Portland General Electric

2016 Integrated Resource Plan

Roundtable #16-2
May 16, 2016

Meeting Logistics

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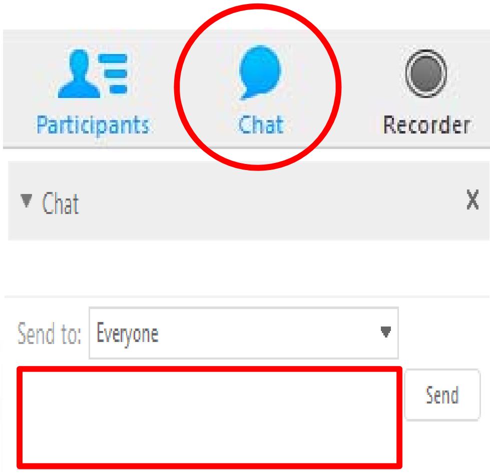
Local Participants:

- 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 –

Today's Round Table Topics

- Overview
- RPS Compliance
- Portfolios & Resources
- Modeling Methodology
- Flexible Capacity Study
- Energy Storage
- Boardman Biomass
- IRP Feedback & Next Steps

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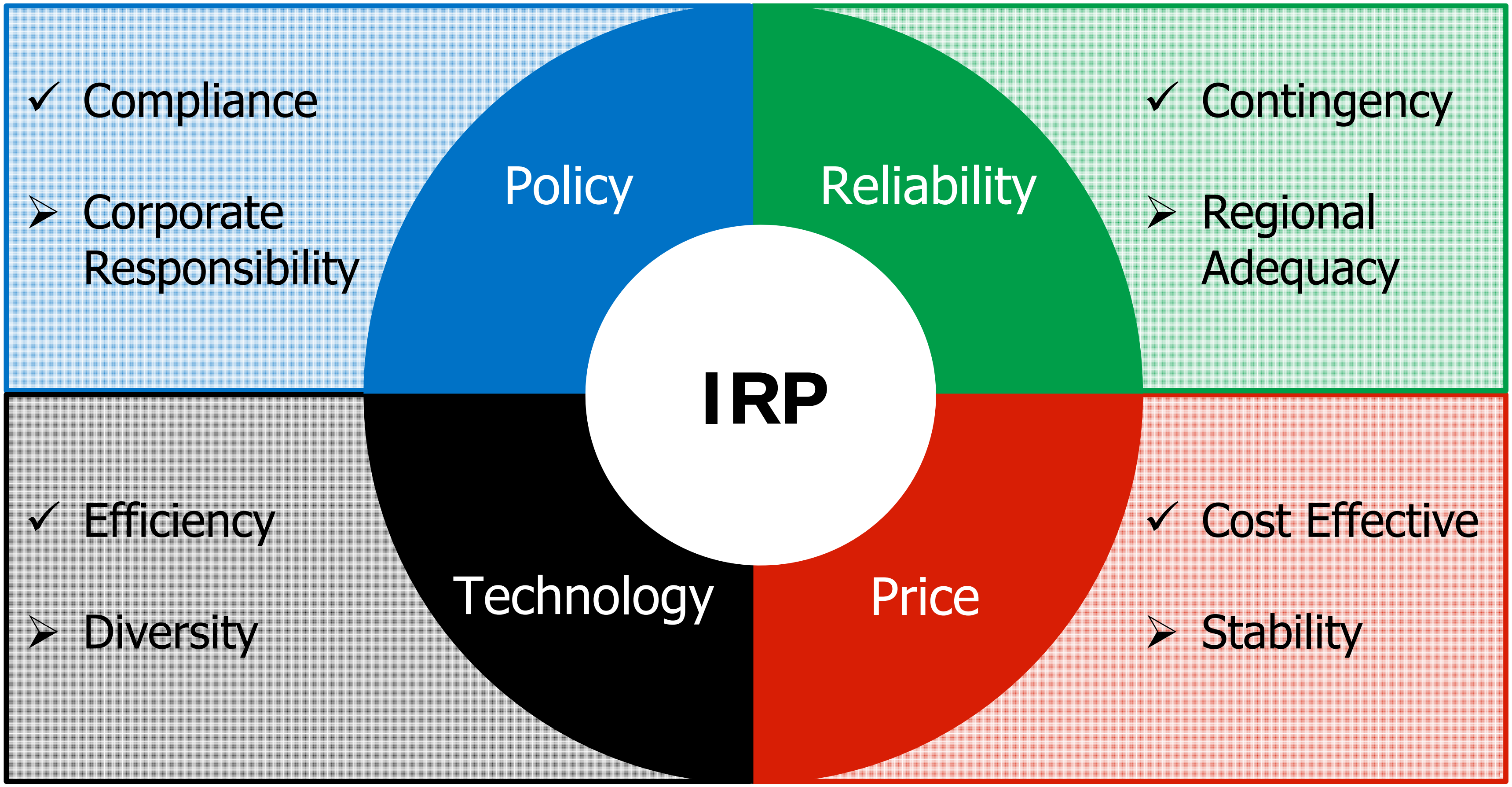
Public Process Overview

