2021 IRP Webinar #11: Draft IRP Results

Electric & Gas Portfolio Model Results
Flexibility Analysis

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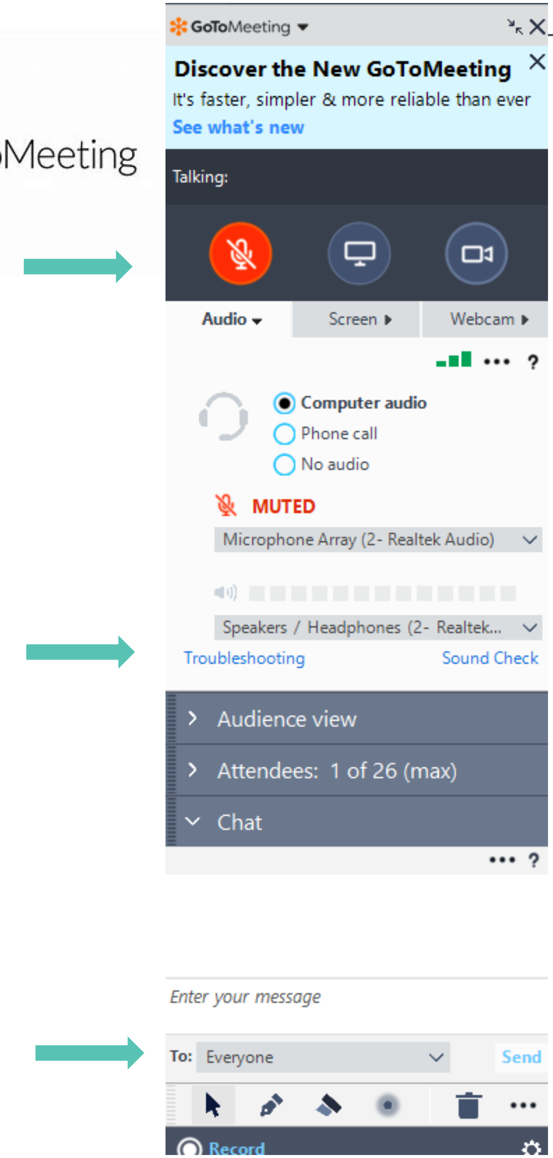
December 15, 2020

Welcome to the webinar and thank you for participating!



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    - **In writing:** your question will be read
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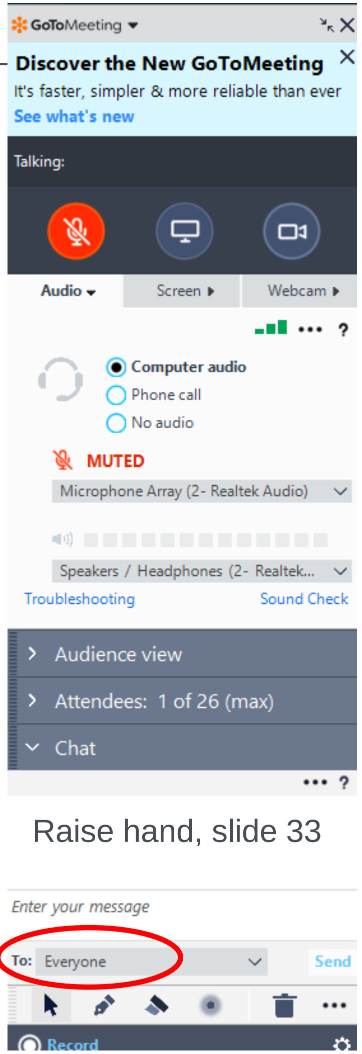
- Be considerate of others waiting to participate
- We will try to get to all questions



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Agenda

- Safety Moment
- Draft Electric Results
  - Draft Mid Portfolio Results
  - Draft Sensitivity Results
- Flexibility Analysis
- Draft Gas Results
  - Draft Mid Portfolio Results
  - Draft Sensitivity Results

Safety Moment: Accident prevention at home

With many of us working from home and with other adults, children and pets in close proximity, keeping out of the ER or vet clinic is a high priority. Consider these tips to help keep yourself and others in the household and pets safe:

- Keep your first-aid kit well stocked; you may be able to administer aid with a consult with a first responder/911 instead of going to the ER
- Do a self assessment to make sure your home environment is safe (hanging cords, trip hazards like rugs and cleaning supplies should be stored carefully)
- Anchor furniture
- Move medication out of kids' and pets' reach

Today’s Speakers

Irena Netik,
Director, Resource Planning & Analysis, PSE

Elizabeth Hossner
Manager Resource Planning & Analysis, PSE

Gurvinder Singh
Senior Resource Planning Analyst, PSE

Alison Peters & Elise Johnson
Co-facilitators, EnviroIssues

Jennifer Magat
Senior Resource Planning Analyst, PSE

Tyler Tobin
Resource Planning Analyst, PSE

Charlie Inman
Associate Resource Planning Analyst, PSE

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

2021 IRP
Electric Mid Portfolio Draft Results

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Participation Objectives

- PSE will inform stakeholders of the draft electric portfolio results.

  IAP2 level of participation: INFORM

- PSE will consult with stakeholder in identifying the key elements of the resource plan.

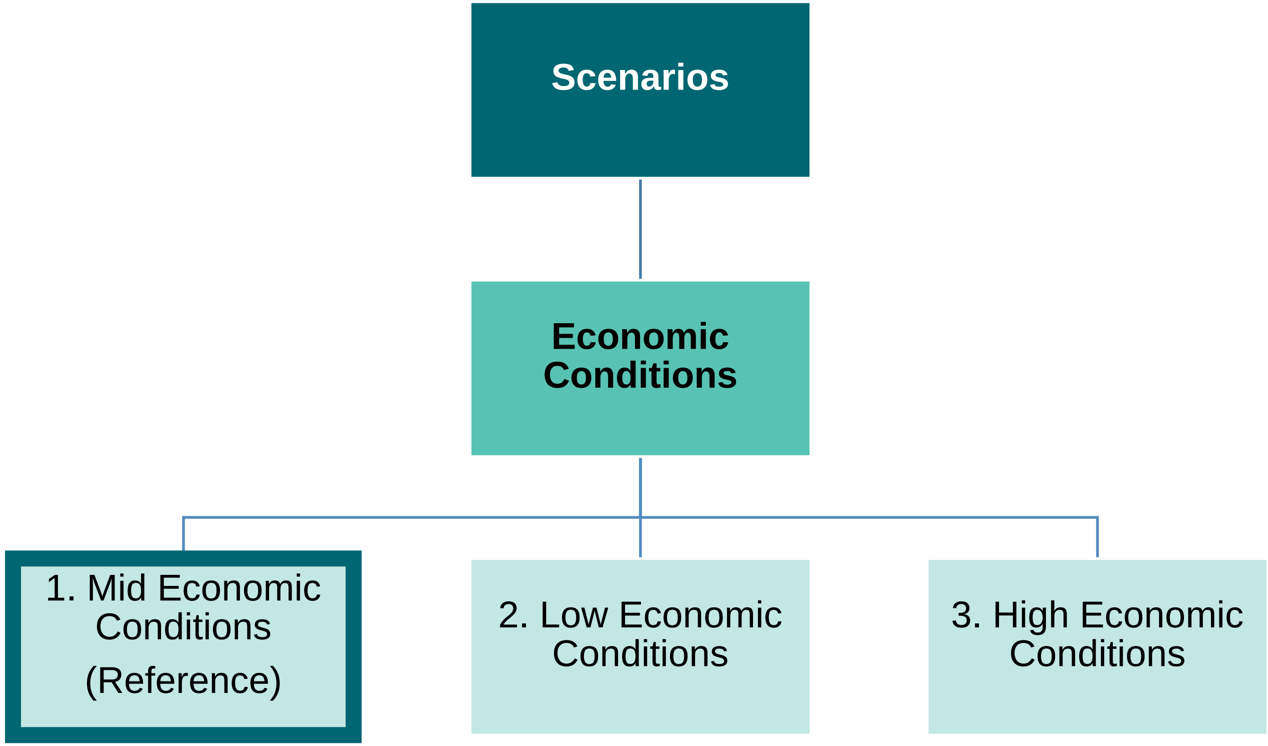
  IAP2 level of participation: CONSULT

2021 IRP draft mid portfolio

- The draft mid portfolio meets the Clean Energy Transformation Act:
  - Coal free by 2025
  - Carbon neutral by 2030
  - 100% carbon free by 2045

- The results are the output from the portfolio optimization model of the least cost set of resources.

- **<u>This is NOT PSE's preferred portfolio or the final resource plan</u>**.



Model Assumptions

Inputs	Assumptions
CETA Constraint	At least 80% of delivered load must be met with renewable or non-emitting resources by 2030 and 100% by 2045. Colstrip units 3 and 4 retire by 12/31/2025.
SCGHG	Modeled as a cost adder.
Demand	The 2020 IRP Base (Mid) Demand Forecast is applied for PSE in the portfolio model.
Economic Retirement	The portfolio model allows for economic retirement of existing resources.
Natural gas price	Mid gas prices are applied, levelized 20-yr Sumas gas price is $3.39/MMBtu.
Power price	Mid electric prices are applied, levelized 20-yr Mid C power price is $24.19/MWh.
Time horizon	2022 – 2045
Transmission	Transmission constraints to resources in eastern Washington unconstrained. Transmission connections to ID, WY, and MT are included. MT limited to 750 MW, ID/WY limited to 400 MW.
Upstream emissions	Upstream CO_2 emissions are added to the emission rate of natural gas plants in PSE's portfolio model.

25 unique supply-side resource alternatives and numerous demand-side resource options were evaluated

Resource alternatives:

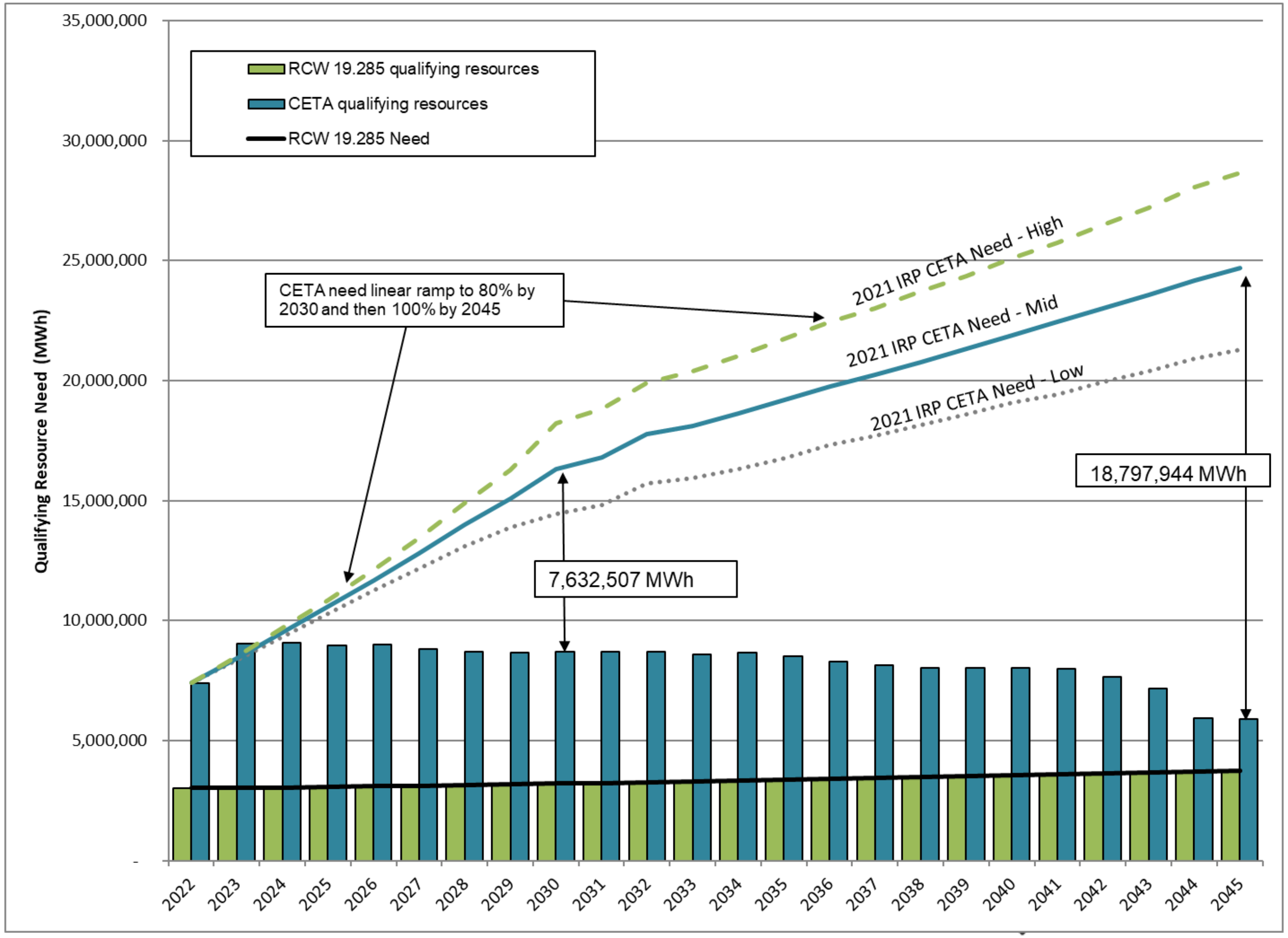
Renewable Resources	Energy Storage	Combined Resources	Combustion Turbine Resources	Demand Side Resources

• Solar (utility scale)
  • WA West
  • WA East
  • Idaho
  • WY East
  • WY West
• Solar (Distributed)
• Wind – onshore
  • WA East
  • Idaho
  • WY East
  • WY West
  • MT Central
  • MT East
• Offshore Wind
• Biomass
	• Battery storage
	  • 2-hr Lithium Ion
	  • 4-hr Lithium Ion
	  • 4-hr Flow
	  • 6-hr Flow
	• Pumped Storage Hydro (PSH)
		• WA Solar + battery
		• WA Wind + battery
		• MT wind + PSH
			• Combined cycle combustion turbines baseload gas plant (CCCT)
			• Simple cycle combustion turbine peaking plant (frame peaker)
			• Reciprocating internal combustion engines peaking plant (recip peaker)
			
			Note: renewable fuel options are evaluated through the sensitivity analysis
				• Energy Efficiency
				• Demand Response
				• Distribution Efficiency
				• Codes and Standards
				• Distributed Solar PV (customer)

Note: Supply-side resources were discussed at the May 28, 2020 webinar. Demand-side resources were discussed at the July 14, 2020 webinar. Modeling assumptions include stakeholder feedback documented through the Feedback Reports and Consultation Updates.

Existing Portfolio and Renewable Need, before demand-side resources

- PSE's current portfolio faces shortfalls of:
  - **7.6 million MWh** of renewable generation in 2030
  - **18.8 million MWh** of renewable generation in 2045
- CETA renewable need is added to the portfolio model as a linear ramp rate to meet the 2030 and 2045 targets.
- The portfolio also meets the RPS requirement, RCW 19.285.



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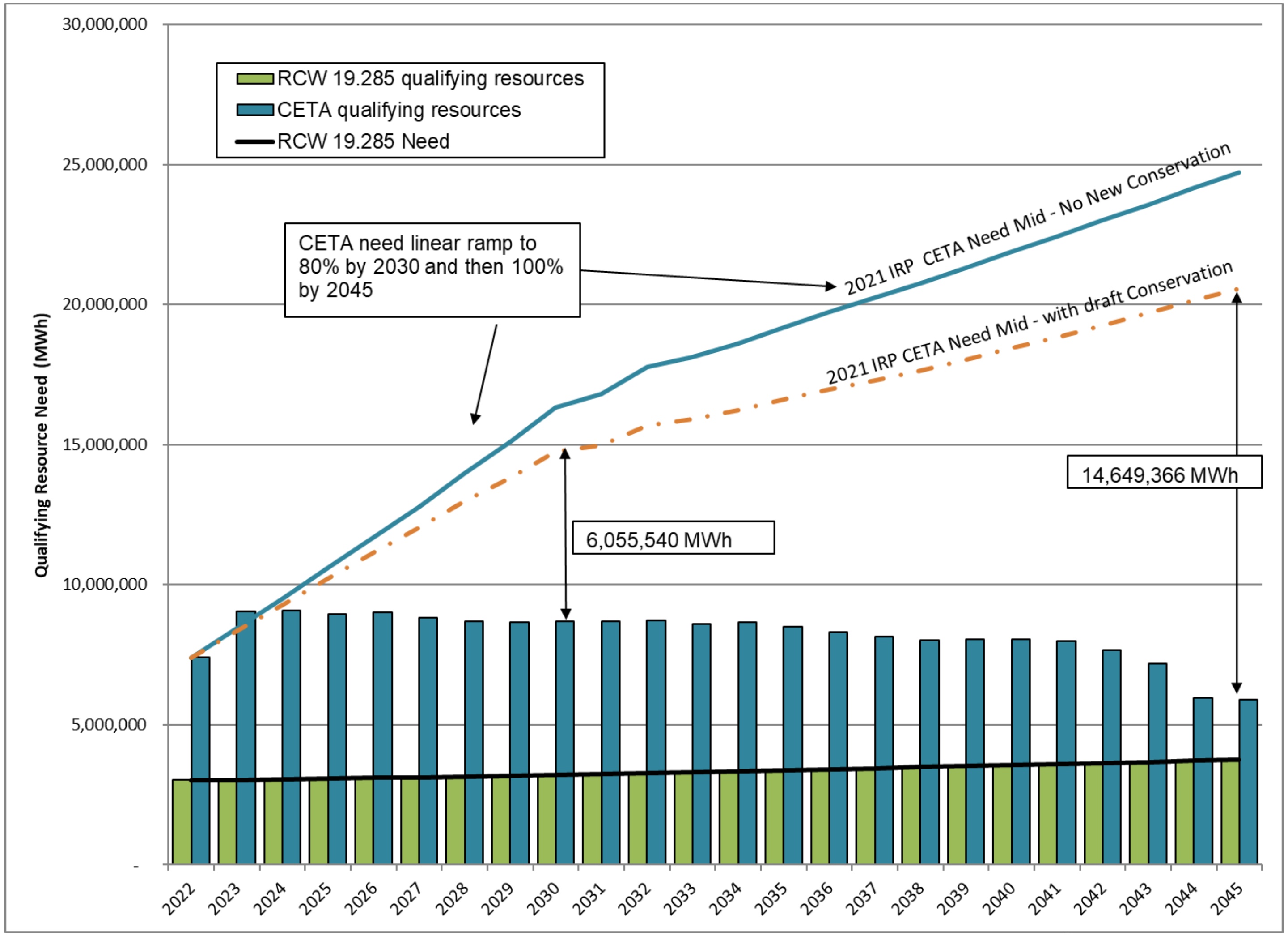
Existing Portfolio and Renewable Need, with cost-effective demand side resources

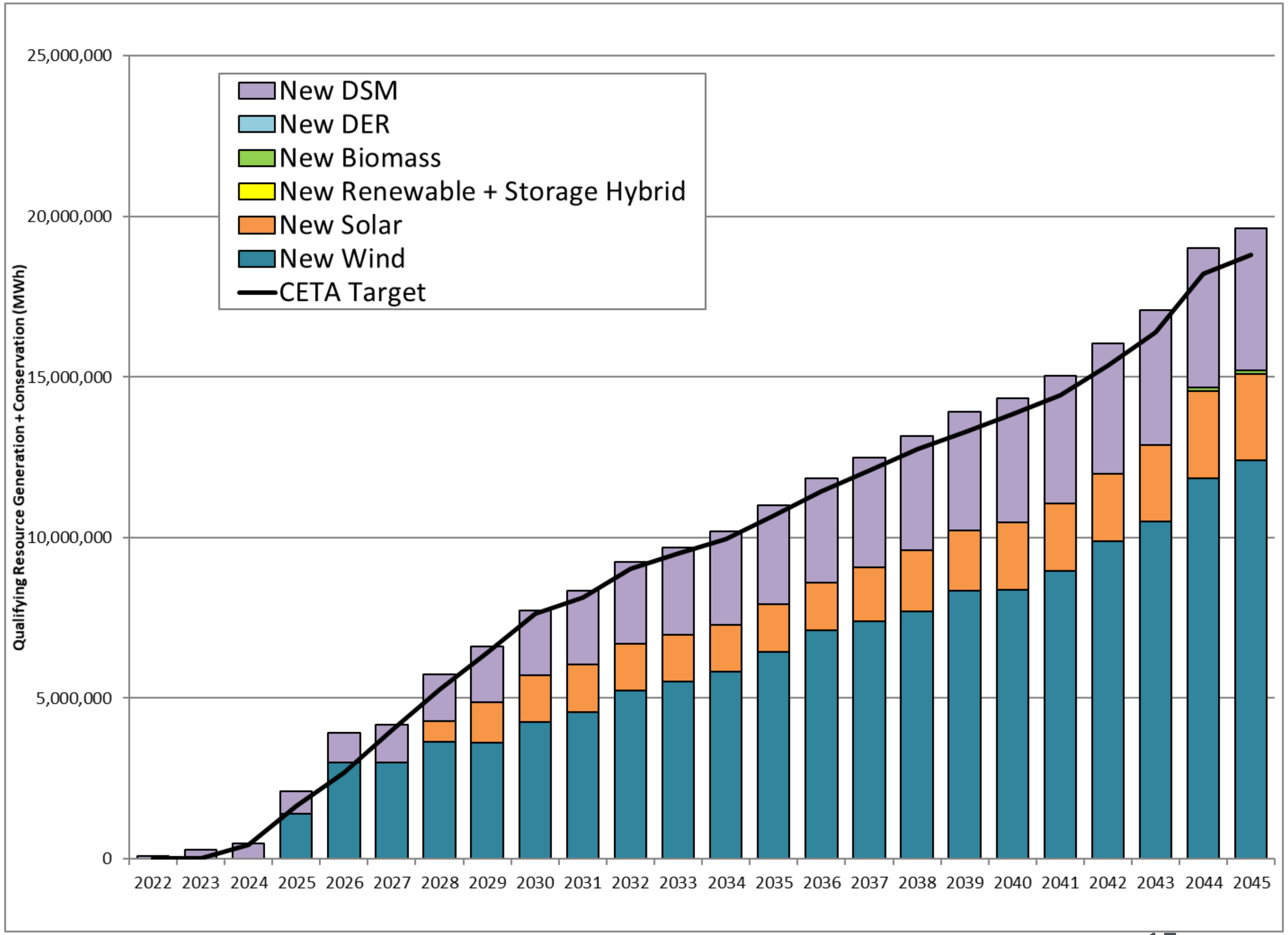
- Cost-effective demand side resources reduce the renewable need by:
  - **1.5 million MWh** of renewable generation in 2030
  - **4.1 million MWh** of renewable generation in 2045

- Electric draft demand side resources include:
  - Conservation savings up to bundle 10 ($175/MWh)
  - Codes and Standards
  - Solar PV BAU
  - Distribution efficiency

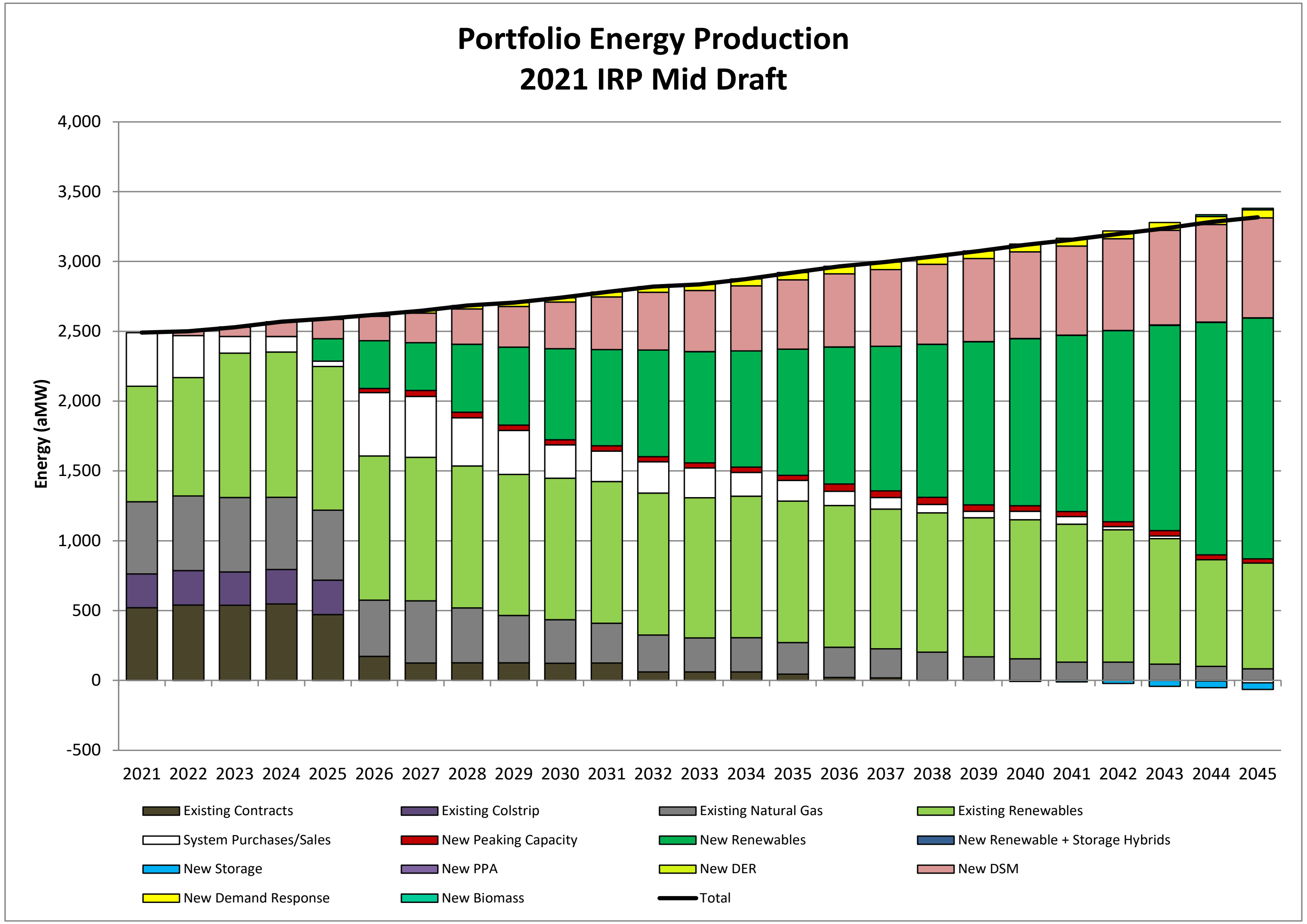


Renewable energy need is met annually across the planning horizon

- Wind is the primary renewable resource added to the portfolio, followed by solar starting in 2028.
- 15 MW of biomass capacity is added in 2044.
- WY and MT wind are the first wind resources added in 2025 and 2026, because their generation profile is well-matched to PSE's load profile but they are limited by transmission.
- Without transmission constraints, WA wind is added consistently through the planning time horizon starting in 2028.



Hourly energy need is met in mid portfolio



- Model is constrained to meet hourly energy need. This chart shows the sum for each year.
- Energy is provided by conservation and new and existing renewable resources.
- The use of existing non-renewable resources decreases significantly over planning horizon.
- Under normal hydro conditions, the capacity factor of existing CCCT plants drops from 70% in 2022 to 5% by 2045.

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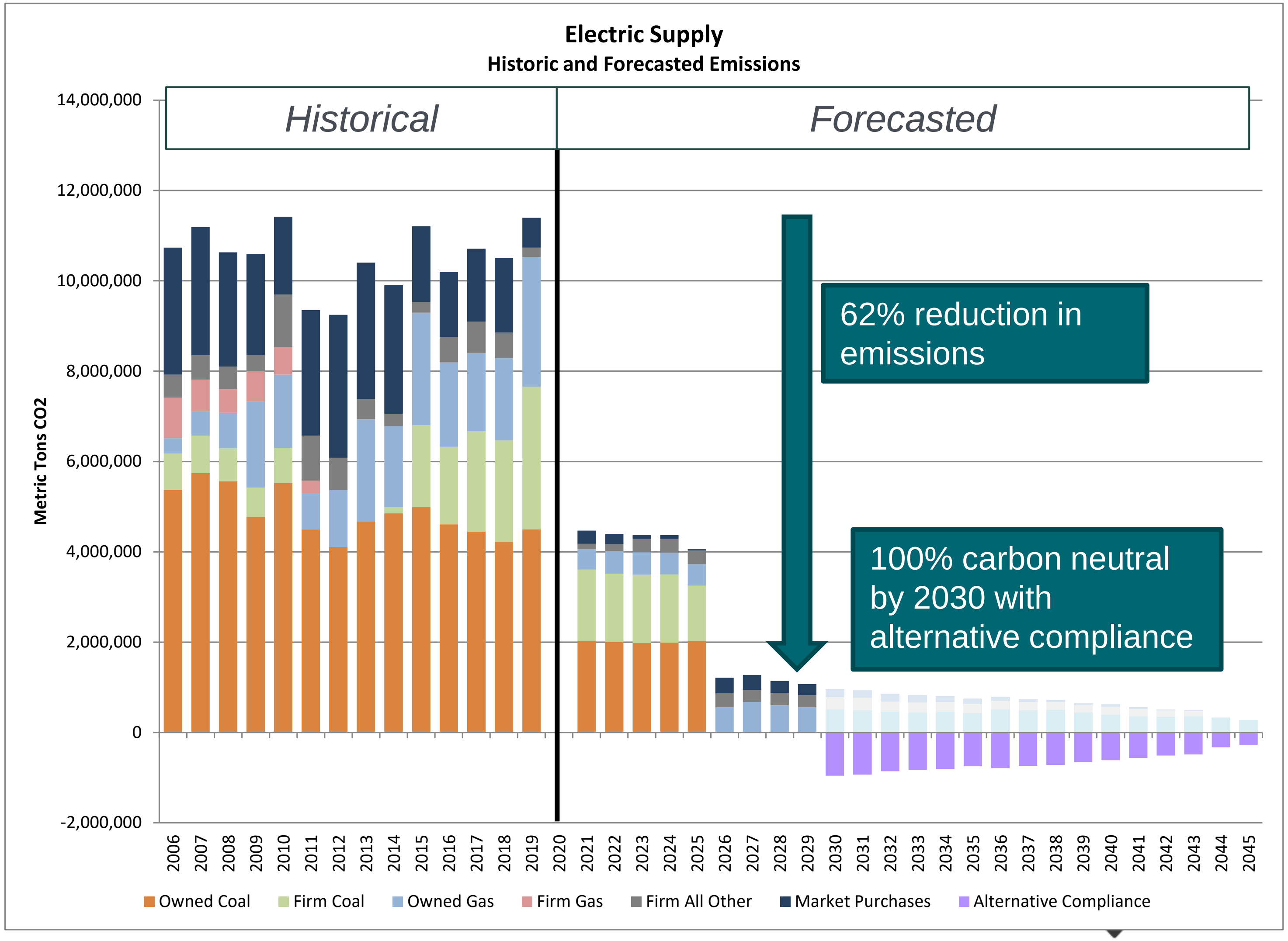
Significant emission reductions are achieved

- 62% reduction in emissions is achieved by 2029 from the retirement of Colstrip and Centralia and reduced dispatch of existing resources.

- PSE is 100% carbon neutral by 2030 with the combination of renewable resources and alternative compliance.



