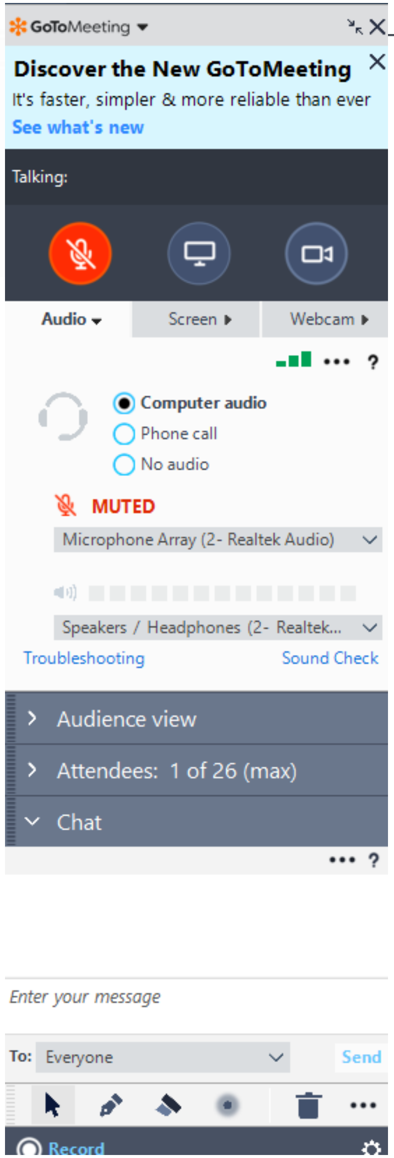
2021 IRP Webinar #9: Electric IRP

Analyze Alternatives & Portfolios
Electric Portfolio Model

PUGET SOUND ENERGY

October 20, 2020

Welcome to the webinar and thank you for participating!



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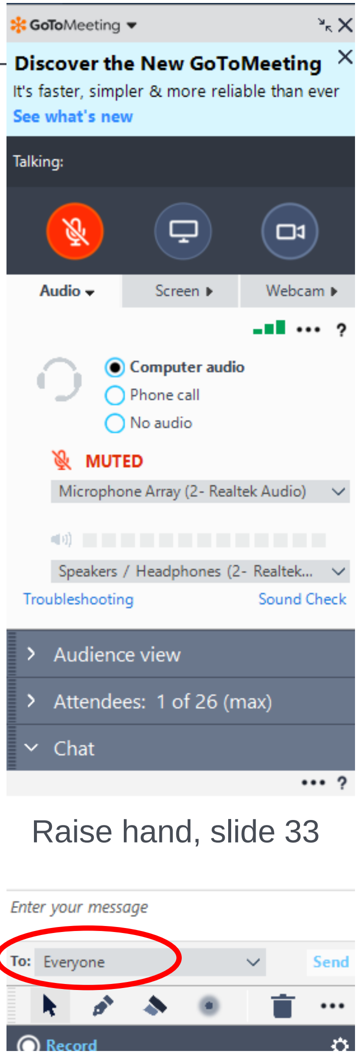
    - **In writing:** your question will be read
    - **Verbally:** type "Raise hand" and slide #, share with "Everyone"; please wait to be called on to ask your question
- Be considerate of others waiting to participate
- We will try to get to all questions



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Agenda

- Safety moment
- Electric portfolio model
- Electric IRP Process
  - Resource need
  - Planning Assumptions
- Portfolio sensitivities
  - Temperature sensitivity

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Safety Moment: Emergency preparedness

1. Get a kit – Learn the essential supplies to put in your family's survival kit.

2. Make a plan – Plan effectively for you and your family in case of an emergency.

3. Be informed – Understand which disasters are likely to occur in your area and what you must know to stay safe.

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Today's Speakers

Elizabeth Hossner
Manager Resource Planning & Analysis, PSE

Zhi Chen
Senior Resource Planning Analyst, PSE

Jennifer Magat
Senior Resource Planning Analyst, PSE

Tyler Tobin
Resource Planning Analyst, PSE

Charles Inman
Associate Resource Planning Analyst, PSE

Alison Peters & Elise Johnson
Co-facilitators, EnviroIssues

Allison Jacobs
Senior Economic Forecast Analyst, PSE

Eric Fox
Director Forecast Solutions, Itron

IRP data available on the website

- Generic resource costs
  - https://oohpseirp.blob.core.windows.net/media/Default/2021/meetings/May_28_Webinar/Generic_Resource_Cost_Summary_PSE%202021%20IRP_post-feedback_v1.xlsx
- Demand Side Resources
  - https://oohpseirp.blob.core.windows.net/media/Default/2021/meetings/July_14_webinar/Webinar_4_Demand-Side-Resources_Presentation.pdf
- Social cost of greenhouse gases
  - https://oohpseirp.blob.core.windows.net/media/Default/2021/meetings/July_21_webinar/Emission_Price_Calculations_workbook_2019_(Inflation-Update).xls
- Demand forecast
  - https://oohpseirp.blob.core.windows.net/media/Default/2021/meetings/September_1_meeting/PSE_2021_IRP_Demand_Forecast_2022-2045_09012020.xlsx

IRP data available on the website

- List of portfolio sensitivities
  - https://oohpseirp.blob.core.windows.net/media/Default/2021/meetings/Oct_20_webinar/Webinar%209%20Updated%20sensitivities%20list.xlsx
- Electric price forecasts
  - https://oohpseirp.blob.core.windows.net/media/Default/2021/meetings/June_10_Webinar/Webinar_2_Electric-Price-Forecast_presentation.pdf
  - https://oohpseirp.blob.core.windows.net/media/Default/2021/meetings/Oct_20_webinar/Webinar%209:%20Final%20electric%20power%20prices.xlsx
- Upstream GHG Emissions
  - https://oohpseirp.blob.core.windows.net/media/Default/2021/meetings/July_21_webinar/Attachment_7_Upsteam_Methane_Emission_Workbook.xlsx
- Transmission Constraints Presentation
  - https://oohpseirp.blob.core.windows.net/media/Default/2021/meetings/June_30_webinar/Webinar_3_Transmission_Constraints_presentation.pdf

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Electric portfolio model

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Participation Objectives

- PSE will inform stakeholders on the electric portfolio model

IAP2 level of participation: INFORM

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IRP electric portfolio model process

Inputs

- Variable operations & Maintenance (VOM)
- Fixed operations & Maintenance (FOM)
- Plant operating characteristics
- capital costs
- PSE monthly load forecast
- hourly load shape
- Normal Peak Load
- Planning Margin (peak need)
- Peak capacity credit (ELCC)
- Renewable need
- Transmission constraints
- Decommissioning cost for existing resources
- Flexibility Benefit

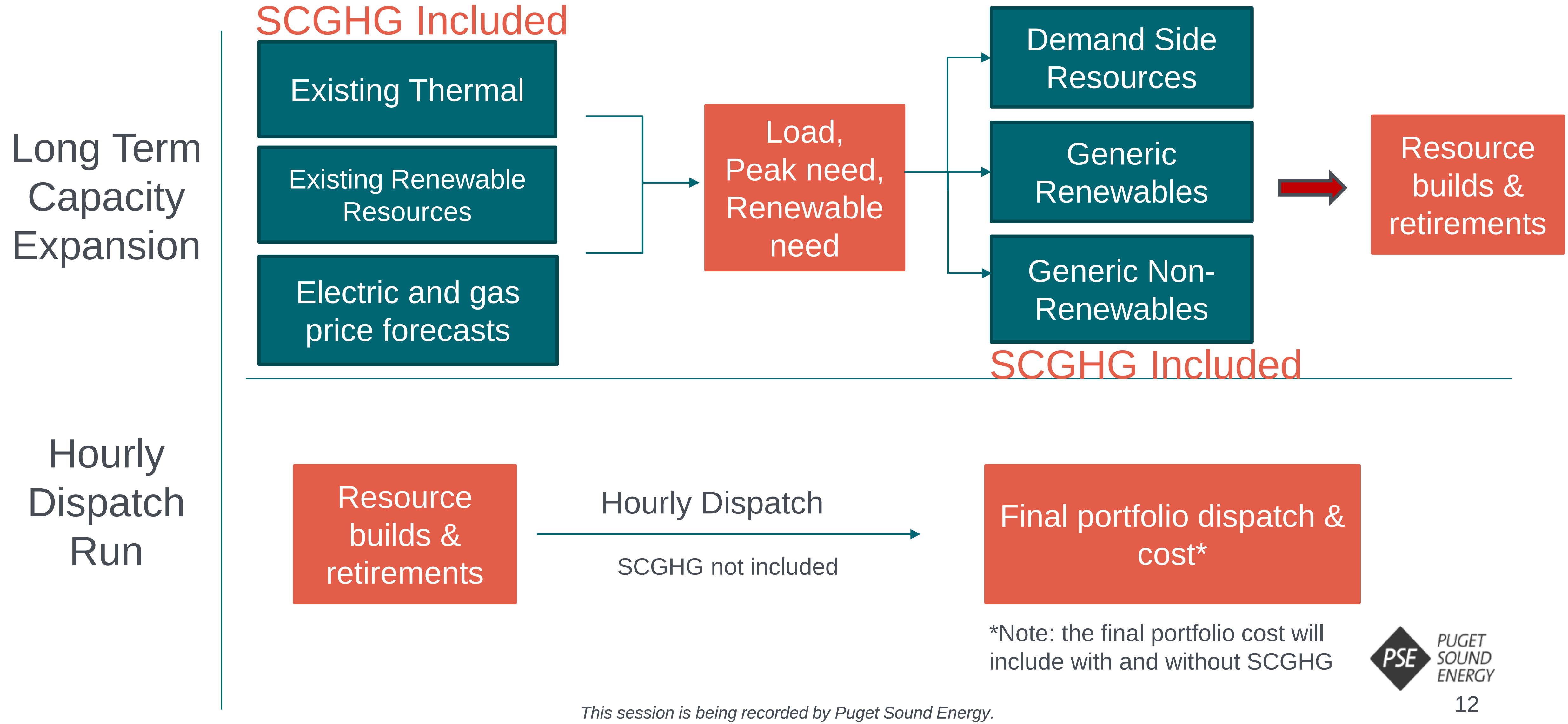
Social cost of carbon added to existing and new thermal resources and market purchases as a cost adder

Mid-C power prices → Long term capacity expansion for PSE only → **New builds and retirements** → Hourly dispatch for PSE only → **Portfolio dispatch & cost**

AURORA (Long term capacity expansion for PSE only)

AURORA (Hourly dispatch for PSE only)

SCGHG as a cost adder in AURORA



*Note: the final portfolio cost will include with and without SCGHG

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The Long Term Capacity Expansion model (LTCE)

- As the population grows, and energy demand with it, utilities must increase their generating capacity in order to keep pace with the growth.

- A Long Term Capacity Expansion (LTCE) model is used to forecast the installation and retirement of resources over a long-term planning horizon in order to keep pace with growth.

- To complete the LTCE modeling process, PSE uses a program called AURORA
  - AURORA is an algebraic solver software provided by Energy Exemplar, and is an industry-standard tool used to perform power system models.
  - The AURORA solver uses a *Mixed Integer Programming (MIP)* method to complete the modeling process.

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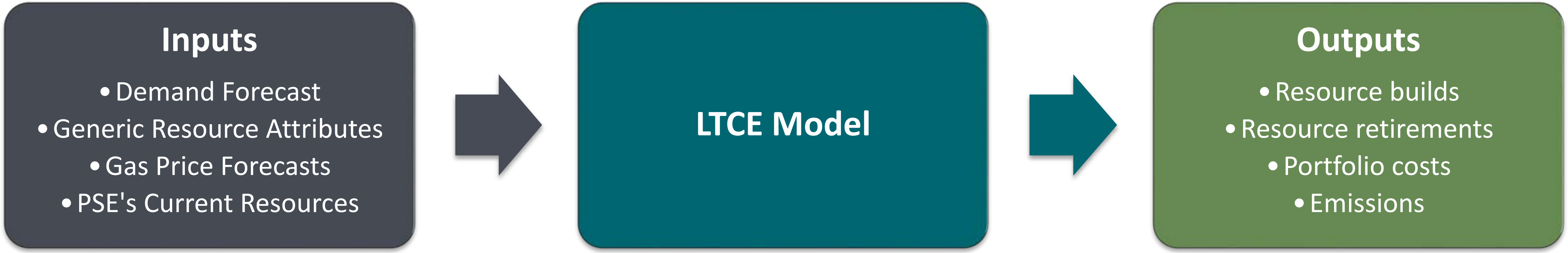
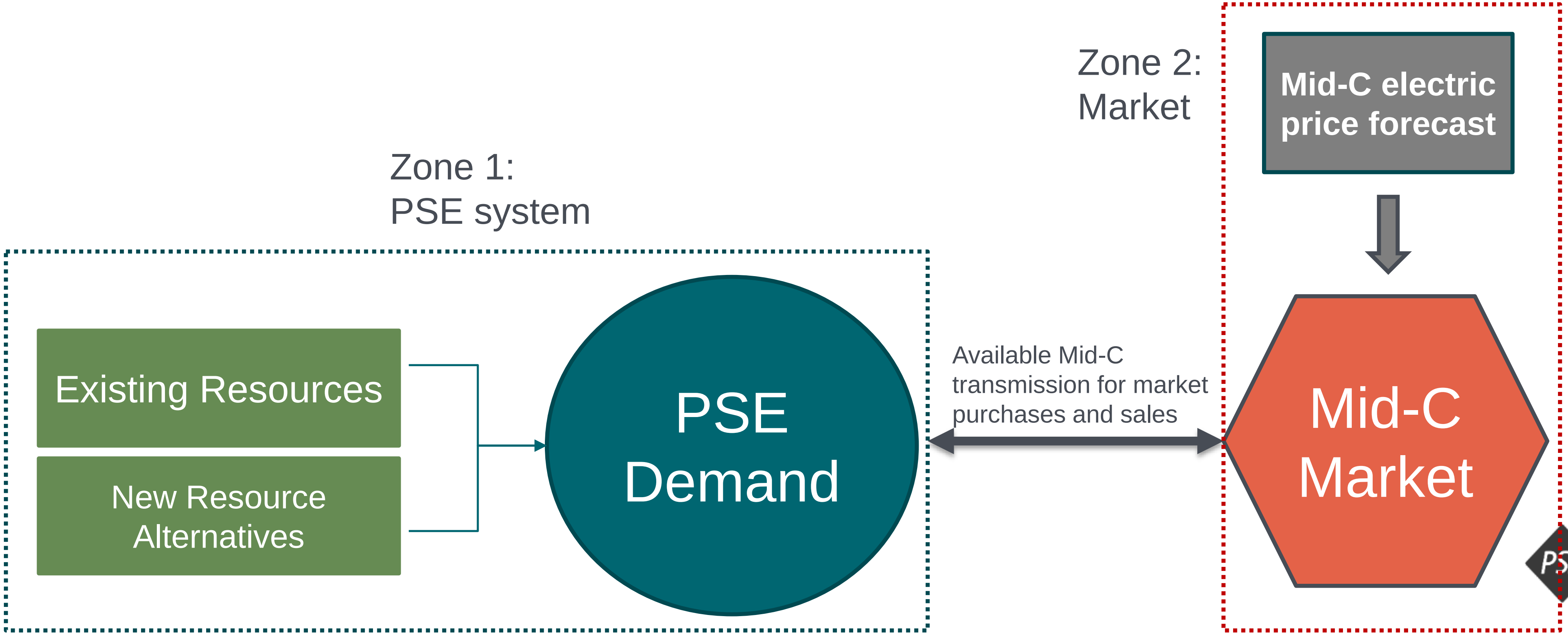
LTCE Inputs and Outputs



- The LTCE model uses data inputs from internal PSE sources (the load forecast, current resources) as well as external sources (generic resource costs, gas price forecasts)
- These inputs are entered into the LTCE model in order to simulate potential resource additions and retirements, as well as portfolio costs.

