2019 TAG Meeting #2: Scenarios, portfolio sensitivities and gas resource alternatives

PUGET SOUND ENERGY

October 11, 2018 TAG #2

Welcome

- Opening remarks
- Safety message

Action items from prior IRPAG and TAG meetings

October 11, 2018 TAG #2

Relevant action items from IRPAG meeting #1 (May 30, 2018) and IRPAG meeting #2 (August 28, 2018)

Action #	Description	PSE Action	Status
1	Identify contact for PSE's carbon reduction goals	PSE is planning a fall listening session with PSE executives and the public is welcome to participate	In progress
2	Include carbon impact in scenarios or sensitivities	PSE will model various carbon impacts such as zero carbon electric modeling – this will be addressed in the October 11 TAG meeting	In progress
3	Finalize charter for the IRPAG	PSE uploaded final charter to pse.com on September 14, 2018	Complete

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Relevant action items from IRPAG meeting #1 (May 30, 2018) and IRPAG meeting #2 (August 28, 2018) (continued)

Action #	Description	PSE Action	Status
4	PSE will include a discussion of the social cost of carbon at the October 11 TAG meeting	This is on the agenda for the October 11 TAG meeting	In progress
5	Meeting notes from IRPAG #2	PSE distributed the meeting notes on September 7, stakeholders provided feedback by September 14, and PSE posted notes September 20	Complete

Relevant action items from TAG meeting #1 (July 26, 2018)

Action #	Description	PSE Action	Status
1	PSE will include larger renewable projects in the modeling assumptions to take into consideration greater economies of scale	PSE will incorporate larger renewable projects in final report	Complete. Final report to be posted at www.pse.com/irp by October 19, 2018
2	PSE accepted comments from TAG members on HDR's electric resource costs report	All comments were considered by PSE and HDR and are available at www.pse.com/irp	Complete. Final report to be posted at www.pse.com/irp by October 19, 2018

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Relevant action items from TAG meeting #1 (July 26, 2018) (continued)

Action #	Description	PSE Action	Status
3	PSE will verify confidentiality of information from individual bids from the 2017 Green Direct RFP process	All content in the bids from the Green Direct RFP is confidential; PSE provided bid content to HDR under a non-disclosure agreement for comparison	Complete. HDR assessed and determined these costs were not complete and it will not be included
4	PSE will clarify and share information about the nomination process for TAG membership	PSE uploaded final TAG charter with information about the nomination process to pse.com on September 14, 2018 and sent it to TAG members	Complete

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Relevant action items from TAG meeting #1 (July 26, 2018) (continued)

Action #	Description	PSE Action	Status
5	Update charter	PSE uploaded final charter to pse.com on September 14, 2018	Complete

Review meeting objectives and agenda

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Meeting objectives

- TAG members understand the scenarios PSE is modeling in the 2019 IRP
- TAG members provide feedback on electric and gas portfolio sensitivities
- TAG members understand how PSE will incorporate reduced carbon in portfolio sensitivities
- TAG members provide feedback on gas utility resource alternatives

Today's agenda

- ✓ Welcome and safety message
- ✓ Action items from previous IRPAG meeting and TAG meeting
- Review agenda and meeting objectives
- Introductions
- Scenarios
- Break for lunch
- Portfolio sensitivities
- Natural gas resource alternatives
- Next steps
- Adjourn and public meet and greet
- IRP comment period

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Introductions

Modeling overview and scenarios modeled

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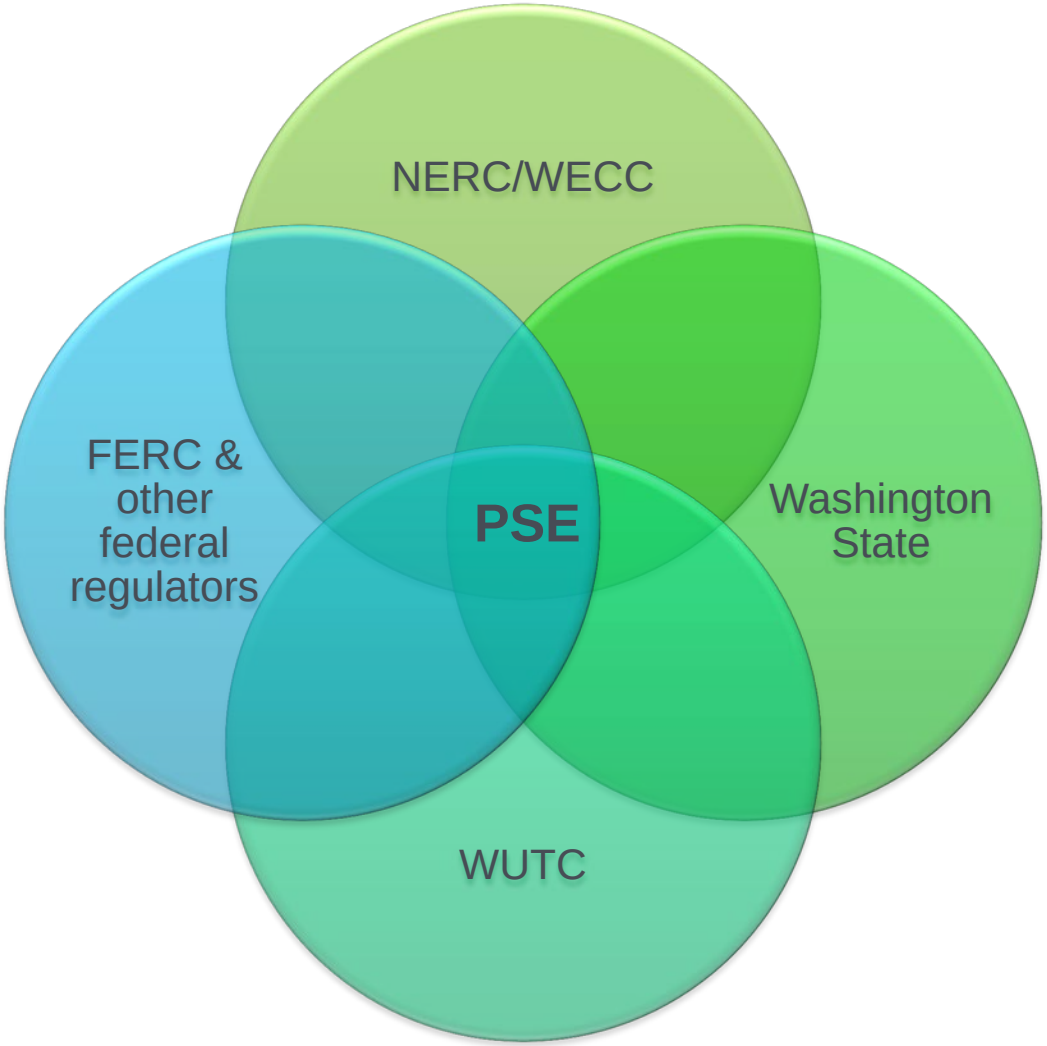
October 11, 2018 TAG #2

Modeling overview

1. What are FERC, NERC, WECC and WUTC?
2. What is a scenario and a portfolio sensitivity?
3. Where does all the information come from?
4. How does PSE create power prices?

PSE's regulatory landscape



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What is FERC?

- Federal Energy Regulatory Commission (FERC) is an independent agency that regulates the interstate transmission of electricity, natural gas and oil.
- FERC also regulates natural gas and hydropower projects.
- FERC:
  - Regulates the transmission and wholesale sales of electricity in interstate commerce
  - Licenses and inspects private, municipal and state hydroelectric projects
  - Protects the reliability of the high voltage interstate transmission system through mandatory reliability standards
  - Monitors and investigates energy markets
- For more information, visit www.ferc.gov.

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What is NERC?

- The North American Electric Reliability Corporation (NERC) is a non-profit international regulatory authority whose mission is to assure the effective and efficient reduction of risks to the reliability and security of the grid.
- NERC develops and enforces reliability standards.
- NERC's area of responsibility spans the continental United States, Canada and the northern portion of Baja California, Mexico.
- NERC is subject to oversight by the Federal Energy Regulatory Commission (FERC) and governmental authorities in Canada
- NERC's jurisdiction includes users, owners and operators of the bulk power system.
- For more information visit www.nerc.com.

NERC key players

In 2007, FERC approved agreements by which NERC delegates its authority to monitor and enforce compliance to seven regional entities.

Florida Reliability Coordinating Council (FRCC)

Midwest Reliability Organization (MRO)

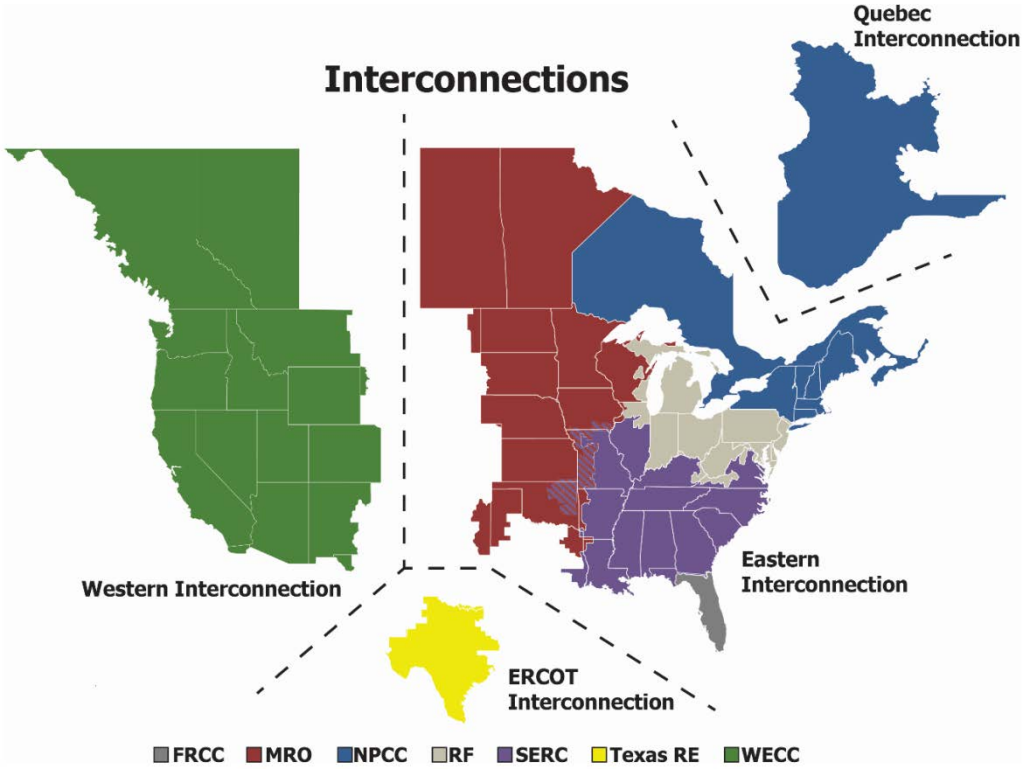
Northeast Power Coordinating Council (NPCC)

