2019 TAG Meeting #4:
System planning (transmission and distribution), portfolio sensitivities, and load forecast

January 9, 2019 TAG #4

Welcome

- Opening remarks
- Safety message
- Introductions

Meeting objectives

- PSE presents the status and progress for system planning commitments in the 2019 IRP and changes PSE is making to incorporate non-wire alternatives and distributed energy resources into the baseline process
- PSE presents the proposed portfolio sensitivities to be modeled in the 2019 IRP
- PSE explains the load forecast methodology and results

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Action items from prior IRPAG and TAG meetings

Open action items from previous IRPAG and TAG meetings

Action item #	Description (and meeting reference)	PSE action	Status
1	Identify contact for PSE's carbon reduction goals. (IRPAG #1, May 30, 2018)	PSE will include a listening session at the March 18, 2019 IRPAG meeting #3.	In progress
2	Include carbon impact in scenarios or sensitivities. (IRPAG #1, May 30, 2018 and TAG #2, October 11, 2018)	PSE will model various carbon impacts.	Complete
3	Investigate converting the gas emission rate to a percentage. (TAG #2, October 11, 2018 and TAG #3, December 6, 2018)	PSE will include gas emission rate as a percentage in the draft IRP and the final IRP.	Complete; information distributed via email

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Open action items from previous IRPAG and TAG meetings

Action item #	Description (and meeting reference)	PSE action	Status
4	Provide graphics to illustrate the IRP process. (TAG #2, October 11, 2018)	PSE provided a graphic at the December 6 TAG meeting and relevant graphics will be provided throughout the rest of the 2019 IRP process.	Complete
5	Distribute the updated sensitivity handout on October 19. (TAG #2, October 11, 2018)	PSE distributed the portfolio sensitivities for consideration on October 19 to the TAG members via email.	Complete
6	Provide an updated IRP stakeholder meeting schedule by December 31, 2018. (TAG #3, December 6, 2018)	PSE uploaded the revised schedule to www.pse.com/irp by 12/31/18.	Complete

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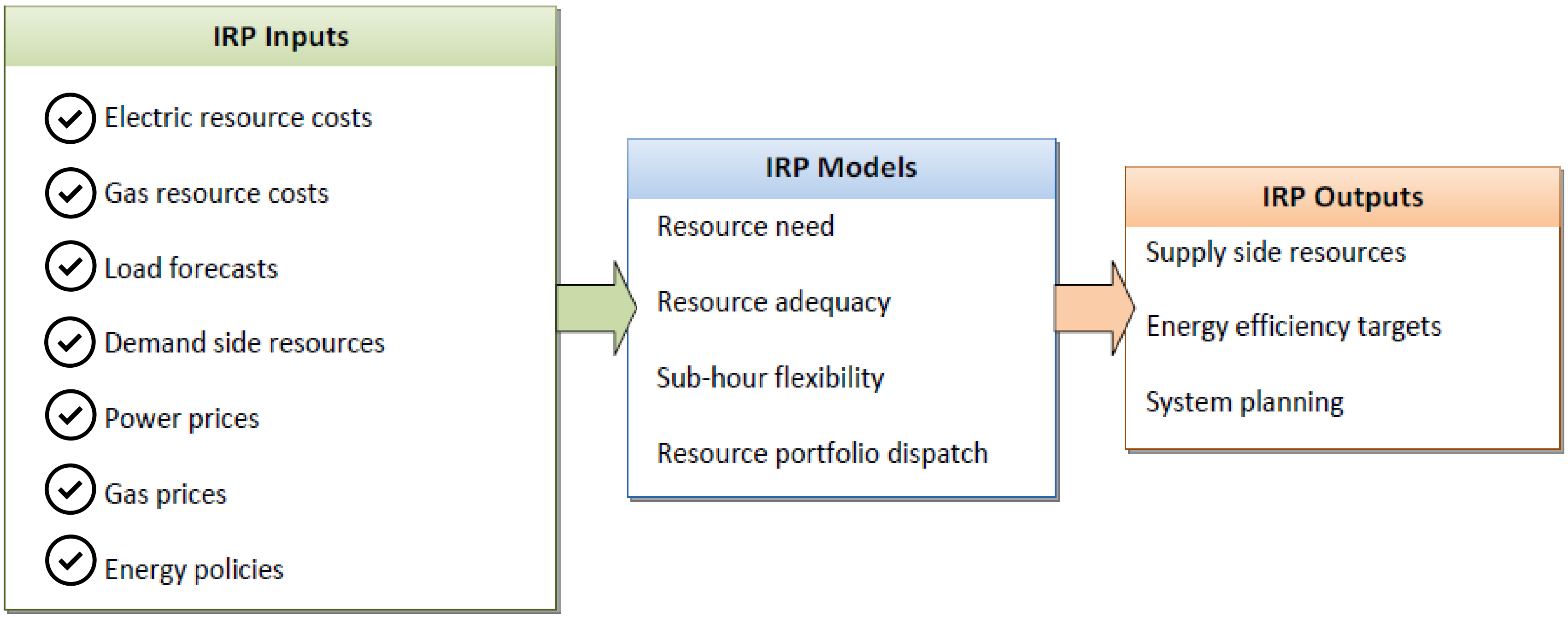
Open action items from previous IRPAG and TAG meetings

Action item #	Description (and meeting reference)	PSE action	Status
7	Provide a description of the difference between the 2017 and 2019 combined heat and power potential prior to the May 15, 2019 Draft IRP. (TAG #3, December 6, 2018)	PSE will provide the description by March 29, 2019.	In progress
8	Consider Lohr's request to post and redistribute questions and answers that PSE receives. (TAG #3, December 6, 2018)	PSE will not redistribute information and take liability of information that may be inaccurate.	Complete
9	Finalize meeting notes from TAG #3. (TAG #3, December 6, 2018).	PSE distributed the meeting notes on December 20; stakeholders provided feedback by December 27; and PSE posted the notes on January 3, 2019.	Complete

IRP analytical process overview

- PSE has established an analytical framework to develop its **20-year forecast of demand side resources and supply side resources** that appear to be cost effective to meet the growing needs of our customers.



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System Planning
(transmission and distribution)

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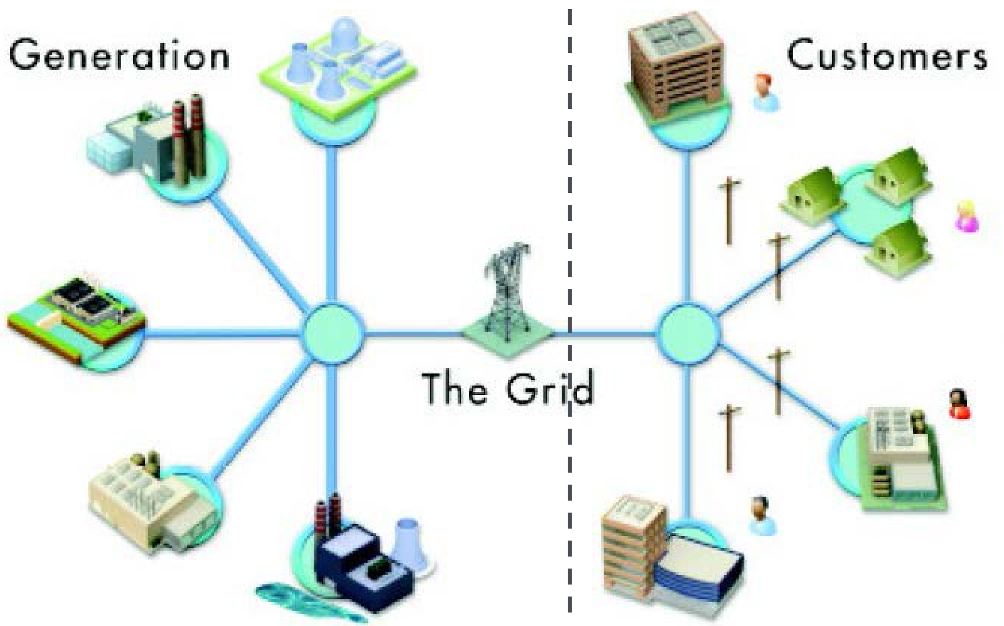
IRP and Delivery System planning different but linked closely

- Integrated Resource Planning (IRP) optimizes resources which deliver power to grid
- Delivery System Planning (DSP) ensures that electricity gets to our customers



Existing grid design – push power to customers
EPRI - 2014

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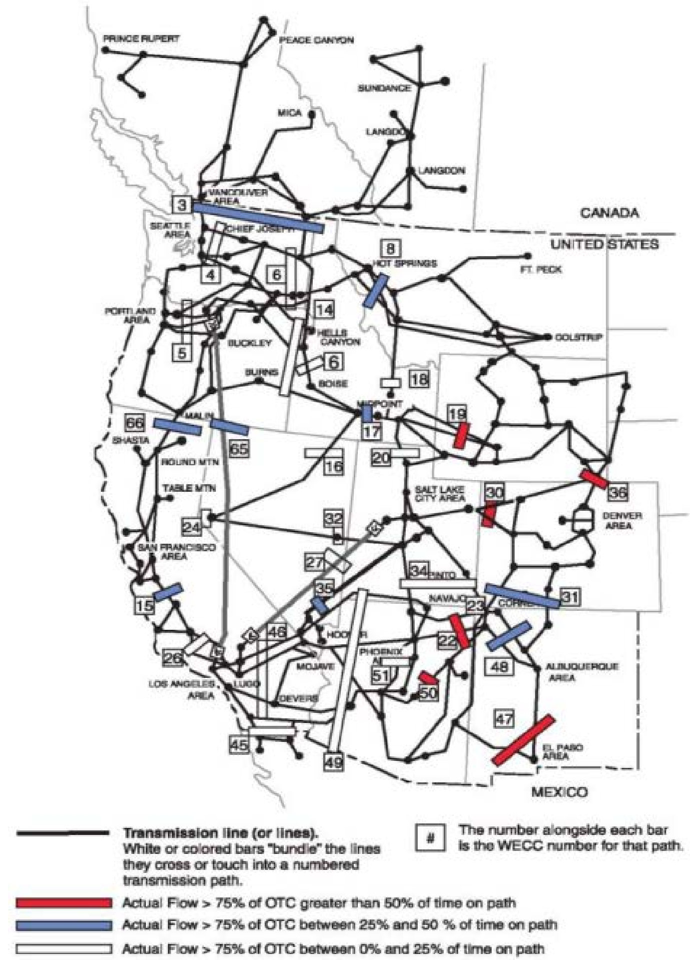
Electric utility transmission planning

- Transmission planning performed by electric utilities for the bulk electric system (generally lines above 100kV)
- Analysis performed by utilities certified by NERC and WECC
- Analysis must include effects on PSE system as well as neighboring utilities in WECC
- ColumbiaGrid is the regional planning entity



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NERC - North American Electric Reliability Corporation
WECC – Western Electricity Coordinating Council

Why we plan - objectives

- Meet our customer’s energy and capacity requirements in a safe and reliable manner at all times.
  - Greatest need is at system peak
  - Annual NERC Transmission Planning (TPL) studies examine needs over 10-year time horizon
- Must also satisfy NERC and WECC requirements so that outages do not affect other WECC utilities
- Expand system in cost effective manner

Why we plan - impacts

- Failure to reliably serve load can result in
  - Significant economic loss
  - Public safety risks to our customers
- Cost of outages
  - E-Source study estimated that power outages cost businesses $27 billion in 2016
  - Outages increasing over time –Eaton's 2017 Blackout Tracker
    - 2009 - 2,840 outage events which affected ~13 million people
    - 2017 – 3,526 outage events which affected ~37 million people

