Portland General Electric

2016 Integrated Resource Plan

Roundtable #16-3
August 17, 2016

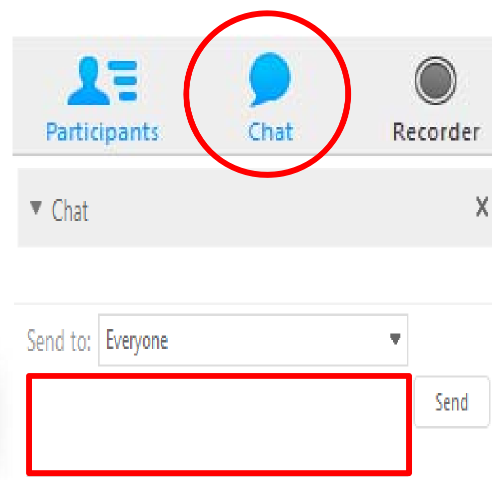
Meeting Logistics

Local Participants:

- World Trade Center facility
- Wireless internet access
- Sign-in sheets

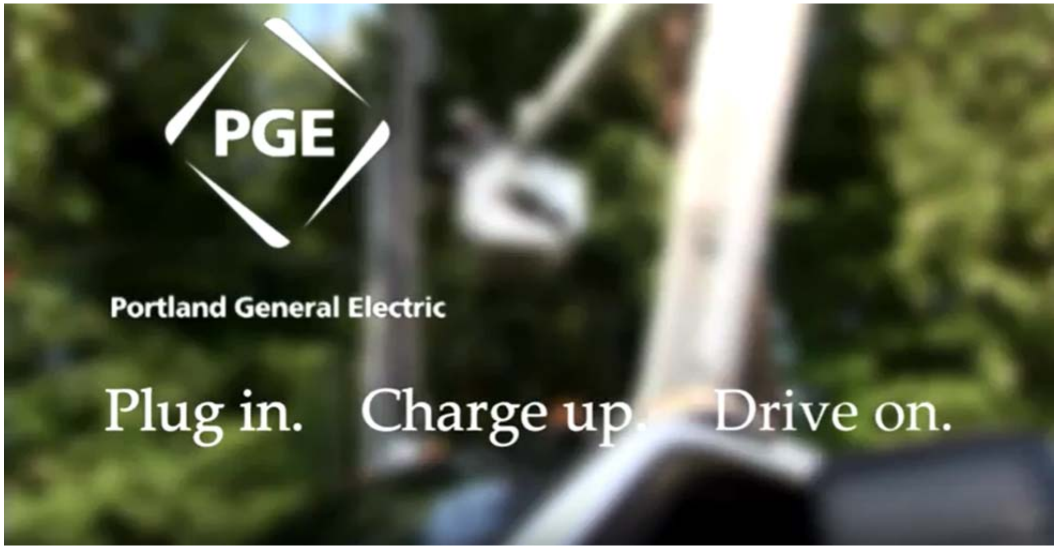
Virtual Participants:

- Ask questions via 'chat' feature
- Meeting will stay open during breaks, but will be muted



- Electronic version of presentation: *portlandgeneral.com/irp >> Integrated Resource Planning*

Safety Moment –



PGE Fleet (as of June 2016)

- Corporate commitment to allocate 10% of fleet budget on electrification
- 38 Electric Vehicles

Electrification Benefits

- Safe
- Reliable
- Efficient
- Clean

Today’s Round Table Topics

- Stakeholder process
- Resource need assessment
- Scenario analysis and results
- Draft Action Plan
- Energy Storage evaluation
- Next Steps

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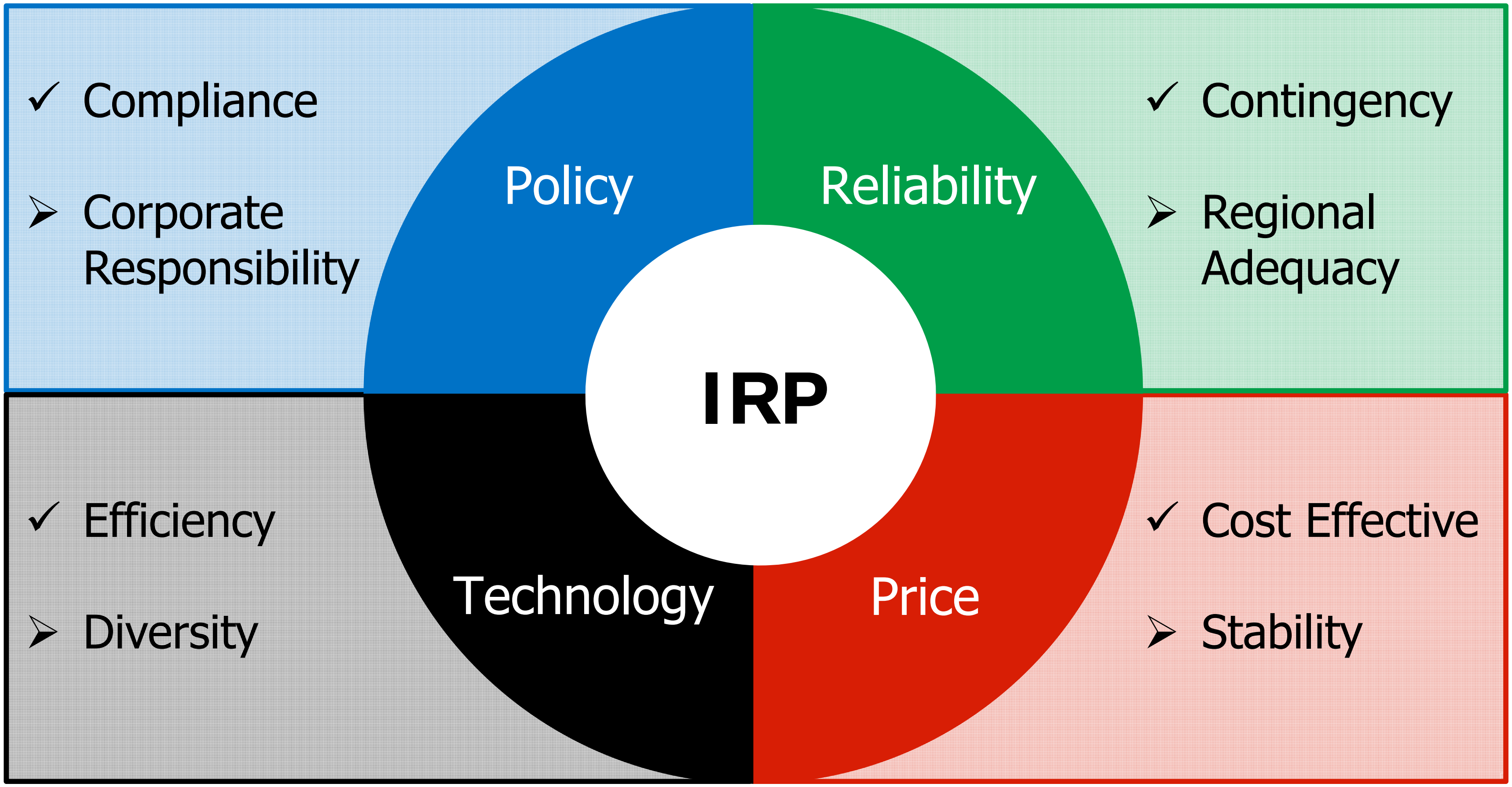
Public Process Overview

Guiding Philosophy

PGE's IRP is framed by four directional drivers



Providing the opportunity to obtain the best resource portfolio while building stakeholder trust in a constantly changing environment

Round Table Meeting Schedule*

PGE holds quarterly round tables to communicate with and receive feedback from stakeholders

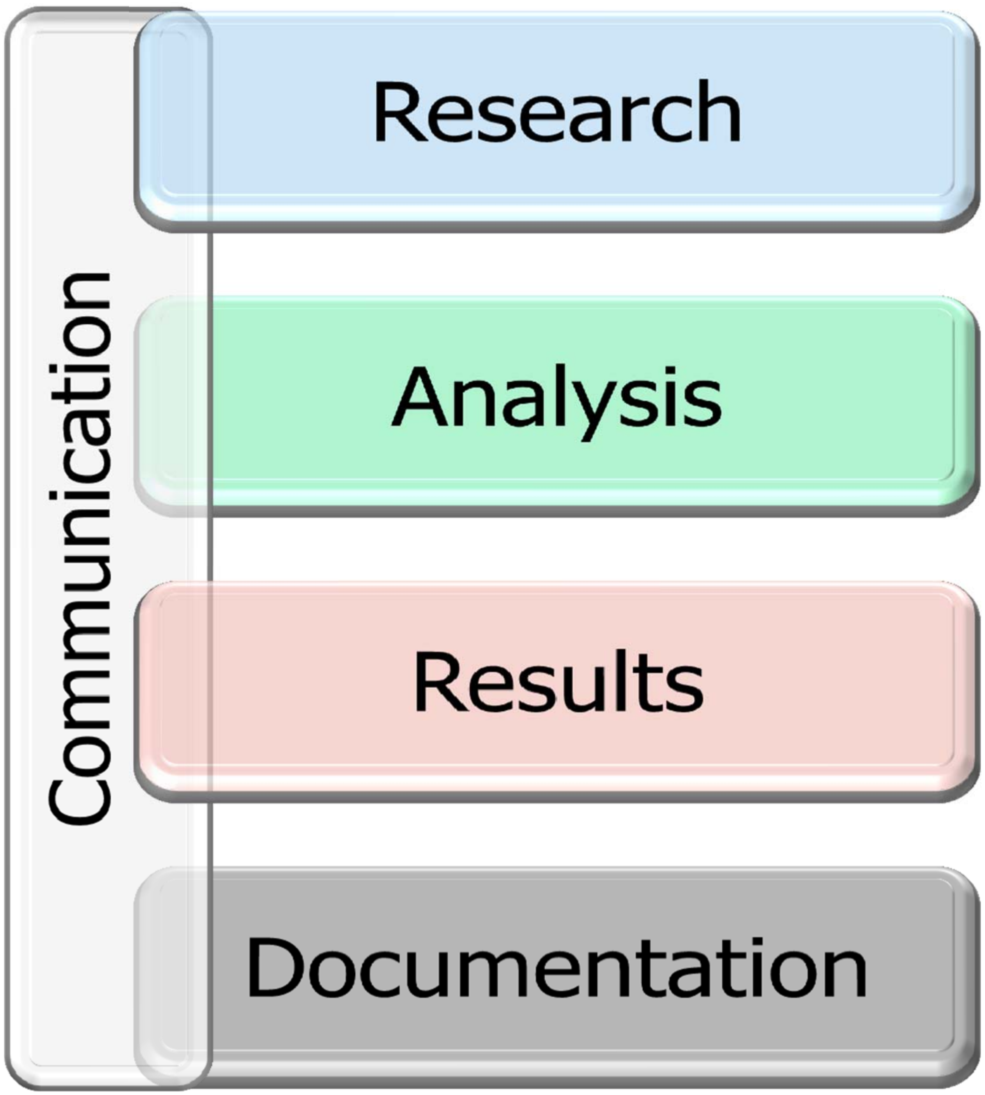
Q1 – March 9	• RPS Landscape • Scoring Metrics • Resource Adequacy • Portfolios
Q2 – May 16	• RPS Strategy (SB 1547 Compliance) • Resource Flexibility
Q3 – August 17	• Discuss Results and Draft IRP**
Q4 – November 16	• Discuss Final IRP*** • OPUC Process

Feedback welcome 24/7 at: https://www.portlandgeneral.com/forms/pge-stakeholder-feedback

* All dates subject to change
** Draft IRP scheduled for distribution on September 26
*** Final IRP scheduled for filing on November 4

2016 IRP Development

PGE, in collaboration with Stakeholders, continues to evolve the IRP



Changing Environment

- Clean Power Plan
- Energy Imbalance Market
- Senate Bill 1547

Total Resource Portfolio Analysis

- Updated Load Forecast methodology
- New Resource Adequacy methodology
- Integration of all resources
  - Resource potential studies
  - Flexibility analysis
  - Energy Storage analysis

Responsive Action Plan

- Maintain Resource Adequacy
- Obtain balance of cost and risk

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Resource Adequacy Update

Review Load Forecast

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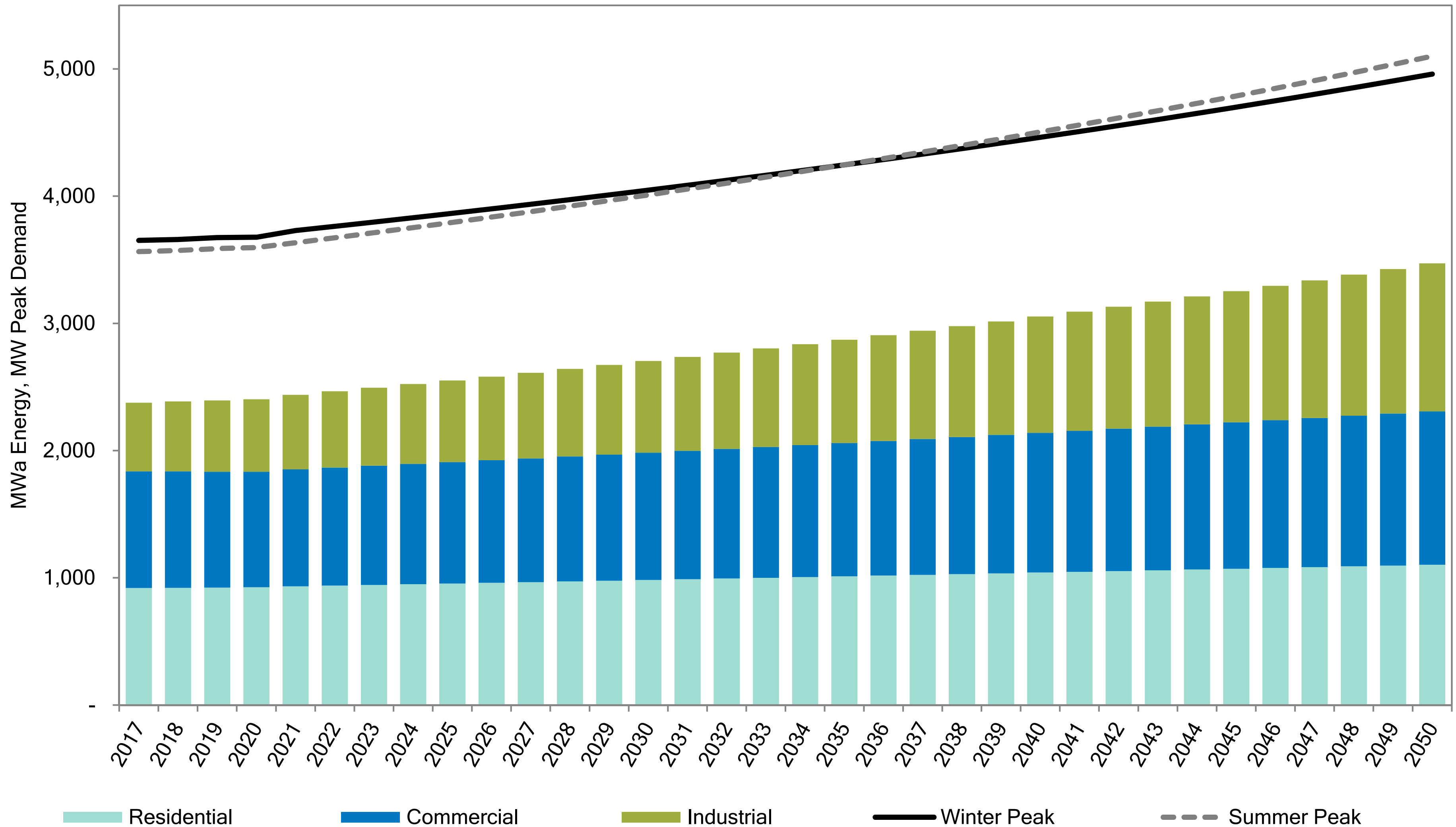
Summer peak demand grows at a slightly faster rate than winter peak demand (1.2% vs. 1.0% for 2022-2050)



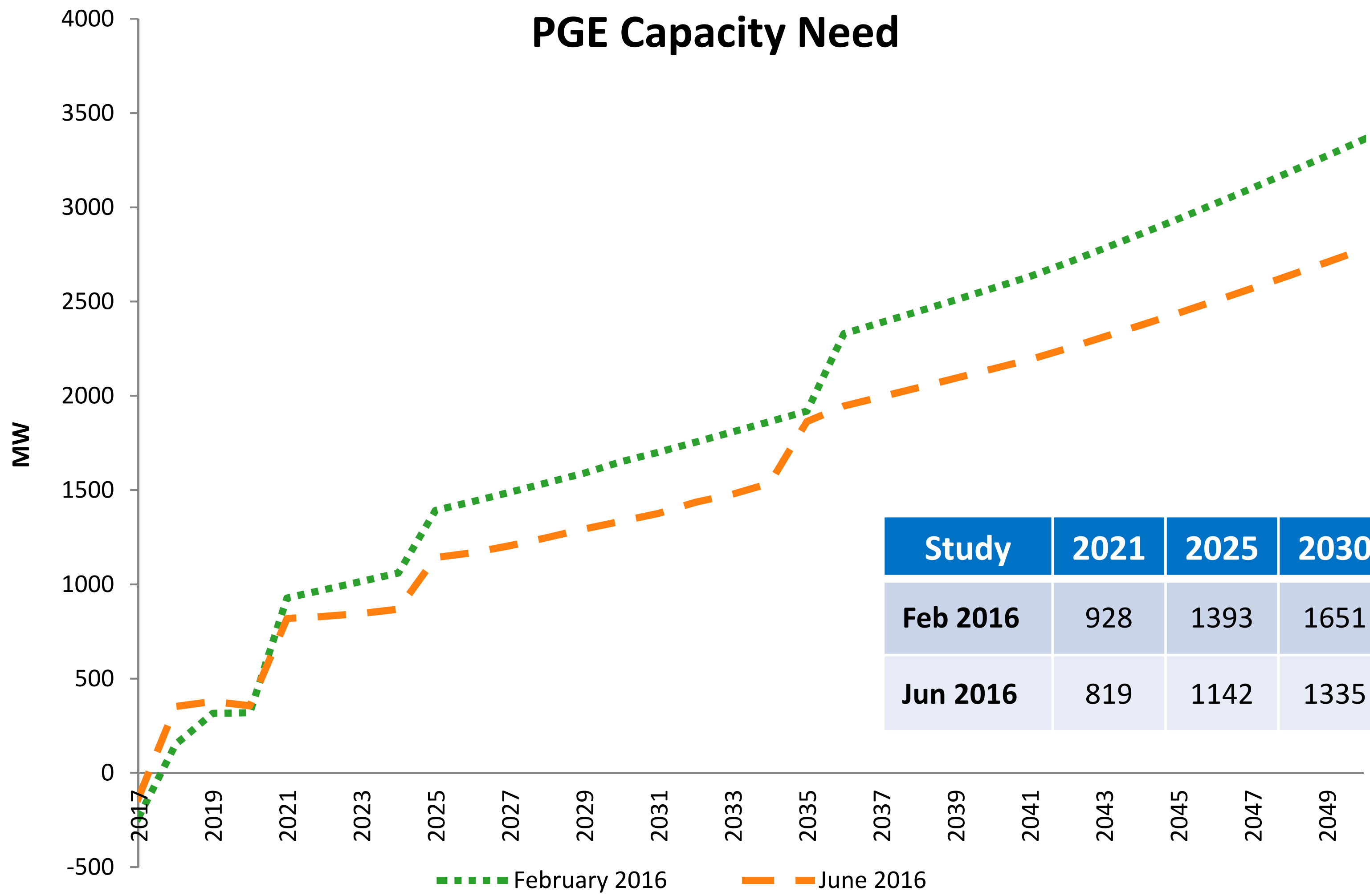
* 1-in-2 forecast from June 2015
Load includes 5-year direct access opt-out customers
Load reduced for energy efficiency actions

Resource Adequacy Update

	Feb 2016	Jun 2016
RECAP Runs	▪ Modeled 2021, 2025, 2030 ▪ Interpolation and extrapolation for other years	▪ Modeled 2017-2050
Colstrip 3 & 4	▪ Removed after 2035	▪ Removed before Jan 1, 2035
Dispatchable Standby Generation (DSG)	▪ All years based on early forecast for 2016	▪ IRP target acquisitions for each year
Demand Response (DR)	▪ All years based on early forecast for 2016	▪ IRP target acquisitions for each year
Contracts	▪ Aug 31, 2015 snapshot	▪ May 31, 2016 snapshot (added ~166 MW, primarily solar; removed ~24 MW, primarily wind)

Updated RECAP Results

- **June 2016 Study** shows remaining capacity need after incremental actions for DR/DSG and with updated contracts

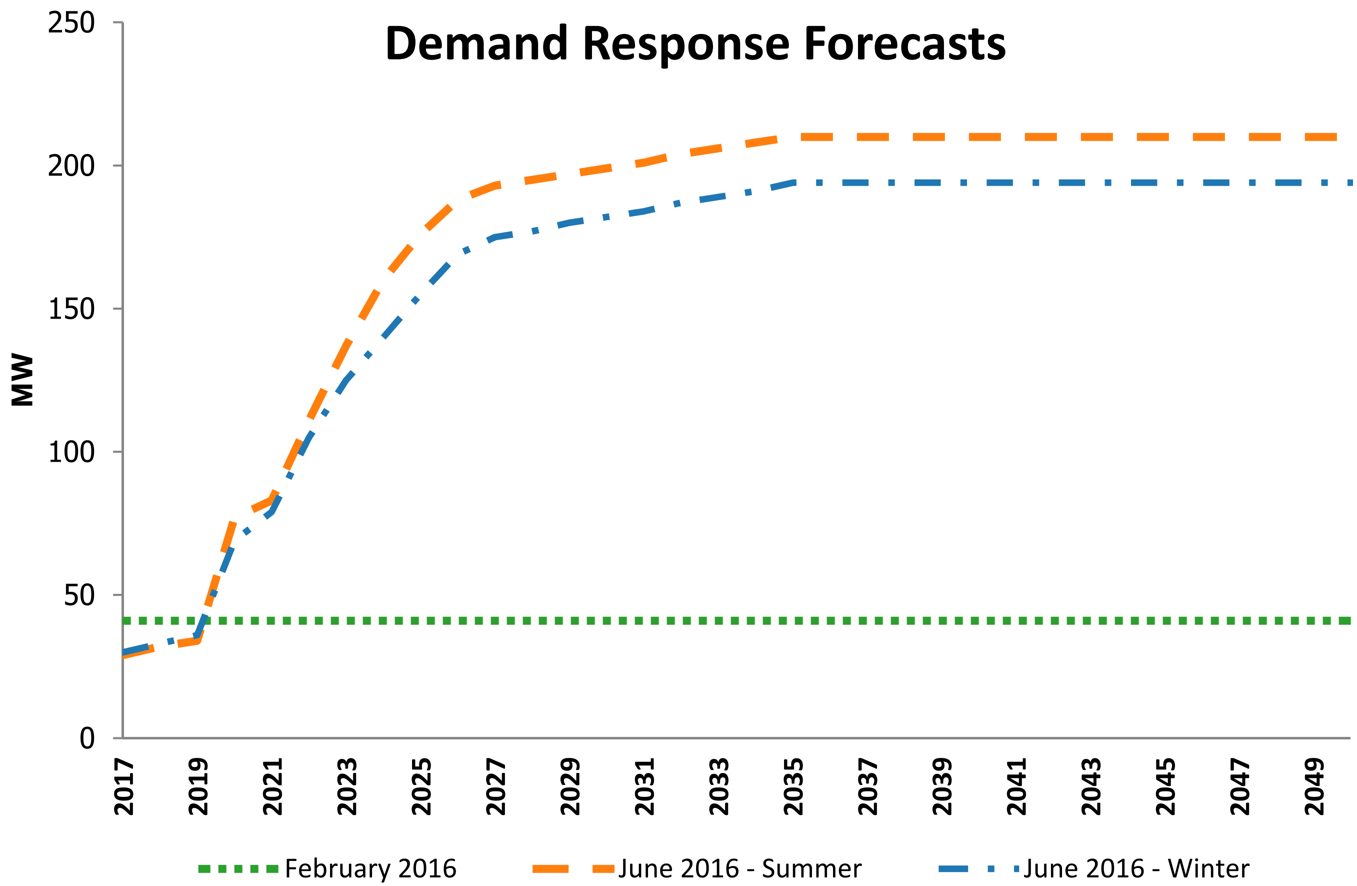


Study	2021	2025	2030
Feb 2016	928	1393	1651
Jun 2016	819	1142	1335

Capacity need based on conventional units, 100 MW, 5% forced outage rate (FOR)

Demand Response Comparison

- Total DR acquisitions included in all portfolios did not change
- Updated modeling in RECAP
  - Feb 2016 Study: ~40 MW fixed DR value for all years in RECAP
  - June 2016 Study: Targeted DR acquisitions for each year