Reliability First (RF)

SERC Reliability Corporation (SERC)

Texas Reliability Entity (Texas RE)

Western Electricity Coordinating Council (WECC)



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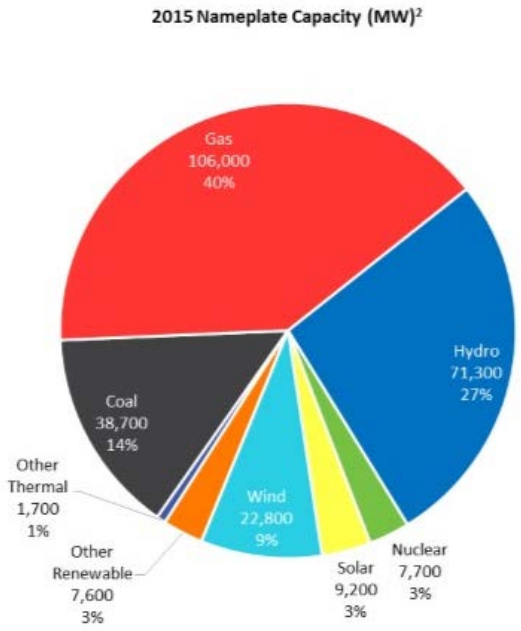
WECC

The Western Electricity Coordinating Council (WECC) is a non-profit corporation that assures a reliable Bulk Electric System in the geographic area known as the Western Interconnection.

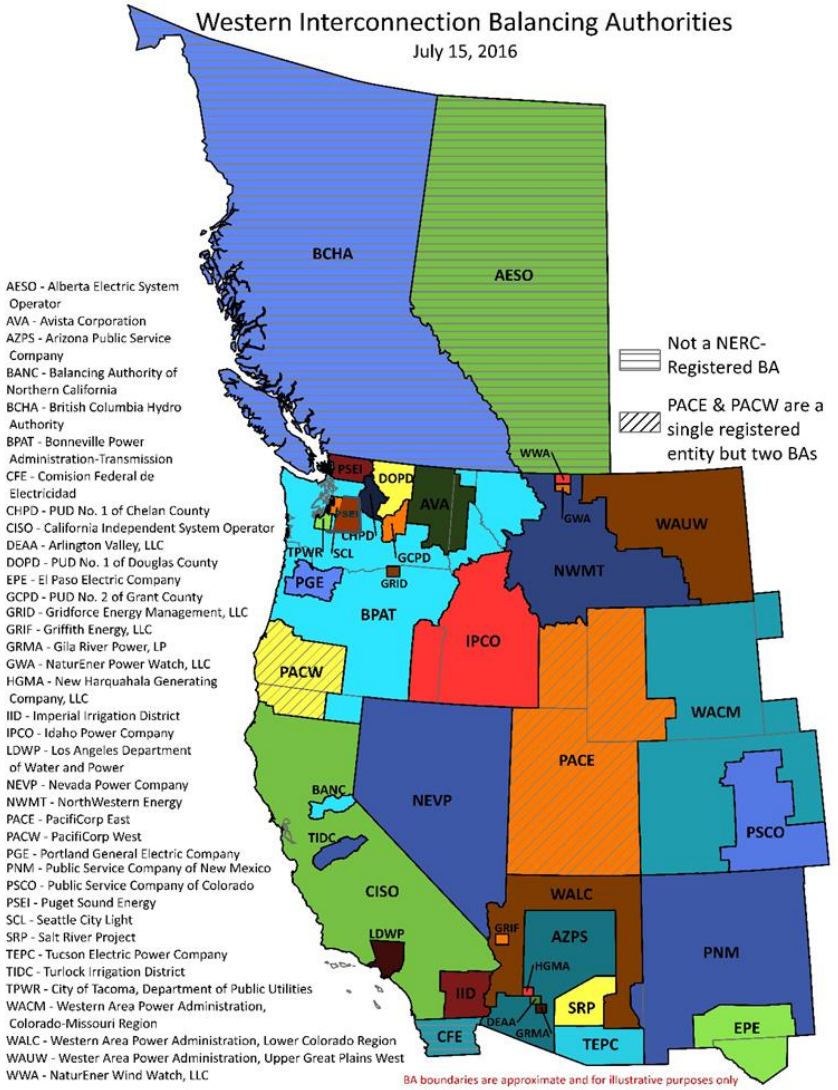
For more information visit www.wecc.biz.

WECC facts:

- 121,200 miles of transmission lines
- 265,000 MW of generation



Source: WECC 2016 State of Interconnection



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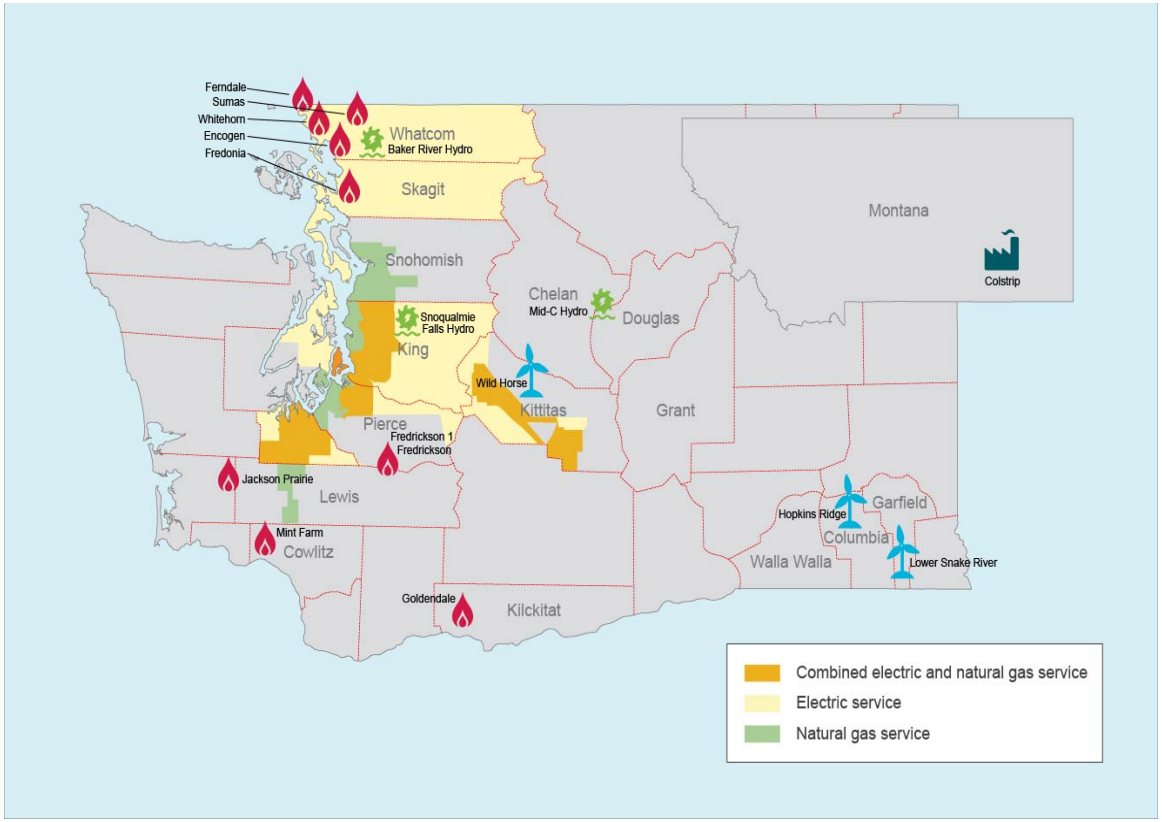
What is WUTC?

- Washington Utilities and Transportation Commission (WUTC or UTC) is a three-member commission appointed by the governor and confirmed by the state senate.
- UTC's mission is to ensure that investor-owned utility and transportation services are safe, available, reliable and fairly priced.
- Washington State law requires that utility and transportation rates be reasonable to customers, giving regulated companies a chance to cover legitimate costs and earn a fair profit, so they can stay in business. The commission decides what is fair to the company and fair to the people and businesses it serves.
- For more information visit www.utc.wa.gov.

Puget Sound Energy



PSE's electric power resources, both company-owned or controlled resources and those under long-term contract, had a total capacity of approximately 4,700 megawatts (MW) in 2017 – 1.6 percent of total generation in WECC.

Modeling overview

1. What are FERC, NERC, WECC and WUTC?
2. What is a scenario and a portfolio sensitivity?
3. Where does all the information come from?
4. How does PSE create power prices?

What is a scenario?

Scenarios are different sets of assumptions that create future power market conditions.

- Gas prices, carbon regulation and regional loads create different wholesale market power prices, which affect the relative value of different resources.
- Wholesale price forecasts developed using the AURORA model.
- This analysis models all major generators in the interconnected Western U.S., along with loads.

What is a portfolio sensitivity?

Portfolio sensitivities are different sets of assumptions that create alternate portfolios of supply and demand side generation for PSE.

- Optimization analysis determines least cost mix of resources for a future scenario.
- Can examine other portfolios in the context of different scenarios.
- Must select a scenario to perform sensitivities.

Scenarios vs. portfolio sensitivities

The purpose of a scenario is to create a 20-year power price.