Why we plan – requirements

- PSE obligated to serve - RCW 80.28.110
- Must comply with NERC and WECC reliability standards

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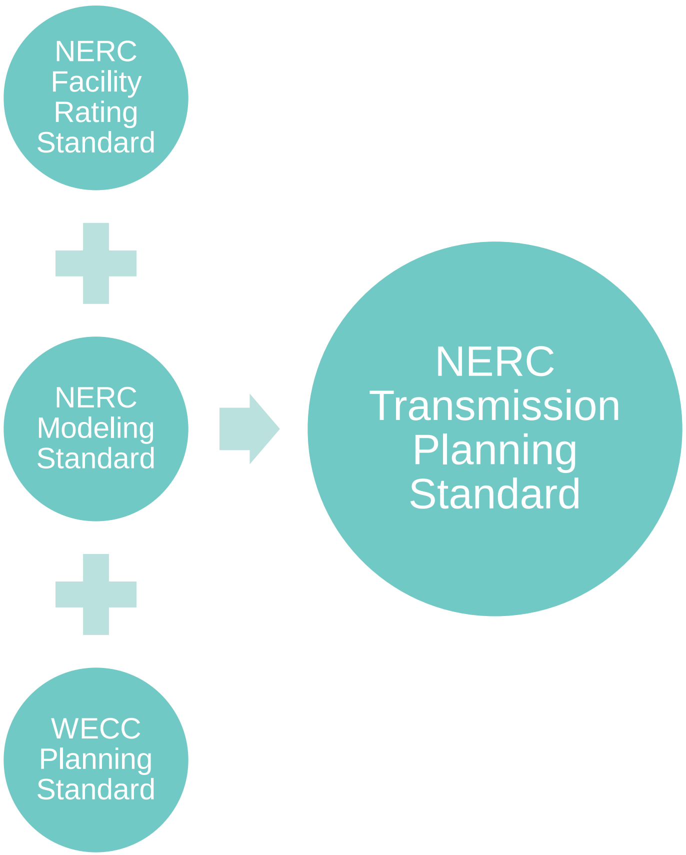
NERC Standards 101

- NERC develops and enforces standards for interconnected utilities
  - Planning standards are designed to ensure a reliable and secure transmission system



Delivery System Planning (DSP):
How we determine grid needs and capacity

System Evaluation

System performance
Load forecasts
External Inputs Goals
Commitments

System needs, modeling & analysis

Issue(s) identification
System modeling
Probabilistic outcomes
Alternatives Financial analysis Cost / Benefit

Alternatives & recommended solution

Peer and management review

Optimize with other projects

Investment Decision Optimization Tool process
Resource planning

Final Plan: portfolio of projects

Management review and approval

Project Implementation

Mobilize resources to complete project

Study frequency: Annual TPL studies examine needs over 10-year time horizon

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PSE planned major projects

- Multiple delivery projects in-flight in various stages: planning, implementation, or closeout

Project Name	Est in Svc.
White River – Electron Heights 115 kV Line Re-rte to Alderton (Phs 2)	2018
Pierce County Transformer Addition	2018
Talbot 230 kV Bus Improvements (Phase 2)	2018
Bellingham 115 kV Substation Rebuild	2019
Lake Hills – Phantom Lake New 115 kV Line	2019
Sammamish – Juanita New 115 kV Line	2020
Energize Eastside	2020
Electron Heights – Enumclaw 55-115 kV Conversion	2020
Sedro Woolley - Bellingham #4 115 kV Rebuild and Reconductor	2021
Bainbridge Island Transmission Project	2021
Lynden Substation Rebuild and Install Circuit Breaker 2023	2022
Kent / Tukwila New Substation	2023
Black Diamond Area New Substation	2023
Issaquah Area New Substation	2023
West Kitsap Transmission Project	2023
Bellevue Area New Substation	2024
Spurgeon Creek Transmission Substation Development (Phase 2)	2024
Electron Heights - Yelm Transmission Project	2024
Inglewood – Juanita Capacity Project	2025

Traditional drivers of DSP

Traditional drivers/criteria

- Customer request
- Growth
- Reliability
- Compliance
- NERC & WECC rules
- Aging Infrastructure
- Integration of resources

Electric delivery system performance criteria are defined by:
Safety and compliance
The temperature at which the system is expected to perform
The nature of service and level of reliability that each type of customer is contracted for
The minimum voltage that must be maintained in the system
The maximum voltage acceptable in the system
The interconnectivity with other utility systems and resulting requirements, including compliance with NERC planning standards

New opportunities for DSP

- Transmission infrastructure is increasingly difficult and time consuming to build
- PSE DSP must adapt to changing mix and locations of resources and still meet the needs of its customers
  - Not your stodgy utility anymore!

PSE is committed to develop a modern grid that will enable our customers flexibility to use DER, storage and EVs

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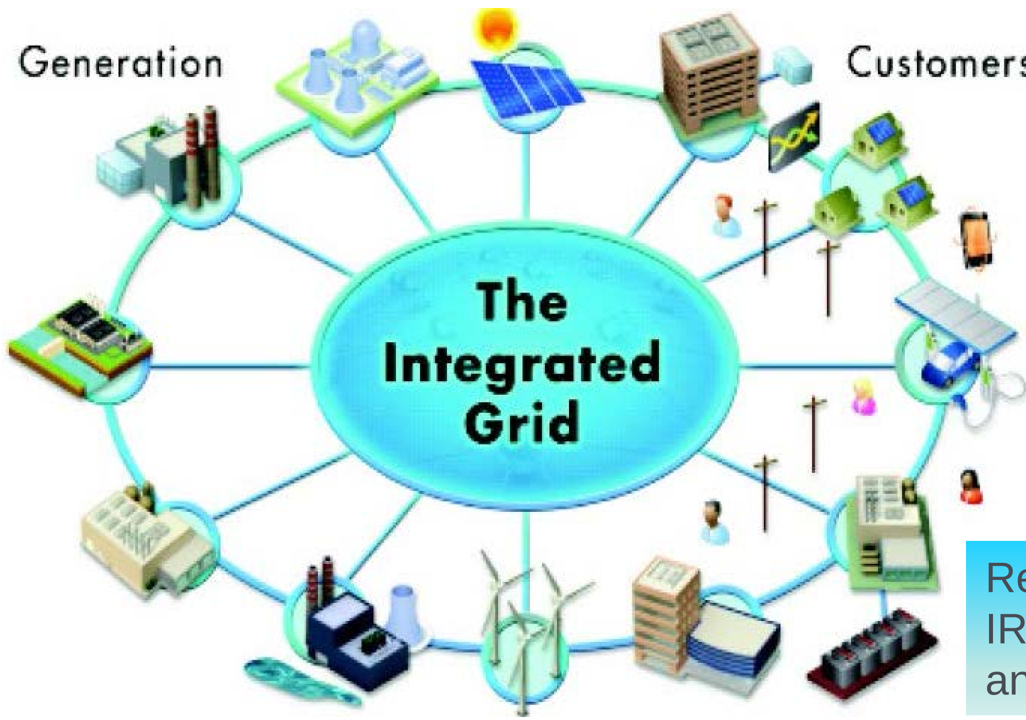
DSP drivers of change

- PSE grid modernization efforts have the following opportunities:
  - Solar & wind require 2-3 times more capacity than thermal
  - Grid-scale renewable resources require transmission specific to their needs
  - Robust distribution network is needed to support high penetration of customer-connected renewables
  - There is potential for new laws which mandate more renewable resources
  - There is potential for explosive growth in EV along with moderate growth in residential/small commercial rooftop solar with storage would require redesign of local grid to permit two-way flow of power

Transformed DSP will build to new grid model

- DSP will build to a grid with extensive penetration of DER and two flow of electricity.



Requires inputs from IRP – value of capacity and energy, etc.

Future grid design – two –way power flows with high DER/EV penetration
EPRI - 2014

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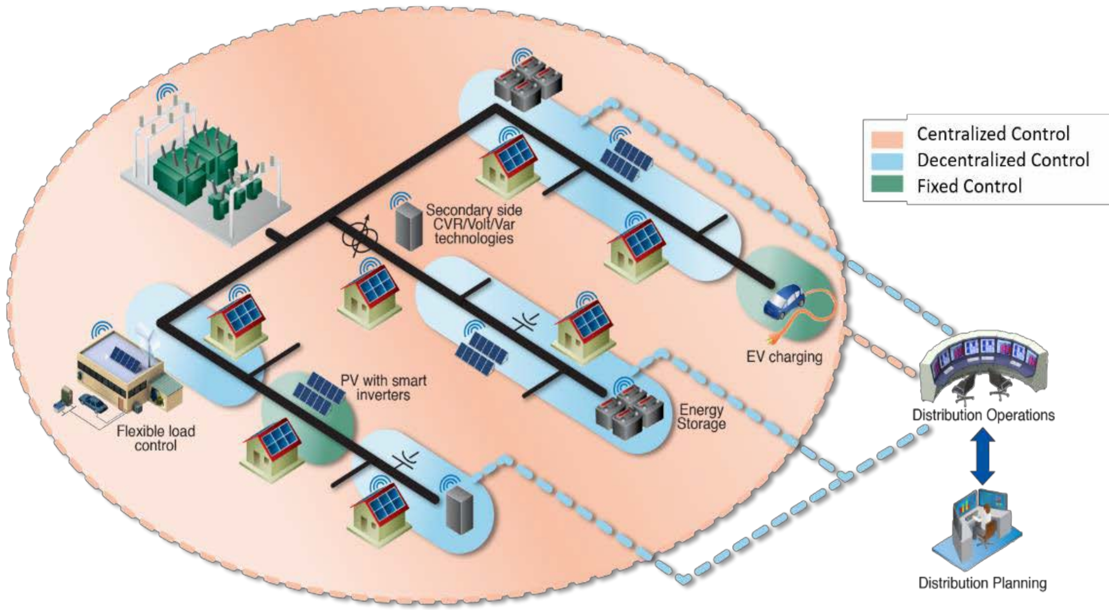
DSP will assess the potential for use of DER on all large projects

- DSP will be linked closely with IRP
- Goal is to examine NWA options for all major grid projects
- DSP will have a separate, open and transparent stakeholder involvement process
- DSP will be advised by team of nationally recognized technical experts from universities, research institutes and electric utilities



Team structure modeled after Hawaiian Electric Integrated Grid Planning Process Technical Advisory Committee

