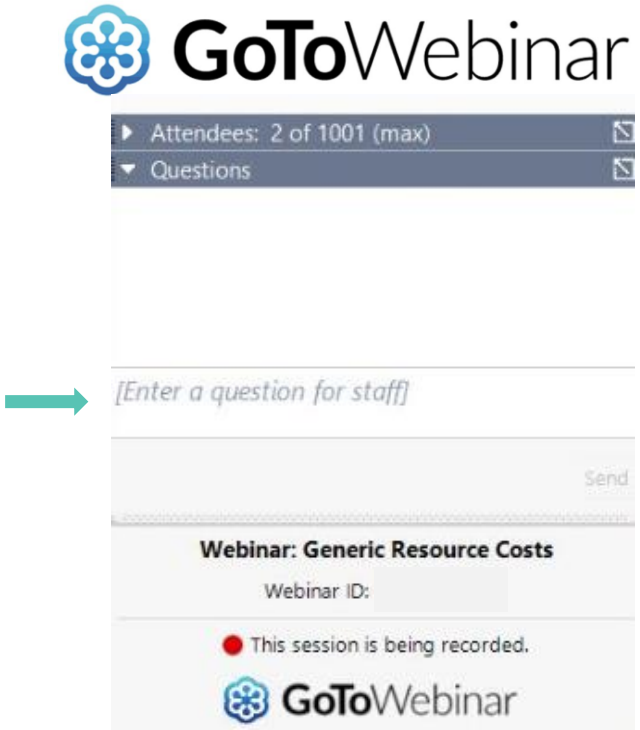
2021 IRP Webinar #1: Generic Resource Assumptions

Planning Assumptions & Resource Alternatives
Electric Portfolio Model

May 28, 2020

Welcome to the webinar and thank you for participating!



How to ask a question or submit a comment

- Expand the Questions window on your control panel
- Type in your question
- Staff are on hand to keep track of questions on generic resource costs
- We will also take a Q&A break at several points during the presentation
- If there's more time available at the end of the presentation, we'll take more questions

Virtual webinar link:
https://attendee.gotowebinar.com/register/4112488354960834319

Webinar ID: 537-409-243

Call-in telephone number: 1-877-309-2074

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Agenda

- Safety moment
- PSE IRP team introduction
- Public participation plan overview
- Introduction to the 2021 IRP
- Electric IRP models overview
- Electric generic resource assumptions

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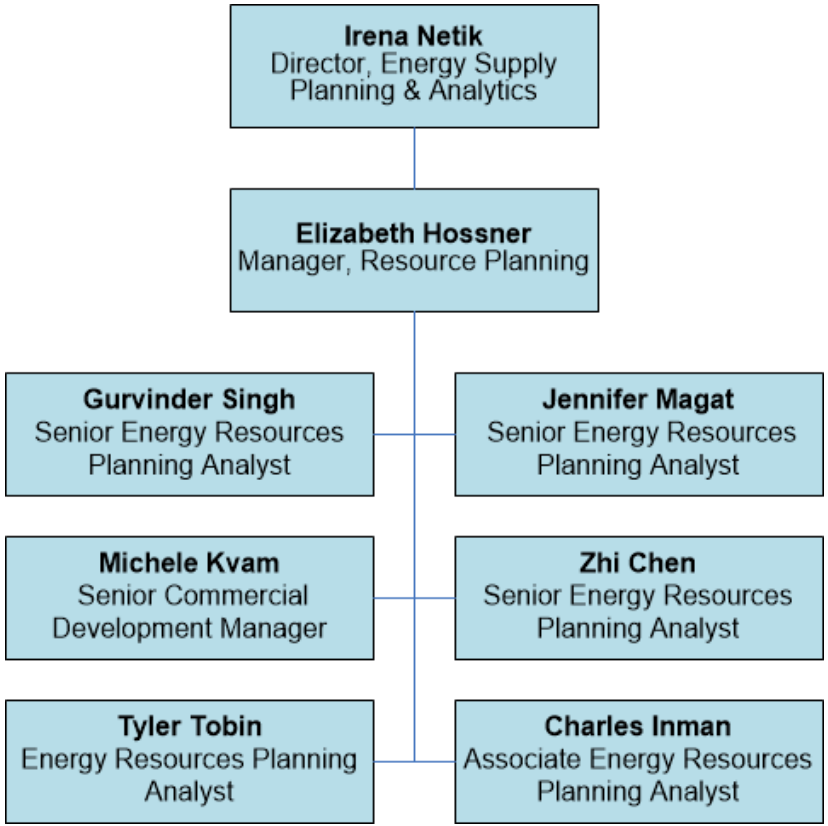
Safety moment: Call 811 before you dig

Dial 811 at least **two full business days** (not including the day you call) before you plan to dig, no matter the size of your project. It's not only smart, **it's the law**.

- It's important to have the locations of underground utilities verified and clearly marked
- Striking a natural gas or electric line may result in service disruptions, bodily harm, fines and/or repair costs

pse.com/pages/know-whats-below

PSE IRP Team



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Public participation approach

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Public participation in the 2021 IRP

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Tools for public participation

To keep you informed...

- Website postings
- Email notifications
- Briefings
- Feedback Reports
- Consultation Updates
- E-Newsletters
- Topical fact sheets

To seek your thoughts, ideas, concerns...