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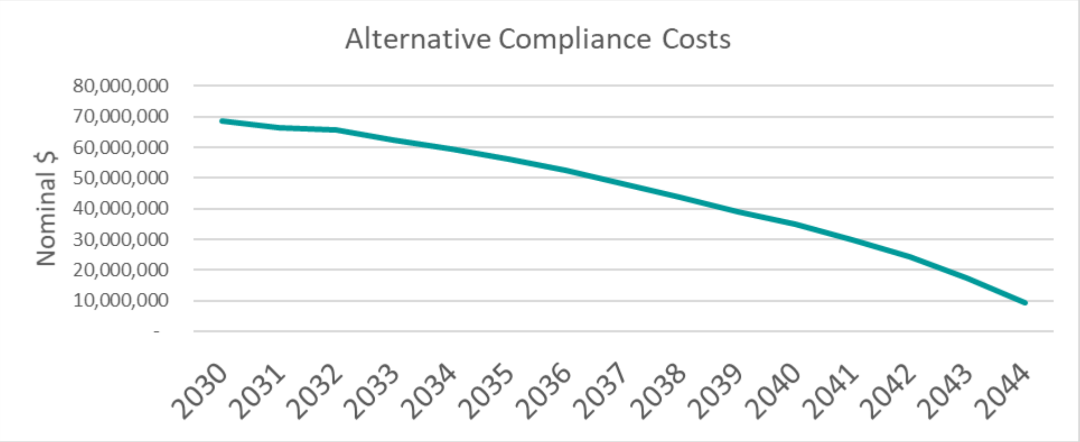
Alternative compliance is used to achieve carbon neutral starting in 2030

- Alternative compliance is represented through renewable energy credits.
  - Actual compliance of the 2030 carbon neutral standard may be met through renewable resources, energy efficiency, unbundled RECs or energy transformation projects.
- In 2030, 20% of load may be met through alternative compliance. 20% decreases linearly to zero in 2045.
- Example calculation:
  - In 2030, the expected load is 20,406,699 MWh
  - 80% of this load, the CETA requirement, is 16,325,360 MWh
  - For the remaining 4,081,340 MWh:

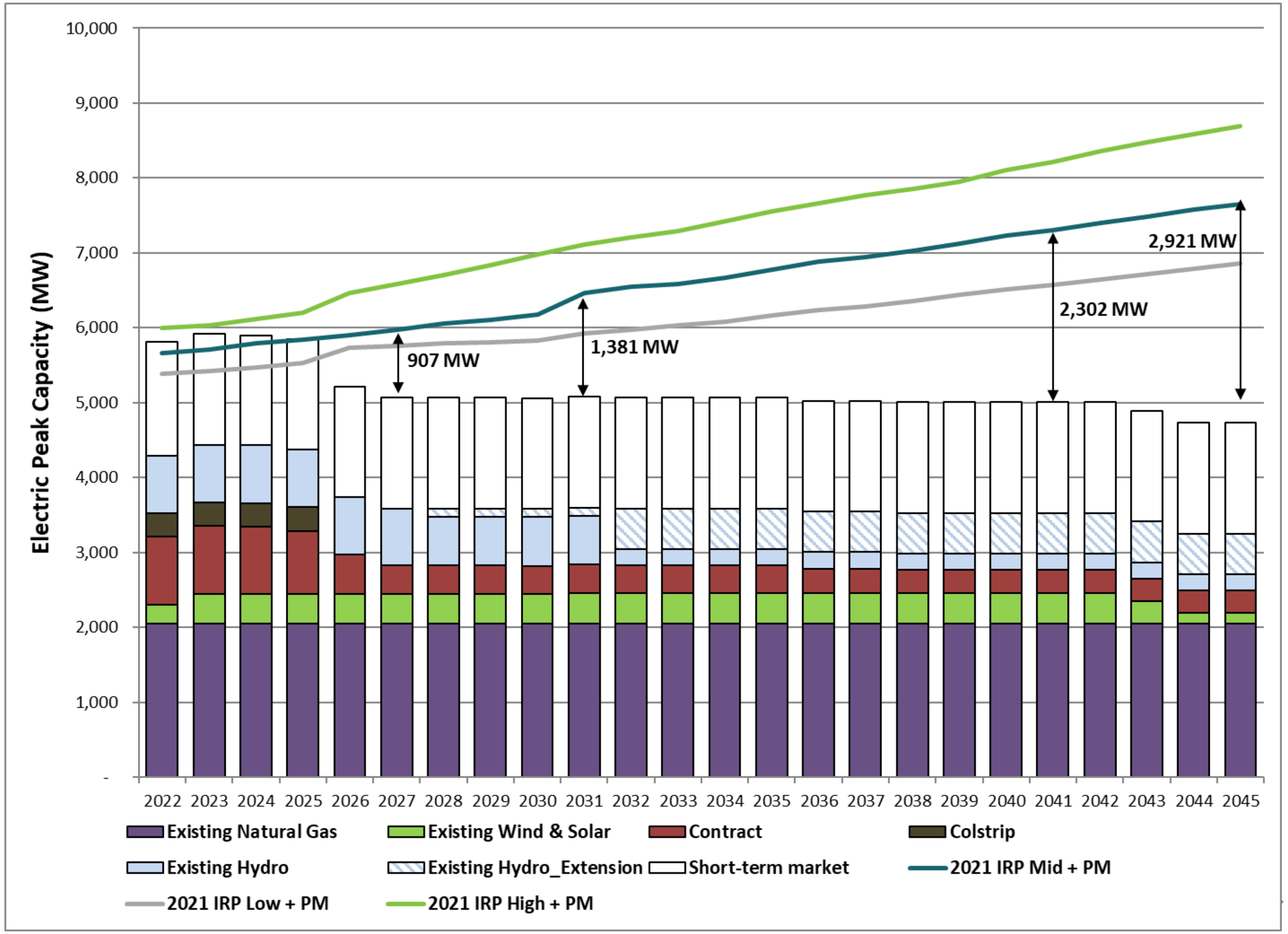
4,081,340 MWh X 0.481709 short ton/MWh X $34.87/short ton = $68,562,923

Remaining energy	CETA market purchase emission rate	CA Carbon Price, Nominal $



Existing Portfolio and Peak Capacity Need, before demand-side resources

- Peak capacity need is the one-hour winter peak needed to meet load plus planning margin.
  - The planning margin is 20.7% in 2027 and 24.2% in 2031.
- PSE's current portfolio is projected to provide sufficient peak capacity until the year 2025.
- In 2025, Centralia and Colstrip 3 & 4 are removed from PSE's portfolio.



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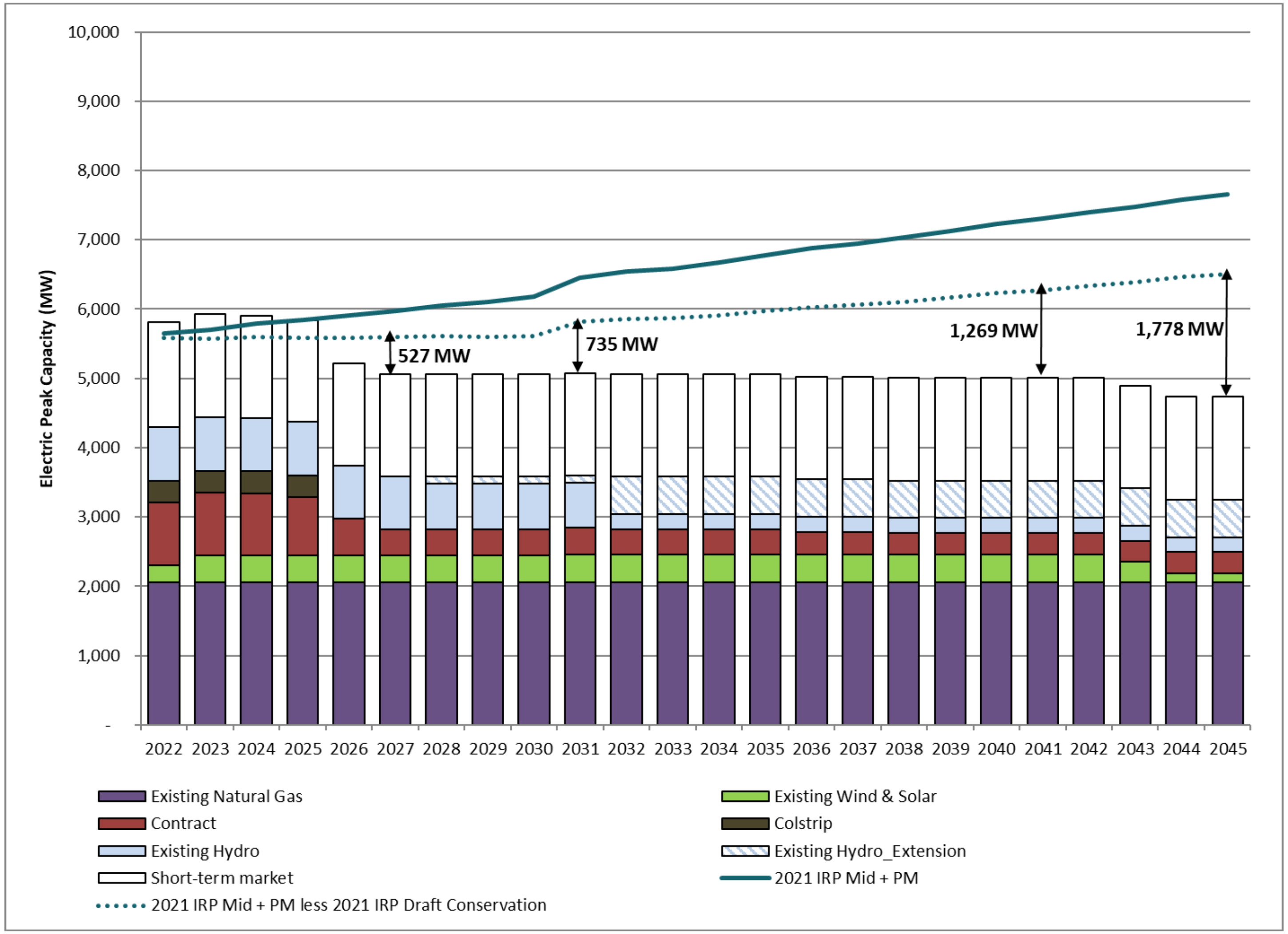
Existing Portfolio and Peak Capacity Need, with cost-effective demand side resources

- In 2027, cost-effective demand side resources reduce the peak capacity need by 380 MW.

- Total peak capacity contribution of electric draft demand side resources is provided by:
  - Codes & Standards
  - Conservation savings up to bundle 10 ($175/MWh)
  - Distribution Efficiency
  - Demand Response



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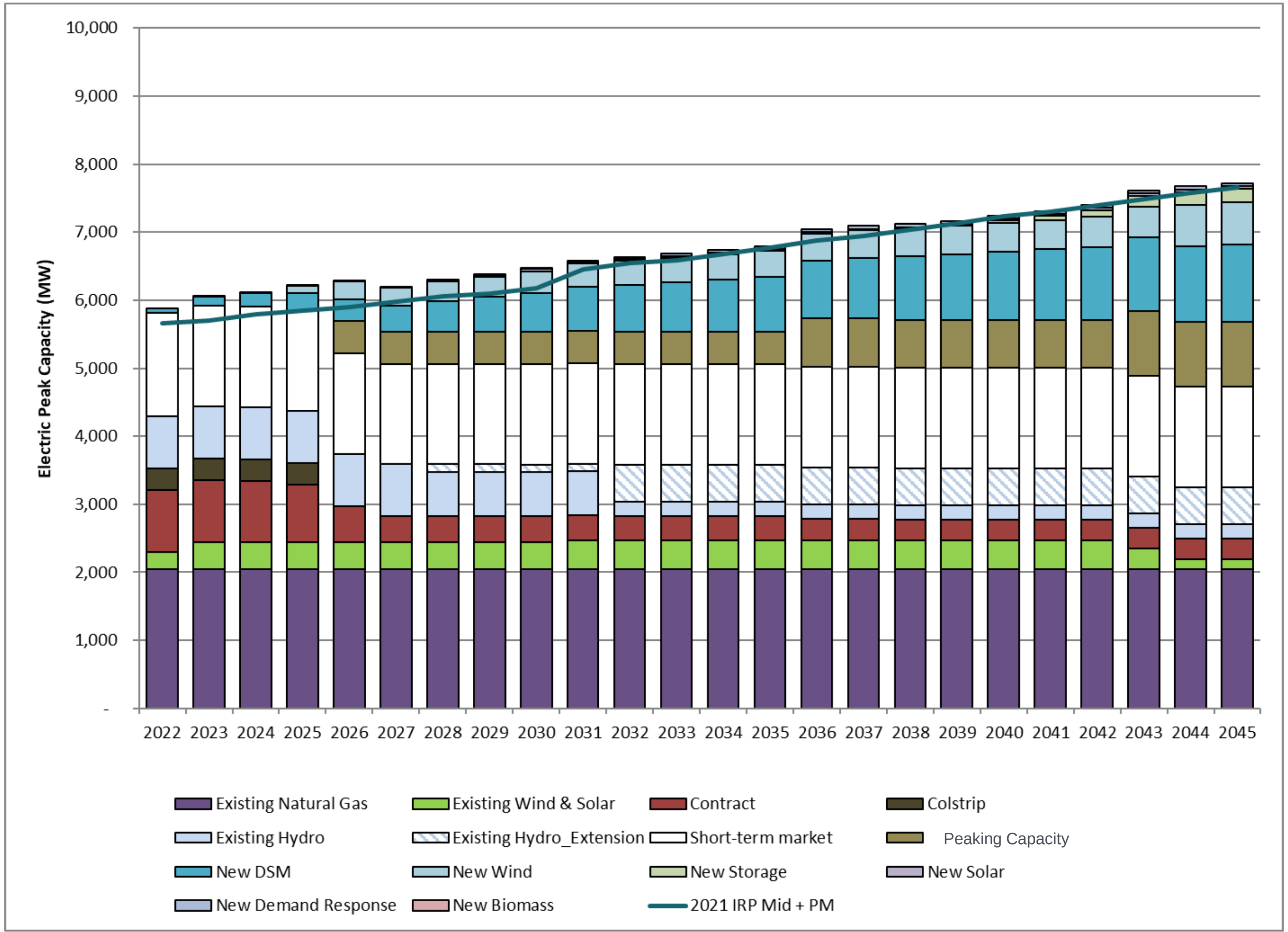
Annual resource additions for mid portfolio

Incremental Resource Additions		DSM Bundles	DSM C&S + PV	Total DSM	DER Solar	DER Storage	Total DER	Demand Response		Biomass		Wind		Solar		Storage		Peaking Capacity	
2022 - 2025 Colstrip and Centralia Retire in 2025	2022	37	37	256	-	3	16	-	5	-	-	-	400	-	-	-	-	-	-
	2023	39	25		3	3		1		-		-		-		-		-	
	2024	42	19		3	6		1		-		-		-		-		-	
	2025	44	13		-	4		3		-		400		-		-		-	
2026 - 2030 CETA 80% Renewable Requirement in 2030	2026	47	16	344	-	3	19	5	46	-	-	400	800	-	697	-	-	474	474
	2027	49	16		-	5		6		-		-		-		-		-	
	2028	52	28		3	3		13		-		200		299		-		-	
	2029	52	18		2	3		9		-		-		299		-		-	
	2030	56	11		-	4		14		-		200		100		-		-	
2031-2045 CETA 100% Renewable Requirement in 2045	2031	58	14	907	1	3	55	14	69	-	15	100	2,550	-	699	-	600	-	474
	2032	28	21		1	4		15		-		200		-		-		-	
	2033	29	29		1	3		15		-		100		-		-		-	
	2034	32	35		1	3		5		-		100		-		-		-	
	2035	29	28		1	4		5		-		200		-		-		-	
	2036	29	3		1	4		2		-		200		-		-		237	
	2037	28	30		1	3		1		-		100		100		-		-	
	2038	27	31		1	3		1		-		100		100		-		-	
	2039	27	45		1	3		1		-		200		-		-		-	
	2040	24	49		1	3		1		-		-		100		150		-	
	2041	21	24		1	4		1		-		200		-		75		-	
	2042	19	27		1	4		1		-		300		-		100		-	
	2043	16	45		1	4		1		-		200		200		175		237	
	2044	17	60		1	4		1		15		350		200		75		-	
	2045	15	68		1	4		1		-		200		-		25		-	
Grand Total		817	690	1,507	28	89	118	121		15		3,750		1,396		600		948	

Flexible, peaking capacity is needed to meet peak capacity need



- Flexible peaking capacity is needed to replace Colstrip 3 & 4 and Centralia in 2026.
- Alternative renewable fuels, such as hydrogen, will be analyzed in the sensitivities.
- The resources shown are the least-cost optimization results and should not be used as an indication of PSE's future acquisitions.
- Includes 1500 MW of available Mid-C transmission to market.

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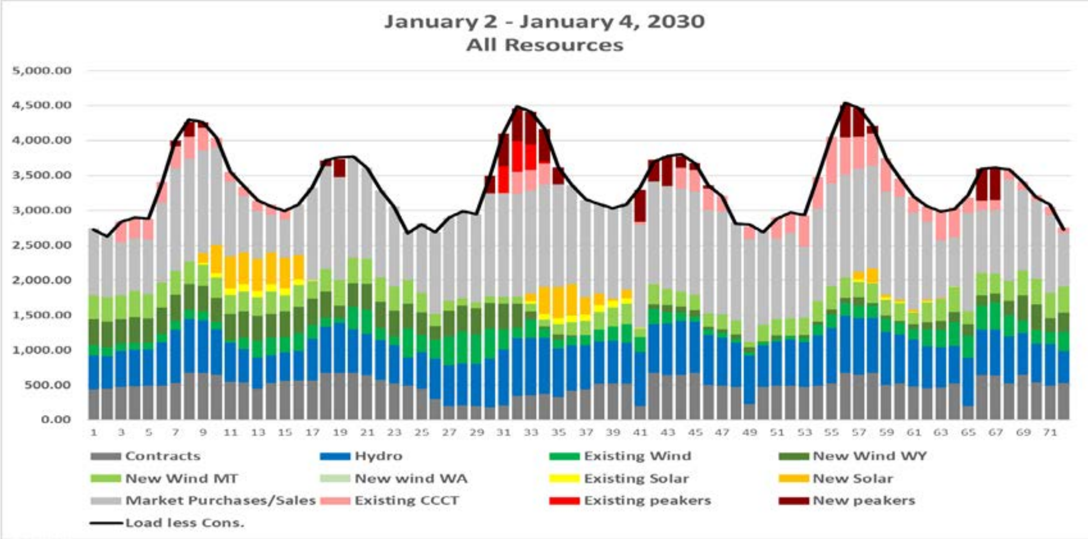
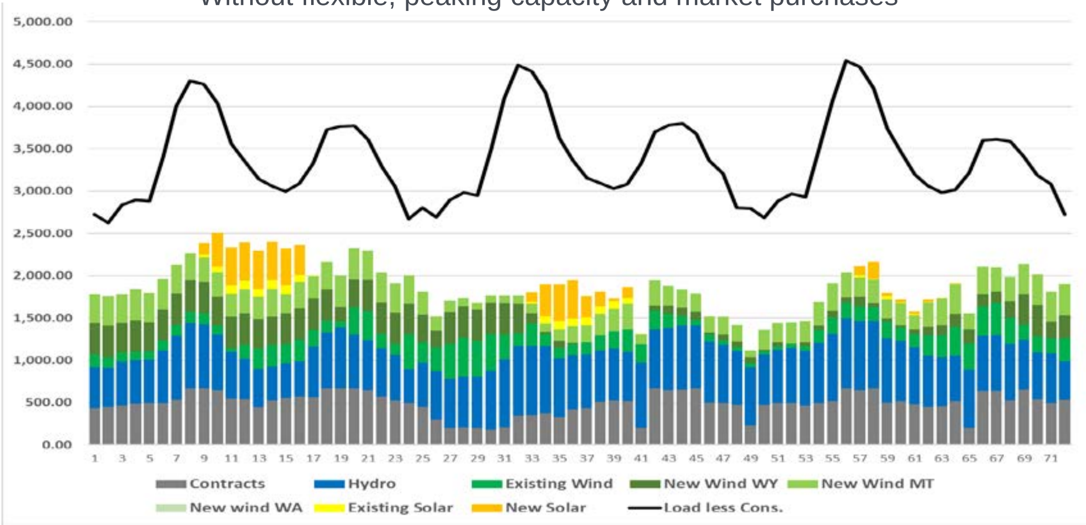
Flexible, peaking capacity is needed during periods of peak load and limited renewable generation



January 2 – January 4, 2030
Without flexible, peaking capacity and market purchases



- Flexible, peaking capacity is needed during extended periods of limited wind and solar supply.
- Results show large amounts of market reliance during a peak event based on economic dispatch. Market reliance will be further evaluated through sensitivity analysis.
- The modeled energy storage resources provide limited capacity contributions during periods of resource shortfall such as the 72-hour period shown.

Resource	Discharge Time
Batteries	2-6 hours
Pumped Hydro Storage	8-10 hours

2021 IRP draft mid portfolio observations

- ✓ CETA targets are met in 2025, 2030 and 2045.
- ✓ Emissions are reduced by 62% by 2029 and 100% carbon neutral by 2030.
- ✓ Conservation is a key resource contributing to meeting CETA targets.
- ✓ Utility-scale renewable resources are added to meet the renewable requirements.
  - Transmission constraints are not included but may be present and are further analyzed in the sensitivities.
- ✓ Flexible, peaking capacity is needed to meet the capacity shortfall starting in 2026 and to reliably meet load during periods of peak load events.
- ✓ There is no early retirement of any existing resources, including Colstrip 3 & 4, even though the portfolio model is allowed economic retirement.
- ✓ Increased amounts of demand response are selected in the least cost portfolio.
- ✓ Capacity factors of existing CCCT drops from 70% in 2022 to 5% by 2045.

Note: Any observations made from the least-cost optimized portfolio only apply to this specific portfolio model results and are not representative of PSE's preferred portfolio or final resource plan.

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2021 IRP Electric Portfolio Sensitivity Draft Results

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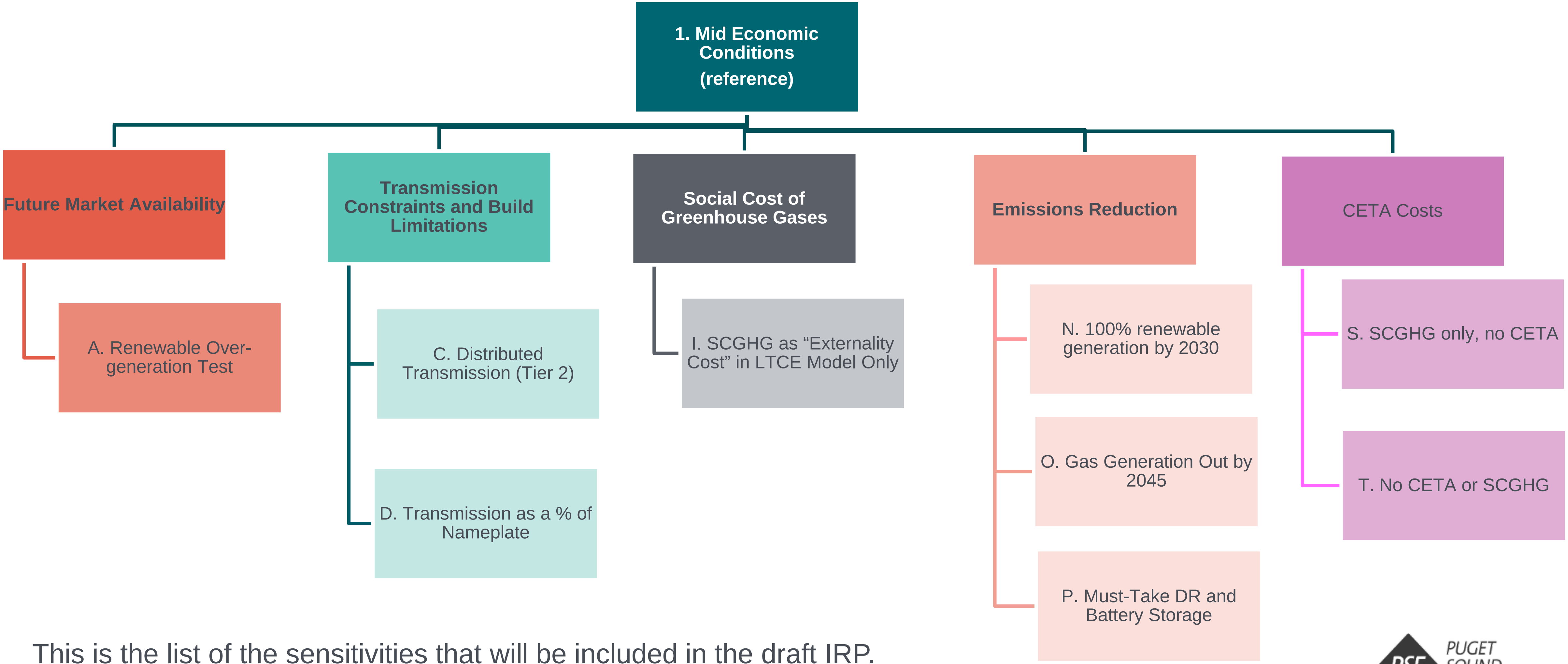
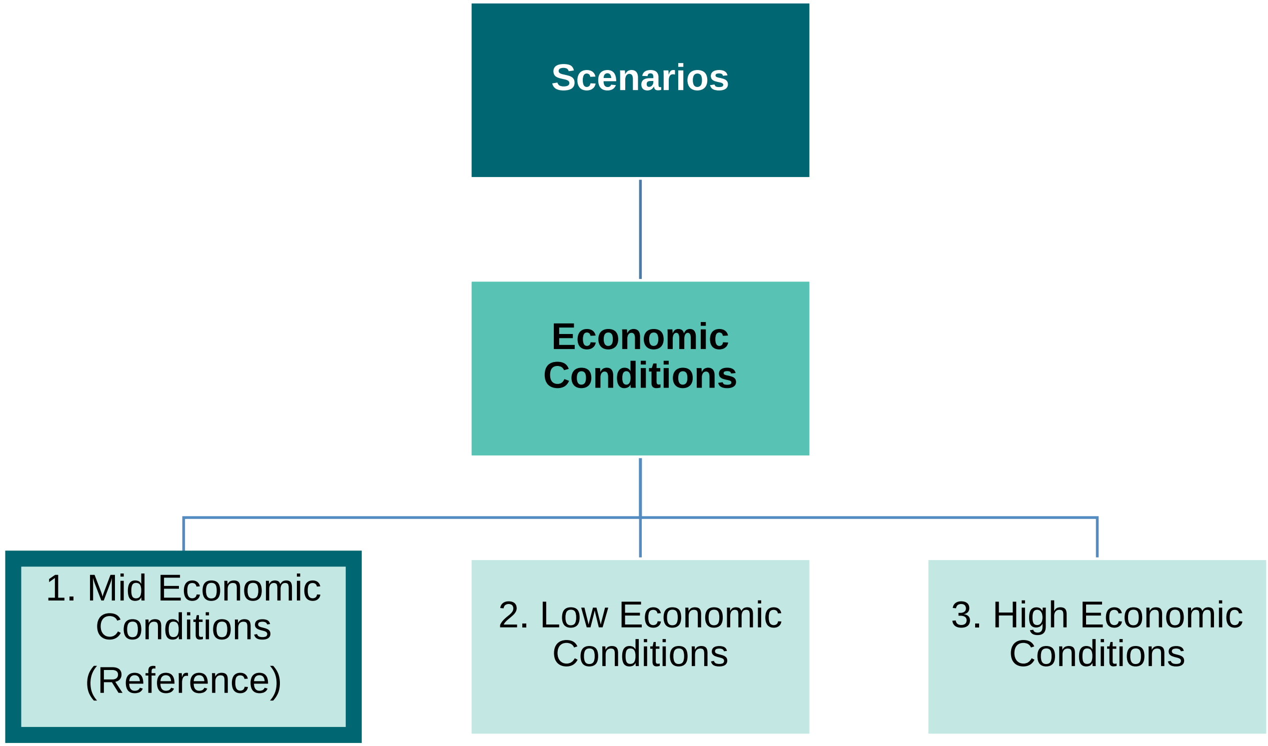
Mid, low and high plus results for 6 sensitivities are included in this presentation



This is the list of the sensitivities that will be included in the draft IRP. Additional sensitivities will be modeled for the final IRP.