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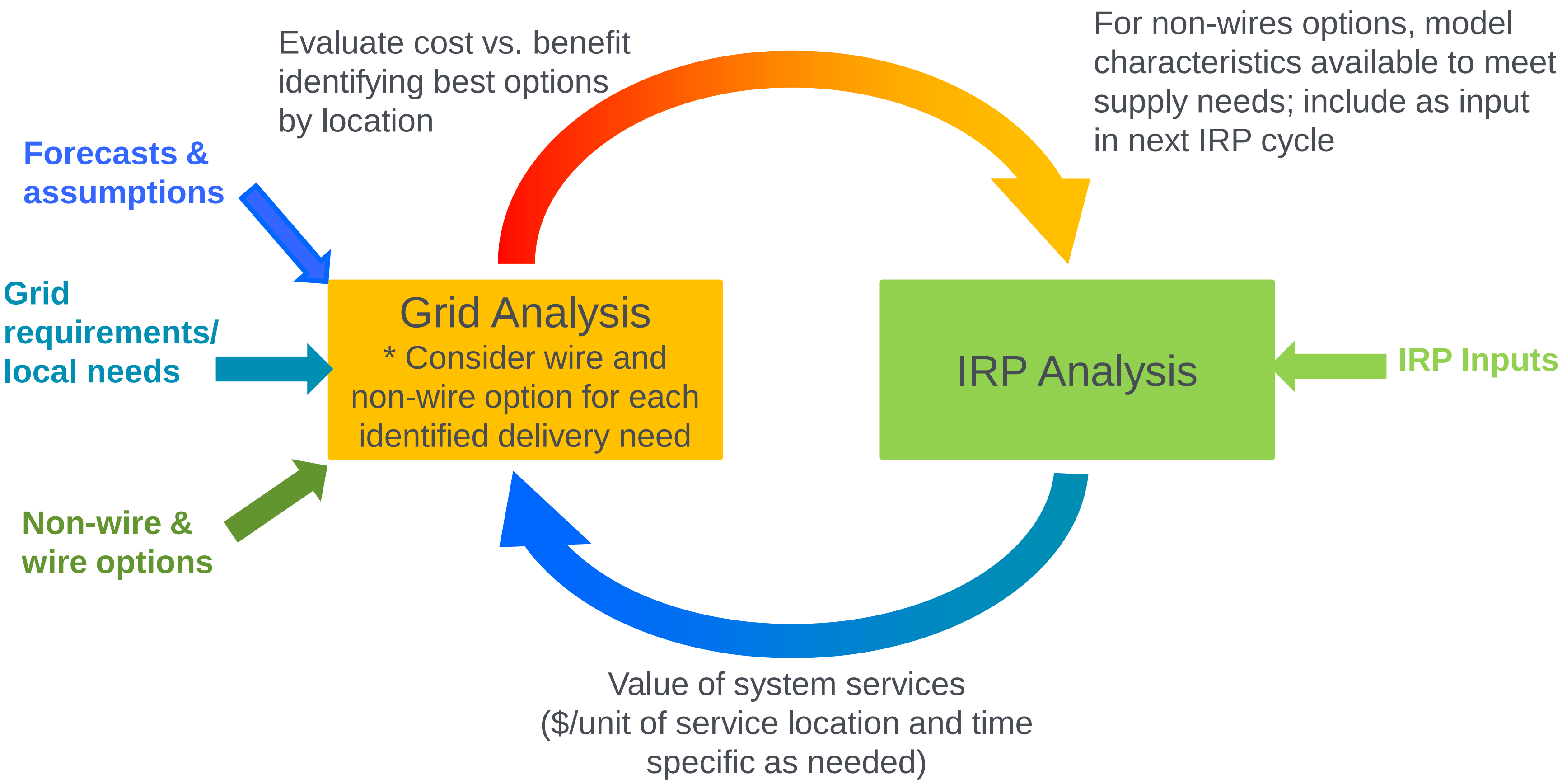
Integration of DSP and IRP



DSP in other States

DSP in HI, CA and NY will transform grid from centralized unidirectional power flow to grid with bi-directional power flows.

These changes are driven by

- Rapid increase in the installation of residential and commercial roof top solar
- Personal and grid-scale energy storage systems and electric vehicles
- Demand response programs and energy efficiency
- Customers will have increased choice and flexibility to manage and control electricity use

These changes have the potential to defer or substitute for large investments in power plants and grid infrastructure.

DSP drivers in other states

- High residential electric rates – $.25/kWh - $.55/kWh
- Summer peaking
- Passed 100% renewable RPS legislation (CA and HI)
- Rapid deployment of Residential and commercial roof top solar (CA & HI)
- Time of use rates with $.10/kWh - $.25/kWh differential
- Aggressive Load Modifying Demand Response programs
- California building code net energy zero by 2020 for residential and small commercial

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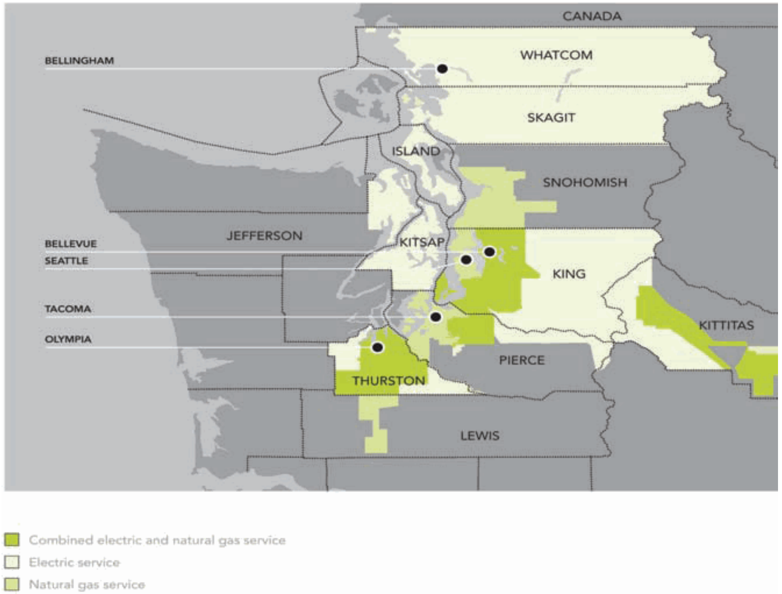
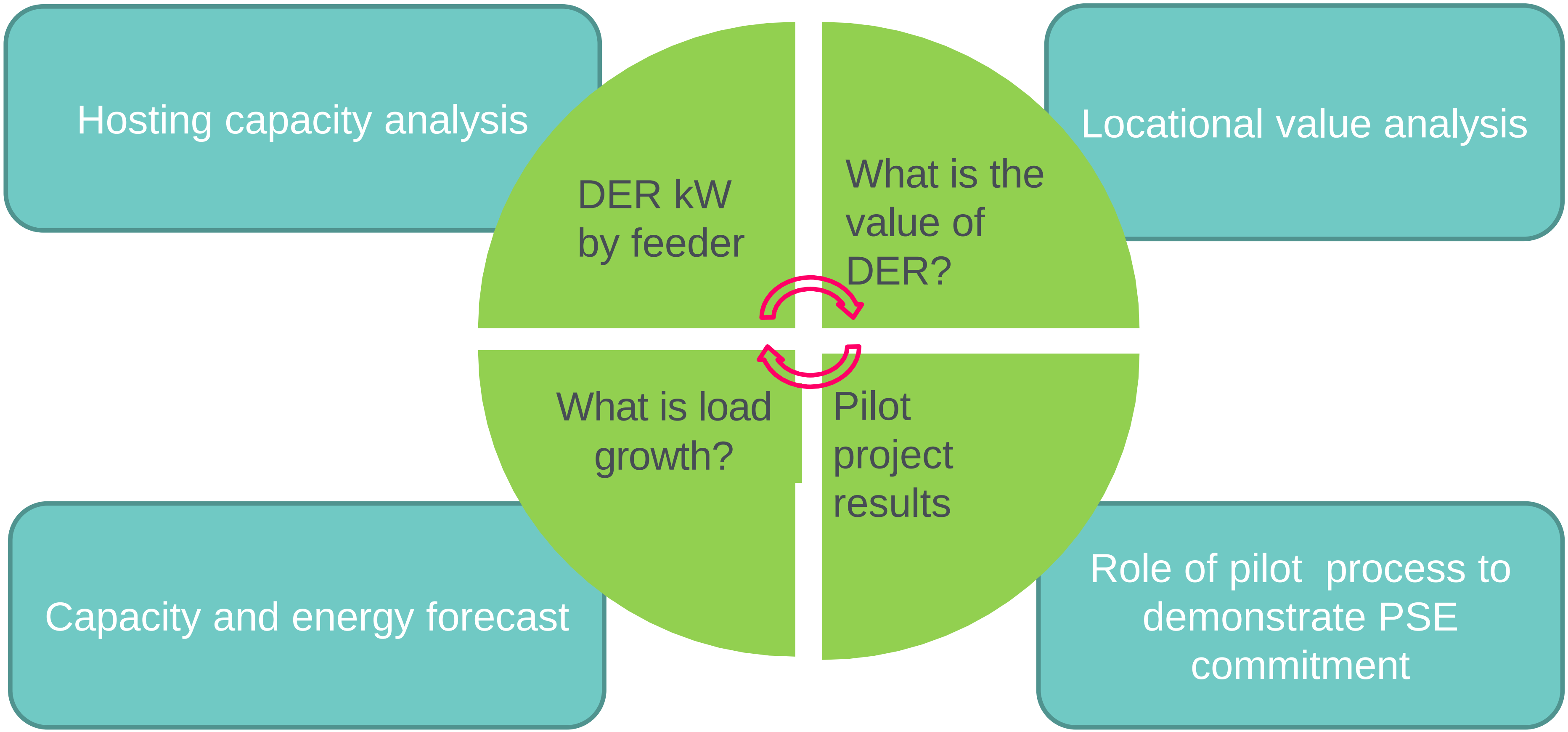
Grid transformation considerations: Western Washington

- Low residential electric rates
- Winter peaking area with localized summer peaking challenges
- Low wholesale power prices
- Potential RPS increase
- Annual solar energy output ~ 50% below CA and HI
- Western Washington solar capacity factor higher in summer and lower in winter



DSP key analytical requirements



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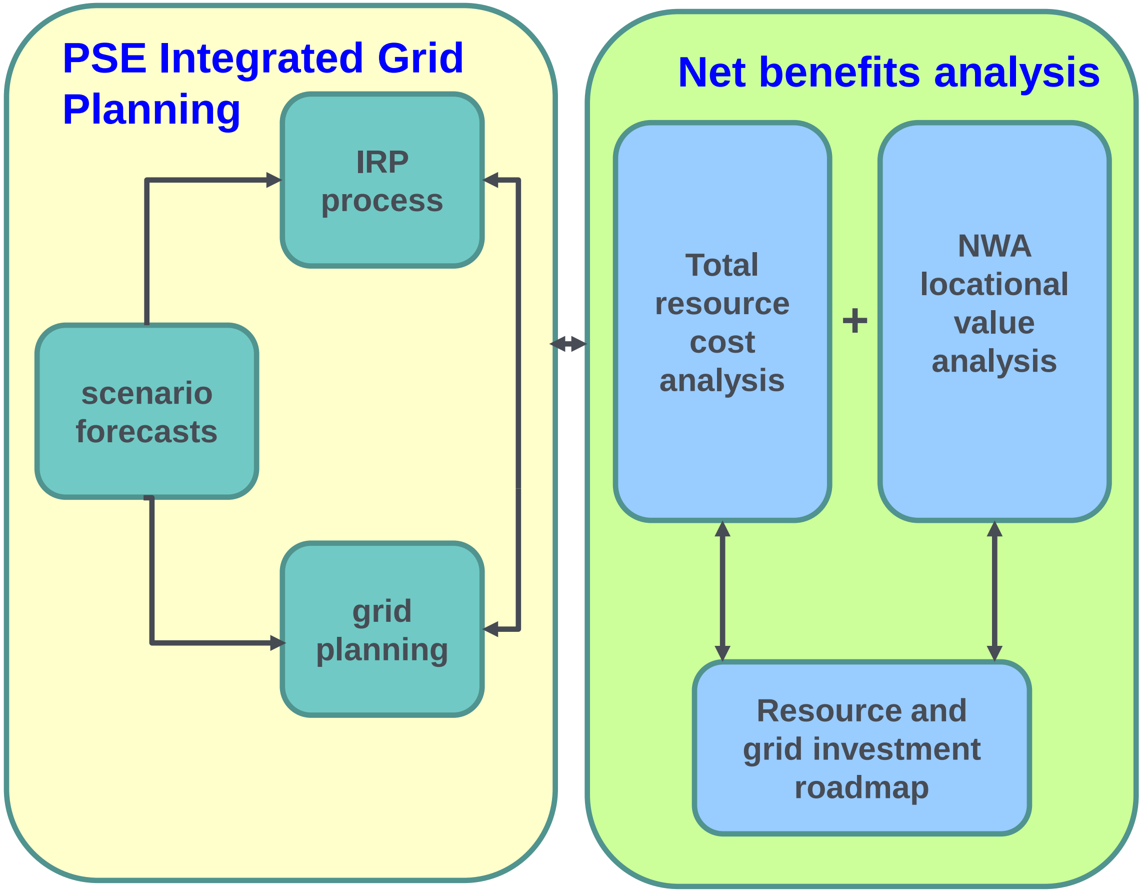
DSP evolution at PSE