The purpose of the sensitivity is to test different resources in PSE's portfolio.

Scenarios are about the market; sensitivities are about PSE's place in the market.

Modeling overview

1. What are FERC, NERC, WECC and WUTC?
2. What is a scenario and a portfolio sensitivity?
3. Where does all the information come from?
4. How does PSE create power prices?

Where does PSE get its information?

Input	Source
Gas prices	• Forward market prices • Wood Mackenzie
Power prices	• PSE forecasts using AURORA
Electric supply-side generic resource assumptions	• HDR
Demand side resources	• Cadmus
Regional demand	• Northwest Power and Conservation Council Seventh Power Plan
CO_2 prices	• Technical Support Document from the Interagency Working Group on Social Cost of Greenhouse Gases, United States Government, August 2016 update • I-1631
Natural gas upstream emissions	• IPCC (AR-4 -100-GWP); GREET Model Canada (NIR, 2017); BC Gas Production Volumes & Export Volumes; EPA Emissions Inventory; PSE distribution system leak reports to EPA

Modeling overview

1. What are FERC, NERC, WECC and WUTC?
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4. How does PSE create power prices?

How does PSE create power prices?

- PSE uses a software model called AURORA.
  - Developed by EPIS, now Energy Exemplar, in 1997
  - Software for forecasting wholesale power market prices, long term capacity expansion, portfolio analysis and risk analysis
  - AURORA is a fundamentals-based model that employs a multi-area, transmission-constrained dispatch logic to simulate real market conditions
  - For more information visit www.epis.com

How is AURORA used and who uses it?

- PSE started using AURORA in 1999 for power costs then in 2003 for IRP and acquisitions.
- AURORA users include
  - Utilities, including investor-owned utilities (IOUs), publics, co-ops and municipalities
  - State public utility commissions, inter-state and federal agencies, system operators and other regional planning authorities
  - Traders, independent power producers (IPPs), developers and financial institutions
  - Consultants, universities and national labs

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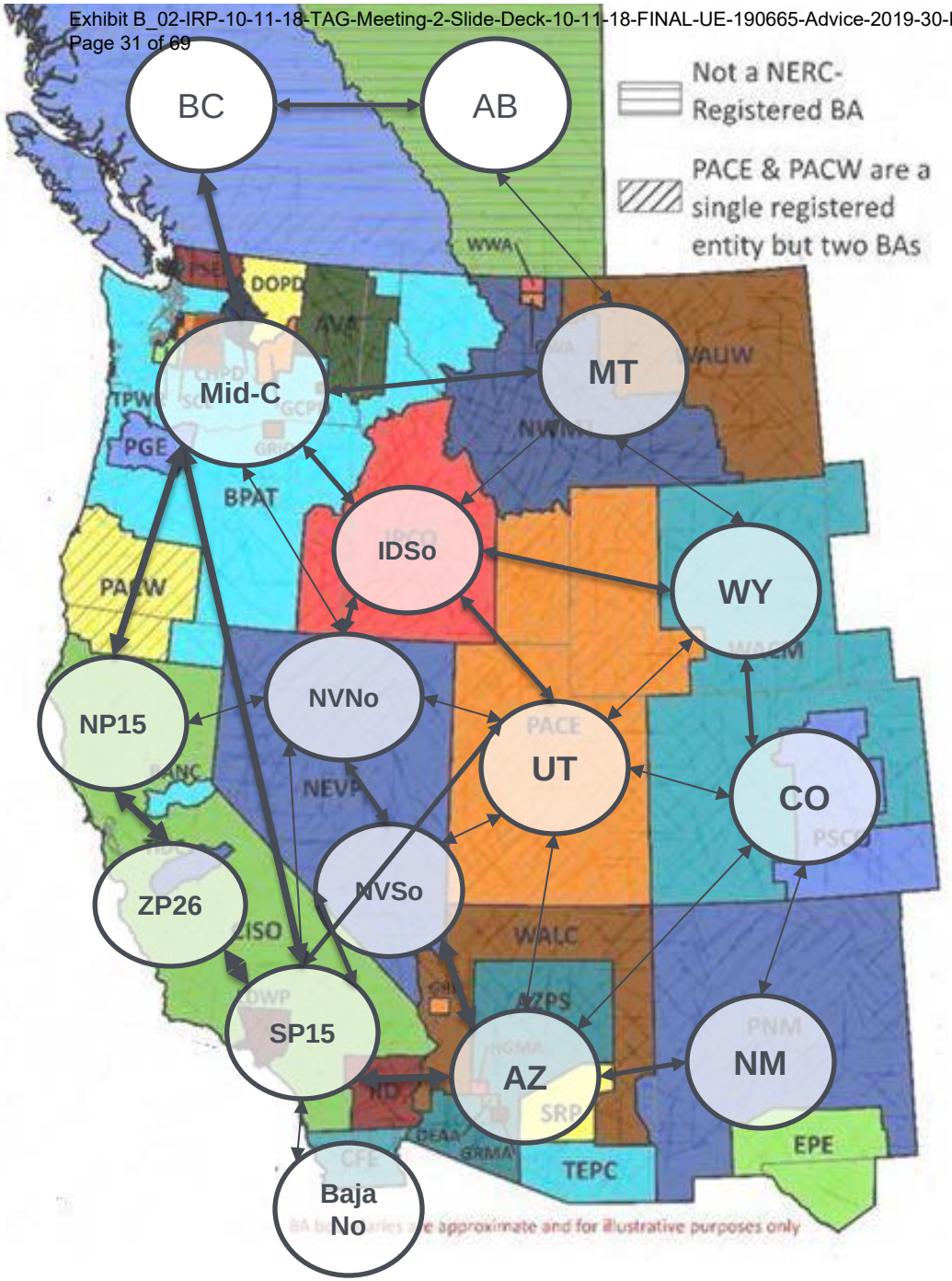

AURORA system diagram for WECC

The WECC system diagram provides an object view of each zone definition system being modeled. A system diagram has been created for all delivered zone definition systems.

Legend – Transmission Links:

< 650 MW	———
650 – 2000 MW	———
> 2000 MW	———

2019 IRP scenarios

Scenarios are created using combinations of:

- CO_2 prices
- Gas prices
- Regional electric demand

The different combination of inputs results in different power prices.

2019 IRP scenarios

	Scenario	Demand	Gas Price	CO2 Price	Notes
1	Base + No CO_2 Price Referred to as "Base + No CO_2"	Mid	Mid	None	Includes existing policies
2	Base + CO_2 Fee	Mid	Mid	I-1631	CO_2 fee applied across WECC
3	Base + Social CO_2 Price Referred to as "Base + Social CO_2"	Mid	Mid	Social ($42/metric ton – 2007$)	CO_2 price applied across WECC; cost of upstream emissions added to gas plants
4	Base + High Social CO_2 Price Referred to as "Base + High Social CO_2"	Mid	Mid	High Social ($62/metric ton – 2007$)	CO_2 price applied across WECC; cost of upstream emissions added to gas plants
5	Low	Low	Low	None	
6	High	High	High	High Social ($62/metric ton – 2007$)	CO_2 price applied across WECC; cost of upstream emissions added to gas plants

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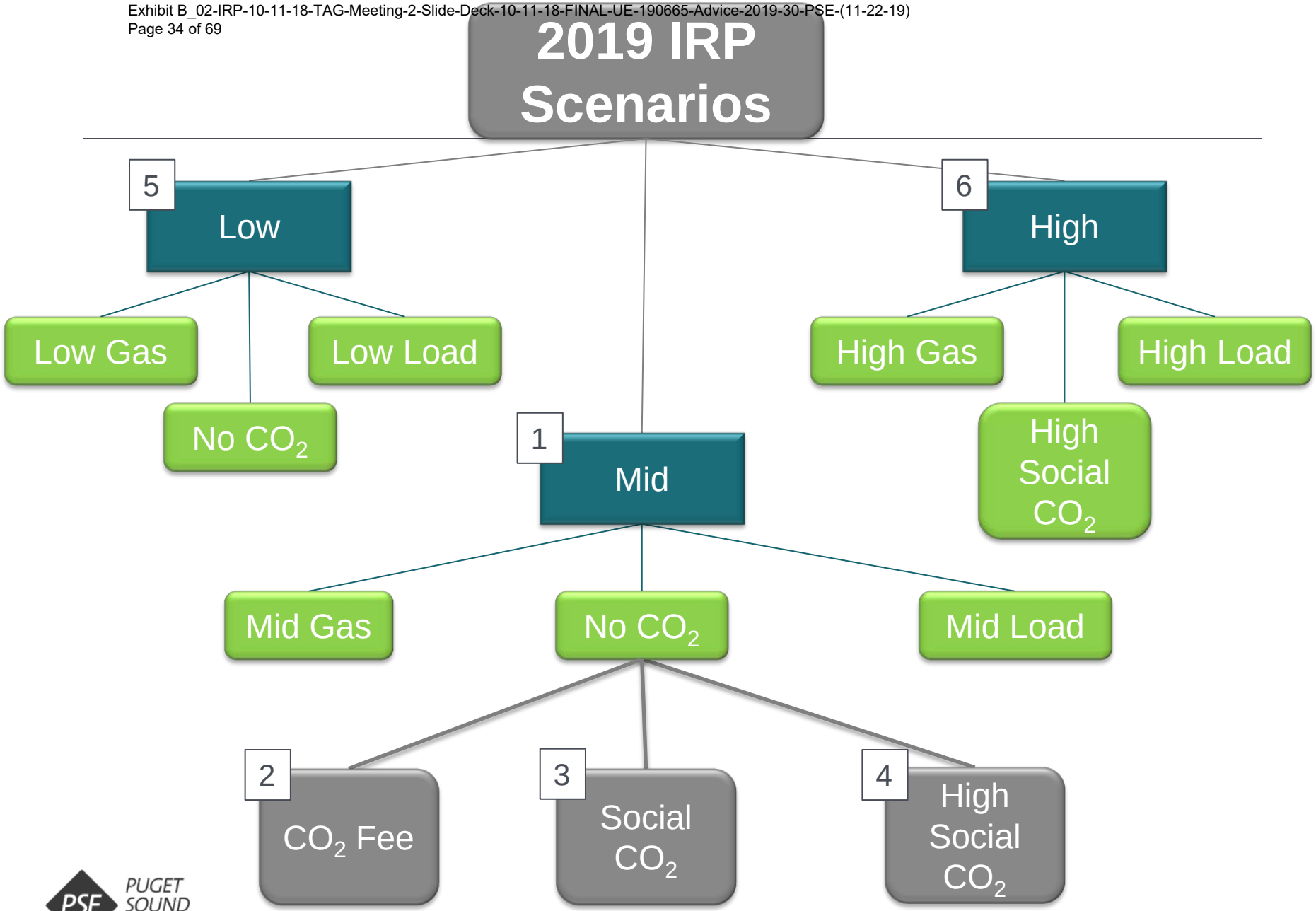
Note: All scenarios account for all existing policies such as state RPS requirements, CA AB32, and BC CO_2 policy