- Stakeholder interviews - *completed*
- Feedback webinars
- Online meetings
- Feedback forms

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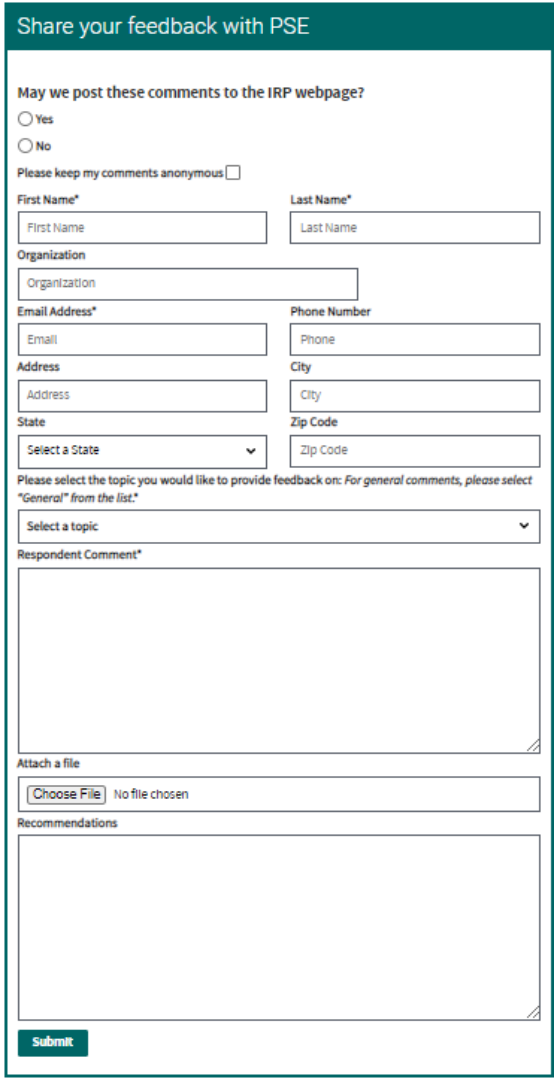
Feedback Form

- An important way to share your input
- Available on the website 24/7
- Comments, questions and data can be submitted throughout the year, but timely feedback supports the technical process
- Please submit your Feedback Form within a week of the meeting topic

Feedback Form → **Feedback Report** → **Consultation Update**



Feedback cycle

Action	Timing
Stakeholders can submit questions and feedback via the Feedback Form.	**Anytime, 24/7 online access**
PSE will share the meeting agenda, presentation slides and any supporting materials on the website.	**One week before each meeting**
A recording of the webinar and the transcript of the chat will be posted to the website so those who were unable to attend can review.	**One day after each meeting**
Feedback Forms related to the specific meeting topic are due.	**One week after each meeting**
A Feedback Report of all comments collected from the Feedback Form, along with PSE's responses, will be shared with stakeholders via the website.	**Two weeks after each meeting**
A Consultation Update, where PSE demonstrates how stakeholder feedback was applied, will be posted to the website.	**Three weeks after each meeting**

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An introduction to the 2021 IRP

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What has happened since the 2019 IRP process?

- The 2019 IRP resulted in a Progress Report filed in November 2019
- In December 2019, PSE hosted a webinar comparing different methods for applying social cost of carbon
- The 2021 IRP Work Plan, including a Public Participation Plan, were filed in April 2020 and recently updated (see Docket No: UE-200304 and UG-200305)
- A new website pse.com/irp has launched and provides a robust platform for engagement
- The Washington Utilities and Transportation Commission (WUTC) is progressing on several rulemakings:
  - Integrated Resource Planning Rulemaking – UE-190698
  - Clean Energy Implementation Plans and Compliance with the Clean Energy Transportation Act Rulemaking, UE-191023
  - Purchase of Electricity Rulemaking – UE-190837

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2021 Electric IRP Priorities

The IRP is a long-term forecast of demand side resources and supply side resources that appear to be cost effective to meet the growing needs of our customers.

The study period for electric planning is 2022-2045.

The 2021 IRP will

- Transition to a carbon free electricity supply by 2045.
- Remove coal generation from the portfolio of resources.
- Reinforce our commitment to reliability as we transition to a cleaner electricity supply.

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CETA timeline

- **2025:** Elimination of coal-fired resources from electric power supply
- **2030:** Carbon neutral energy supply
  - 80% non-emitting and renewable resources
  - 20% can be met with alternative compliance
- **2045:** 100 percent non-emitting electricity supply

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2021 IRP modeling process

The 2021 IRP will follow a 6-step process for analysis:

1. Establish peak capacity, energy and renewable energy need
2. Determine planning assumptions and identify supply-side and demand-side resource alternatives
3. Analyze scenarios and sensitivities using deterministic and stochastic risk analysis
4. Analyze results
5. Develop resource plan
6. Develop 10-year Clean Energy Action Plan

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2021 IRP process timeline

Meeting dates are available on [pse.com/irp](pse.com/irp) and will be updated throughout the process. This is a tentative timeline subject to revision.

