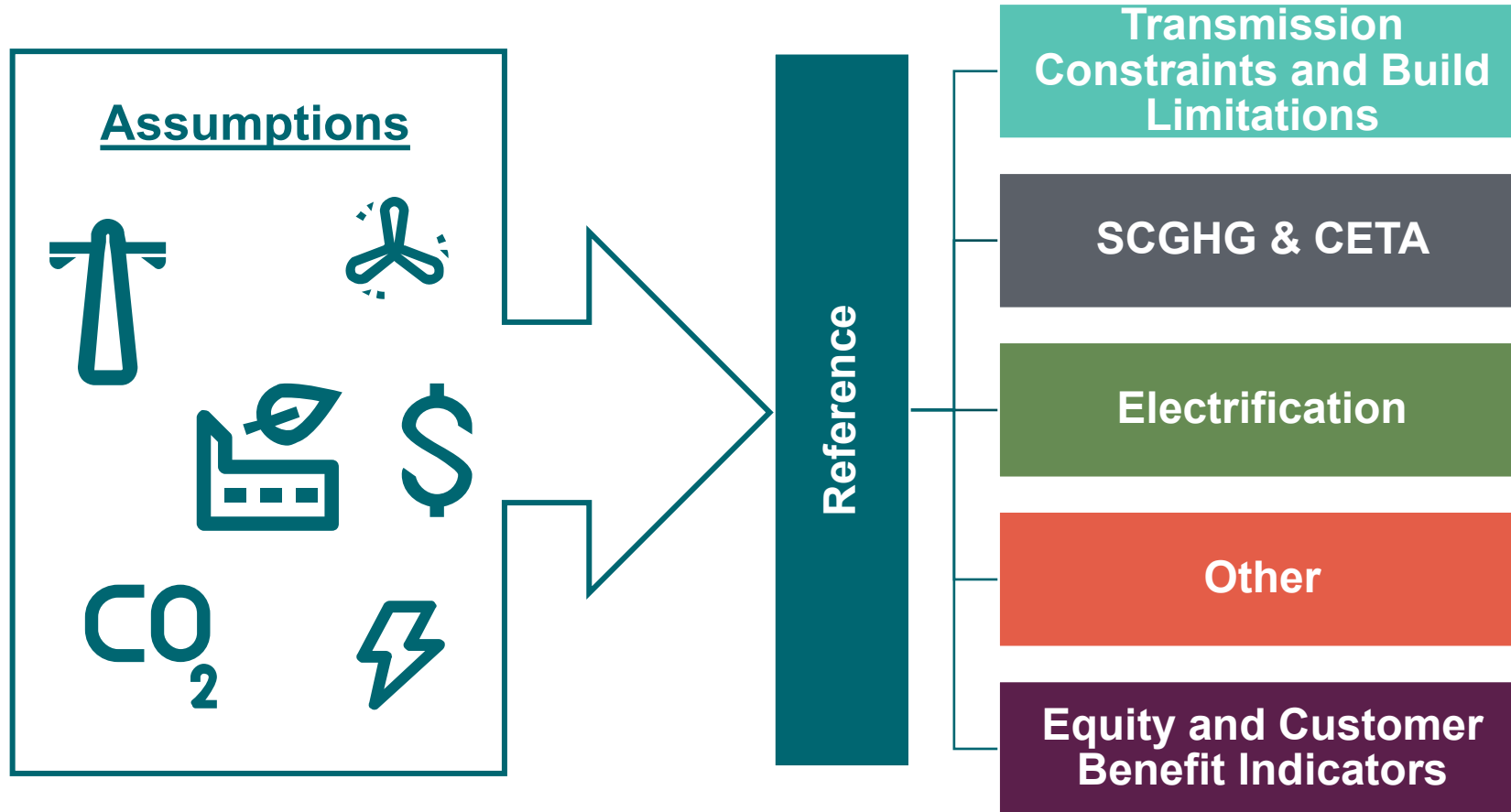
1. Are there ideas on other sensitivities?
2. How would you prioritize the sensitivities for schedule and work load?