Economic Conditions – mid, low, and high



Economic Conditions:

Mid –

- Mid gas price
- Mid demand forecast
- Mid power price

Low –

- Low gas price
- Low demand forecast
- Low power price

High –

- High gas price
- High demand forecast
- High power price

Economic Conditions - results

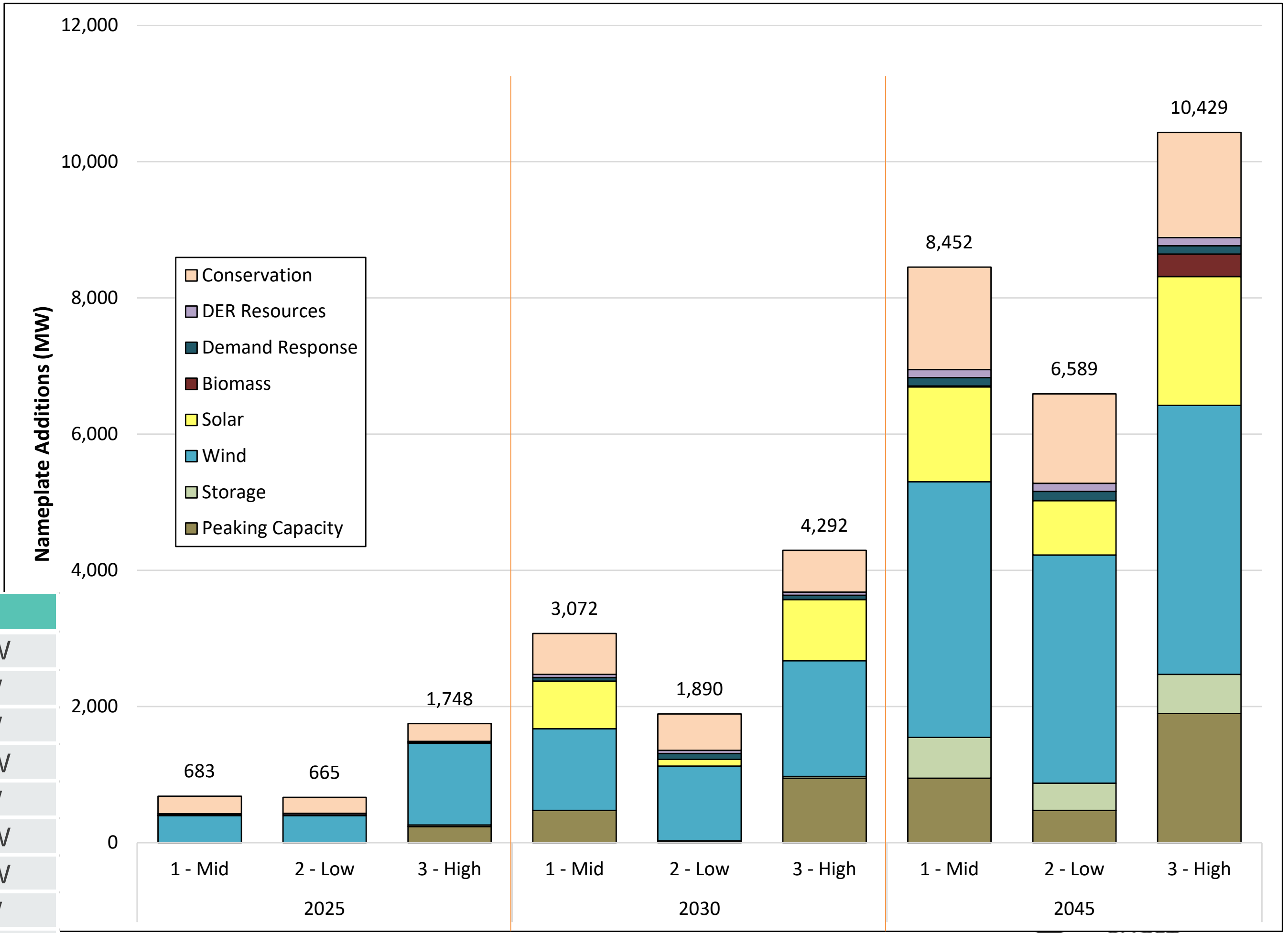
Low

- Less resources added because of lower peak capacity and renewable energy need
- Conservation savings up to bundle 8
- No economic retirements of existing resources

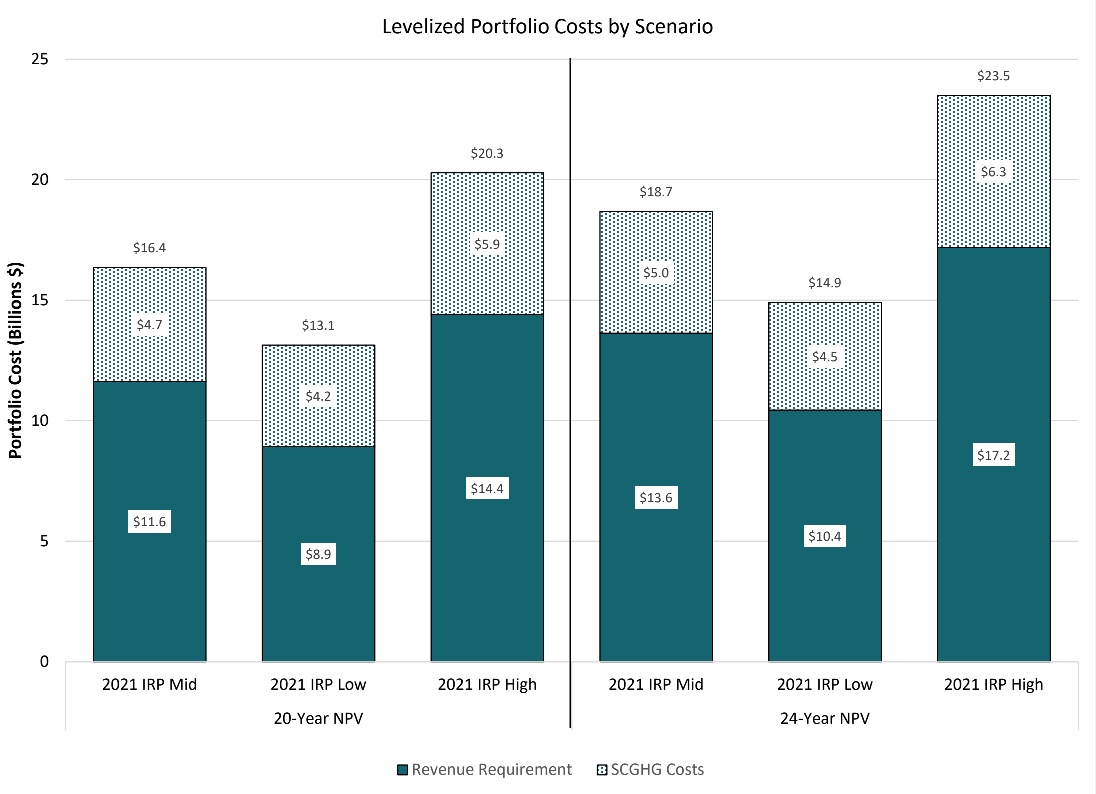
High

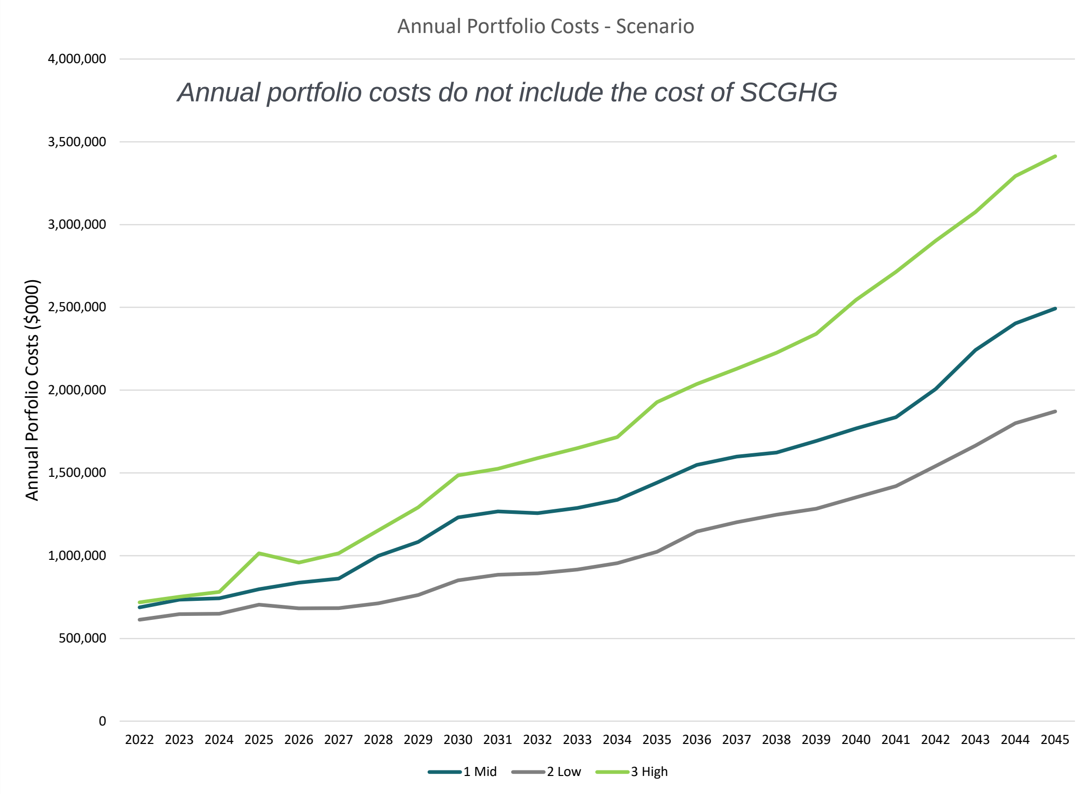
- More resources added because of higher peak capacity and renewable energy need
- Conservation savings up to bundle 11
- No economic retirements of existing resources

Resource Additions by 2045	Mid	Low	High
Conservation	1507 MW	1313 MW	1547 MW
DER Resources	118 MW	118 MW	118 MW
Demand Response	121 MW	137 MW	122 MW
Renewable Resources	5158 MW	4147 MW	6171 MW
Biomass	15 MW	0 MW	330 MW
Solar	1393 MW	797 MW	1891 MW
Wind	3750 MW	3350 MW	3950 MW
Storage	600 MW	400 MW	575 MW
Peaking Capacity	948 MW	474 MW	1896 MW



Economic Conditions – portfolio costs





Portfolio Costs	Mid	Low	High
Total Portfolio Costs 24 Yr Levelized	$18.7	$14.9	$23.5
Revenue Requirement	$13.6	$10.4	$17.2
SCGHG Costs	$5.0	$4.5	$6.3
Total Portfolio Costs 20 Yr Levelized	$16.4	$13.1	$20.3
Revenue Requirement	$11.6	$8.9	$14.4
SCGHG Costs	$4.7	$4.2	$5.9

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Market Sensitivities – renewable over-generation test

1. Mid Economic Conditions

(reference)

Future Market Availability

A. Renewable Over-generation Test

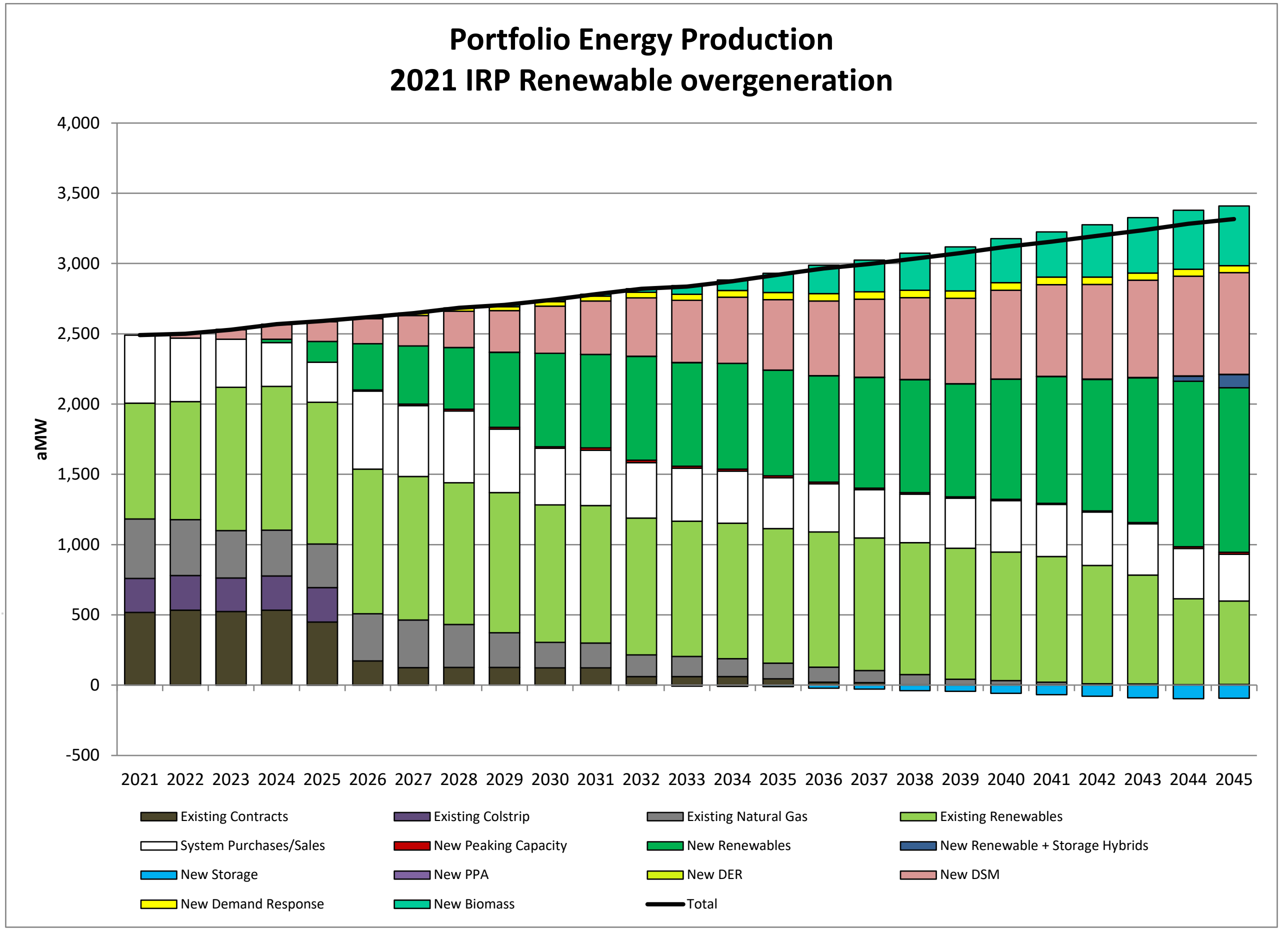
A. Renewable Over-generation test

- The model currently counts any energy that is generated and sold to the Mid-C market towards meeting PSE's CETA targets.
- This sensitivity forces the curtailment of any energy sold to the Mid-C market instead and the model has to meet the CETA requirements strictly by serving load.
- **In short, this sensitivity allows PSE to purchase from the Mid-C market, but not to sell to the Mid-C market.**

A Market Sensitivity – renewable over-generation test - results

- Increased energy storage and lowered peaking capacity
- Lack of sales and overbuilding leads the portfolio to a greater reliance on market at peak hours and higher cost
- Less solar wind, and peaking capacity built
- More biomass added
- Constant, though reduced, market purchases
- Conservation savings up to bundle 12
- No economic retirements of existing resources
- Further analysis is needed to assess the effect of eliminating market purchases

Resource Additions by 2045	Mid	A - Renewable Overgeneration
Conservation	1507 MW	1554 MW
DER Resources	118 MW	118 MW
Demand Response	121 MW	183 MW
Renewable Resources - Biomass Excluded	5143 MW	3640 MW
Biomass	15 MW	525 MW
Storage	600 MW	1125 MW
Peaking Capacity	948 MW	692 MW



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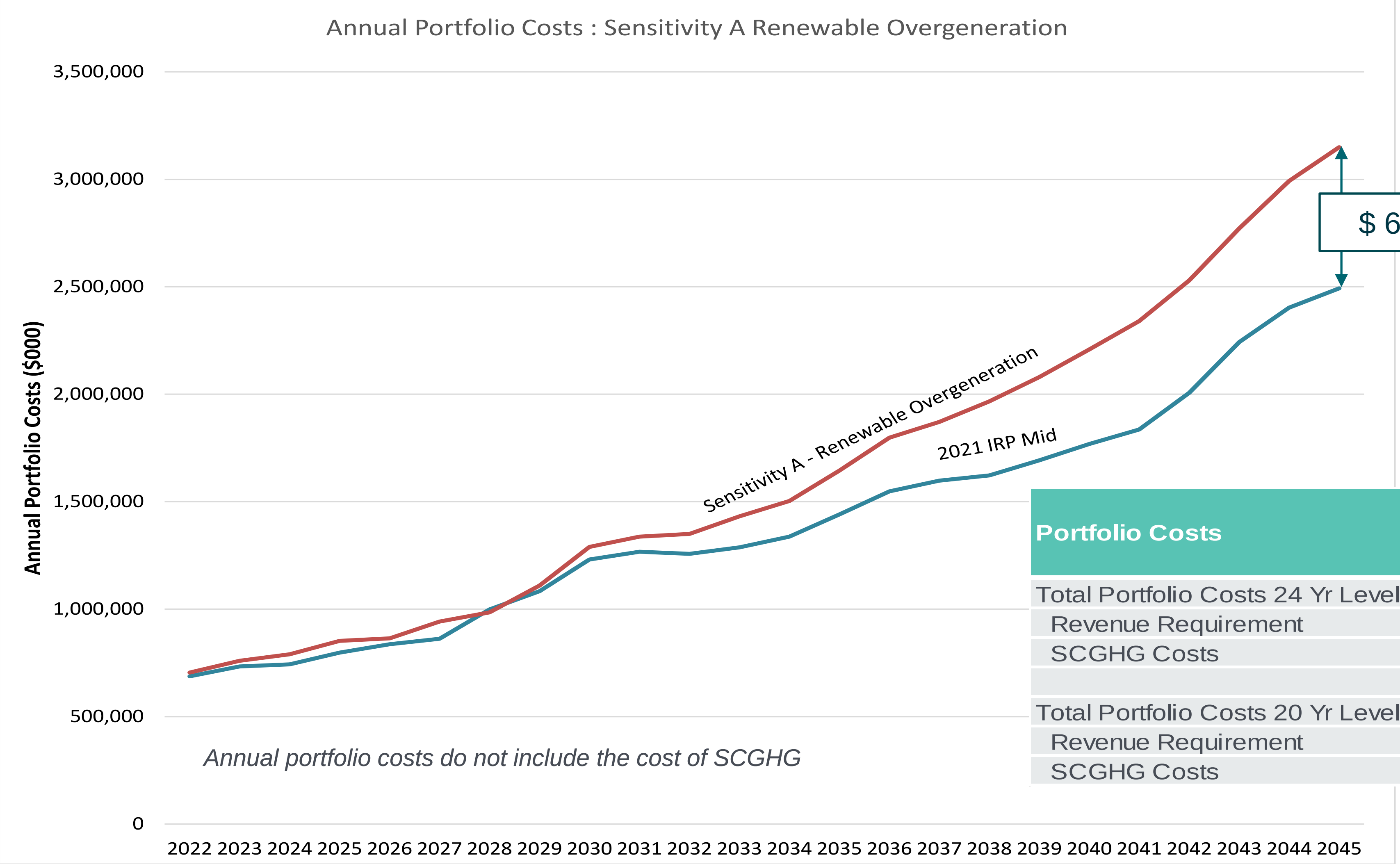
Market Sensitivity – renewable over-generation test – portfolio costs



Portfolio Costs	Mid	A - Renewable Overgeneration
Total Portfolio Costs 24 Yr Levelized	$18.7	$19.6
Revenue Requirement	$13.6	$15.3
SCGHG Costs	$5.0	$4.2
Total Portfolio Costs 20 Yr Levelized	$16.4	$16.8
Revenue Requirement	$11.6	$12.8
SCGHG Costs	$4.7	$4.0

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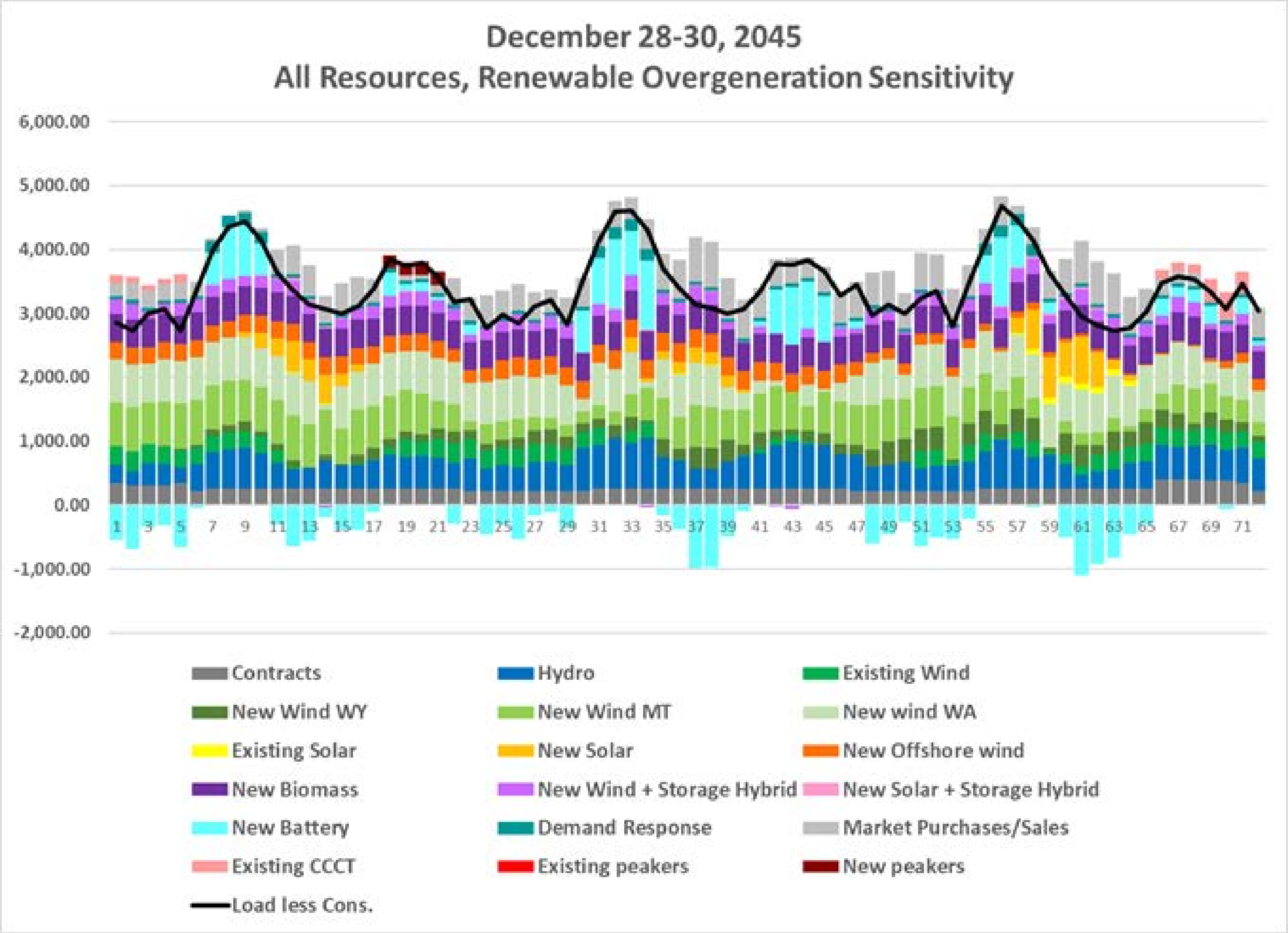
Market Sensitivity – renewable over-generation test – generation during peak load hours



- **The portfolio is relying heavily on market purchase availability to charge the batteries.** There is no oversupply of resources from PSE's portfolio to charge the batteries.
- Nearly twice the storage capacity of the Mid Portfolio is added by 2045.
- The batteries charge in the lower load hours using market purchases in excess of load and discharge during high load hours.
- Further sensitivity analysis is needed to assess the effect of eliminating market purchases.
- Increased biomass generation tads baseload capacity and helps meet CETA targets.

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Market Sensitivity – renewable over-generation test - hourly generation of renewable resources in 2030

Mid Portfolio - 2030

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0:00	564	655	480	344	49	(11)	334	500	707	474	456	423
1:00	518	620	464	340	(1)	(69)	274	426	662	422	419	337
2:00	551	640	452	285	(112)	(142)	234	381	662	384	423	367
3:00	597	709	508	327	(59)	(125)	232	412	685	420	468	391
4:00	556	633	583	410	32	(79)	311	462	768	489	327	333
5:00	944	873	719	354	(56)	(127)	214	437	714	496	528	680
6:00	1283	1152	1044	486	60	(10)	368	572	826	734	774	1091
7:00	1421	1130	971	416	(41)	(87)	291	514	670	695	812	1259
8:00	1375	1041	884	272	(107)	(106)	298	534	609	565	735	1235
9:00	1180	953	742	245	(64)	(71)	379	585	660	569	674	1163
10:00	1110	897	626	182	(123)	(92)	392	591	661	492	682	1136
11:00	980	842	507	111	(147)	(90)	386	606	643	464	633	954
12:00	856	751	351	38	(189)	(143)	326	591	620	429	567	807
13:00	761	670	291	22	(209)	(143)	318	565	643	405	515	787
14:00	684	621	222	50	(177)	(187)	294	568	620	355	503	758
15:00	684	693	343	79	(167)	(127)	299	581	653	415	590	883
16:00	998	789	530	163	(142)	(138)	325	629	693	608	875	1306
17:00	1253	1042	879	408	(9)	42	437	787	992	809	949	1393
18:00	1338	1137	1169	694	303	284	605	935	1126	858	900	1308
19:00	1323	1149	1166	646	297	282	618	904	1077	801	841	1304
20:00	1196	987	1118	636	352	345	712	900	1086	739	741	1105
21:00	1015	871	941	544	300	344	625	812	979	662	633	899
22:00	890	919	701	441	158	78	470	605	796	455	732	904
23:00	640	713	635	500	185	127	444	598	839	559	589	627

Negative Values = Renewable Oversupply

Positive Values = Renewable Undersupply

Renewable Over-generation Test- 2030

2030	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0:00	578	673	514	380	134	71	354	528	715	500	485	450
1:00	546	655	482	371	103	33	300	465	682	472	460	377
2:00	582	675	475	327	23	14	265	442	677	440	476	395
3:00	618	737	533	366	48	15	271	470	685	486	506	410
4:00	575	660	605	442	120	52	349	525	771	533	379	341
5:00	948	886	732	404	48	19	234	484	713	530	549	664
6:00	1255	1161	1054	511	107	76	350	558	803	733	778	1061
7:00	1388	1129	953	394	31	14	235	476	592	683	811	1205
8:00	1342	999	820	262	-11	-13	207	451	509	557	701	1175
9:00	1111	892	662	228	-1	3	271	467	543	533	619	1088
10:00	1056	828	569	170	-19	-12	271	462	527	447	634	1074
11:00	929	769	481	140	-16	-2	261	474	509	413	587	887
12:00	812	692	348	81	-20	-23	203	454	484	394	539	734
13:00	719	602	292	71	-7	-26	201	421	514	381	490	719
14:00	660	557	256	105	0	-33	185	413	500	351	474	712
15:00	655	641	326	146	26	-15	172	424	531	400	562	845
16:00	978	743	514	177	18	-35	193	481	588	574	865	1285
17:00	1253	1030	842	381	63	65	314	683	940	796	940	1366
18:00	1337	1135	1177	681	283	260	518	875	1109	855	891	1277
19:00	1312	1142	1176	648	301	264	577	880	1069	802	846	1276
20:00	1196	996	1134	636	367	342	689	891	1072	751	744	1080
21:00	1013	878	946	554	326	357	611	813	971	673	662	899
22:00	896	923	713	459	195	122	465	621	793	469	756	916
23:00	660	729	651	518	238	152	448	630	842	573	618	631

- Decreased renewable over-generation in this sensitivity, as PSE can only store or curtail this over-generation instead of selling to market.
- In the mid portfolio, 14% of hours had over-generation totaling 1.4% of 2030 load.
- In the sensitivity, 15% of hours had over-generation totaling 0.3% of load.

PSE PUGET SOUND ENERGY

Transmission Sensitivities

1. Mid Economic Conditions (reference)

Transmission Constraints and Build Limitations

C. Distributed Transmission (Tier 2)

D. Transmission as a % of Nameplate

C. "Distributed" Tier 2 Transmission Constraints

- Transmission constraints with "Tier 2" projects available, defined as projects that are available by 2030, with a moderate degree of confidence in their feasibility.
- Available projects in this category total 3,070 MW of available transmission.

D. Transmission as a % of nameplate

- Analyzed the level of firm transmission needed for wind and solar resources.

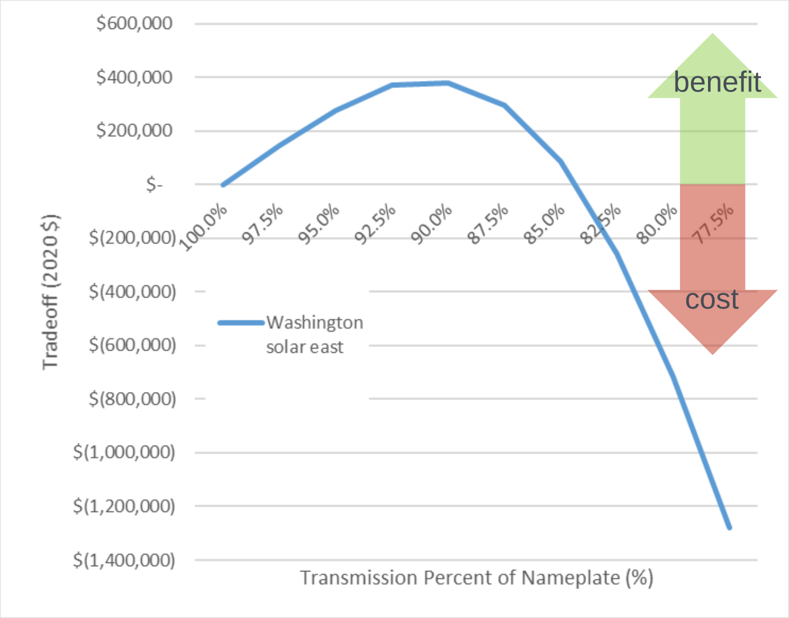
D Transmission Sensitivities – transmission as % nameplate – results

- Analysis performed outside of portfolio model

- Methodology summary:
  tradeoff = [reduced Tx incremental benefit] – [power replacement cost of Tx curtailments]

[fixed Tx cost] * [Tx increment]   [Tx curtailed production] * [levelized cost of power]

Tx percent of nameplate (%)	Tx limit (MW)	Tx curtailed production (MWh)	Delivered power (MWh)	Tx incr. (MW)	Tx incr. benefit ($)	Power replace. cost ($)	Tradeoff ($)
100.0%	200	0	427,800	0	0	0	0
97.5%	195	0	427,800	5	152,000	6,000	146,000
95.0%	190	200	427,600	10	305,000	27,000	277,000
92.5%	185	700	427,100	15	457,000	87,000	370,000
90.0%	180	1,800	426,000	20	610,000	229,000	380,000
87.5%	175	3,700	424,100	25	762,000	468,000	294,000
85.0%	170	6,600	421,300	30	914,000	829,000	85,000
82.5%	165	10,500	417,300	35	1,067,000	1,326,000	-259,000
80.0%	160	15,300	412,500	40	1,219,000	1,938,000	-719,000
77.5%	155	21,000	406,900	45	1,372,000	2,650,000	-1,279,000



Tx = transmission

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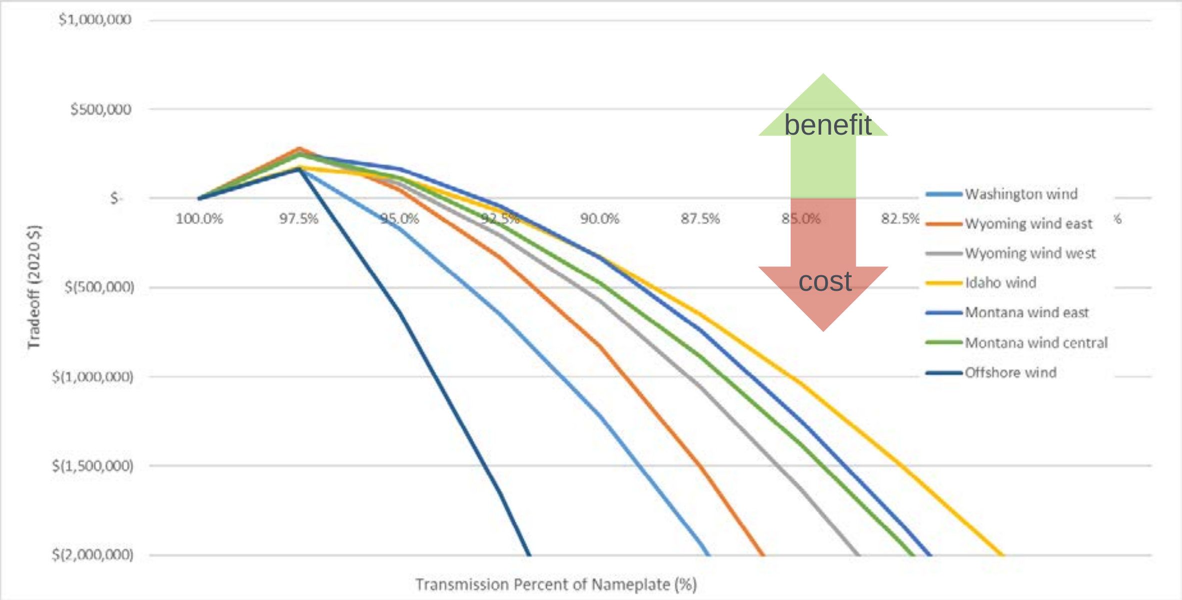
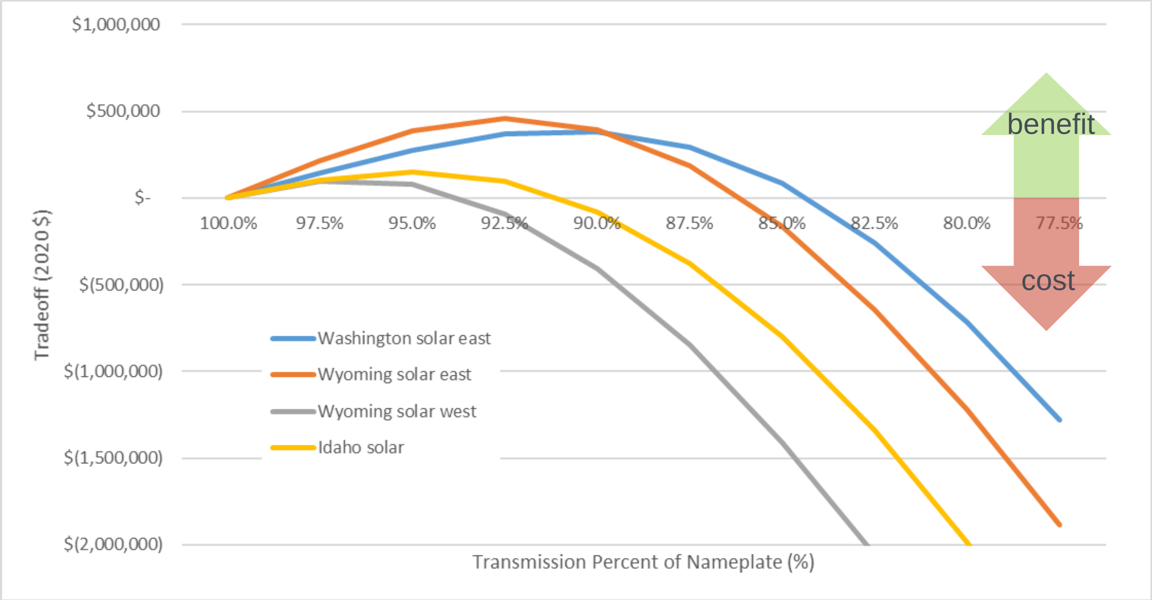
Transmission Sensitivities – transmission as % nameplate – results