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IRP modeling process

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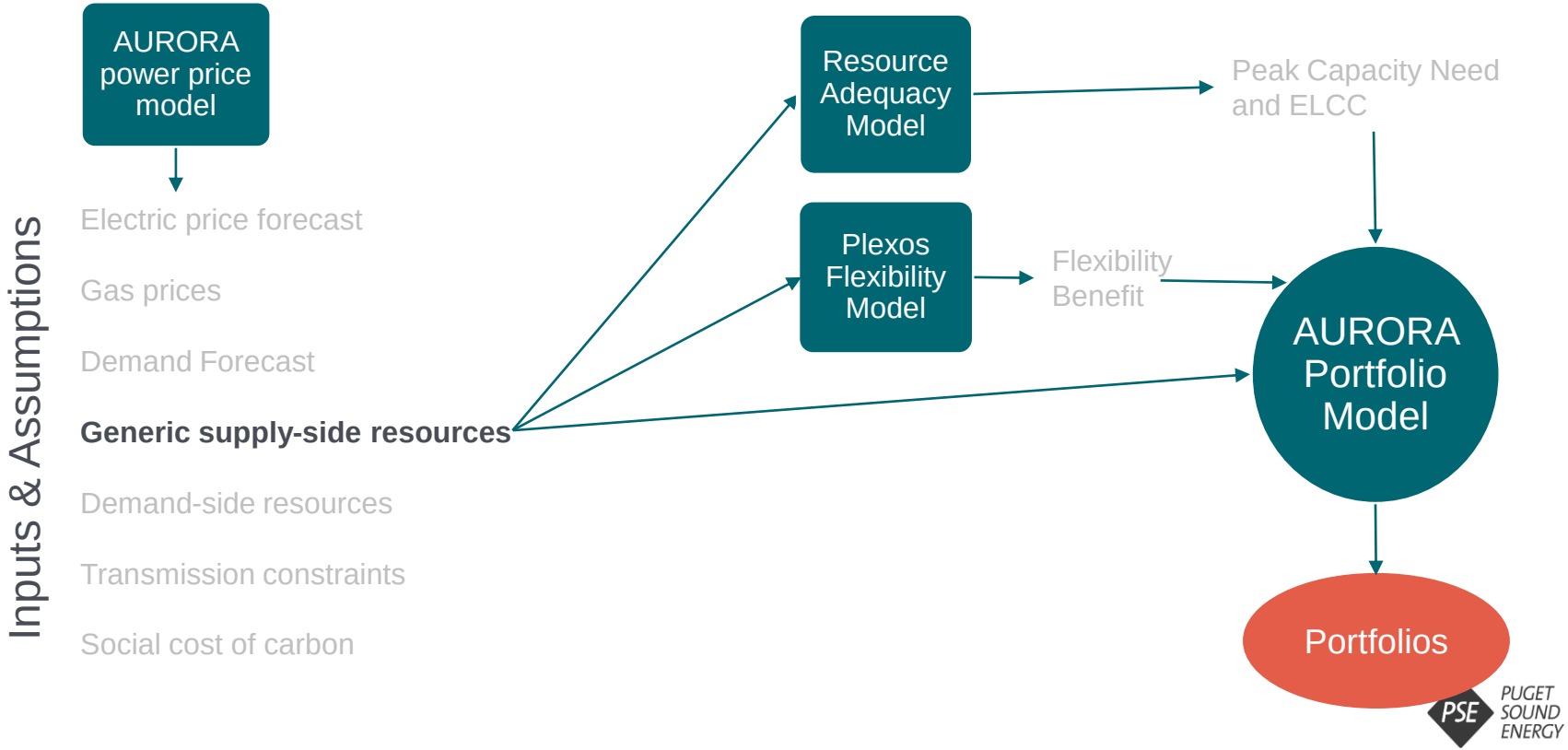
Electric IRP Models



Electric generic resource assumptions

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Participation Objective

- Stakeholders share input on generic resource costs for the electric portfolio

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The purpose of generic resources

- What are the generic resources used for?
  - Generic resources are used for planning purposes only. They are a stand-in to build portfolios of potential new resources
  - Generic Resources give us an idea of what new resources might cost in the future and how different resources can fit into PSE's needs
  - During an acquisition process, the generic resources are replaced with actual resources

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We heard you…

- As part of the 2019 IRP process, PSE received feedback from stakeholders about generic resource assumptions. As a result, PSE has researched and revised aspects of our generic resource assumptions.

- What we've changed:
  - Greater reliance on publicly available data sources
  - New renewable resource options
  - Generating resource capital costs have been updated
  - Aspects of operations and maintenance costs have been updated

- What we've retained:
  - PSE will continue to use the HDR report from the 2019 IRP for the operating characteristics of thermal and energy storage resources

- Data available online as an excel spreadsheet that provides all the costs that we will review in the slides. This is all the data that PSE has collected on capital costs, fixed costs, and variable costs.
  - Generic Resource Assumptions Workbook Summary

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Generic resource assumptions

Generic resource assumptions are made up of different components

1. Operating characteristics
2. Ongoing costs for fuel and maintenance
3. Capital cost to build the plant

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1 Operating characteristics – Thermal Plants

	CCCT	Frame Peaker	Recip Peaker
Nameplate (MW)	336	225	18.7
Heat Rate (Btu/kWh)	6,624	9,904	8,445
Min up (minutes)	60	60	35
Min Down (minutes)	15	15	15
Ramp Rate (MW/minute)	40	40	16
Start time (warm, minutes)	60	21	5
Forced outage rate (%)	3.88	2.38	3.30
Min capacity (%)	38	30	30

Where does this data go?

This data goes to the AURORA portfolio model, Plexos flexibility model and the Resource Adequacy Model

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1 Operating characteristics – Energy Storage

	Pumped Storage Hydro	Battery
Nameplate (MW)	300	25
Round Trip Efficiency (%)	80	87
Discharge rate (hours)	8	4
Degradation (%/yr)	near zero	near zero
Operating Range (%)	37.5 - 100	2 - 100
Forced outage rate (%)	1	2

Where does this data go?

This data goes to the AURORA portfolio model, Plexos flexibility model and the Resource Adequacy Model

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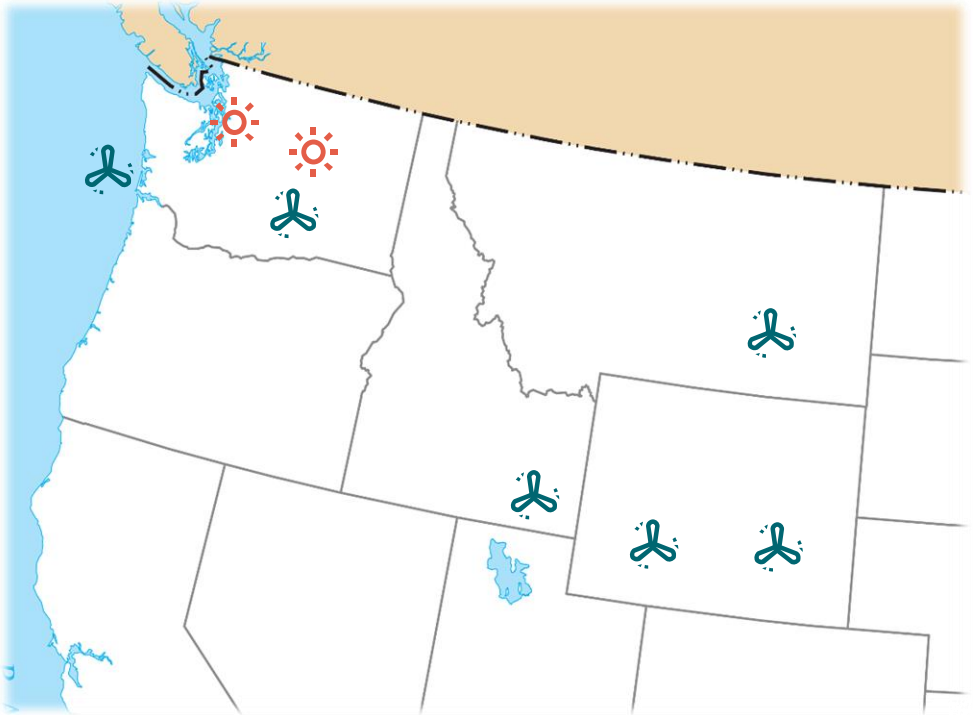
1 Operating characteristics – Renewable resources