LTCE – 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



LTCE Model – Mixed Integer Programming

- In order to solve the complex power system models, AURORA employs **Mixed Integer Programming** (MIP).

- MIP solving methods are a combination of Linear Programming and Integer Programming methods.
  - Linear Programming – The optimization of an objective function that is subject to certain constraints.
  - Integer Programming – The optimization of an objective function where some of the values are restricted as integer values (-1, 0, 1, 2, etc.)

- MIP methods are the best suited to handling power system and utility models, as the decisions and restraints faced by utilities are both discrete (how many resources to build, resource lifetimes, how those resources connect to one another) and non-discrete (the costs of resources, renewable profiles, emissions limitations).

Optimization modeling – objective function

The objective is formulated as the total net present value (NPV) of the production, fixed, and build costs to meet all of the requirements.

- The MIP will search to find the mix of resources (both existing and new build/retrofit options) over time that satisfies all energy and demand requirements while minimizing the total NPV.
- The solver uses an iterative simulation process until the total portfolio costs converge.

Optimization Modeling – resource value

- Aurora determines resource value from the difference between market price and resource cost. This determination is performed for every hour for every resource in the region. Thus, a very accurate value is developed which takes into account system value during all time periods (i.e., on-peak, off-peak and other hours; and during daily, seasonal, and annual periods)

Total resource cost = the present value (PV) of resource costs over the life of the plant (n) – market revenue (market price at time of generation)

$$Resource\ value = \sum_{t=1}^{n} (capital\ cost_t + fixed\ cost_t + variable\ cost_t + fuel\ cost_t + transmission\ cost_t\ ) - Market\ Revenue_t$$

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LTCE model constraints

- In order to accurately represent the PSE service territory and resource additions, **constraints** must be placed on the model to produce a reasonable output.

- Multiple constraints are placed on the model in order to make the system behave as closely as possible to PSE:

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

SCGHG in the LTCE model – Fixed Cost Adder

PSE will be using the SCGHG as a **Fixed Cost Adder** as a baseline in the modeling process.

- When considering a resource to build, an economic forecast of the resource is performed.
- The total emissions generated by the resource in the forecast are summed together, and the SCGHG is applied to that total.
- The SCGHG penalties generated by that resource are factored in as a fixed cost over the life of that resource before a build decision is made.

$$Resource\ value = \sum_{t=1}^{n} (capital\ cost_t + fixed\ cost_t + variable\ cost_t + fuel\ cost_t + transmission\ cost_t\ ) - Market\ Revenue_t$$

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Electric IRP process

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Participation Objectives

- PSE will inform stakeholders on the IRP process
  - Final resource adequacy analysis
  - Final resource need
  - Final planning assumptions

IAP2 level of participation: INFORM

2021 IRP modeling process

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

1. Analyze and establish resource need
2. Determine planning assumptions and identify resource alternatives
3. Analyze scenarios and sensitivities using deterministic and stochastic risk analysis
4. Analyze results
5. Develop resource plan
6. 10-year Clean Energy Action Plan

1 Establish Resource Needs

Three types of resource need are identified:

1. Peak capacity need
   - Physical peak need refers to the resources required to ensure reliable operation of the system. It is an operational requirement that includes three components: customer peak demand (demand forecast), planning margins (LOLP modeling) and operating reserves.

2. Renewable need
   - Washington State's Clean Energy Transformation Act (CETA) requires PSE to meet specific percentages of our load with renewable resources or renewable energy credits (RECs) by specific dates.

3. Energy need
   - Energy need refers to the resources required to meet customer demand in every hour. How the demand is met changes by scenario and is dependent on how resources are dispatched versus buying on the market.

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1 Establish Resource Needs

Resource Adequacy Analysis

Electric peak capacity need: 2027

881 MW resource need for 5% LOLP

Reliability metrics at 5% LOLP:

Metric Name	Base System, No Added Resources	System at 5% LOLP, 881 MW Added
LOLP	63.60%	4.99%
EUE	4533 MWh	381 MWh
LOLH	11.06 hours/year	0.76 hours/year
LOLE	2.18 days/year	0.12 days/year
LOLEV	2.93 events/year	0.14 events/year

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1 Establish Resource Needs

Resource Adequacy Analysis

Electric peak capacity need: 2031

1,361 MW resource need for 5% LOLP

Reliability metrics at 5% LOLP:

Metric Name	Base System, No Added Resources	System at 5% LOLP, 1361 MW Added
LOLP	97.09%	5.00%
EUE	16335 MWh	372 MWh
LOLH	43.42 hours/year	0.79 hours/year
LOLE	9.65 days/year	0.12 days/year
LOLEV	11.99 events/year	0.17 events/year

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1 Establish Resource Needs

Resource Adequacy Analysis

Effective Load Carrying Capability (ELCC) for 5% LOLP relative to Perfect Capacity

ELCC = $-(\text{Need}_2 - \text{Need}_1)/\text{Change}$

Example:
Base case, Need1 = 500 MW
Add 100 MW nameplate renewable
Need2 = 475 MW
ELCC = –(475 MW – 500 MW)/100 MW = 25%

Resource	IRP 2019 Process ELCC	IRP 2021 ELCC 2027	IRP 2021 ELCC 2031
Existing Wind	10%	16%	16%
Green Direct – WA West Wind	36%	37%	34%
Green Direct – WA East Solar	2%	9%	8%

1 Establish Resource Needs

Resource Adequacy Analysis

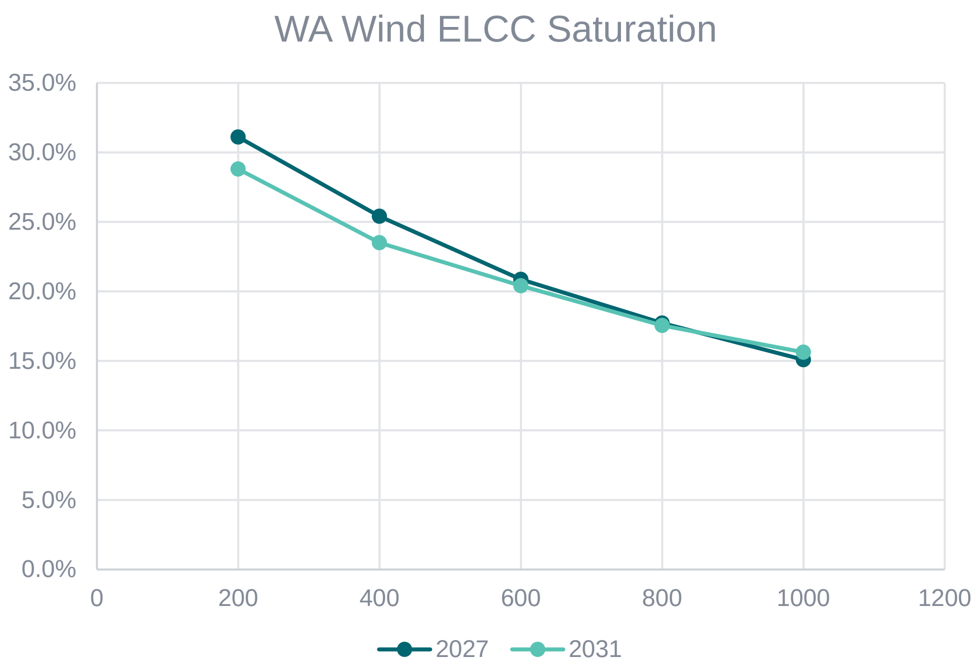
Effective Load Carrying Capability (ELCC) for 5% LOLP relative to Perfect Capacity

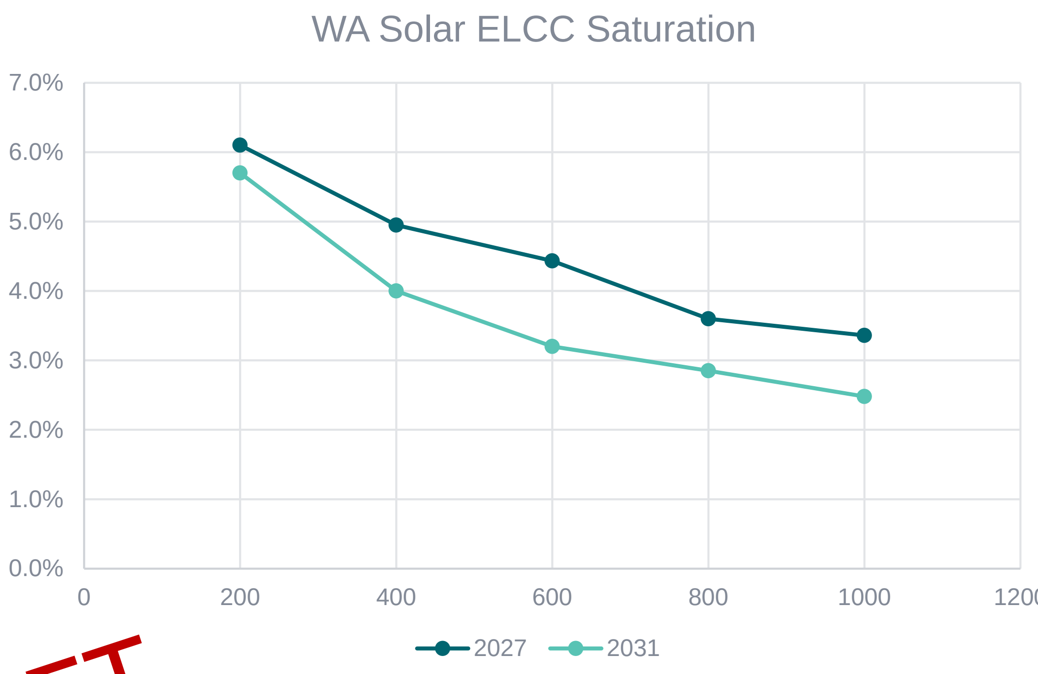
Resource	2019 IRP Process ELCC	IRP 2021 ELCC 2027	IRP 2021 ELCC 2031
Generic WY-East Wind	-	57%	57%
Generic WY-West Wind	-	22%	22%
Generic MT-East Wind	42%	33%	34%
Generic MT-Central Wind	-	46%	44%
Generic Offshore Wind	48%	43%	47%
Generic ID Wind	-	26%	25%
Generic WA Wind	6%	17%	17%
Generic WY-East Solar	-	9%	11%
Generic WY-West Solar	-	10%	10%
Generic ID Solar	-	6%	10%
Generic WA-East Solar	1%	7%	7%

1 Establish Resource Needs

Resource Adequacy Analysis

Effective Load Carrying Capability (ELCC) for 5% LOLP relative to Perfect Capacity





1 Establish Resource Needs

Resource Adequacy Analysis

Effective Load Carrying Capability (ELCC) for 5% LOLP relative to Perfect Capacity

Energy Limited Resource	IRP 2019 ELCC EUE at 5% LOLP	IRP 2021 ELCC 2027 EUE at 5% LOLP	IRP 2021 ELCC 2031 EUE at 5% LOLP
Lithium-Ion Battery 2 hr, 82% RT efficiency	19%	13%	16%
Lithium-Ion Battery 4 hr, 87% RT efficiency	38%	28%	34%
Flow Battery 4 hr, 73% RT efficiency	36%	24%	31%
Flow Battery 6 hr, 73% RT efficiency	46%	32%	40%
Pumped Hydro Storage 8 hr, 80% RT efficiency	37%	27%	32%

1 Establish Resource Needs

Planning Margin (expressed as percent) is determined as:

Planning Margin = (Peak Need – Normal Peak Load) / Normal Peak Load

Where Peak Need (in MW) is the resource capacity that meets the reliability standard established in a probabilistic resource adequacy model (Peak Capacity Need from LOLP) in addition to the peak capacity contribution from existing resources (Total Resources) and short-term Mid-C bilateral market purchases.

	Winter Peak 2027	Winter Peak 2031
Peak Capacity Need to meet 5% LOLP	881 MW	1,361 MW
Total Resources Peak Capacity Contribution	3,650 MW	3,641 MW
Short-term Market Purchases	1,492 MW	1,497 MW
Peak Need	5,983 MW	6,459 MW
Normal Peak Load	4,949 MW	5,199 MW
Planning Margin	**21.7%**	**25.0%**