Capacity Need After EE, DR, DSG Actions

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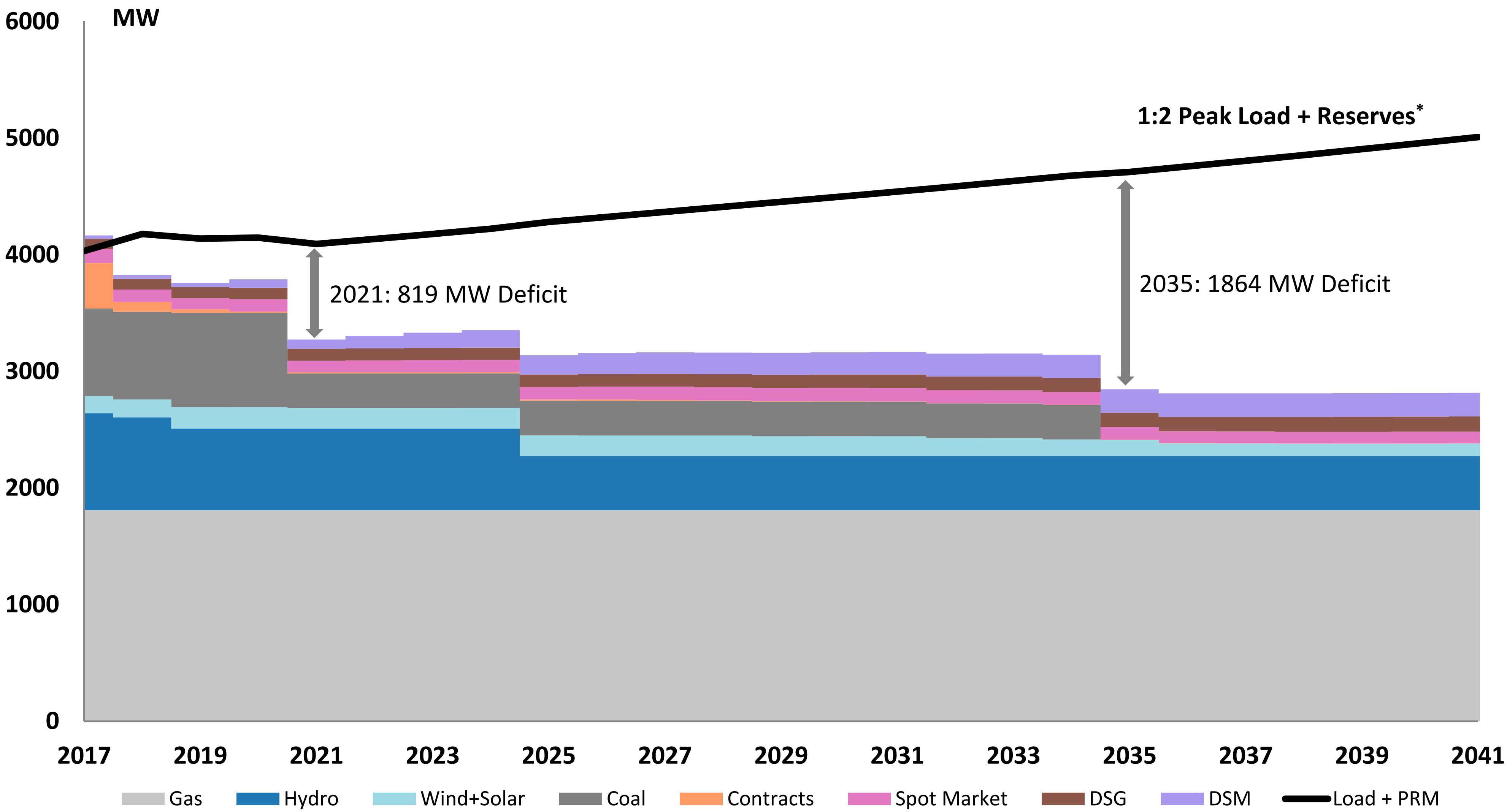
A capacity gap of 819 MW is expected in 2021, driven mainly by Boardman cessation of coal-fired generation in 2020 and contract expirations



*1:2 Peak Load adjusted for EE actions, excluding long-term opt-outs, including operating and planning reserves

Capacity Heat Map for 2021 (Jun 2016 RECAP)

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Heat map shows seasonal and hourly nature of PGE's capacity needs

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
5	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
6	0.13	0.11	0.05	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.13	0.28
7	0.47	0.37	0.32	0.04	0.00	0.00	0.01	0.02	0.03	0.09	0.54	1.13
8	1.88	1.01	0.68	0.09	0.00	0.00	0.03	0.10	0.10	0.16	1.17	2.48
9	3.20	1.73	0.77	0.05	0.01	0.01	0.13	0.39	0.12	0.13	2.12	3.97
10	2.55	1.16	0.53	0.04	0.01	0.04	0.38	0.83	0.17	0.07	1.72	3.60
11	1.88	0.80	0.34	0.02	0.02	0.09	0.81	1.52	0.23	0.05	1.27	2.89
12	1.58	0.51	0.17	0.01	0.03	0.18	1.35	2.33	0.36	0.04	0.99	2.41
13	1.46	0.31	0.09	0.01	0.06	0.33	2.10	3.36	0.53	0.03	0.86	1.79
14	1.19	0.16	0.05	0.00	0.08	0.50	3.08	4.57	0.82	0.02	0.72	1.34
15	0.91	0.13	0.04	0.00	0.11	0.66	3.91	5.57	1.22	0.03	0.62	1.05
16	0.79	0.14	0.03	0.00	0.12	0.86	4.59	6.36	1.65	0.04	0.76	1.40
17	1.27	0.25	0.06	0.00	0.16	1.00	4.78	6.69	1.99	0.09	1.32	3.22
18	3.14	0.66	0.15	0.01	0.16	0.84	4.51	6.71	2.11	0.26	3.01	5.66
19	5.04	1.47	0.40	0.01	0.15	0.58	3.72	6.26	1.96	0.41	4.62	7.40
20	4.86	1.74	0.58	0.02	0.12	0.36	2.84	5.09	1.75	0.35	4.22	6.62
21	3.55	1.23	0.40	0.02	0.06	0.19	1.75	3.75	1.42	0.14	3.01	4.63
22	2.01	0.65	0.12	0.01	0.02	0.07	0.72	2.01	0.38	0.02	1.62	2.60
23	1.08	0.33	0.02	0.00	0.00	0.01	0.03	0.22	0.01	0.00	0.54	1.27
24	0.16	0.04	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.08	0.22

Resources included

- Existing portfolio
- QFs executed as of 5/31/2016
- Target EE, DR, DSG
- Spot Market 200 MW (excluding Summer On-peak)
- No Boardman coal
- No new RPS or capacity resources

Loss of Load Expectation (per year)

- 253 hours (in 2021)
- Target ≤ 2.4 hours

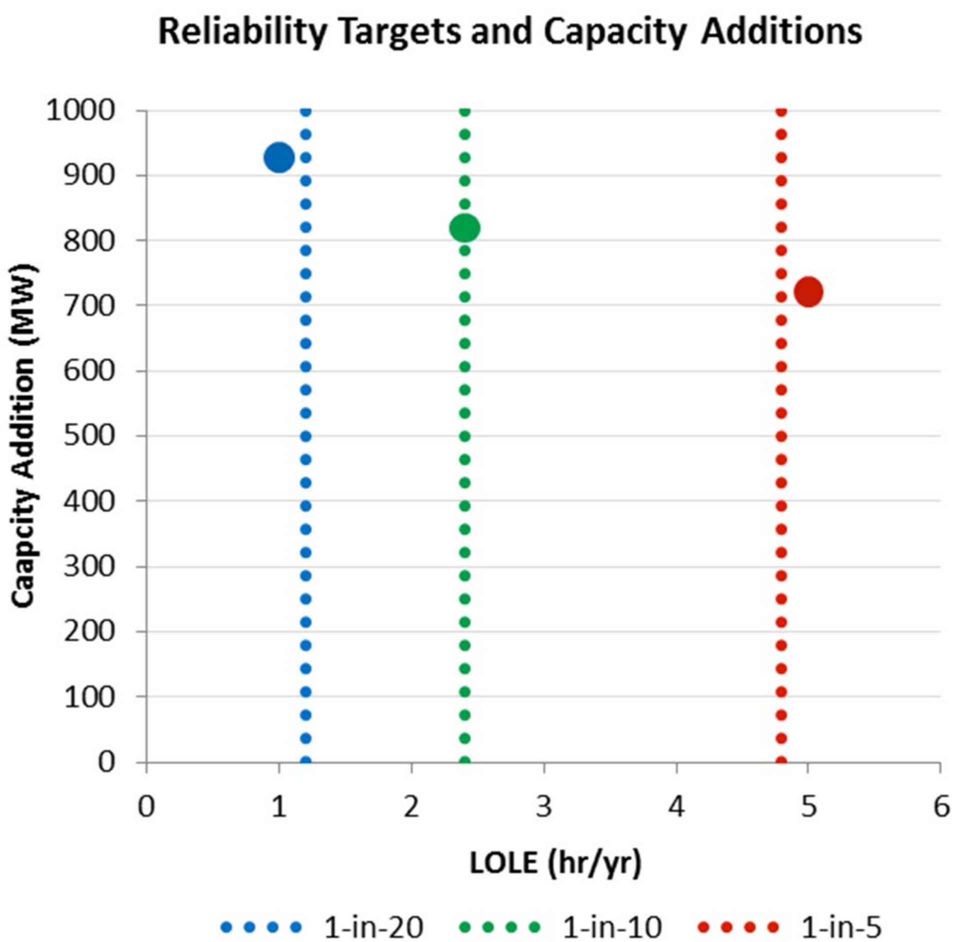
2021 LOLE = 253 hours per year

More Adequate — Less Adequate

Less Need — More Need

2021 Capacity Need and LOLE Target

Resource adequacy target[1] of 1-day-in-10-year metric



- Reliability metrics change substantially for ~±100 MW change to capacity addition[2]

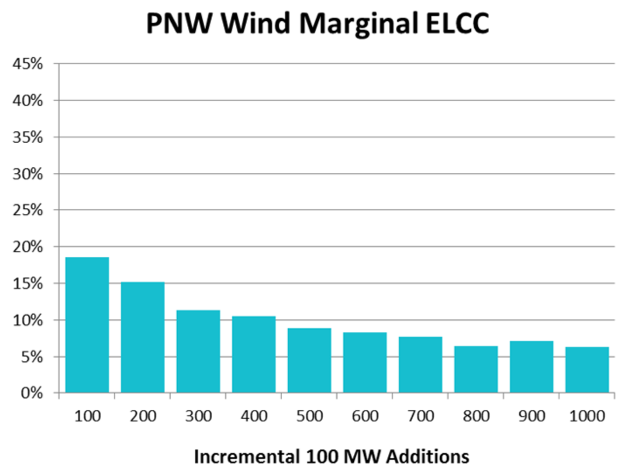
Capacity	Reliability
928 MW	> 1-in-20
819 MW	~ 1-in-10
721 MW	< 1-in-5

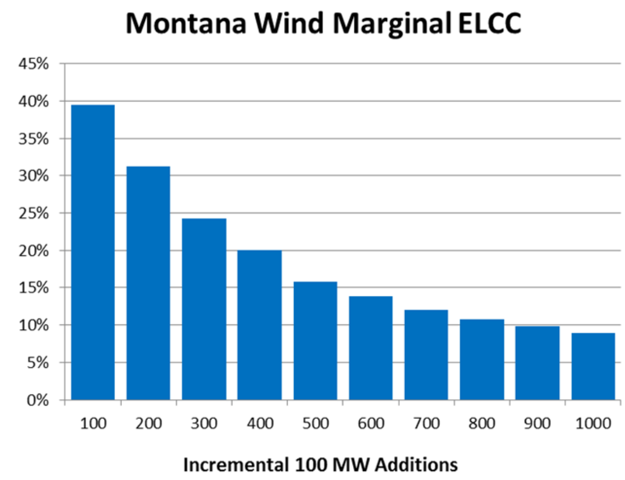
- PGE's capacity need continues to increase after 2021
- Regional capacity adequacy deficit in 2021 (increasing if Colstrip 1&2 retire in 2021)

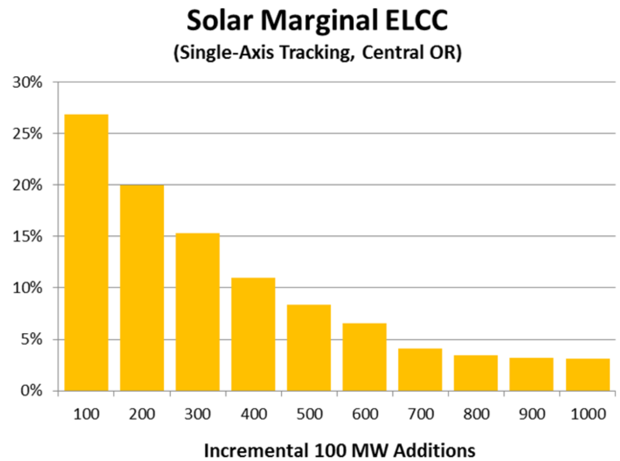
[1] Target defined as meeting hourly load plus operating reserves (spin and non-spin)
[2] Conventional units, 100 MW, 5% FOR, incremental to actions for EE, DR, DSG, and Spot Market assumption

Capacity Contribution – Incremental Wind/Solar

Marginal ELCC values for 100 MW incremental additions calculated in RECAP[1]



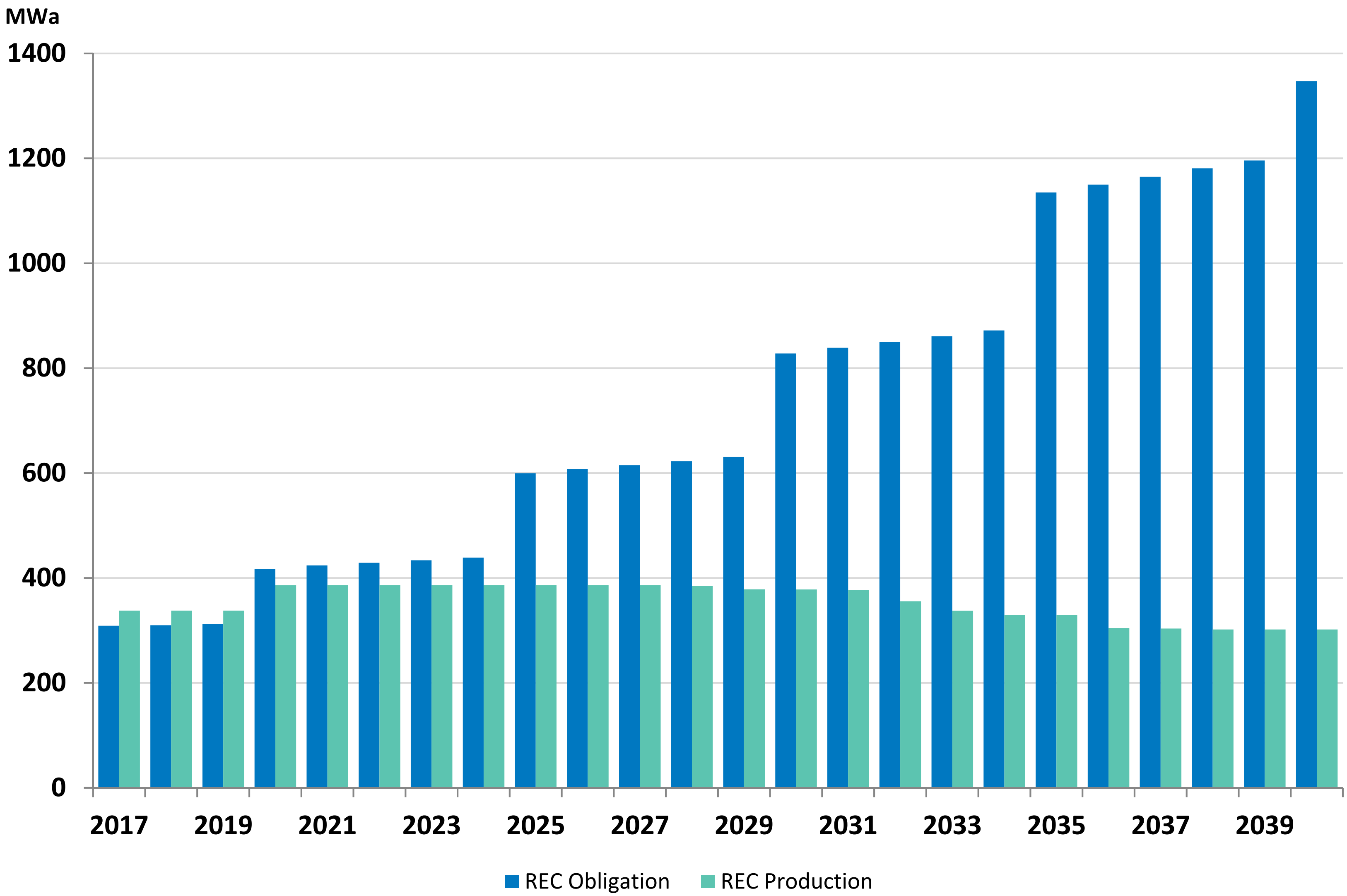




- **Marginal ELCC values decline as incremental 100 MW additions are included in the system**
- **RECAP was used to calculate ELCC values for each IRP portfolio**

[1] ELCC values based on May 31, 2016 snapshot

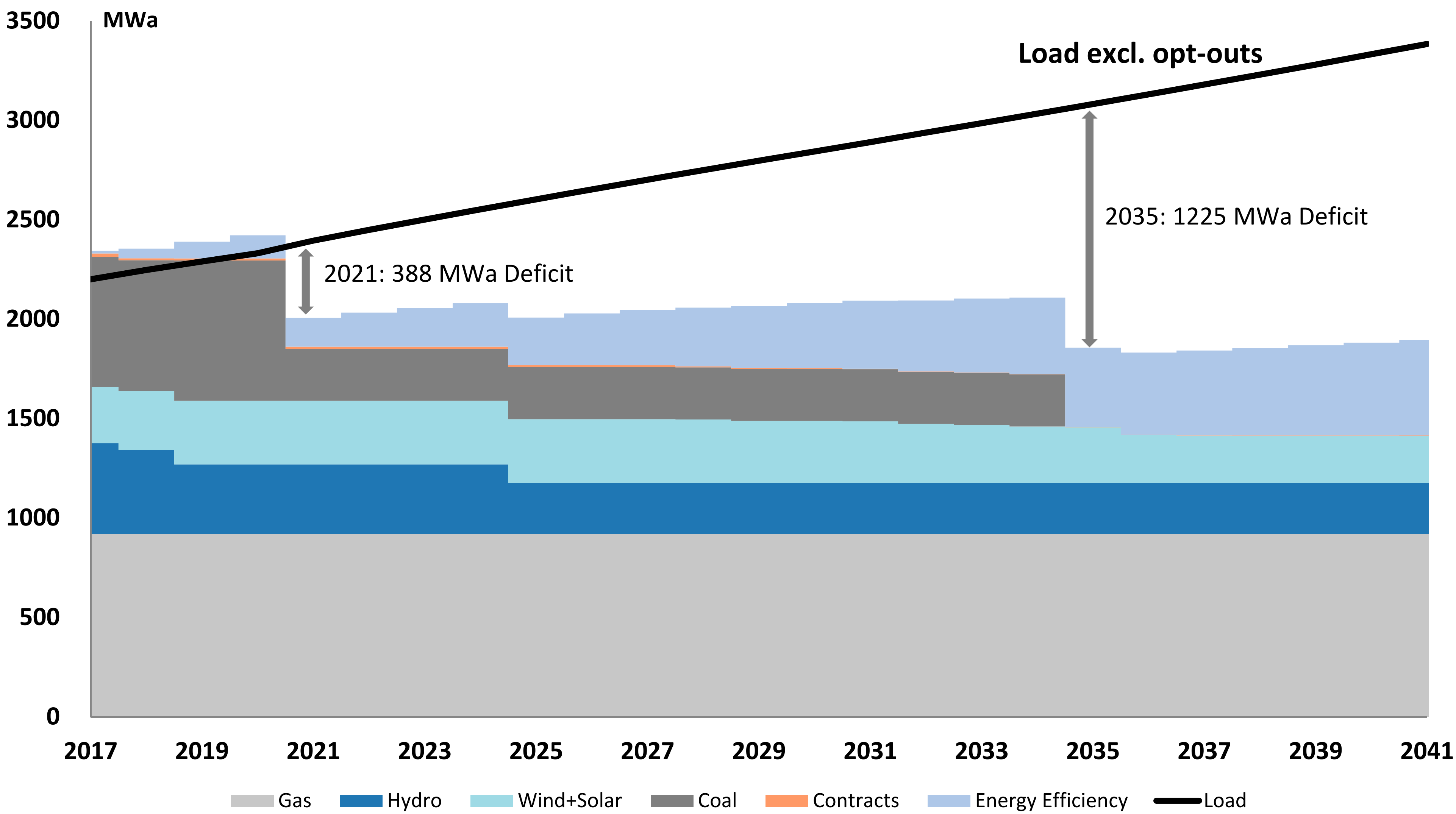
RPS REC Obligation and Production



	2017	2020	2025	2030	2035	2040
RPS Obligation %	15%	20%	27%	35%	45%	50%
PGE REC Obligation, MWa	309	417	600	828	1135	1347
PGE REC Production, MWa	338	386	387	378	330	302

Energy Load-Resource Balance

An energy gap of 388 MWa is expected in 2021, of which a portion may be met with renewable portfolio standard (RPS) compliant resources



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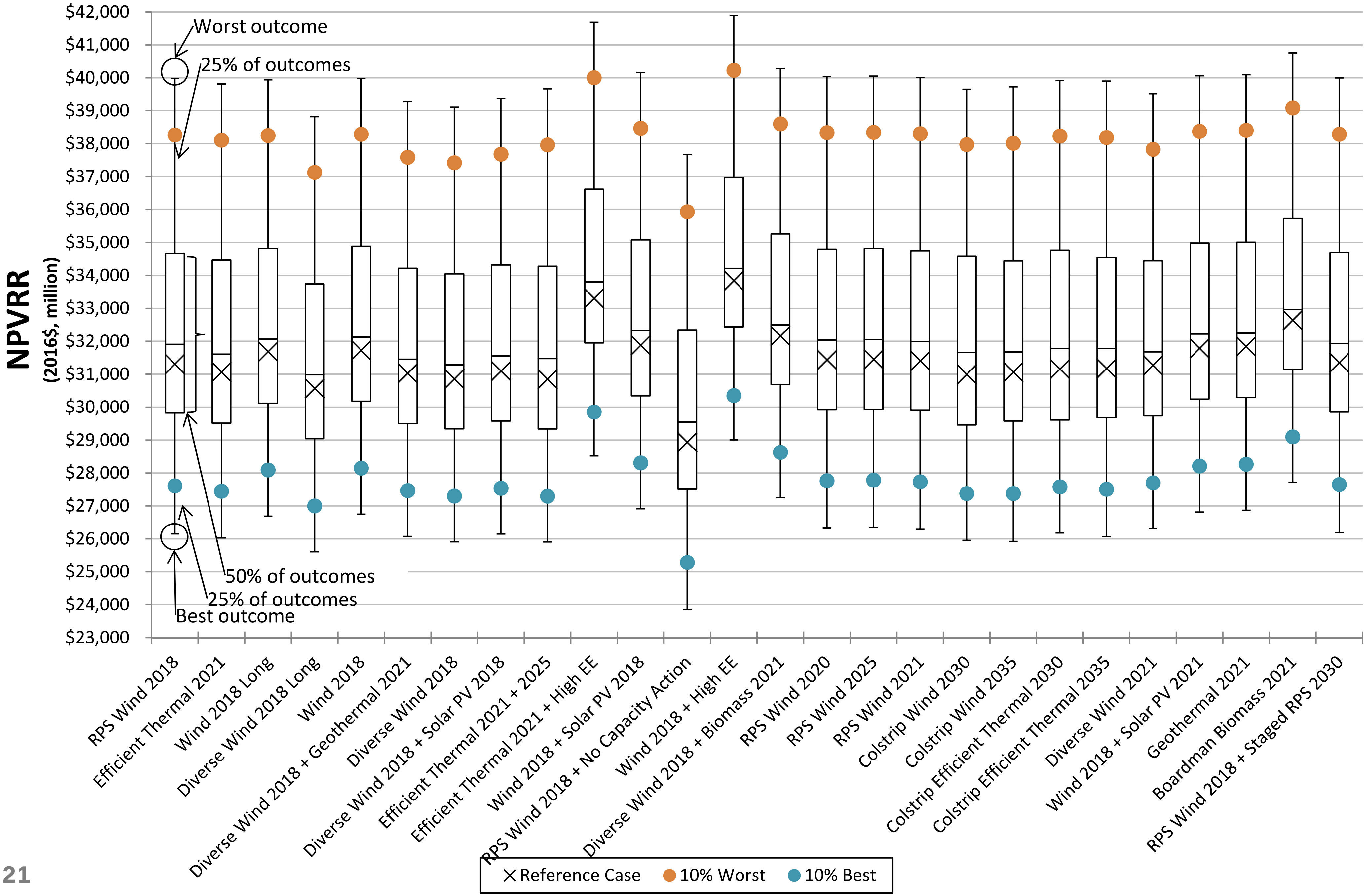
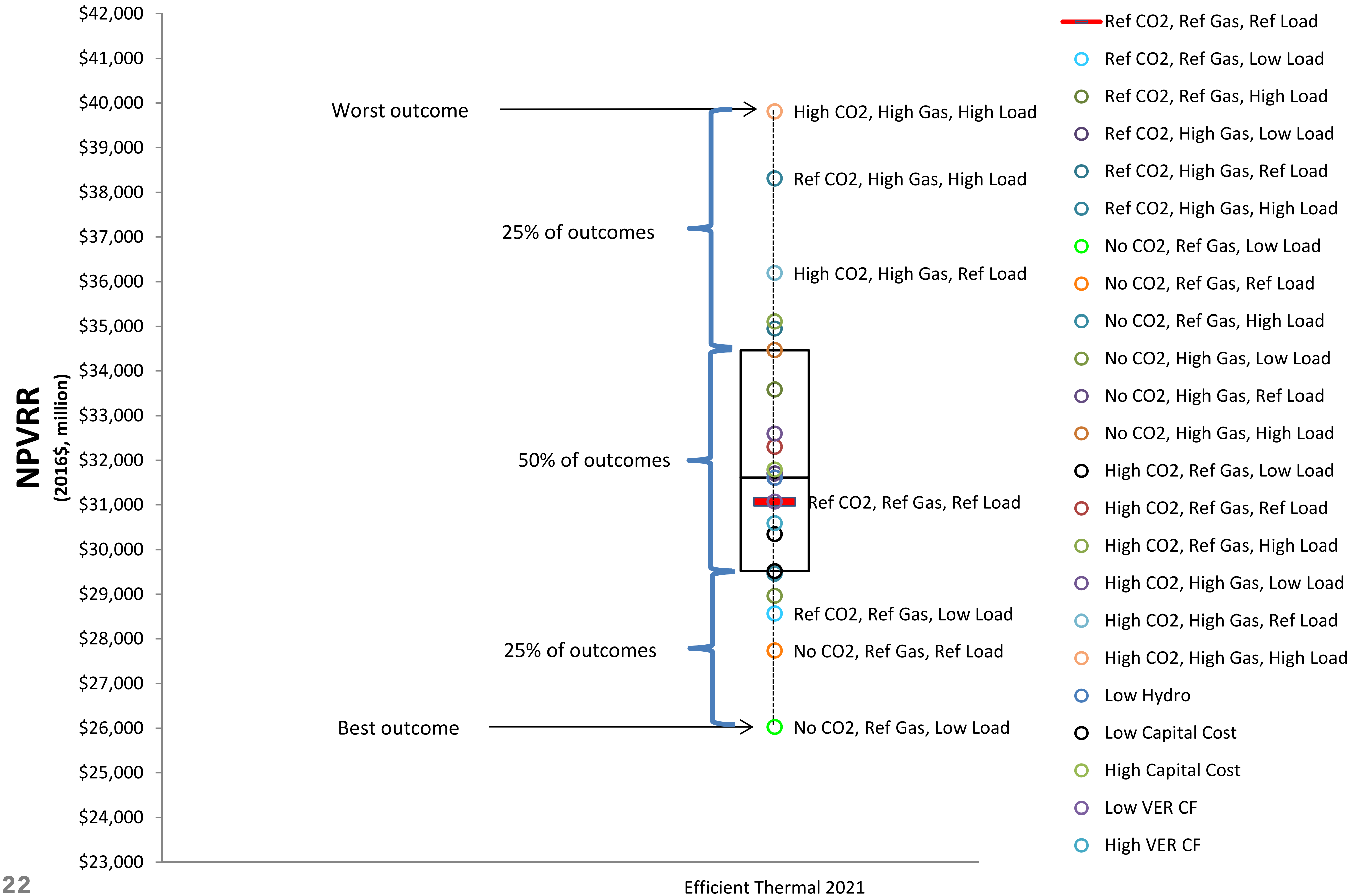
Scoring Metrics/Scoring Results