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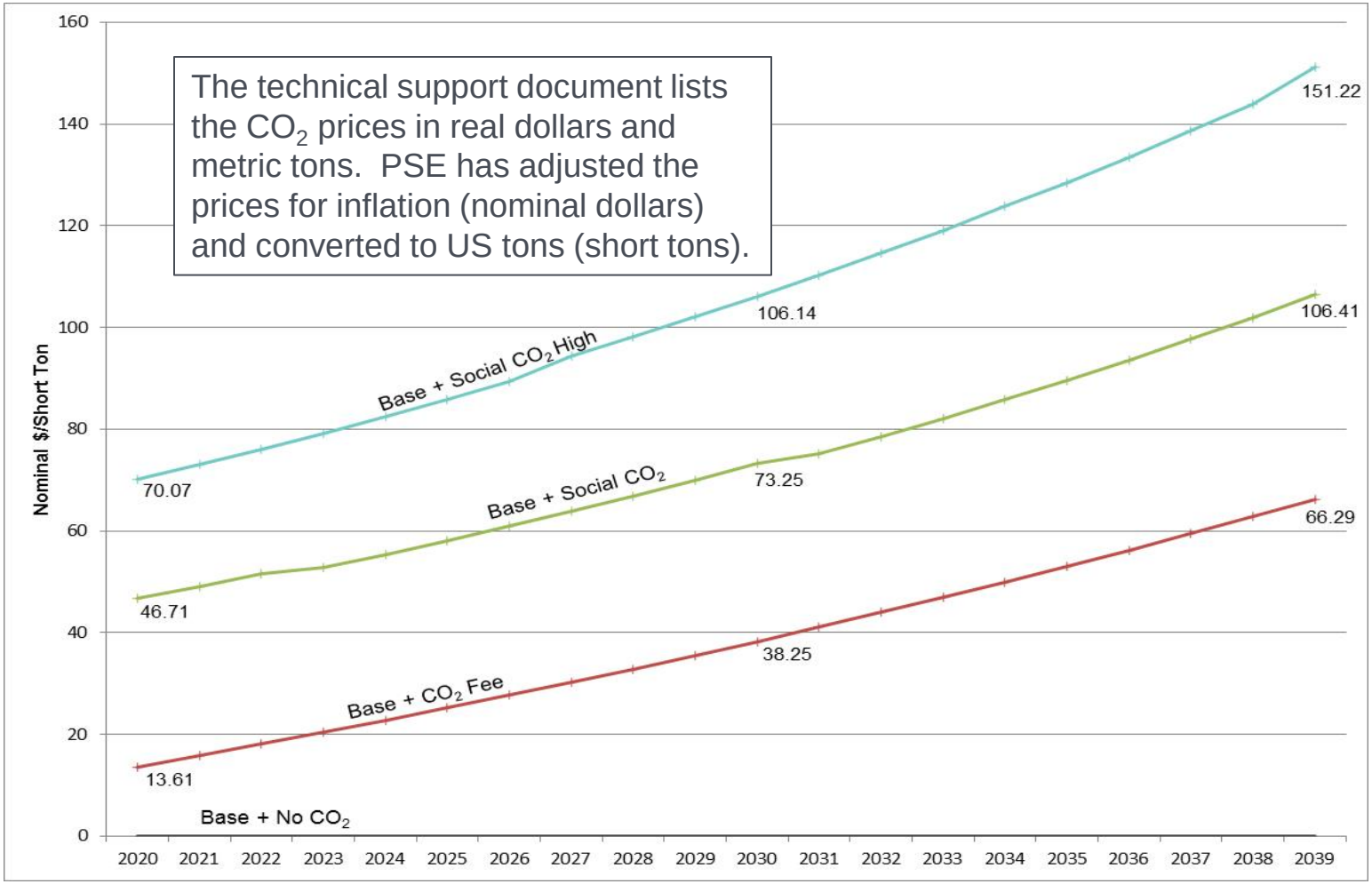
CO_2 prices (US ton)



What is levelized?

- Levelized – “average” power price over 20 years including the effects of the time value of money
- The 2019 IRP uses the time horizon 2020-2039, so levelized prices are in 2020 dollars

Upstream CO_2 emissions for natural gas

- Upstream CO_2 emissions applied to the natural gas in the social cost of carbon scenarios
- Includes production, processing and transmission from BC
- Uses Intergovernmental Panel on Climate Change Fourth Assessment Report (AR4) 100-year global warming potentials (GWP)
- EPA and Ecology directs reporting entities to use the AR4 100-year GWPs in their annual compliance reports
  - Specified in Table A-1 at 40 CFR 98 and WAC 173-441-040
- Table A-1 was used to convert each greenhouse gas into carbon dioxide equivalents (CO_2e)

PSE System Upstream CO_2e Emissions Rate: 0.009484 Metric tons/MMBtu	Social Cost of Carbon from Technical Support Document: $/Metric ton	20-yr Levelized ($/MMBtu)	
		Mid CO_2	$0.76
		High CO_2	$1.11

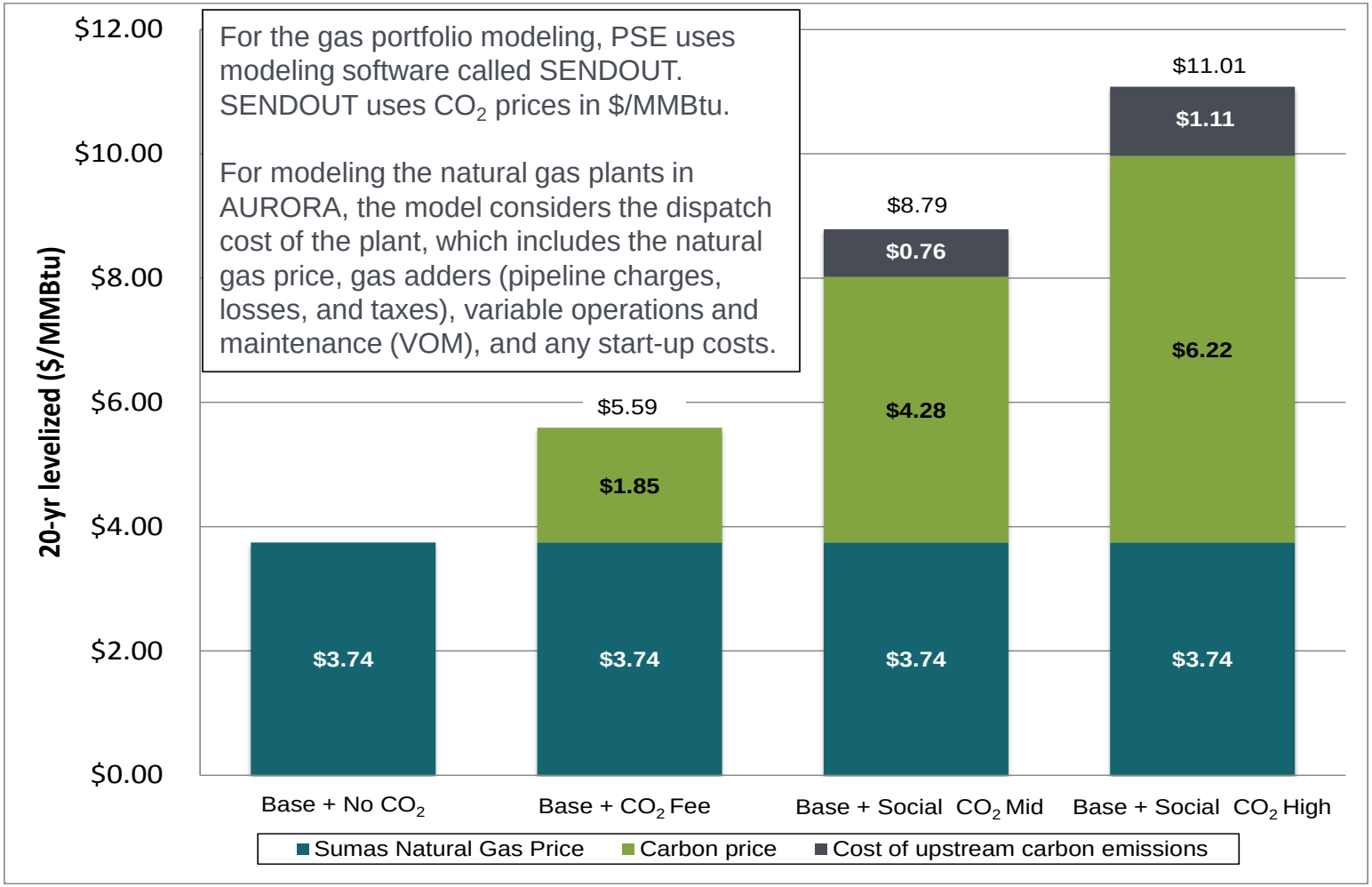
Natural gas prices at Sumas

MID GAS PRICES. From 2020-2023, this IRP uses the three-month average of forward marks for the period ending June 29, 2018. Forward marks reflect the price of gas being purchased at a given point in time for future delivery. Beyond 2023, this IRP uses Wood Mackenzie long-run, fundamentals-based gas price forecasts that were published in Spring 2018.
LOW GAS PRICES. These reflect forward marks from 2020-2023 forward marks and the Wood Mackenzie's low forecast beyond 2023.
HIGH GAS PRICES. Wood Mackenzie's high forecast 2020-2039.