Note: planning margin includes contingency and balancing reserves

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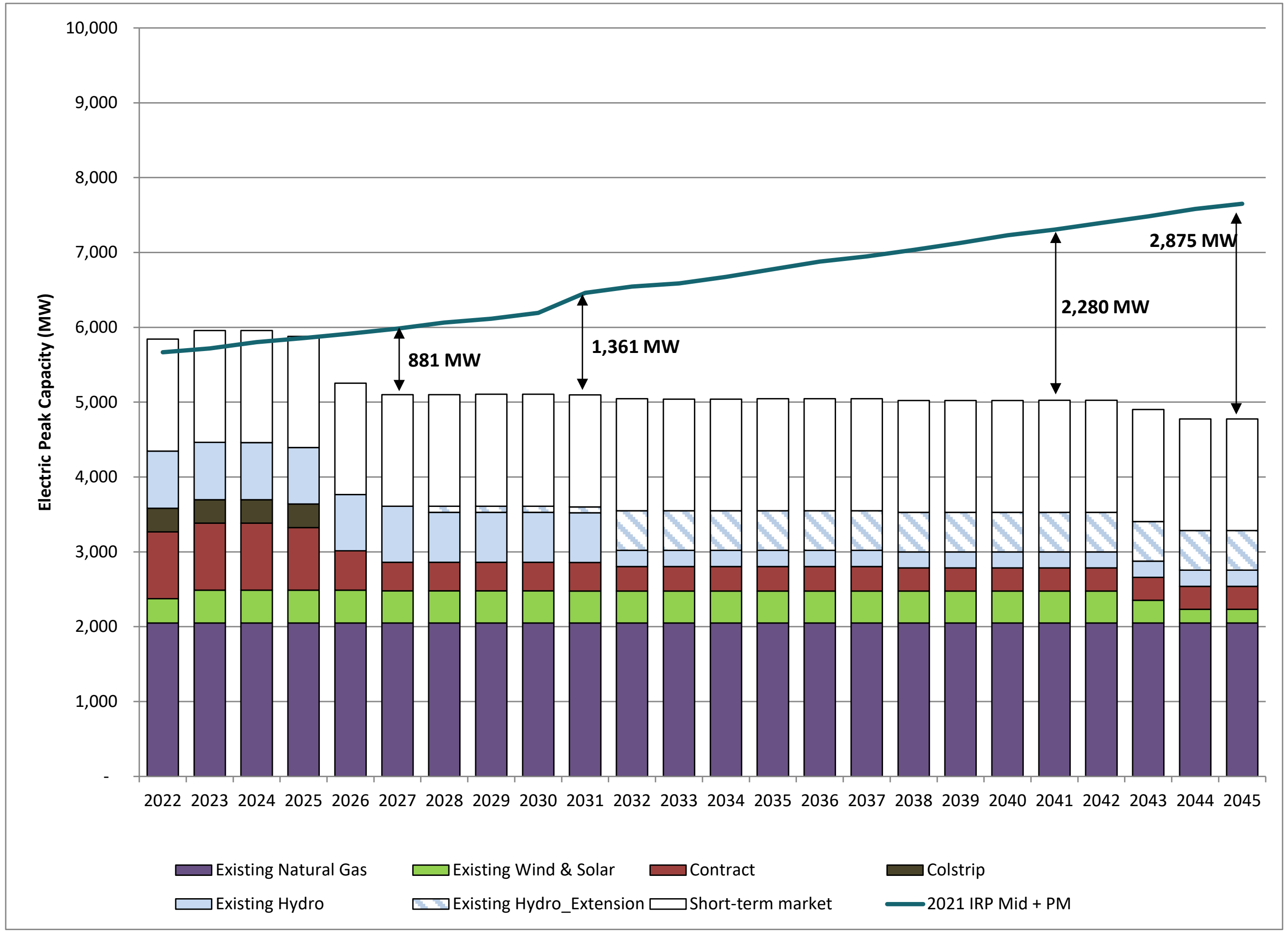
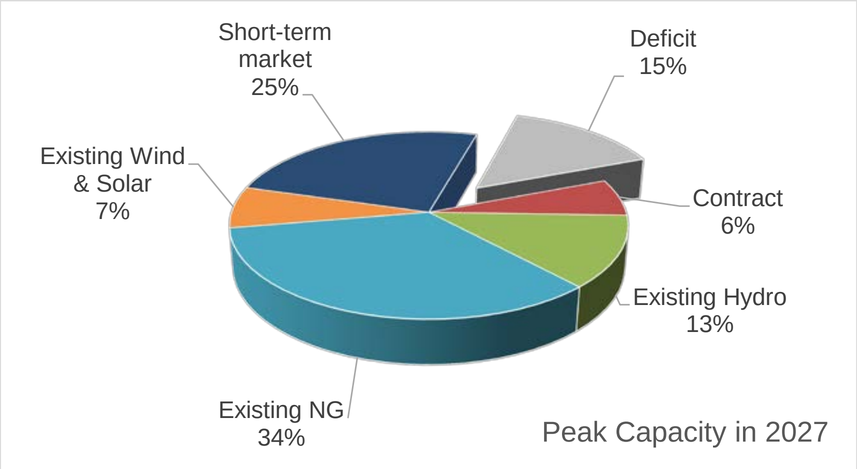
Establish Resource Needs

Electric peak hour capacity resource need

Projected peak hour need and effective capacity of existing resources.





Note: 2021 IRP peak capacity need does not include any demand side resources. Demand side resources will be determined as part of the 2021 IRP and include conservation (energy efficiency), codes and standards, distribution efficiency, or demand response.

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1 Establish Resource Needs

Electric renewable need

PSE's estimated need for non-emitting or renewable energy by 2030

	MWh
2030 estimated sales before conservation	24,004,160
Conservation*: codes and standards, solar PV	(774,387)
Customer programs *Green Power, Green Direct	(849,644)
Estimated sales net of conservation and customer programs	20,800,505
80% of estimated sales net of conservation	16,640,404
Existing non-emitting resources *Assume normal hydro conditions and P50 wind & solar	(8,390,019)
Need for new non-emitting resources	8,250,385

*Note: 2021 IRP renewable need does not include any new energy efficiency. Cost effective energy efficiency will be determined as part of the 2021 IRP. Since codes and standards and solar PV are must take bundles, they have been included in the base calculation to get the net renewable need.

After existing resources, PSE still needs over 8.2 million MWh of new non-emitting resources or demand-side resources to get to at least 80% of electric sales.

1 Establish Resource Needs

Electric renewable need

This example is for illustrative purposes only. The 2021 IRP will optimize the mix of resources with conservation.

For example a 100 MW renewable resource such as wind at 30% capacity factor will produce 100*8760*0.30 = 262,800 MWh/year.

- In order to produce 8,250,385 MWh/year with a 30% capacity factor resource, we would need 3,139 MW nameplate.
- This is an additional 3,139 MW on top of the current 2,363 MW of existing non-emitting resources.

Annual Capacity Factor	MWh/year for 100 MW	MWh target at 80%	Nameplate (MW) Needed
30%	262,800	8,250,385	3,139
44%	385,440	8,250,385	2,140
27%	236,520	8,250,385	3,488
12%	105,120	8,250,385	7,848

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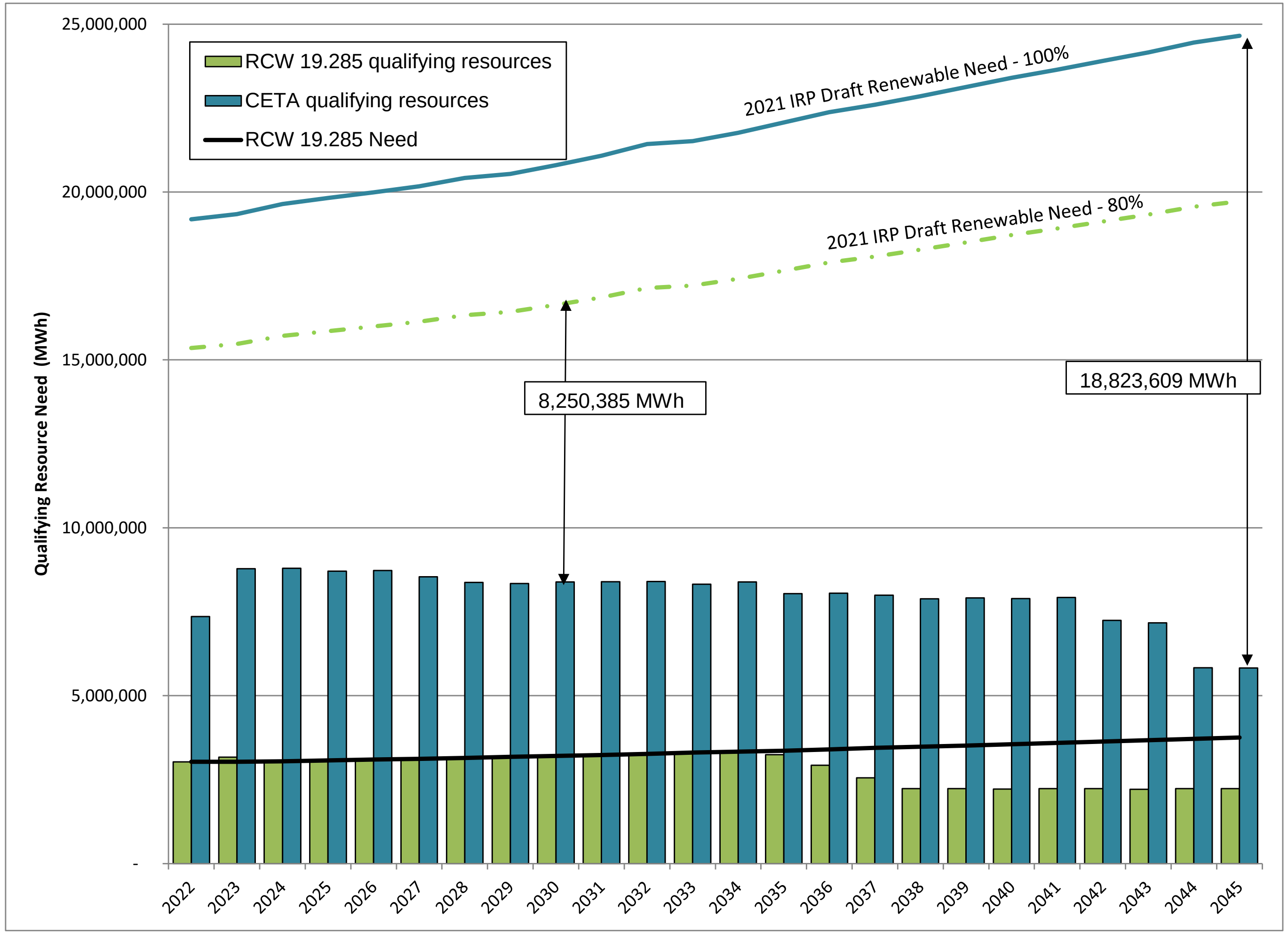
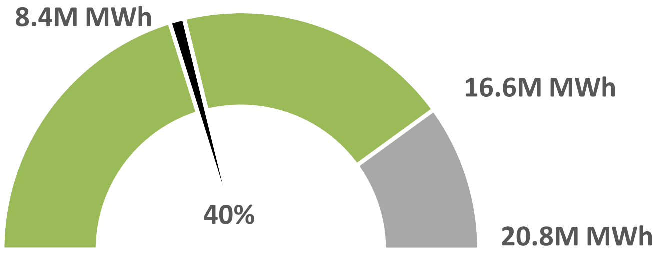
1 Establish Resource Needs

Electric renewable need

Renewable resource need/REC need for RCW 19.285 and CETA



CETA Eligible Resources for 2030 Target



Note: 2021 IRP renewable need does not include any demand side resources. Demand side resources will be determined as part of the 2021 IRP and include conservation (energy efficiency), codes and standards, distribution efficiency, or demand response.

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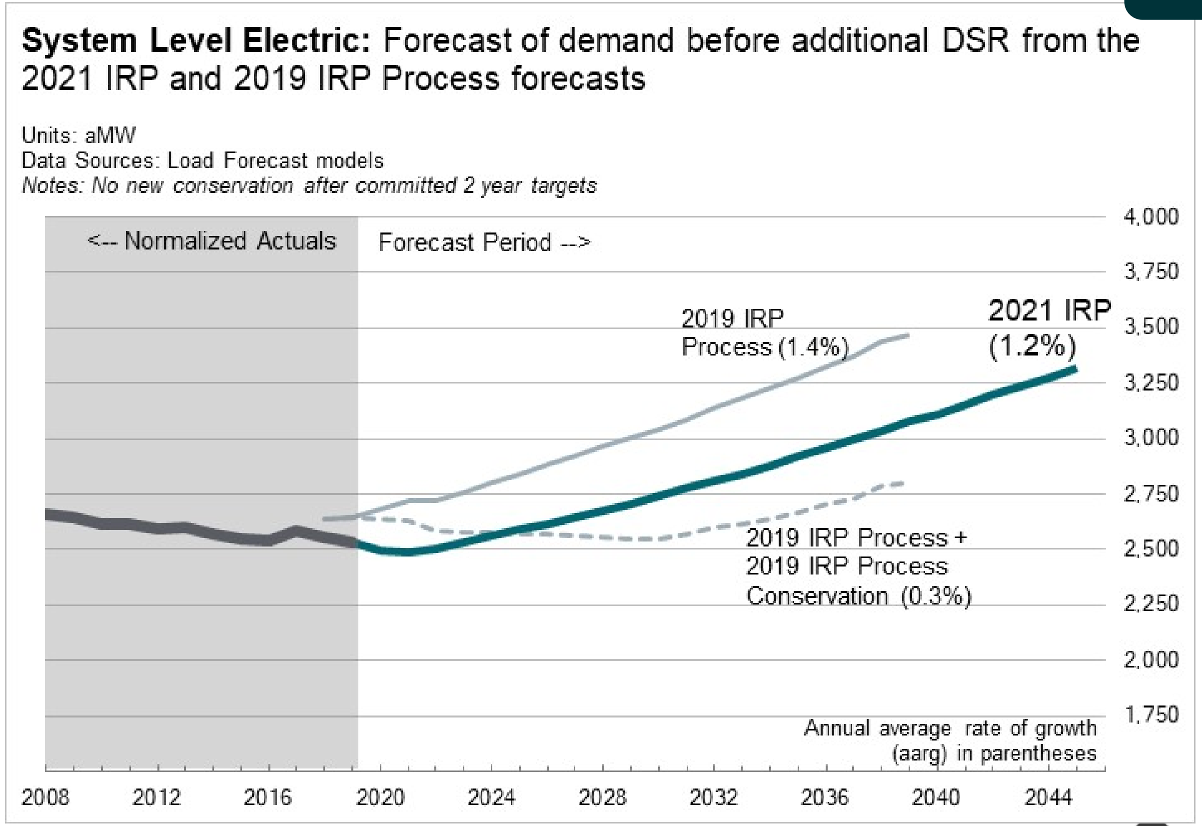
1 Establish Resource Needs

Electric energy need: presented on September 1, 2020

- Positive customer growth, steady UPC, and EVs yield demand growth, before DSR.
  - Applying DSR will result in an “after DSR” forecast with lower growth than “before DSR.”
- Conservation targets for 2020/21 decreases load materially (standard IRP methodology, ~50% of initial 2022 forecast change).
- Lower growth than 2019 IRP process forecast due to:
  - Lower customer growth (commercial significantly).
  - Lower UPC forecast (all non-residential).
- The 2021 IRP demand forecast after DSR will be available once final DSR determined by the 2021 IRP process.