Draft 2016 IRP Portfolio Analysis Output



Example Distribution of Results



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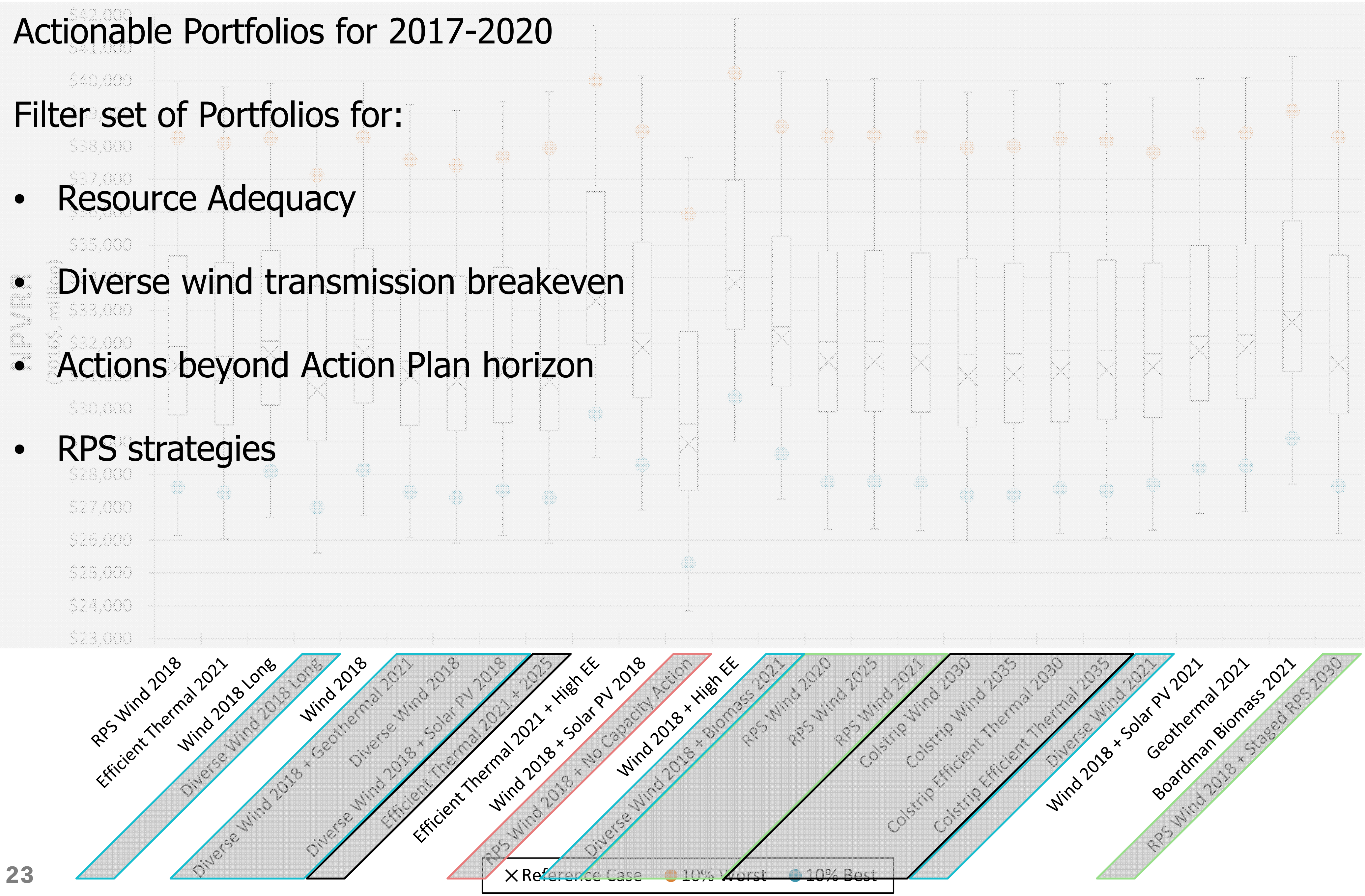
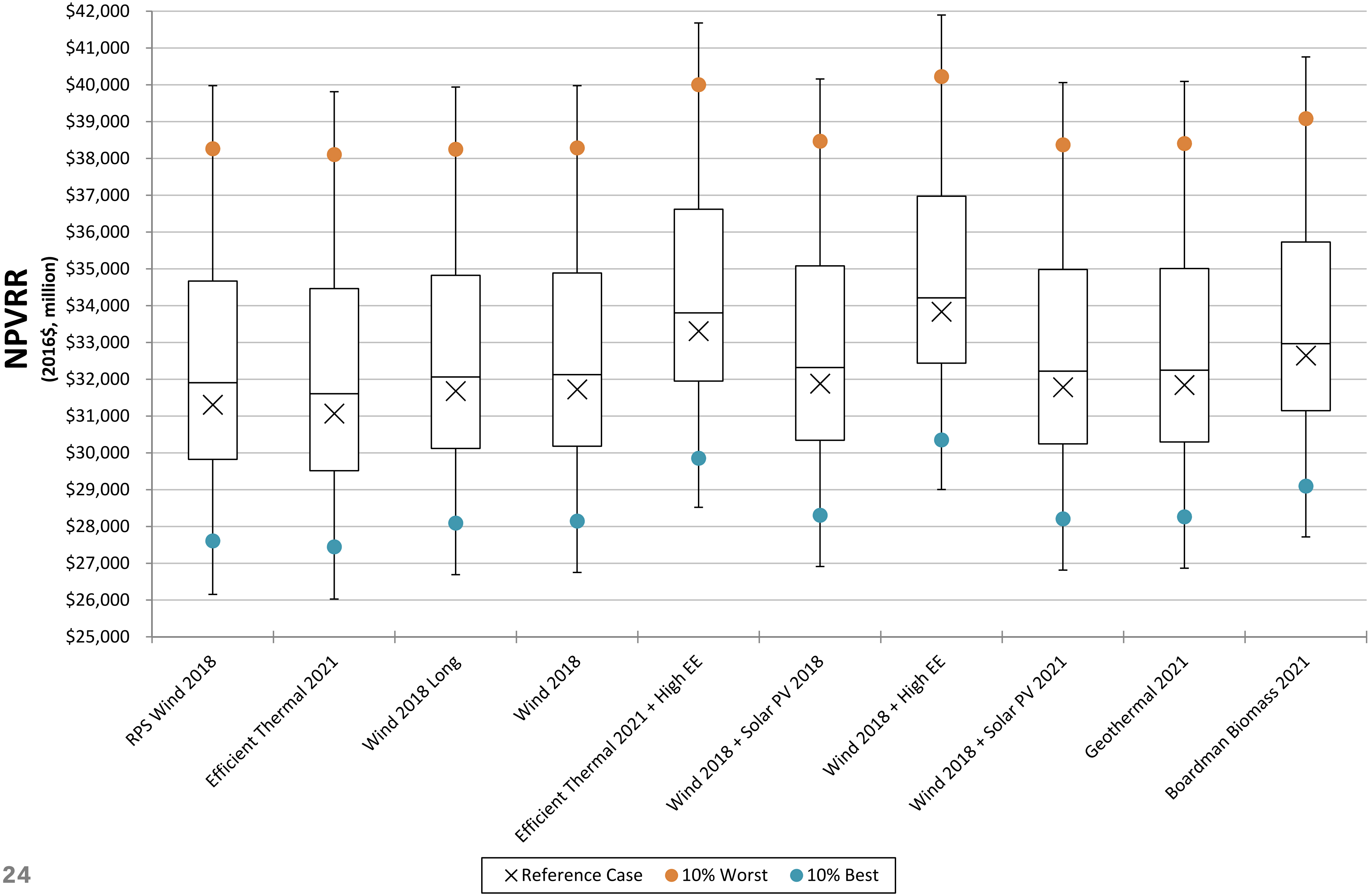
Actionable Portfolios for 2017-2020

Filter set of Portfolios for:

- Resource Adequacy
- Diverse wind transmission breakeven
- Actions beyond Action Plan horizon
- RPS strategies



Action Plan Portfolios (Draft)



Scoring Metrics

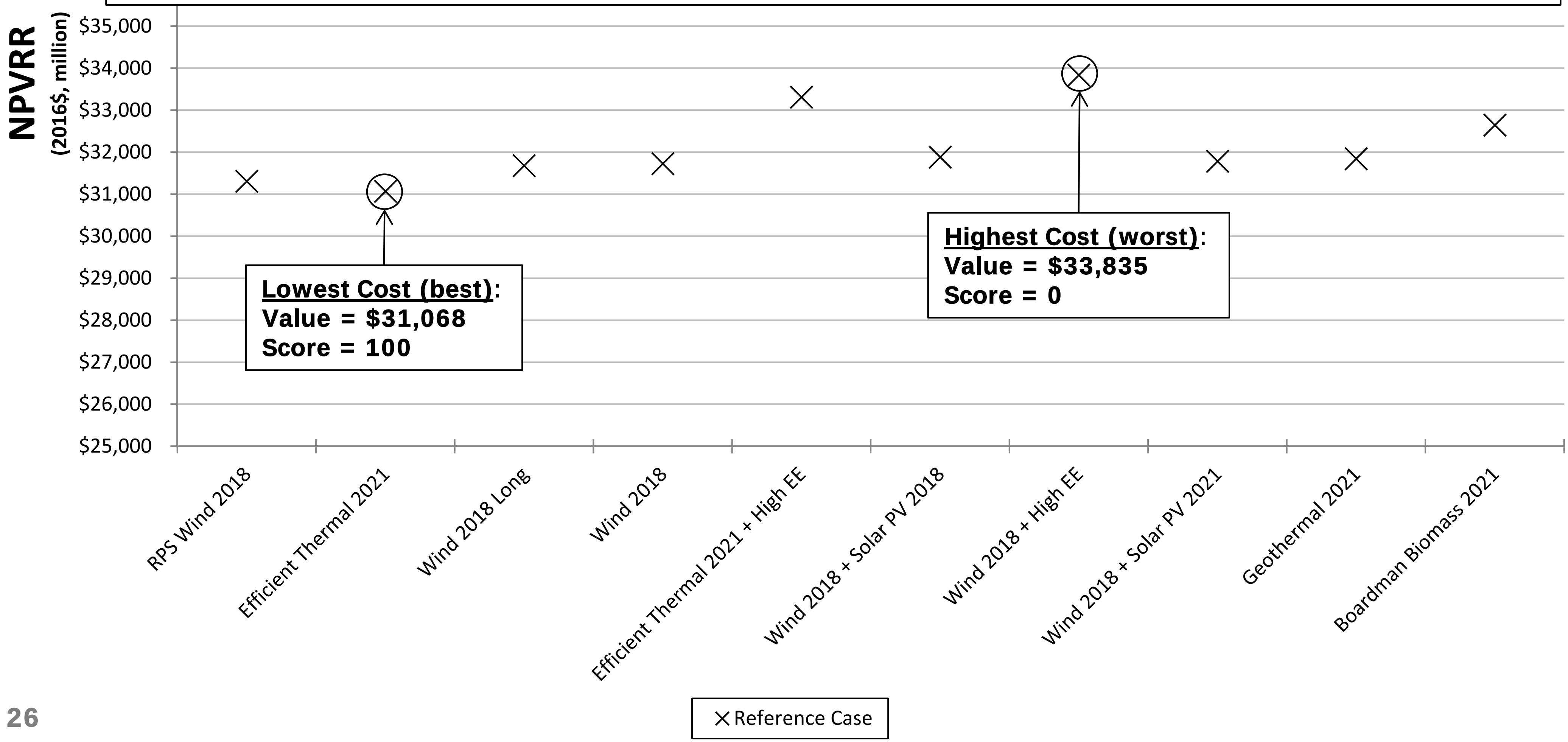
- Cost, Severity, Variability, Future Durability, Curtailment metrics calculated for each Portfolio
- Normalized score 0–100 (worst to best) is determined for each Portfolio under each metric based on Portfolio's performance relative to best result
  - Portfolio Scoring results are relative; the specific Portfolios included may change the results
- Metrics are weighted:
  - 50% to Cost
  - 5% Curtailment
  - 15% to each of Severity, Variability, Future Durability
- Weighted average score leads to final Portfolio ranking

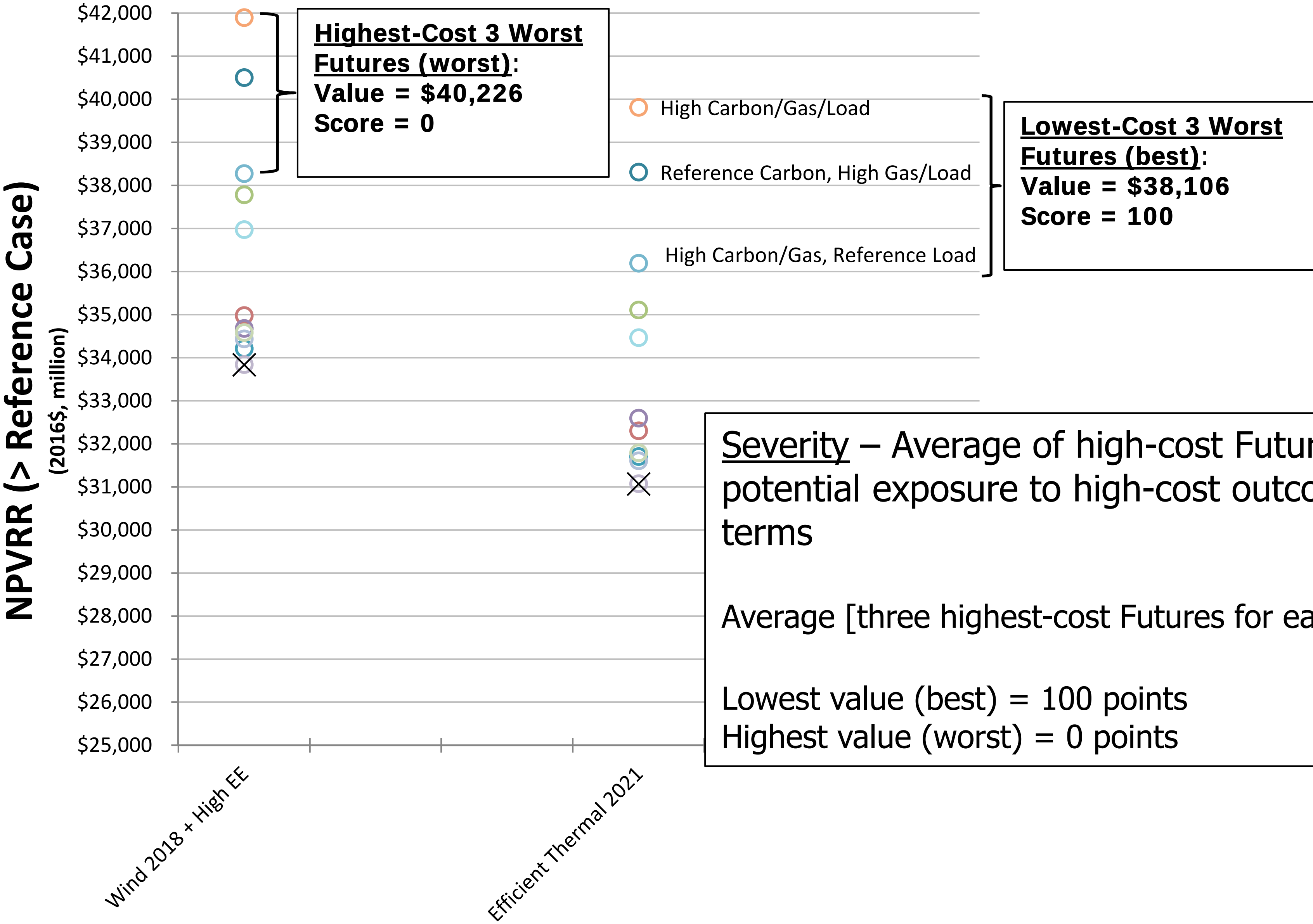
Scoring Metrics: Cost

Cost – Net Present Value of Revenue Requirements (NPVRR)

Annually, 2017-2050: [Resource Fixed Cost + Resource Variable Costs + (Purchases – Sales)]
Present Value at PGE cost of capital

Lowest value (best) = 100 points
Highest value (worst) = 0 points



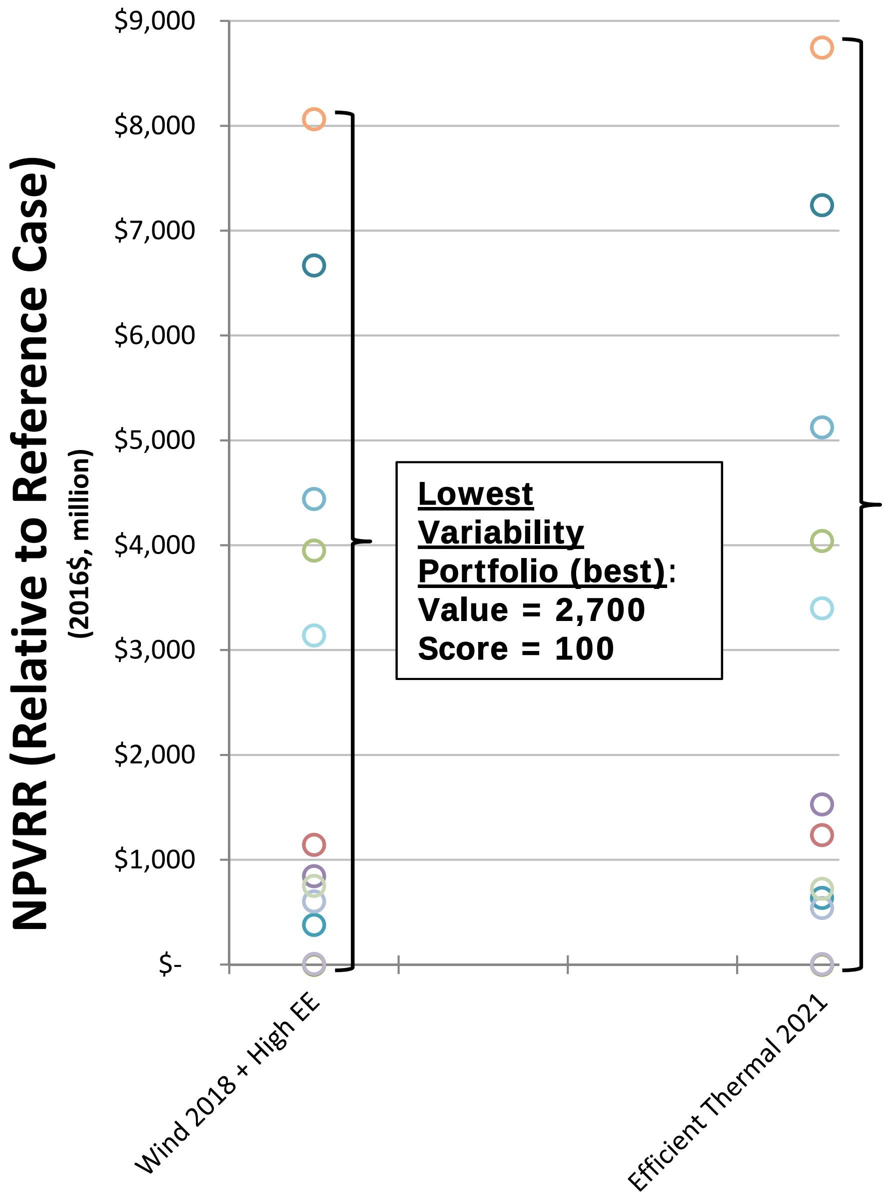


Severity – Average of high-cost Futures (NPVRR); potential exposure to high-cost outcomes in absolute terms

Average [three highest-cost Futures for each Portfolio]

Lowest value (best) = 100 points
Highest value (worst) = 0 points

Scoring Metrics: Variability



Lowest Variability Portfolio (best):
Value = 2,700
Score = 100

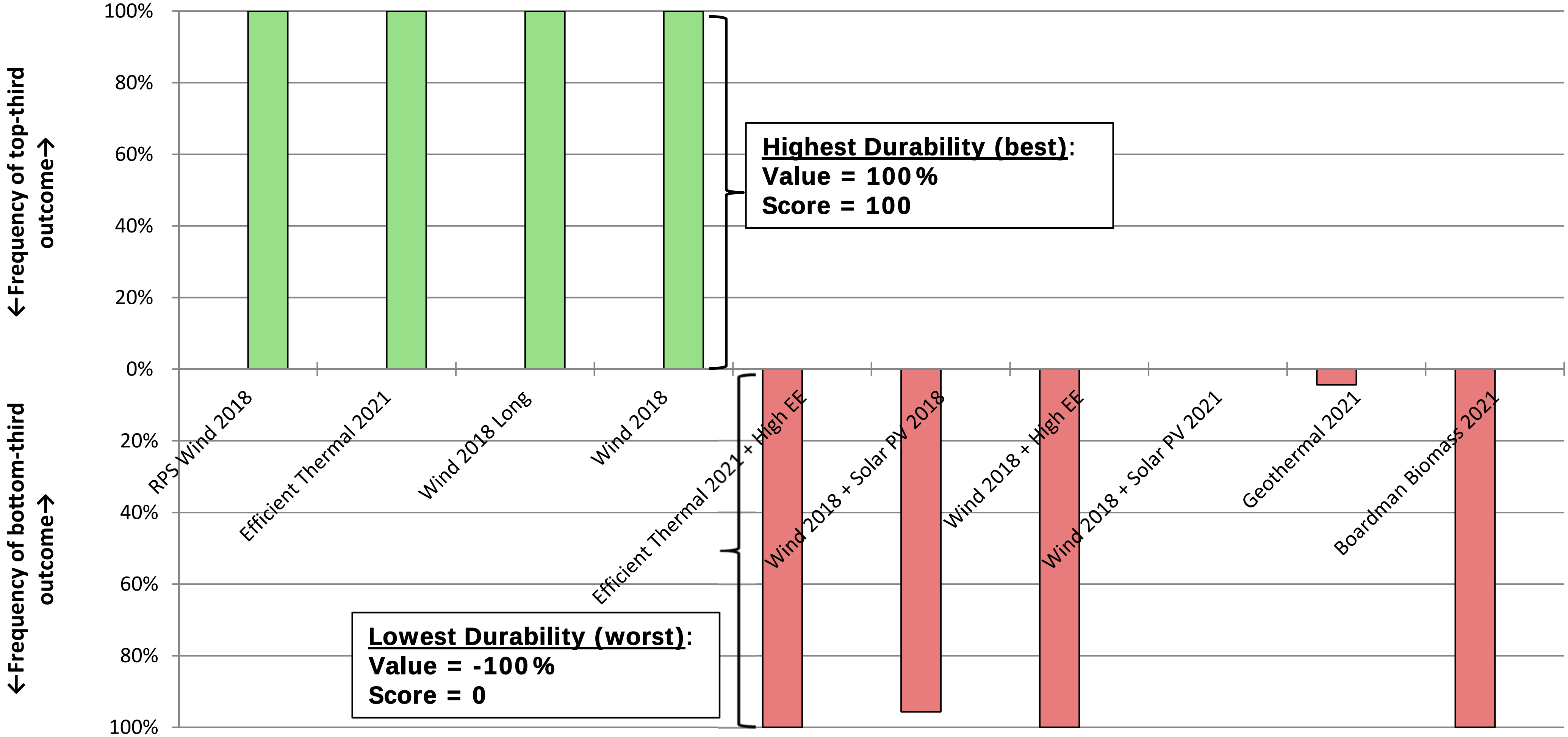
Highest Variability Portfolio (worst):
Value = 2,957
Score = 0

Variability – Dispersion of Futures, NPVRR > Reference Case

Square root [average sum of squared diffs. from Reference Case, where diff. > zero]

Lowest value (best) = 100 points
Highest value (worst) = 0 points

Scoring Metrics: Future Durability



Durability – frequency of top- or bottom-third ranking of each Portfolio across Futures

Rank Portfolios in each Future; Count [# of times Portfolio is in top- or bottom-third],
Divide by # Futures, [Frequency top less frequency bottom]