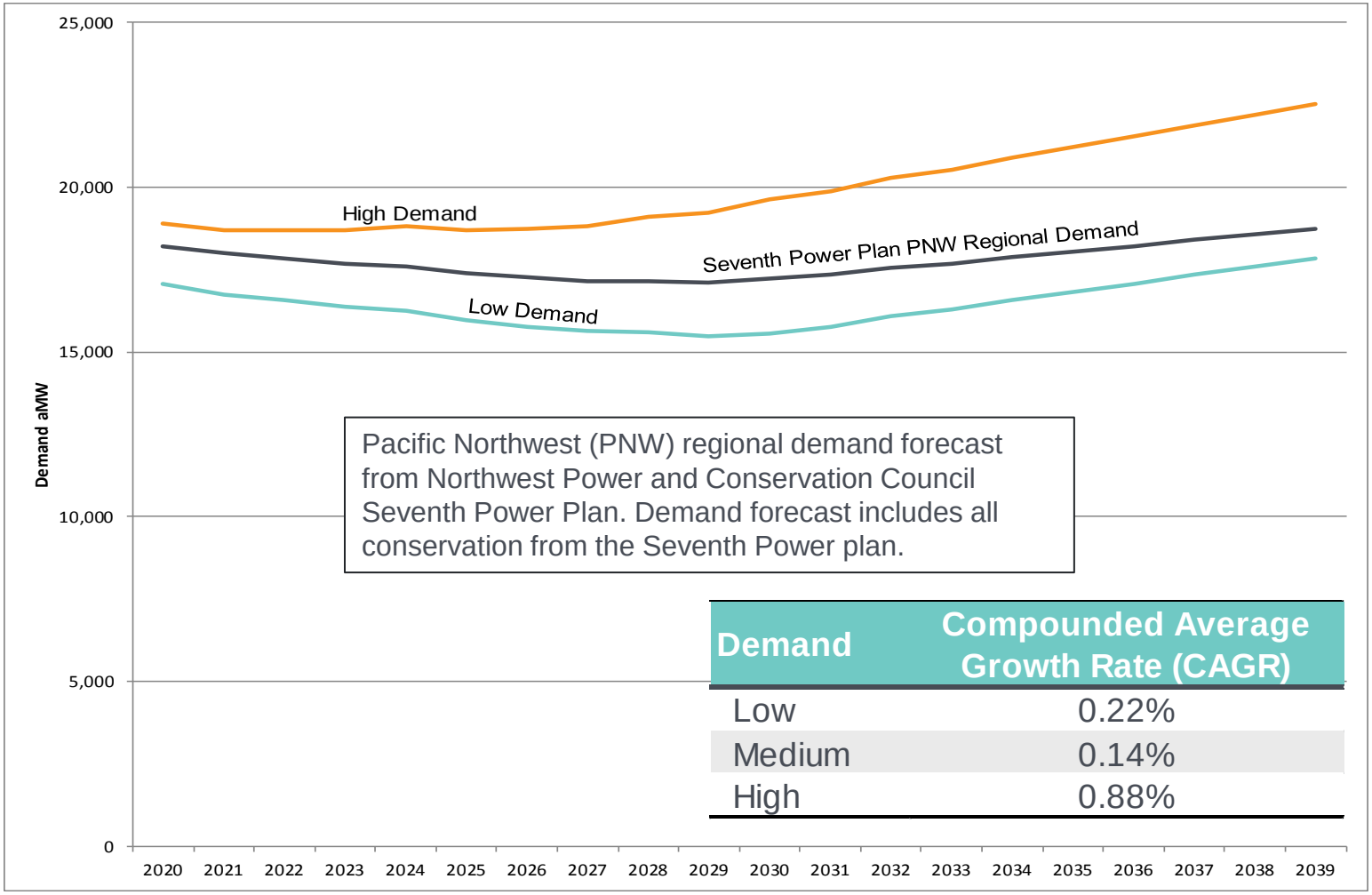
Effective natural gas prices at Sumas

For the gas portfolio modeling, PSE uses modeling software called SENDOUT. SENDOUT uses CO_2 prices in $/MMBtu.

For modeling the natural gas plants in AURORA, the model considers the dispatch cost of the plant, which includes the natural gas price, gas adders (pipeline charges, losses, and taxes), variable operations and maintenance (VOM), and any start-up costs.



Regional electric demand – Pacific Northwest



Pacific Northwest (PNW) regional demand forecast from Northwest Power and Conservation Council Seventh Power Plan. Demand forecast includes all conservation from the Seventh Power plan.

Demand	Compounded Average Growth Rate (CAGR)
Low	0.22%
Medium	0.14%
High	0.88%

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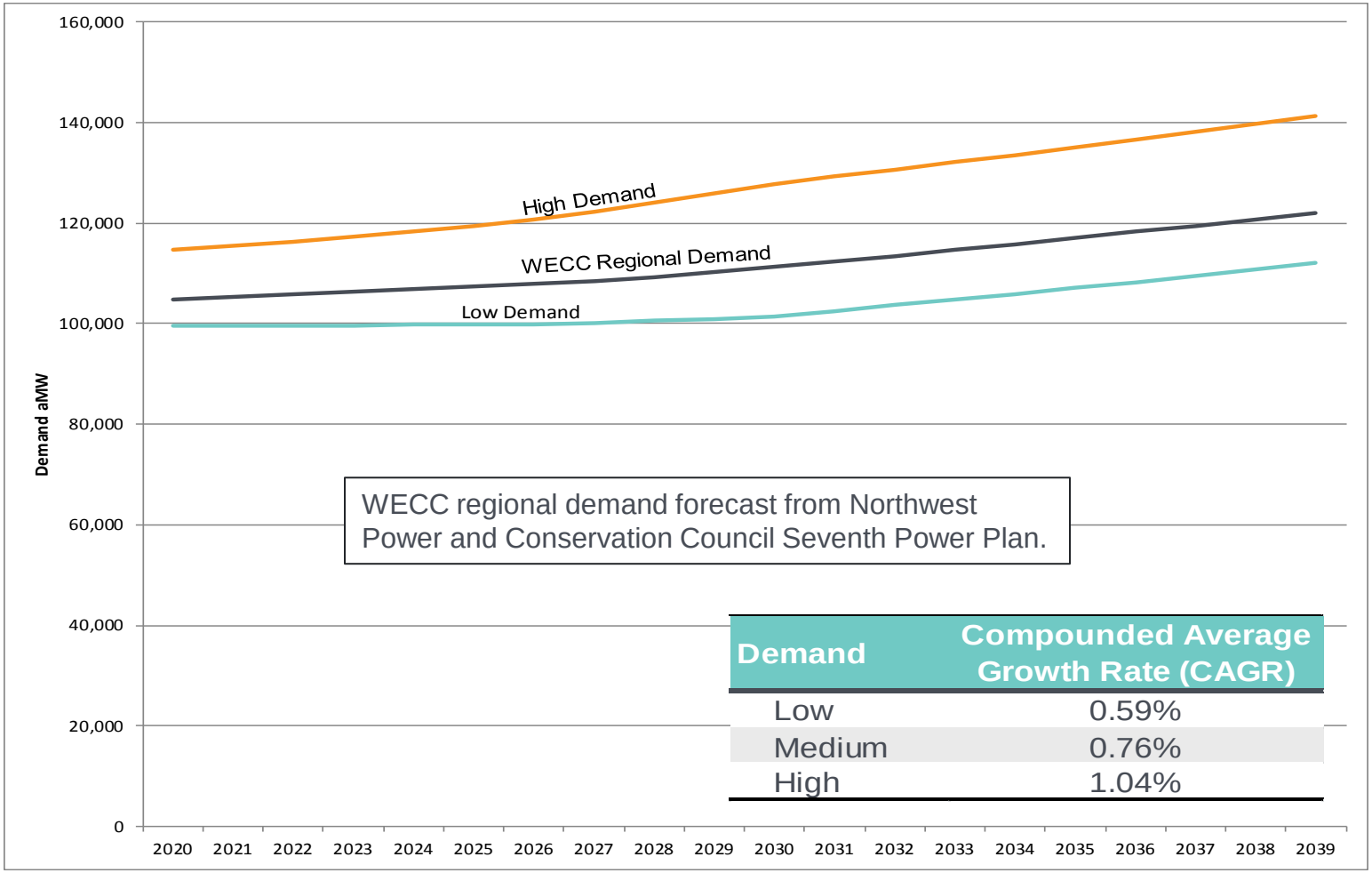
Regional electric demand – WECC



WECC regional demand forecast from Northwest Power and Conservation Council Seventh Power Plan.

Demand	Compounded Average Growth Rate (CAGR)
Low	0.59%
Medium	0.76%
High	1.04%

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2019 IRP scenarios

Scenarios are created using combinations of:

- CO_2 prices
- Gas prices
- Regional electric demand

The different combination of inputs results in different power prices.