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5-minute break

2 Planning assumptions and resource alternatives

This category encompasses everything needed to run the portfolio analysis

Electric price forecast

Natural gas price forecast

Social Cost of Greenhouse Gases

New resource alternatives

Transmission constraints

Flexibility benefit

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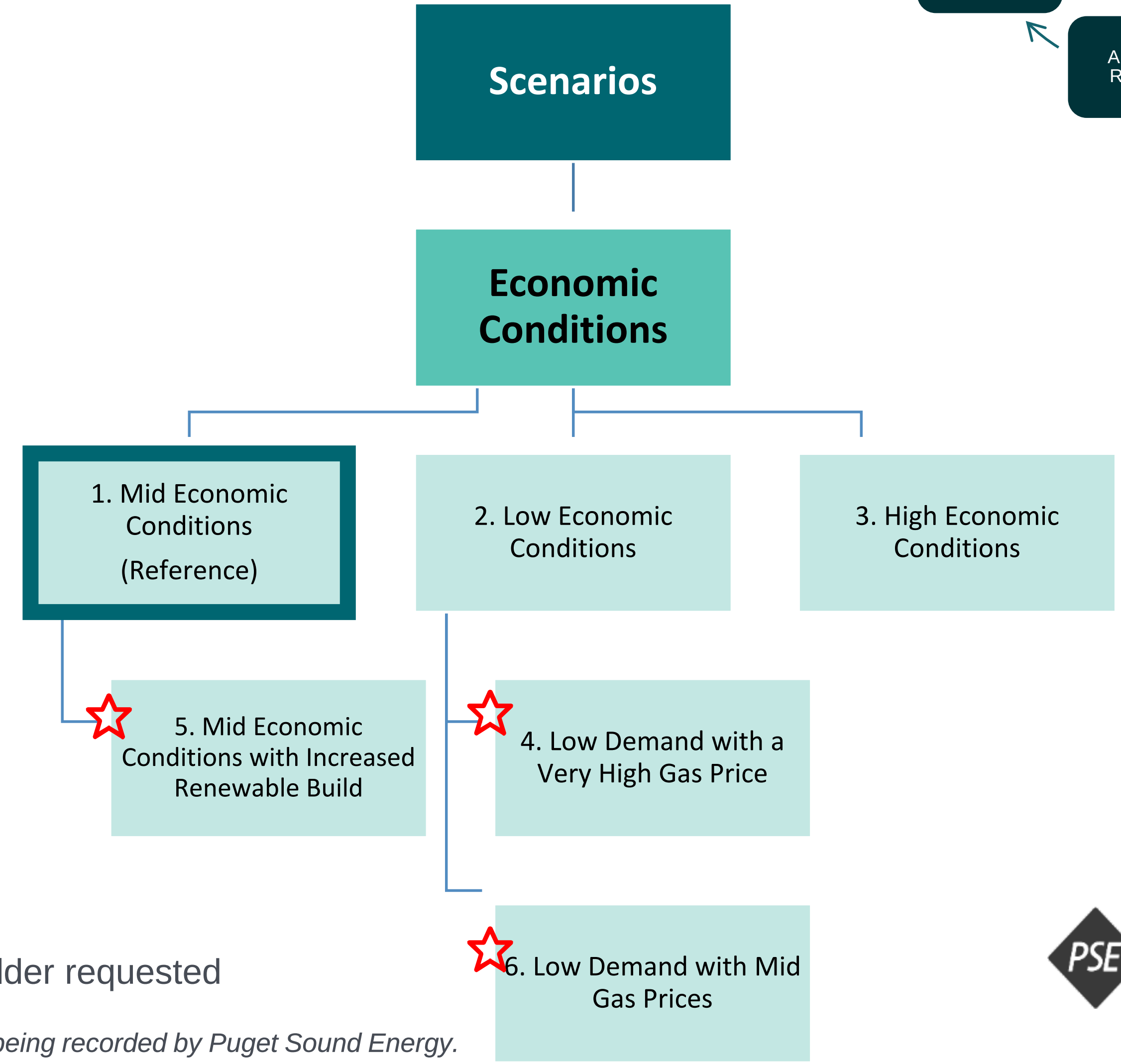
2 Planning assumptions and resource alternatives

Electric price scenarios

- Gas prices, carbon regulation and regional loads create different wholesale electric prices, which affect the relative value of different resources.
  - Electric price **scenarios** create future market conditions
  - **Sensitivities** test different PSE portfolio resources in the market



☆Stakeholder requested

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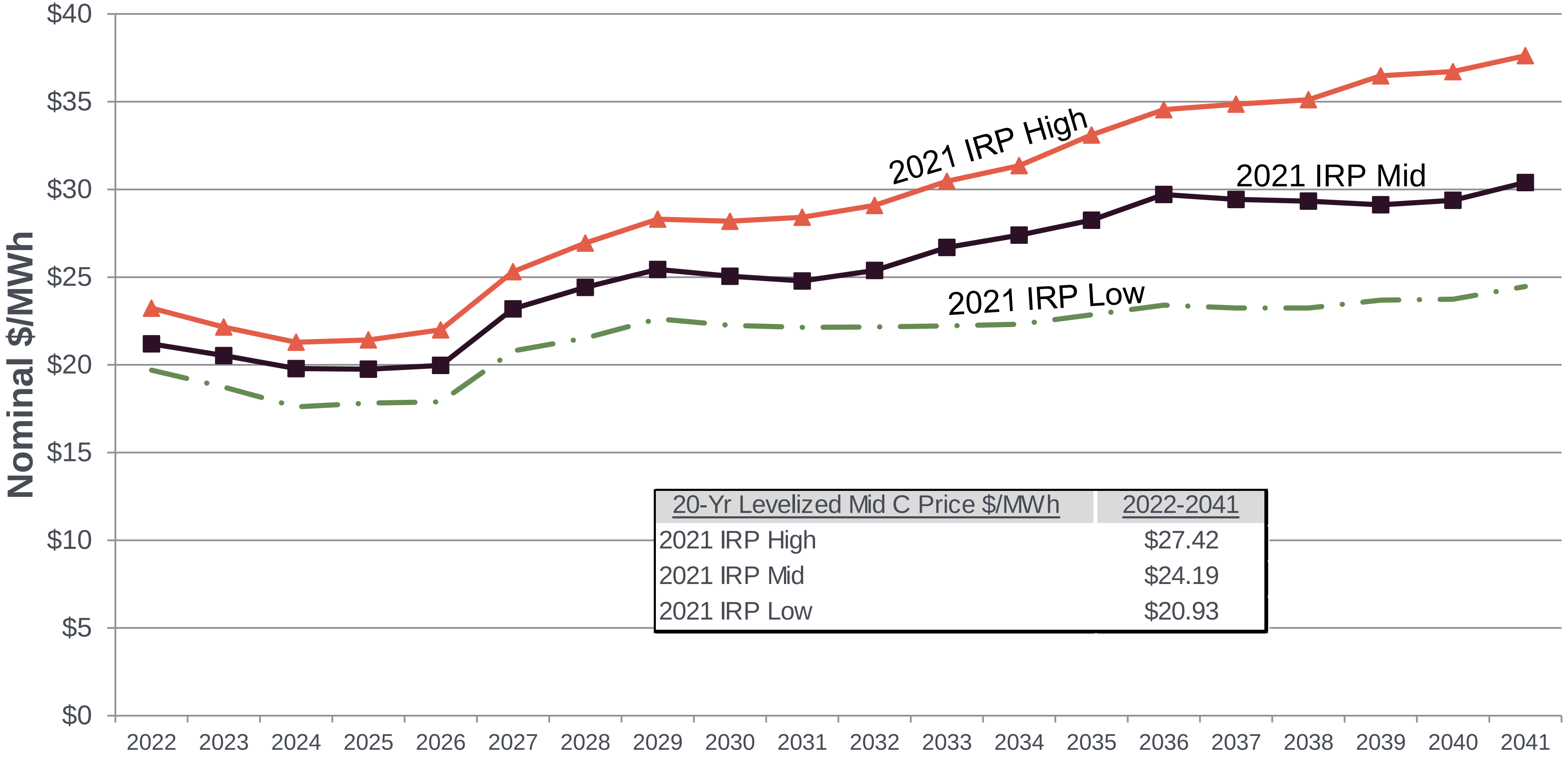
2 Planning assumptions and resource alternatives

Electric price forecasts: presented June 10, 2020 and updated with stakeholder recommendations



20-Yr Levelized Mid C Price $/MWh	2022-2041
2021 IRP High	$27.42
2021 IRP Mid	$24.19
2021 IRP Low	$20.93

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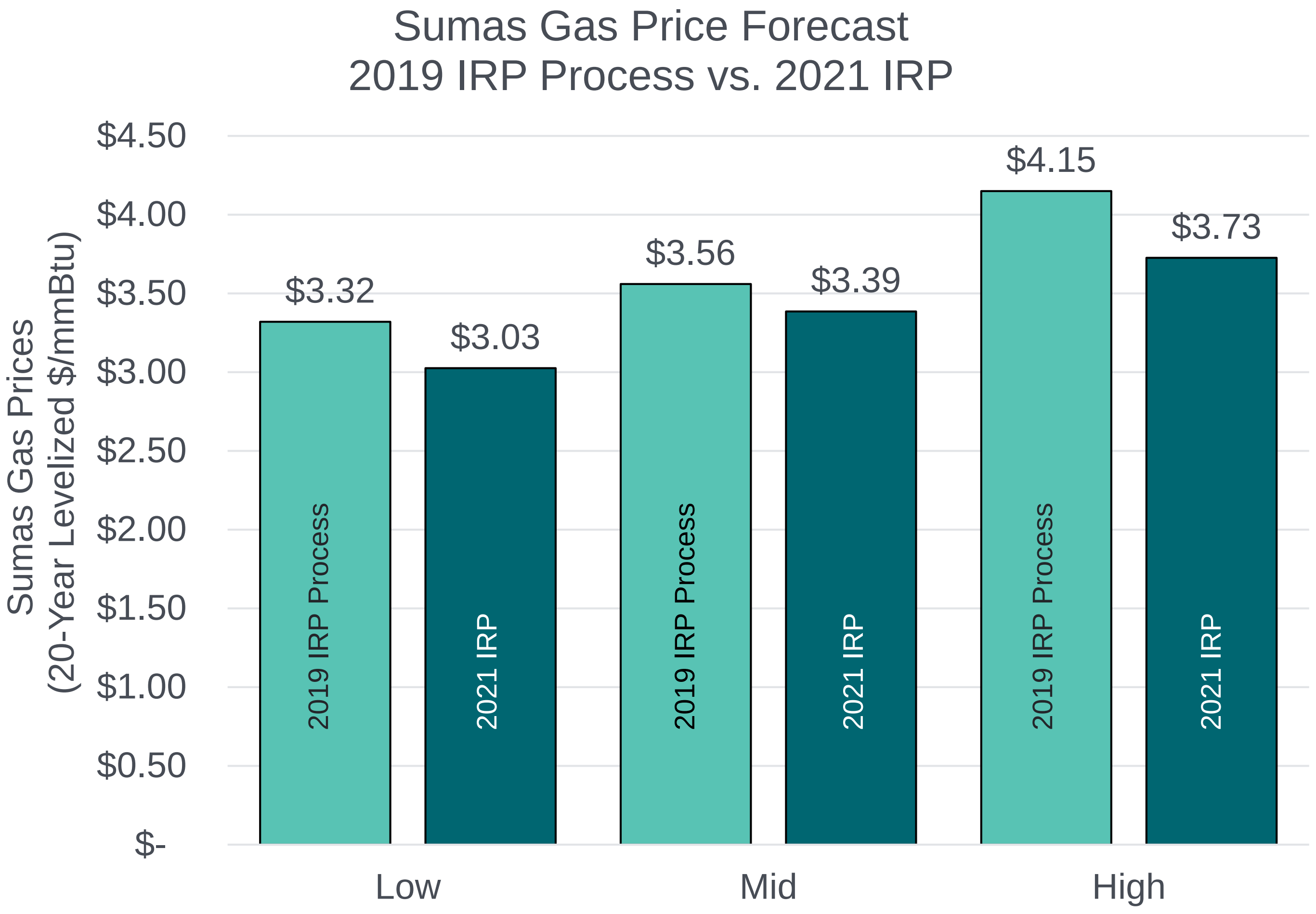
2 Planning assumptions and resource alternatives

Natural gas price forecast at Sumas



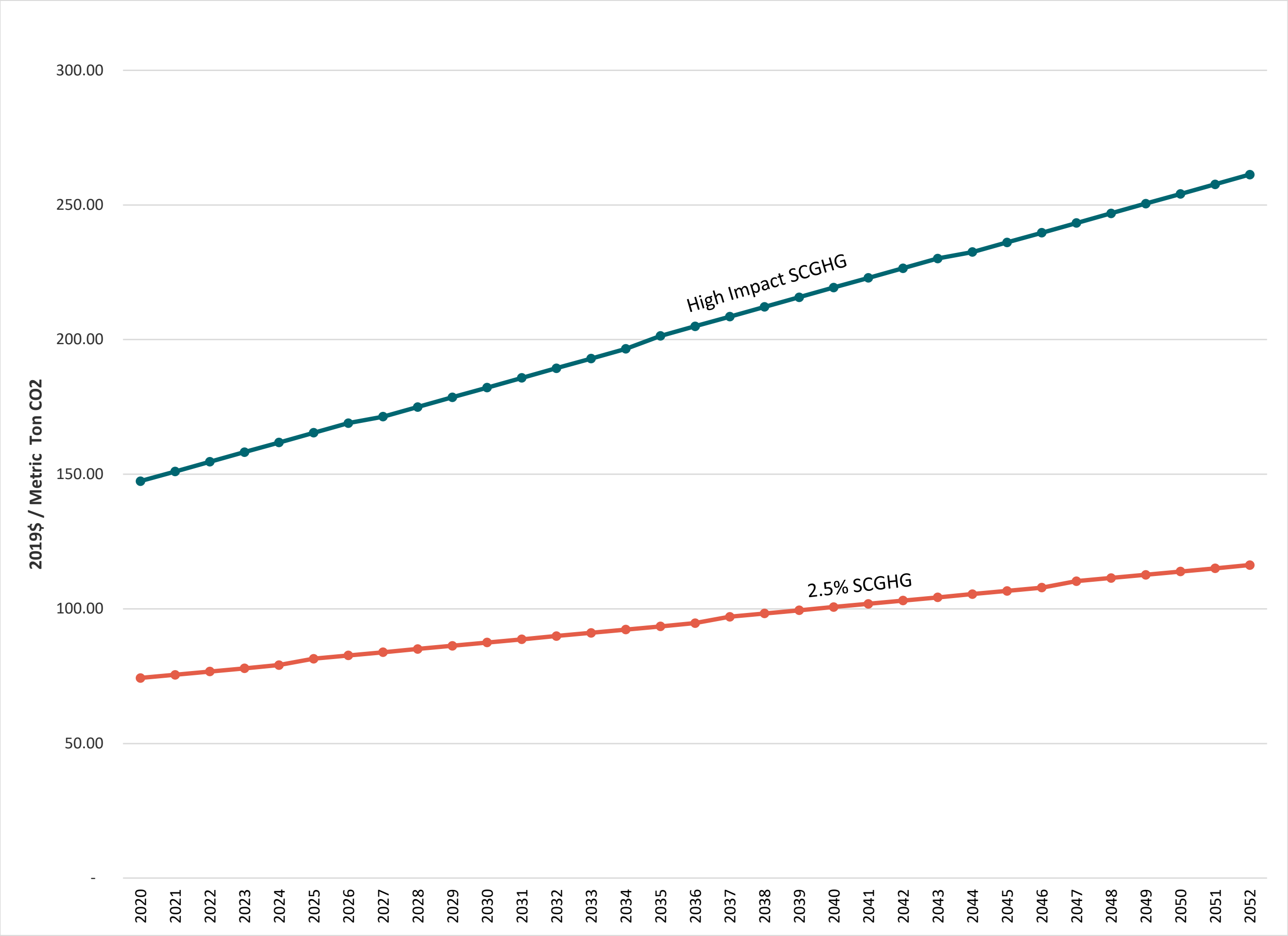
2021 IRP mid natural gas price

→ From 2022-2025, three-month average of forward marks for the period ending June 30, 2020

→ Beyond 2025, Wood Mackenzie long-run, fundamentals-based gas price forecasts that were published in Spring 2020.