Integrated Grid Planning (IGP) requires significant investment in people, process and technology

- Modernize grid design to enable higher penetration of DER while maintaining power quality, reliability and safety.
- Key technology enablers for IGP under development at PSE:
  - Advanced Metering Infrastructure (AMI)
  - Automated Distribution Management System (ADMS)
  - Distributed Energy Resource Management System (DERMS)
- Committed to continuous improvement

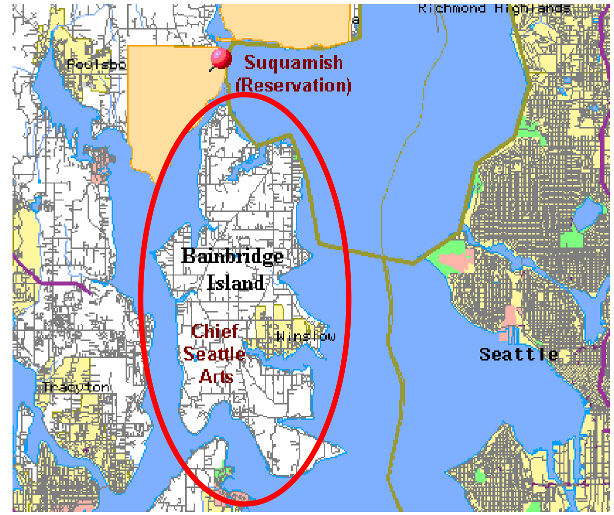


Status on 2018 Grid Planning commitments

- Considering the full range of DER and NWA options for four focus areas:
  - Bainbridge – draft analysis complete and under review, assisted by Navigant and Quanta
  - Three other areas under various stages of analysis and review
  - Including quantitative analysis for energy storage impacts

- Working on having a separate, open and transparent stakeholder involvement process for DSP

- Continuing work on energy storage pilot projects that will provide additional quantitative analysis for energy storage impacts



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Lunch break

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Portfolio sensitivities

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Description of scenarios and sensitivities

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

- Sensitivities test different resource portfolios of supply and demand side generation for PSE.

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

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Scenarios (review from TAG #2)

- Portfolios will be developed for each deterministic scenario with a focus on greenhouse gas regulation

	Scenario	Mid-C Power Price Nominal ($/MWh)	Demand	Gas Price	CO_2 Price
1	Current command & control regulation	$33.92	Mid	Mid	None
2	Low carbon price	$43.62	Mid	Mid	I-1631
3	Social cost of carbon	$60.14	Mid	Mid	$42/metric ton (2007$)
4	High social cost of carbon	$69.18	Mid	Mid	$62/metric ton (2007$)
5	Low	$29.23	Low	Low	None
6	High	$81.23	High	High	$62/metric ton (2007$)

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

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Sensitivities input process

- PSE presented 18 electric and gas sensitivities during TAG meeting #2 on October 11, 2018
- TAG members' feedback expanded the portfolio sensitivities to 31
- PSE distributed the modified table of sensitivities showing the level of effort
- PSE asked TAG members to rank up to ten sensitivities they would prioritize for PSE to work on
- TAG members submitted ranked sensitivities by October 31, 2018

Input received

- 10 TAG members selected portfolio sensitivities:

James Adcock, TAG Member at Large
FortisBC
Public Counsel
Vashon Climate Action Group
WUTC Staff
Renewable Northwest
National Grid Ventures
Citizens' Climate Lobby
Northwest Energy Coalition
Climate Solutions

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Ranking sensitivities

- TAG members' results were analyzed by giving points to rankings using the following approach:
  - A ranked vote of #1 gets 10 points, a ranked vote of #2 gets 9 points, and so on, until a ranked vote of #10 gets 1 point
  - Unranked ballots were all given 1 point
  - Points were added to determine overall rank by point total so that ranked votes are emphasized

Main themes of TAG member input

- Clear preference for clean energy standards and emission reductions as well as the retirement of Colstrip units 3 and 4 by 2025
  - ✓ Clean Energy Standard: Net Zero by 2030 was present on 7 of the 10 ballots
    - Ranked #1 on 2 ballots and ranked #2 on 2 ballots
  - ✓ Force Retirement of Colstrip 3&4 by end of 2025 was present on 9 of the 10 ballots
    - Ranked #1 on 1 ballot and Ranked #2 on 1 ballot

Summary of 2019 IRP sensitivities

Theme	Sensitivity	Portfolio	Sensitivity Number
Emission Reduction Policies	1. Clean Energy Standard: net zero by 2030	Electric	5
	2. 100% Clean Energy Standard: no fossil fuel plants by 2030	Electric	9
	3. CO_2 emission reduction: 80% by 2035	Electric	29
	4. CO_2 emission reduction: PSE's 50 x 2040 Goal	Electric & Gas	31
	5. Carbon Abatement Curve	Electric	23
Market Reliance	6. Declining market reliance for peak capacity	Electric	24
	7. Declining market reliance: hydro slice	Electric	25
	8. Increasing market reliance for peak capacity: Colstrip transmission redirect	Electric	26
Emission Reductions Resource Assumptions	9. Force retirement of Colstrip: 3&4 by end of 2025 ➢ Depending on results of portfolio analysis	Electric	2
	10. Demand side resources: extended DSR potential	Electric & Gas	20
	11. Demand side resources: alternative discount rate	Electric & Gas	18
	12. Alternative resource costs	Electric	15
	13. Shortened life of new baseload gas plants: 20 years	Electric	16
	14. No LNG	Gas	
	15. Force retirement of Colstrip: 1&2 by end of 2019	Electric	1
	16. Force retirement of Colstrip: 1-4 by end of 2019	Electric	3

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Note: refer to handout for complete results

Possible future IRP sensitivities

Sensitivity 30: Gas to Electric Conversions (Rank 7)

- ✓ PSE agrees that this is an important issue which will be studied extensively in the next IRP

Sensitivity 27: Higher Electric Vehicles with Load Shaping (Rank 9)

- ✓ PSE will provide a qualitative discussion of peak load impacts of electric vehicles
- ✓ The WUTC just approved PSE's electric vehicle pilot

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Modeling next steps

- PSE will endeavor to model portfolios for the ranked sensitivities

- PSE will examine different aspects of how the portfolio changed, such as:
  - Resource mix
  - Portfolio cost
  - Portfolio emissions

- Available results of the electric and gas portfolio sensitivities modeling will be presented at TAG meeting # 6 on April 18, 2019

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Load forecast

January 9, 2019 TAG #4

Outline for load forecasting

- Forecast performance
- Role of load forecast in IRP
- Review of the 2019 IRP load forecast results
  - Electric
  - Gas
- Forecasting methodology overview
- Drivers of the forecast

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Forecast performance

- PSE updates and adopts a new long-term load forecast each year
- Forecasts are projections of future load with normal temperatures
- Each forecast is tracked in its initial year by comparing forecasted values to “weather-normalized” actual loads observed
  - “weather normalization” – what would have happened had we experienced 30 year average weather conditions
- Given what actual loads would have been under normal weather circumstances, we can measure forecast performance

Forecast Year	Forecasted Energy (GWh)	Actual Energy (GWh)	Weather Normalized Energy (GWh)	Forecast to Weather Normalized Actual % Variance
2011	21.53	21.54	21.25	-1.3
2013	21.15	21.20	21.19	0.2
2015	21.13	20.45	20.95	-0.9
2017	21.31	21.80	21.59	1.3

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Role of load forecasts in the IRP

- The 20-year load forecasts are used as an input into the IRP, and do not include long-term projections of conservation
  - Note: demand side resource measures through December 2019 (i.e., committed targets) are included in the load forecast
- The IRP analysis determines the most cost-effective amount of future conservation to include in the resource plan
- Demand is reduced significantly when forward projections of conservation savings are applied
- This presentation is the load forecasts used as an input into the IRP analysis, therefore is the load forecast before forward projections of conservation are applied

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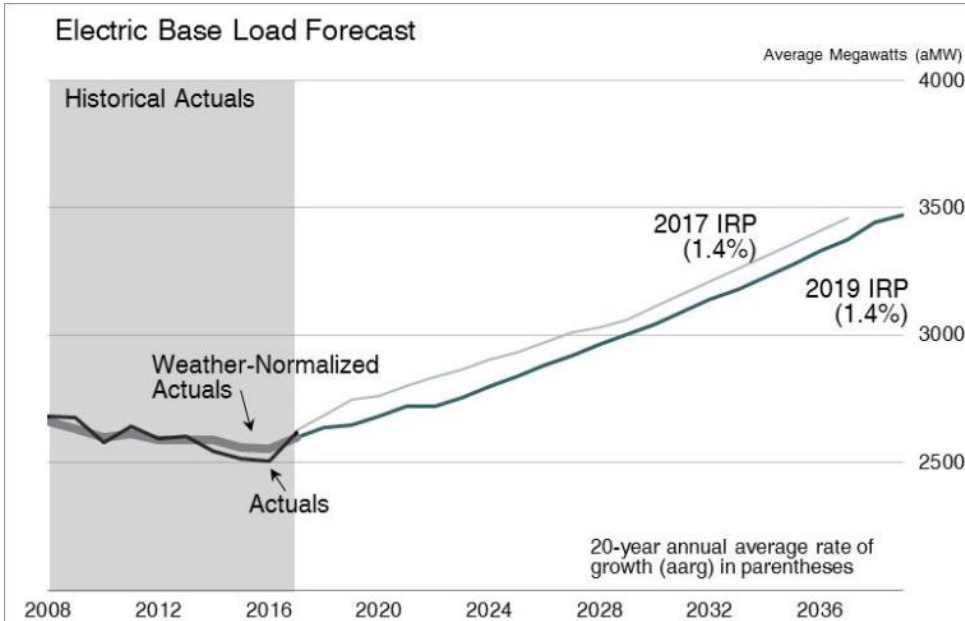
Electric load forecast

- Very similar 2017 IRP and 2019 forecasts: upward and downward drivers have balanced each other out
- Downward driving forces in short term are a revised retail rate/consumer price index forecast, incorporation of 2016/2017 actual loads, and Microsoft’s exit
- Major new growth drivers:
  - Near term: More new large loads coming online (i.e., “block loads”)
  - Long term: Electric transportation infrastructure (both vehicles and transit)



Annual electric base load forecast (aMW) in the 2019 IRP and the 2017 IRP

Ten years of actual loads and weather normalized loads are shown. Weather normalized loads calculate what the load would have been expected to be if the weather had been normal. Weather normalization is important when comparing actuals to a forecast, because the forecasted values assume normal weather, while actuals could be different from normal. The electric base load forecast does not include new conservation after 2019.