Levelized power prices

Levelized – "average" power price over 20 years including the effects of the time value of money

Prices are in 2020 dollars

	Scenario	Mid-C Power Price Nominal ($/MWh)	Change from Base No CO_2 Price	% Change from Base No CO_2 Price
1	Base + No CO_2 Price	$33.92		
2	Base + CO_2 Fee	$43.62	$9.70	29%
3	Base + Social CO_2 Price	$60.14	$26.23	77%
4	Base + High Social CO_2 Price	$69.18	$35.26	104%
5	Low	$29.23	($4.69)	-14%
6	High	$81.23	$47.32	140%

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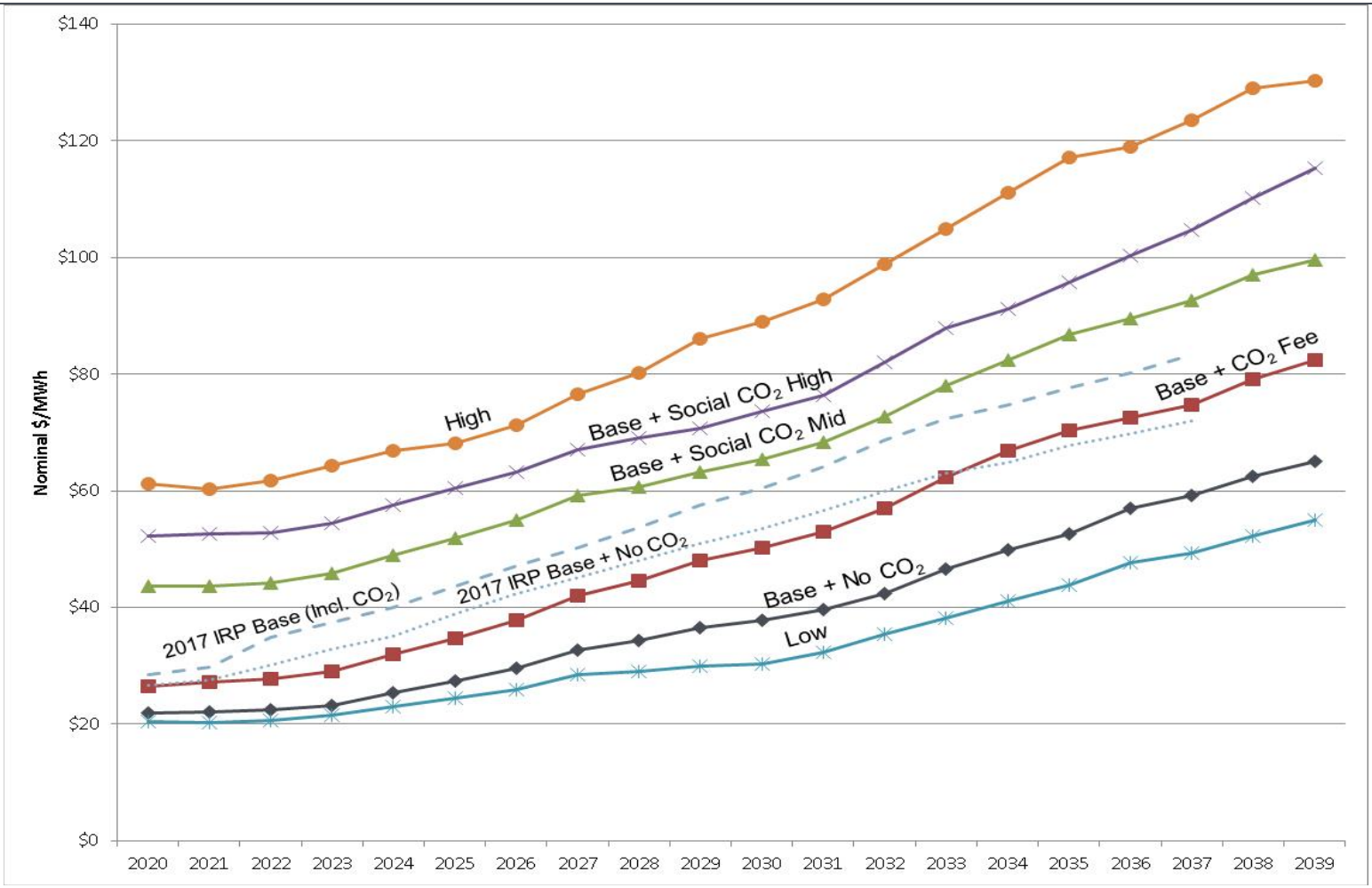
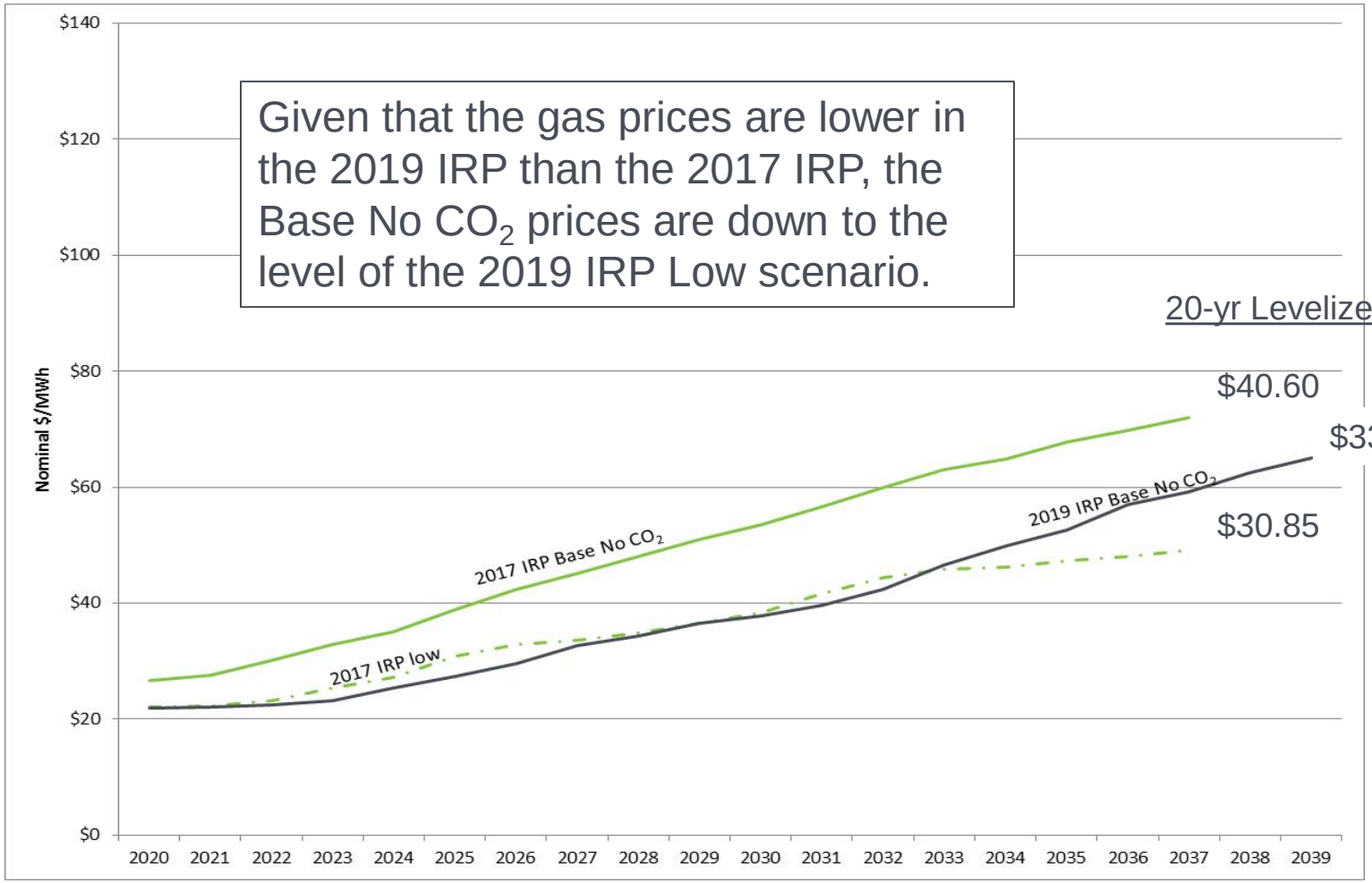
Annual power prices



2019 IRP power prices are down



Lunch break

Portfolio sensitivities

Portfolio sensitivities

- The purpose of the sensitivity is to test how different resources or environmental regulations change PSE's portfolio.

- Portfolio sensitivity analysis must be performed within a scenario and the results compared back to the least cost portfolio for that scenario.

- When looking at a sensitivity, PSE examines different aspects of how the portfolio changed, such as:
  - Resource mix
  - Portfolio cost
  - Portfolio emissions

PSE will consider sensitivities from the following list, but will not have time to complete all.

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Portfolio sensitivities for consideration

	Electric Sensitivities	
A	Colstrip retirement	1. Retire units 1 and 2 by the end of 2019 2. Retire units 3 and 4 by the end of 2025 3. Retire units 1 through 4 by the end of 2019
B	Clean Energy Standard	4. Adequate carbon free resources to fully cover PSE load under normal hydro by 2035 5. Must have non-emitting resources to meet all reliability needs by 2035
C	Stakeholder-requested alternative resource costs	6. Lower renewable resource costs than HDR report 7. New CCCT plants have 20-year life
D	Demand-side resources	8. Alternative discount rate 9. Value of conservation 10. Extended DSR potential
E	Planning adder	11. Social cost of carbon planning adder
F	Carbon abatement curve	12. Examine the cost of reducing CO_2 emissions
G	Declining market reliance	13. Reduction in reliance on short-term market to meet peak capacity

Portfolio sensitivities for consideration

	Combined Electric and Natural Gas Sensitivities	
A	CO_2 emission reduction	14. PSE Goal: 50% below 2016 levels by 2040 15. 80% below 2005 levels by 2035

	Natural Gas Sensitivities	
B	LNG	1. Examine potential effects if the Tacoma LNG facility does not go into service
C	Demand-side resources	2. Alternative discount rate 3. Value of conservation 4. Extended DSR potential