2 Planning assumptions and resource alternatives

Social cost of greenhouse gases (SCGHG): presented July 21, 2020



- 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) https://www.utc.wa.gov/regulatedIndustries/utilities/Pages/SocialCostofCarbon.aspx

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2 Planning assumptions and resource alternatives

[Upstream CO2 emission for natural gas plants: presented July 21, 2020]

Upstream emissions added to emission rate of NG plants

GHGenius: 10,803 g/MMBtu = 23 lbs/MMBtu

Upstream emissions added to emission rate of NG plants

Example:

New NG plant emission rate:	117 lbs/MMBtu
Upstream emission rate:	23 lbs/MMBtu
Total emission rate:	140 lbs/MMBtu

2 Planning assumptions and resource alternatives

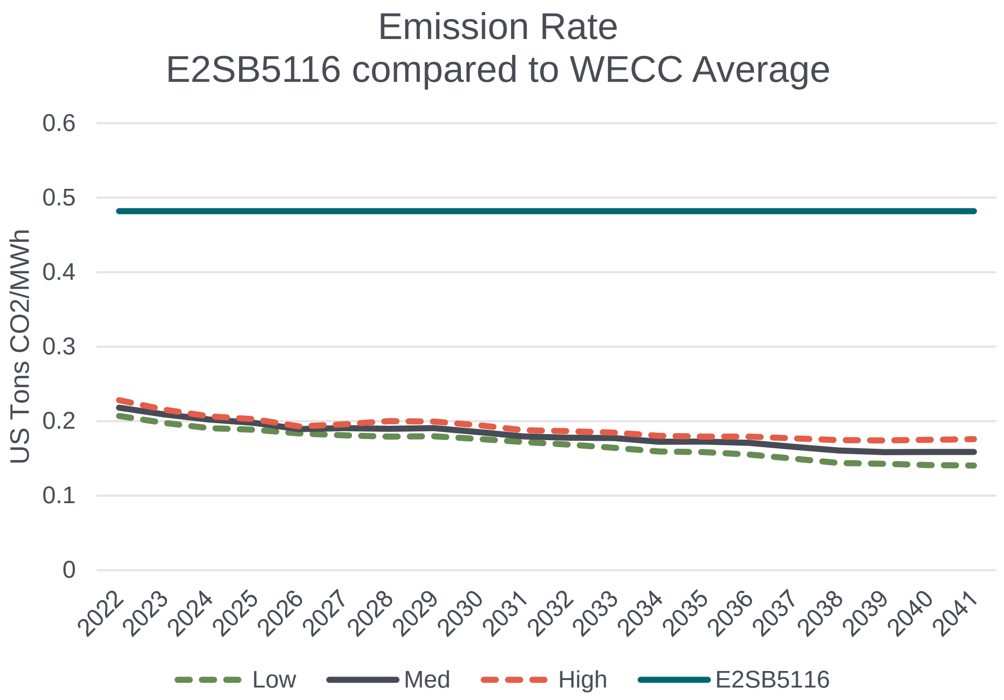
Emission rate for market purchases

Emission rate for unspecified market purchases.

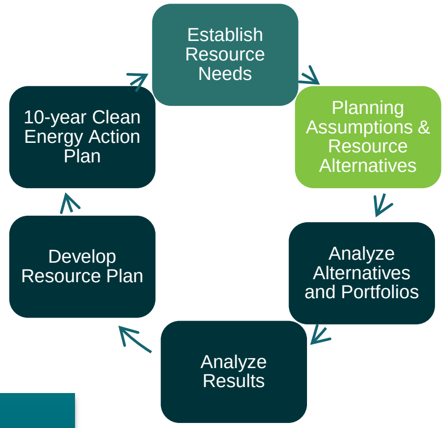
- Section 7 of E2SB5116, paragraph 2 states to use 0.437 metric tons CO_2/MWh for unspecified market purchases

Comparison of emission rate from E2SB5116 and the WECC average CO_2 rate.

- ➢ WECC average CO_2 rate calculated form AURORA WECC wide runs for the electric price forecast



2 Planning assumptions and resource alternatives



Demand-side resource alternatives

- Energy Efficiency
- Demand Response
- Distribution Efficiency
- Codes and Standards
- Distributed Solar PV (net metering)

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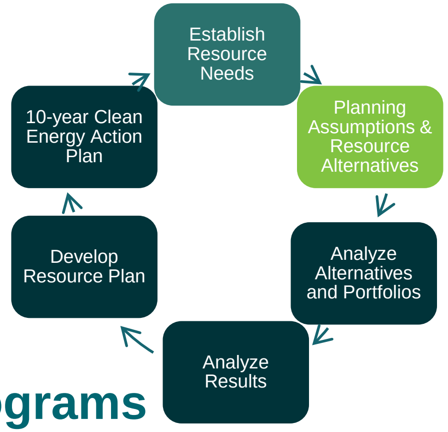
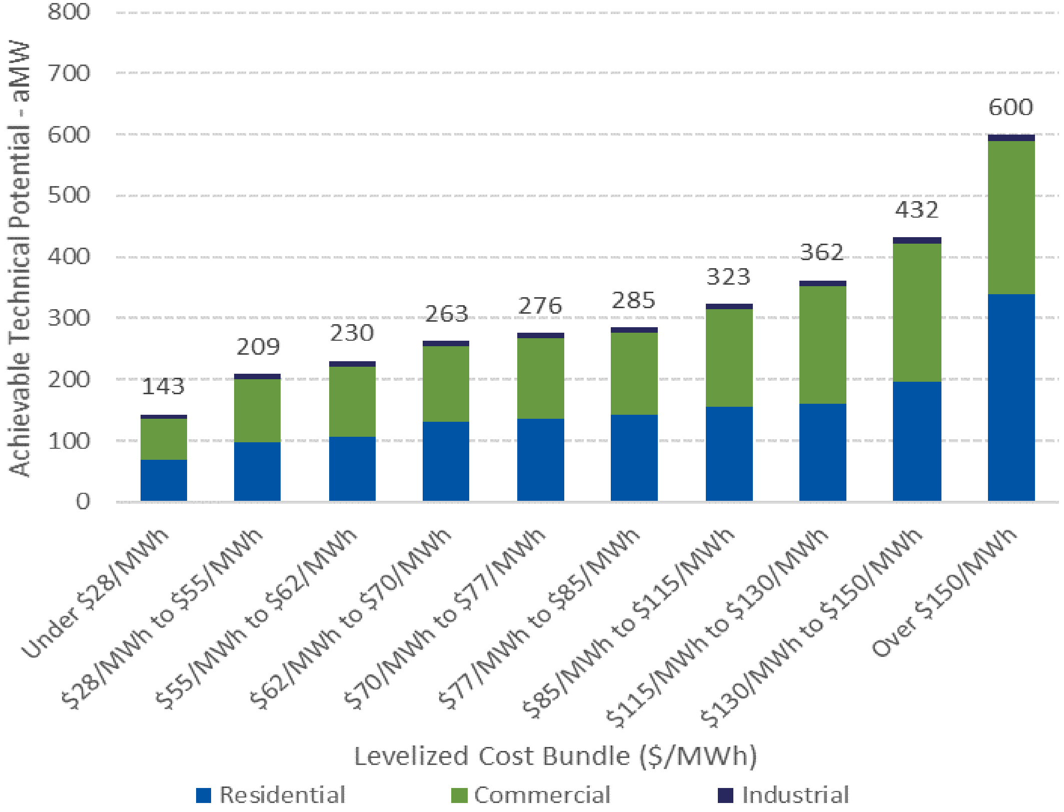


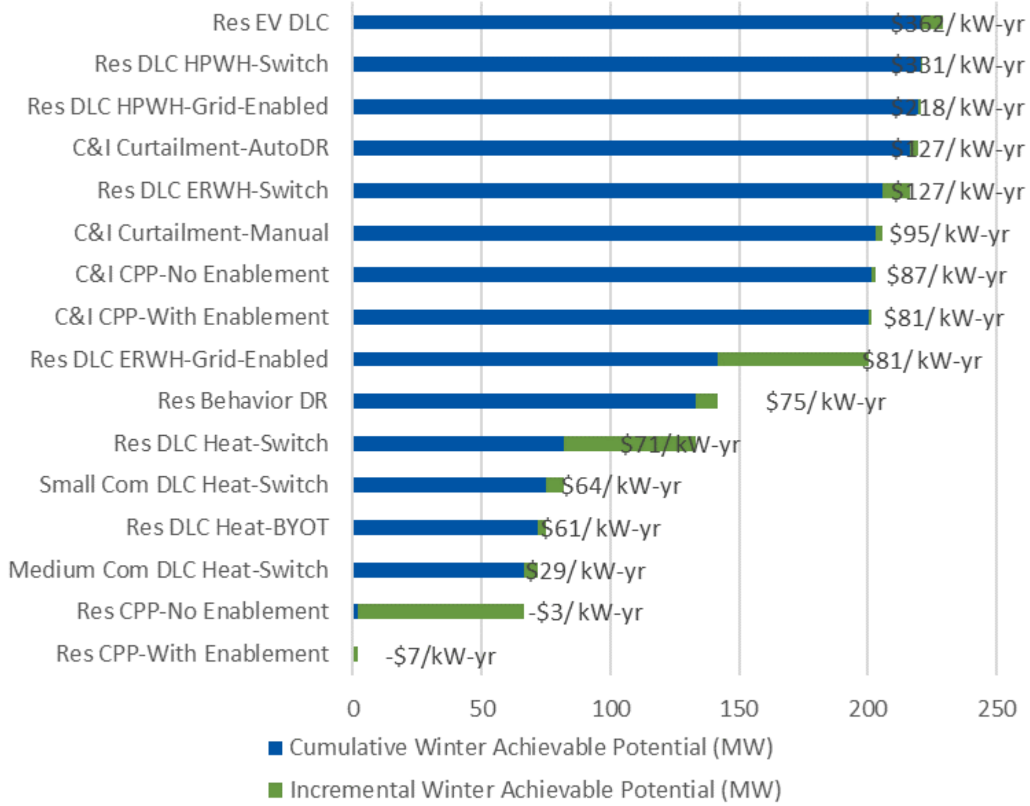
2 Planning assumptions and resource alternatives

Demand-side resource alternatives: presented on July 14, 2020

Energy Efficiency Supply Curve



Demand Response Programs



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2 Planning assumptions and resource alternatives

Supply-side resource alternatives: presented May 28, 2020

Gas plants

- 1 – Combined cycle combustion turbines baseload gas plant (CCCT)
- 2 – Simple cycle combustion turbine peaking plant (frame peaker)
- 3 – Reciprocating internal combustion engines peaking plant (recip peaker)

Renewable resources

- Solar (utility scale)
  - 4 – WA West
  - 5 – WA East
  - 6 – Idaho
  - 7 – WY East
  - 8 – WY West
  - 9 – MT Central
  - 10 – MT East
- 11 – Solar (Distributed)
- Wind – onshore
  - 12 – WA East
  - 13 – Idaho
  - 14 – WY East
  - 15 – WY West
- 16 – Offshore Wind
- 17 – Biomass

Energy storage

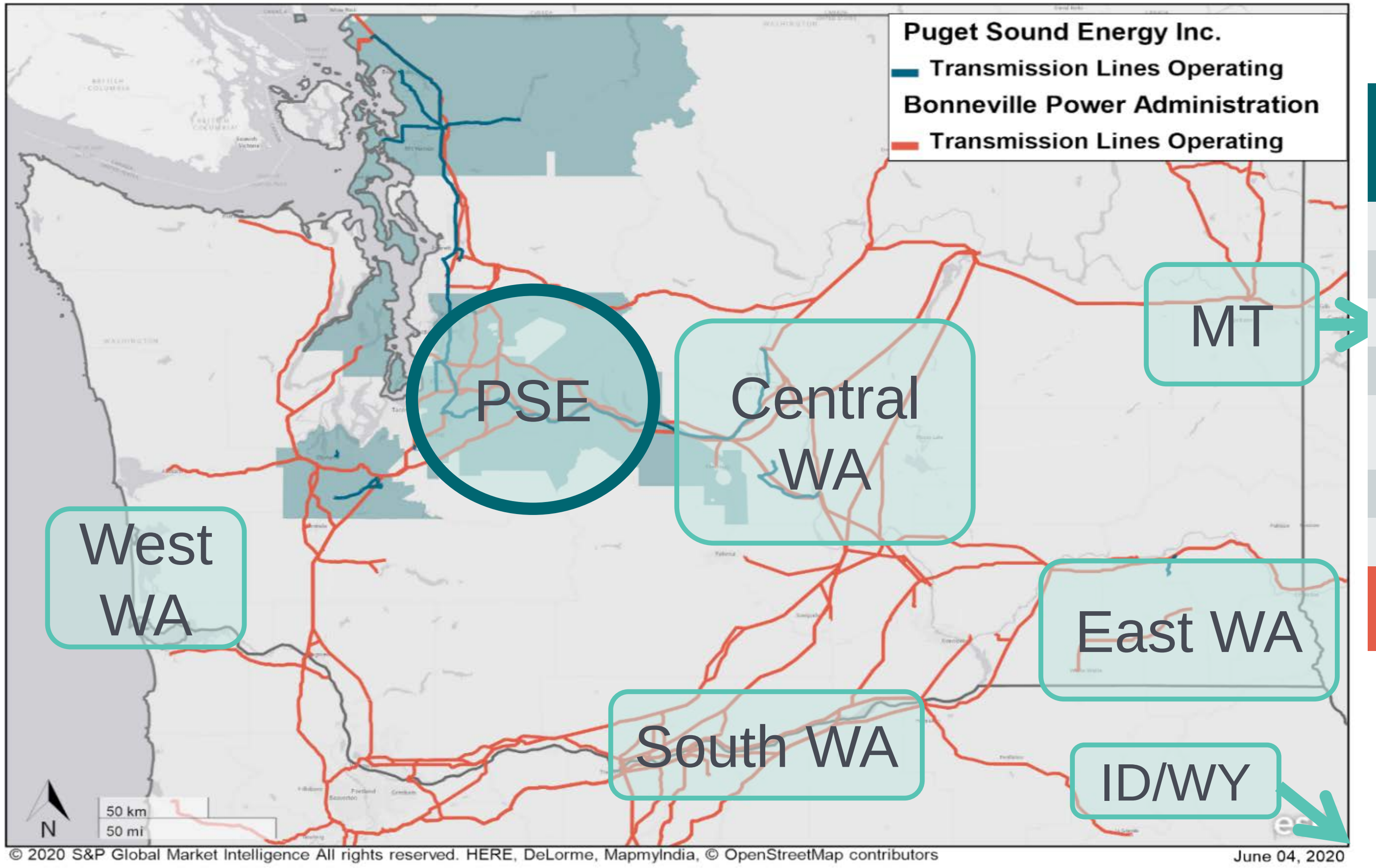
- Battery storage
  - 18 – 2-hr Lithium Ion
  - 19 – 4-hr Lithium Ion
  - 20 – 4-hr Flow
  - 21 – 6-hr Flow
- 22 – Pumped Storage Hydro (PSH)

Combined resources

- 23 – WA Solar + battery
- 24 – WA Wind + battery
- 25 – MT wind + PSH

2 Planning assumptions and resource alternatives

Transmission constraints: presented on June 30, 2020



Resource Group Region	Added Transmission (MW) Tier 0	Tier 1	Tier 2	Tier 3
PSE territory (a)	(b)	(b)	(b)	(b)
Eastern Washington	unconstrained	300	675	1,515
Central Washington	unconstrained	250	625	875
Western Washington	unconstrained	0	100	635
Southern Washington/Gorge	unconstrained	150	705	1,015
Montana	565	350	565	565
Idaho / Wyoming	600	0	400	600
TOTAL	generally unconstrained	1,050	3,070	5,205

Notes:
(a) Not including the PSE IP Line (cross Cascades) or Kittitas area transmission which is fully subscribed
(b) Not constrained in resource model, assumes adequate PSE transmission capacity to serve future load

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2 Planning assumptions and resource alternatives

	Generic Resource											
Resource Group Region	**Onshore Wind**	**Offshore Wind**	**CCCT**	**Frame**	**Recip**	**Biomass**	**Distributed Solar**	**Utility Solar**	**Pumped Storage**	**Battery**	**Wind + Battery**	**Solar + Battery**
PSE territory*			x	x	x	x	x	x		x		
Eastern Washington	x					x		x	x		x	x
Central Washington	x					x		x	x		x	x
Western Washington	x	x				x		x				
Southern Washington/Gorge	x					x		x	x		x	x
Montana	x								x			
Idaho / Wyoming	x							x				

*Not including the PSE IP Line (cross Cascades) or Kittitas area transmission which is fully subscribed

Annual Average Capacity Factor (%)	
Washington Wind	36.7
Montana-East Wind	44.3
Montana-Central wind	39.8
Wyoming-East Wind	47.9
Wyoming-West Wind	39.2
Idaho Wind	33.0
Offshore Wind	34.8
Washington-West Distributed Solar	13.6
Washington-East Utility Solar	24.4
Wyoming-East Solar	27.3
Wyoming-West Solar	28.0
Idaho Solar	26.4

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2 Planning assumptions and resource alternatives

Sub-hourly system flexibility cost savings

- PLEXOS is an hourly and sub-hourly chronological production simulation model that utilizes mixed-integer programming (MIP) to simulate unit commitment of resources at a day-ahead level, and then simulate the re-dispatch of these resources in real-time to match changes in supply and demand on a 5-minute basis.