Wind Tradeoff

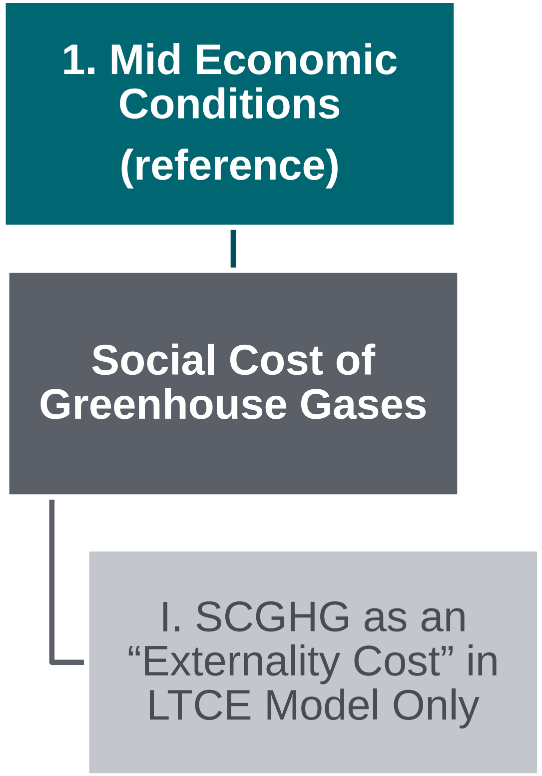


Solar Tradeoff



- Tradeoff benefit is low as compared to annual revenue requirement of resources, therefore, not a viable means to reduce portfolio cost in IRP models
- Effective load carrying capability (ELCC) will be reduced, necessitating additional resource builds
- Assessment holds more value in resource acquisition and project development processes, instead of IRP long-term planning

SCGHG Sensitivities – SCGHG as an externality cost



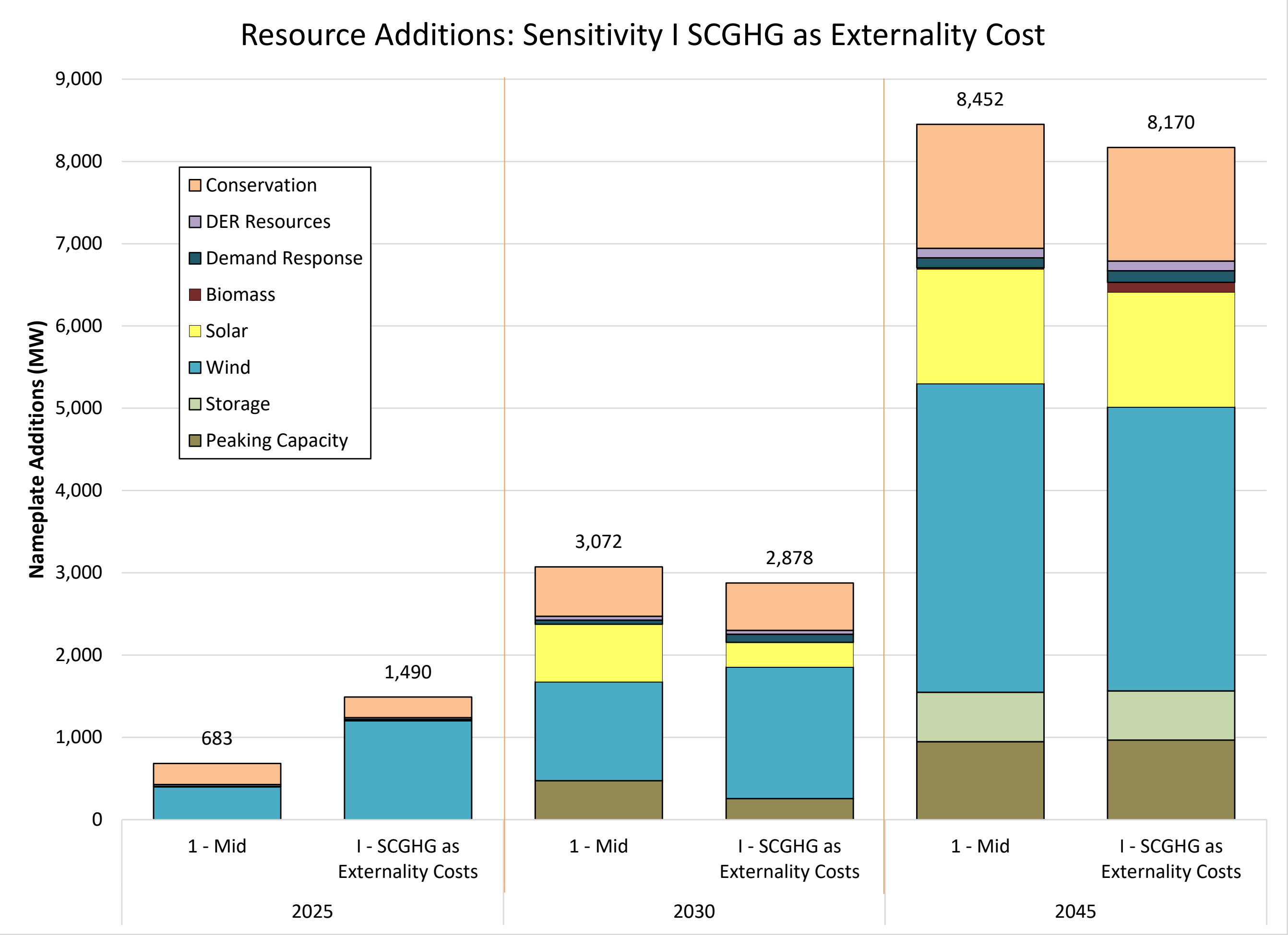
I. SCGHG as an "externality cost"

- The SCGHG is included as a dispatch cost in the LTCE model instead of a fixed cost adder.
- There is still no SCGHG applied in the hourly dispatch model.

SCGHG Sensitivities – SCGHG as an externality costs – results

- Resource additions are very similar to the mid scenario
- Conservation savings are lower than mid portfolio (up to bundle 9)
- No economic retirements of existing resources

Resource Additions by 2045	Mid	I SCGHG as Externality Costs
Conservation	1507 MW	1381 MW
DER Resources	118 MW	118 MW
Demand Response	121 MW	141 MW
Renewable Resources	5158 MW	4964 MW
Biomass	15 MW	120 MW
Solar	1393 MW	1394 MW
Wind	3750 MW	3450 MW
Storage	600 MW	600 MW
Peaking Capacity	948 MW	966 MW



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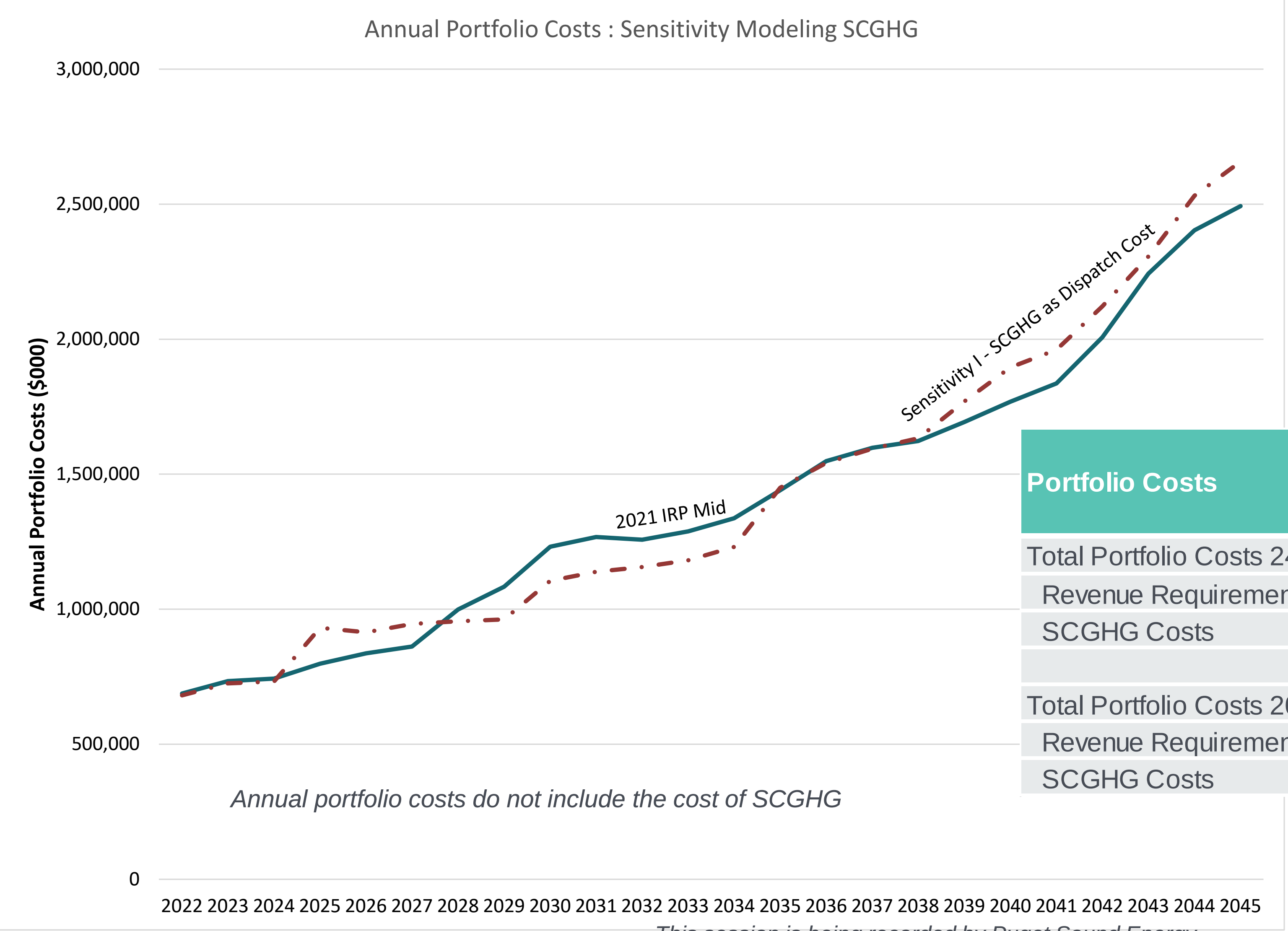
SCGHG Sensitivities – SCGHG as an externality cost – portfolio costs



Annual portfolio costs do not include the cost of SCGHG

- Lower dispatch of thermal plants leads to a lower avoided costs

Portfolio Costs	Mid	I SCGHG as Externality Costs
Total Portfolio Costs 24 Yr Levelized	$18.7	$18.4
Revenue Requirement	$13.6	$13.6
SCGHG Costs	$5.0	$4.8
Total Portfolio Costs 20 Yr Levelized	$16.4	$16.0
Revenue Requirement	$11.6	$11.5
SCGHG Costs	$4.7	$4.5

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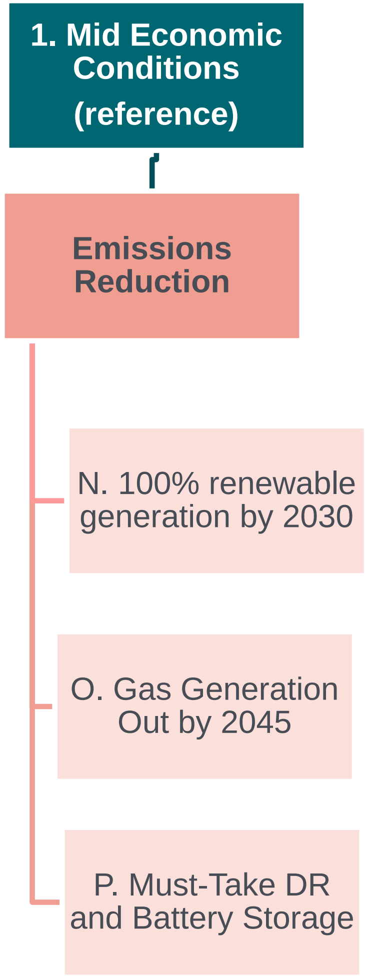
Emission Reduction Sensitivities



N. 100% renewable generation by 2030

- All existing natural gas plants are retired by the year 2030 regardless of their economic viability with CETA penalties.
- Not included in presentation, but will be in draft IRP

O. Gas Generation Out by 2045

- All existing natural gas plants are retired by the year 2045 regardless of their economic viability with CETA penalties.
- Not included in presentation, but will be in draft IRP

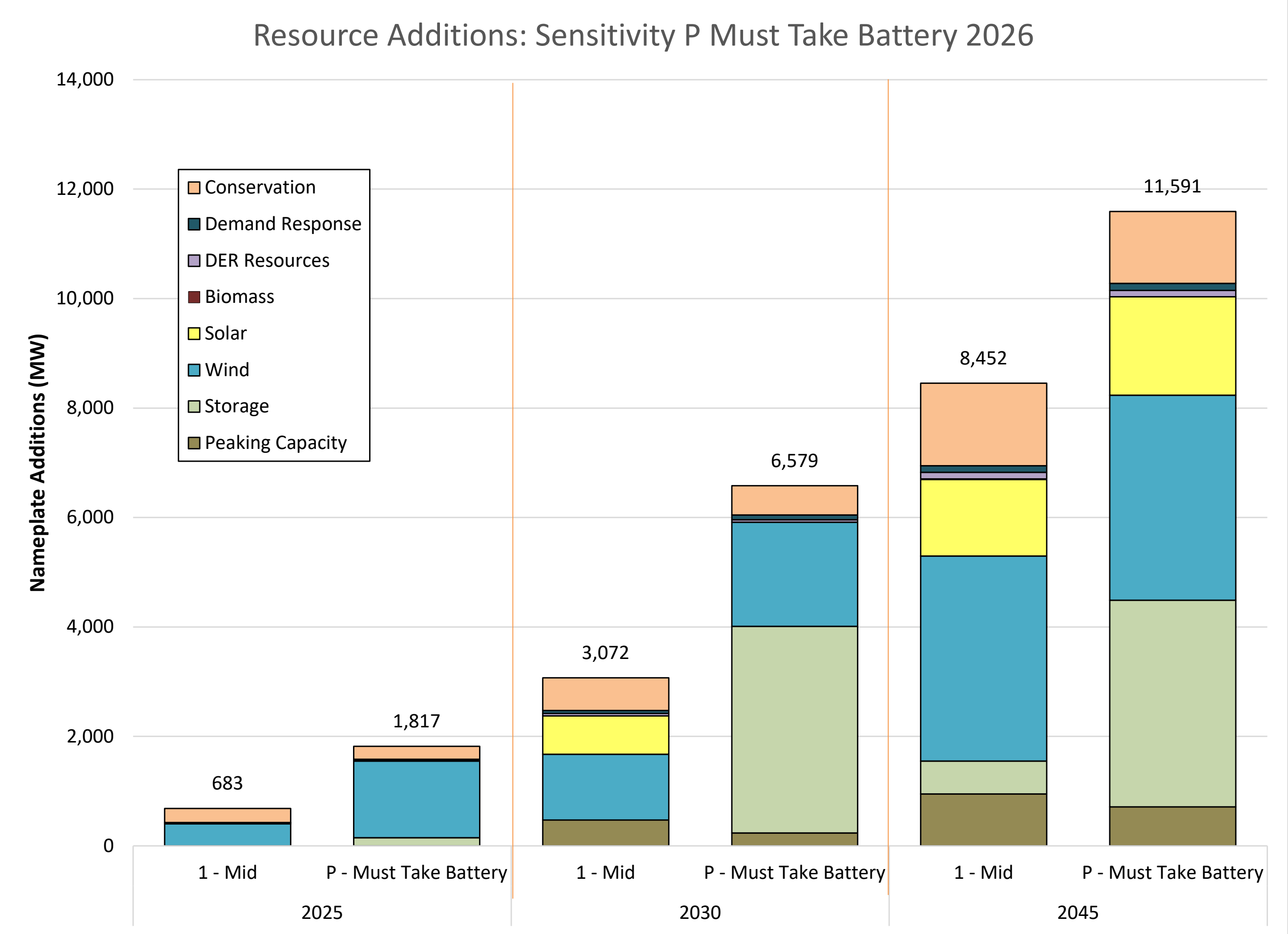
P. Must-Take Demand Response (DR) and Battery Storage

- Starting in 2026, the model is forced to reach the build limits of Demand Response and battery storage options before building any new peaking resources.

Emissions reduction sensitivities – must take DR & battery – results

- Instead of 474 MW of peaking capacity added in 2026, batteries are required to meet peak need.
  - 474 MW peaking capacity at 12.4% ELCC = 3,800 MW nameplate of batteries
- Lower cost-effective conservation in comparison to mid scenario (bundle 8)
- Colstrip 4 economic retirement in 2022

Resource Additions by 2045	Mid	P - Must Take Battery 2026
Conservation	1507 MW	1313 MW
DER Resources	118 MW	118 MW
Demand Response	121 MW	128 MW
Renewable Resources	5158 MW	5546 MW
Biomass	15 MW	0 MW
Solar	1393 MW	1796 MW
Wind	3750 MW	3750 MW
Storage	600 MW	3775 MW
Peaking Capacity	948 MW	711 MW



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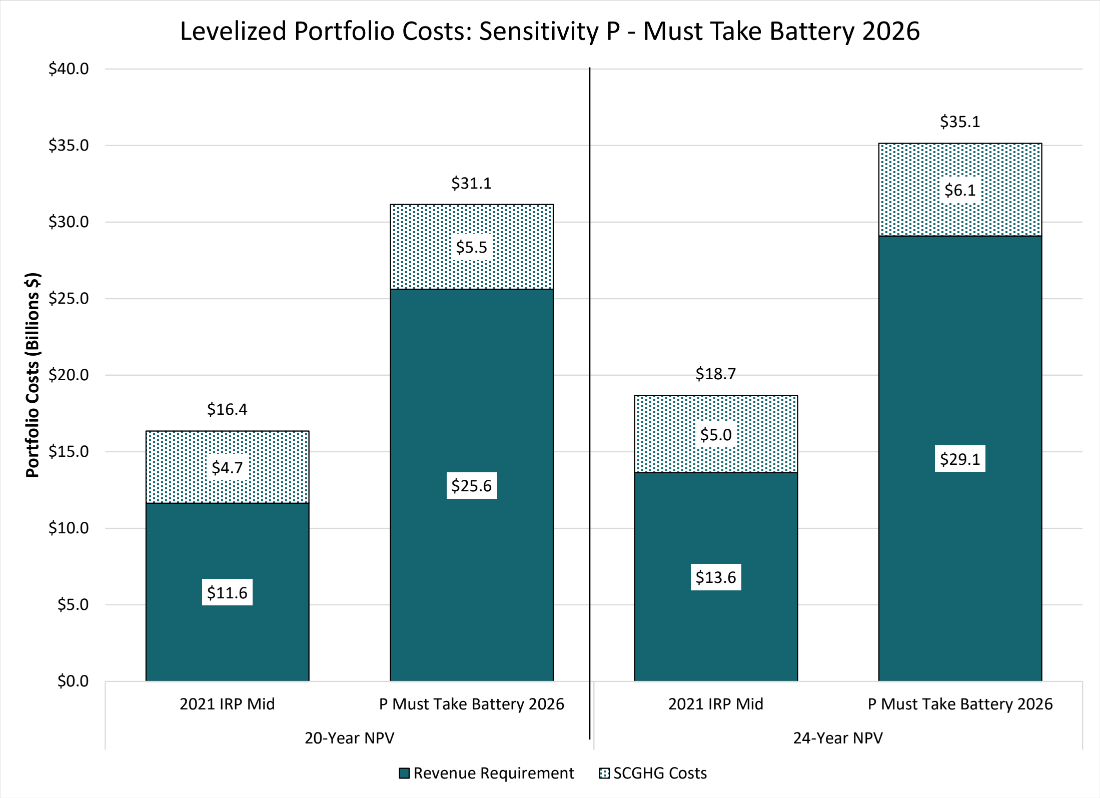
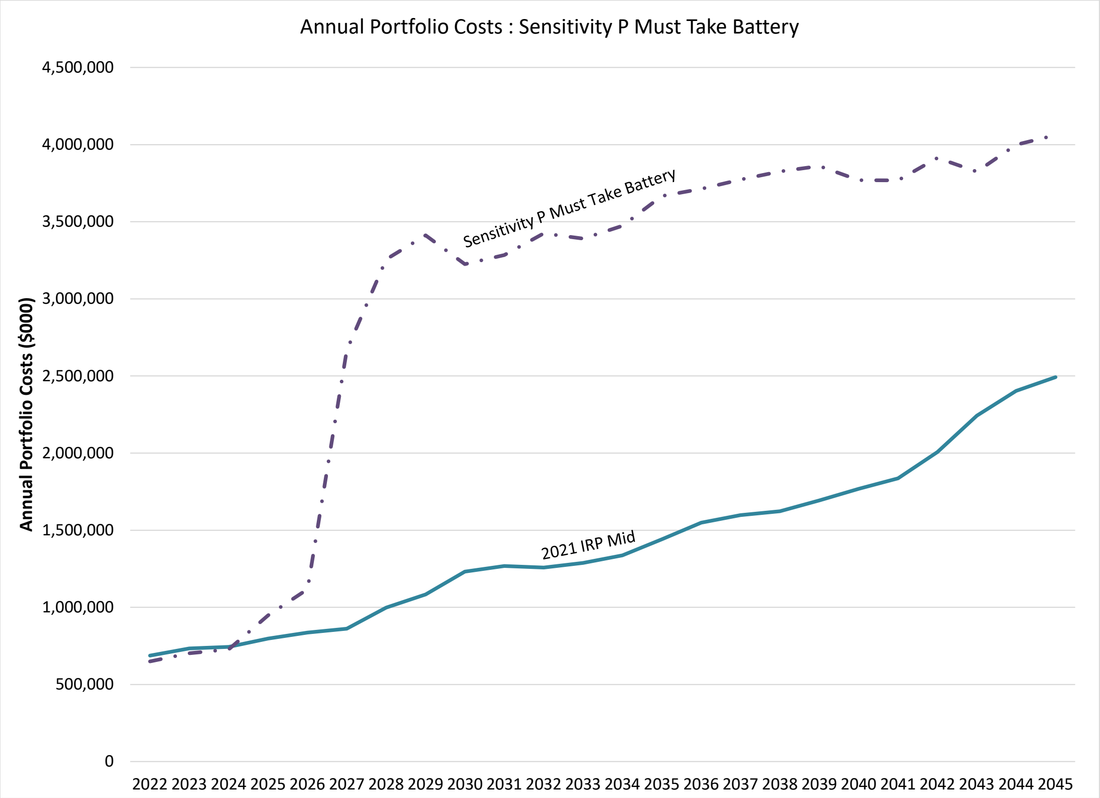
Emission reductions - must take DR & battery – portfolio costs





Portfolio Costs	Mid	P - Must Take Battery 2026
Total Portfolio Costs 24 Yr Levelized	$18.7	$35.1
Revenue Requirement	$13.6	$29.1
SCGHG Costs	$5.0	$6.1
Total Portfolio Costs 20 Yr Levelized	$16.4	$31.1
Revenue Requirement	$11.6	$25.6
SCGHG Costs	$4.7	$5.5

CETA Cost Sensitivities

- **1. Mid Economic Conditions (reference)**
  - CETA Costs
    - S. SCGHG only, no CETA
    - T. No CETA or SCGHG

S. SCGHG Only, No CETA

- The SCGHG is modeled as a fixed cost adder
- CETA renewable requirements are not included
- 15% RPS requirement is still applied

T. No CETA or SCGHG

- SCGHG and CETA regulation are not included
- The 15% RPS requirement is still applied

CETA cost sensitivities - results

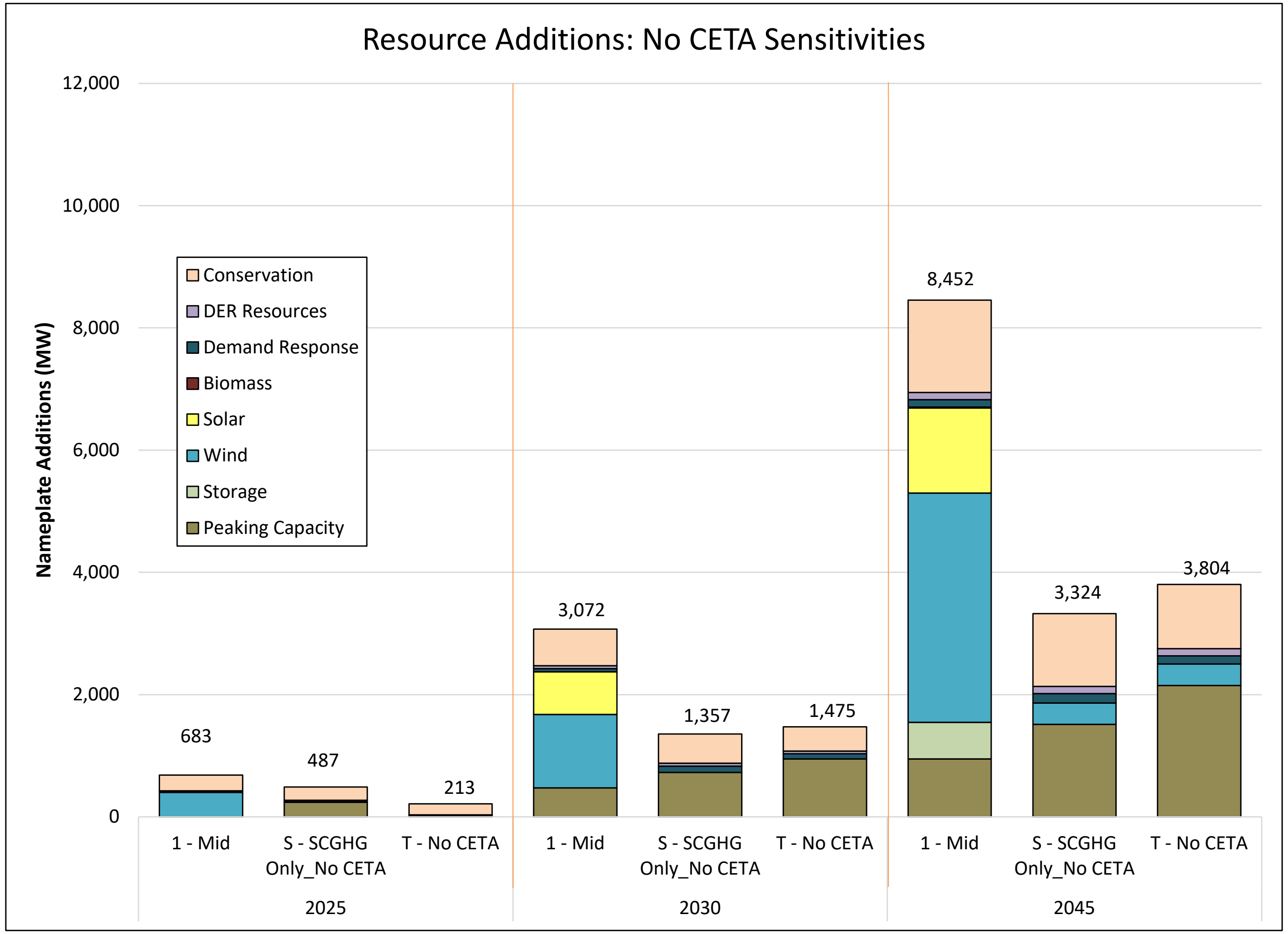
SCGHG only

- One new renewable resource added in 2044 to maintain RPS
- Future capacity needs met with capacity resources and increased demand response
- Conservation savings up to bundle 6
- No economic retirements of existing resources

No CETA & No SCGHG

- One new renewable resource added in 2044 to maintain RPS compliance
- Future capacity needs met with peaking capacity resources and increased demand response
- Conservation savings up to bundle 2
- No economic retirements of existing resources

Resource Additions by 2045	Mid	S - SCGH Only No CETA	T - No CETA
Conservation	1507 MW	1188 MW	1052 MW
DER Resources	118 MW	118 MW	118 MW
Demand Response	121 MW	155 MW	133 MW
Renewable Resources	5158 MW	350 MW	350 MW
Biomass	15 MW	0 MW	0 MW
Solar	1393 MW	0 MW	0 MW
Wind	3750 MW	350 MW	350 MW
Storage	600 MW	0 MW	0 MW
Peaking Capacity	948 MW	1513 MW	2151 MW



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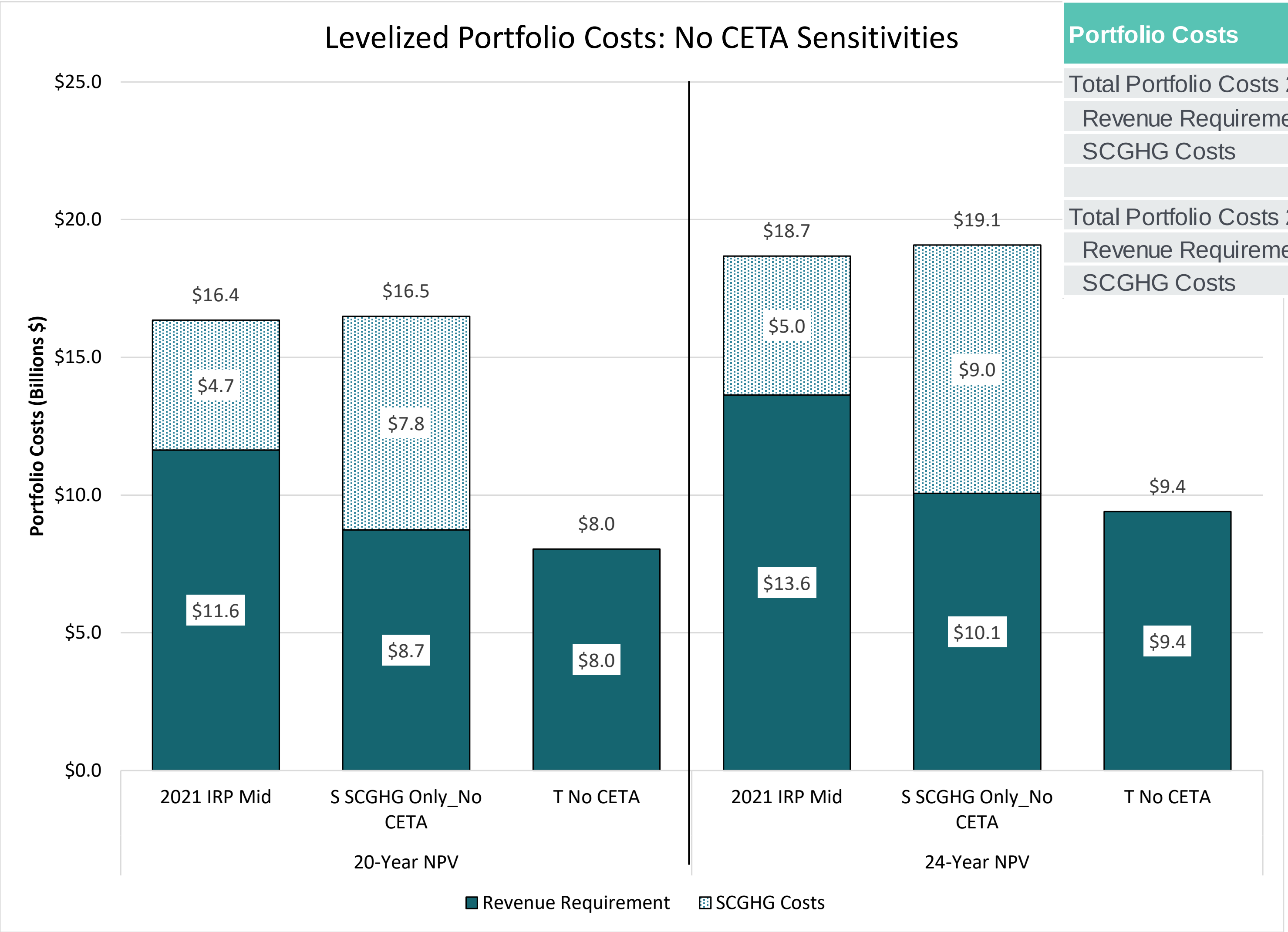
CETA Cost Sensitivities – total portfolio costs



Portfolio Costs	Mid	S - SCGHG Only No CETA	T - No CETA
Total Portfolio Costs 24 Yr Levelized	$18.7	$19.1	$9.4
Revenue Requirement	$13.6	$10.1	$9.4
SCGHG Costs	$5.0	$9.0	$0.0
Total Portfolio Costs 20 Yr Levelized	$16.4	$16.5	$8.0
Revenue Requirement	$11.6	$8.7	$8.0
SCGHG Costs	$4.7	$7.8	$0.0