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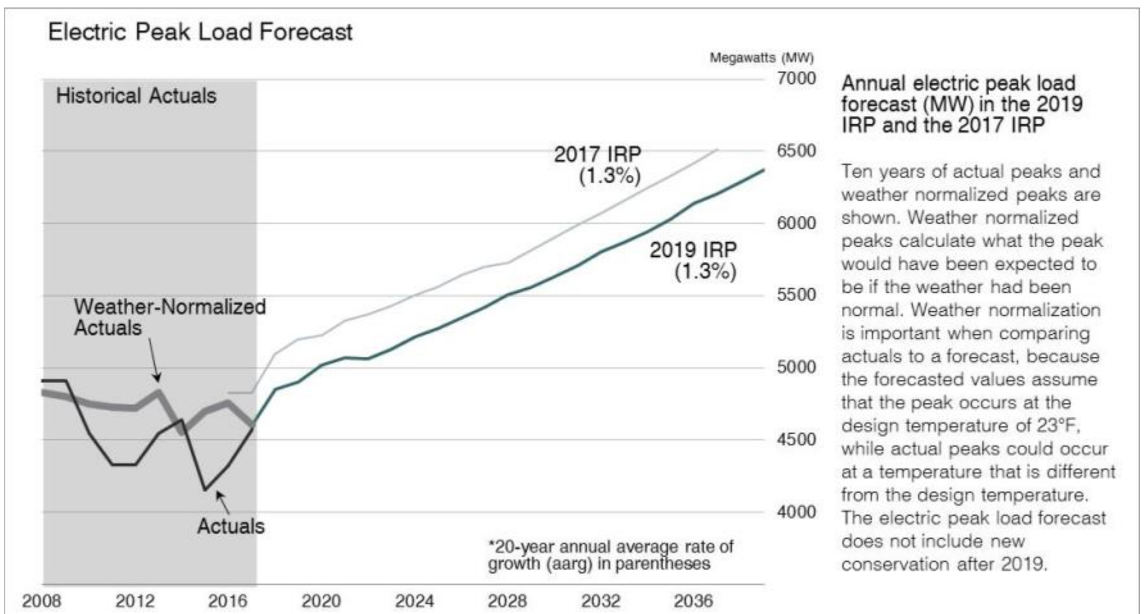
Electric peak forecast

- The Peak forecast projects electric peaks that occur at 23 degrees Fahrenheit
- Comparing the 2019 Peak Load forecast to the 2017 forecast:
  - The Peak Load forecast uses the Load forecast, which results in the downward shift in the 2019 Peak Load forecast compared to 2017
  - 2019 incorporates observations of system temperature sensitivity from the January 2017 peak event (resulting in a downward shift), whereas the 2017 forecast's most recent cold weather event was February 2014



Electric customer forecast by class

- Residential and commercial customer growth drive year to year system load growth
- 2019 customer count projections differ very little from 2017 for residential and commercial classes

Customer Counts	Year 2020		Year 2037		2019 IRP 20-Year AARG (2017 IRP)
	2019 IRP Total (2017 IRP)	2019 IRP Share (2017 IRP)	2019 IRP Total (2017 IRP)	2019 IRP Share (2017 IRP)	
Total	**1,186,237 (1,181,874)**		**1,452,861 (1,446,944)**		**1.2% (1.2%)**
Residential	1,040,778 (1,037,695)	87.7% (87.8%)	1,264,976 (1,261,057)	87.1% (87.2%)	1.1 (1.2)
Commercial	134,693 (134,781)	11.4 (11.4)	175,905 (176,764)	12.1 (12.2)	1.6 (1.6)
Industrial	3,310 (3,321)	0.3 (0.3)	2,956 (2,971)	0.2 (0.2)	-0.7 (-0.7)
Other	7,456 (6,077)	0.6 (0.5)	9,024 (6,152)	0.6 (0.4)	1.1 (0.1)

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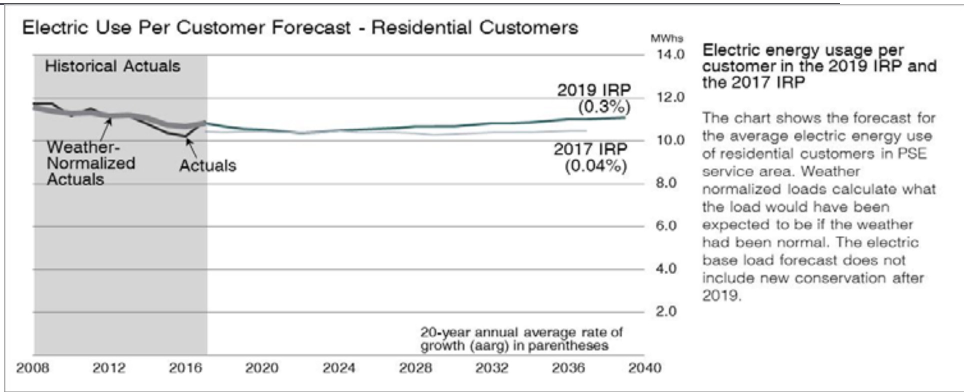
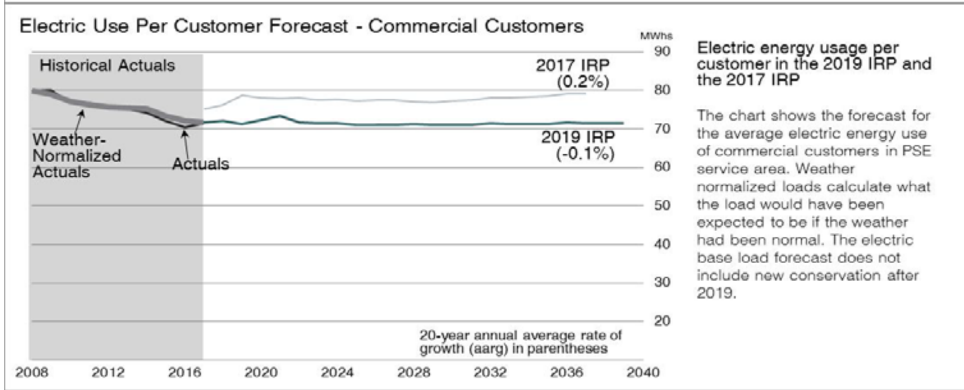
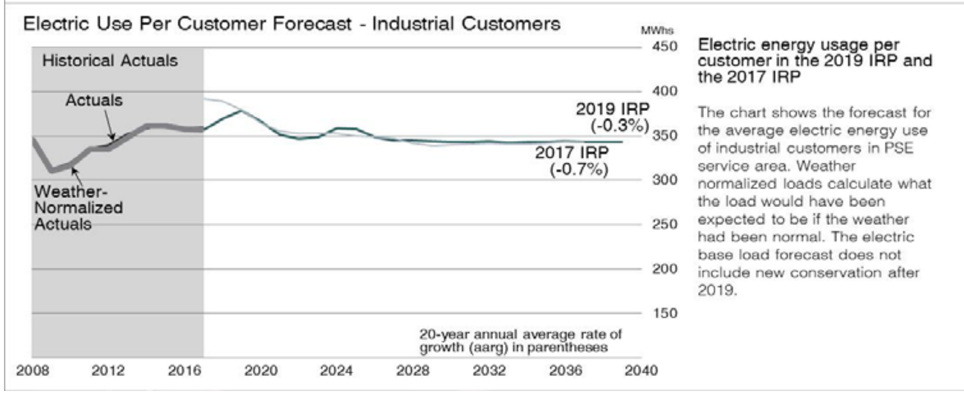
Electric energy use per customer forecast

- Residential
  - EV load forecast assumption produces a modest upward long-term trend
- Commercial
  - Some larger-use customer additions causing a bump in the early 2020s
  - In comparison to the 2017 IRP shifted down partially due to a large customer exit
- Industrial
  - Some larger-use customer additions causing an uptick in the near term







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Electric load forecast by class

- Residential and Commercial customer growth drive year to year system load growth
- Comparing the 2019 forecast to the 2017 forecast:
  - 2019 forecast assumes less load in the Commercial and Industrial classes, but more in the Residential class
  - Residential electric vehicles are included in 2019 forecast, which impact Residential load share in long term

Load in aMW	Year 2020		Year 2037		2019 IRP 20-Year AARG (2017 IRP)
	2019 IRP Total (2017 IRP)	2019 IRP Share (2017 IRP)	2019 IRP Total (2017 IRP)	2019 IRP Share (2017 IRP)	
Total	**2,684 (2,762)**		**3,374 (3,461)**		**1.4% (1.4%)**
Residential	1,242 (1,224)	46.3% (44.3%)	1,584 (1,499)	47.0% (43.3%)	1.4 (1.2)
Commercial	1,103 (1,189)	41.1 (43.0)	1,426 (1,586)	42.3 (45.8)	1.5 (1.8)
Industrial	138 (138)	5.1 (5.0)	116 (117)	3.4 (3.4)	-1.0 (-1.3)
Other	10 (9)	0.4 (0.3)	8 (7)	0.2 (0.2)	-1.1 (-1.8)
Losses	191 (202)	7.1 (7.3)	240 (253)	7.1 (7.3)	n/a

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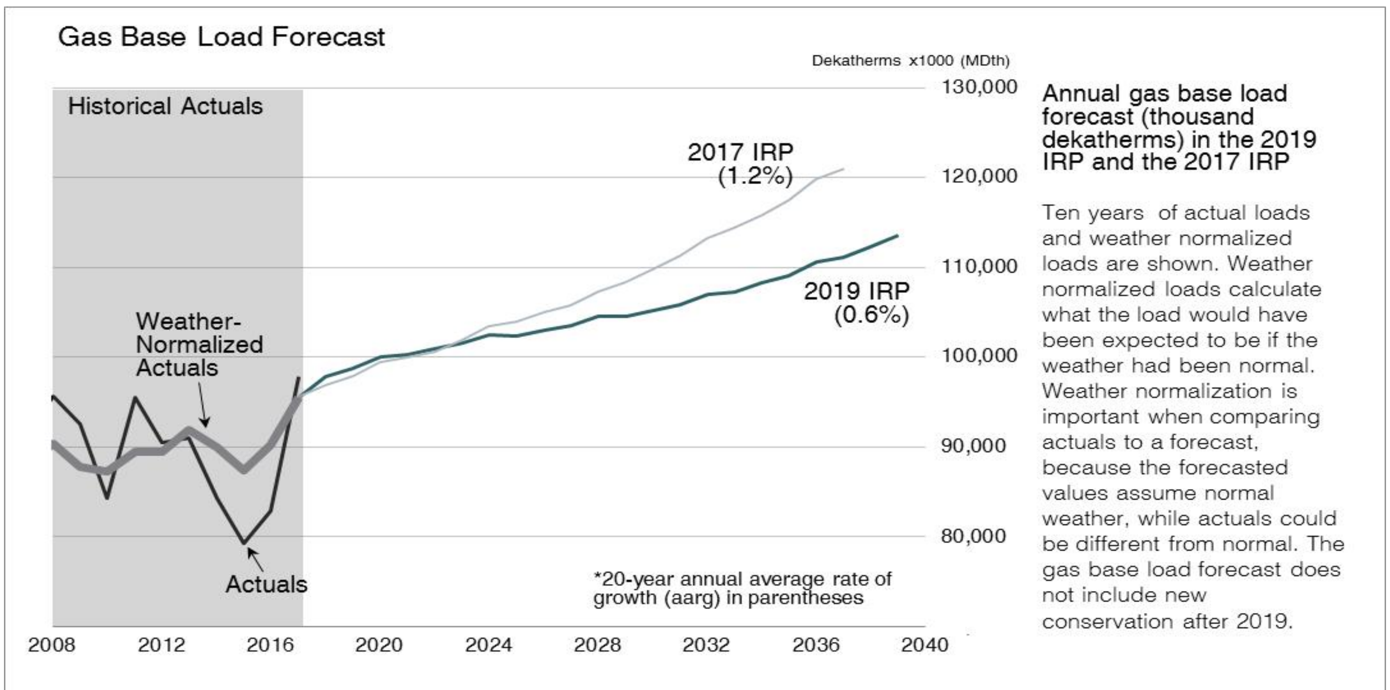
Gas load forecast