- For the sub-hourly cost analysis using PLEXOS, PSE will first created a current portfolio case based on PSE's existing resources.

- Then test each resource in the portfolio and calculate the cost difference in the real-time re-dispatch from the current portfolio case.

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3 Analyze portfolios and alternatives

- Analyze scenarios and sensitivities using deterministic and stochastic risk analysis
- The portfolio model is an optimization model that determines the mix of supply and demand-side resources that meets the objective function to minimize total portfolio cost while meeting all the constraints.
- The purpose of the stochastic analysis is to understand how uncertainty affects findings

3 Analyze portfolios and alternatives

Draft results for mid economic conditions portfolio

- Results are draft and represent current place in modeling process
- Increased renewable and conservation over the 2017 IRP due to CETA requirements.
- The 2021 IRP is modeling over 25 unique supply-side resources, the most modeled in any PSE IRP.
- With a lower demand forecast the renewable need and peak need are lower than the 2019 IRP process, so over all less resources added to the portfolio.
  - ➢ Updated wind curves to reflect newer technology resulted in a higher average capacity factor for wind and a switch from solar to wind in the portfolio builds

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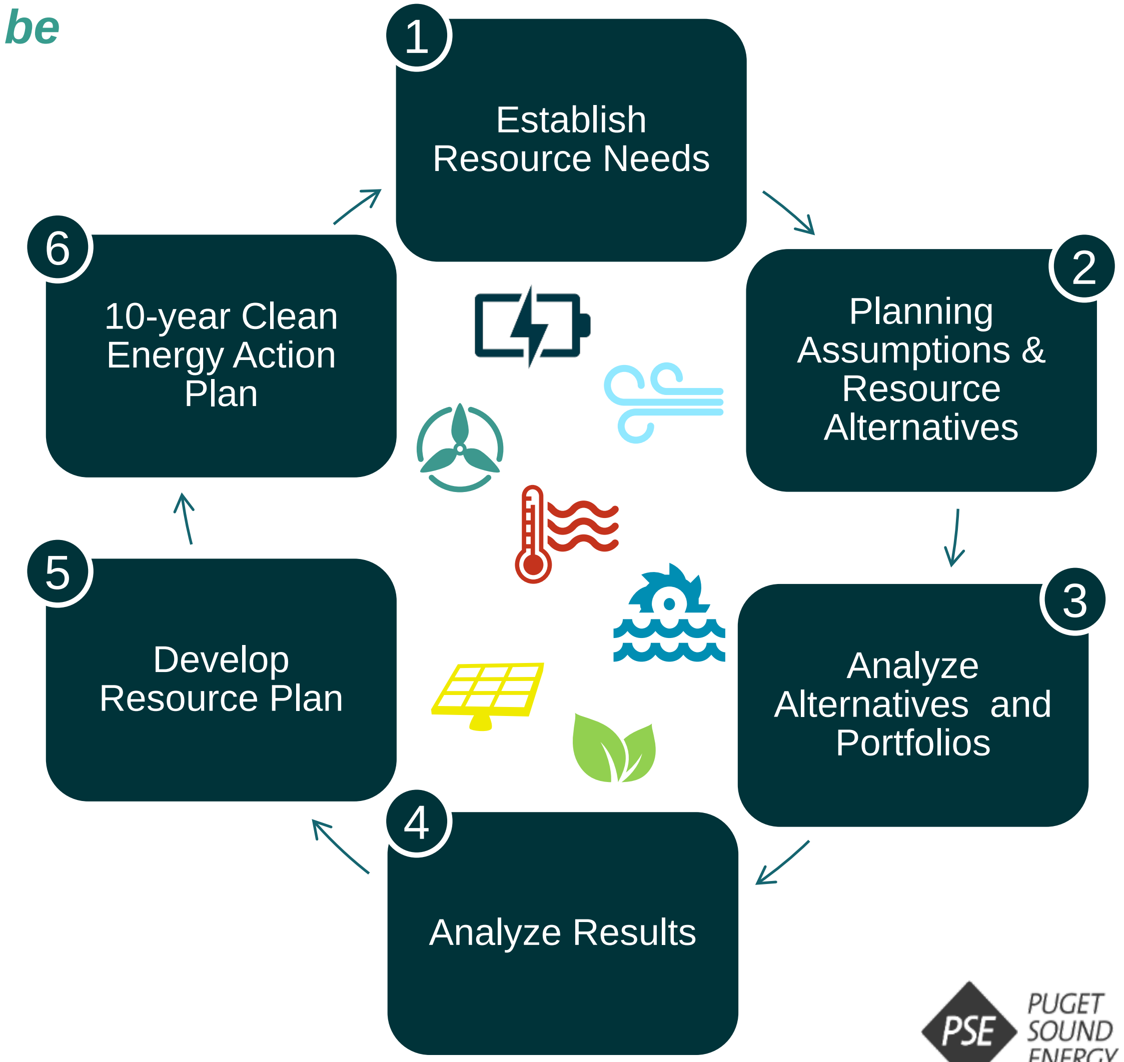
2021 IRP modeling process

Updated draft results and draft resource plan will be discussed at the December 9 IRP meeting.

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

1. Analyze and establish resource need
2. Determine planning assumptions and identify resource alternatives
3. Analyze scenarios and sensitivities using deterministic and stochastic risk analysis
4. Analyze results
5. Develop resource plan
6. 10-year Clean Energy Action Plan



5-minute break

Electric portfolio sensitivities

Participation Objectives

- PSE will present possible scenarios or sensitivities for the electric analysis.
- Stakeholders to share input on prioritization on scenarios or sensitivities for the electric analysis

IAP2 level of participation: INVOLVE

Stakeholder involvement

- PSE requested stakeholder involvement at the August 11 webinar to help create the list of portfolio sensitivities.
- With stakeholder input, the list has grown to 47 portfolio sensitivities.
- PSE is now asking for stakeholders to help to prioritize the analysis.
- PSE will make best efforts to complete all the requested analysis, however some analysis may take longer than others to complete and it is possible that not everything can be finished to meet the IRP filing date.
    - PSE will start modeling with the highest priority items.

Voting process to prioritize the list

- PSE values your participation in the 2021 IRP and asks that you provide feedback in the form of a survey, which will be opening soon and closed October 27.

- In this survey we ask that you select the 10 sensitivities you feel hold the highest importance to the IRP assessment. This does not mean that PSE is only going to complete 10 sensitivity assessments. The number of selections was chosen to ensure a meaningful prioritization of options could be calculated.

- PSE has pre-selected 15 sensitivities that represent different themes and will help inform the IRP process. These are called “must run” sensitivities.

- Link to survey to be provided

“Must run” portfolio sensitivities

Description	Corresponding number in spreadsheet
Mid economic conditions	1
Low economic conditions	2
High economic conditions	3
Renewable over generation test	7
Reduced market reliance at peak	8
"Distributed" Transmission/build constraints, Tier 2	10
Firm transmission as a % of nameplate	13
SCGHG as an “externality cost” - dispatch cost in portfolio model only	19
Alternative fuel for peakers	25
Gas generation out by 2045	27
Must take DR and battery storage first, then optimize	29
Fuel switching from gas to electric	30
Temperature sensitivity *will vote on 3 different approaches	31
SCGHG only, fixed cost adder	38
2% cost threshold	43

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Alternative Definition of Normal Temperatures

- The load forecast assumes normal temperatures for the forecast period.

- Several approaches for consideration:
  1. Trended normal based on historical observed trends (Itron)
  2. Normal based on most recent 15 years
  3. Northwest Power and Conservation Council’s climate model temperature assumption

- Comparison of three approaches

- Normal temperatures are translated into normal heating and cooling degree days for the model.

- HDD base 65: if daily average temperature < 65, then 65 - temperature
  if daily average temperature > 65, then 0
- CDD base 65: if daily average temperature > 65, then temperature - 65
  if daily average temperature < 65, then 0

Approach 1: Itron Temperature Trend Study

- Puget Sound initiated study in light of the significant work on understanding the regional impact of climate change
  - River Management Joint Operating Committee (RMJOC)
  - Northwest Power and Conservation Council (NWPCC)

- Study Objectives
  - Evaluate historical temperature trends (Seattle-Tacoma International Airport)
  - Compare PSE’s observed temperature trends to other regions and climate impact studies
  - Translate temperature trends to Heating and Cooling Degree Days for modeling

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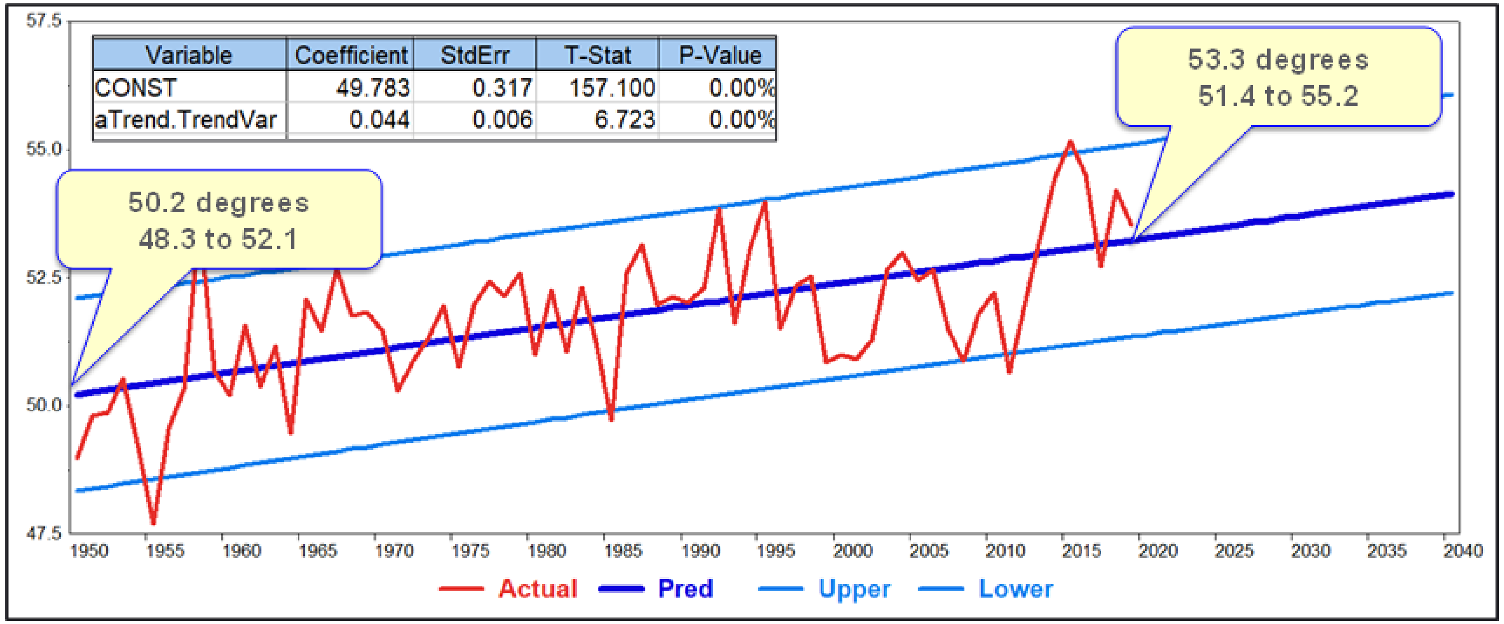
Since 1950 Average Temperature Has Been Increasing



- Statistically significant trend
- Trend coefficient of .044 implies average temperatures increasing .044 per year or 0.44 degrees per decade. Depending on start year, temperature trend varied from 0.33 to 0.47, average is 0.40 degrees per decade.