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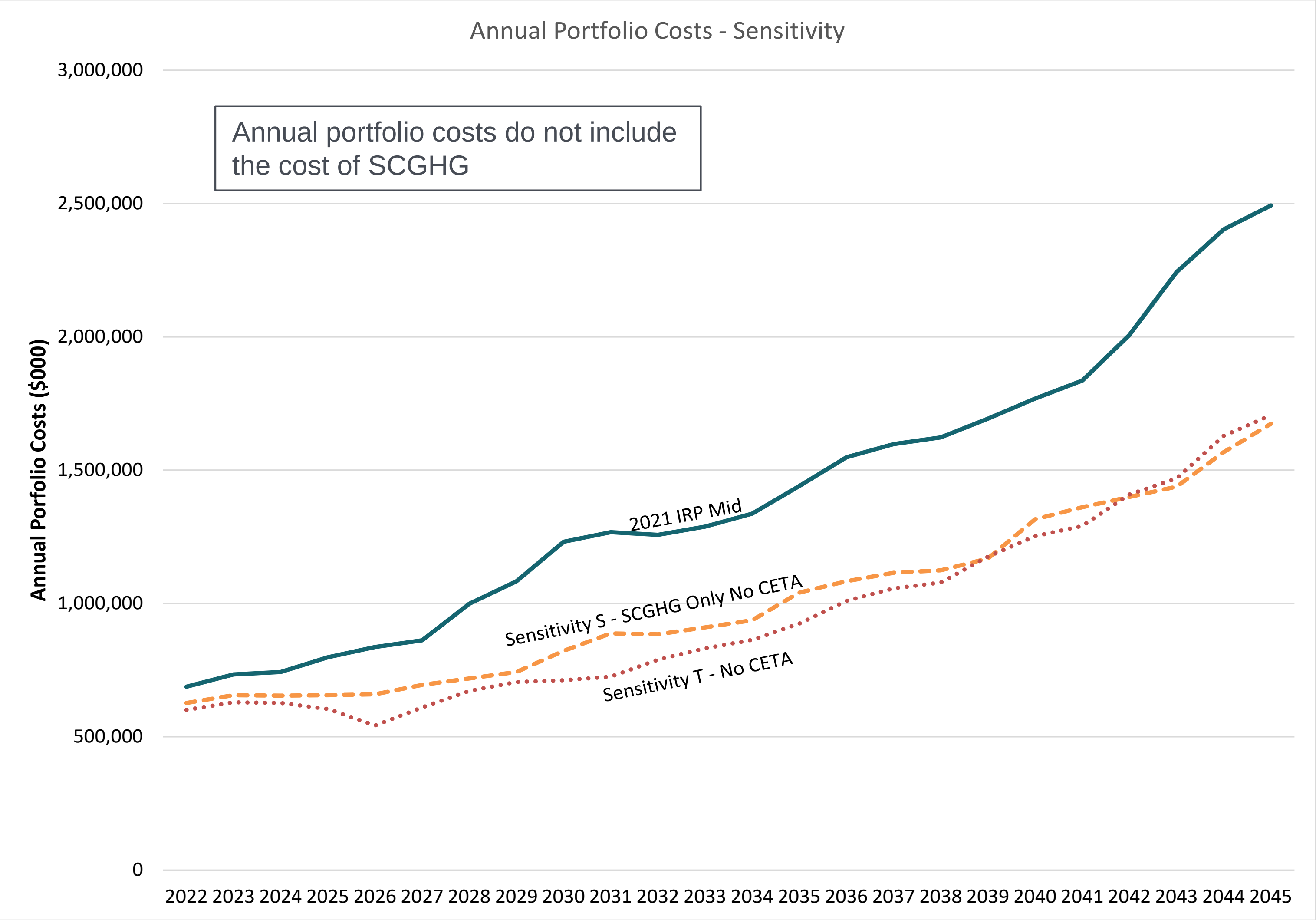
CETA Cost Sensitivities – annual portfolio cost



- Mid scenario is the least cost optimized portfolio results and does not represent PSE's resource plan
- 2% annual increase for cost of compliance will be calculated based on the resource plan

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Comparison of all the portfolios costs and renewable resource additions

Portfolio	24-yr Levelized Cost ($ Billions)			Renewable Additions by 2045 Nameplate (MW)			
	Revenue Requirement	SCHGH adder	Total	Biomass	Solar	Wind	Total
1. Mid	$13.6	$5.0	$18.7	15	1,393	3,750	5,158
2. Low	$10.4	$4.5	$14.9	-	797	3,350	4,147
3. High	$17.2	$6.3	$23.5	330	1,891	3,950	6,171
A. Renewable Over-generation	$15.3	$4.2	$19.6	525	1,490	2,150	4,165
I. SCGHG as Externality Cost	$13.6	$4.8	$18.4	120	1,394	3,450	4,964
P. Must take Battery	$29.1	$6.1	$35.1	-	1,796	3,750	5,546
S. SCGHG Only, No CETA	$10.1	$9.0	$19.1	-	-	350	350
T. No CETA	$9.4	$0.0	$9.4	-	-	350	350

Consulting stakeholders

- Draft portfolio results help inform the draft resource plan

- PSE would like stakeholder feedback:
  - What conclusions are stakeholders making from the results?
  - Should these sensitivities be adjusted to better inform the resource plan? What adjustments should be made?
  - What other factors should PSE consider?

10-minute break

Flexibility Analysis

PUGET SOUND ENERGY

Participation Objectives

- PSE will review and solicit stakeholder feedback on flexibility analysis results

IAP2 level of participation: CONSULT

Sub-hourly flexibility analysis in Plexos

- 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 15-minute basis.

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

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

- The purpose of the flexibility analysis to explore the sub-hourly flexibility needs of the portfolio and determine how new resources can contribute to those needs.

- Flexibility benefit = day-ahead (DA) dispatch costs – Intra-hour (IH or “real-time”) dispatch costs

- The flexibility benefit is then calculated as the total cost ($) / nameplate (MW) of resources as a fixed benefit per year ($/kw-year) and then added back to the resource in the capacity expansion model for making resource decisions.

Operating Reserves

Contingency reserves

- Bal-002-WECC-1 requires balancing authorities to carry reserves for every hour:
  - 3% of online generating resources
  - 3% of load to meet contingency obligations

Balancing reserves

- Utilities must also have sufficient reserves available to maintain system reliability within the operating hour; this includes frequency support, managing load and variable resource forecast error, and actual load and generation deviations.
- Balancing reserves do not provide the same kind of short-term, forced-outage reliability benefit as contingency reserves, which are triggered only when certain criteria are met.
- Balancing reserves are resources that have the ability to ramp up and down instantaneously as loads and resources fluctuate each hour.

Balancing reserve requirement

The balancing reserve requirements were assessed by E3 for two study years, using the CAISO flex ramp test. The results depend heavily on the Mean Average Percent Error (MAPE) of the hour-ahead forecasts vs real time values for load, wind and solar generation.

- 2025 case includes PSE's current portfolio
- 2030 case includes PSE's current portfolio, plus generic wind and solar resources to meet the 80% renewable requirement target

Case	Capacity of PSE balanced Wind (MW)	Capacity of PSE balanced solar (MW)	Average Annual Flex up (MW)	Average Annual Flex down (MW)	99th percentile of forecast error (flex up cap)	1st percentile of forecast error (flex down cap)
2025 case	875	-	141	146	190	196
2030 case	2,375	1,400	492	503	695	749

- When the model must flex generation down, it can turn off dispatchable plants, charge batteries, curtail renewable generation, or sell power to the market.
- When the model must flex generation up, it can turn on dispatchable plants, discharge batteries, or buy power from the market.

PLEXOS Simulation Phases

Inputs:

- Existing resources and contracts
- Natural gas price forecast
- Electric price forecast (from Aurora)
- Pond volumes daily max and min
- Hydro initial and end volume
- Inflow for baker
- **Reserve requirement**
- Demand forecast

PASA

- Simulates the scheduled maintenance
- Random outage simulation for forced outages

scheduled maintenance and forced outage

Mid-Term (MT)

- mid-term optimization run for the entire year with low resolution 3 steps/day
- utilize water for lower and upper baker over next 12 months

daily water storage target for Baker

Day Ahead (DA)

- Day ahead unit commitment for CCCT units
- 16-hour block trades with Mid-C for the next operating day

CCCT units commitment and block trade

Intra-day (ID)

- hourly trade with Mid-C for the balancing day
- Hourly dispatch

hourly market purchases and sales

Intra-hour (IH)

- CAISO EIM engine, optimize dispatch for slow start resources, quick-start resources, and fifteen minute market (FMM) real-time (RT) trade with EIM

Sub-hourly dispatch of flexible capacity and total portfolio cost

Generic resources providing flexibility

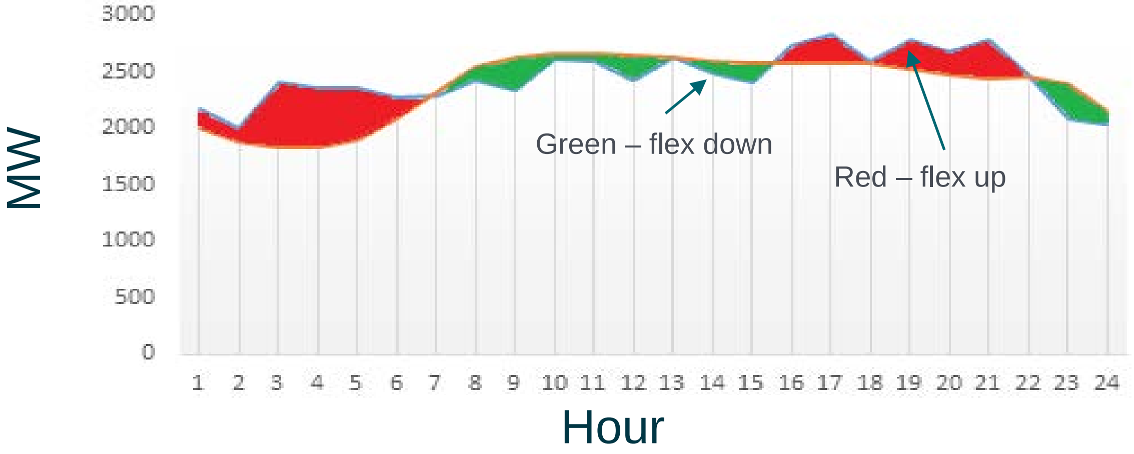
- The PLEXOS model performs flexibility tests on the base portfolio, and compares changes from the base portfolio with the new resource additions.

Resource	Capacity (MW)	Heat Rate (Btu/kWh)	Energy Storage (MWh)	Roundtrip Efficiency (%)
Frame Peaker	237	9,904	-	-
Recip Peaker	18.2	8,445	-	-
CCCT	355	6,624	-	-
Li-Ion Battery 2-hr	100	-	200	82
Li-Ion Battery 4-hr	100	-	400	87
Flow Battery 4-hr	100	-	400	73
Flow Battery 6-hr	100	-	600	73
Pumped Storage Hydro	100	-	800	80
Demand Response	100	40 hours/season, 1 call/day, max of 4 hours/day		

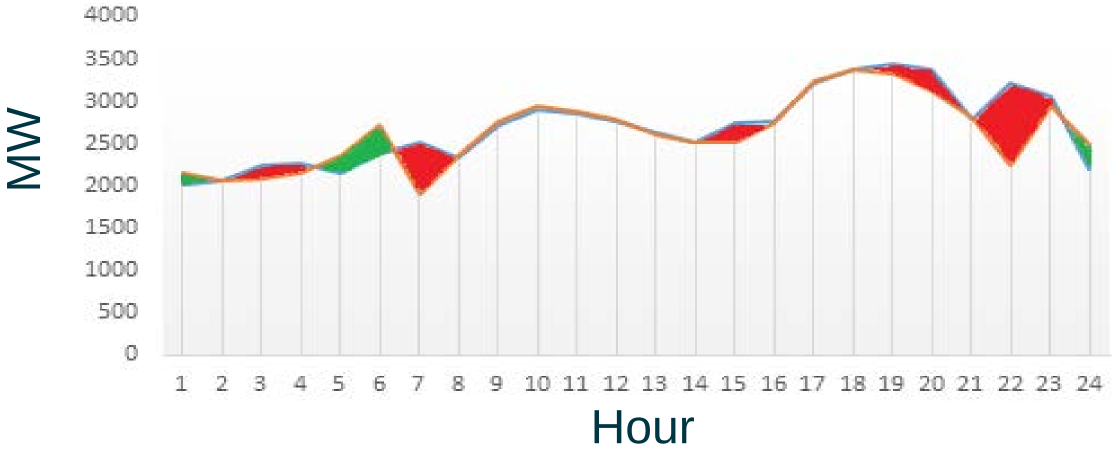
2025 case – adjustments to load day-ahead to hourly

- Differences between the Day-Ahead and hourly load for summer and winter months

June 13, 2025



December 30, 2025



- Green area is the flex down needed
- Red area is the flex up needed
- More flex up and flex down capacity is needed in summer because of more intermittent resources such as solar
- New resources will be tested to fill in the flex up and flex down need
- Expect that the flex up and flex down need will increase with 2030 case

2025 case – flex violations

DRAFT RESULTS

Number of hours of flex up/flex down violations and magnitude (MWh)

Month	Flex up (Hours)	Flex Down (Hours)	Flex up (MWh)	Flex Down (MWh)
January	16.5	8.75	374	615
February	20	10.75	452	497
March	45.25	21.5	1,666	704
April	18.5	14	658	402
May	35.75	41.25	970	1,160
June	28	6.75	721	221
July	46.5	3.75	1,297	168
August	54.5	5	1,413	151
September	36	11.75	921	286
October	28.25	10.75	735	300
November	30.75	14	850	511
December	23.75	15.75	879	625
Annual	383.75	164	10,934	5,639

2025 case – draft portfolio results

DRAFT RESULTS

Dispatch cost increased by $0.6 Million in the intra-hour model run

Resource Type	2025 PSE System Costs ($MM)	2025 PSE System Energy (GWh)
Wind	23.0	3,456
Hydro	1.9	4,808
Thermal	143.2	4,614
Solar	13.5	343
Contracts	292.2	5,324
IRP Resource	-	-
Total Generation	*473.8*	*18,545*
Net Market Purchases/Sales	*97.0*	*4,512*
Total	**570.9**	**23,057**

−

Resource Type	2025 PSE System Costs ($MM)	2025 PSE System Energy (GWh)
Wind	22.8	3,523
Hydro	2.0	4,881
Thermal	153.8	4,681
Solar	13.5	343
Contracts	292.2	5,324
IRP Resource	-	-
Total Generation	*484.3*	*18,752*
Net Market Purchases/Sales	*87.2*	*4,235*
Total	**571.5**	**22,988**

=

Resource Type	2025 PSE System Costs ($MM)	2025 PSE System Energy (GWh)
Wind	0.2	(67)
Hydro	(0.1)	(72)
Thermal	(10.6)	(67)
Solar	-	(0)
Contracts		
IRP Resource	-	-
Total Generation	*(10.5)*	*(207)*
Net Market Purchases/Sales	*9.9*	*276.3*
Total	**(0.6)**	**69.3**

Day-Ahead dispatch cost − Intra-hour dispatch cost = change to portfolio for sub –hourly flexibility

2025 case – day-ahead system costs ($MM)

DRAFT RESULTS

2025 PSE System Costs ($MM)	Base Portfolio	CCCT	Frame Peaker	Recip Peaker	Li-Ion 2-hr	Li-Ion 4-hr	Flow 4-hr	Flow 6-hr	Pumped Hydro Storage	Demand Response
Wind	23	23	23	23	24	24	24	24		
Hydro	2	2	2	2	2	2	2	2		
Thermal	143	101	130	141	128	127	126	128		
Solar	14	14	14	14	14	14	14	14		
Contracts	292	292	292	292	292	292	292	292		
IRP Resource	-	47	11	-	-	-	-	-		
Total Generation	*474*	*478*	*471*	*472*	*460*	*458*	*458*	*459*	-	-
Net Market Purchases/Sales	*97*	*80*	*95*	*97*	*101*	*102*	*103*	*101*		
Total	**571**	**558**	**566**	**569**	**561**	**560**	**560**	**560**		
Change in Cost from Base		**(13)**	**(4)**	**(2)**	**(10)**	**(11)**	**(11)**	**(11)**		

2025 case – intra-hour system costs ($MM) DRAFT RESULTS

2025 PSE System Costs ($MM)	Base Portfolio	CCCT	Frame Peaker	Recip Peaker	Li-Ion 2-hr	Li-Ion 4-hr	Flow 4-hr	Flow 6-hr	Pumped Hydro Storage	Demand Response
Wind	23	23	23	23	23	23	23	23		
Hydro	2	2	2	2	2	2	2	2		
Thermal	154	115	134	151	137	137	133	135		
Solar	14	14	14	14	14	14	14	14		
Contracts	292	292	292	292	292	292	292	292		
IRP Resource	-	46	11	0	0	-	-	-		
Total Generation	*484*	*491*	*474*	*482*	*469*	*467*	*464*	*466*	-	-
Net Market Purchases/Sales	*87*	*61*	*81*	*81*	*86*	*87*	*88*	*87*		
Total	**572**	**553**	**555**	**562**	**554**	**554**	**552**	**552**		
Change in Cost from Base		**(19)**	**(17)**	**(9)**	**(17)**	**(18)**	**(19)**	**(19)**		

PUGET SOUND ENERGY

2025 – draft flex benefit

DRAFT RESULTS

2025 PSE System Costs ($MM)	Base Portfolio	CCCT	Frame Peaker	Recip Peaker	Li-Ion 2-hr	Li-Ion 4-hr	Flow 4-hr	Flow 6-hr	Pumped Hydro Storage	Demand Response
Wind	0	0	1	0	1	1	1	1		
Hydro	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)		
Thermal	(11)	(14)	(4)	(9)	(9)	(10)	(7)	(7)		
Solar	-	-	-	-	-	-	-	-		
Contracts	0	0	0	0	0	0	0	0		
IRP Resource	-	1	1	(0)	(0)	-	-	-		
Total Generation	*(10)*	*(13)*	*(3)*	*(10)*	*(9)*	*(9)*	*(7)*	*(7)*	-	-
Net Market Purchases/Sales	*10*	*18*	*15*	*17*	*15*	*15*	*14*	*14*		
Total	**(1)**	**5**	**12**	**7**	**7**	**6**	**8**	**8**		
Change in Cost from Base		**6**	**12**	**8**	**7**	**7**	**9**	**8**		
Nameplate		355	237	18.2	100	100	100	100		
$/kw-yr		**16.79**	**51.32**	**417.25**	**71.51**	**66.52**	**85.17**	**84.26**		

- Significantly higher flexibility benefit than 2017 IRP analysis could be driven by higher flex violations

PSE PUGET SOUND ENERGY

Consulting Stakeholders

- PSE is soliciting feedback from stakeholders on how to make the best use of the Flexibility Analysis data.

- Questions:
  - What metrics are the most valuable in determining the flexibility benefit of a resource?
  - What aspects are at risk of being double-counted in the modeling process?
  - How do we determine flexibility need? Is it based on the flex violations size?
    - Should we create a placeholder resource similar to the resource adequacy model to come a certain level of flex violations?
    - What is the level?
  - What resources are there on other flexibility analysis studies to help benchmark results?

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2021 IRP Draft Natural Gas Portfolio Results

PUGET SOUND ENERGY

Participation Objectives

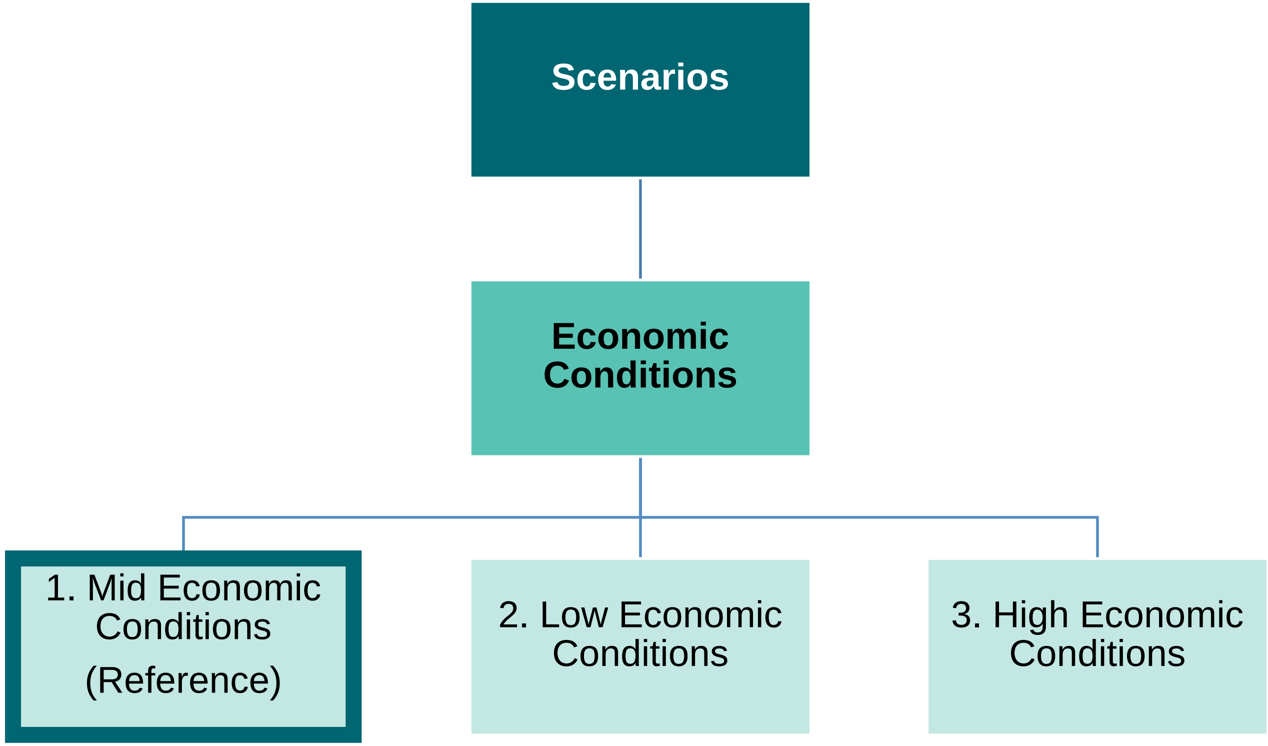
- PSE will inform stakeholders of the draft natural gas portfolio results.

IAP2 level of participation: INFORM

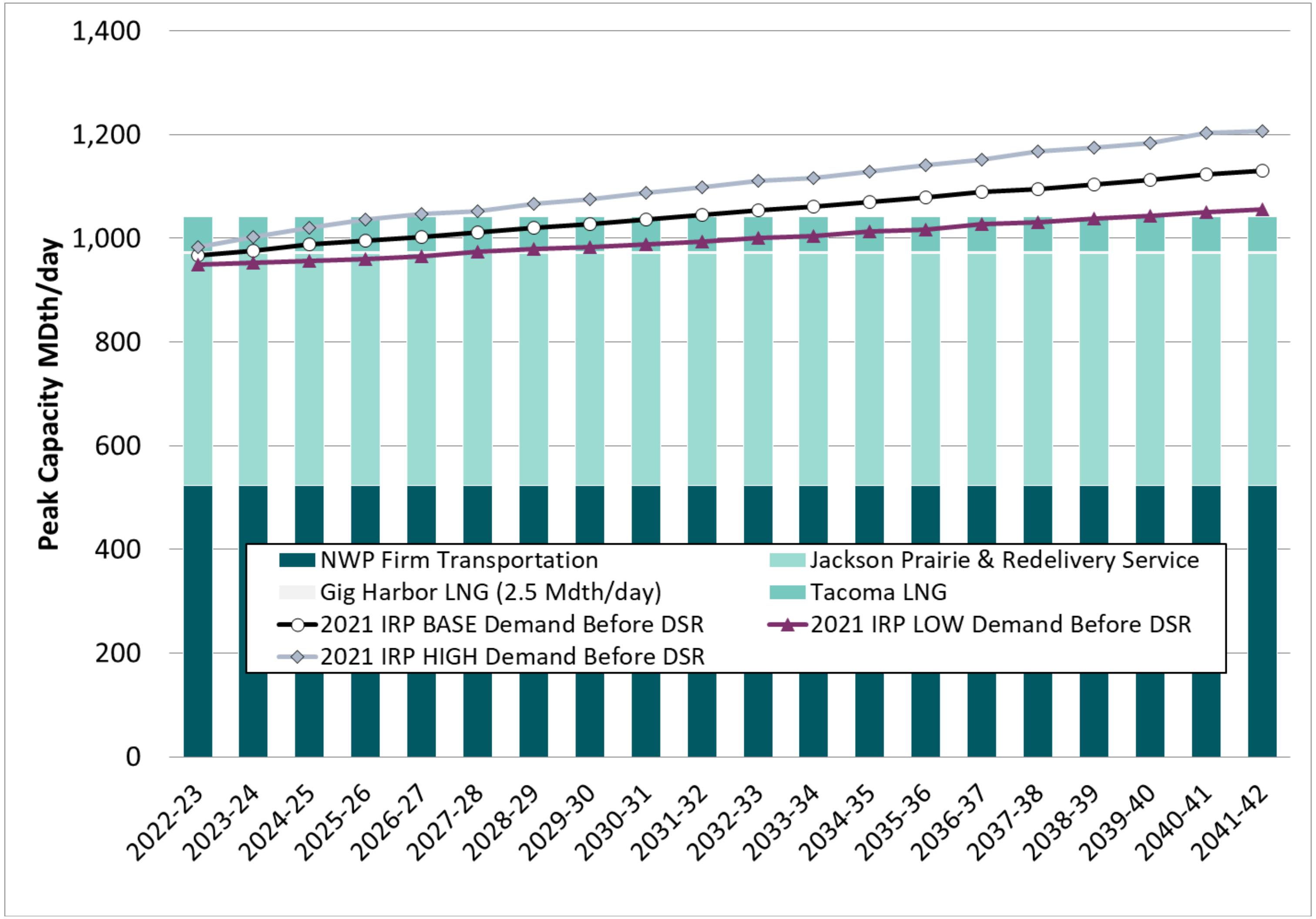
PUGET SOUND ENERGY

Outline for Today

- Resource Need: Mid/Low/High
- Results
  - Mid/Low/High
  - Sensitivities:
    - 6 year Ramp
    - Upstream Emissions with AR5
    - Social Discount Rate (SDR)
- Conclusions



2021 IRP natural gas capacity need: mid, low and high



- The high and the low are modelled using 250 stochastic simulations.
- The peak simulations vary the economic and demographic conditions, such as population, employment, and income
- The high and low are the 90th percentile and 10th percentile of the 250 simulations, respectively.

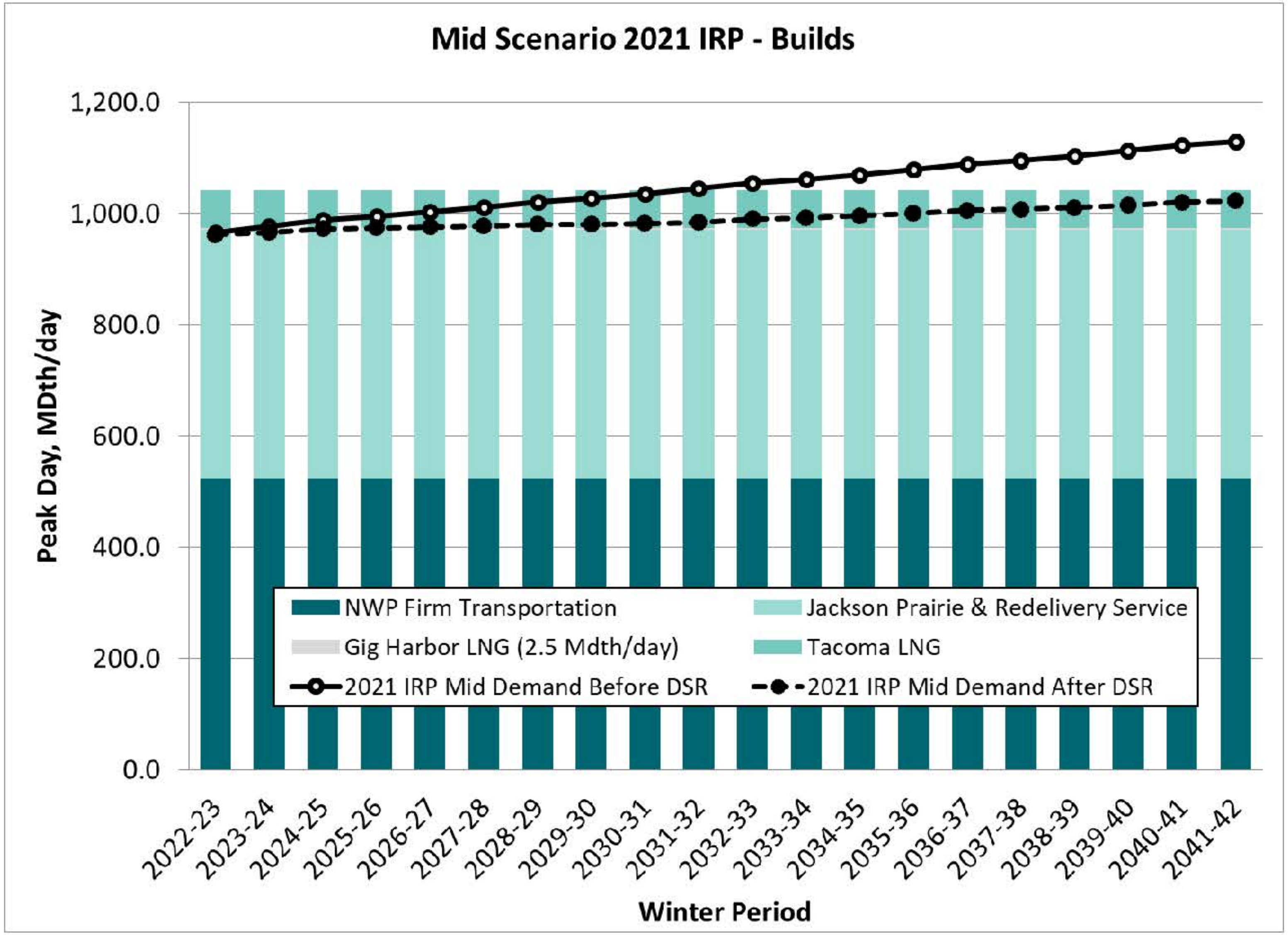
Draft results – summary builds by scenario

- Cost-effective DSR did not vary by scenario – Bundle 9 ($0.85-$0.95/therm)
- In the mid and low scenario DSR is sufficient to fill resource need
- High scenario chooses supply side resources in PSE's control, some pipeline added starting in 2034.