Highest value (best) = 100 points
Lowest value (worst) = 0 points

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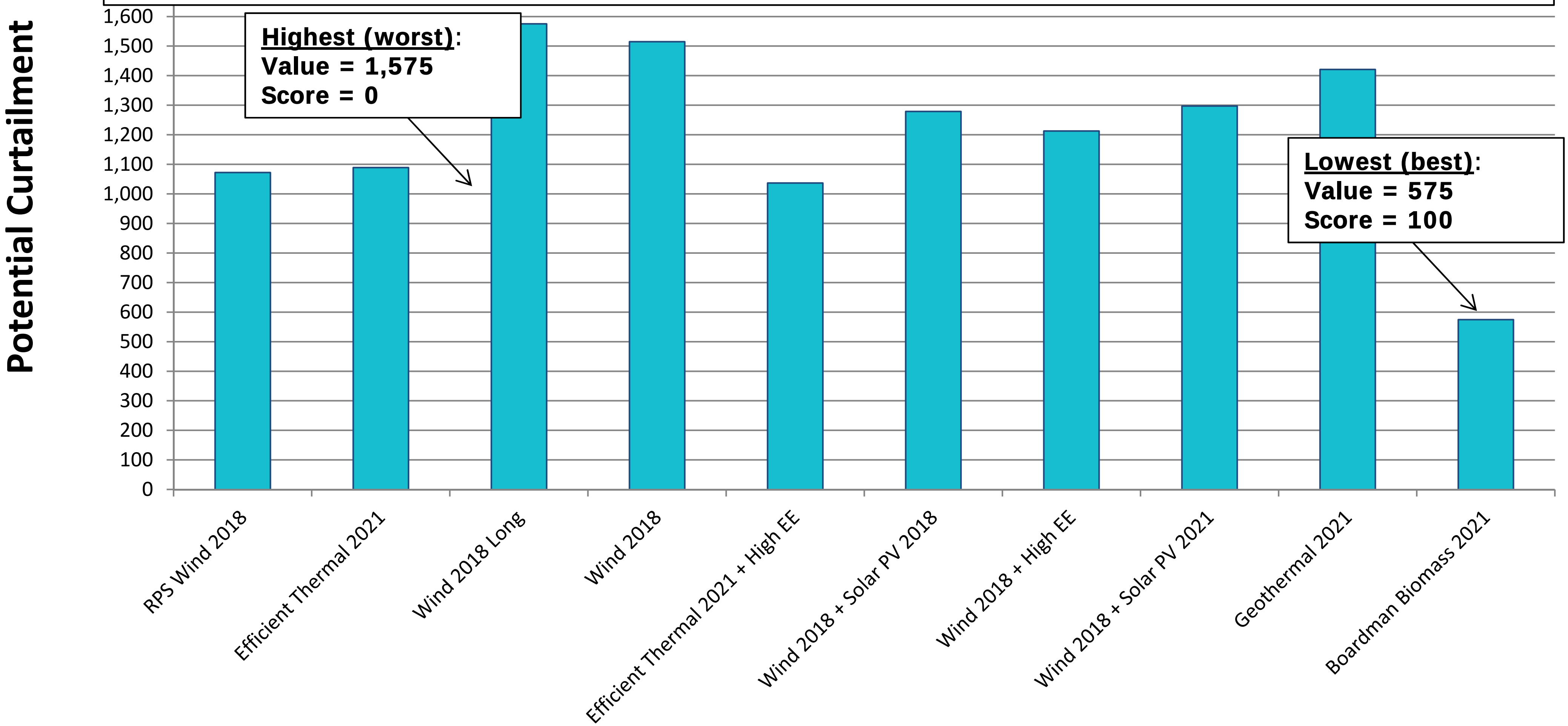
Potential Curtailment – Discounted future potential curtailment of resource mix

REFLEX study-based approximation of potential renewable curtailment

Lowest value (best) = 100 points
Highest value (worst) = 0 points



...Apply Scoring Metrics

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DRAFT

Weights	50%	15%	15%	15%	5%	Score					Rank					Score	Rank
Portfolio Name	Cost	Severity	Variability	Future Durability	Curtailment	Cost	Severity	Variability	Future Durability	Curtailment	Cost	Severity	Variability	Future Durability	Curtailment	Total Wtd	Total Wtd
RPS Wind 2018	31,307	38,263	2,929	100%	1,073	91	93	11	100	50	2	3	9	1	3	79	**3**
Efficient Thermal 2021	31,068	38,106	2,957	100%	1,089	100	100	0	100	49	1	1	10	1	4	82	**1**
Wind 2018 Long	31,680	38,249	2,770	100%	1,575	78	93	73	100	0	3	2	5	1	10	79	**2**
Wind 2018	31,726	38,287	2,768	100%	1,515	76	91	74	100	6	4	4	3	1	9	78	**4**
Efficient Thermal 2021 + High EE	33,308	40,002	2,817	(100%)	1,037	19	11	54	0	54	9	9	8	8	2	22	**9**
Wind 2018 + Solar PV 2018	31,880	38,469	2,779	(96%)	1,279	71	83	69	2	30	7	7	6	7	6	60	**7**
Wind 2018 + High EE	33,835	40,226	2,700	(100%)	1,213	0	0	100	0	36	10	10	1	8	5	17	**10**
Wind 2018 + Solar PV 2021	31,782	38,371	2,780	0%	1,298	74	87	69	50	28	5	5	7	5	7	69	**5**
Geothermal 2021	31,842	38,404	2,769	(4%)	1,421	72	86	73	48	15	6	6	4	6	8	68	**6**
Boardman Biomass 2021	32,644	39,080	2,713	(100%)	575	43	54	95	0	100	8	8	2	8	1	49	**8**

- Calculate values for each metric
- Normalize scores 0–100 (worst to best) for each metric
- Weight scores:
  - 50% to Cost
  - 5% Curtailment
  - 15% to each of Severity, Variability, Future Durability
- Weighted average score leads to final Portfolio ranking
  - Top-ranked Portfolio = Preferred Portfolio

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Preferred Portfolio

Draft 2016 IRP Preferred Portfolio

- Based on portfolio analysis and scoring, Preferred Portfolio: "Efficient Thermal 2021"
- Resource strategy comprises:
    - Capacity adequacy
    - Efficient dispatchable resource (i.e., flexible, low heat rate) addition in 2021 in lieu of low fixed cost, low efficiency
    - Renewables capturing greatest amount of PTC in 2018 (assuming no long-term Unbundled market)
- This strategy represents the lowest cost, while balancing the identified risks
- Additional analysis will determine extent to which potential acquisition of Unbundled RECs could reduce or defer the need for incremental Bundled RECs (beyond 2025)

Capacity Heat Map for 2021

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A portion of PGE's capacity need may be suited to seasonal products

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
5	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
6	0.13	0.11	0.05	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.13	0.28
7	0.47	0.37	0.32	0.04	0.00	0.00	0.01	0.02	0.03	0.09	0.54	1.13
8	1.88	1.01	0.68	0.09	0.00	0.00	0.03	0.10	0.10	0.16	1.17	2.48
9	3.20	1.73	0.77	0.05	0.01	0.01	0.13	0.39	0.12	0.13	2.12	3.97
10	2.55	1.16	0.53	0.04	0.01	0.04	0.38	0.83	0.17	0.07	1.72	3.60
11	1.88	0.80	0.34	0.02	0.02	0.09	0.81	1.52	0.23	0.05	1.27	2.89
12	1.58	0.51	0.17	0.01	0.03	0.18	1.35	2.33	0.36	0.04	0.99	2.41
13	1.46	0.31	0.09	0.01	0.06	0.33	2.10	3.36	0.53	0.03	0.86	1.79
14	1.19	0.16	0.05	0.00	0.08	0.50	3.08	4.57	0.82	0.02	0.72	1.34
15	0.91	0.13	0.04	0.00	0.11	0.66	3.91	5.57	1.22	0.03	0.62	1.05
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21	3.55	1.23	0.40	0.02	0.06	0.19	1.75	3.75	1.42	0.14	3.01	4.63
22	2.01	0.65	0.12	0.01	0.02	0.07	0.72	2.01	0.38	0.02	1.62	2.60
23	1.08	0.33	0.02	0.00	0.00	0.01	0.03	0.22	0.01	0.00	0.54	1.27
24	0.16	0.04	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.08	0.22

More Adequate — Less Adequate

Less Need — More Need

Resources included

- Existing portfolio
- QFs executed as of 5/31/2016
- Target EE, DR, DSG
- Spot Market 200 MW (excluding Summer On-peak)
- No Boardman coal
- No new RPS or capacity resources

Loss of Load Expectation (per year)

- 253 hours (in 2021)
- Target ≤ 2.4 hours

2021 LOLE = 253 hours per year

Seasonal Capacity Products

A portion of the capacity need may be met by seasonal products

- The optimal blend of seasonal and annual products will depend on several factors, including capacity needs, flexibility needs, fixed costs, and variable costs/benefits
- RECAP was used to estimate example seasonal product[1] capacity contributions (ELCC values) and residual annual need[2] for 2021; assumes 175 MWa PNW Wind acquired
- Seasonal product capacity contributions decline as quantities increase
  (seasonal products alone unlikely to achieve resource adequacy)

ELCC of Seasonal Products (MW)

Winter \ Summer	0	100	200	300	400	500	600	700	800	900	1000
0	0	65	112	140	155	161	164	165	165	166	166
100	17	93	151	190	212	222	227	229	230	230	230
200	24	108	174	221	250	265	271	274	275	276	276
300	28	114	186	239	272	291	299	303	304	305	305
400	29	117	191	247	284	304	314	318	320	321	321
500	29	118	193	250	289	310	321	326	327	328	328
600	30	119	194	252	291	313	324	328	330	331	331
700	30	119	194	252	291	314	325	330	331	332	332
800	30	119	194	252	292	314	325	330	332	333	333
900	30	119	194	252	291	314	325	330	332	333	333
1000	30	119	194	252	292	314	325	330	332	333	333

Residual Annual Need (MW)

Winter \ Summer	0	100	200	300	400	500	600	700	800	900	1000
0	760	695	648	620	606	599	596	595	595	595	595
100	744	667	610	570	549	538	533	531	530	530	531
200	736	653	586	539	510	495	489	486	485	484	484
300	732	646	574	521	488	469	461	458	456	455	455
400	731	643	569	514	476	456	446	442	440	439	439
500	731	642	567	510	471	450	439	435	433	432	432
600	730	641	567	508	470	447	436	432	430	429	429
700	730	641	566	508	469	447	436	430	429	428	428
800	731	641	566	508	469	446	435	431	429	428	427
900	731	641	566	508	469	446	435	430	428	427	427
1000	730	642	566	508	469	446	435	430	428	427	428

[1] Seasonal products modeled as available On-peak hours, Jul-Sep, Dec-Feb
[2] Capacity need after addition of EE, DR, DSG, Spot Market, and 175 MWa PNW Wind to portfolio

Seasonal Price Scenario Example

Scenarios examine relative costs for a range of annual / seasonal combinations that achieve the same reliability target

Price Scenario Example (25%)

1. To simplify values, set annual resource cost for 760 MW (no seasonal products) equal to \$100M/yr, (~\$11/kW-mo)

2. Set seasonal product[1] monthly cost to 25% of annual resource monthly cost, ~\$2.7/kW-mo

3. For each combination of seasonal/annual, calculate total \$M/yr to achieve reliability target:

Winter \ Summer	0	100	200	300	400	500	600	700	800	900	1000
0	100	92	87	84	83	83	83	84	85	86	86
100	99	89	83	78	76	76	76	76	77	78	79
200	98	88	80	75	72	71	71	71	72	73	74
300	99	88	80	74	70	68	68	68	69	70	71
400	99	89	80	73	69	67	67	67	68	68	69
500	100	89	80	74	69	67	67	67	68	68	69
600	101	90	81	74	70	68	67	68	68	69	70
700	102	91	82	75	71	69	68	68	69	69	70
800	103	92	83	76	72	69	69	69	70	70	71
900	103	93	84	77	72	70	70	70	70	71	72
1000	104	93	84	78	73	71	70	71	71	72	73

[1] Seasonal products modeled Jul-Sep, Dec-Feb

Seasonal Capacity Products – Price Scenarios

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Optimal seasonal acquisition depends on pricing relative to annual resources

Scenario 25%

Winter \ Summer	0	100	200	300	400	500	600	700	800	900	1000
0	100	92	87	84	83	83	83	84	85	86	86
100	99	89	83	78	76	76	76	76	77	78	79
200	98	88	80	75	72	71	71	71	72	73	74
300	99	88	80	74	70	68	68	68	69	70	71
400	99	89	80	73	69	67	67	67	68	68	69
500	100	89	80	74	69	67	67	67	68	68	69
600	101	90	81	74	70	68	67	68	68	69	70
700	102	91	82	75	71	69	68	68	69	69	70
800	103	92	83	76	72	69	69	69	70	70	71
900	103	93	84	77	72	70	70	70	70	71	72
1000	104	93	84	78	73	71	70	71	71	72	73

Scenario 50%

Winter \ Summer	0	100	200	300	400	500	600	700	800	900	1000
0	100	93	89	86	86	87	88	90	91	93	95
100	99	91	85	82	80	81	82	83	85	86	88
200	100	91	84	79	77	77	77	79	80	82	83
300	101	92	84	78	76	75	75	77	78	80	81
400	103	93	85	79	76	75	75	76	78	79	81
500	104	94	86	80	77	76	76	77	78	80	82
600	106	96	88	82	78	77	77	78	80	81	83
700	108	98	89	83	80	78	79	80	81	83	84
800	109	99	91	85	81	80	80	81	83	84	86
900	111	101	93	87	83	82	82	83	84	86	87
1000	113	102	94	88	85	83	84	85	86	87	89

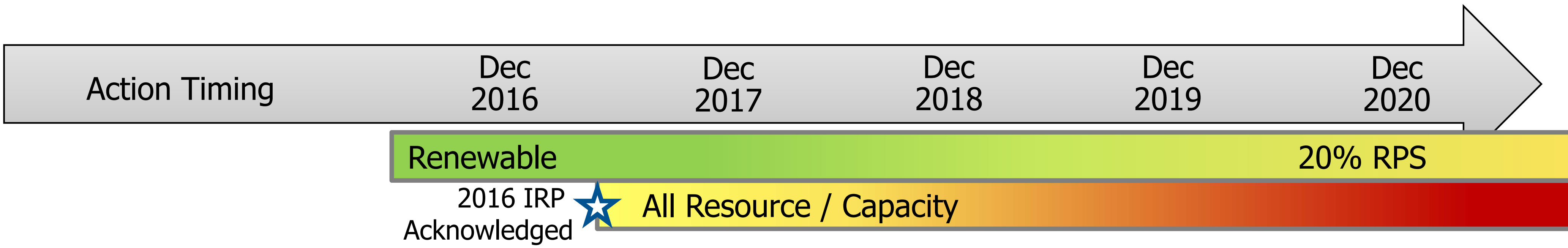
Scenario 100%

Winter \ Summer	0	100	200	300	400	500	600	700	800	900	1000
0	100	95	92	91	93	95	98	101	105	108	111
100	101	94	90	88	89	90	93	96	99	103	106
200	103	96	90	87	87	88	91	93	97	100	103
300	106	98	92	88	87	88	90	93	96	99	103
400	109	101	95	91	89	90	92	94	97	101	104
500	113	104	98	93	92	92	94	97	100	103	106
600	116	107	101	96	95	95	97	100	103	106	109
700	119	111	104	100	98	98	100	103	106	109	112
800	122	114	107	103	101	101	103	106	109	112	115
900	126	117	111	106	104	105	107	109	112	115	119
1000	129	121	114	110	108	108	110	112	115	119	122

Scenario 200%

Winter \ Summer	0	100	200	300	400	500	600	700	800	900	1000
0	100	98	98	101	106	112	118	124	131	137	144
100	104	101	100	101	105	110	116	123	129	136	142
200	110	106	103	104	107	111	117	123	130	136	143
300	116	111	108	108	110	114	120	126	132	139	145
400	123	117	114	114	115	119	124	130	137	143	150
500	129	124	121	120	121	125	130	136	142	149	155
600	136	130	127	126	128	131	136	142	149	155	162
700	142	137	134	133	134	138	143	149	155	162	168
800	149	144	140	139	141	144	149	155	162	168	175
900	155	150	147	146	147	151	156	162	168	175	181
1000	162	157	153	152	154	157	162	168	175	181	188

Draft Responsive Action Plan[1]



Supply-side

▪ Renewable[2]	0-175	MWa
▪ Capacity	800-850	MW
▪ Annual	400-850	MW (dispatchable)
▪ Seasonal	0-600	MW (summer)
▪ Seasonal	0-500	MW (winter)
▪ DSG[3]	20	MW
▪ Hydro Contracts:	Renew if cost-effective	

Demand-side

▪ Energy Efficiency	135 MWa / 176 MW (ETO Ongoing)
▪ Demand Response	77 MW / 69 MW (winter/summer)
▪ CVR[4]	1 MWa / 1 MW

1. All values approximate; incremental resources
2. Includes bundled RPS compliant resources only. Unbundled resources to be determined by RFP.
3. DSG: Dispatchable Standby Generation
4. CVR: Conservation Voltage Reduction

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Preliminary Energy Storage Evaluation

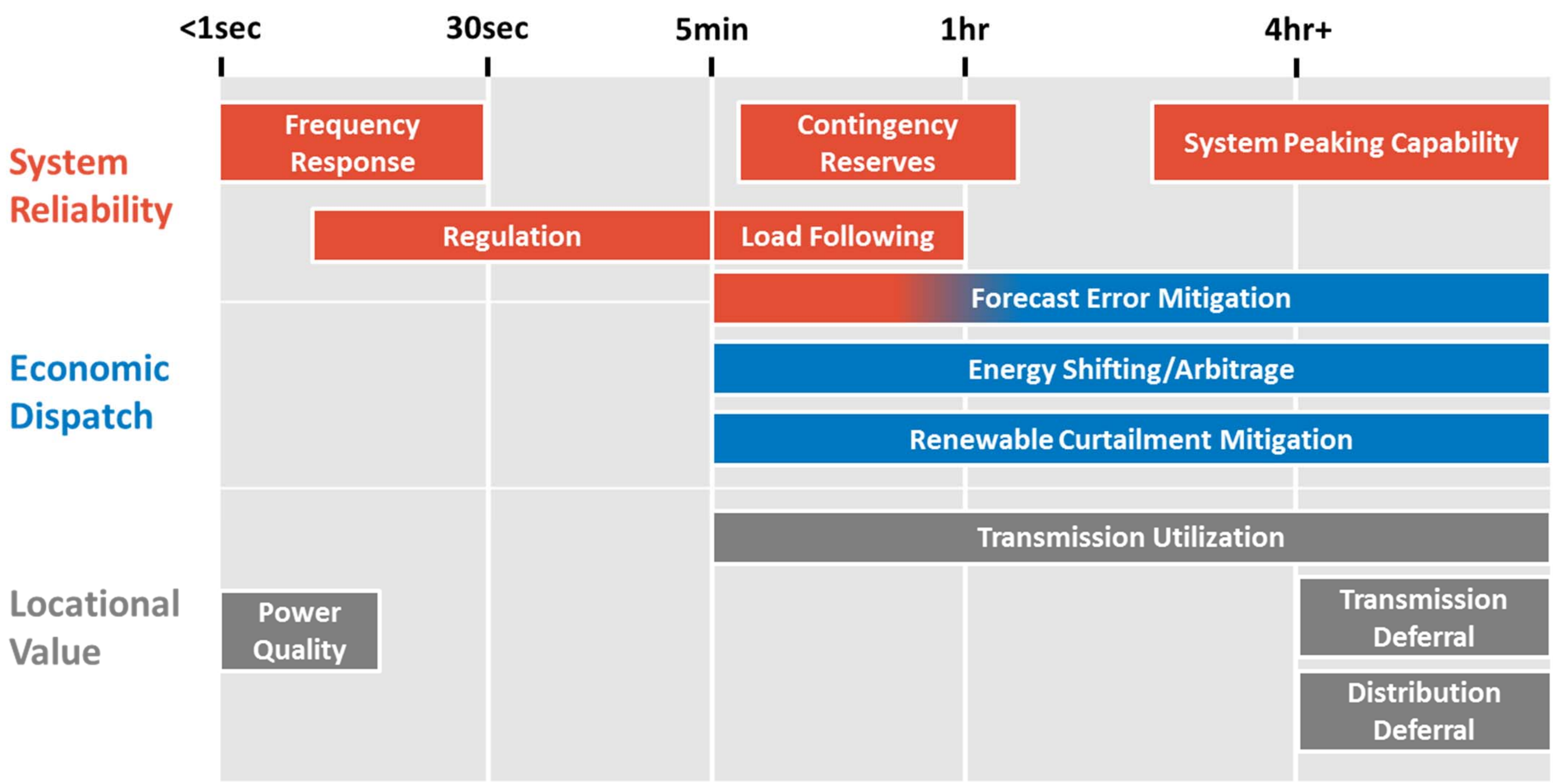
Energy storage evaluation

With increasing renewable penetration, dropping technology costs, and new market paradigms in the West, energy storage economic evaluation is gaining importance in long term planning exercises.

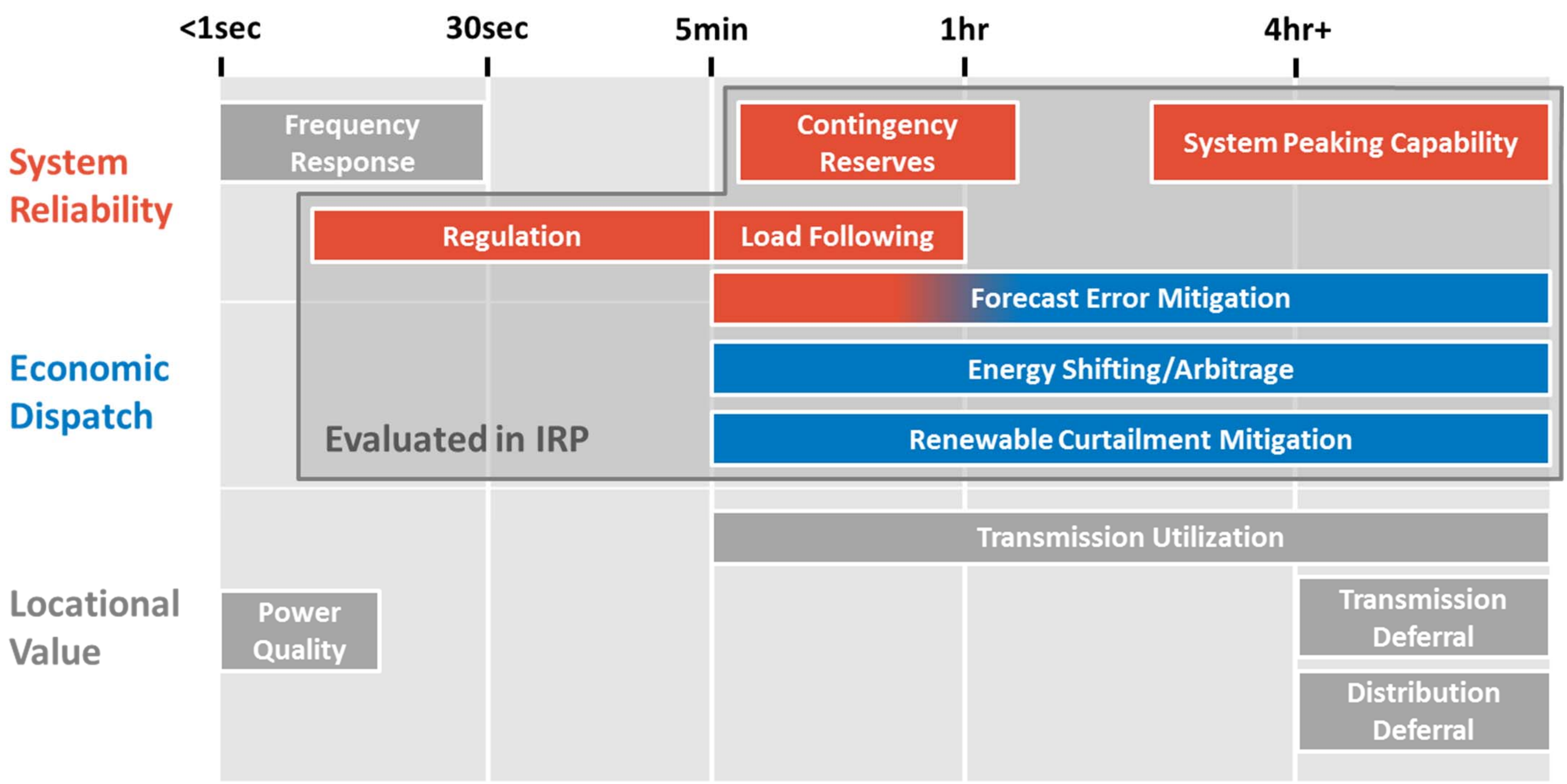
This discussion will cover:

- Energy storage value streams under consideration in PGE's 2016 IRP
- Evaluation methodology – Energy Storage Dispatch
    - Resource Optimization Model (ROM)
    - Test portfolio dispatch behavior
    - Energy shifting versus ancillary services
    - Operational cost impacts
- Evaluation methodology – System Peaking Capability
    - Economic comparison to default capacity resource
    - Capacity value approach
- Preliminary economic evaluation
- Additional considerations and next steps

Primary energy storage value streams identified by PGE



Energy storage value streams evaluated on a preliminary basis in 2016 IRP



Preliminary Evaluation Methodology

Methodology under ongoing development

- IRP will include preliminary evaluation of energy storage with the goals of identifying promising value streams and establishing a framework for evaluating energy storage in future resource procurement decisions
  - Sets the stage for HB2193/UM1751 evaluation methodology
- PGE looks forward to improving and refining methodology through stakeholder engagement

Evaluation approach

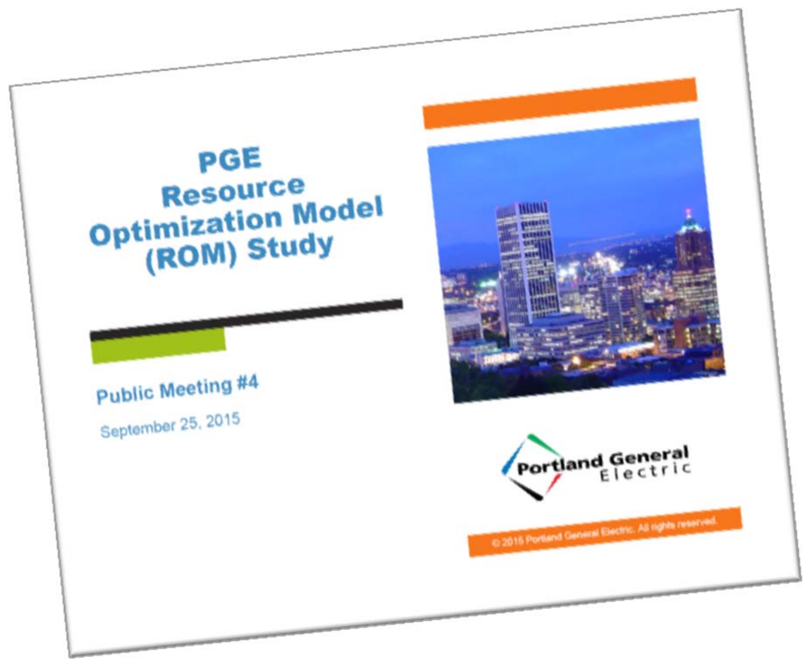
- Operational value
  - PGE will rely on the Resource Optimization Model (ROM) to simulate the optimal dispatch of an energy storage device within the PGE resource portfolio
  - ROM optimizes value associated with both energy shifting and providing ancillary services
- System peaking capability
  - Economic comparison to the default capacity resource (Frame CT) is used to incorporate the capacity value of the storage device
- Locational value
  - Will depend on individual storage system, not evaluated within IRP, but PGE is working to quantify this value for specific locations on the grid