Objective: to discuss sensitivities and give feedback on what PSE should include

Sensitivity analysis


1. The reference portfolio is the least-cost set of resources to meet the base set of assumptions.

2. Sensitivity Analysis goes through a process to change one or more of the base assumptions to examine the effect on the portfolio



Draft 25 IRP Sensitivities

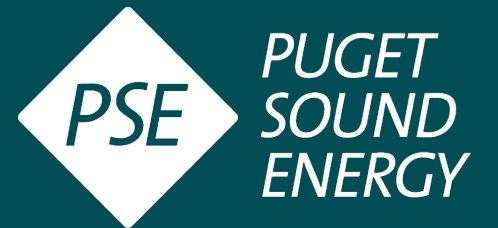
Transmission Constraints and Build Limitations	SCGHG & CETA	Electrification	Other	Equity & Customer Benefit Indicators (CBI) – Portfolio Benefit Analysis
<ul style="list-style-type: none"> <input checked="" type="checkbox"/> 2. Lower transmission available (BPA) <input type="checkbox"/> 3. Delay BPA availability <input type="checkbox"/> 4. More transmission 2035 (PSE) <input type="checkbox"/> 5. More transmission 2038 (BPA) <input type="checkbox"/> 6. More transmission 2035 (PSE) + 2038 (BPA) <input checked="" type="checkbox"/> 7. Non-Firm Transmission for variable energy resources 	<ul style="list-style-type: none"> <input checked="" type="checkbox"/> 8. SCGHG as a dispatch cost <input checked="" type="checkbox"/> 9. No CETA w/ SCGHG <input checked="" type="checkbox"/> 10. No CETA, no SCGHG <input type="checkbox"/> 11. CCA ceiling price 	<ul style="list-style-type: none"> <input checked="" type="checkbox"/> 12. Building electrification (high) <input checked="" type="checkbox"/> 13. Building electrification (low) <input checked="" type="checkbox"/> 14. EV forecast (high) <input checked="" type="checkbox"/> 15. EV forecast (low) <input type="checkbox"/> 16. Combined building electrification (high) & EV forecast (high) 	<ul style="list-style-type: none"> <input checked="" type="checkbox"/> 17. Energy Efficiency bundled by winter peak capacity <input checked="" type="checkbox"/> 18. WRAP Planning reserve margin and peak capacity contribution 	<ul style="list-style-type: none"> <input checked="" type="checkbox"/> 19. Maximum customer benefit <input checked="" type="checkbox"/> 20. Increased Distributed Storage (can include V2G) <input type="checkbox"/> 21. ?

 Feedback from interested parties

 Required by CETA or CEIP conditions

Next steps

Sophie Glass, Triangle Associates



Upcoming activities

Date	Activity
June 6, 2024	Public webinar: Equity in the IRP
June 7, 2024	Feedback form for this meeting closes
June 12, 2024	RPAG meeting: Equity in the IRP



Email us at irp@pse.com



Visit our website at pse.com/irp



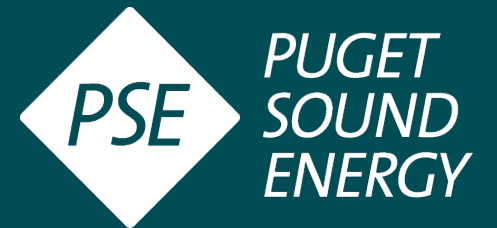
[Register for email updates](#)



Leave a voice message at 425-818-2051

Public comment opportunity

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



Thanks for joining us!



Appendix



Cost of capital

2022 GRC	Weight	Cost	WACC	Tax Deduction	After-Tax WACC
Debt	51.00%	5.00%	2.55%	-0.54%	2.01%
Equity	49.00%	9.40%	4.61%		4.61%
Total	100.00%		7.16%	-0.54%	6.62%

Acronyms

Acronym	Meaning
BAA	Bonneville Power Administration Balancing Authority Area
BPA	Bonneville Power Administration
CAES	Compressed air energy storage
CAMX	Canada-Mexico
CAN	Canada
CBI	Customer benefit indicator
CEIP	Clean Energy Implementation Plan
CETA	Clean Energy Transformation Act
DER	Distributed energy resources
EHEB	Economic, health, environmental burdens and benefits
ELCC	Effective load carrying capability
EPR	2023 Electric Progress Report
IRA	Inflation Reduction Act

Acronyms

Acronym	Meaning
IRP	Integrated Resource Plan
ITC	Investment Tax Credit
MILP	Mixed integer linear programming
MMBtu	One million British thermal units
MW	Megawatts
NG	Natural gas
NPCC	Northeast Power Coordinating Council
NPV	Net present value
LTCE	Long term capacity expansion
NWPP	Northwest Power Pool
PTC	Production tax credit
PV	Photovoltaics
RA	Resource Adequacy
RFP	Request for proposal

Acronyms

Acronym	Meaning
RPAG	Resource Planning Advisory Group
RPS	Renewable portfolio standard
SCGHG	Social cost of greenhouse gas
SMR	Small modular reactor
UTC or Commission	Washington Utilities and Transportation Commission
V2G	Vehicle to grid
V2X	Vehicle to everything
WECC	Western Electricity Coordinating Council