Annual Average Capacity Factor (%)	
Washington Wind	28.6
Montana Wind	49.1
☆ Wyoming-East Wind	48.2
☆ Wyoming-West Wind	39.4
☆ Idaho Wind	32.3
Offshore Wind	34.8
☆ Washington-West Distributed Solar	12.9
Washington-East Utility Solar	27.7

☆ Indicates new resource added for 2021 IRP

Capacity factor data is from NREL database and DNV GL. This data reflects the total energy not the peak capacity



Location is a key driver of renewable resource characteristics

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1 Operating characteristics – Renewable resources

- Renewable resource data sources include:
  - NREL (WY Wind, ID Wind and W WA Solar)
  - DNV GL (WA Wind, MT Wind and E WA Solar)

- Deterministic renewable resource shapes were selected as the most-representative annual capacity factor (P50) value out of 250 draws
  - The 250 draws are used in the resource adequacy model and in the stochastic model.
  - The most-representative shape is used in the deterministic portfolio model.

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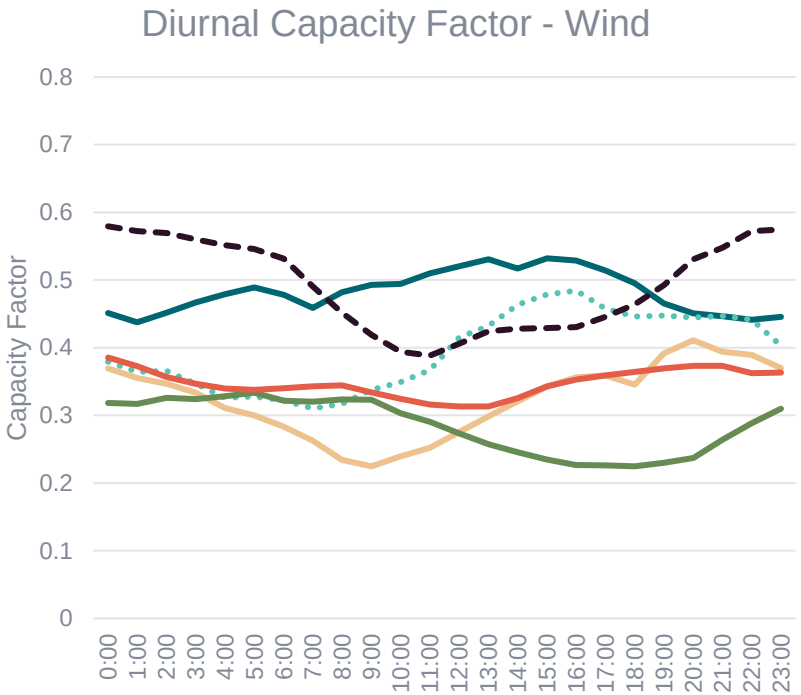
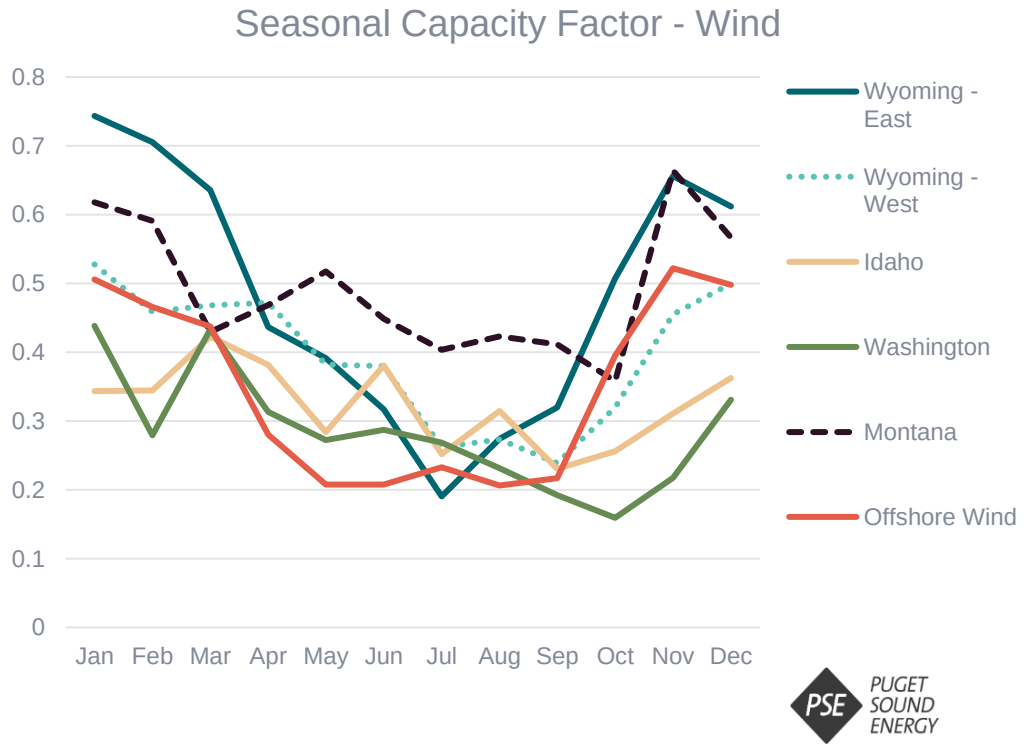
1 Operating characteristics – Renewable resources - Wind