Resource Optimization Model (ROM)

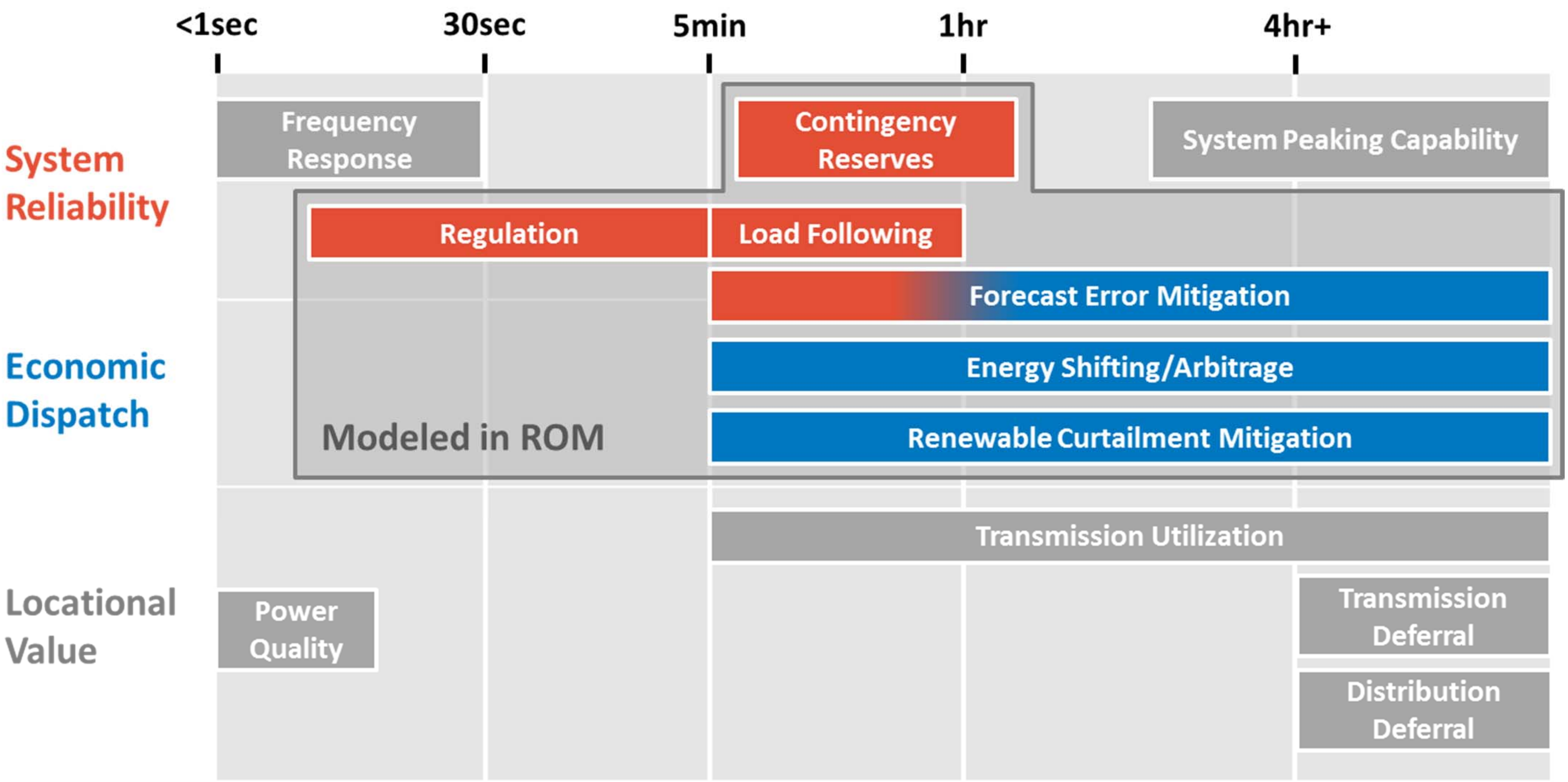
Background

- ROM was originally built by PGE to calculate the wind integration cost adder
- ROM solves for the least cost commitment and dispatch of PGE's resource fleet at a 15-min timestep over the course of a future test year
- ROM captures operational costs associated with renewable integration, resource flexibility, forecast errors, and operating reserve requirements
- Prior enhancements to ROM have been made on a rolling basis under the advisement of a Technical Review Committee and are documented in the IRP
- Does not incorporate: capital costs, revenue requirement modeling, loss of load expectation analysis (capacity contribution), or locational value – these effects must be captured using other models

For more information about ROM, refer to the September 25, 2015 IRP Public Meeting slides, available on PGE's IRP website



Energy storage value streams quantifiable in ROM



ROM Battery test portfolio

PGE Test Portfolio

- 2021 Scenario developed for the 2016 IRP Integration Cost Adder Study

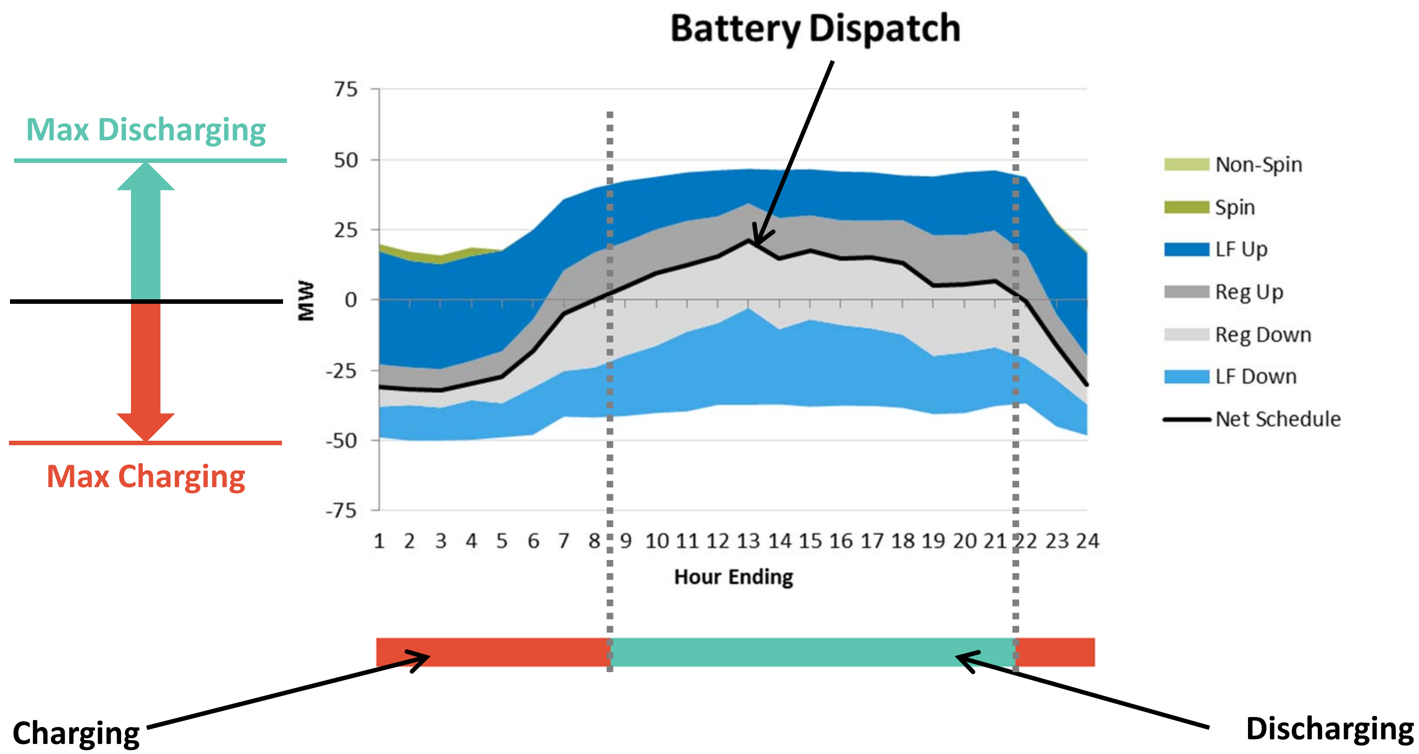
Test battery systems

- Six systems were dispatched in ROM:
    - 50MW 2-hr, 4-hr, and 6-hr batteries
    - 100MW 2-hr, 4-hr, and 6-hr batteries
- Roundtrip efficiency: 81%
- No ramp rate limit
- Able to provide: Regulation, Load following, Spinning, and Non-spinning reserves
- Able to switch from charging to discharging and vice-versa on time scales quick enough to contribute full operating range to meet reserve requirements
- Can dynamically allocate capacity and energy between use cases on a 15-minute basis

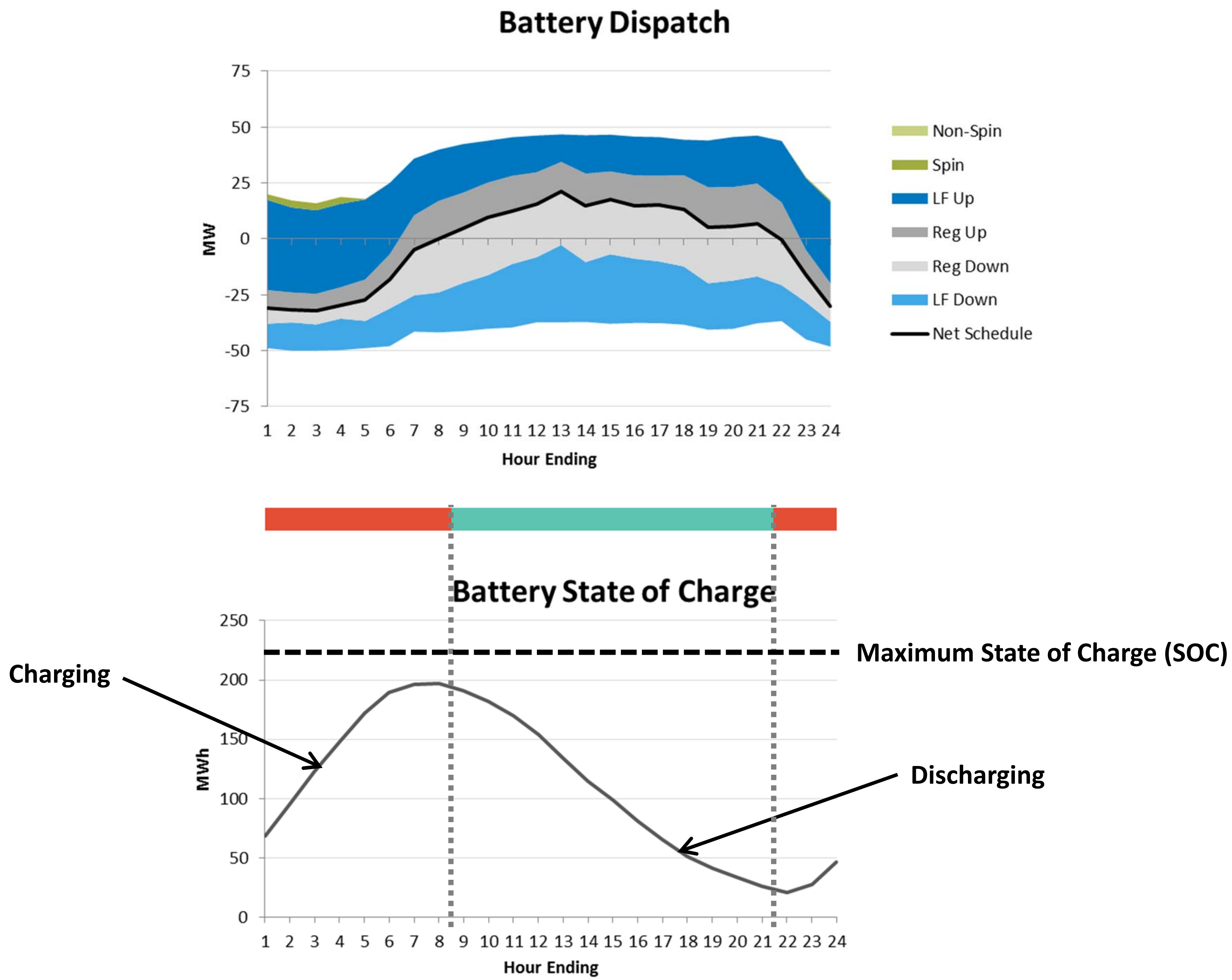
Key caveats

- Preliminary operational analysis is specific to a single year with specific assumptions about renewables, fuel prices, electricity prices, etc.
- Energy storage roundtrip efficiencies will vary by technology
- Electricity prices consistent with 2013 IRP Update

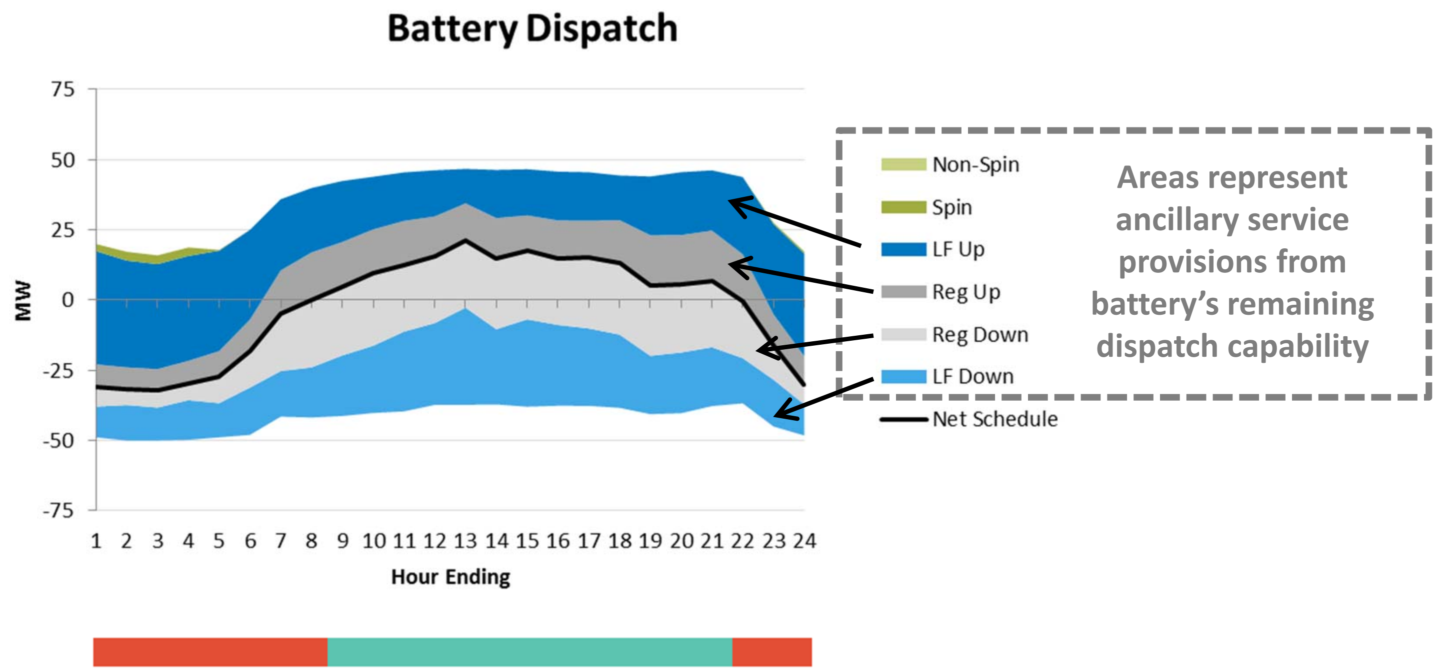
Visualizing Battery Storage Dispatch

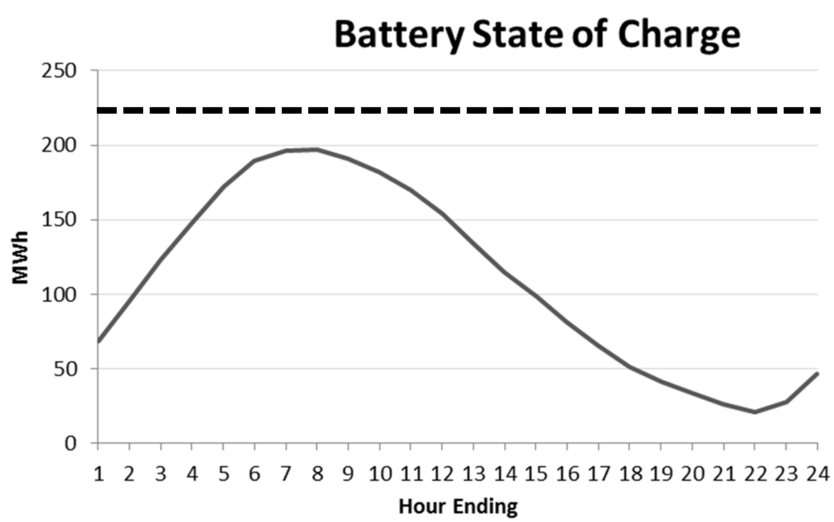


Visualizing Battery Storage Dispatch

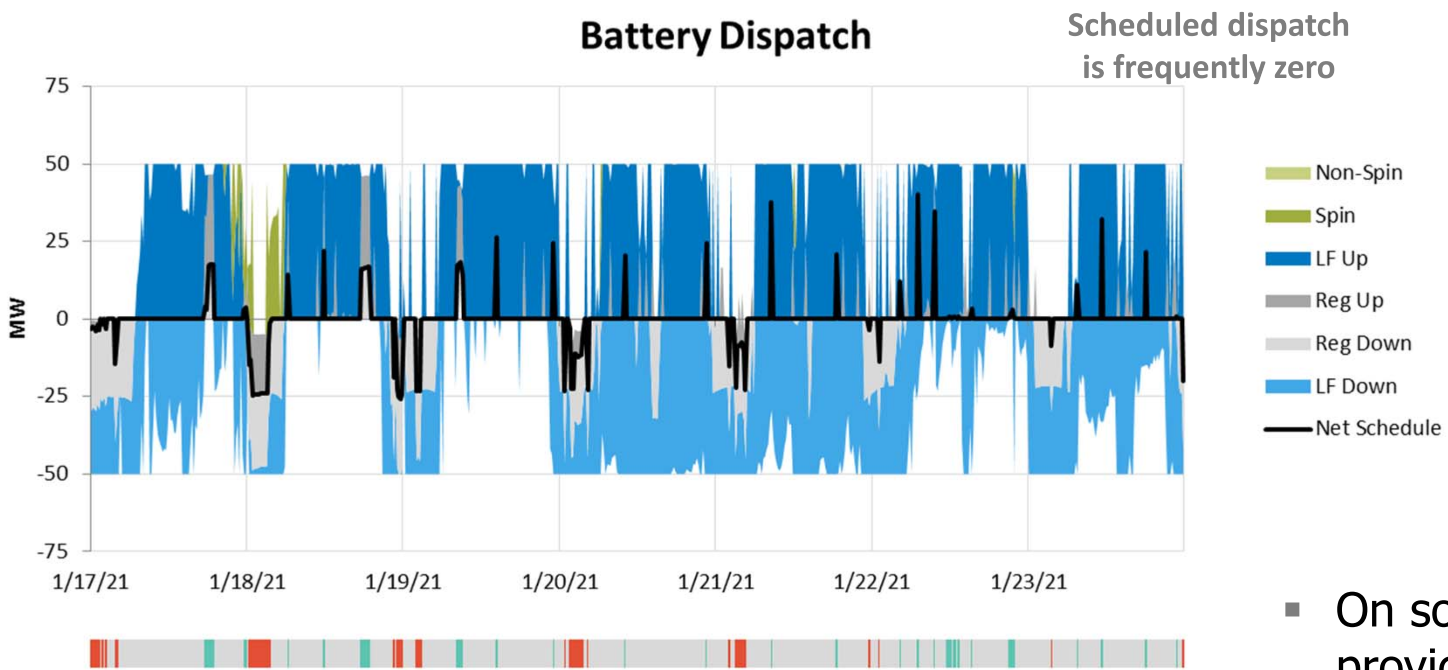


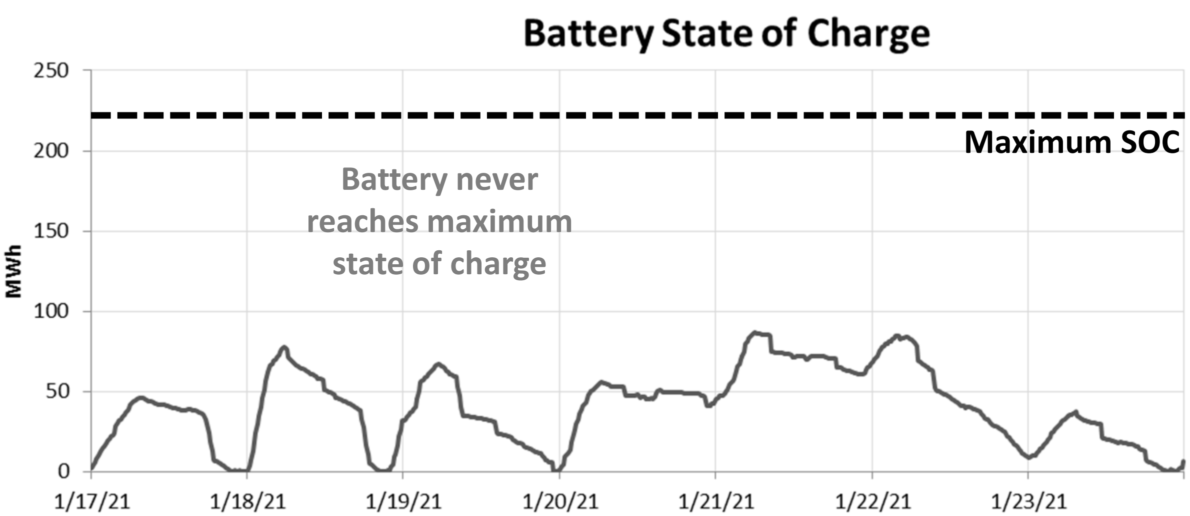
Visualizing Battery Storage Dispatch





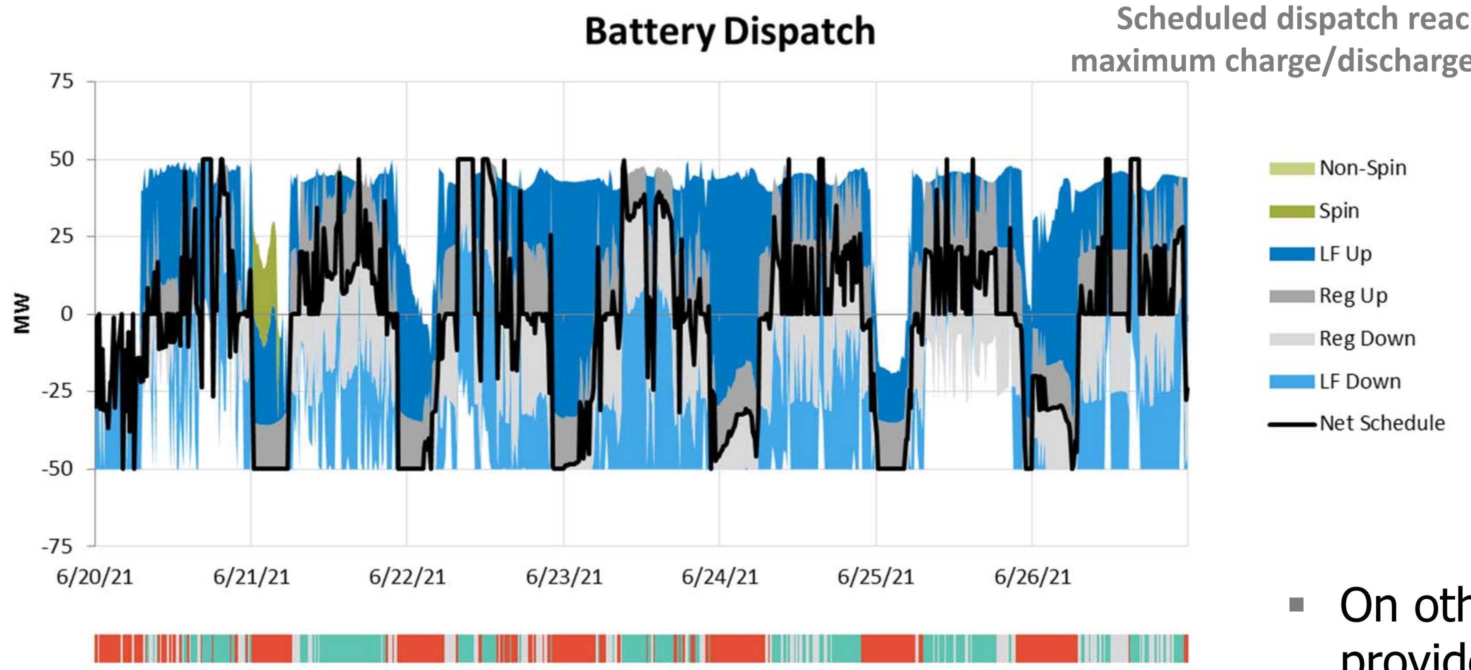
Example 50MW 4-hr battery dispatch (January week)