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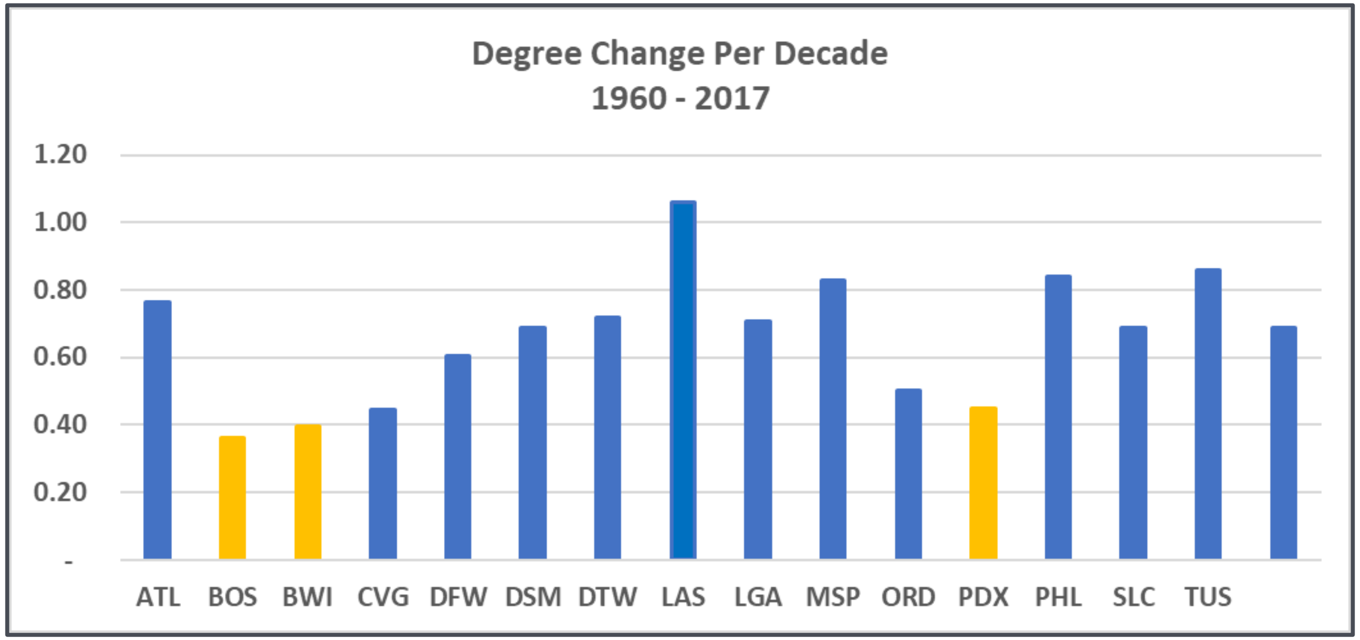
Consistent with U.S. Temperature Trends

PIER Study - Estimated Temperature Change
1960 - 2017

City	Station	TempChg	Per Decade
Atlanta	ATL	4.36	0.76
Boston	BOS	2.06	0.36
Baltimore	BWI	2.25	0.39
Cincinnati	CVG	2.53	0.44
Dallas-Fort Worth	DFW	3.44	0.60
Des Moines	DSM	3.93	0.69
Detroit	DTW	4.09	0.72
Las Vegas	LAS	6.05	1.06
New York (LGA)	LGA	4.03	0.71
Minneapolis	MSP	4.72	0.83
Chicago	ORD	2.86	0.50
Portland	PDX	2.55	0.45
Philadelphia	PHL	4.78	0.84
Salt Lake City	SLC	3.92	0.69
Tucson	TUS	4.89	0.86
Median		**3.93**	**0.69**



On the Evolution of U.S. Temperature Dynamics, July 2019. Francis Diebold, University of Pennsylvania, Glenn Rudebusch, FRB San Francisco. Penn Institute for Economic Research (PIER).
https://economics.sas.upenn.edu/pier/working-paper/2019/evolution-us-temperature-dynamics

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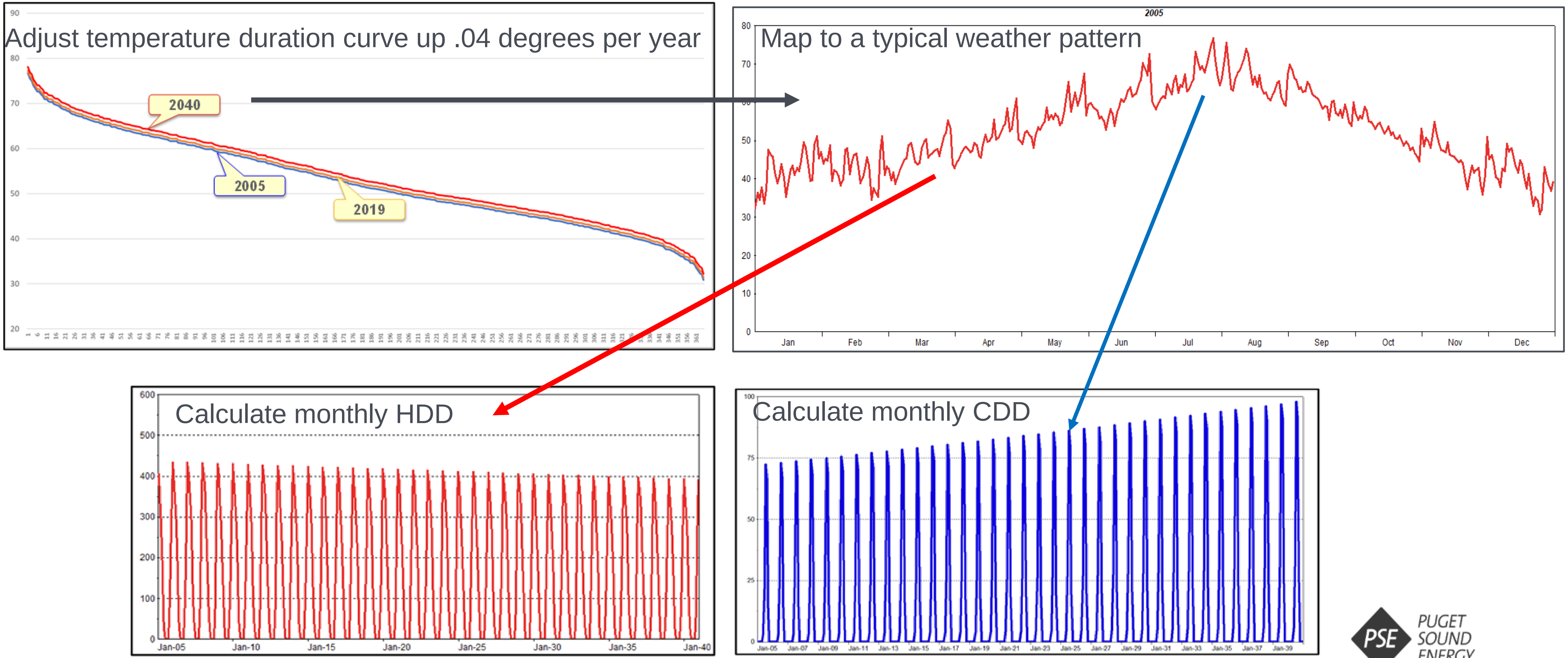
Translation of Temperature Trend to Normal Degree-Days



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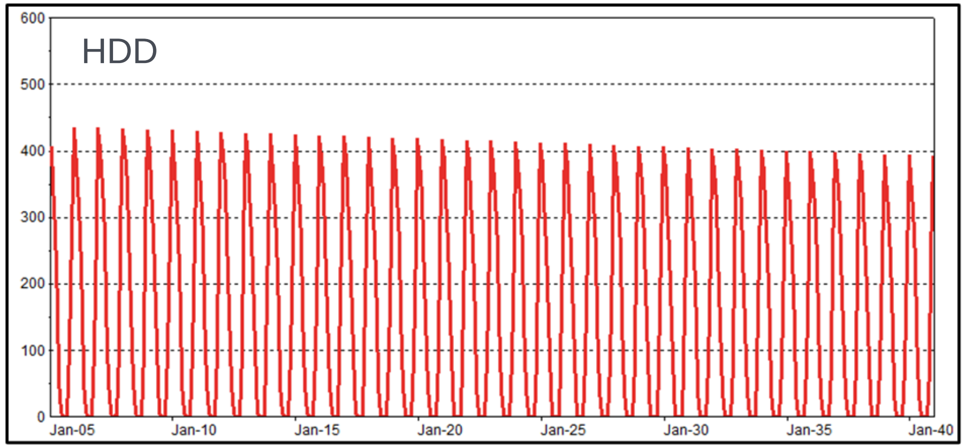
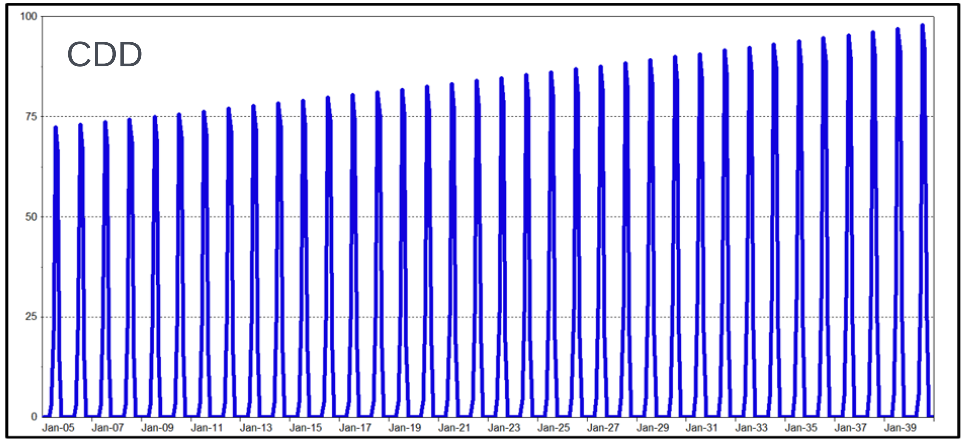
Trended Normal Heating and Cooling Degree Days

- Increasing temperature trend translates into decline in expected number of HDD and increase in number of CDD



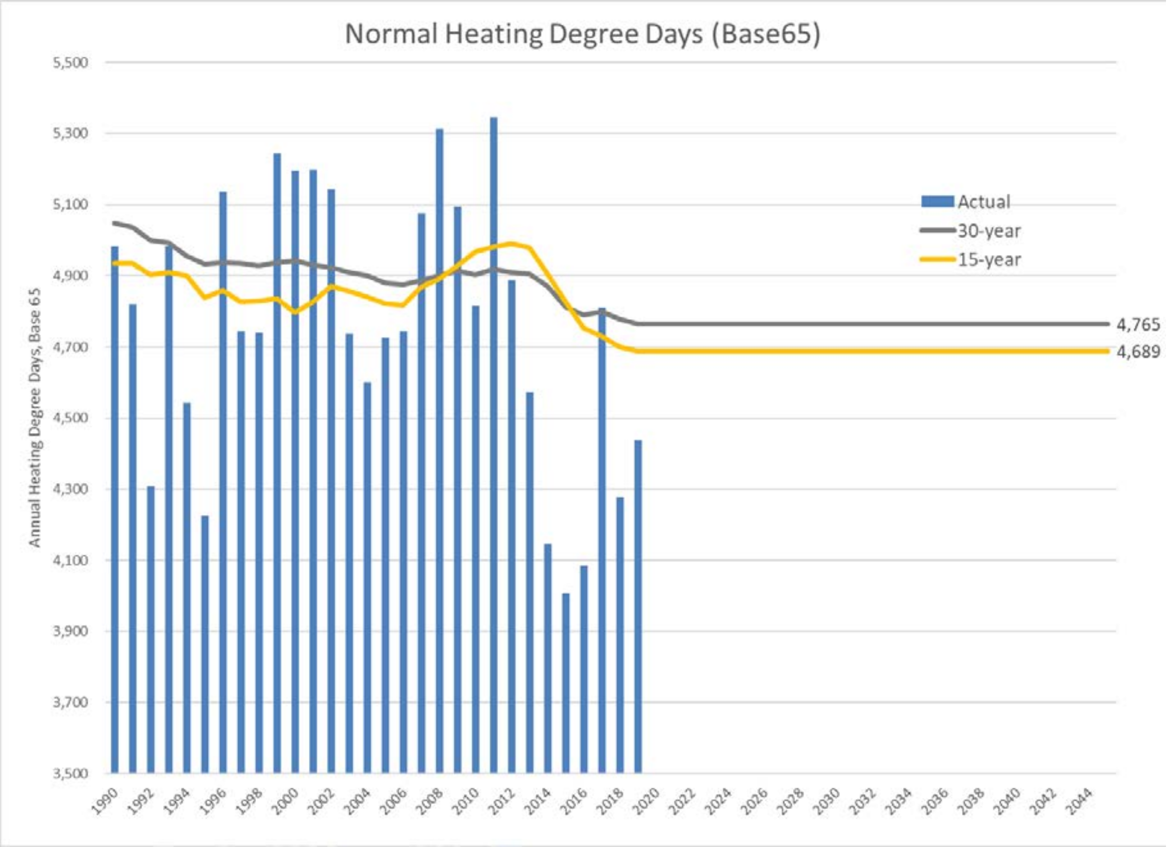


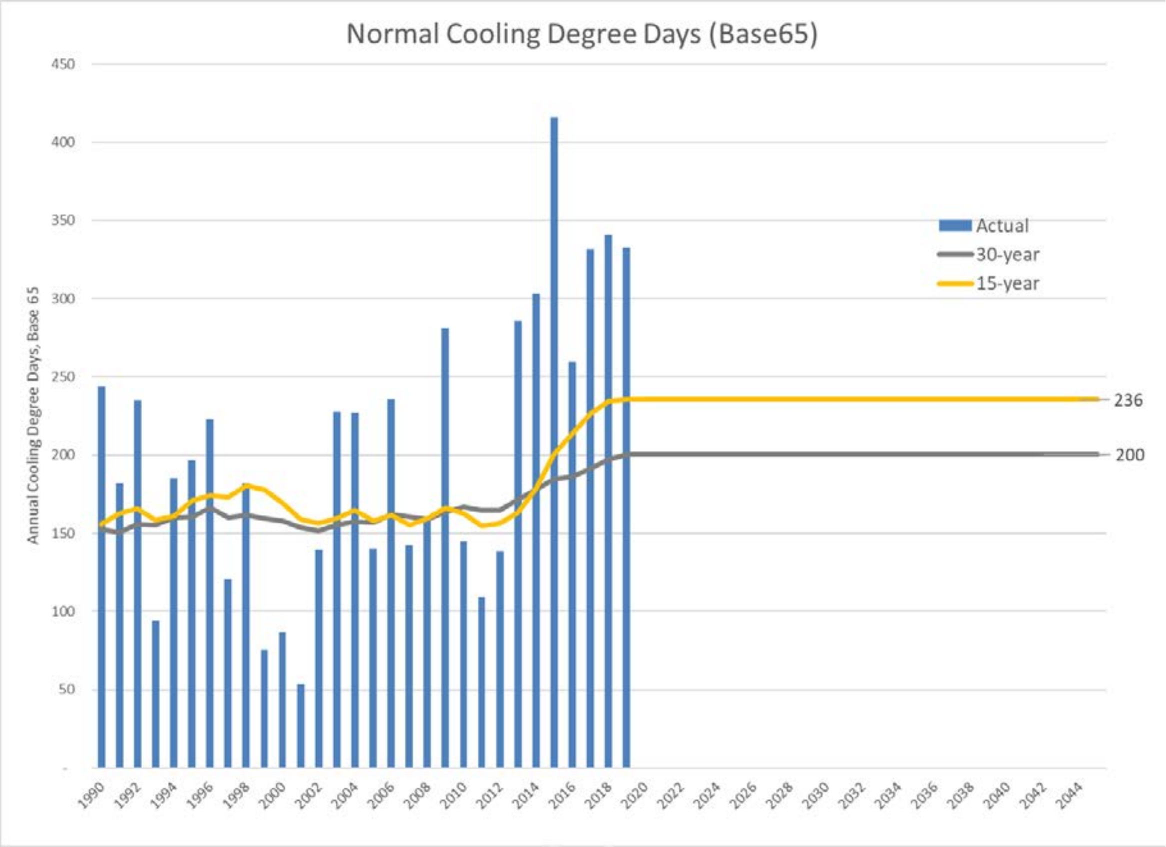
2020 Normal HDD65		
Month	**30-Year**	**Trended**
Jan	714.3	695.5
Feb	638.8	636.2
Mar	586.7	567.9
Apr	450.2	431.9
May	287.2	269.3
Jun	159.9	144.4
Jul	53.8	43.6
Aug	44.7	34.7
Sep	135.2	120.3
Oct	389.5	370.6
Nov	580.6	562.4
Dec	743.8	725.0
Total	**4,784.8**	**4,601.6**

2020 Normal CDD65		
Month	**30-Year**	**Trended**
Jan	-	-
Feb	-	-
Mar	0.2	-
Apr	0.7	-
May	6.9	9.8
Jun	25.7	30.2
Jul	78.5	89.6
Aug	71.6	82.5
Sep	16.8	21.6
Oct	-	-
Nov	-	-
Dec	-	-
Total	**200.3**	**233.7**