Natural gas resource alternatives

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Regional Overview

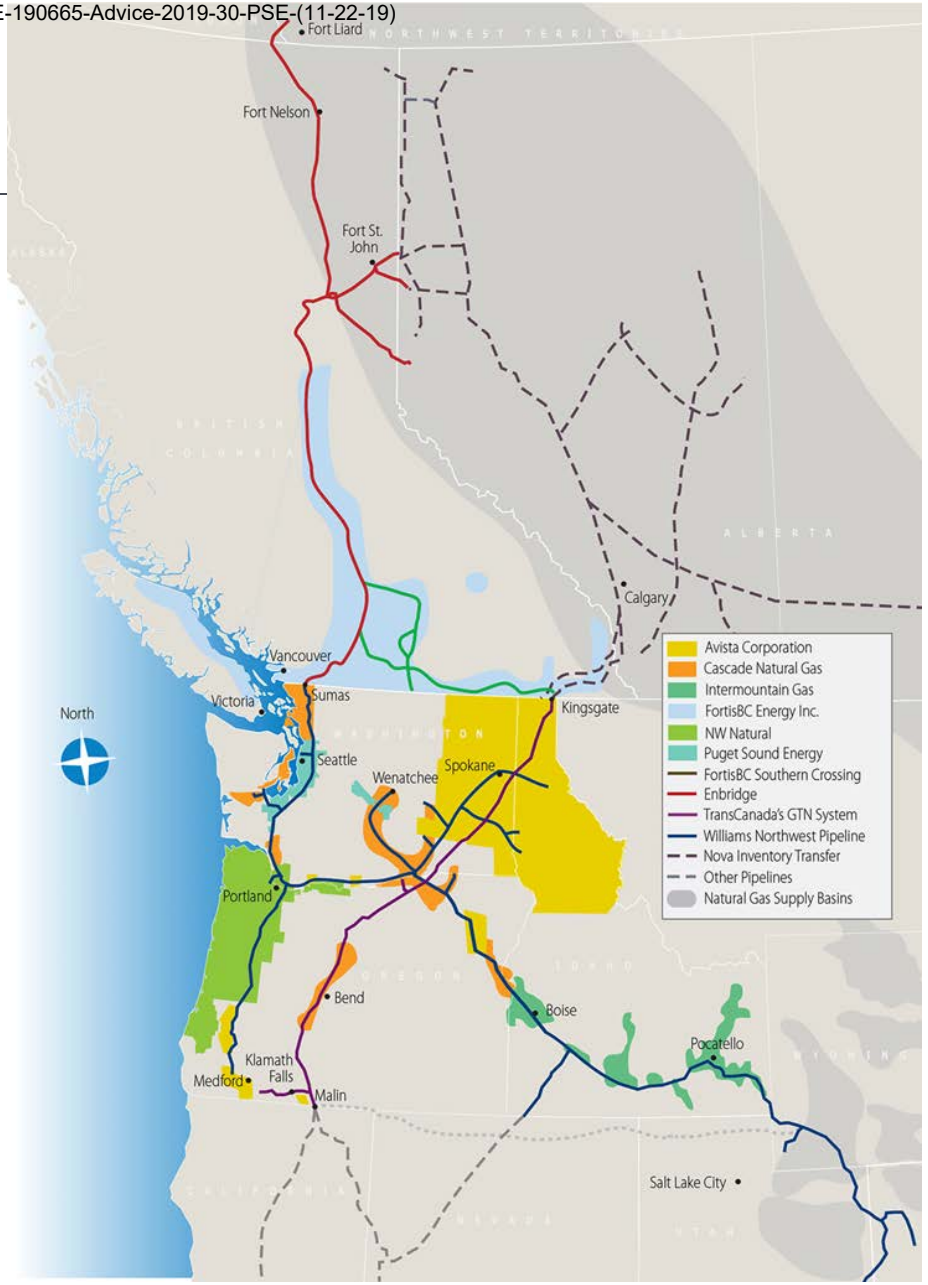
Supply basins and hubs:

- BC-Station 2
- BC-Sumas
- Alberta- NIT (AECO)
- Alberta at Stanfield
- Rockies- including Clay Basin Storage

Pipelines

- Northwest
- Westcoast
- GTN/Foothills/NGTL
- Cascade

There are 91,503 miles of gas pipeline in the region (Washington, Oregon and Idaho).



Long-term* supply resource alternatives

- Acquisition of other shippers' surplus pipeline and storage capacity
- New pipeline capacity from a liquid trading hub or storage facility
- On-system resources
  - SWARR propane air peaker upgrade
  - LNG distribution upgrade

Considerations

- Minimum construction time: four year lead time due to environmental risk and permitting
- If expansion of existing route, PSE contract could drive expansion
- If a new pipeline route or storage basin, a critical mass of new demand (250-500 MDth/d) is required (with timing not in PSE control)

* Long-term = 3 years or more

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Short-term supply resource alternatives

- Acquisition of other shippers' surplus pipeline capacity
- Acquisition of other shippers' surplus storage and pipeline capacity
- Gas supply delivered to PSE system (city gate)

Transportation pipeline pricing

- In the United States, new capacity is incrementally priced
  - rates on existing capacity remain unchanged

- In Canada, new capacity is “rolled-in” pricing
  - all capacity (old and new) share cost of new resource

2019 gas resource alternatives

Option 1	Purchase northern British Columbia gas at Station 2 and transport via expanded capacity on Westcoast, along with expanded capacity on Northwest Pipeline (NWP) south.	2023-on	assumed minimum 50,000 Dth/d
1a	*Option #1a – Purchase short term NWP TF-1 capacity from Sumas - compare to delivered product quotes.*	2019-2022	no minimum
Option 2	Purchase AECO gas and transport via expanded capacity on TC-AB (Nova) and TC-BC (Foothills) pipelines, along with the proposed Fortis BC Kingsvale -Oliver Reinforcement Project (KORP) and a NWP expansion.	2023-on	likely requires min. 250,000 Dth/d
Option 3	Purchase AECO gas and transport via expanded capacity on NGTL, Foothills and GTN, along with a new Cross-Cascades pipeline with a NWP expansion north.	2023-on	likely requires min. 350,000 Dth/d
Option 4	Purchase gas at Malin (Rockies via Ruby Pipeline or Alberta via GTN), transport by back-haul on GTN and transport on a new Cross-Cascades pipeline with a NWP expansion north.	2023-on	likely requires min. 350,000 Dth/d
Option 5	MIST Storage Expansion – lease capacity from NW Natural with expansion on NWP north.	2025 -on	assumed minimum 50,000 Dth/d

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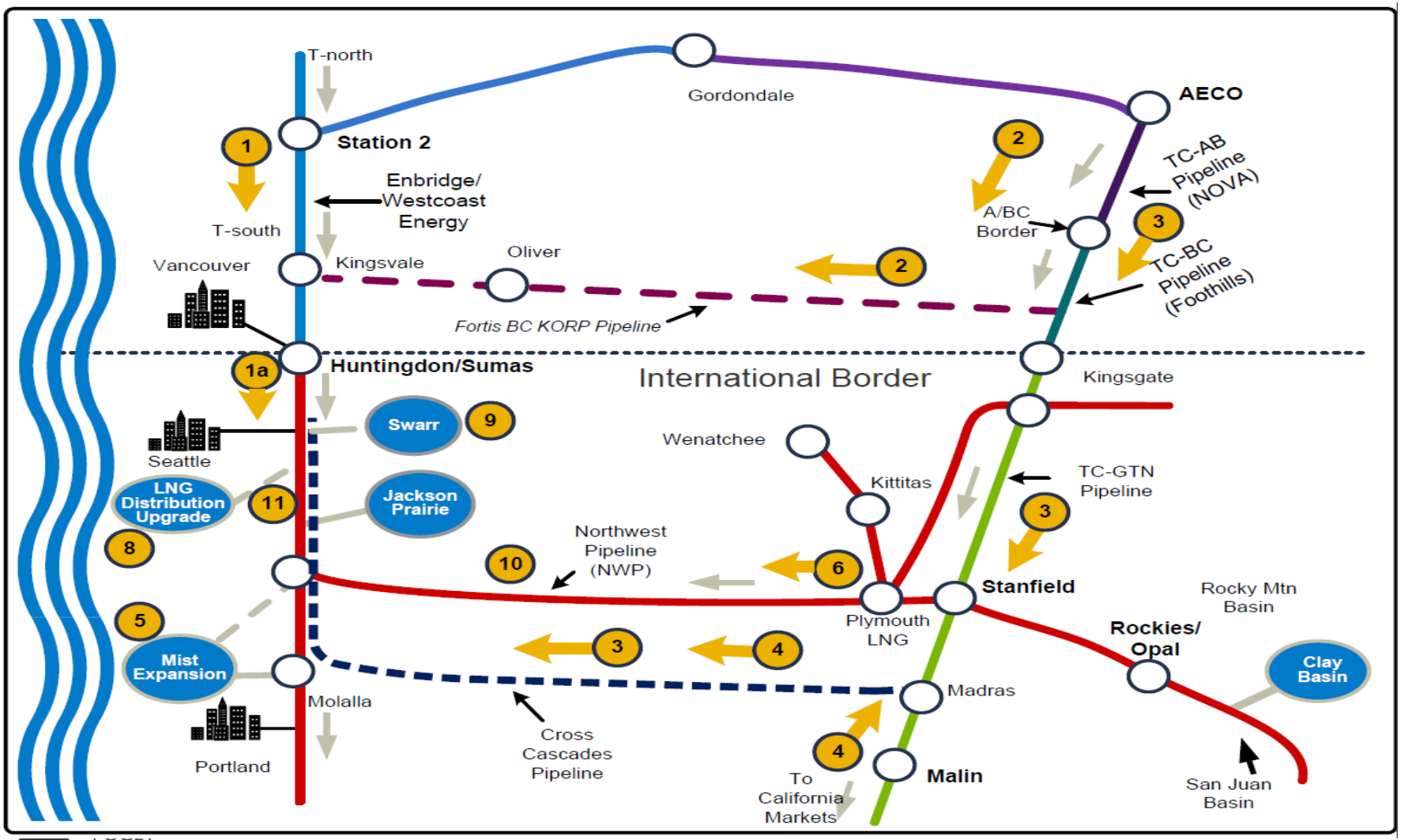
2019 gas resource alternatives (continued)

Option 6	Plymouth LNG and 15 MDth/d new firm pipeline capacity on NWP.	2020-on	fixed size, one-time
Option 7	Exchange 10 MDth/d Clay Basin storage capacity and matching firm pipeline capacity from the Rockies for comparable firm pipeline capacity from Stanfield.	2020-on	fixed size, one-time
Option 8	Upgrade of Tacoma Area distribution system, allowing additional 16 MDth/d of vaporization from Tacoma LNG.	2023-on	fixed size, one-time
Option 9	Upgrade & reactivate the existing Swarr LP-air facility to 30 MDth/d.	2022- on	fixed size, one-time
Option 10	Replace Sumas or Rockies supply (depending on project location) with Renewable Natural Gas connecting to NWP.	2021- on	Up to 5%
Option 11	Supplement supply (and avoid pipeline costs) with Renewable Natural Gas connecting directly to PSE system.	2021- on	Up to 5%

Map of gas resource alternatives



Renewable Natural Gas (RNG)

- Methane recovered from anaerobic decomposition of waste
- Processed to pipeline quality and used as a substitute for natural gas
- Major Sources:

	Value of credits ($/Dth)
• Landfill gas (LFG)	$20-$35*
• Dairy manure digesters (Dairy)	$20-$35*
• Waste-water treatment plants (WWTP)	$20-$35*
• Agricultural/food digesters (Ag/Food)	$5-$10*

*only if used as vehicle fuel

- Most projects today are supplying vehicle fueling programs
  - US EPA - Renewable Fuel Standards II program
    - RINs – renewable identification number
  - California Low Carbon Fuel Standards (CaLCFS)

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Source dependent reduction of carbon intensity

Carbon Intensity – grams CO_2e/MMbtu

	Source	Use	Total	Reduction
Natural Gas	13,779	66,202	79,981	
LFG – RNG	(49,307)	66,202	16,895	63,086
Dairy – RNG	(90,778)	66,202	(24,576)	104,557
WWTP - RNG	(105,017)	66,202	(38,815)	118,796

Please note that these are preliminary values and further verification is underway.