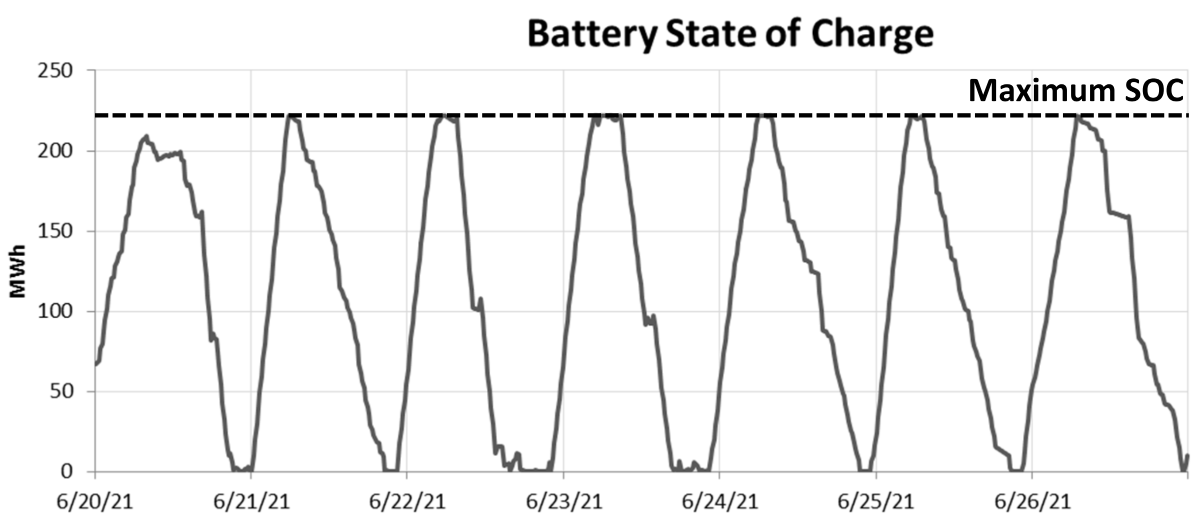


- On some days, battery provides ancillary services without making use of full energy storage capabilities

Example 50MW 4-hr battery dispatch (June week)



Scheduled dispatch reaches maximum charge/discharge levels



Battery cycles over full range once per day

- On other days, battery provides both ancillary services and significant energy shifting services

Example 50MW 4-hr battery dispatch (Seasonal and diurnal behavior)

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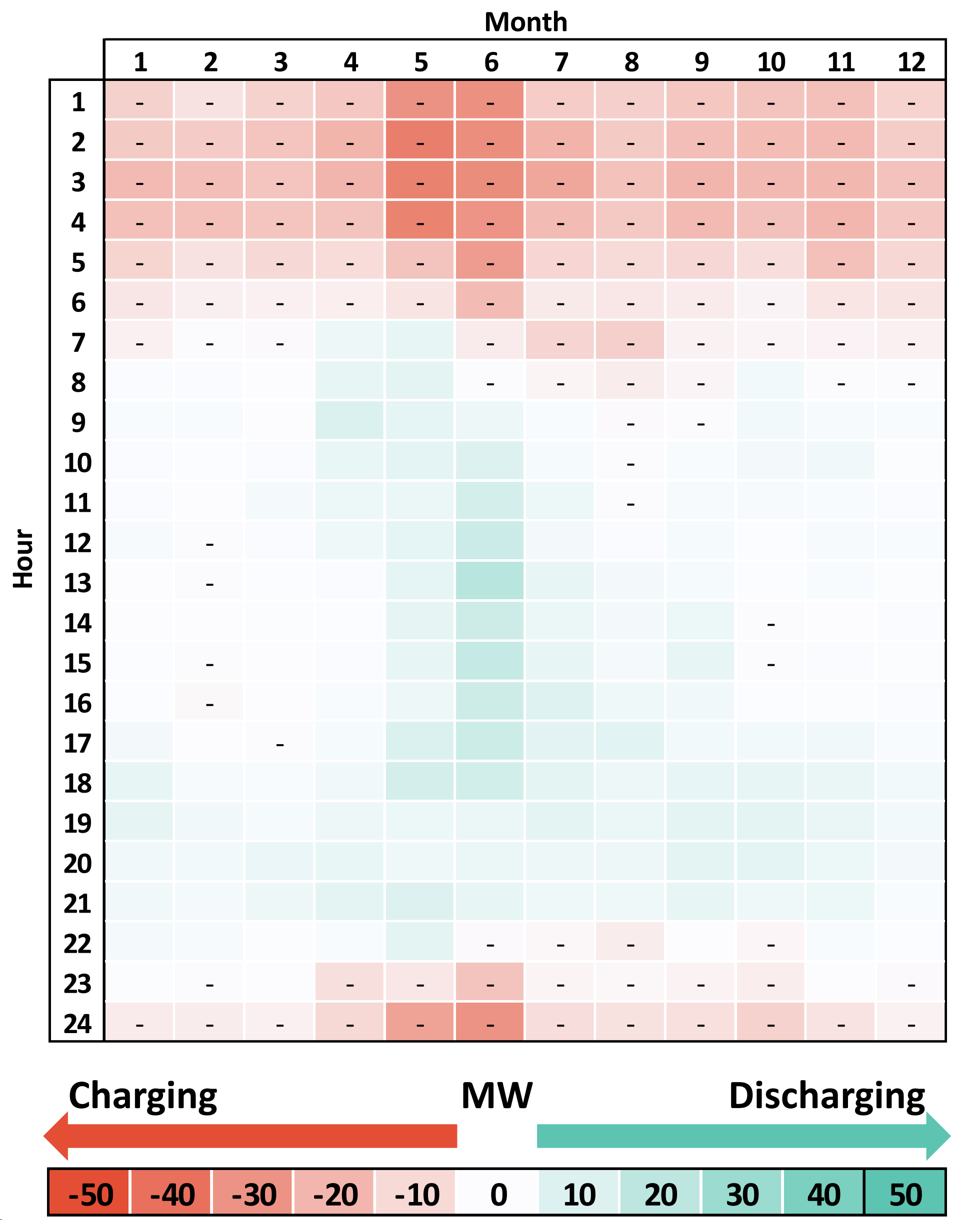
Average Net Schedule (MW)



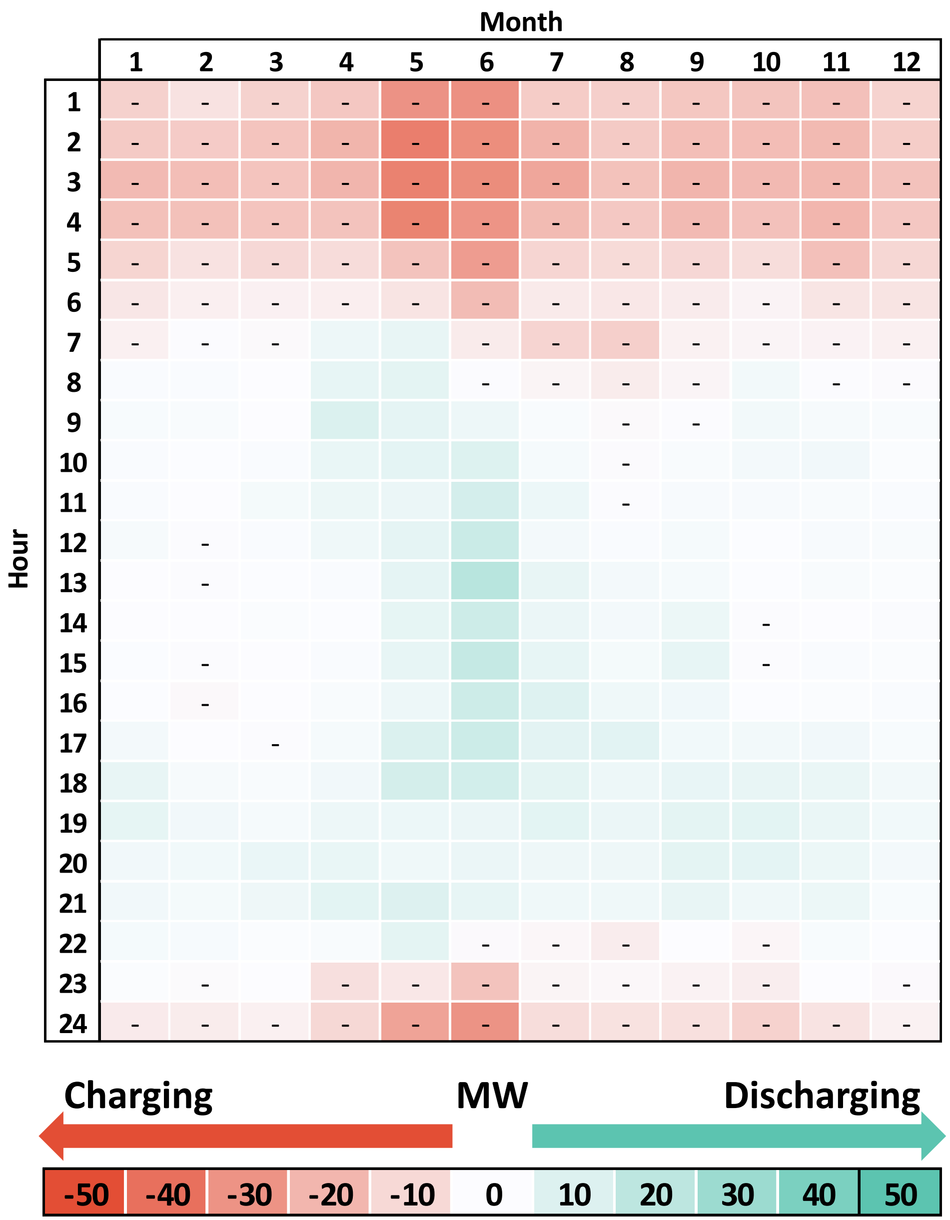
Battery tends to:

- Charge at relatively high levels during off-peak period (~6 hrs)
- Discharge at relatively low levels across the on-peak period (~18hrs)
- Discharge levels are highest during mid-day in spring/summer months
- Charging levels tend to be higher in spring/summer off-peak periods to support increased discharge levels over a longer portion of the spring/summer on-peak period

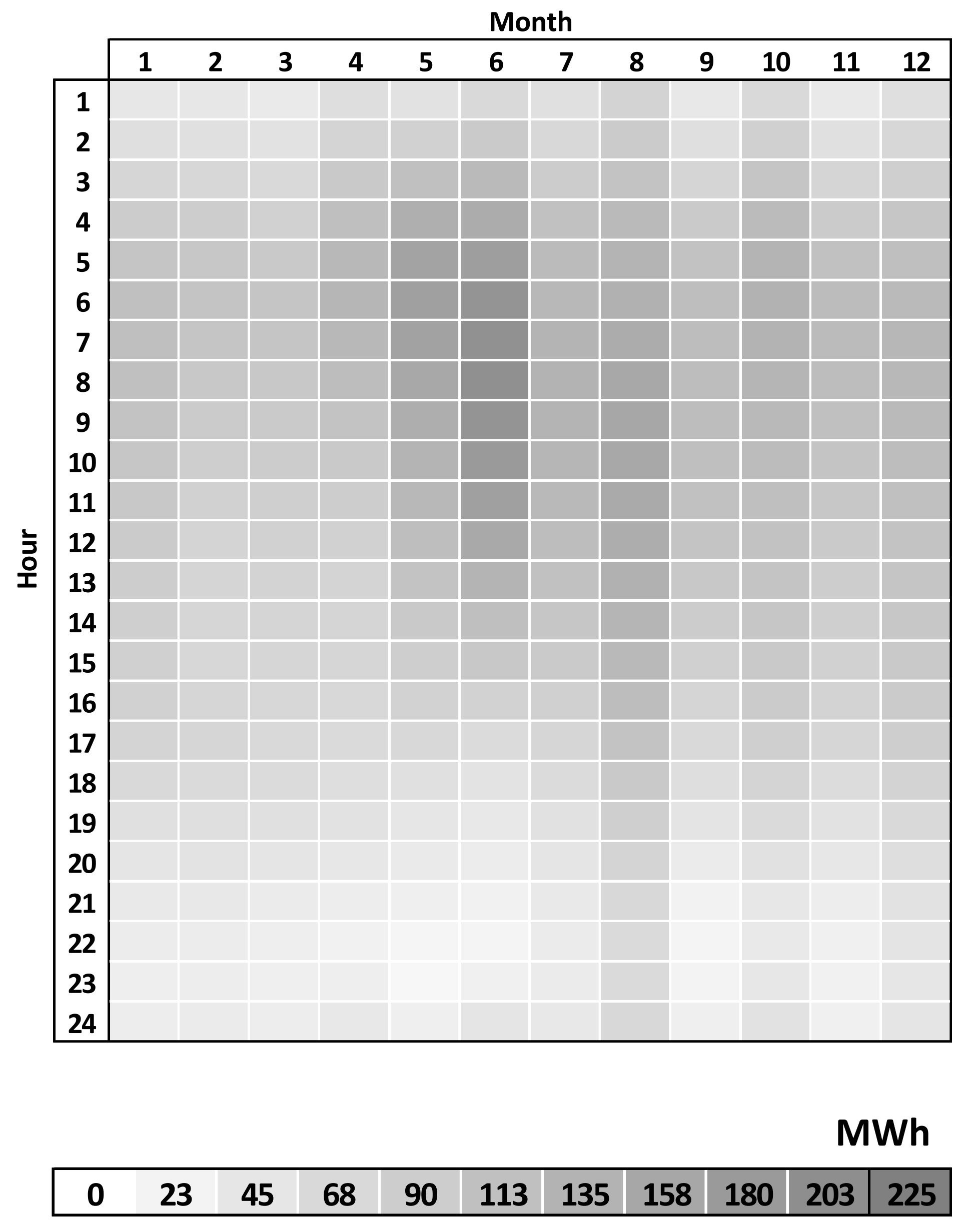
Example 50MW 4-hr battery dispatch (Seasonal and diurnal behavior)

Portland General Electric

Average Net Schedule (MW)

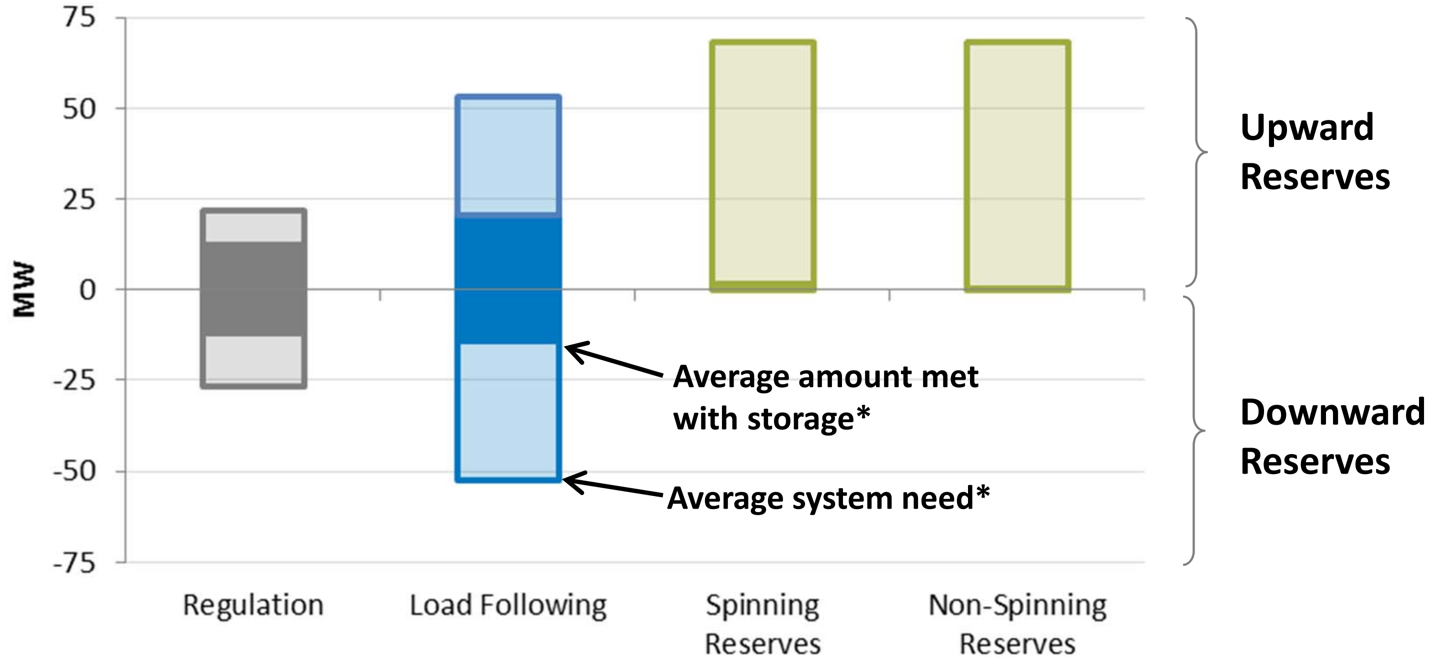


Average State-of-Charge (MWh)



Example ancillary service provisions (Annual average)

Average reserve requirements and portions met with 50MW 4-hr battery in 2021 test portfolio (preliminary)



Battery system tends to provide:

- A significant portion of the upward and downward regulation and load following reserves
- A very small portion of spinning reserves
- Very little to no non-spinning reserves

*Reserve requirements and provisions are based on simulated 2021 test scenario with full renewable integration and vary by hour. Values represent averages across all hours and should not be interpreted as specific to an hour or timestep.

Preliminary operational cost impacts in 2021 test portfolio

- Energy storage systems modeled in 2021 test portfolio saved between

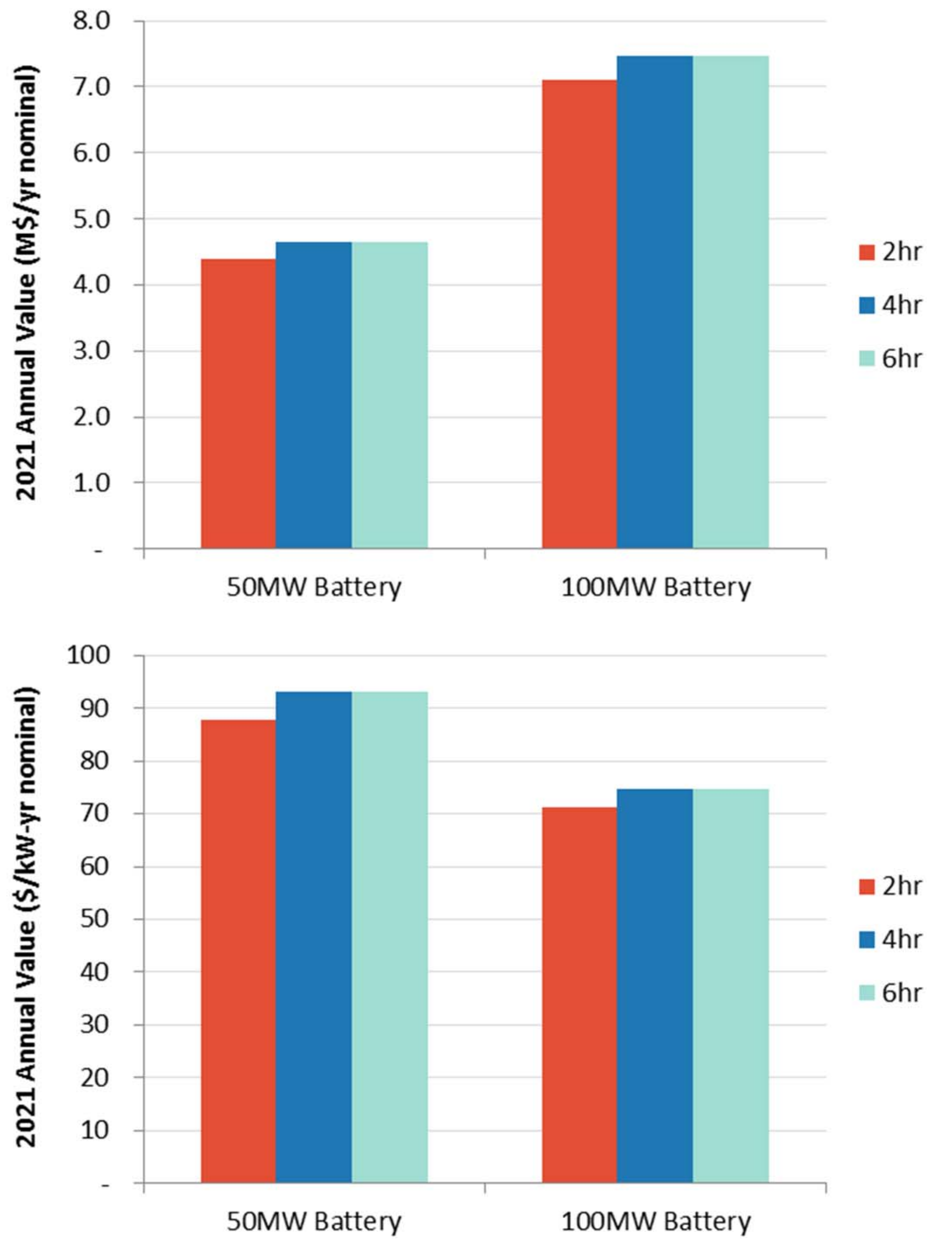
  ~$4.4M/yr and ~$7.5M/yr

  of operating costs, depending on size and duration, assuming PGE dispatch

- This translates into per unit operational value of:

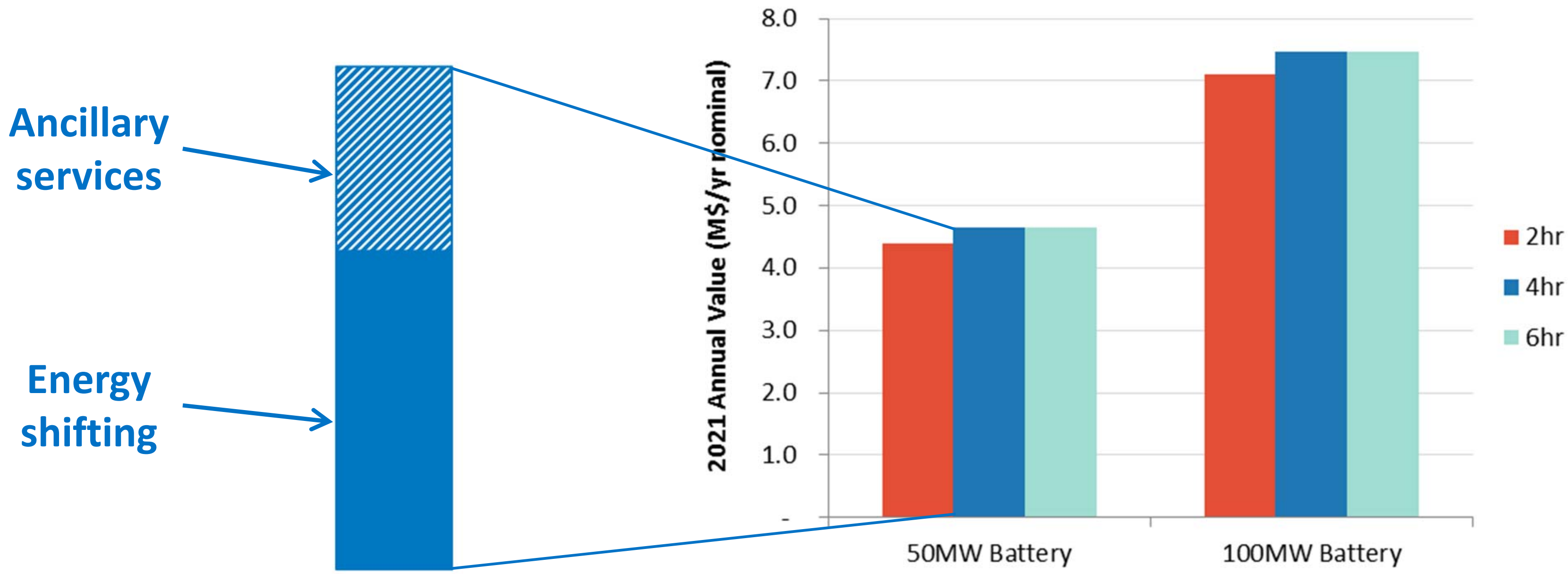
  ~$90/kW-yr for a 50MW fleet or
  ~$75/kW-yr for a 100MW fleet

- Energy storage shows declining marginal value with respect to both installed capacity and duration



Preliminary - 2021 Snapshot

Energy shifting versus ancillary services



- Operational value encompasses both energy shifting and ancillary services
- 50MW, 2-hr battery system in 2021 test portfolio:
  - ~60% energy shifting, ~40% ancillary services
- This breakdown is anticipated to vary by portfolio, test year, and battery configuration

Preliminary - 2021 Snapshot

System peaking capability

- Two methodologies are used to approximate system peaking capability/capacity contribution of a grid-connected battery system being operated by PGE

Duration-based approximation (Upper bound)

- **Background:** Other jurisdictions (e.g. CAISO) have required storage systems to provide four hours of discharge capability to count toward resource adequacy
- **Method:** Assume that storage devices can provide the maximum discharge rate that can be sustained for four hours
- Example #1: 50MW 4-hr battery provides 50MW of peaking capability
- Example #2: 50MW 2-hr battery provides 25MW of peaking capability
- Assumes that the operator has <u>perfect knowledge</u> of the need for peaking capability prior to reliability events (results in upper bound)