Renewable resource capacity is often a function of both time of day and time of year

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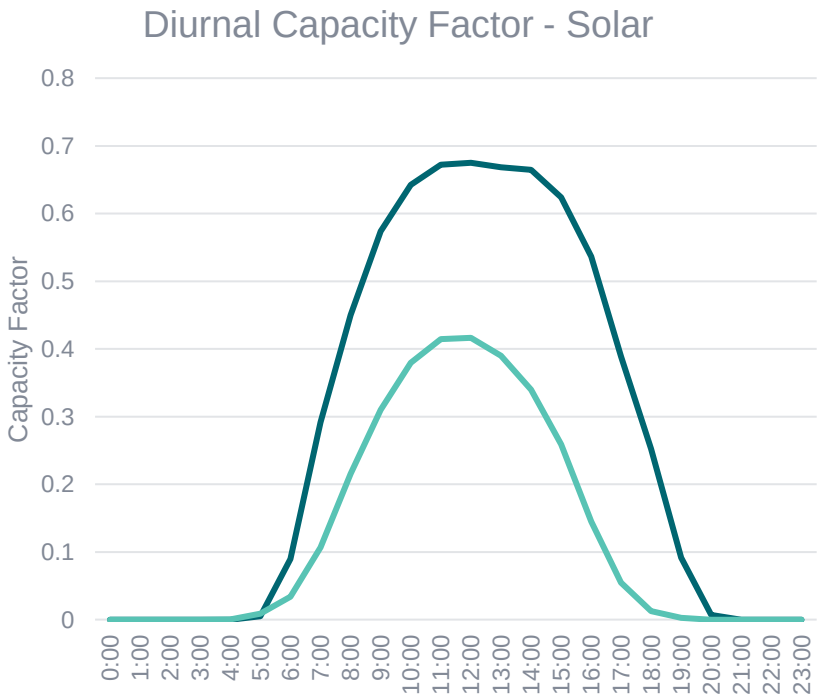
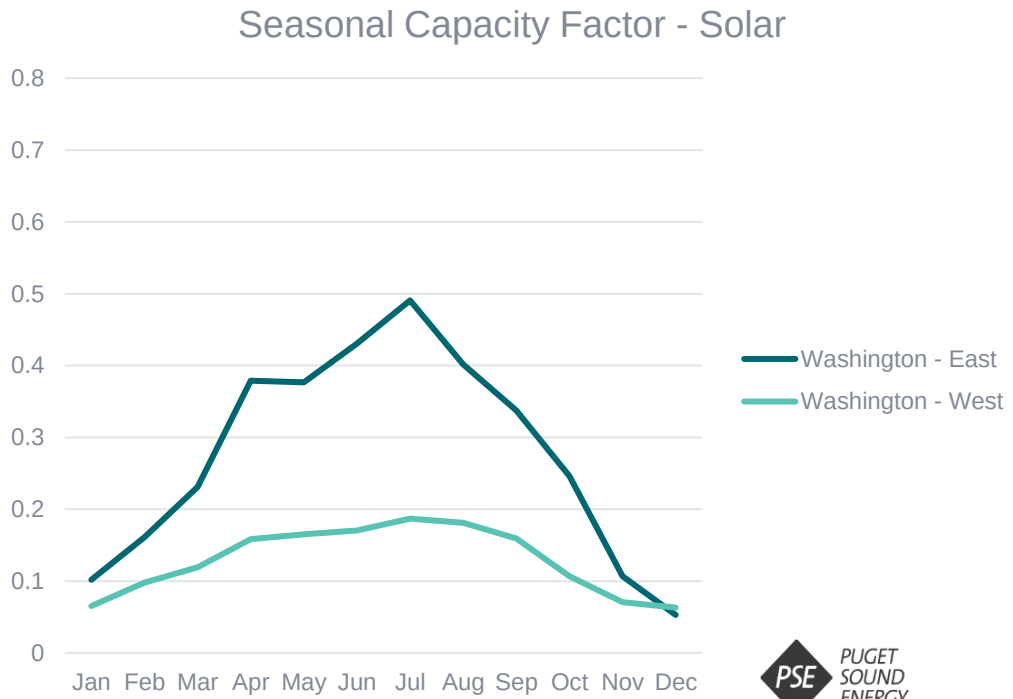
1 Operating characteristics – Renewable resources - Solar





Renewable resource capacity is often a function of both time of day and time of year

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2 Ongoing costs

Ongoing costs are divided into two categories

1. **Variable costs** – these are costs that are dependent on the energy produced by the plant

2. **Fixed costs** – these are costs that must be paid regardless if the plant runs or not

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2 Ongoing Costs – Variable – Operations and maintenance costs

- Includes fuel, waste disposal and other costs dependent upon the quantity of energy produced
- Renewable resources typically have very low to zero Variable Operations and Maintenance costs
- Publically available data sources have been compiled for comparison and will be presented for discussion shortly

Where does this data go?

This data goes to the AURORA portfolio model, and the Plexos flexibility model

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2 Ongoing Costs – Variable – Start-up Costs

- Thermal resources require additional resources during start-up procedures as compared to normal operation
- PSE assumes a start-up cost of **$6,502 per start** for frame peaker generators.
  - Source: 2019 HDR report on Generic Resource Costs, in 2018 US dollars

Where does this data go?