Scenario	Resource Type	2022-2025	2026-2030	2031-2041
Mid	*DSR*	21	32	54
Low	*DSR*	21	32	54
High	*DSR*	21	32	54
	Plymouth LNG	15	15	15
	Swarr	0	0	30
	NWP + Westcoast	0	0	30

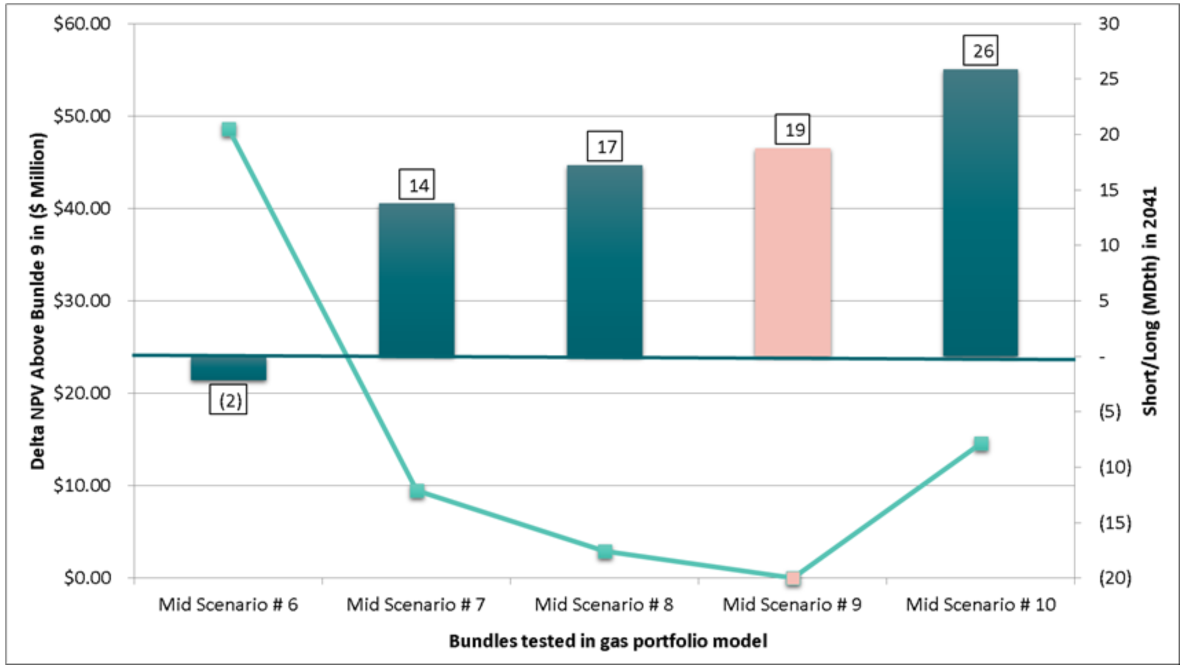
PUGET SOUND ENERGY

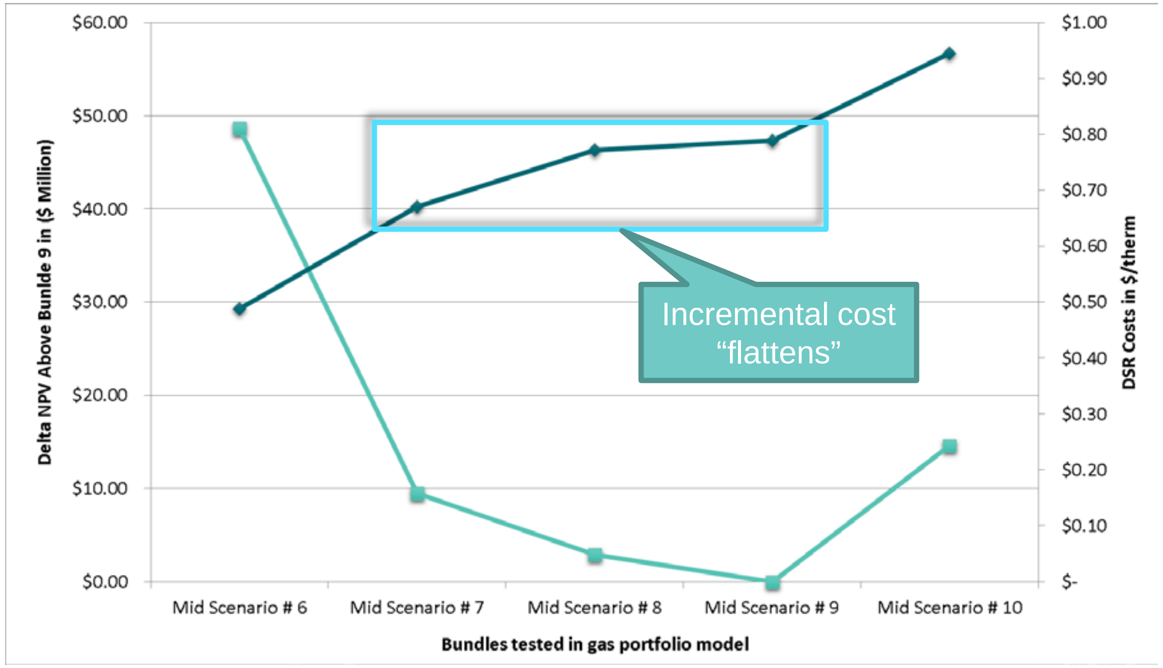
Draft mid scenario – DSR sufficient to meet future demand



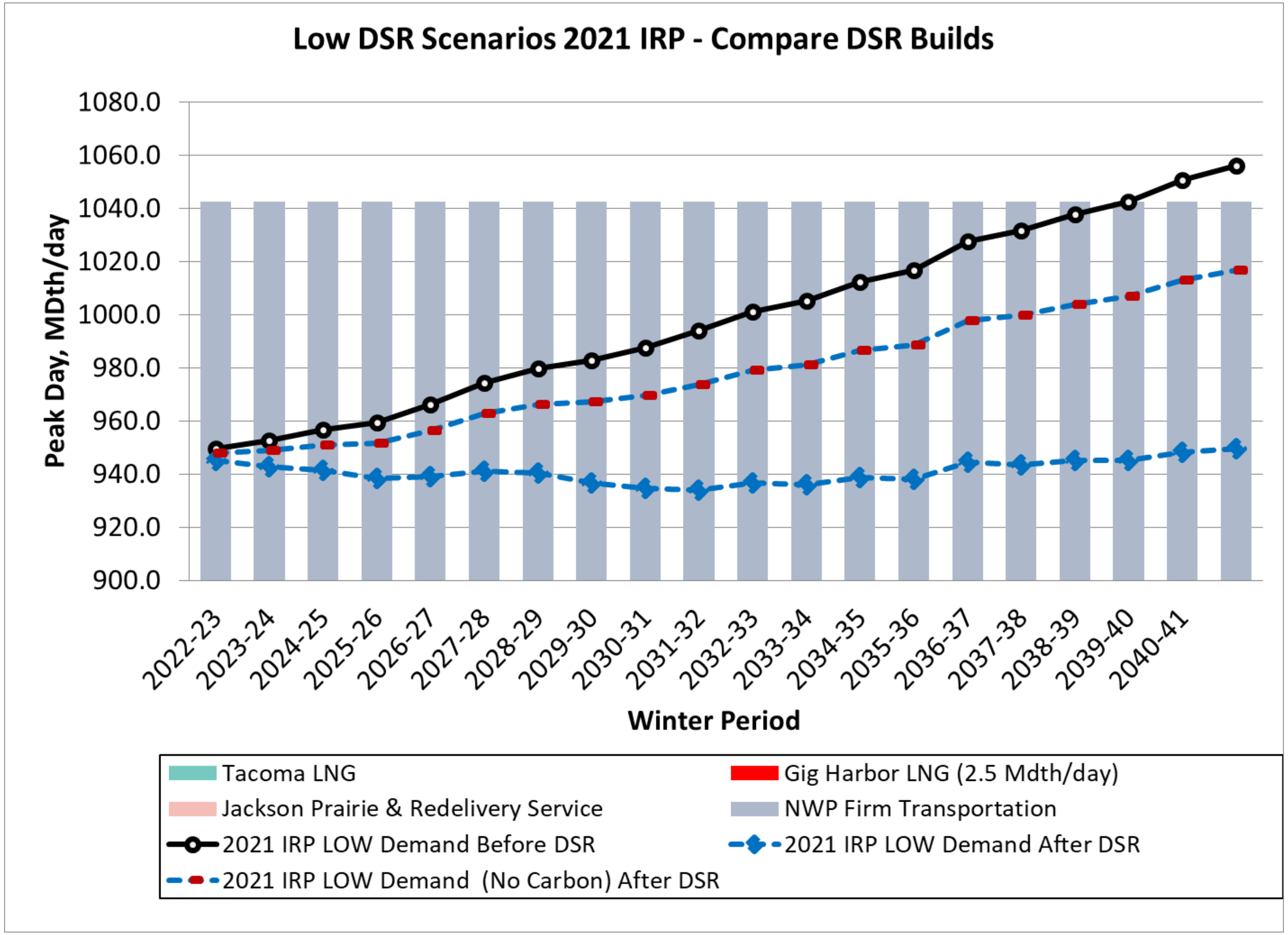
PSE PUGET SOUND ENERGY

Draft mid scenario – Overbuilding DSR reduces portfolio cost



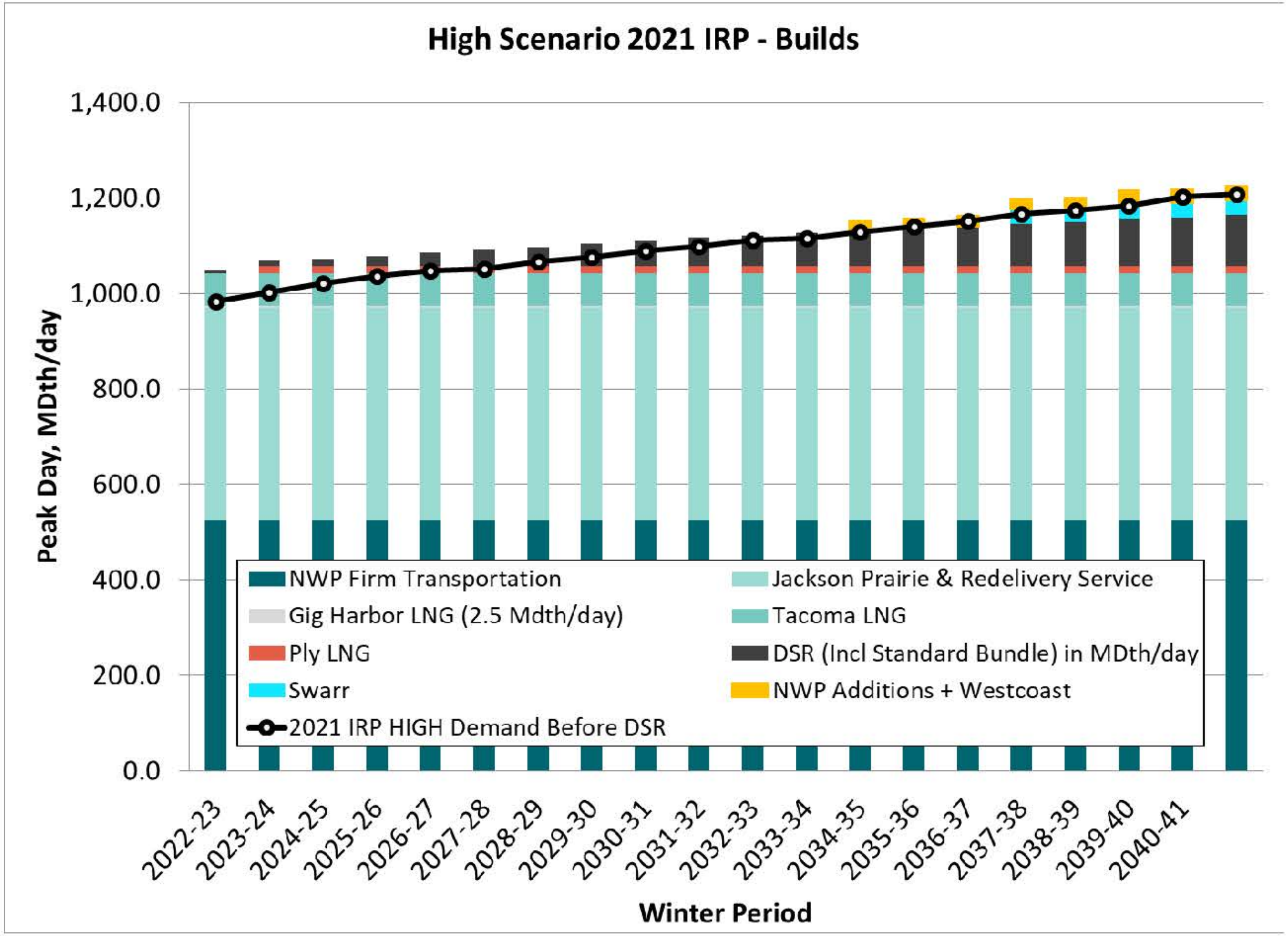


Draft Low scenario – Overbuilding DSR due to high carbon cost



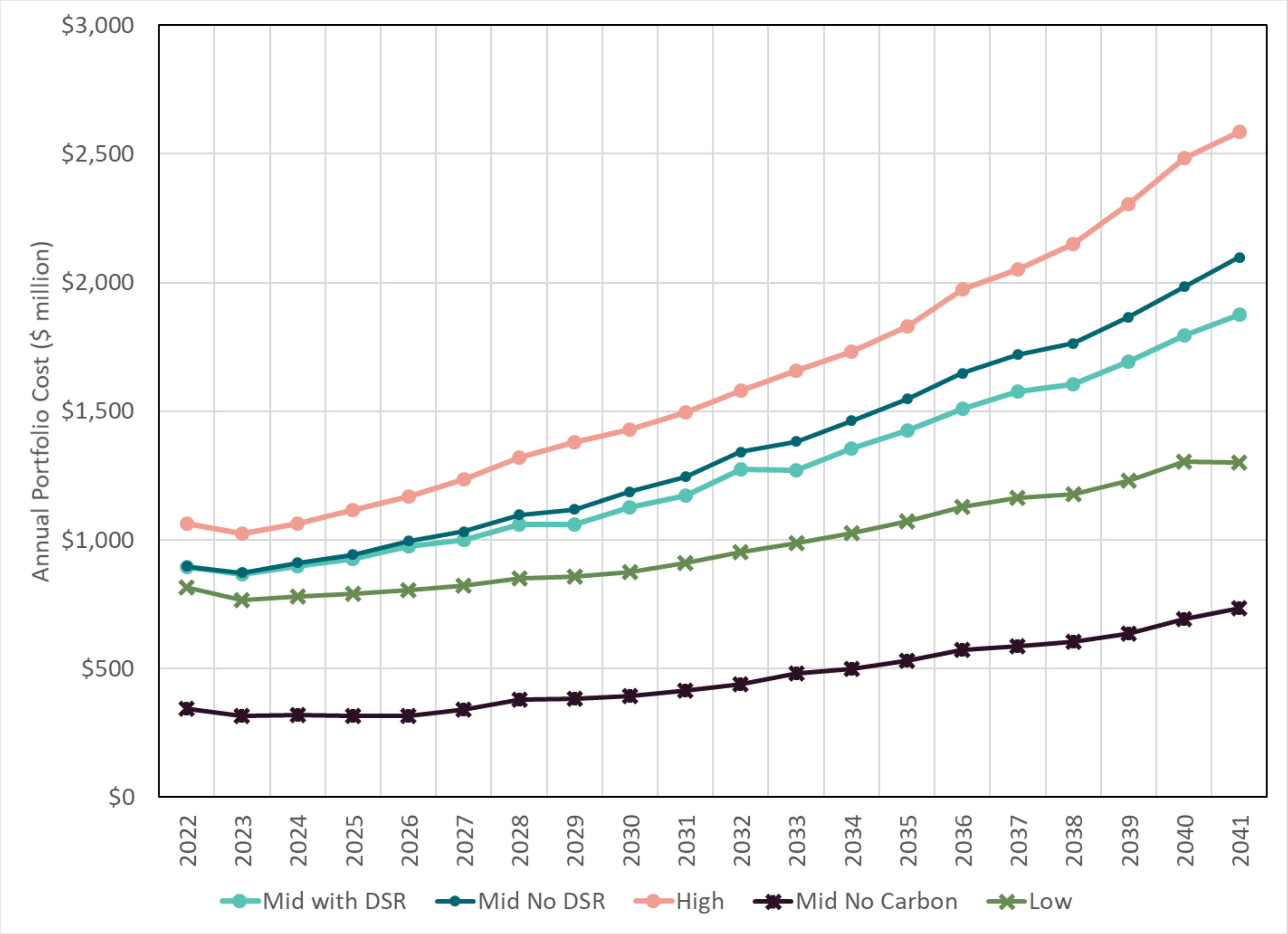
Scenario	Portfolio NPV, $ billion
Low	$9.899
Low No DSR	$10.327

Draft high scenario – Mostly DSR and PSE supply side resources



PSE PUGET SOUND ENERGY

Draft results Mid/Low/High – portfolio costs



The mid scenario with cost effective DSR has an NPV about $500 million less than without: DSR reduces portfolio costs by $0.5 billion.

Carbon adders (SCGHG and Upstream emissions) add significant cost to the portfolio. Which drive more conservation.

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Draft summary results – Sensitivities

Three sensitivities were run in the Mid Scenario:

- 6 Year Ramp vs 10 year ramp in the Mid
- AR5 on the upstream emissions vs AR4 in the Mid
- Social discount rate: 2.5% vs WACC 6.80% in the Mid

Results:

- 6 year ramp added the same bundle 9 as in Mid, but more savings early
- AR5 sensitivity had the same bundle as Mid Scenario
- Social discount rate sensitivity has more conservation than the Mid

Sensitivity	Resource Type	2022-2025	2026-2030	2031-2041
6 year ramp	*DSR*	29	27	51
AR5	*DSR*	21	32	54
Social Discount Rate	*DSR*	25	37	60

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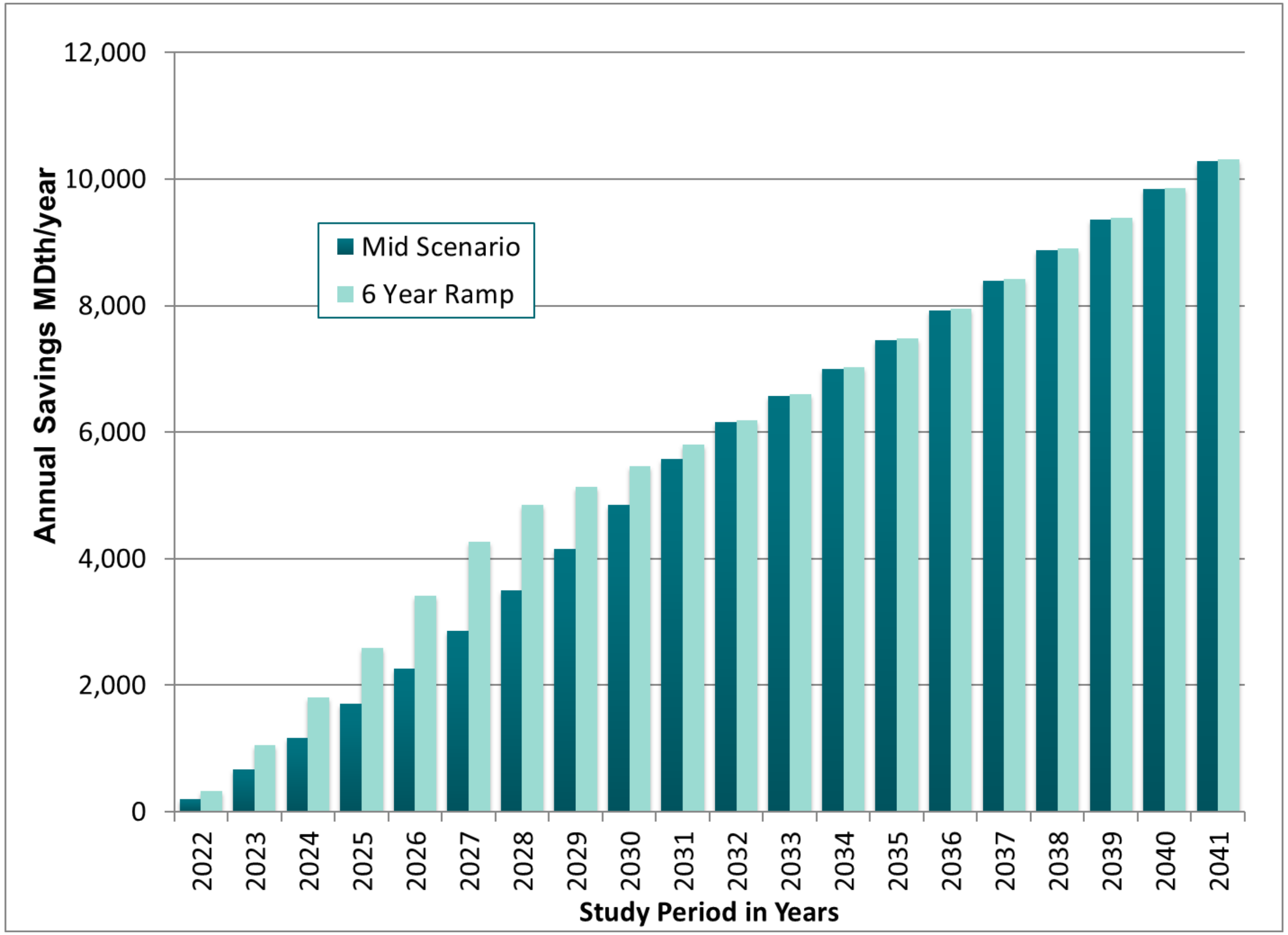
Draft sensitivity results – 6 year ramp



Result:

- Only chose DSR, no supply side resources
- Portfolio NPV was lower than Mid – due to earlier acquisition of DSR
- Same level of conservation as the Mid – Bundle 9 (Commercial Interruptible is 6)

Draft sensitivity results – AR5 upstream emissions

- Used AR5 data to update the upstream emissions
- Used the 10 year ramp same as Mid case DSR input
- Result: same amount of cost effective DSR as in Mid scenario

May 29, 2019 TAG#6	May 29, 2019 TAG#6
(Canadian Supply)	(Domestic Supply)
gCO2e/MMBtu	*gCO2e/MMBtu*
10,803	12,121
AR5	
Dec 15th, 2020	Dec 15th, 2020
(Canadian Supply)	(Domestic Supply)
gCO2e/MMBtu	*gCO2e/MMBtu*
11,564	13,180

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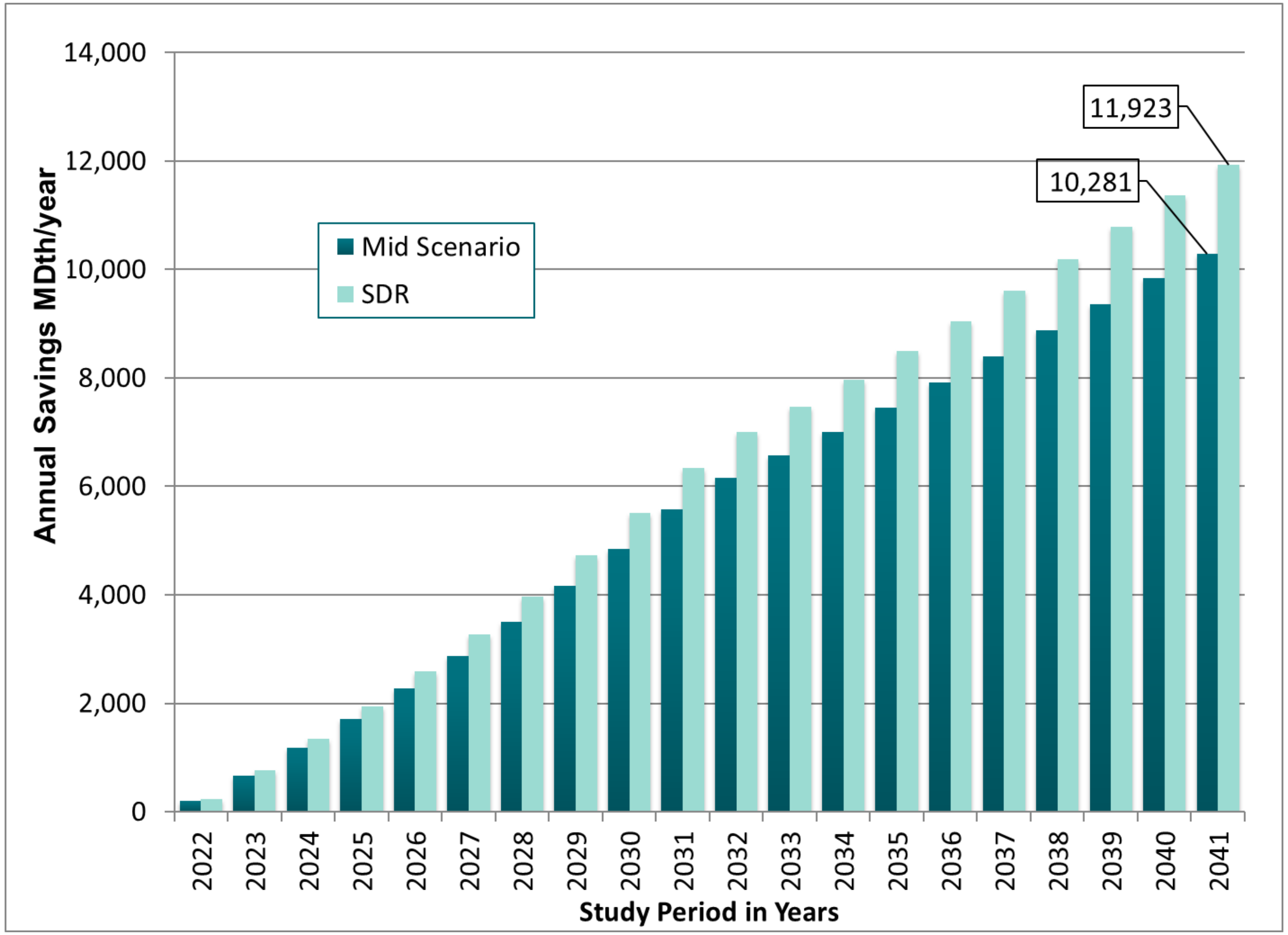
Draft sensitivity results – SDR



SDR was lower bundle 7 than Mid scenario bundle 9, but slightly higher savings.

Draft 2021 IRP gas portfolio - conclusions

- Cost effective conservation is “sticky” - same in the three scenarios

- Higher total gas costs are driving cost effective conservation higher on the conservation supply curve

- PSE is long and does not need incremental new supply side resources to meet resource need.

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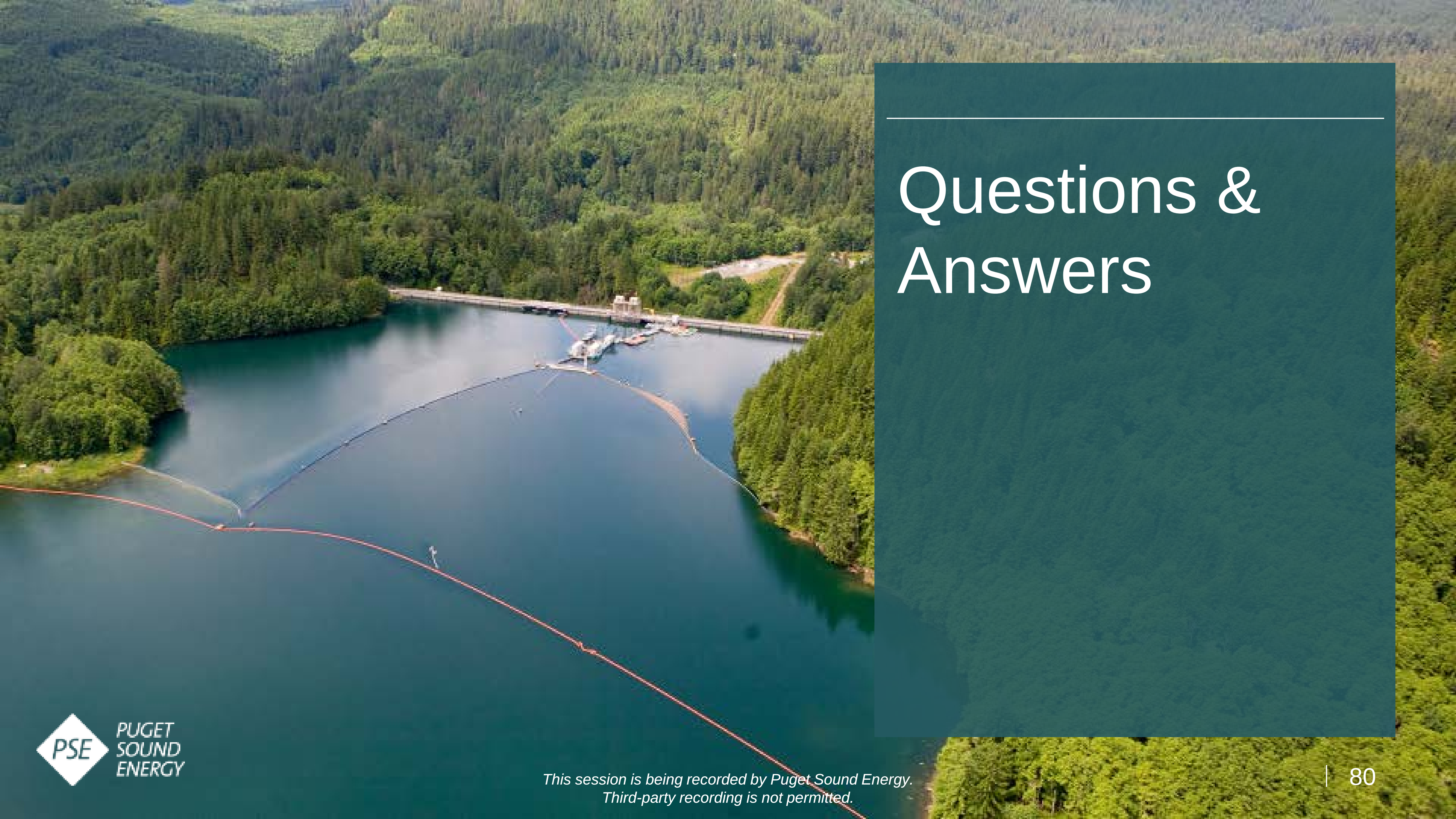

Questions & Answers

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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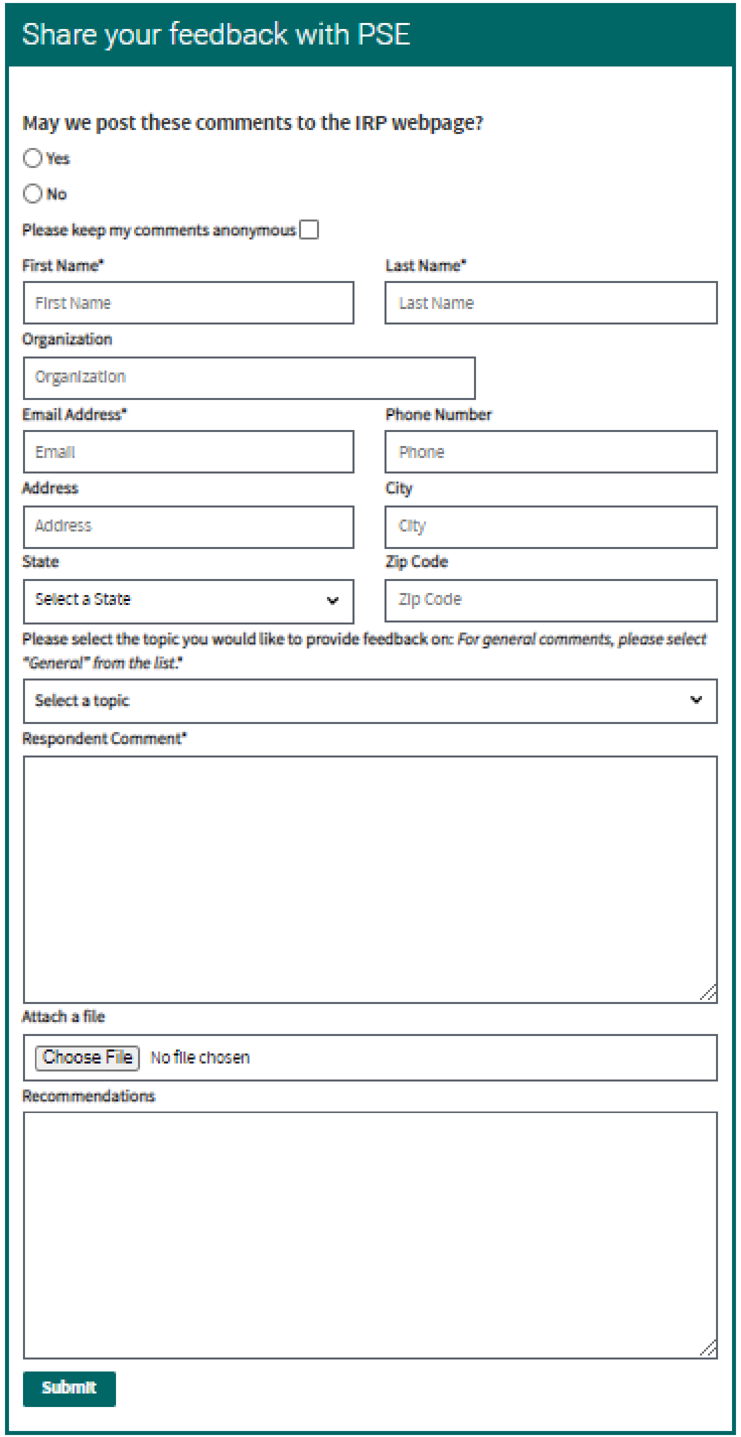

Share your feedback with PSE

May we post these comments to the IRP webpage?