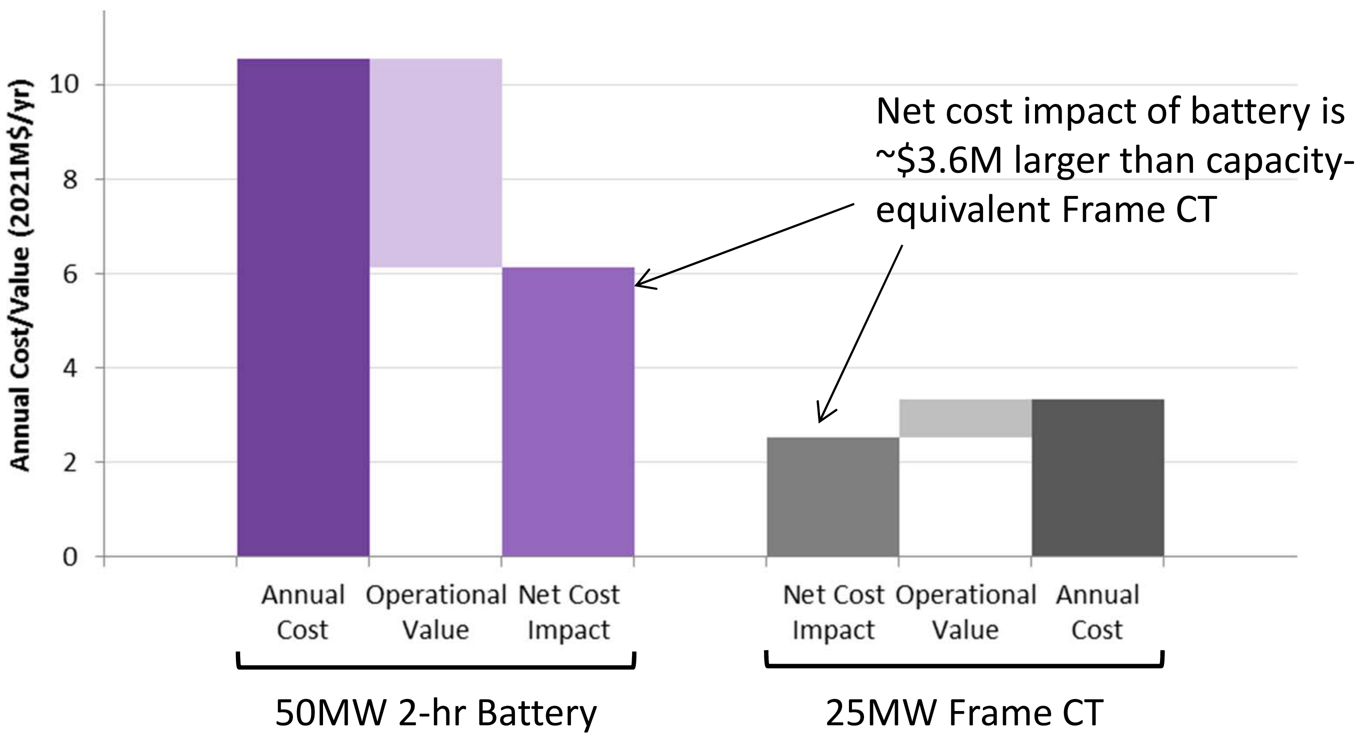
RECAP-based approximation (Lower bound)

- **Method:** Assume battery charges on off-peak and provides four hours of continuous discharge during the highest LOLE hours in each month; Use this shape in RECAP to approximate an ELCC for storage
- Example #1: 50MW 4-hr battery has ELCC of 65%, or ~33MW
- Example #2: 50MW 2-hr battery has ELCC of 34%, or ~17MW
- Assumes that the operator has <u>imperfect knowledge</u> of the need for peaking capability prior to reliability events (results in lower bound)

Portfolio cost impact

- Capacity value represents the cost savings associated with avoiding procurement of additional capacity resources to meet reliability requirements
- In IRP portfolio analysis, Frame Combustion Turbines (CTs) are the default capacity resource incorporated into each portfolio to meet a Loss of Load Expectation (LOLE) of 2.4 hrs/yr
- If a battery system lowers portfolio costs on a net basis relative to a Frame CT with an equivalent capacity contribution, then the battery is a cost effective resource addition to the portfolio

Example: 50MW 2-hr battery vs. capacity-equivalent (25MW) Frame CT

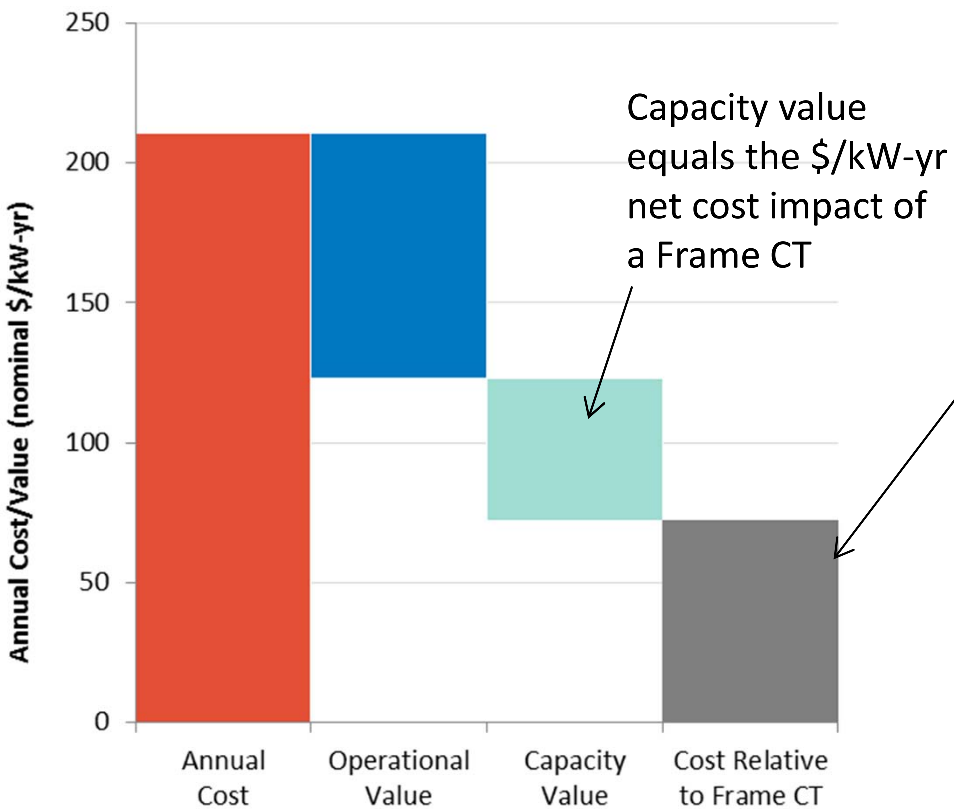


Preliminary - 2021 Snapshot

Capacity value approach

- Sometimes it is easier to think about the economic comparison between a battery and the "capacity-equivalent" default capacity resource through a ***capacity value*** or ***system peaking value*** associated with the battery

Example: 50MW 2-hr battery cost effectiveness relative to Frame CT



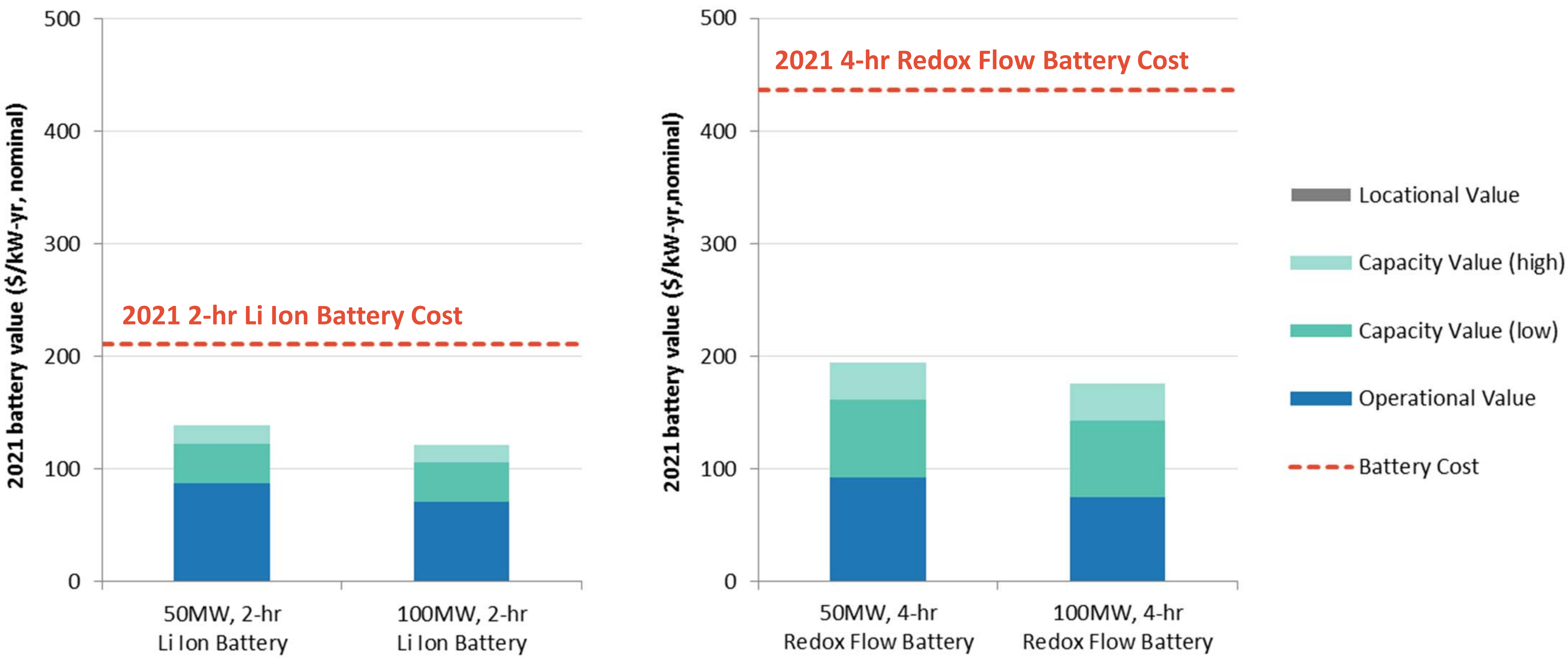
In this framework, the per unit cost relative to a Frame CT equals ~$72/kW-yr

For a 50 MW project, this equals ~$3.6M/yr (same as cost difference shown on last slide)

When the Operational Value + Capacity Value exceeds the Annual Cost, the battery is cost effective relative to the default capacity resource

Storage economic analysis in 2016 IRP

- The operational cost impacts of the 2-hr and 4-hr duration storage cases in the ROM 2021 test portfolio were used to evaluate the cost effectiveness of four potential energy storage devices/fleets:
  - 2-hr Lithium Ion Batteries (50MW and 100MW)
  - 4-hr Redox Flow Batteries (50MW and 100MW)
  - Cost data based on the same Black & Veatch study used to evaluate the costs of conventional resources
- None of the evaluated storage options were cost effective relative to a Frame CT in the 2021 test portfolio (this conclusion is specific to the resource portfolios and cost assumptions in the analysis)



Preliminary - 2021 Snapshot

Additional considerations and next steps

- The methodology presented here is under ongoing development

  Next steps:

  - Engage the ROM Technical Review Committee to refine modeling
  - Continue to research methodologies for determining the capacity contribution of energy storage resources
  - Expand energy storage modeling to incorporate pumped storage systems
  - Continue to explore options for full incorporation of energy storage evaluation tools into IRP portfolio analysis

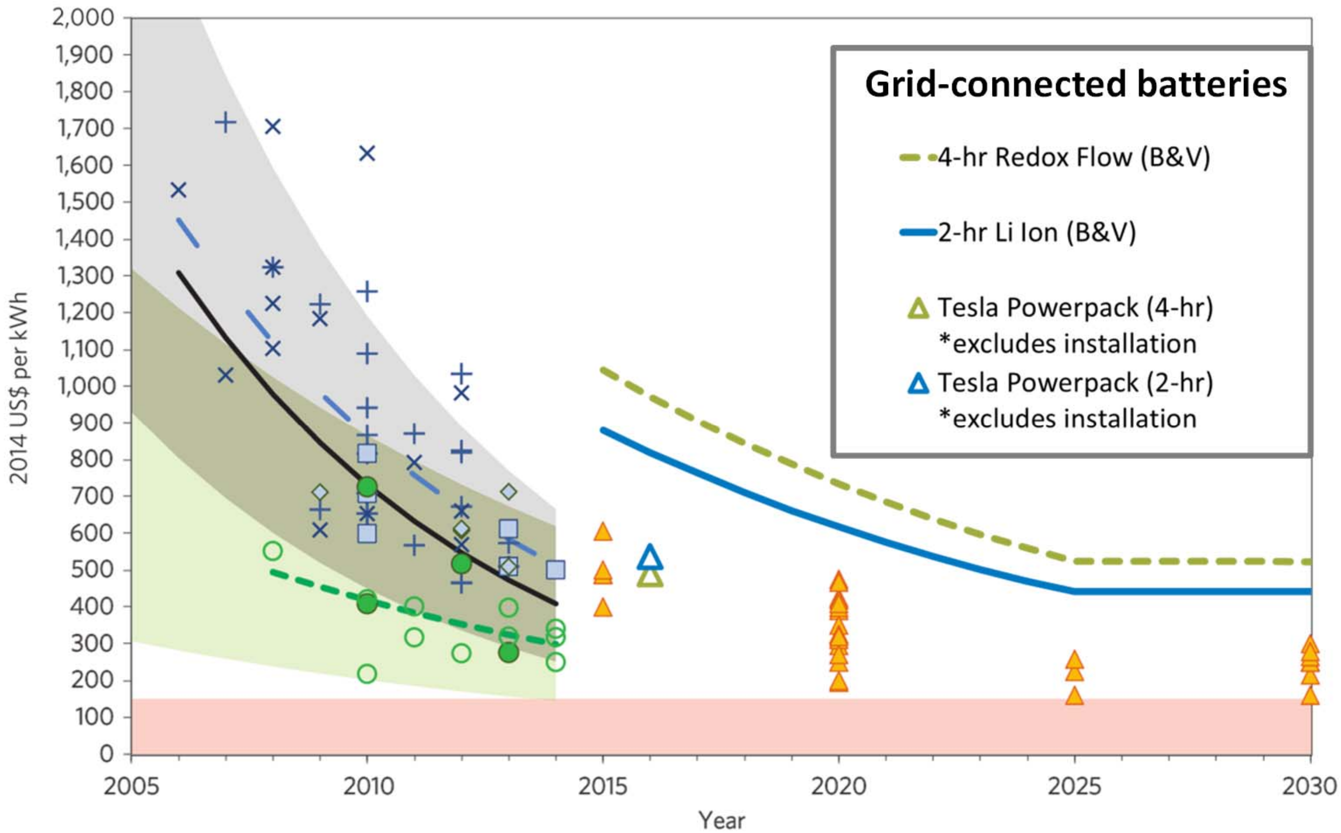
- The value of energy storage is not fixed, as represented by this single year snapshot; will be impacted by:
  - Incremental renewable procurement
  - EIM
  - Fuel and CO_2 price trends
  - Continued evolution of Western markets

- Specific storage projects may also provide locational value related to transmission and/or distribution infrastructure deferral, which is not evaluated in the 2016 IRP

Additional considerations and next steps

- Energy storage technology costs are rapidly dropping and highly uncertain

<u>Vehicle</u> battery cost trajectories



Source: Nykvist & Nilsson, *Nature Climate Change*, 2015.

- This environment requires ongoing evaluation and incorporation of the latest data as it becomes available in order to appropriately treat energy storage in resource procurement decisions

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Next Steps

2016 IRP Timeline

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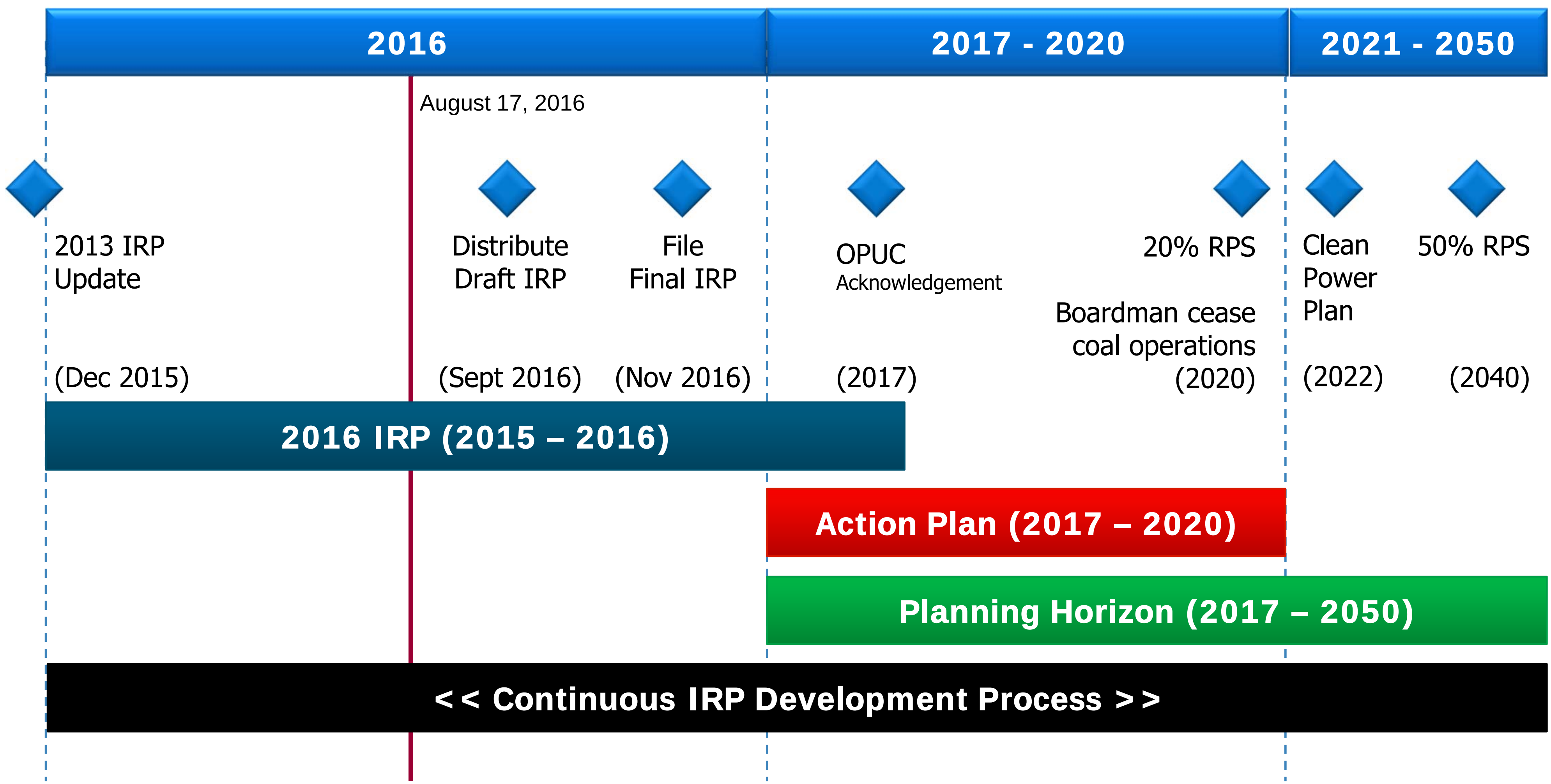
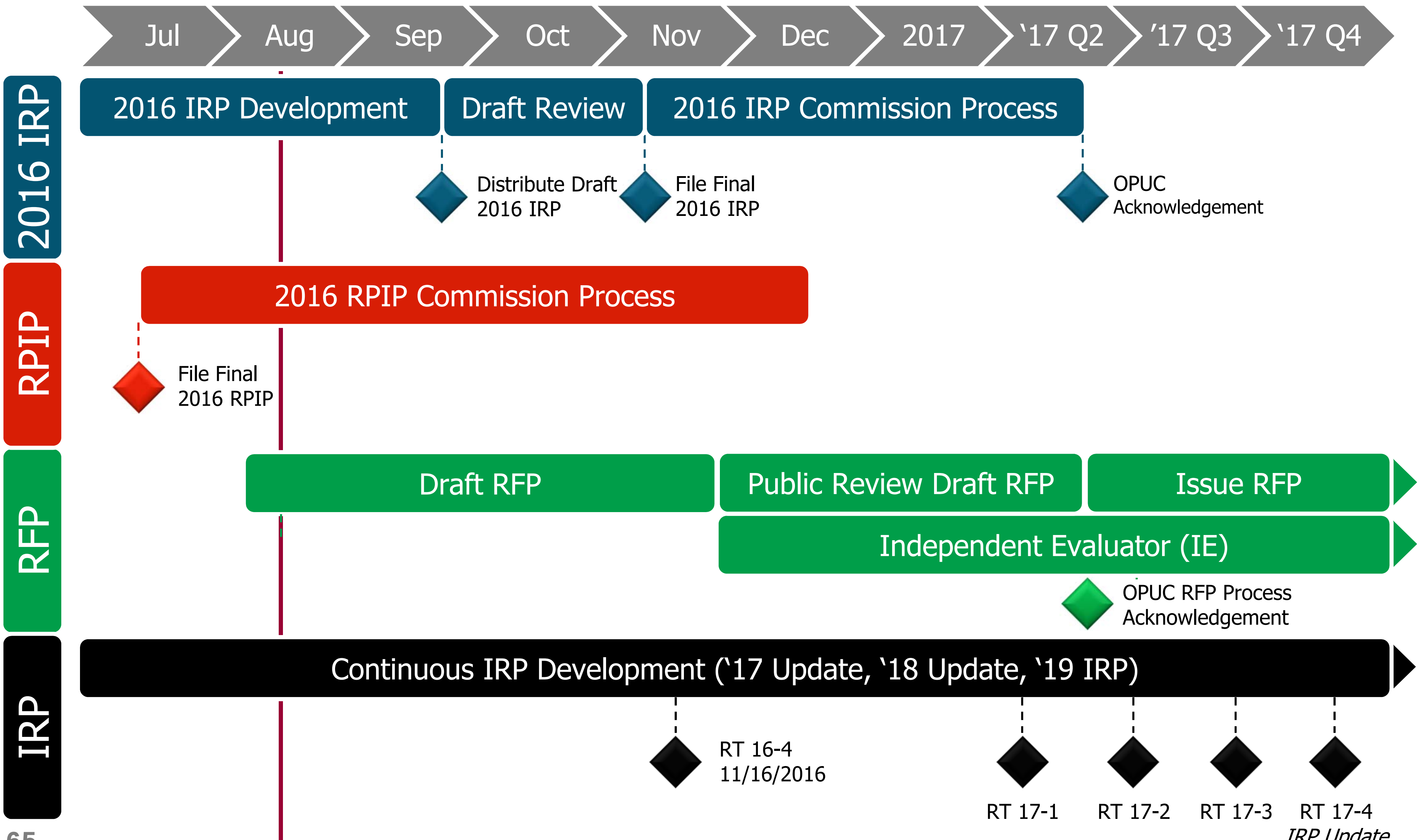
The 2016 IRP evaluates a planning horizon through 2050



IRP, RPIP, and RFP Timelines

Efficient acknowledgement processes are required to meet resource need timing



Draft Responsive Action Plan[1]

Action Timing	Dec 2016	Dec 2017	Dec 2018	Dec 2019	Dec 2020

Renewable — 20% RPS

2016 IRP Acknowledged — All Resource / Capacity

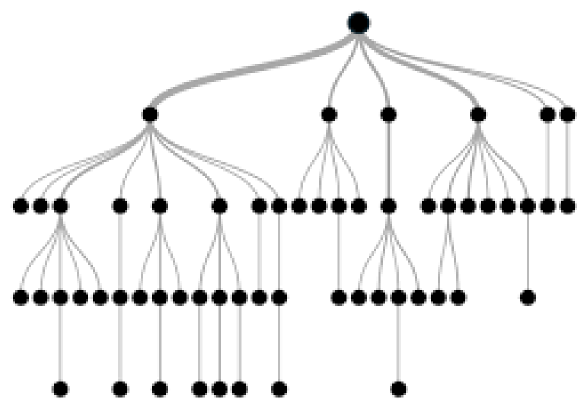
Supply-side

▪ Renewable[2]	0-175	MWa
▪ Capacity	800-850	MW
▪ Annual	400-850	MW (dispatchable)
▪ Seasonal	0-600	MW (summer)
▪ Seasonal	0-500	MW (winter)
▪ DSG[3]	20	MW
▪ Hydro Contracts:	Renew if cost-effective	

Quickly evolving resource needs
plus
overlapping regulatory processes
require
an adaptable, responsive Action Plan

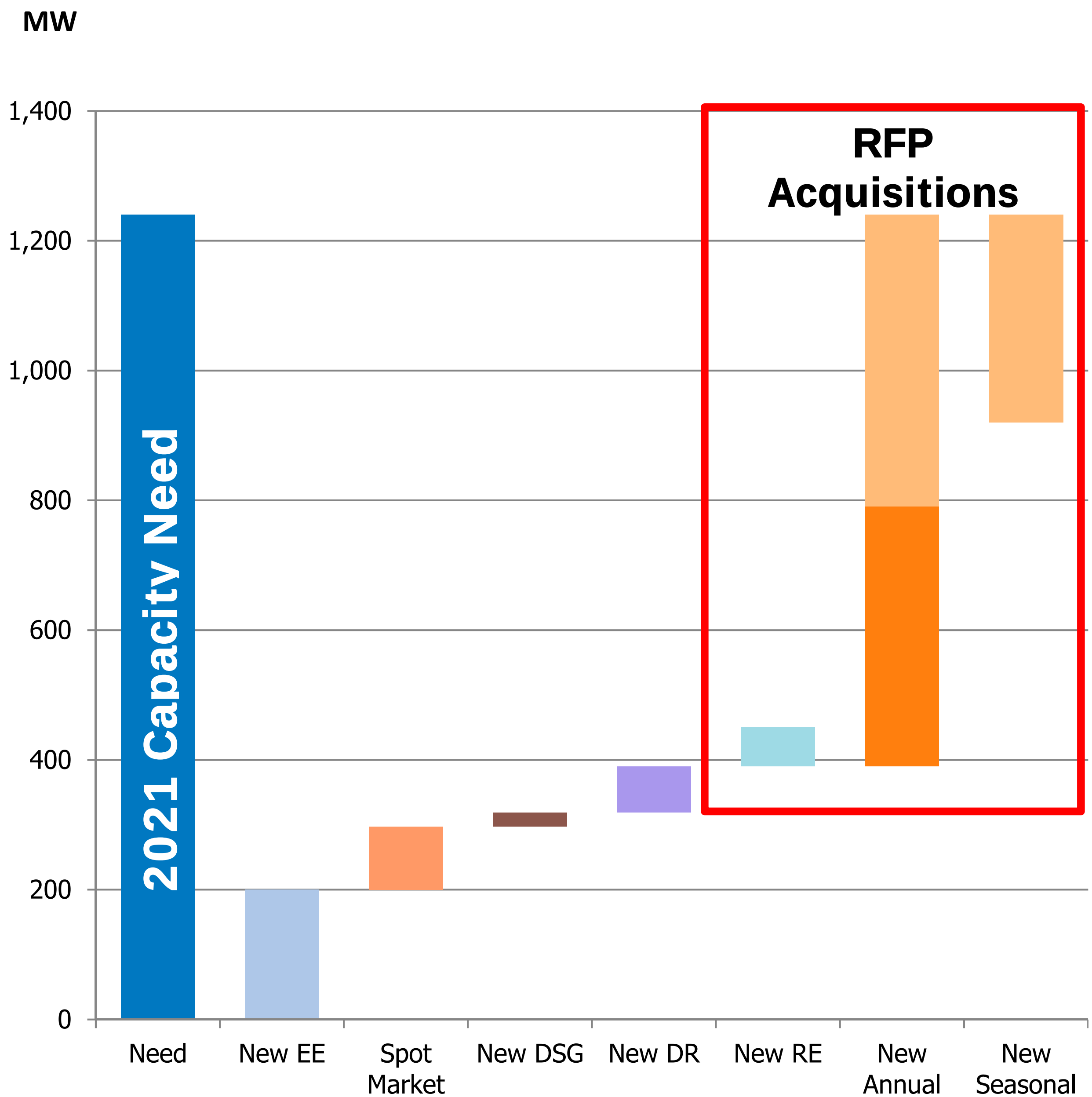
Demand-side

- Energy Efficiency — 135 MWa / 176 MW (ETO Ongoing)
- Demand Response — 77 MW / 69 MW (winter/summer)
- CVR[4] — 1 MWa / 1 MW



1. All values approximate; incremental resources
2. Includes bundled RPS compliant resources only. Unbundled resources to be determined by RFP.
3. DSG: Dispatchable Standby Generation
4. CVR: Conservation Voltage Reduction

2021 Incremental Capacity Need



- Estimated annual contributions[1]
- Need includes EE actions, Spot Market, new DSG, and new DR,
- Renewable: 0-60 MW[1]
- Annual resource: 400-850 MW
- Seasonal product: 0-300 MW[1]
  - winter 0-500 MW
  - summer 0-600 MW

1. Based on Effective Load Carrying Capability (ELCC)

Responsive Action Plan

Enables resource acquisition through an adaptable roadmap which is responsive to changes which occur from the time the Action Plan is acknowledged

- **Periodically update information (i.e. more frequently than with IRP filing)**
  - Gas price forecast (annual)
  - Load forecast (annual)
  - CO_2 pricing (annual)
  - Resource acquisition/procurement/COD
  - Policy

Key drivers of resource decisions planned for update more frequently than the 'traditional' IRP cycle.