- The 2019 load forecast is overall lower than the 2017 load forecast
- In the near team, slightly higher loads due to higher customer counts and the increase in employment
- In the long term, lower customer counts are driving the load forecast down
- Overall system use per customer is driven by lower industrial and interruptible use per customer



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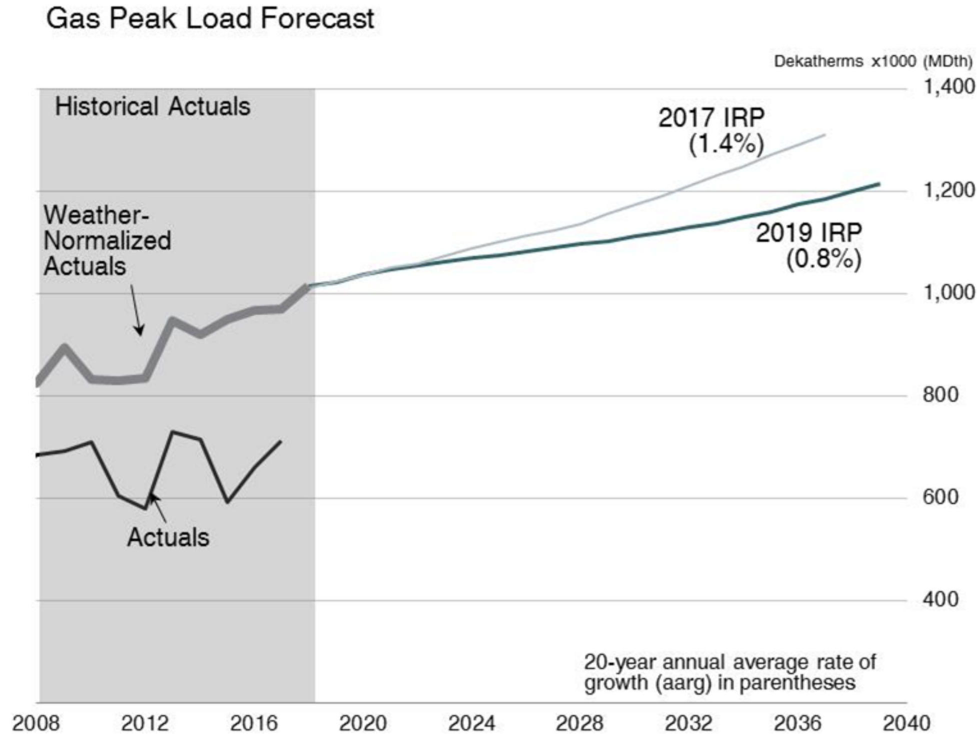
Gas peak load forecast

- The peak forecast projects gas peaks that occur at 13 degrees Fahrenheit
- The peak forecast has decreased because forecasted loads have come down
- Since the last forecast, PSE was better able to capture the weather sensitivity with the 2017 cold year



Annual gas peak load forecast (thousand dekatherms) in the 2019 IRP and the 2017 IRP

Ten years weather normalized peaks are shown. Weather normalized peaks calculate what the peak would have been expected to be if the weather had been a design peak. Weather normalization is important when comparing actuals to a forecast, because the forecasted values assume that the peak occurs at the design temperature of 13°F, while actual peaks could occur at a temperature that is different from the design temperature. The gas peak load forecast does not include new conservation after 2019.

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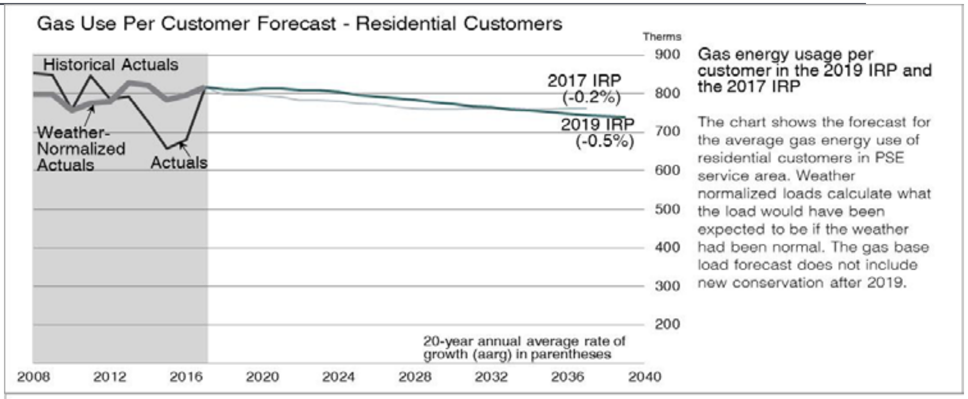
Gas customer forecast by class

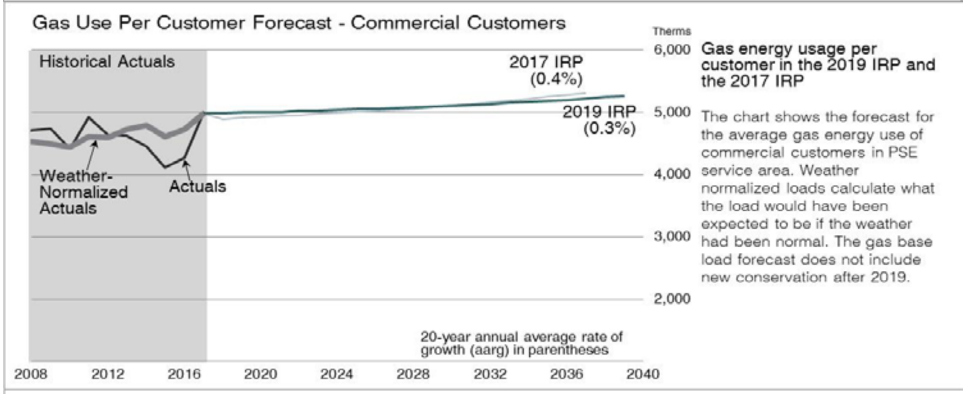
- Residential customers are the major source of growth in number of customers
- Commercial customer counts are increasing as well
- Industrial customer counts are declining over time
- Interruptible and transport classes have very few customers

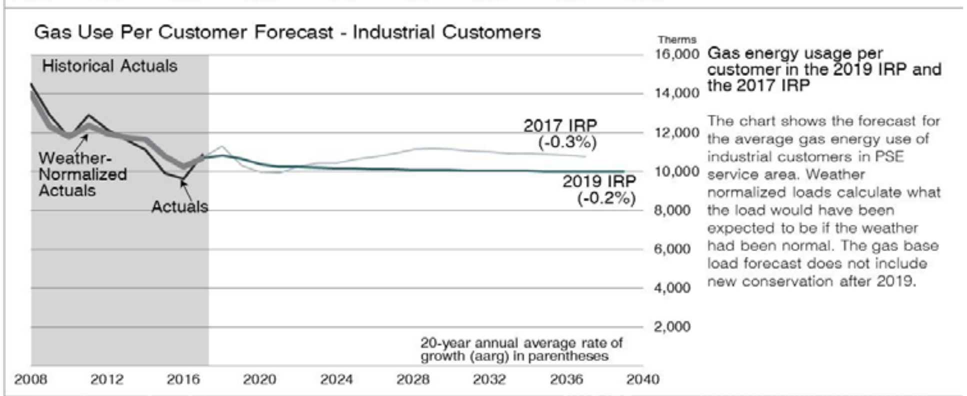
Customer Counts	Year 2020		Year 2037		2019 IRP 20-Year AARG (2017 IRP)
	2019 IRP Total (2017 IRP)	2019 IRP Share (2017 IRP)	2019 IRP Total (2017 IRP)	2019 IRP Share (2017 IRP)	
Total	**854,265** **(850,817)**		**1,058,136** **(1,058,943)**		**1.3%** **(1.3)**
Residential	795,076 (789,961)	93.1% (92.8%)	994,430 (982,574)	94.0% (92.8%)	1.4 (1.3)
Commercial	56,464 (58,126)	6.6 (6.8)	61,420 (74,146)	5.8 (7.0)	0.5 (1.5)
Industrial	2,241 (2,256)	0.3 (0.3)	1,868 (1,832)	0.2 (0.2)	-1.1 (-1.2)
Interruptible	236 (250)	>0.1 (>0.1)	153 (167)	>0.1 (>0.1)	-2.5 (-2.4)
Transport	248 (224)	>0.1 (>0.1)	265 (224)	>0.1 (>0.1)	0.3 (>0.1)

Gas energy use per customer forecast

- Residential
  - Slight downward long-term trend driven by increase in retail rates
- Commercial
  - Driven by increases in employment
  - Partially offset by increase in retail rates
- Industrial
  - Driven by manufacturing employment







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Gas load forecast by class

- Residential loads are growing more slowly in the 2019 forecast compared to the 2017 forecast
- Commercial loads are lower and are growing more slowly in the 2019 forecast compared to 2017, due to lower commercial customer counts
- Industrial and Interruptible loads are slightly lower than the 2017 forecast, and are declining more quickly

Load in Thousand Dekatherms	Year 2020		Year 2037		2019 IRP 20-Year AARG (2017 IRP)
	2019 IRP Total (2017 IRP)	2019 IRP Share (2017 IRP)	2019 IRP Total (2017 IRP)	2019 IRP Share (2017 IRP)	
Total	**123,791 (123,152)**		**130,761 (140,623)**		**0.4% (0.8)**
Residential	64,513 (63,075)	52.1% (51.2%)	73,452 (74,846)	56.2% (53.2%)	0.8 (1.0)
Commercial	28,632 (29,206)	23.1 (23.7)	32,121 (39,708)	24.6 (28.2)	0.7 (1.9)
Industrial	2,364 (2,286)	1.9 (1.9)	1,899 (1,999)	1.5 (1.4)	-1.3 (-1.4)
Interruptible	4,265 (4,337)	3.4 (3.5)	3,387 (3,812)	2.6 (2.7)	-1.3 (-0.6)
Transport	23,769 (23,632)	19.2 (19.2)	19,640 (19,555)	15.0 (13.9)	-1.1 (-1.0)
Losses	248 (616)	0.2 (0.5)	262 (703)	0.2 (0.5)	n/a