Yes

No

Please keep my comments anonymous

First Name* | Last Name*

First Name | Last Name

Organization

Organization

Email Address* | Phone Number

Email | Phone

Address | City

Address | City

State | Zip Code

Select a State | Zip Code

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

Next steps

- Submit Feedback Form to PSE by **December 28, 2020.**

- A recording and the chat from today's webinar will be posted to the website **tomorrow**

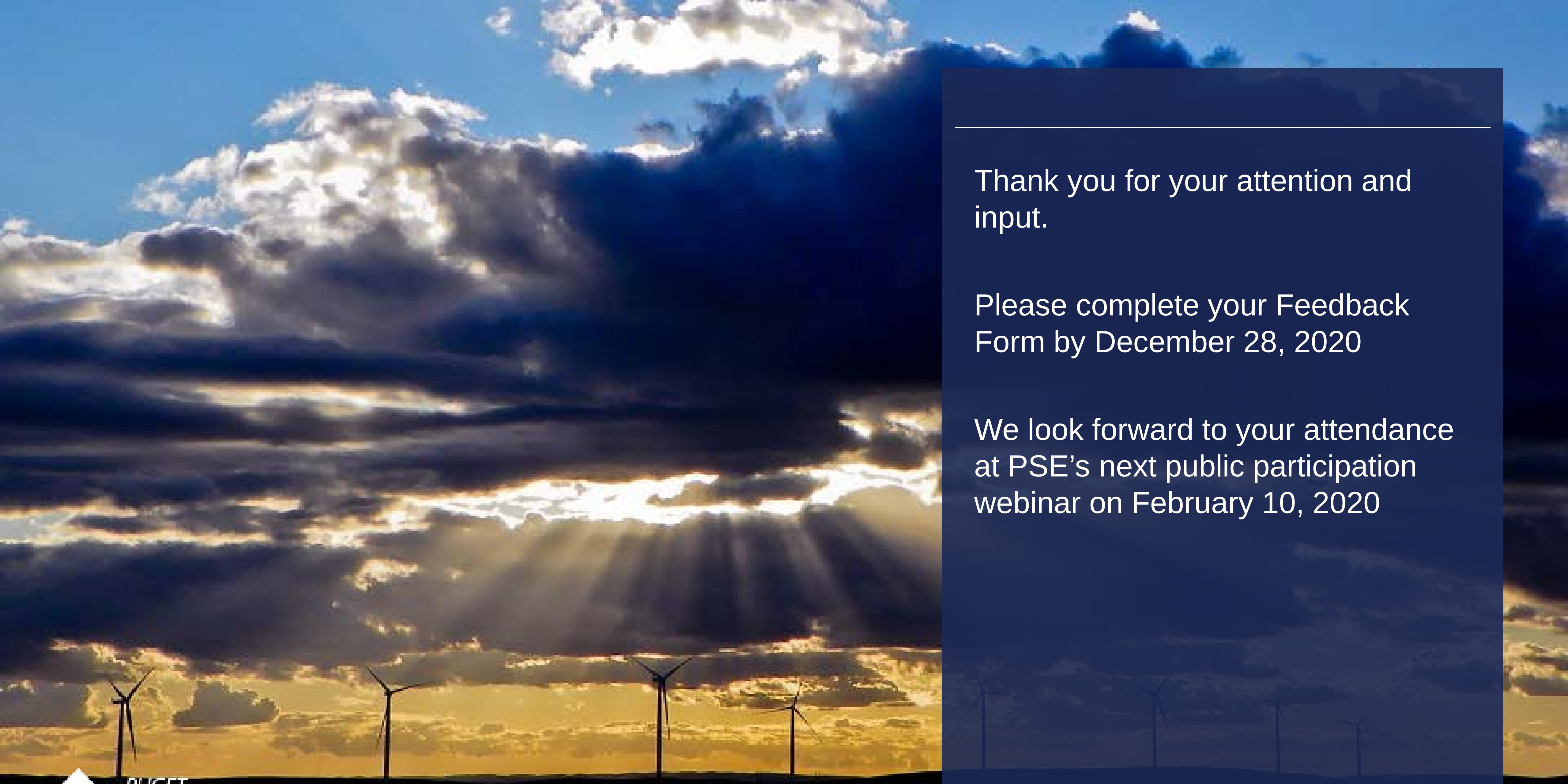
- PSE will compile all the feedback in the Feedback Report and post all the questions by **January 11, 2021.**

- The Consultation Update will be shared on **January 19, 2021.**

Upcoming meetings and key dates

Date	Topic
January 4, 2021	DRAFT 2021 Electric and Natural Gas IRP filed with the WUTC
February 10, 2021 1:00 – 5:00 pm	Wholesale market risk Portfolio draft results Delivery System Planning: 10-year distribution & transmission plan solutions with non-wire alternatives
March 5, 2021 1:00 – 5:00 pm	Stochastic analysis Resource plan Clean Energy Action Plan
April 1, 2021	FINAL 2021 Electric and Natural Gas IRP filed with the WUTC

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



Thank you for your attention and input.

Please complete your Feedback Form by December 28, 2020

We look forward to your attendance at PSE’s next public participation webinar on February 10, 2020

Electric Appendix

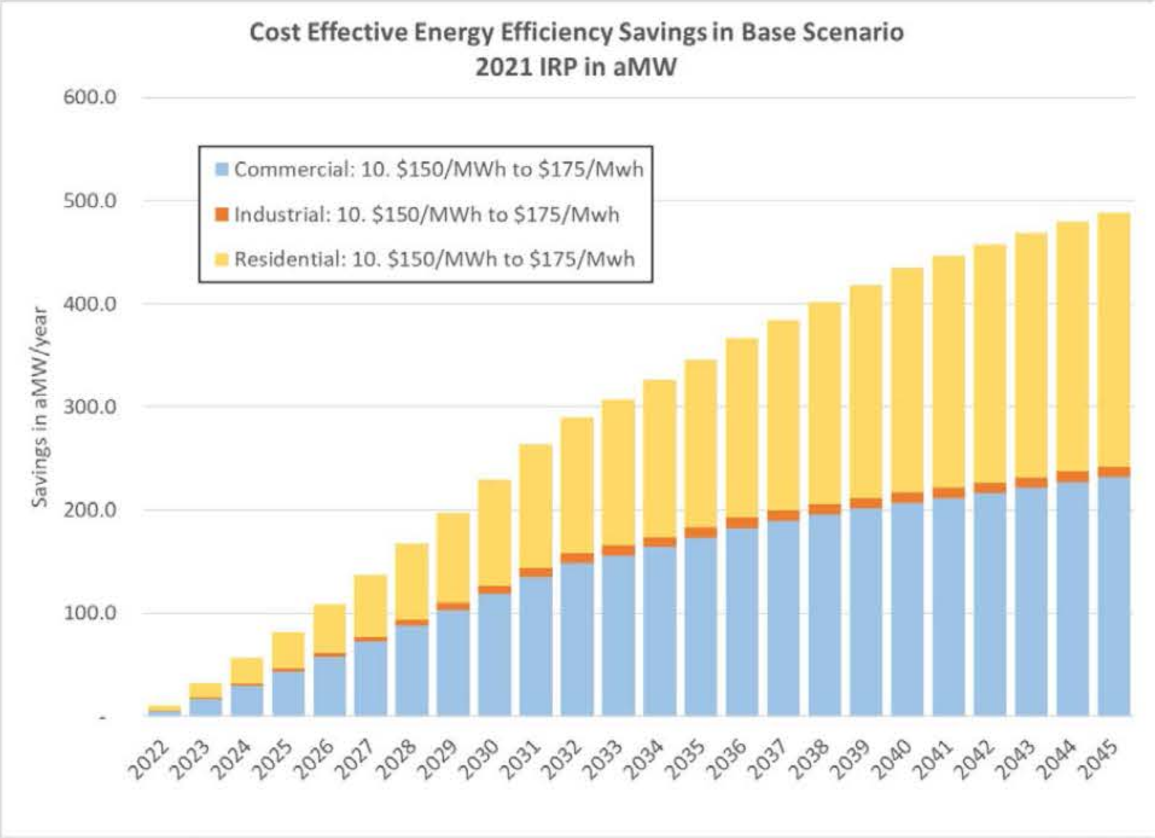
Demand side resources total savings

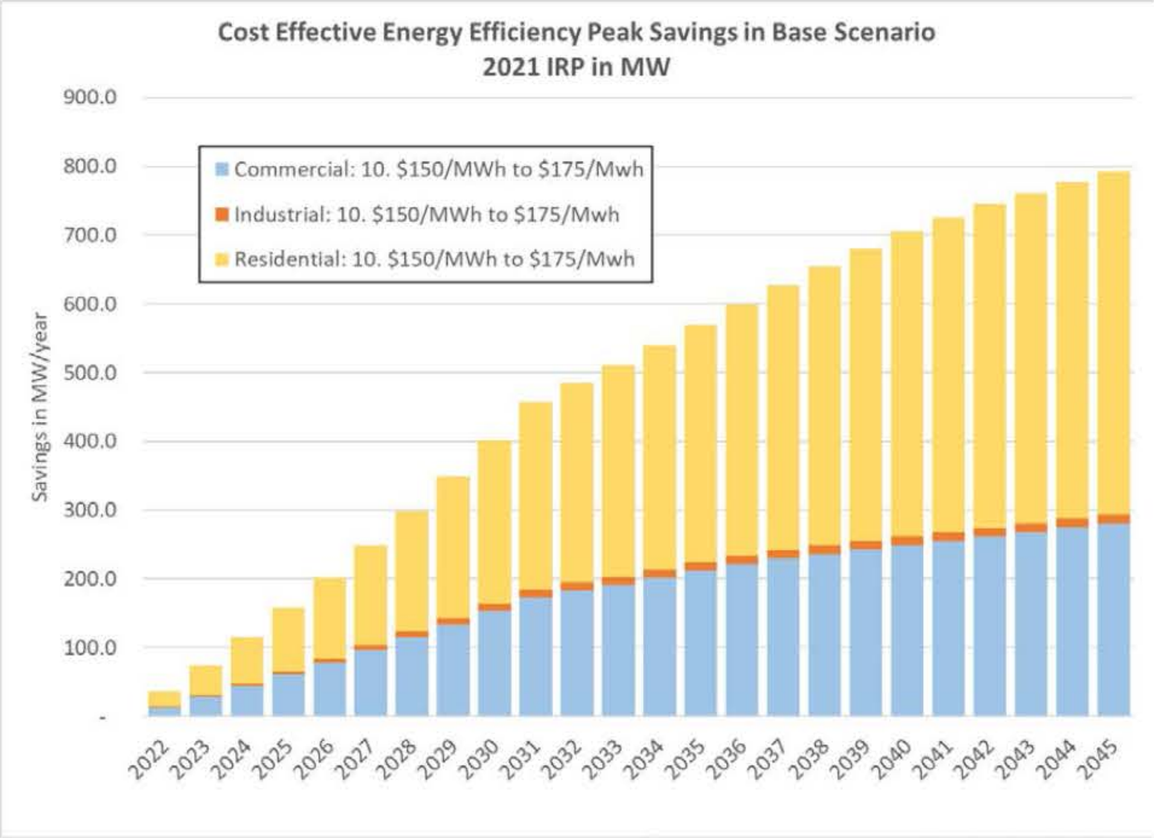
Electric draft demand side resources include:

- Energy efficiency
- Conservation up to bundle 10 ($175/MWh)
- Distributed generation
- Distribution Efficiency

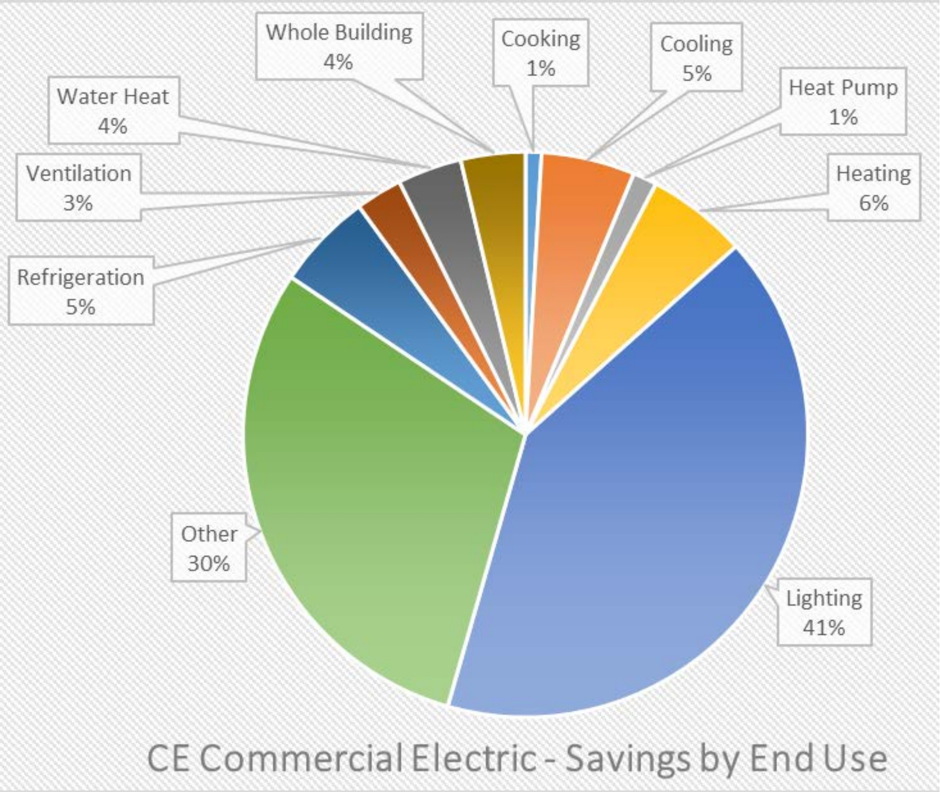
ELECTRIC	2017 IRP Electric CE Results			2021 IRP Electric DRAFT Mid Scenario Results		
Cost Effective DSR - Electric	**Total Energy (MWh)**	**Average Energy (aMW)**	**DR Capacity (MW)**	**Total Energy (MWh)**	**Average Energy (aMW)**	**DR Capacity (MW)**
20-Year Potential	2,336,387	267	114	4,080,018	466	111
10-Year Potential	1,799,149	205	107	2,423,908	277	36
2-Year Potential	358,547	41	25	293,248	33	0

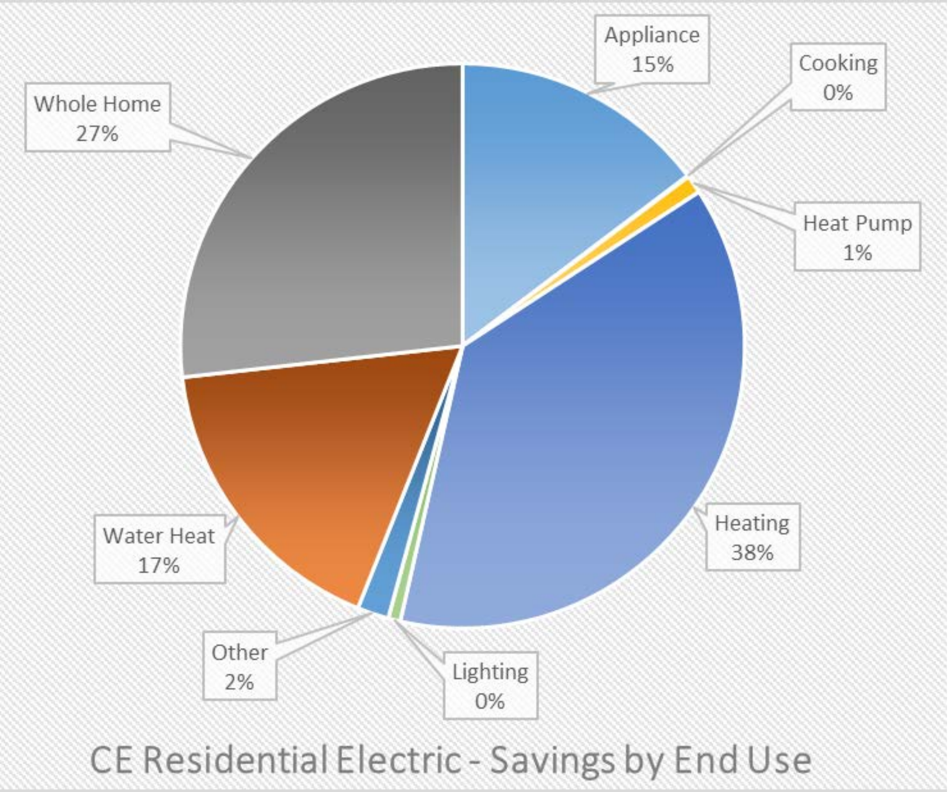
Cost effective energy efficiency savings by sector





Cost effective conservation by end use

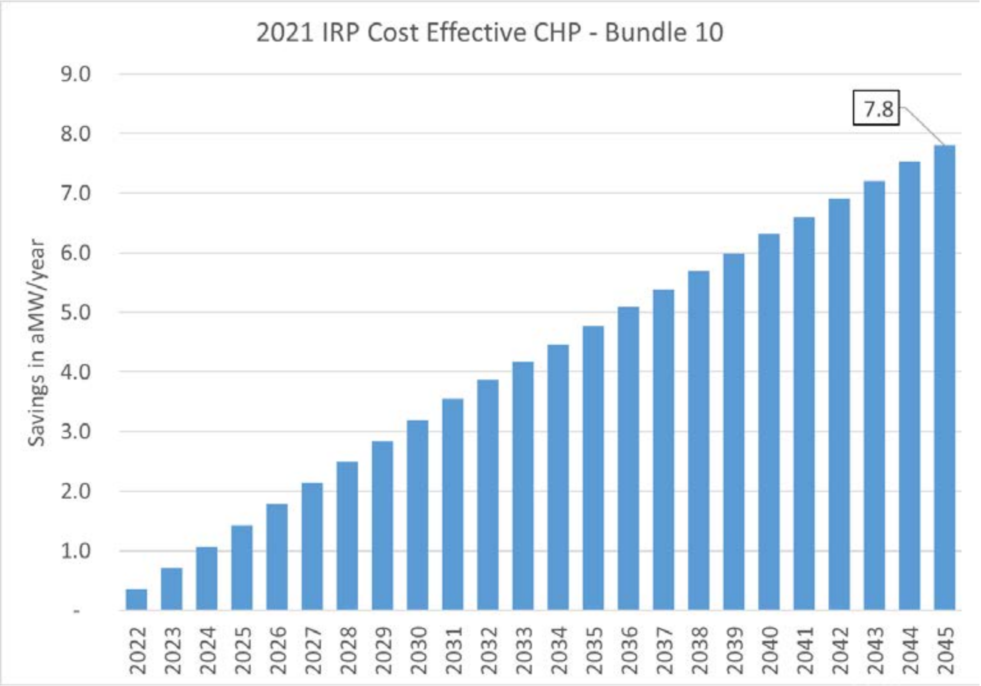


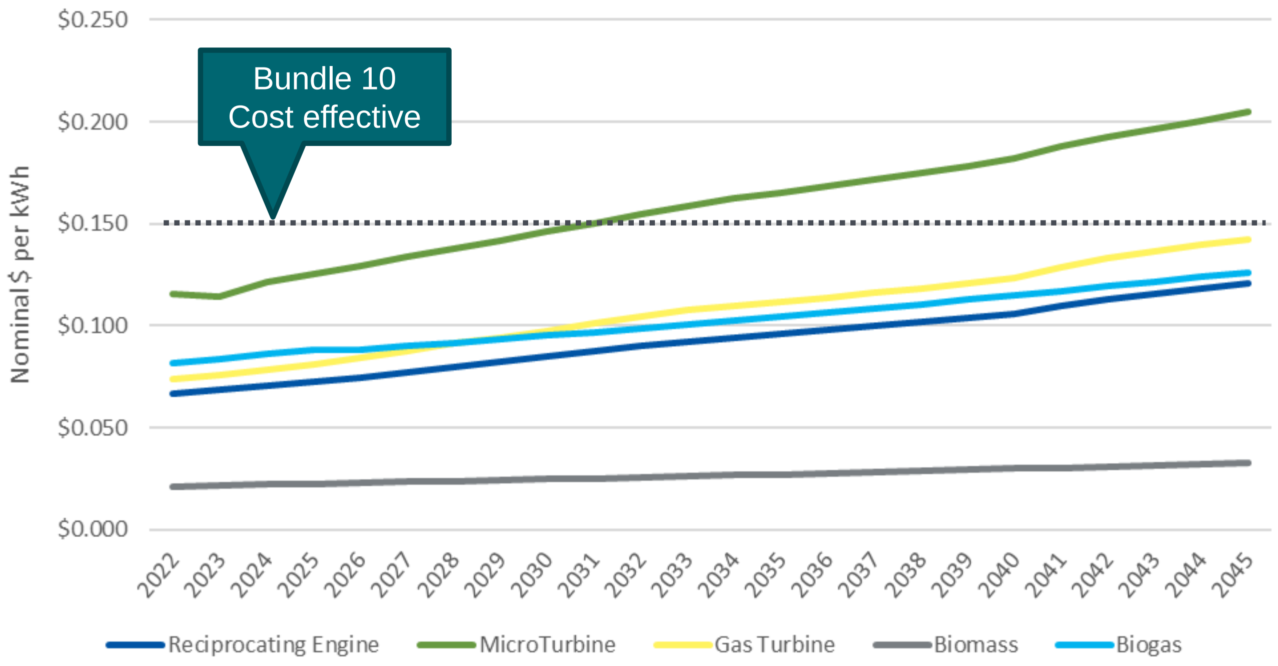


- Most savings are derived from lighting
- Space heating, water heating, and refrigeration make up an additional 15% of savings
- Other category includes: wastewater, pumps, and pool covers and pumps

- Heating, appliances, water heating and whole home in new construction are main areas for residential measures
- Lighting savings are small in comparison to the commercial sector

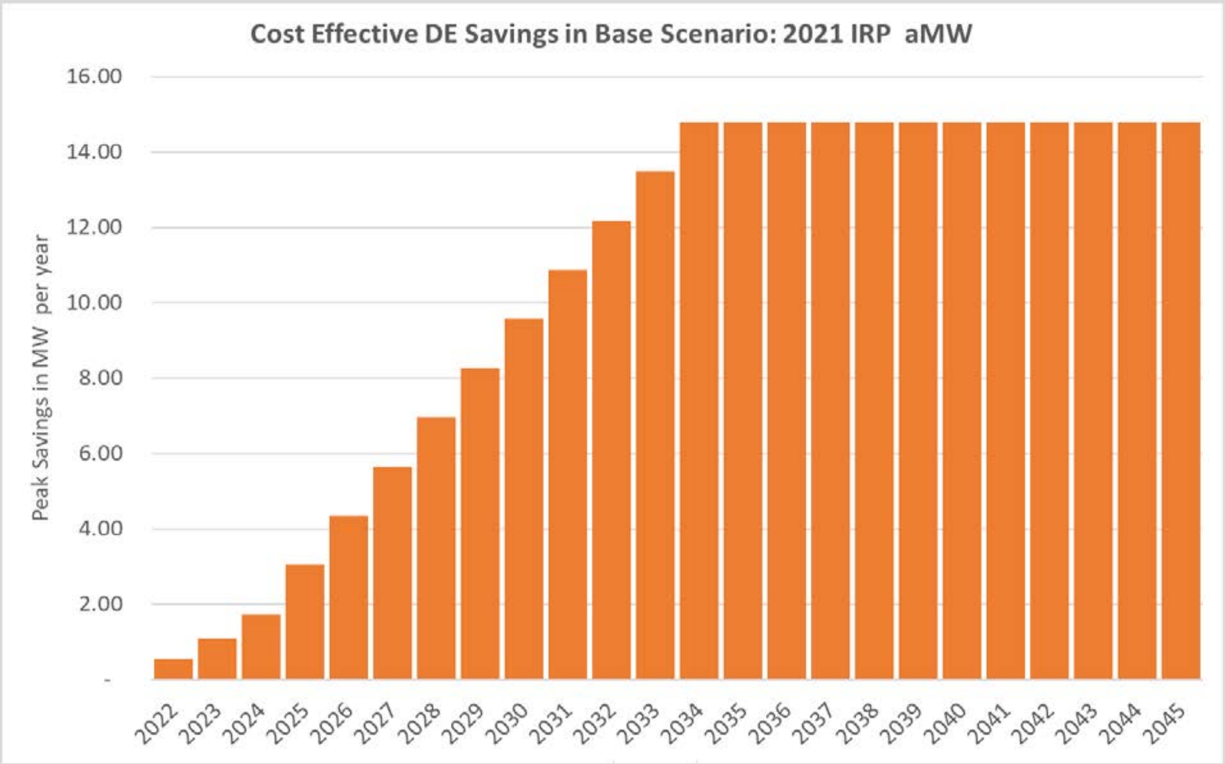
Combined Heat & Power (CHP) contributes to cost-effective DSR



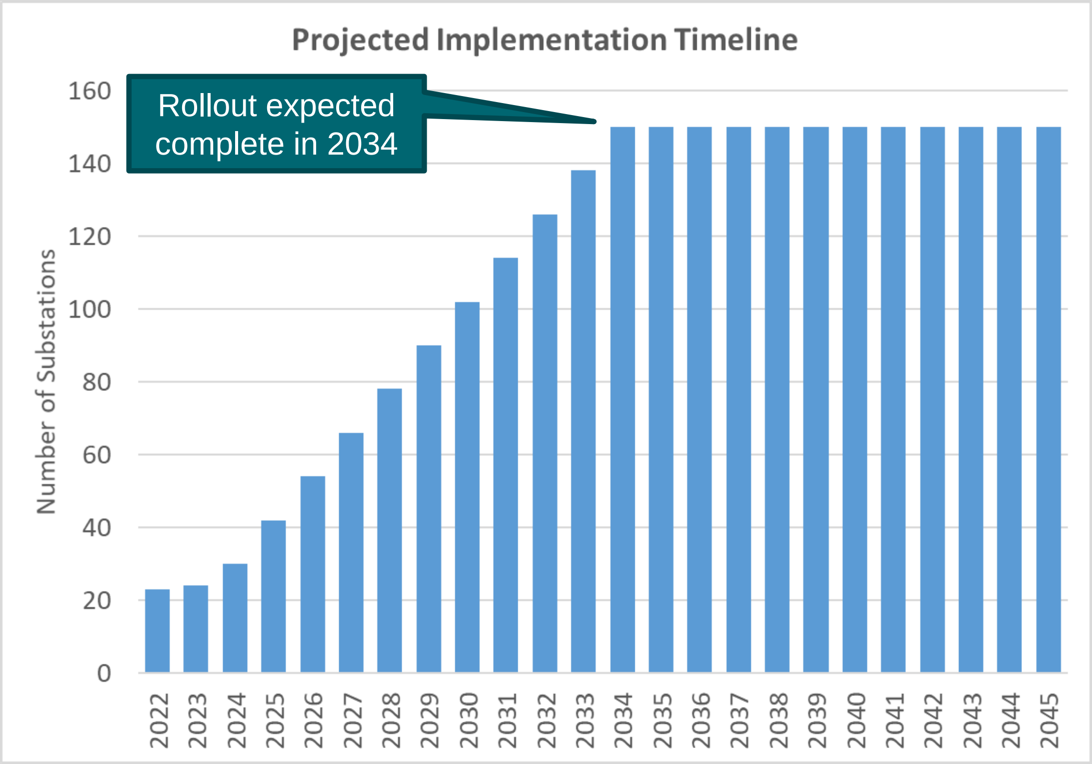


PUGET SOUND ENERGY

Distribution Efficiency peak savings are realized by 2034



Distribution efficiency savings are based on Volt-Var optimization with Automated Distribution Management System (ADMS) and Advanced Metering Infrastructure (AMI)

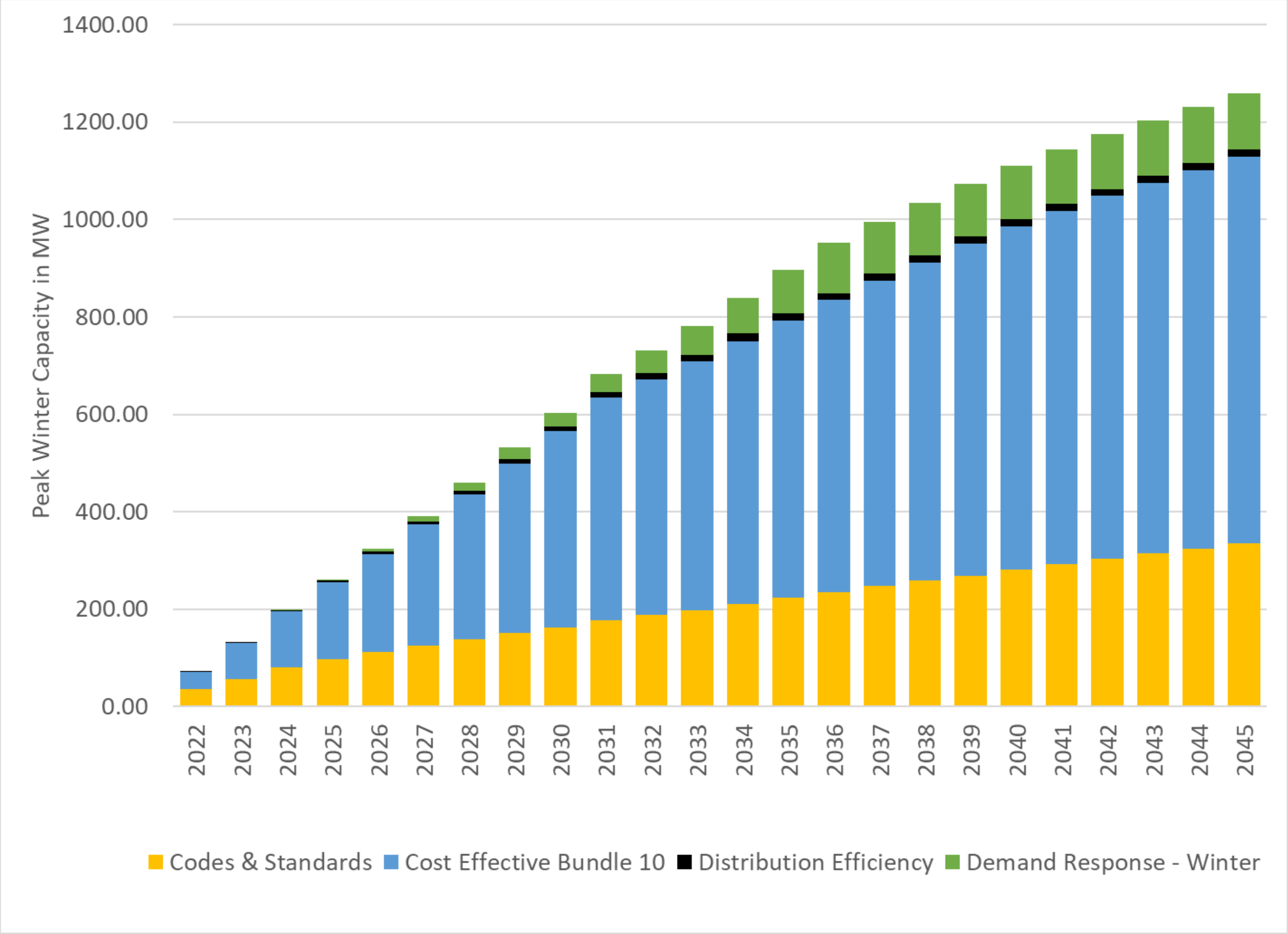


Rollout schedule on substations, identified as eligible for CVR application, is expected to be complete in 2034