- **Basis for acknowledgement**
  - IRP
  - IRP Addenda / Updates

Multiple venues will be pursued to seek acknowledgement of all, or part of, PGE's resource needs.

- **Regulatory processes**
  - IRP
  - Competitive Bidding

Current regulatory processes must be flexible to enable acquisition options in best interest of customers.

Portland General Electric

Next IRP

Next IRP

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Key issues and potential areas of focus for next IRP

General industry/national trends

- Flattening/declining load
- Carbon policy uncertainty
- Aging Infrastructure

Changing resource diversity

- Variable and distributed resource integration
- Increasing capacity and ancillary services needs
- Loss of coal generation and effect on system inertia
- Natural gas management as fuel switching continues nationally

Regional market transformation

- Expanding regional markets (EIM/ISO)
- Market availability risk
- Market price fluctuations, evolving trends
- Integration of transmission and distribution system planning

Increasing need to evolve modeling tool capabilities

- Improving alignment between planning and operations
- Adaptability in rapidly changing planning environment

Next IRP

Portland General Electric

Research to inform the next IRP is conducted through Enabling Studies

Wholesale Market Risk

Evaluate the financial and physical risks of the wholesale market given shifts in the region which may move the system to a regional capacity deficit.

Energy Imbalance Market

Study how Western EIM participation influences operational assumptions. Compare current planning assumptions used when modeling day-ahead, hour-ahead, and real-time operation, with actual operations to better align planning tools with operational realities.

Energy Storage

Develop tools and methodologies to assess technical and economic feasibility of regionally located energy storage facilities, including pumped hydro storage.

Customer Insights

Design and conduct research to quantify customers’ perceptions and receptivity to a variety of resource options to meet future energy needs.

Thank You!

Feedback welcome 24/7 at:

- https://www.portlandgeneral.com/forms/pge-stakeholder-feedback
- www.portlandgeneral.com/irp
- irp@pgn.com

Portland General Electric

2016 IRP Feedback Roundup

2016 IRP: Feedback Status

Topic	Feedback Received	Resolution	Completed
General	Passing the mic was cumbersome.	For stakeholder questions, provide a stationary microphone at a podium or mics at each table.	4/13/2015
Process	Why is schedule different on handout?	Update schedule slides to account for automation. Plan to revise and post updated slide deck to website and include summary update in ‘thank you’ email.	4/9/2015
Process	Is schedule firm or can the November 18th date be adjusted? (Power Council has important meeting on November 18)	Moved IRP meeting to November 20th.	4/9/2015
Process	Can the October 23rd date be adjusted? (CUB has important meeting on October 23)	Moved IRP meeting to October 21st.	4/9/2015
Environmental Policy	Why will climate data set be a scenario instead of a base case?	PGE to consider suggestion after vetting data.	9/25/2015
Environmental Policy	Does PGE place any type of weather weighting on load forecast?	PGE uses 15-year average weather, with rolling updates	7/15/15

2016 IRP: Feedback Status

Topic	Feedback Received	Resolution	Completed
Load Forecast Methodology	For future discussion, how is the ETO forecast in later years developed?	PGE to address questions about EE projection in the future. Refer to April 2nd Slide 31.	7/15/15 and 7/16/15
Load Forecast Methodology	Comment on in-fill vs. suburban sprawl – suggestion to be cautious about moving to more standard household variables	PGE to take note.	4/8/2015
Load Forecast Methodology	Request to show load growth with and without EE.	PGE to meet this request.	8/13/2015
Load Forecast Methodology	What % of PGE service territory is within the urban growth boundary?	90% of the UGB is within PGE Service Territory UGB is 822.7 sq. mi. PGE SVC Territory is 7532.2 sq. mi. Overlap is 741.6 sq. mi.	4/8/2015
Environmental Policy	Will temperature data drive (1) increased cooling demand and (2) an acceleration of cooling device purchases?	PGE to follow-up internally with load forecast staff.	Est. 8/13/2015 (with scenarios and climate change weather discussion)

2016 IRP: Feedback Status

Topic	Feedback Received	Resolution	Completed
Demand Response	How is PGE using the convergence of EE and DR programs, and avoiding over-counting benefits?	PGE is engaging the ETO on a number of DR programs, particularly with Energy Partner and the smart thermostat pilot. Our current plan is to only attribute incremental demand reductions (after EE) to the DR programs. This may change in the future if a more integrated program was offered. In either case, only measured impacts are used and therefore we should not see double counting.	Ongoing
Demand Response	What happened to the EV charging pilot?	The manufacturing of the twenty CEA-2045-equipped smart EVSEs [EV chargers] was delayed. Ten are for PGE and ten for another utility in the EPRI project. PGE now expects delivery in Q1 of 2016 and when we get them we intend to install them at employee homes and systematically test the smart features.	Q1 2016
Demand Response	What is the preferred method of evaluating the cost effectiveness of DR in Oregon?	PGE will be engaging stakeholders in 2016 as part of the larger integrated (smart) grid report process. At a high level, our preferred approach is to look at both total resource and utility cost tests when assessing cost effectiveness.	12/17/15

2016 IRP: Feedback Status

Topic	Feedback Received	Resolution	Completed
Demand Response	Would PGE provide a copy of the DR study, along with the assumptions (particularly materials supporting the basis for electric heating load control)?	PGE uploaded the final report to portlandgeneral.com	02/16/16
Flexible Capacity Study	Rather than focusing on how renewable curtailment can reduce the trough of the duck, can PGE assess how to change the slope of the neck? (Reference- “Teaching the Duck to Fly”)	Our goal is to begin exploring the potential role that energy storage may play with respect to flexibility challenges in this IRP.	12/17/15
Flexible Capacity Study	Can the Flexible Capacity Study include a range of CO2 prices?	At this point, the flexible capacity modeling effort will likely not consider a range of CO2 prices.	12/17/15

2016 IRP: Feedback Status

Topic	Feedback Received	Resolution	Completed
Futures	Can there be discussions about the Clean Power Plan and mass vs. rate-based modeling?	PGE is willing to host detailed modeling discussions; we look forward to receiving detailed feedback regarding the specific aspects that stakeholders would like to discuss.	12/17/15
Portfolios	How will the results of the Flexible Capacity Study inform portfolio scoring? How will REFLEX work with Aurora to help PGE insure that each type of capacity is appropriately valued?	PGE is willing to host detailed modeling discussions; we look forward to receiving detailed feedback regarding the specific aspects that stakeholders would like to discuss.	12/17/15
Portfolios	Stakeholders would like to see portfolios that intuitively account for the geographical diversity of renewables (i.e., better examples than Gorge wind).	Our goal is for the resource portfolios tested in this IRP to include aspects of diversification benefits of renewable resources.	12/17/15

2016 IRP: Feedback Status

Topic	Feedback Received	Resolution	Completed
PRM Study	What is PGE's definition of dependable hydro capacity or what does it mean in this context? What method was used to create PGE's estimates?	The definition is dependent on the particular capacity assessment question. PGE presented an overview of the treatment of hydro capacity in the Dec 17 Public Meeting. PGE is willing to host a more detailed technical discussion.	12/17/15
PRM Study	When will PGE share the other portions of the reliability assessment (in addition to the statistics presented at the meeting)?	PGE plans to use the results of the PRM study in the 2016 IRP without other adjustments applied.	12/17/15
PRM Study	How will risk adjustment measures fit in with the PRM study?	PGE plans to use the results of the PRM study in the 2016 IRP without other adjustments applied.	12/17/15
PRM Study	What was the market import assumption?	The import assumption was 200 MW, excluding summer On-peak hours.	12/17/15

2016 IRP: Feedback Status

Portland General Electric

Topic	Feedback Received	Resolution	Completed
PRM Study	Can PGE provide clarification on the net capacities used in winter and summer?	The plant capacities were discussed in the 12/17/15 Public meeting.	12/17/15
PRM Study	Why does DSM not change from winter to summer?	As in the 2013 IRP, the PRM Study models the same quantity of demand response (DR) in the winter as in the summer.	12/17/15
PRM Study	Can energy efficiency be pulled out of load forecast and shown as a capacity resource?	EE cannot be removed from load and shown as a resource in the PRM Study for this IRP cycle. PGE is willing to investigate options for future cycles, but due to the relationship between EE and load, there may be impacts to the quality of the results.	12/17/15
Wind Integration	How does the wind integration study intersect with an EIM?	There is no explicit modeling of the EIM in the wind integration study. The study, however, does assume liquid market transactions every 15 minutes.	12/17/15

2016 IRP: Feedback Status

Topic	Feedback Received	Resolution	Completed
Clean Power Plan	Is PGE going to treat Carty as an existing resource? Can PGE provide the correspondence between PGE and EPA regarding Carty?	Yes. PGE's correspondence with EPA regarding Carty is ongoing. PGE is willing to share the letter dated September 7, 2015, with stakeholders on request.	12/17/15
Clean Power Plan	Does PGE have a preferred state plan option?	PGE prefers a sub-category specific rate based standard.	12/17/15
Clean Power Plan	Is there a more detailed analysis about PGE's Montana obligations with respect to Colstrip 3 and 4?	No. Detailed analysis will be performed in the 2016 IRP.	12/17/15
Clean Power Plan	What will the new emphasis be between mass-based and rate-based futures? Does PGE know the ratio of studied mass-based vs. rate-based scenarios?	PGE will study both rate and mass based implementation plans. PGE does not yet know the ratio of mass to rate based scenarios.	12/17/15

2016 IRP: Feedback Status

Topic	Feedback Received	Resolution	Completed
Climate Study	Can the report be provided to stakeholders?	Yes. The report will be included in the 2016 IRP.	Est. 7/29/2016
Climate Study	Is the study providing information about plant cooling requirements? Transmission interruptions from wild fires? Higher temperature implications for transformers and line capacities?	No. The focus of the report is the forecasted change of temperatures in the Portland metropolitan area.	12/17/2015
2016 IRP Schedule	At the last public meeting (9/25/15), the schedule showed the draft IRP was planned to be filed at the end of Q1 and the final was to be complete by the end of Q2. Now the schedule is for a draft July 29th and final Sept 16th. What was the reasoning behind this change?	The schedule provided at the September 25th meeting was a preliminary schedule and did not include the filing of a 2013 IRP Update. The work done to complete the update, along with the time needed to finish the 2016 analysis and complete internal PGE reviews, required an adjustment to the 2016 IRP draft release and filing dates. It is important to note that the filing schedule is ahead of the December 2016 due date for the 2016 IRP.	05/16/2016

2016 IRP: Feedback Status

Topic	Feedback Received	Resolution	Completed
Load Forecast	Commercial growth rate appears to be much greater (1.3%) than residential according to the April 2015 presentation (slide 10). What part of this was smaller commercial?	PGE forecasted commercial energy growth rate of 0.9% (presented at the June 2015 load forecast workshop, slide 14) reflects growth in secondary delivery voltage service, of which small commercial (defined as service < 30 kw, PGE current rate schedule 32 in PGE UE 294/1402/page 2) has historically been approximately 21% of energy deliveries and 84% of customer count. PGE forecasts long-term energy deliveries and customer count by delivery voltage service level and does not have specific forecasted growth rates for more disaggregated customer segments.	03/09/16

2016 IRP: Feedback Status

Portland General Electric

Topic	Feedback Received	Resolution	Completed
Load Forecast	PGE's service territory experienced stronger economic growth in 2014 and 2015 than was predicted in the economic forecast used as an input assumption for the initial 2013 IRP filing. p 18. What part of that was in the smaller commercial?	PGE tracks economic indicators such as the unemployment rate, unemployment claims, employment levels and growth by industry sector and building permits for the state of Oregon and counties within PGE service territory. PGE's source for regional economic outlook, the Oregon Office of Economic Analysis, does not provide forecasts of employment disaggregated by business size needed to determine which size groups exceeded expectations, nor does PGE track specific data on economic growth indicators by business size. The Oregon Employment Department periodically reports annual data on Oregon employment by business size which can be found online: https://www.qualityinfo.org/-/portrait-of-oregon-businesses-by-size-of-firm.	03/09/16

2016 IRP: Feedback Status

Portland General Electric

Topic	Feedback Received	Resolution	Completed
Energy Conservation	PGE continues to work with the ETO to achieve the targeted energy efficiency savings. (IRP Update page 12). What conversations are specific to small commercial?	PGE collaborates with the Energy Trust to increase customer awareness and participation in Energy Trust small to mid-sized commercial energy efficiency programs through outreach and marketing activities. PGE has a three outreach specialists who work directly with small business customers. Outreach specialists provide small commercial customers with energy efficiency consultations and connect them with Energy Trust Trade allies. Business community outreach is supplemented with targeted marketing and through small business customer newsletters. PGE coordinates its outreach activity with Energy Trust though regular meetings. PGE and Energy Trust identified challenges in increasing Energy Trust participation rates among small business customers. In response to the challenge, Energy Trust recently created a new lighting program for small business customers which includes increased incentives and 0% interest financing. PGE is currently supporting the program through its outreach and marketing efforts.	03/09/16
Energy Conservation	How has PGE focused on the smaller commercial customer group to realize potential in conservation through lighting (slide 40 of 140) showing lighting as highest potential for conservation (e.g. 500,000 MW cost effective potential)?	PGE primarily focuses on lighting projects in the activities described below due to the potential and cost effectiveness for lighting projects.	03/09/16

2016 IRP: Feedback Status

Topic	Feedback Received	Resolution	Completed
Energy Conservation	How has PGE focused on the smaller commercial customer group to realize potential in conservation through lighting (slide 40 of 140) showing lighting as highest potential for conservation (e.g. 500,000 MW cost effective potential)?	PGE primarily focuses on lighting projects in the activities described below due to the potential and cost effectiveness for lighting projects.	03/09/16
Integrated Grid	You note the large number of use cases for the Salem Smart Power project. Initially 6, now 14. The large number is interesting and implies more value to be derived from storage but any analysis/quantification of the end use cases would be valuable to present. What is the timing for having more quantifiable evaluation data available? How do the values compare relative to each other and how has this work helped you quantify values?	PGE has a project with Pacific Northwest National Laboratory, with funding received from the US Department of Energy, to model the financial benefits of the 14 identified use cases. This work will not only provide PGE an understanding of the value of various use cases to each other, but will also model the financial benefits of providing multiple simultaneous use cases, which we expect to improve the overall economics of the energy storage system. This project will begin in Q3 of 2016 and conclude in Q3-Q4 of 2017.	05/16/16

2016 IRP: Feedback Status

Topic	Feedback Received	Resolution	Completed
Integrated Grid	You mention working with Energy Trust on the Rush Hour Rewards Pilot. Specifically, what has been/will be their role in the pilot?	Energy Trust and PGE are co-marketing the Rush Hour Rewards program with the Energy Trust's smart thermostat rebates. Both parties are providing links to the other's websites/enrollment portals. Energy Trust promotes Rush Hour Rewards on its Smart Thermostat program web page and PGE includes Energy Trust's program information on its website. This will become more important as PGE moves from simply enrolling existing thermostat owners to expanding the base of installed thermostats. Given the quantified efficiency benefits of Nest thermostats in particular (per the evaluations conducted for ETO by Apex Analytics), we feel that this collaboration is a win-win for ETO, PGE, and our customers.	03/06/2016

2016 IRP: Feedback Status

Portland General Electric

Topic	Feedback Received	Resolution	Completed
Integrated Grid	What is your estimate per household reduction for the Pricing Pilots for the estimated 3,500-7,000 customers? Why is the range of households participating so large? Which pilot has the most uncertainty in gaining targeted participation?	The uncertainty lies in the opt-in components, in particular time-of-use rates without a peak time rebate component. Preliminary results of initial enrollment show that signing up customers on these rates can be tough and often requires multiple touchpoints before getting to conversion. Additionally, our experimental design for the opt-in components requires a recruit-and-deny approach, meaning we have to over enroll each program and then assign some portion to the control group. We are targeting 3,850 participants for our opt-in rates, but this will require enrolling 6,340 all told. In addition, we will have 13,610 enrolled in opt-out Peak Time Rebates or Behavioral Demand Response.	05/06/2016

2016 IRP: Feedback Status

Topic	Feedback Received	Resolution	Completed
DR Potential Study	Please share your evaluation of the Energy Partner Pilot. You noted overlap with energy savings and Energy Trust's work. How is energy savings realized at these sites attributed to Energy Partner quantified and reported? Is an Energy Trust program also working with these sites and if so, have interactive effects between programs been addressed?	PGE's year 1 evaluation is available upon request. The final year 2 report will be provided to staff along with our annual report 4/29/16. In general, participants in Energy Partner are industrial customers with load that is simply being shifted to a later time. For this reason, estimation of total energy impacts was not included in the scope of work for the current evaluation. Events occur only a handful of times a year for a few hours and they are not expected to have a large impact on total energy consumption at the annual level. That being said, it may be interesting for Energy Trust to look at differences in energy savings between DR and non-DR participants in their SEM evaluations in the future.	03/09/16

2016 IRP: Feedback Status

Topic	Feedback Received	Resolution	Completed
Integrated Grid	What does “identifying the system benefit of targeted peak energy usage education….” mean? Does it mean “quantifying”? If so, is the system benefit the actual capacity reduction or is the benefit quantified in dollars?	The evaluation will identify both the benefit both in terms of average peak reductions (our planning estimates are 3% of residential load for behavioral intervention alone) and the monetary value of the avoided capacity investment.	05/16/2016
DR Potential Study	In the High Case for DR Potential, do default TOU and Peak time Rebates replace the opt-in type programs in the low and base cases?	Yes, that is correct.	05/16/2016

2016 IRP: Feedback Status

Topic	Feedback Received	Resolution	Completed
DR Potential Study	If the High Case programs are cost effective, listing the barriers to acquisition and risk factors and any specific actions that may help overcome those barriers would be helpful. The difference in potential impact is high so it will be necessary to clearly see the barriers and the magnitude of effort/costs for what it would take to overcome the barriers in order to reach that high impact level.	The biggest component that differentiates the high case form the others is the default time-variant rates. We have received feedback from several stakeholders (most recently CUB and ODOE) that they would not be comfortable moving forward with these sorts of programs. The other barrier is simply one of funding and timeline. The high case includes more aggressive participation targets and timelines that would require a rapid scaling of resources. This would be a departure from the more measured phasing-in of programs that stakeholders have seemed to favor to date.	05/16/2016

2016 IRP: Feedback Status

Topic	Feedback Received	Resolution	Completed
Resource Adequacy Study	Slide 89 (Public Meeting, 12/17/2015) states that generalizations will be made for capacity needs and capacity contributions for other years and resource combinations. Does this mean that the analysis was done for 2021 only and other years will be estimated based off the 2021 work? Please provide more description as to how this study will be used.	PGE presented data from RECAP runs for 2025 and 2030 in the 03/09/2016 meeting (Roundtable #16-1). The presentation also included capacity need values for all years of the IRP study based on interpolating/extrapolating from the RECAP runs. Interpolations and extrapolations are used to reduce the quantity of model runs that would be needed to cover every year and every combination of resources in those years.	05/16/2016
Resource Adequacy Study	Slide 72 (Public Meeting, 12/17/2015) notes that energy efficiency is in the load forecast. Does the hourly shape (binned hour and day type impacts vs hourly) of the energy savings align with the Energy Trust's updated end use load shapes from the Power Council?	The hourly shape of the energy efficiency in the load forecast is not based on the load shapes from the Power Council.	05/16/16

2016 IRP: Feedback Status

Portland General Electric

Topic	Feedback Received	Resolution	Completed
Resource Adequacy Study	Slide 91 (Public Meeting, 12/17/2015), Please add energy efficiency to this list of modeling options for next cycle to be modeled as a resource, not a decrement to load.	PGE discussed this issue in the 12/17/2015 Public Meeting and the 03/09/2016 Round Table. It is on the list to investigate for the next IRP cycle. As discussed, due to modeling issues, it may not be practical to capture energy efficiency as a resource, but it may be possible to use different load scenarios to examine the impacts of different levels of energy efficiency.	05/16/16
Futures & Portfolios	Please clarify assumptions used for market depth for energy and capacity. Recommend limiting the amount of market purchases to a level in line with historical capabilities or justified future market depth projections to provide energy/capacity. For example, in portfolio 1, how does the 961 MW of market capacity compare to historical and estimated future market possible size?	Portfolio 1 is not intended to be representative of forward-going energy or capacity "market depth." Rather, this portfolio serves an analytical baseline from which to judge the relative costs and risks of strategies that are intended to satisfy resource adequacy standards. The assessment of portfolio reliability occurs as an element of the portfolio scoring process.	05/16/2016

2016 IRP: Feedback Status

Portland General Electric

Topic	Feedback Received	Resolution	Completed
Futures & Portfolios	Generally, why study 2021 for ELCC and 2025 for portfolio coverage? Why the difference?	PGE is studying 2021, 2025, and 2030 for resource adequacy and renewable capacity contribution. Resource portfolio cross-sectional views have been presented at 2021 and 2025 snapshots.	05/16/2016
Futures & Portfolios	Slides 99 and 100 differentiate between Capacity and Summer or Winter capacity. Please explain the difference between the two and how they were determined. Suggest showing capacity needs by having portfolios not reach the capacity need line, not with two blocks (Capacity and either summer or winter capacity)	In PGE's December Public Meeting, we attempted to illustrate the expectation that different resource portfolios contribute to PGE's system capacity differently on a seasonal basis. For example, an incremental portfolio composed primarily of solar resources might contribute more towards system capacity in the summer than the winter, and the opposite might be true for particular wind resources. Please refer to PGE's current resource portfolios for a more streamlined representation of portfolio capacity contribution.	05/16/2016

2016 IRP: Feedback Status

Topic	Feedback Received	Resolution	Completed
Futures & Portfolios	How was this portfolio creation process illustrated in the past and is this current approach meant to be a new approach that addresses concerns from last time?	PGE's portfolio creation process was generally described verbally rather than illustrated visually, and did not consider factors such as ELCC or attempt make distinctions based on seasonal needs or capabilities. I'm unaware of any specific feedback regarding concerns surrounding the portfolio creation process in PGE's prior IRPs.	05/16/2016
Futures & Portfolios	Slide 98 (Public Meeting, 12/17/2015), portfolio 3 shows 600aMW of PNW Wind. This resource then equates to just 127 MW winter VER capacity and 235 MW summer VER capacity. Compare that to portfolio 2 where 243aMW PNW Wind equates to 98 MW winter VER capacity and 111 MW summer VER capacity. For more than 2 times the PNW Wind in energy in portfolio 3 vs portfolio 2, why is the winter capacity contribution in portfolio 3 just 30% more than in portfolio 2?	In general, a given variable resource is expected to provide diminishing marginal contribution to system capacity as increasing quantities are included in a portfolio (the last MW addition contributes less than the first MW addition).	05/16/2016

2016 IRP: Feedback Status

Topic	Feedback Received	Resolution	Completed
Futures & Portfolios	Please describe the methodology used in determining the Capacity needs vs the market needs for slides 99 and 100 (Public Meeting, 12/17/2015).	PGE needs more information to address this question.	05/09/2016
Futures & Portfolios	Consistency in labeling between all three plots would be helpful. VER should remain differentiated by type of wind and solar added (Public Meeting, 12/17/2015)	PGE's approach to estimating the capacity contribution of variable energy resources considers the portfolio of incremental variable resources and does not attempt to parse the contribution of that portfolio back to its constituents.	
Futures & Portfolios	When are scenario discussions scheduled?	PGE has presented the risk factors (Futures) that will be considered in scenario analysis at the August and December IRP Public Meetings. Feedback was sought during those discussions.	12/17/2015

2016 IRP: Feedback Status

Topic	Feedback Received	Resolution	Completed
Futures & Portfolios	Please provide an exploration of how SB 1547 affects resource choices near-term.	The May 16, 2016 presentation will address this feedback.	05/16/2016
Futures & Portfolios	Discuss how later RPS obligations (2025; 2030; 2035; 2040) should influence Boardman replacement choices; as well as how these are affected by Federal tax considerations, the RPS cap on rate increases, etc.	The May 16, 2016 presentation will address this feedback.	05/16/2016
Futures & Portfolios	PGE’s scenarios account for fuel cost future variability, how is the Company capturing sensitivities related to wind, solar, and storage technology cost curve variability	The May 16, 2016 presentation will address this feedback.	05/16/2016