This data goes to the AURORA portfolio model, and the Plexos flexibility model

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2 Ongoing Costs – Fixed – Operations and Maintenance

- Includes annual maintenance, labor, materials, site leasing, gas pipeline capacity cost and other recurring costs not dependent on quantity of energy produced
- Publically available data sources have been compiled for comparison and will be presented for discussion shortly

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2 Ongoing Costs – Gas Transport and Transmission

- **Gas Transport Costs**
  - Gas transport costs are costs associated with moving gas from the source to the generator
  - Gas transport cost values and assumptions will be discussed with the natural gas resource alternatives that will be released by June 30, 2020

- **Transmission Costs**
  - Transmission costs are costs associated with moving power from a generator onto PSE's distribution network
  - Transmission cost values and assumptions will be discussed during the Transmission Constraints Webinar to be held on June 30, 2020

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3 Capital Costs

- Capital costs represent the upfront cost to construct a new generating resource.
  - PSE has elected to represent capital costs as an ‘Overnight Capital Cost’ which includes Engineering, Procurement and Construction costs plus Financing costs for ‘overnight’ construction of a project
  - What is not included in Overnight Capital Costs?
    - Extra costs incurred during construction such as AFUDC (Allowance for Funds During Construction)
    - The cost of interconnection – the cost of the substation along with the transmission lines or gas pipelines to connect to the system

- The Northwest Power and Conservation Council has compiled capital, VOM and FOM costs for their Generic Resource Reference Plants for the updated Power Plan. PSE has utilized this dataset to present a range of resource costs
- Data sources include:

National Renewable Energy Laboratory (NREL)	U.S. Energy Information Administration (EIA)	Lazard
Northwest Power and Conservation Council (NPCC)	Lawrence Berkeley National Laboratory (LBNL)	Regional IRPs

3 PSE recommended costs

- PSE recommended costs are the average of the costs from the different resources reviewed.
  - Each resource vintage year for averaging varies depending on the most available data
- PSE applied the EIA Annual Energy Outlook (AEO) cost curves for future years to the recommended costs
- All costs in 2016 real dollars
- Additional information and charts provided in Excel file
- All capital costs are overnight costs only, they do not include AFUDC or interconnection costs

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PSE recommended costs – CCCT, F-Class

Data Source (2019 Vintage, 2016 U.S. Dollars)	Overnight Capital Cost ($/kW)	Fixed Operating and Maintenance ($/kW-yr)	Variable Operating and Maintenance ($/MWh)
GTW (+ 20% owner's cost) 1x1 GE 7F.05 - 372MW	812	--	--
2019 Idaho Power 1x1 300MW F-Class Frame	1,138	--	--
2019 Avista draft 1x1 413MW GE 7F.06 Adv CCCT	918	--	3.62
2019 Avista draft 1x1 480MW SGT6-5000F Adv CCCT	849	12.56	3.62
2019 Avista draft 1x1 424MW MHI-501F1 Adv CCCT	899	12.56	3.38
2019 Avista draft 1x1 308MW GE 7F.04 Conv CCCT	987	13.53	2.90
Lazard High	1,235	12.82	3.56
Lazard Low	665	10.45	2.85
EIA AEO Generic Conv CCCT - 702 MW F-class	965	10.95	3.49
NREL ATB - average of adv. H-class and conv. F-class	878	10.38	2.72
PSE 2019 IRP HDR 1x1 348MW F-Class Frame	1,006	13.68	2.44
Average (PSE 2021 IRP Reference Plant)	**941**	**12.12**	**3.18**

PSE recommended costs – Frame Peaker, F-Class

Data Source (2019 Vintage, 2016 U.S. Dollars)	Overnight Capital Cost ($/kW)	Fixed Operating and Maintenance ($/kW-yr)	Variable Operating and Maintenance ($/MWh)
GTW GE 7F.05 - 239 MW Frame (+20% owners cost)	497	--	--
Lazard - Generic Gas Peaker - Frame	665	5.22	4.51
EIA 2019 AEO - Adv CT - 1x237MW F-class Frame	668	6.77	10.65
NREL ATB - average of H-class (frame) and LM-6000 (aero)	881	12.02	7.02
PSE 2019 IRP HDR 1x237 F-Class Frame	625	3.80	6.34
Average (PSE 2021 IRP Reference Plant)	**667**	**6.95**	**7.12**

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PSE recommended costs – Recip Peaker

Data Source (2018 Vintage, 2016 U.S. Dollars)	Overnight Capital Cost ($/kW)	Fixed Operating and Maintenance ($/kW-yr)	Variable Operating and Maintenance ($/MWh)
Wartsila 220MW recip	1,061	--	--
Seventh Plan 12x 18V50SG 220MW Wartsila Recip	1,382	10.63	9.57
Seventh Plan MTA 12x 18V50SG 220MW Wartsila Recip (Low)	1,250	--	--
Seventh Plan MTA 12x 18V50SG 220MW Wartsila Recip (High)	1,450	--	--
2019 PGE 6x18MW Wartsila 18V50SG Recip	1,222	4.98	5.24
2019 PGE 6x18MW Wartsila 18V50SG Recip - Low Est.	893	--	--
2019 PGE 6x18MW Wartsila 18V50SG Recip - High Est.	1,552	--	--
2019 NorthWestern draft 2019 IRP 1x18MW Recip	1,771	--	--
E3 Gen WECC Recip	1,305	--	--
2019 PSE pre-IRP HDR 12x18MW Recip	943	3.61	5.12
PSE 2019 IRP HDR 12x18MW Recip - Dual Fuel	1,081	3.98	5.60
Average (PSE 2021 IRP Reference Plant)	**1,265**	**5.80**	**6.38**

PSE recommended costs – Residential Solar

Data Source (2018 Vintage, 2016 U.S. Dollars)	Overnight Capital Cost ($/kW)	Fixed Operating and Maintenance ($/kW-yr)	Variable Operating and Maintenance ($/MWh)
Lazard High (AC)	3,141	--	--
Lazard Low (AC)	2,851	--	--
NREL ATB 2019 Mid (AC)	3,373	--	--
NREL ATB 2018 Mid (AC)	3,271	--	--
NREL US PV Benchmark 2018 (AC)	3,000	--	--
E3 2019 (AC)	3,141	--	--
Average (PSE 2021 IRP Reference Plant)	**3,129**	**--**	**--**

This is a new resource added for 2021 IRP, so there is no 2019 IRP comparison

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PSE recommended costs – Utility Solar