Annual renewable resource additions

Incremental Resource Additions		WA Wind	MT Wind East	MT Wind West	ID Wind	WY Wind East	WY Wind West	Offshore Wind	Total Wind	WA Solar East	WA Solar West	ID Solar	WY Solar Anticline	WY Solar West	Total Solar
2022 - 2025 Colstrip and Centralia Retire in 2025	2022	-	-	-	-	-	-	-	400	-	-	-	-	-	-
	2023	-	-	-	-	-	-	-		-	-	-	-	-	
	2024	-	-	-	-	-	-	-		-	-	-	-	-	
	2025	-	200	200	-	-	-	-		-	-	-	-	-	
2026 - 2030 CETA 80% Renewable Requirement in 2030	2026	-	-	-	-	400	-	-	800	-	-	-	-	-	697
	2027	-	-	-	-	-	-	-		-	-	-	-	-	
	2028	200	-	-	-	-	-	-		299	-	-	-	-	
	2029	-	-	-	-	-	-	-		299	-	-	-	-	
	2030	200	-	-	-	-	-	-		100	-	-	-	-	
2031-2045 CETA 100% Renewable Requirement in 2045	2031	100	-	-	-	-	-	-	2550	-	-	-	-	-	699
	2032	200	-	-	-	-	-	-		-	-	-	-	-	
	2033	100	-	-	-	-	-	-		-	-	-	-	-	
	2034	100	-	-	-	-	-	-		-	-	-	-	-	
	2035	200	-	-	-	-	-	-		-	-	-	-	-	
	2036	200	-	-	-	-	-	-		-	-	-	-	-	
	2037	100	-	-	-	-	-	-		100	-	-	-	-	
	2038	100	-	-	-	-	-	-		100	-	-	-	-	
	2039	200	-	-	-	-	-	-		-	-	-	-	-	
	2040	-	-	-	-	-	-	-		100	-	-	-	-	
	2041	200	-	-	-	-	-	-		-	-	-	-	-	
	2042	200	-	-	-	-	-	100		-	-	-	-	-	
	2043	100	-	-	-	-	-	100		-	200	-	-	-	
	2044	-	350	-	-	-	-	-		100	100	-	-	-	
	2045	100	-	-	-	-	-	100		-	-	-	-	-	
Grand Total		2300	550	200	-	400	-	300	3750	1096	300	-	-	-	1396

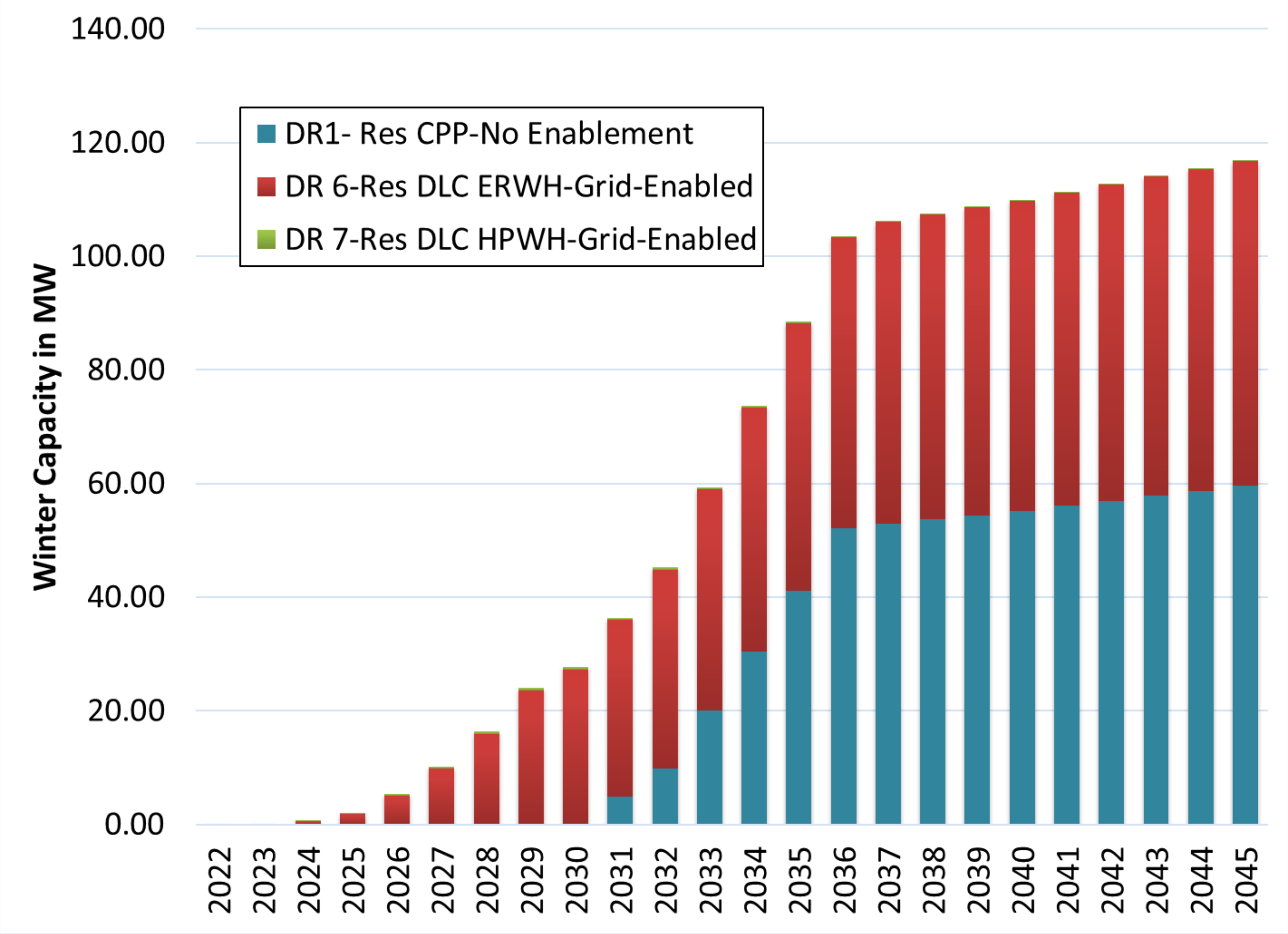
Demand-side resources total peak capacity savings



Electric draft demand-side resources include:

- Codes & Standards
- Conservation savings up to bundle 10 ($175/MWh)
- Distribution Efficiency
- Demand response

Three demand response programs were selected from the sixteen modeled



The portfolio optimization model selected 3 Demand Response programs in the mid portfolio:

- DR 1 Residential critical peak price
- DR 6 Residential direct load control (electric residence water heater)
- DR 7 Residential direct load control (heat pump water heater)

Grid-enabled refers to a two way communication with grid.

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Flexibility Analysis Appendix

Creating sub-hourly data inputs

Demand forecast

- Demand forecast was input into Plexos using the monthly energy need (MWh) and peak need (MW).
- Using the Boundary Interpolate method, Plexos extrapolated the hourly and 15-minute loads.
- PSE used the historical load shape from 2017 to create the 15-minute loads.

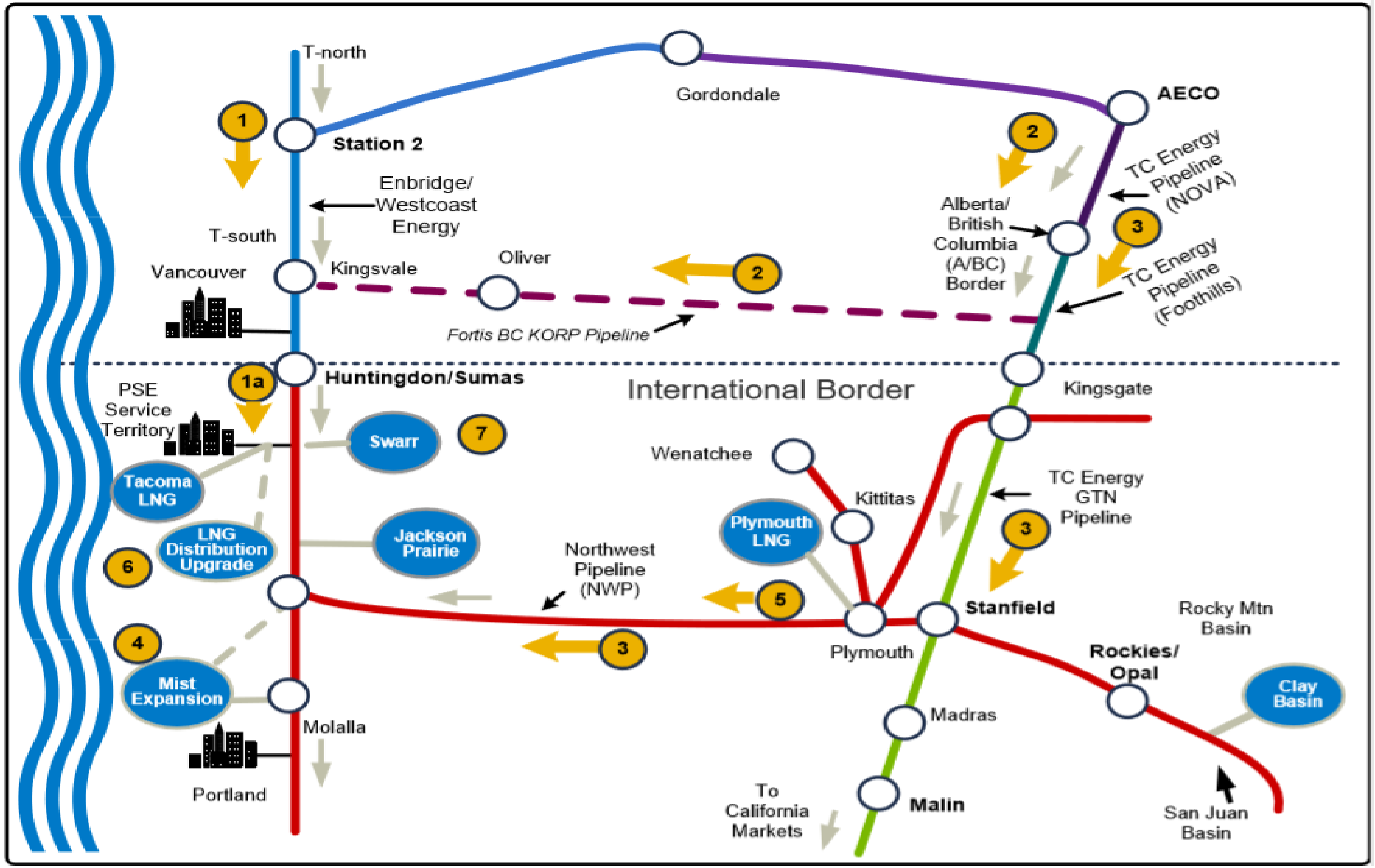
Power prices

- Aurora is run as an hourly model, so the hourly electric price forecast from the mid scenario as input into Plexos. This was used for the Mid-C day ahead and hourly market sales and purchases.
- Using the Step Method, Plexos extrapolated the 15-minute electric prices for the EIM market.

PUGET SOUND ENERGY

Natural Gas Appendix

Resource alternatives - schematic



PUGET SOUND ENERGY

2021 IRP CPA - low income customers

- The CPA identified Low Income customers from 2017 Residential Characteristics Survey (RCS) data and the qualifying income from PSE's Weatherization Assistance program.

Segment	Electric Low Income Customers as a Percent of Total Electric Housing Segment Customers
Single Family	9.1%
Multifamily	8.3%
Manufactured	11.3%

- Levelized cost for low income customers used a lower benefit cost ratio adjustment
- The achievable technical potential associated with Low Income customers:

Segment	Cumulative 10-Year Achievable Technical Potential (MM Therms)	Cumulative 20-Year Achievable Technical Potential (MM Therms)
Single Family - Low Income	8.6	13.8
Multifamily - Low Income	2.7	5.0
Manufactured - Low Income	0.2	0.4
Total	**11.6**	**19.2**

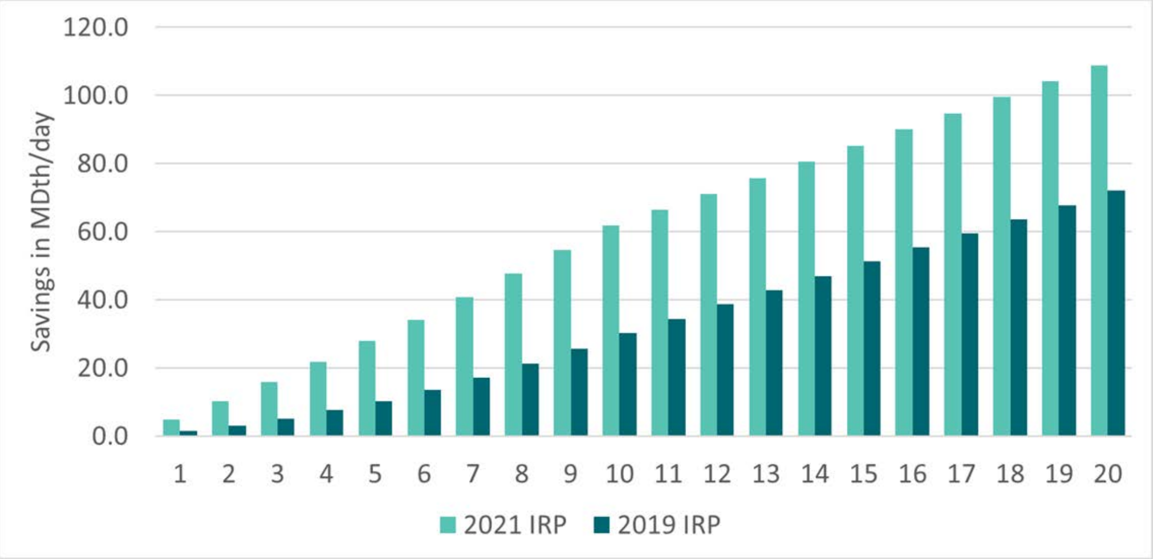
PSE PUGET SOUND ENERGY

Cost effective DSR results comparisons: 2017, 2019 vs 2021 IRP

- Cost effective DSR for gas: 2017 Base vs 2021 IRP draft Mid Scenario

Cost Effective DSR- GAS	2017 IRP	2021 IRP DRAFT - Mid Scenario
20-Year Potential	54,096,456	102,807,113
10-Year Potential	30,778,000	55,775,135
2-Year Potential	6,155,000	6,690,013

- Cost effective DSR for gas: 2019 IRP process vs 2021 IRP draft Mid Scenario



2017 IRP –

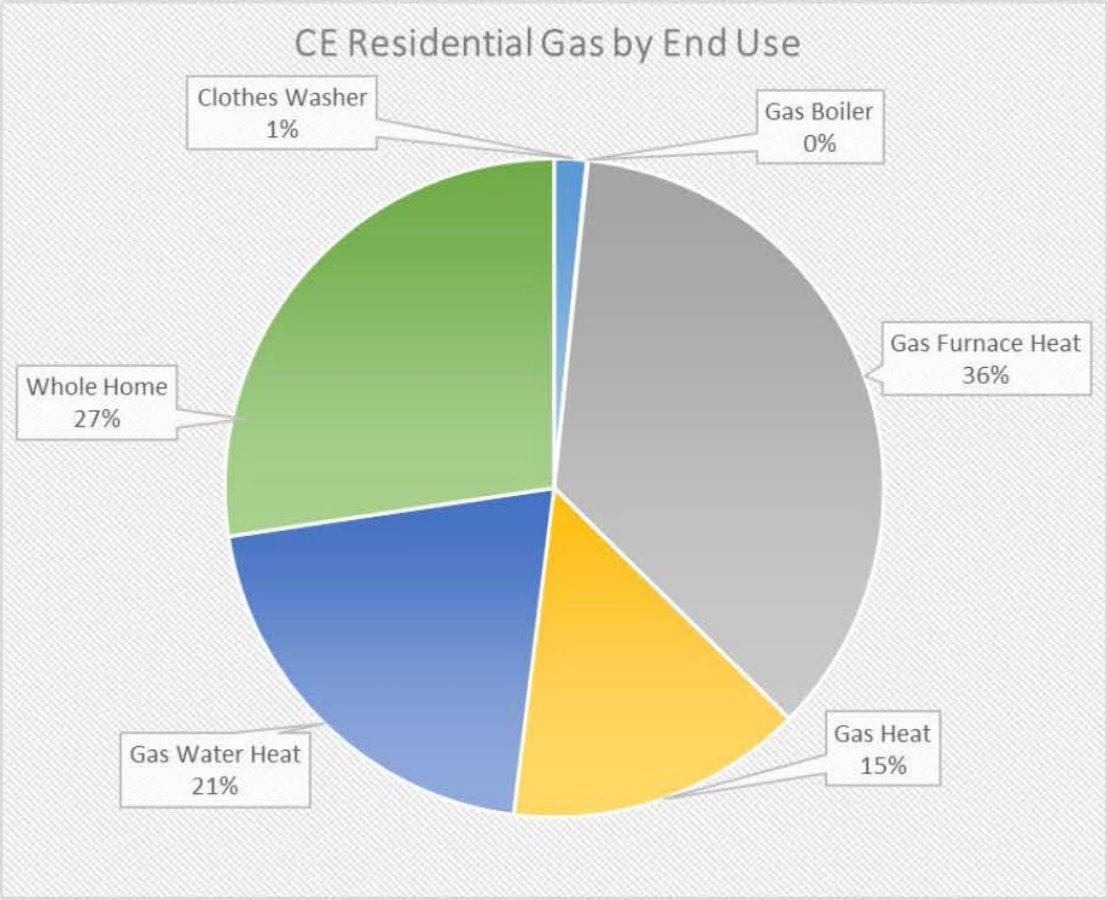
- Lower carbon adders
- Lower achievable technical potential
- Picked lower bundle

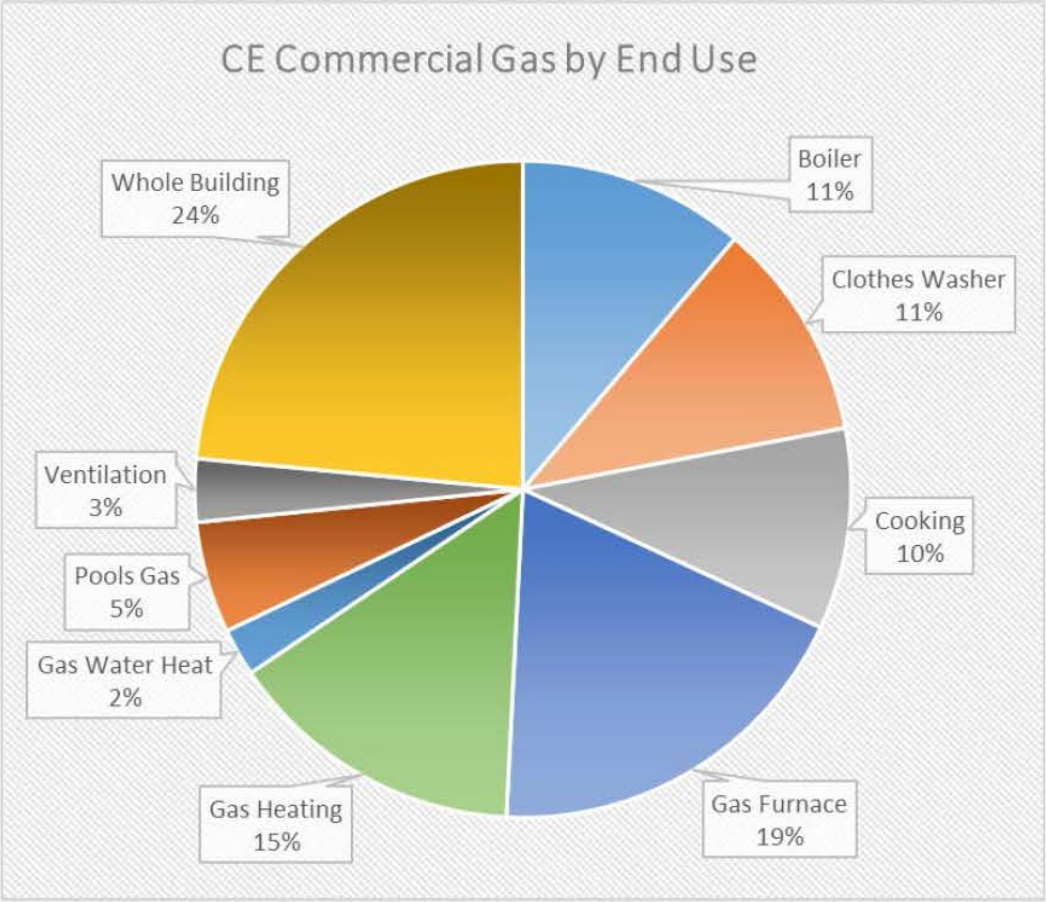
2019 IRP-

- Higher achievable technical potential
- Similar bundle cost point selected

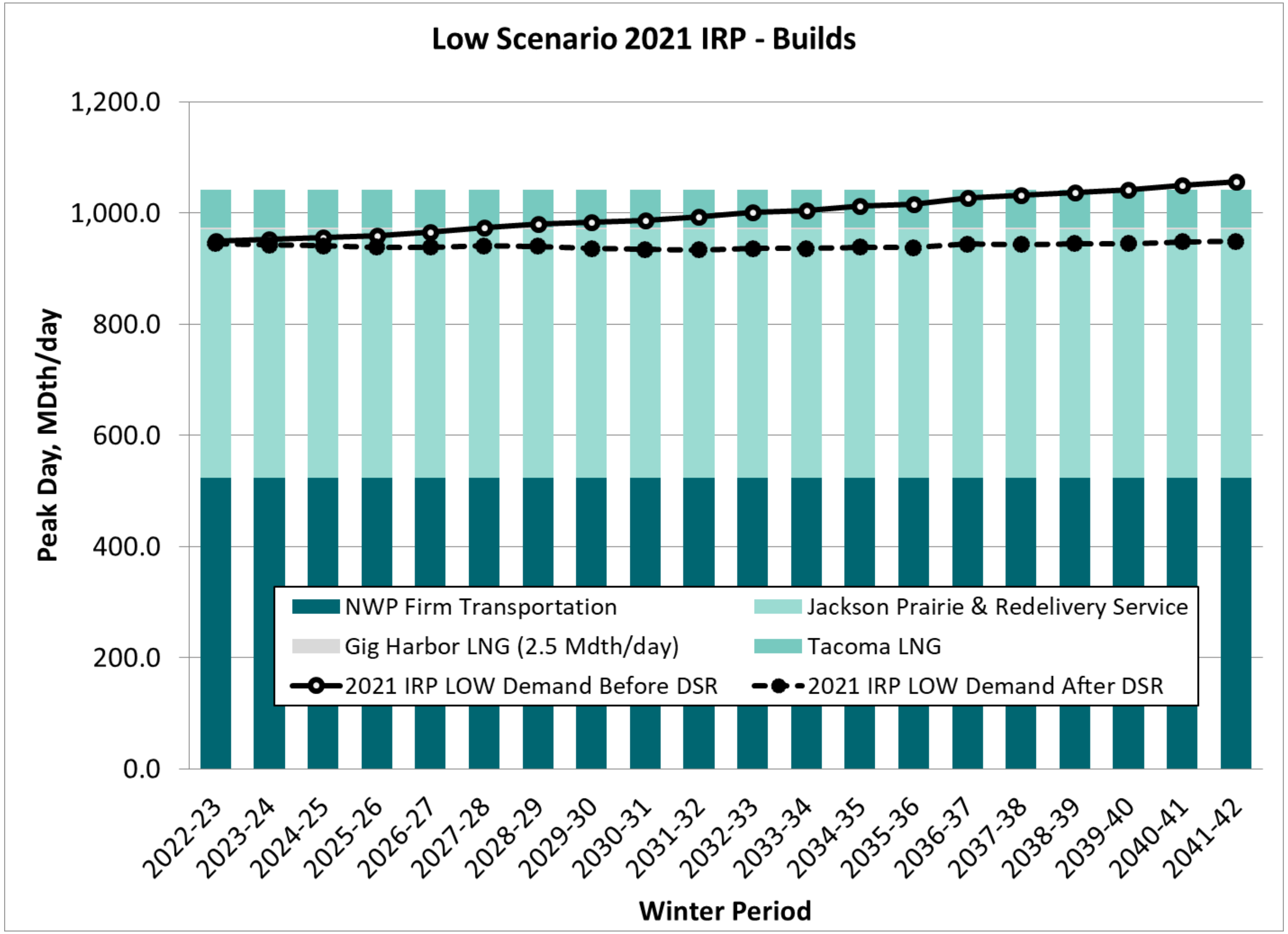
PUGET SOUND ENERGY

Draft mid scenario – cost effective savings by end use





Draft Low scenario – DSR more than sufficient to meet need



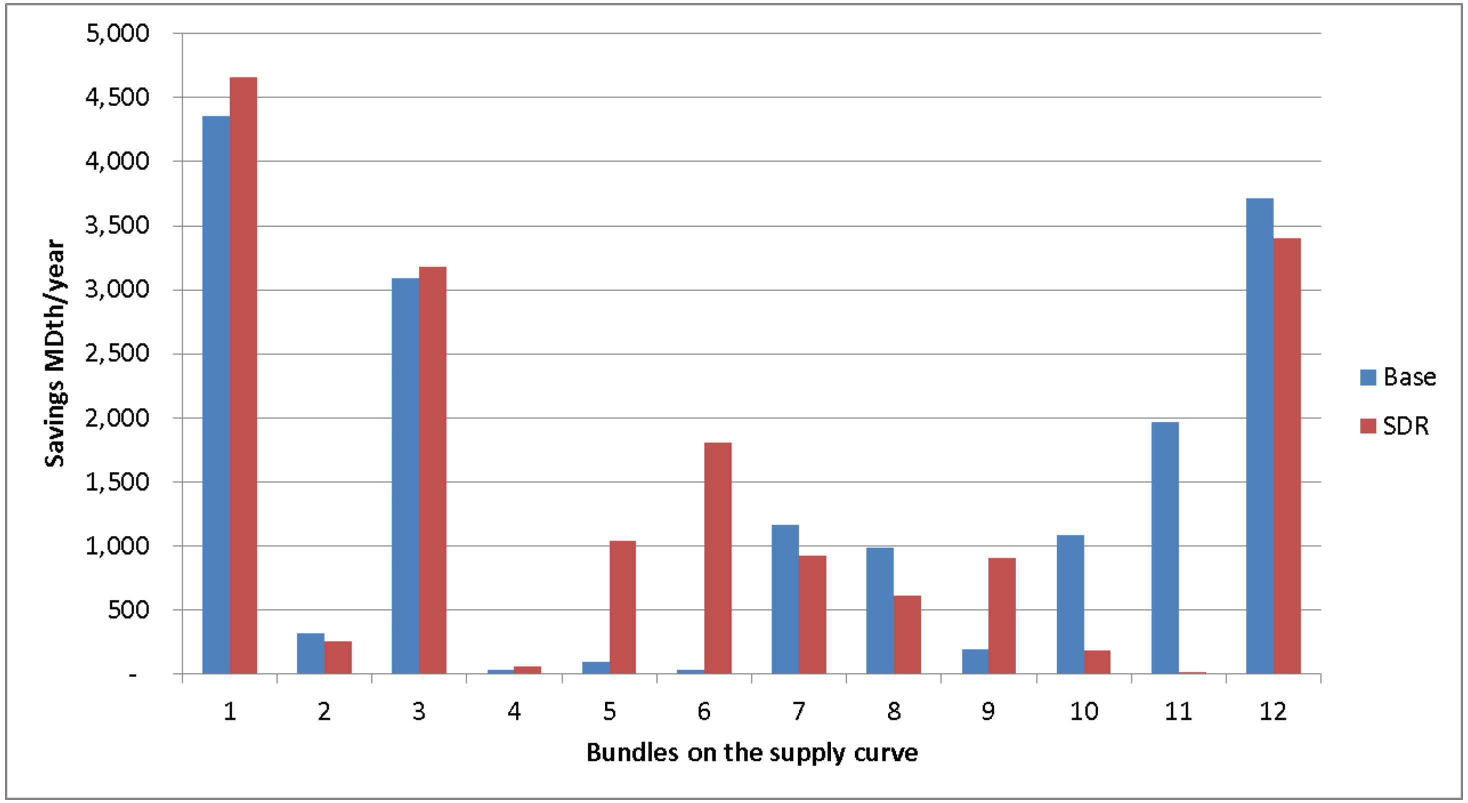
First resource need occurs in 2040-41 winter of 14 MDth/day

Same amount of cost effective DSR as in Mid scenario is selected by gas portfolio model

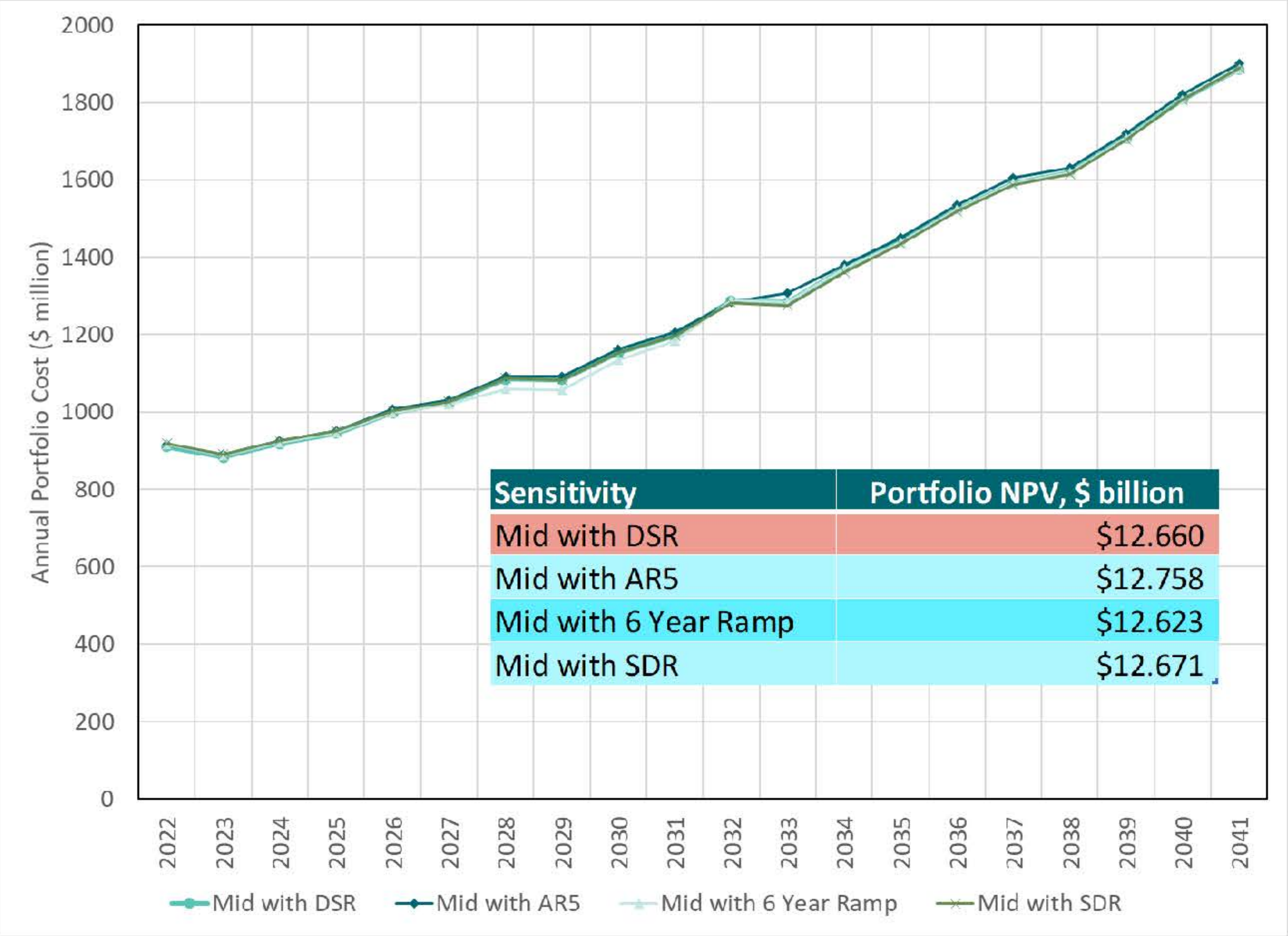
PSE PUGET SOUND ENERGY

Draft sensitivity results – social discount rate (SDR)

- Inputs:
  - Used a SDR of 2.5%
  - Used the 10 year ramp
  - Measure shifted to lower cost bundles



Draft sensitivity results – portfolio costs



Sensitivity	Portfolio NPV, $ billion
Mid with DSR	$12.660
Mid with AR5	$12.758
Mid with 6 Year Ramp	$12.623
Mid with SDR	$12.671

PUGET SOUND ENERGY