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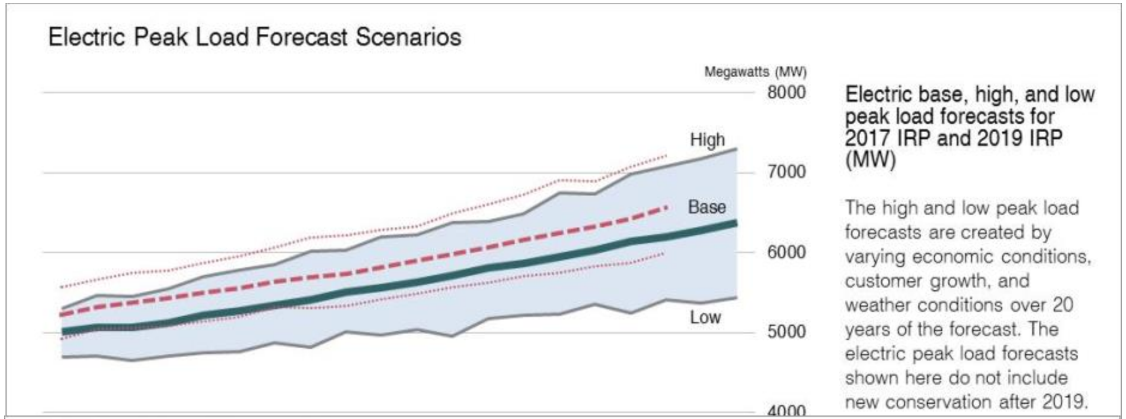
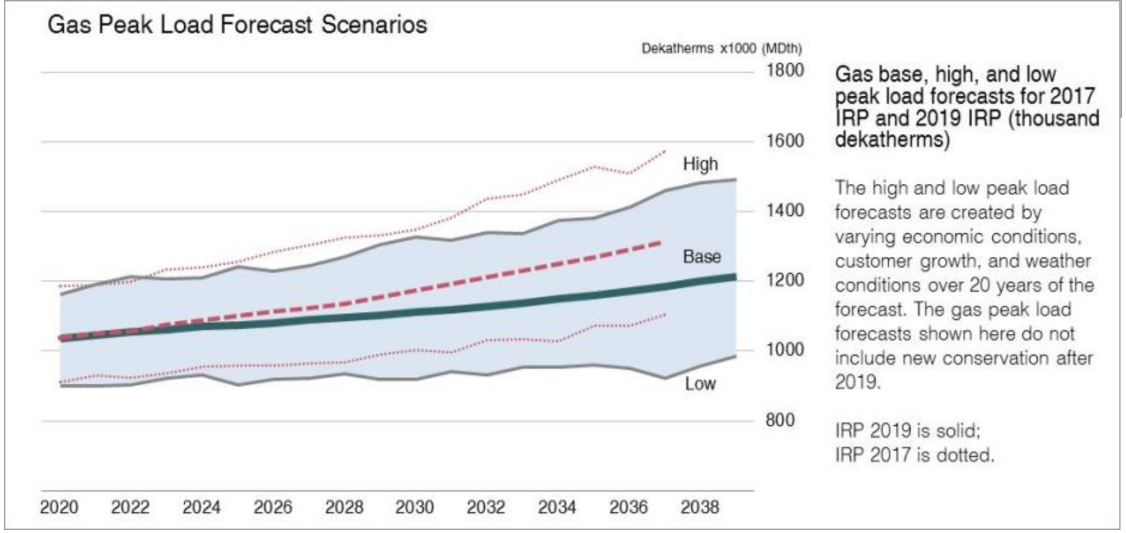
Base, high, and low forecast scenarios

- High and low forecasts are created by varying economic conditions, customer growth, and weather conditions using a Monte Carlo simulation
- The 2019 base peak forecasts are lower than the 2017 base forecast, therefore the high and low forecasts are also lower in the 2019 forecast





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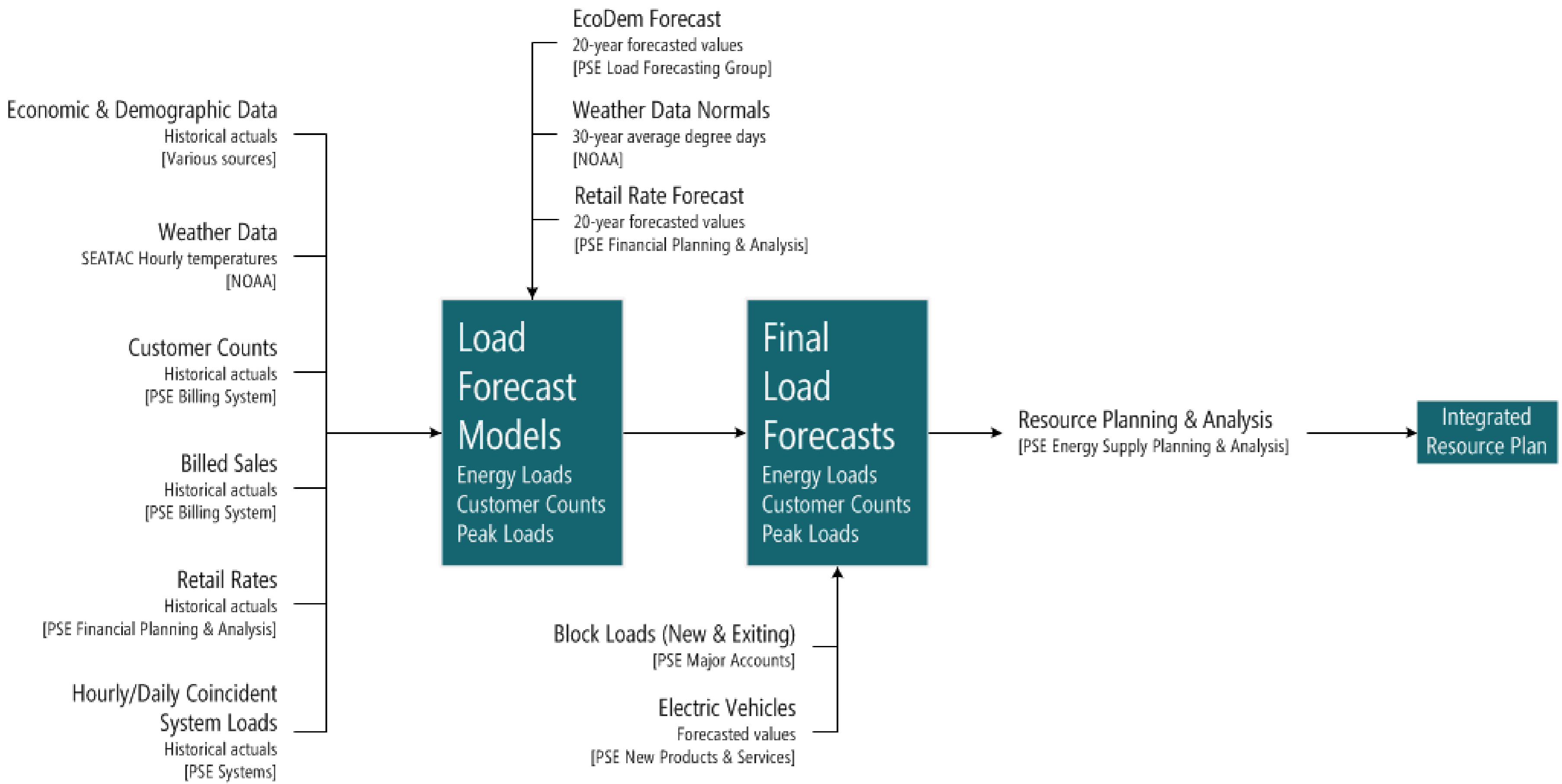
Load forecast development



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Load forecast models

Total Energy = Customer Counts × Energy Use Per Customer

Typical Drivers (Customer Counts):
- Population
- Housing Permits
- Employment

Typical Drivers (Energy Use Per Customer):
- Employment
- Energy retail rates
- Personal Income
- Weather

- STEP 1: Compile actual history
  - Compile actual PSE sales data and drivers
  - Determine the *relationship* of drivers to customer growth and sales
- STEP 2: Forecast the future
  - Compile forecasts of economic and demographic drivers, normal weather
  - Apply historical *relationships* to forecasts of drivers and normal weather

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Economic & demographic model: data sources

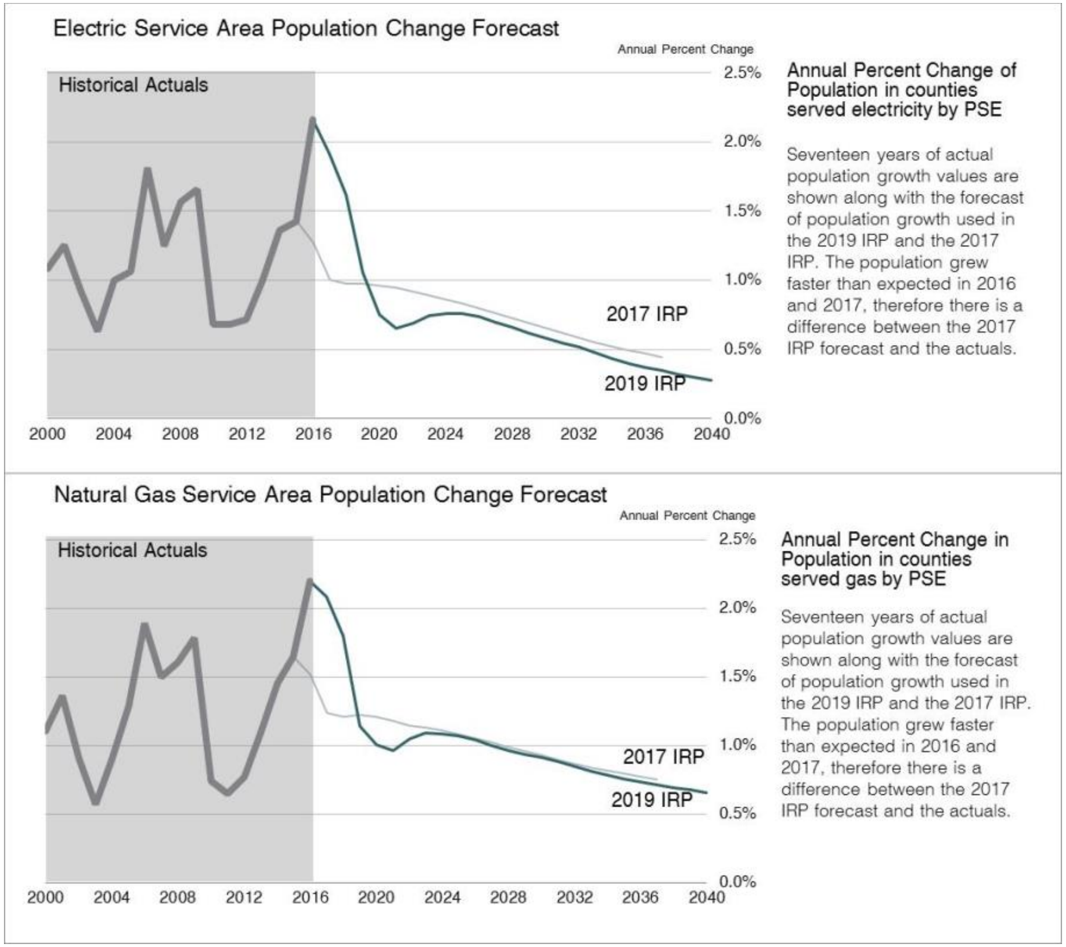
- Historical data are sourced from a number of external data sources, including local and federal agencies
- US-level forecasts come from Moody's Analytics