Data Source (2018 Vintage, 2016 U.S. Dollars)	Overnight Capital Cost ($/kW)	Fixed Operating and Maintenance ($/kW-yr)	Variable Operating and Maintenance ($/MWh)
Lazard High (AC)	1,208	--	--
Lazard Low (AC)	918	--	--
NREL ATB 2019 Mid (AC)	1,425	17.64	0.00
NREL ATB 2018 Mid (AC)	1,278	11.04	0.00
NREL US PV Benchmark 2018 (AC)	1,420	--	--
E3 2019 (AC)	1,401	--	--
PGE 2016 IRP Update (AC)	1,471	8.57	--
PGE 2019 IRP (AC)	1,459	21.16	--
Avista 2017 IRP (AC)	1,119	20.58	--
Idaho Power 2017 IRP (AC)	1,493	--	--
Mid-Term, Low (AC)	1,350	--	--
Mid-Term, High (AC)	1,500	--	--
PSE 2019 IRP HDR 100 MW (AC)	1,422	21.16	--
Average (PSE 2021 IRP Reference Plant)	**1,347**	**15.77**	**0.00**

PSE recommended costs – Onshore Wind

Data Source (2018 Vintage, 2016 U.S. Dollars)	Overnight Capital Cost ($/kW)	Fixed Operating and Maintenance ($/kW-yr)	Variable Operating and Maintenance ($/MWh)
PGE 2016 IRP Update	1,425	43.37	0.84
Avista 2017 IRP	1,737	--	--
NWPCC Mid-Term - Low	1,500	--	--
NWPCC Mid-Term - High	1,700	--	--
NREL ATB 2019 Mid	1,556	42.47	0.00
Lazard High	1,498	35.27	0.00
Lazard Low	1,111	27.06	0.00
LBNL 2018	1,419	--	--
E3 2019	1,594	--	--
PSE 2019 IRP HDR-WA	1,452	35.75	--
Average (PSE 2021 IRP Reference Plant)	**1,499**	**36.79**	**0.00**

Public sources do not identify different capital cost by region, so one cost will be used for each onshore wind option and the transmission costs will vary depending on location

PSE recommended costs – Offshore Wind

Data Source (2018 Vintage, 2016 U.S. Dollars)	Overnight Capital Cost ($/kW)	Fixed Operating and Maintenance ($/kW-yr)	Variable Operating and Maintenance ($/MWh)
NREL ATB 2019 TRG6, Depth: 144m, Landfall: 38km, Floating	4,211	83.50	--
PSE 2019 IRP, Depth: 18 - 121m, Landfall: 5 - 24km, Floating	5,730	115.96	--
Average (PSE 2021 IRP Reference Plant)	**4,971**	**99.73**	**0.00**

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PSE recommended costs – Pumped Storage

Data Source (2020 Vintage, 2016 U.S. Dollars)	Overnight Capital Cost ($/kW)	Fixed Operating and Maintenance ($/kW-yr)	Variable Operating and Maintenance ($/MWh)
Swan Lake - 393 MW/9hr, COD 2025	2,093	--	--
Badger Mountain - 300 MW/8hr, COD 2025	2,137	--	--
2019 PAC Draft IRP - 400MW/9.5hr, COD 2025	2,991	16.20	--
2019 Avista Draft IRP - 100MW/16hr share, COD 2025	2,754	14.50	--
2019 NWE Draft IRP (Low) - 500MW/9hr, COD 2025	1,971	14.06	--
2019 NWE Draft IRP (High) - 500MW/9hr, COD 2025	3,479	14.06	--
US DOE HydroWire 2019 Avg	--	15.36	--
2019 PSE Draft IRP - 500MW/8hr, COD 2025	2,176	14.06	--
Average (PSE 2021 IRP Reference Plant)	**2,515**	**14.84**	**0.00**

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PSE recommended costs – Battery Storage, 4hr Li-Ion

Data Source (2020 Vintage, 2016 U.S. Dollars)	Overnight Capital Cost ($/kW)	Fixed Operating and Maintenance ($/kW-yr)	Variable Operating and Maintenance ($/MWh)
NREL ATB 2019 Mid	1,262	31.56	0.00
PGE 2019 IRP 4 hour	1,485	--	--
Avista 2019 IRP 4 hour	1,390	48.61	--
PAC 2019 pre-IRP 4 hour	3,297	54.34	--
PAC 2019 pre-IRP 4 hour large	1,707	31.53	--
PSE 2019 IRP HDR 4 hour	2,472	31.08	--
Average (PSE 2021 IRP Reference Plant)	**1,935**	**39.42**	**0.00**

For the 2019 IRP process, PSE modeled 2-hr Li-Ion, 4-hr Li-Ion, 4-hr Flow, and 6-hr Flow. Public sources only have 4-hr Li-Ion assumptions.

Should PSE use HDR report for other battery options or just model the 4-hr Li-Ion?

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PSE recommended costs – Biomass

Data Source (2019 Vintage, 2016 U.S. Dollars)	Overnight Capital Cost ($/kW)	Fixed Operating and Maintenance ($/kW-yr)	Variable Operating and Maintenance ($/MWh)
NREL ATB 2019 Dedicated Mid	3,713	110.10	5.90
EIA – AEO 2019	3,899	118.92	4.57
PSE 2019 IRP 15MW Woodfired Biomass	7,744	333.58	6.38
Average (PSE 2021 IRP Reference Plant)	**5,119**	**187.53**	**5.62**

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PSE recommended costs

- Challenging to work with different data sources with varying vintage year
- The final cost summary is for vintage year 2021
- All costs are in 2016 real U.S. dollars
- Capital costs represent overnight costs only. PSE will add AFUDC and interconnection costs as well

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3 PSE recommended costs - Summary

(2021 Vintage, 2016 U.S. Dollars)	Overnight Capital Cost ($/kW)		Fixed Operating and Maintenance ($/kW-yr)		Variable Operating and Maintenance ($/MWh)	
	2019 IRP	2021 IRP	2019 IRP	2021 IRP	2019 IRP	2021 IRP
CCCT	991	927	13.68	12.12	2.44	3.18
Frame Peaker	618	660	3.80	6.95	6.34	7.12
Recip Peaker	931	1,248	3.61	5.80	5.12	6.38
Solar Utility	1,422	1,226	21.16	15.77	0.00	0.00
Solar Residential	--	2,848	--	--	--	--
Onshore Wind	1,438	1,484	35.75	36.79	0.00	0.00
Offshore Wind	5,730	4,971	115.96	99.73	0.00	0.00
Pumped Storage	2,176	2,515	14.06	14.84	0.00	0.00
Battery (4hr, Li-Ion)	2,427	1,900	31.08	39.42	0.00	0.00
Biomass	7,744	5,119	333.58	187.53	6.38	5.62