Approach 2: Normal degree days based on most recent 15 years

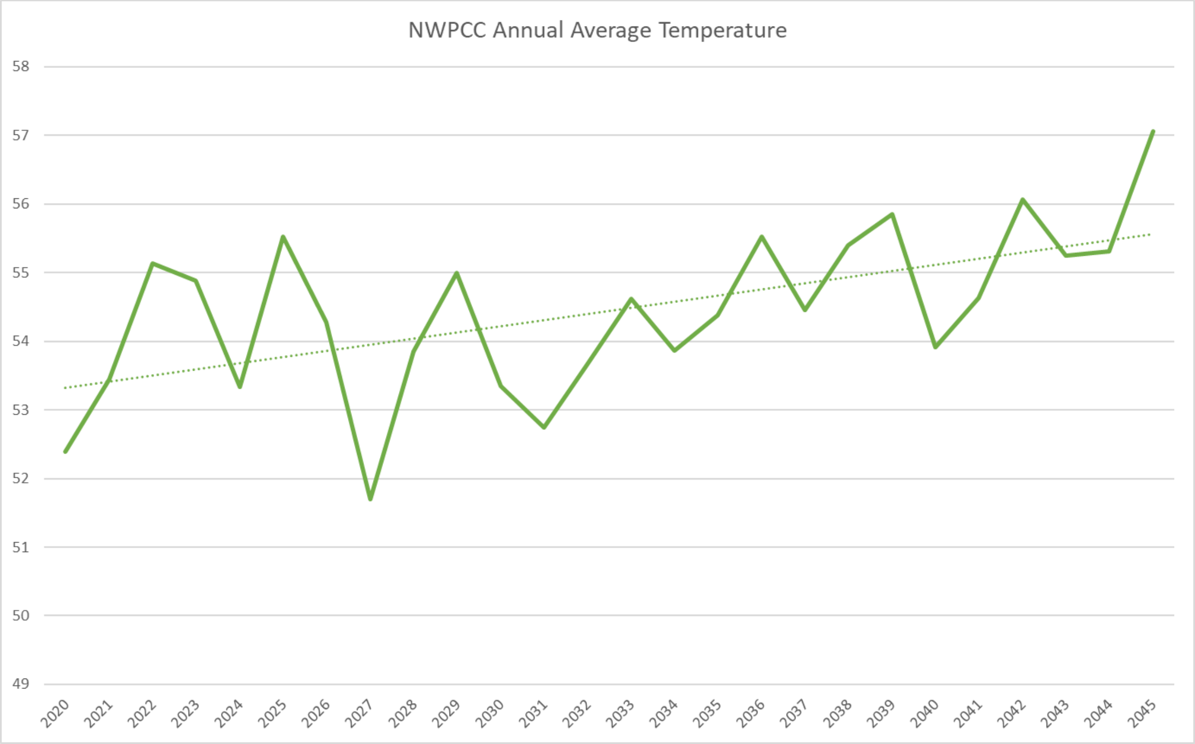
- Same methodology as current normal definition, except reducing the historical period for the calculation from 30 to 15 years.





Approach 3: Northwest Power and Conservation Council climate change temperature model

- NWPCC developed Seattle-Tacoma temperature series incorporating a warming trend.
- The temperature series assumes warming of 0.9 degrees per decade (2020-2045).
- Approach: Calculate trended normal degree days using this temperature series.



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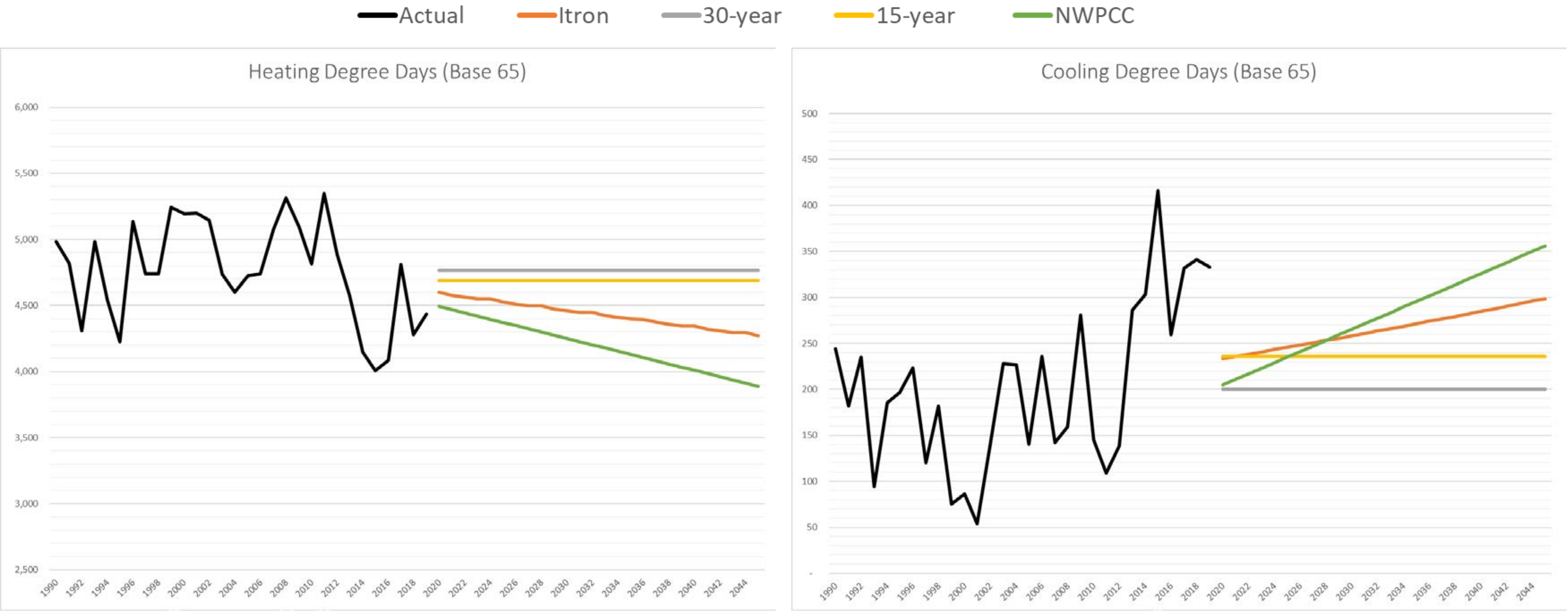
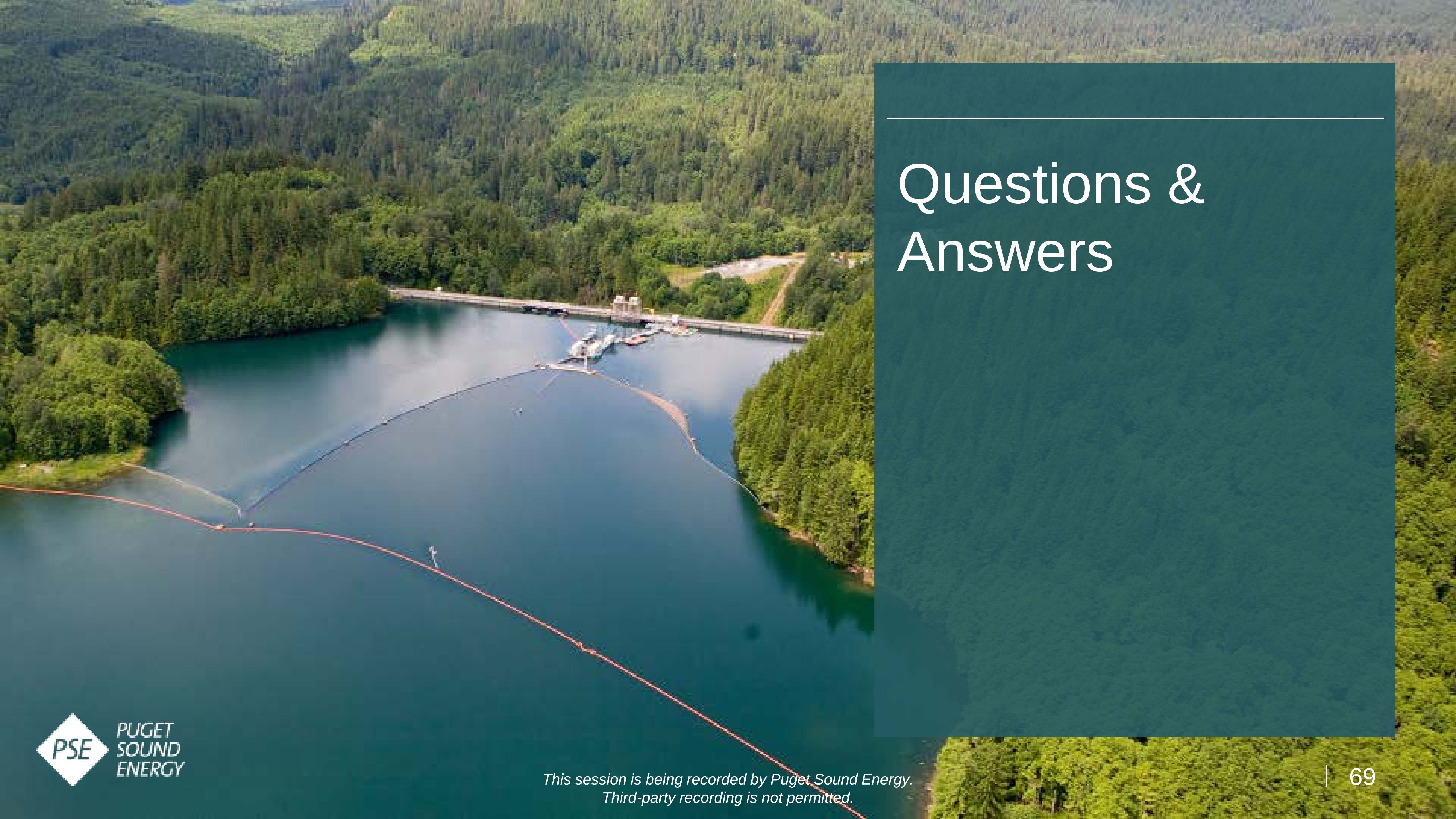
Comparison of Normal Degree Days



Heating degree days (HDD) are a measure of how *cold* the daily averages temperature are for a given month or year.

Cooling degree days (CDD) are a measure of how *warm* the daily average temperatures are for a given month or year.



Questions & Answers

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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 – *seven completed*
- Feedback forms – *seven completed*

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 <u>within a week of the meeting topic</u>

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

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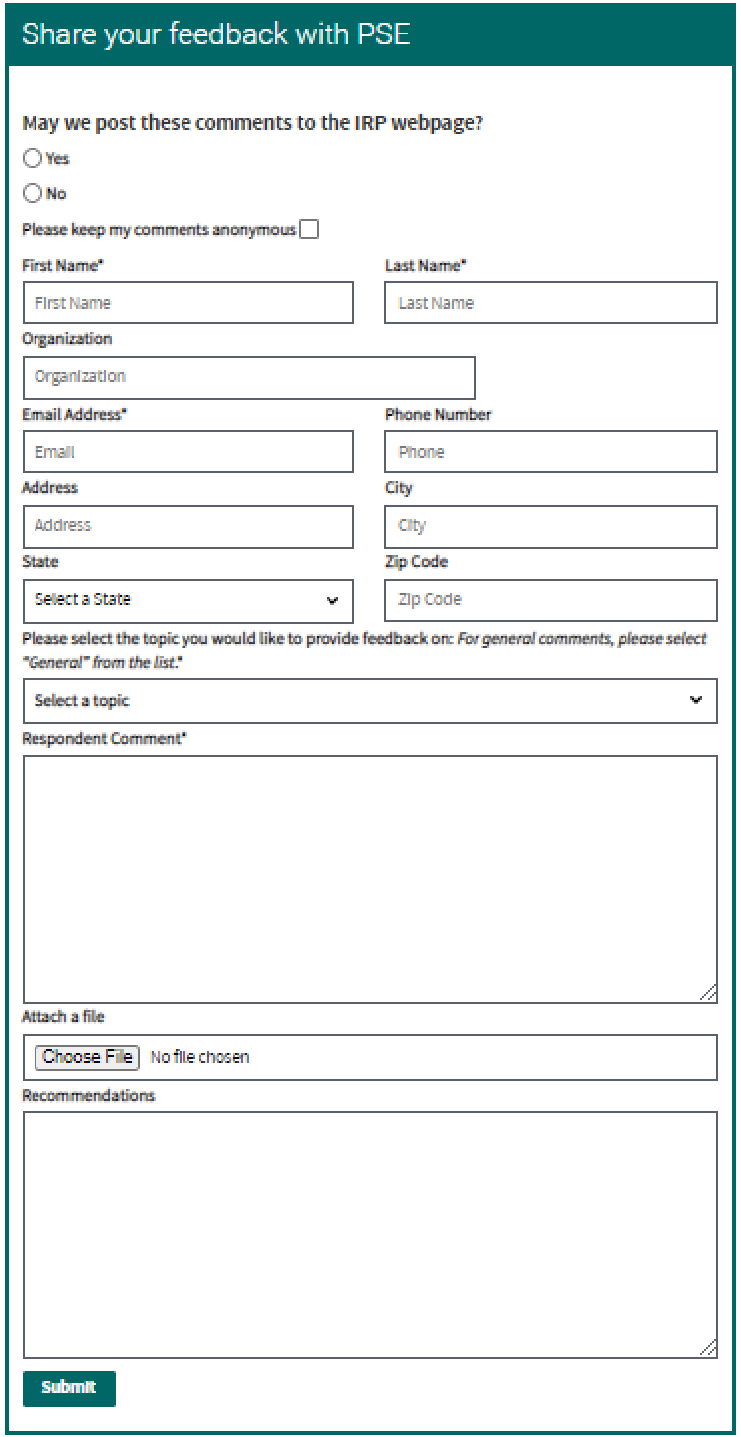
Share your feedback with PSE

May we post these comments to the IRP webpage?

Yes

No

Please keep my comments anonymous

First Name* | Last Name*

Organization

Email Address* | Phone Number

Address | City

State | Zip Code

Select a State

Please select the topic you would like to provide feedback on: *For general comments, please select "General" from the list.**

Select a topic

Respondent Comment*

Attach a file

Choose File | No file chosen

Recommendations

Submit

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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Thank you for your participation in PSE's 2021 IRP!

- To date, 145 unique individuals have participated in webinars
- Over 1,900 unique individual website users since May 2020
- 1,441 total audience members are receiving IRP newsletters
- 130 Feedback Forms received for the first 7 webinars
- Average message open rate of 20% for all newsletters sent between May and August 2020

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Next steps

- Submit Feedback Form to PSE by **October 27, 2020**
- A recording and the chat 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 **November 3, 2020**
- The Consultation Update will be shared on **November 10, 2020**

Details of upcoming meetings can be found at pse.com/irp

Date	Topic
November 16 1:00 – 4:30 pm	Clean Energy Action Plan 10-year Distribution & Transmission Plan Highly Impacted and Vulnerable Communities Assessment
December 9, 1:00 – 4:30 pm	Portfolio draft results Flexibility analysis Wholesale market risk

Note: A revision to the 2021 IRP webinar schedule will be released soon

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Thank you for your attention and input.

Please complete your Feedback Form by October 27, 2020

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

Clean Energy Action Plan and

10-year Distribution and Transmission plan

November 4, 2020

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