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RNG challenges

- Limited supply
- Higher cost than natural gas (five to eight times)
  - Processing equipment to reach pipeline quality (beyond vehicle quality) is expensive
  - Compression equipment and pipeline and metering costs (to get from remote locations to high pressure pipeline) and significant

- Under consideration by PSE
  - Spreading connection costs to all customers
  - Offering an opt-in program for RNG like PSE's Green Power
  - Offering a dedicated RNG portfolio similar to PSE's Green Direct

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Next steps

Next steps

Date	Action
October 25	PSE posts draft meeting notes with action items on IRP website and distributes draft meeting notes to TAG members
November 1	TAG members review meeting notes and provide comments to PSE
November 8	PSE posts final meeting notes on IRP website: www.pse.com/irp

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THANK YOU

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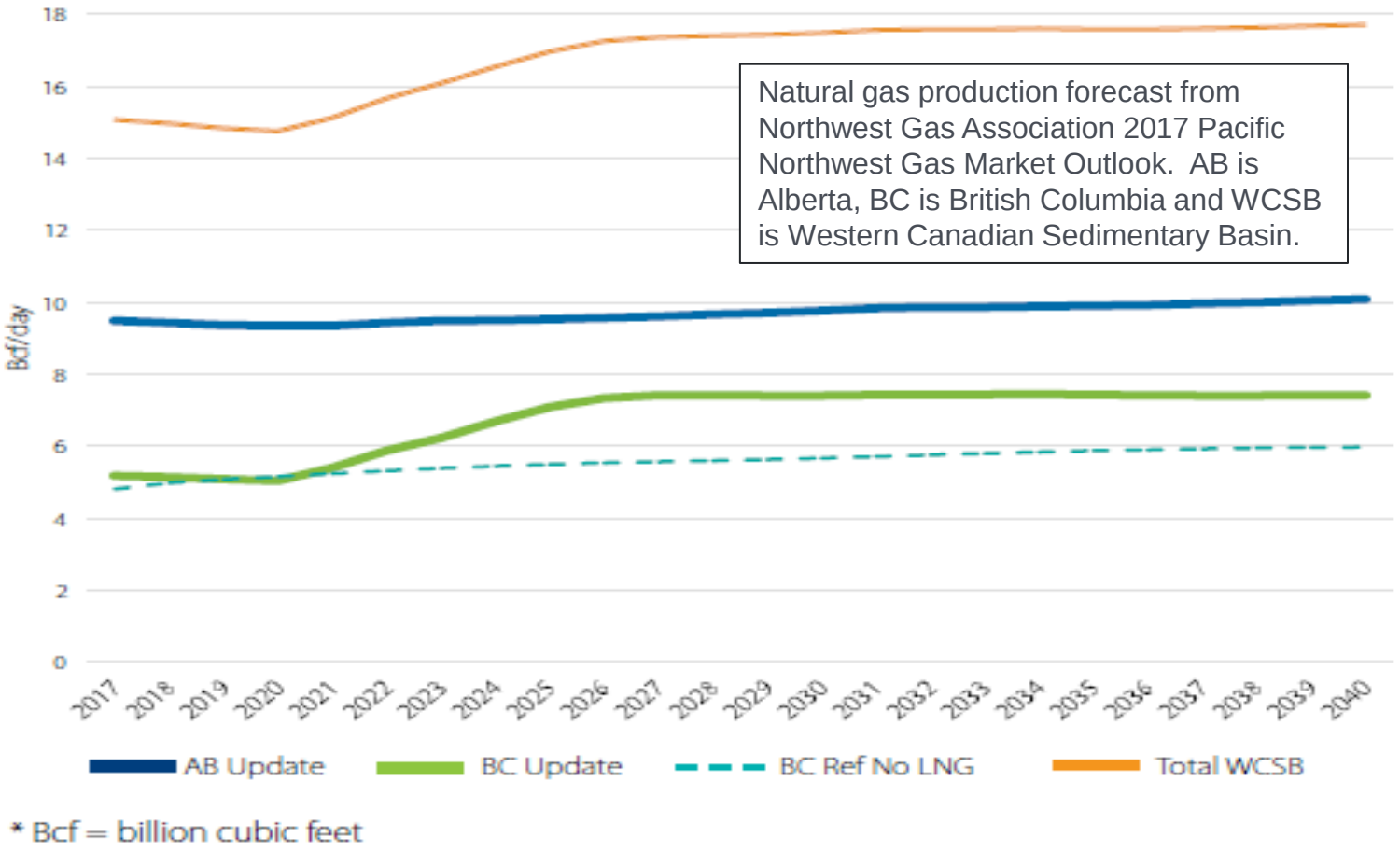
IRP comment period

October 11, 2018 TAG #2

Appendix

Natural gas production by basin: Alberta and British Columbia



* Bcf = billion cubic feet

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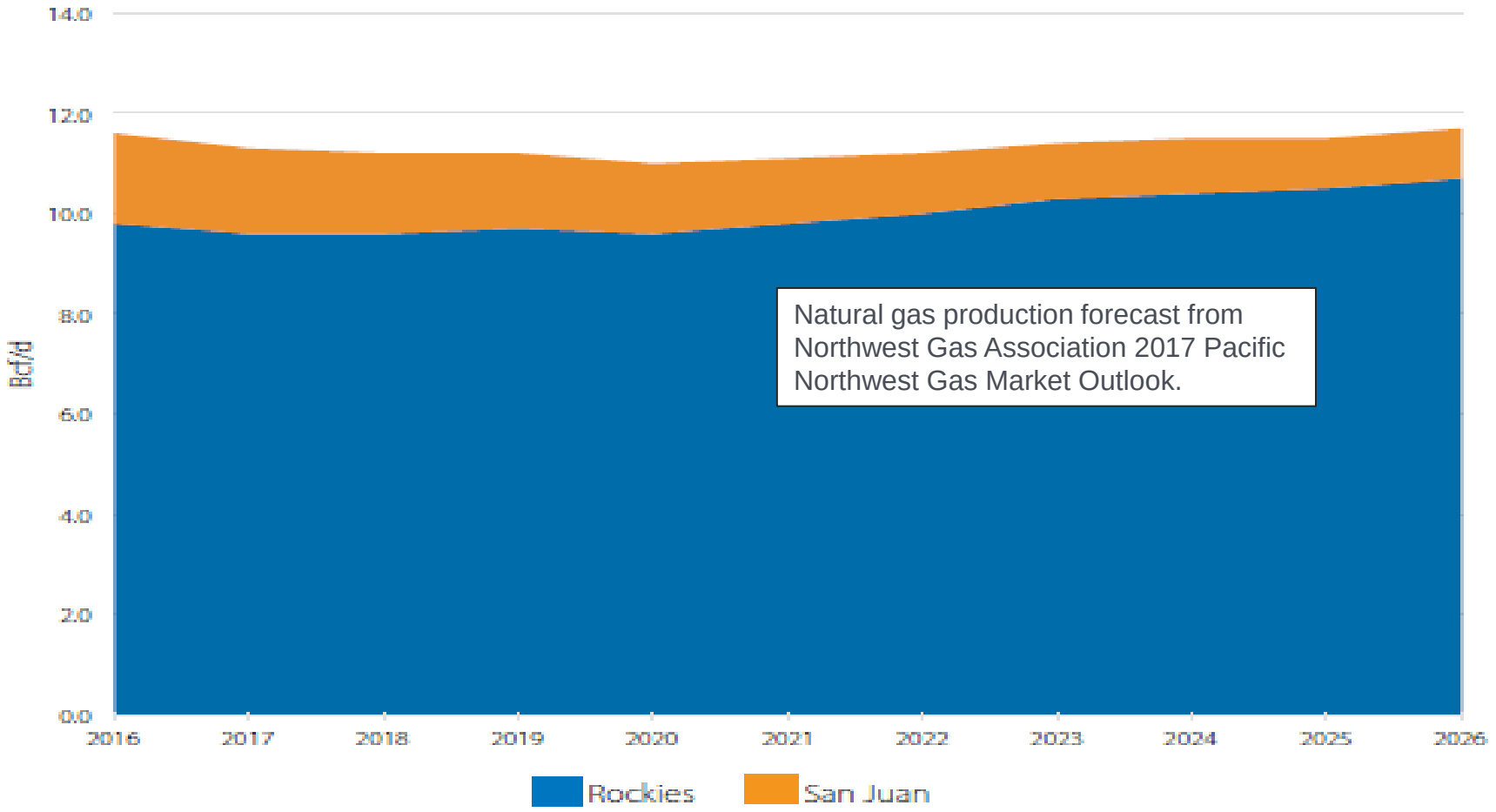
Natural gas production by basin: Rockies and San Juan



PUGET SOUND ENERGY

Western natural gas infrastructure