Next steps

- Submit Feedback Form to PSE by **June 4, 2020**
- A recording from today's webinar will be posted to the website **tomorrow**
- PSE will compile all the feedback in the Feedback Report and post all the questions by **June 11**
- By **June 18**, PSE will make a decision on what costs to use. The documentation for the decision made will be released in a Consultation Update that will be posted to the website

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Upcoming meetings

- Stakeholders can register for upcoming meetings on the website
- Agendas and meeting materials will be posted one week prior to each meeting
- Meetings will be added as the IRP technical work progresses

Date	Topic
June 10	Electric Price Forecast
June 30	Transmission Constraints
July 14	Demand Side Resources
July 21	Social Cost of Carbon
August 11	Develop Portfolio Sensitivities

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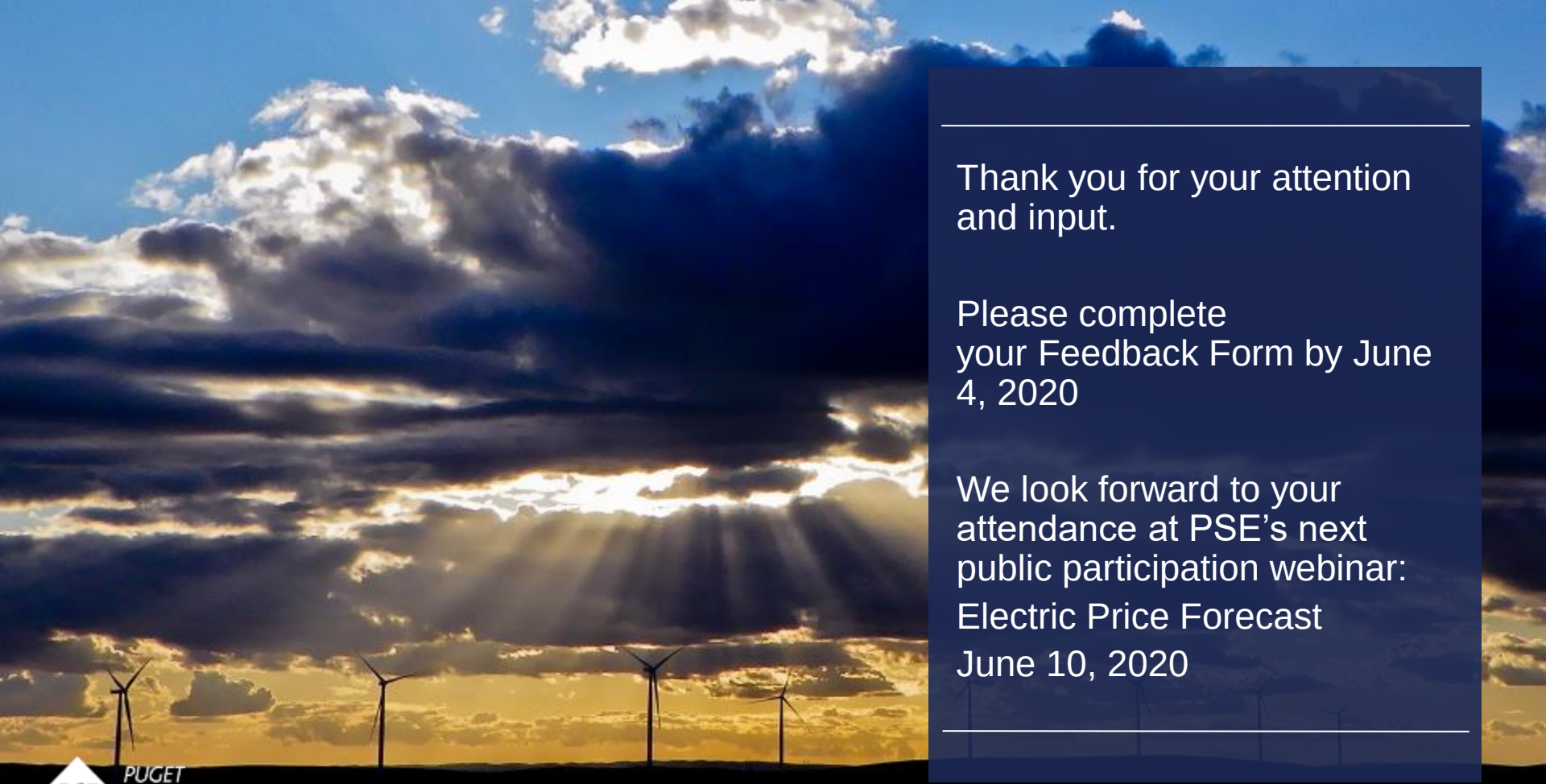

Thank you for your attention and input.

Please complete your Feedback Form by June 4, 2020

We look forward to your attendance at PSE's next public participation webinar:

Electric Price Forecast

June 10, 2020

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Appendix

Capital Costs – Context for excel file available online

- PSE has curated the data compiled by NPCC into a spreadsheet for quick and easy comparison
- How to interpret this data:
  - Data is organized by resource type
  - **“Raw”** sheets contain **all** of the data compiled by NPCC (e.g. mix of F- and H-Class CTs at various nameplate capacities)
  - **“Clean”** sheets represent only data **meaningful** to PSE’s portfolio (e.g. only F-Class CTs with nameplate capacity near 200 MW)
  - Costs are color coded with GREEN prices being the LOWEST and RED prices being the HIGHEST
  - Costs are ‘most-representative’ and do not reflect variability of real-world construction
  - Costs are in 2016 U.S. Dollars
  - PSE 2021 IRP Reference Plant – is PSE’s recommendation for the given generator cost, generally an average of the presented costs

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