DATA USED IN ECONOMIC AND DEMOGRAPHIC MODEL	
County-level Data	**Source**
Labor force, employment, unemployment rate	U.S. Bureau of Labor Statistics (BLS) www.bls.gov Puget Sound Regional Council (PSRC) www.psrc.org
Total non-farm employment, and breakdowns by type of employment	WA State Employment Security Department, using data from Quarterly Census of Employment and Wages https://fortress.wa.gov/
Personal income	U.S. Bureau of Economic Analysis (BEA) www.bea.gov
Wages and salaries	
Population	U.S. Bureau of Economic Analysis (BEA) / WA State Office of Financial Management (OFM) www.ofm.wa.gov
Households, single- and multi-family	U.S. Census www.censtats.census.gov
Household size, single- and multi-family	
Housing permits, single- and multi-family	U.S. Census / Puget Sound Regional Council (PSRC) / City Websites / Building Industry Association of Washington (BIAW) www.biaw.com
Aerospace employment	Puget Sound Economic Forecaster www.economicforecaster.com
US-level Data	**Source**
GDP	Moody's Analytics www.economy.com
Industrial Production Index	
Employment	
Unemployment rate	
Personal income	
Wages and salary disbursements	
Consumer Price Index (CPI)	
Housing starts	
Population	
Conventional mortgage rate	
T-bill rate, 3 months	

PSE PUGET SOUND ENERGY

Economic & demographic model: population forecast

- The forecasted trend for the PSE service area is similar to the national trend predicted by Moody's Analytics
- Higher population growth rate in recent history than previously forecasted
- Decline in population growth rate due to less forecasted immigration to the US



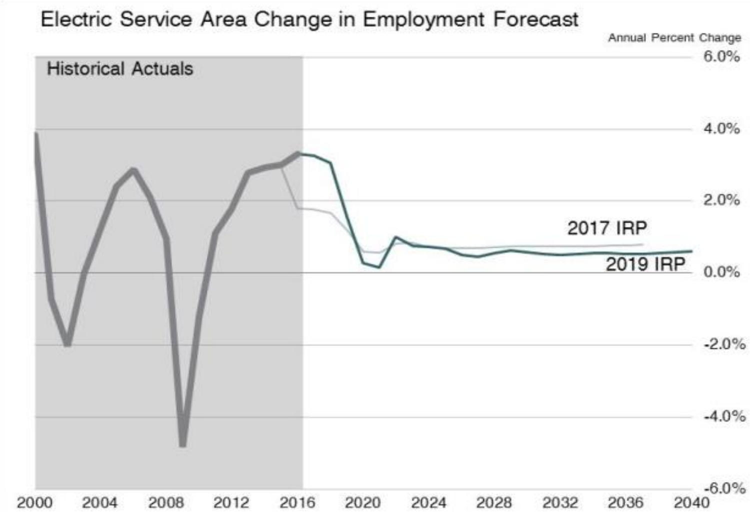
PSE PUGET SOUND ENERGY

Economic & demographic model: employment forecast

- The forecasted trend for the PSE service area is similar to the national trend predicted by Moody's Analytics

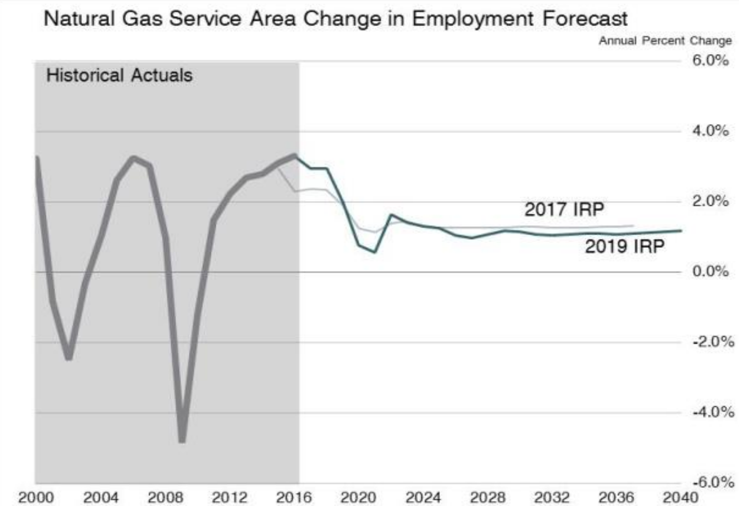
- Tax stimulus is causing more forecasted growth in 2018 (i.e., an increase in jobs in the short term)

- More softening expected around 2020/2021 due to the recession anticipated by Moody's Analytics



Annual Percent Change in Total Non-Farm Employment in counties served electricity by PSE

Annual Percent Change in Total Non-Farm Employment in counties served electricity by PSE. Seventeen years of actual employment growth values are shown along with the forecast of employment growth used in the 2019 IRP and the 2017 IRP. Periods of negative employment growth (or decreases in employment) occurred during the two most recent recessions. Employment grew faster than expected in 2016 and 2017, therefore there is a difference between the 2017 IRP forecast and the actuals.



Annual Percent Change in Total Non-Farm Employment in counties served gas by PSE

Annual Percent Change in Total Non-Farm Employment in counties served gas by PSE. Seventeen years of actual employment growth values are shown along with the forecast of employment growth used in the 2019 IRP and the 2017 IRP. Periods of negative employment growth (or decreases in employment) occurred during the two most recent recessions. Employment grew faster than expected in 2016 and 2017, therefore there is a difference between the 2017 IRP forecast and the actuals.

PUGET SOUND ENERGY

Temperature for electric design peak

- The most common minimum temperature during winter peak hours is 23°F.

Heating Season (November – February)	Minimum Temp (°F) During Hours 8AM to 9PM
1987	27
1988	10
1989	22
1990	12
1991	26
1992	23
1993	22
1994	23
1995	18
1996	23
1997	24
1998	17
1999	30
2000	28
2001	28
2002	28
2003	21
2004	26
2005	24
2006	19
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2008	15
2009	19
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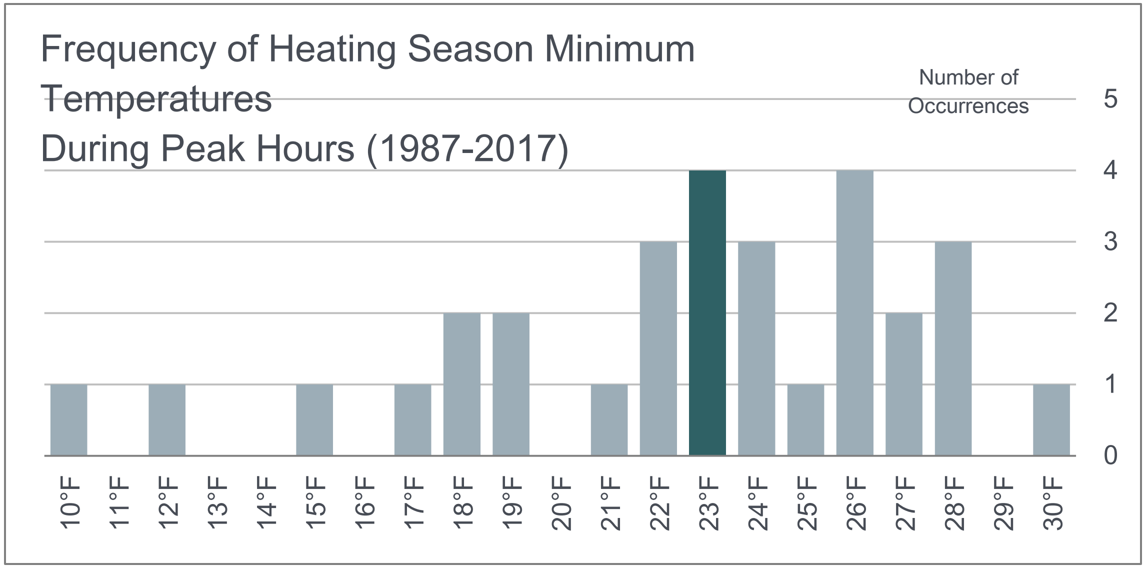
2013	22
2014	26
2015	26
2016	23



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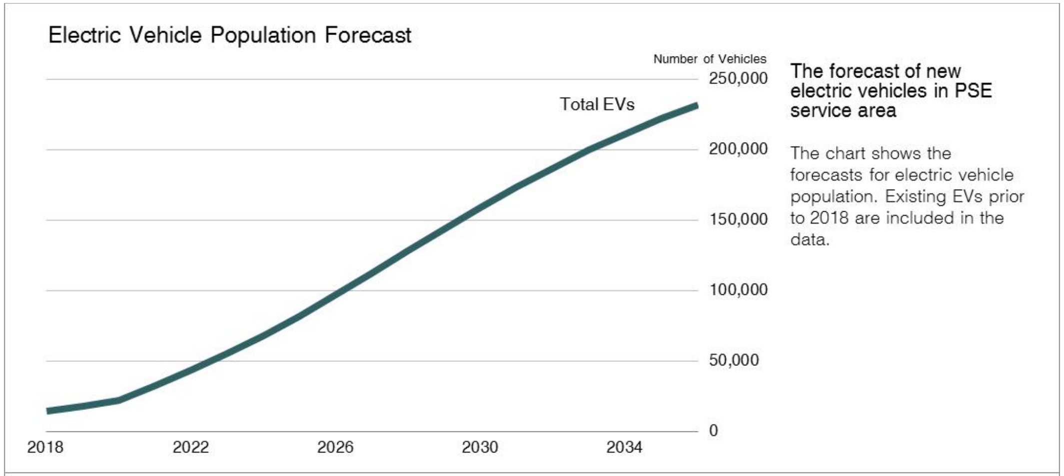
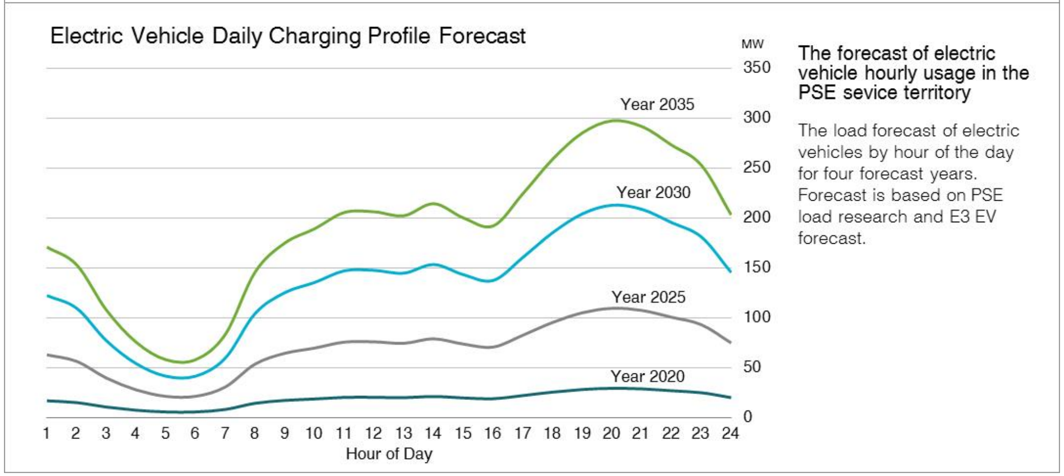
Electric Vehicles

- E3 electric vehicle (EV) forecast
- Charging load occurs in both residential and commercial classes
- Forecasted EV load increases to 2% of total load and peak forecasts by 2030, and 3% by the end of forecast period





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Other drivers

- Short-term block loads (known new large additions/deletions to system)
  - Electric block loads
    - Downtown Bellevue, developments, Sound Transit, indoor horticulture
  - Gas block loads
    - Incorporating new, large gas developments in downtown Seattle as well as other locations
- Retail rate forecast

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Next steps

Next steps

Date	Action
January 23	PSE posts draft meeting notes with action items on IRP website and distributes draft meeting notes to TAG members
January 30	TAG members review meeting notes and provide comments to PSE
February 6	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

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January 9, 2019 TAG #4