Guiding Philosophy

PGE's IRP is framed by four directional drivers



Metric based-decisions

- ✓ Constraints which will be met
- ➢ Values that inform decisions

2016 IRP Development Status

Item	Status
Round Table Meetings	**8 Planned** (6 complete, 2 scheduled)
Commission Meetings	**2 Planned** (2 complete)
Feedback Forms	**4 Received** (0 since last meeting)
2013 IRP Action Plan	**5 Actions (OPUC Order No. 14-415)**
Supply Side	Hydro contracts, portfolios, no major resources
Demand Side	Energy Efficiency, Demand Response, Conservation Voltage Reduction
Enabling Studies	Load forecast, EE, DG, EIM, Capacity, Flexibility, Biomass
Transmission	PGE continues to retain and acquire service under the BPA's Open Access Transmission Tariff
Other	RPS, Clean Power Plan
Related Topics	UM 1708 (DR); UM 1716 (VoS); UM 1719 (VER CC); UM 1751 (Energy Storage)
2016 IRP Development	**~13 Chapters**
Draft	Content under development
Final	Planned filing September 16, 2016*

*Date subject to change

Round Table Meeting Schedule*

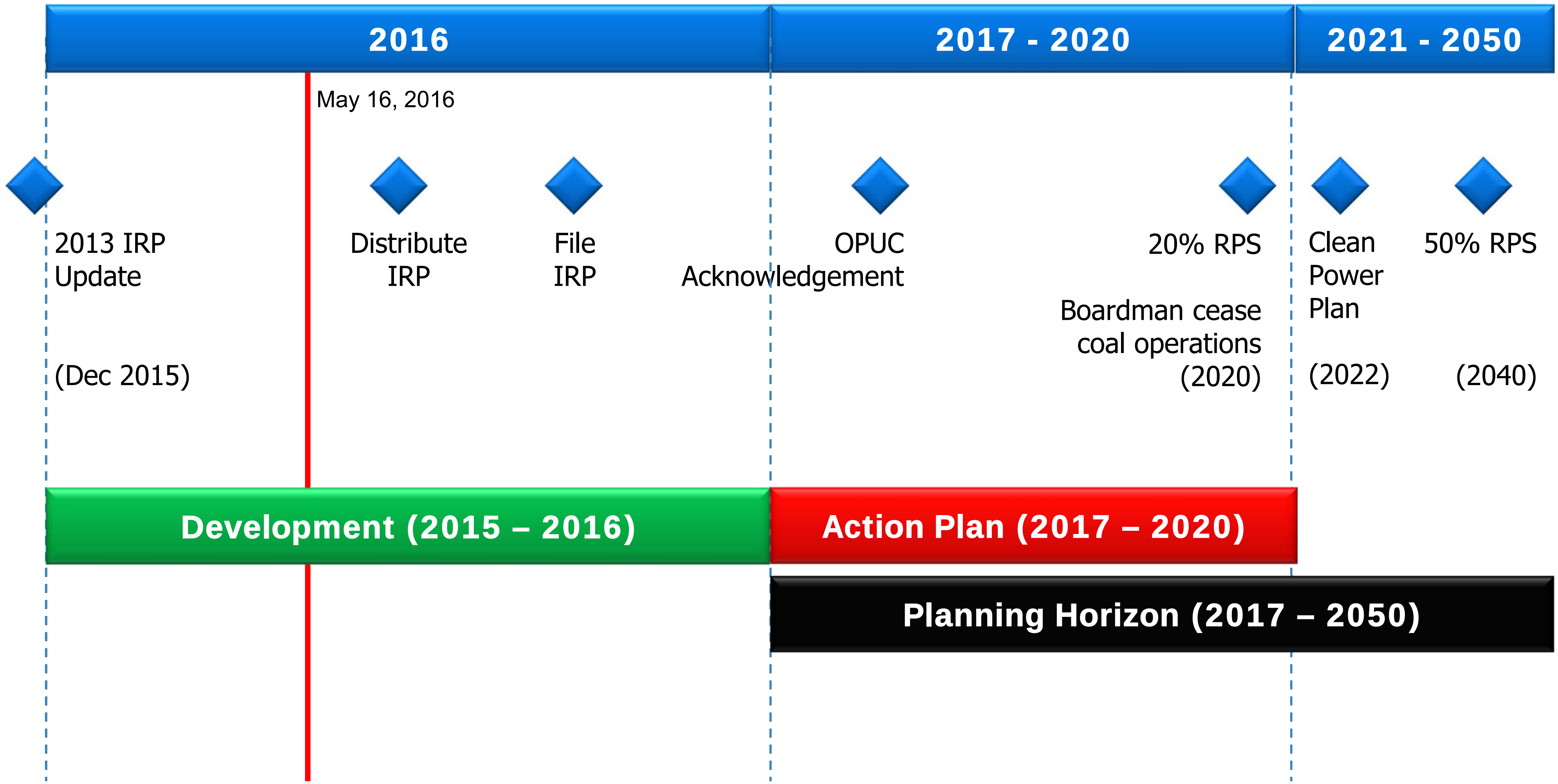
PGE plans to hold quarterly round tables to communicate with and gather feedback from stakeholders

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

* All dates subject to change
** Draft IRP scheduled for distribution on September 16
*** Final IRP scheduled for filing on November 4

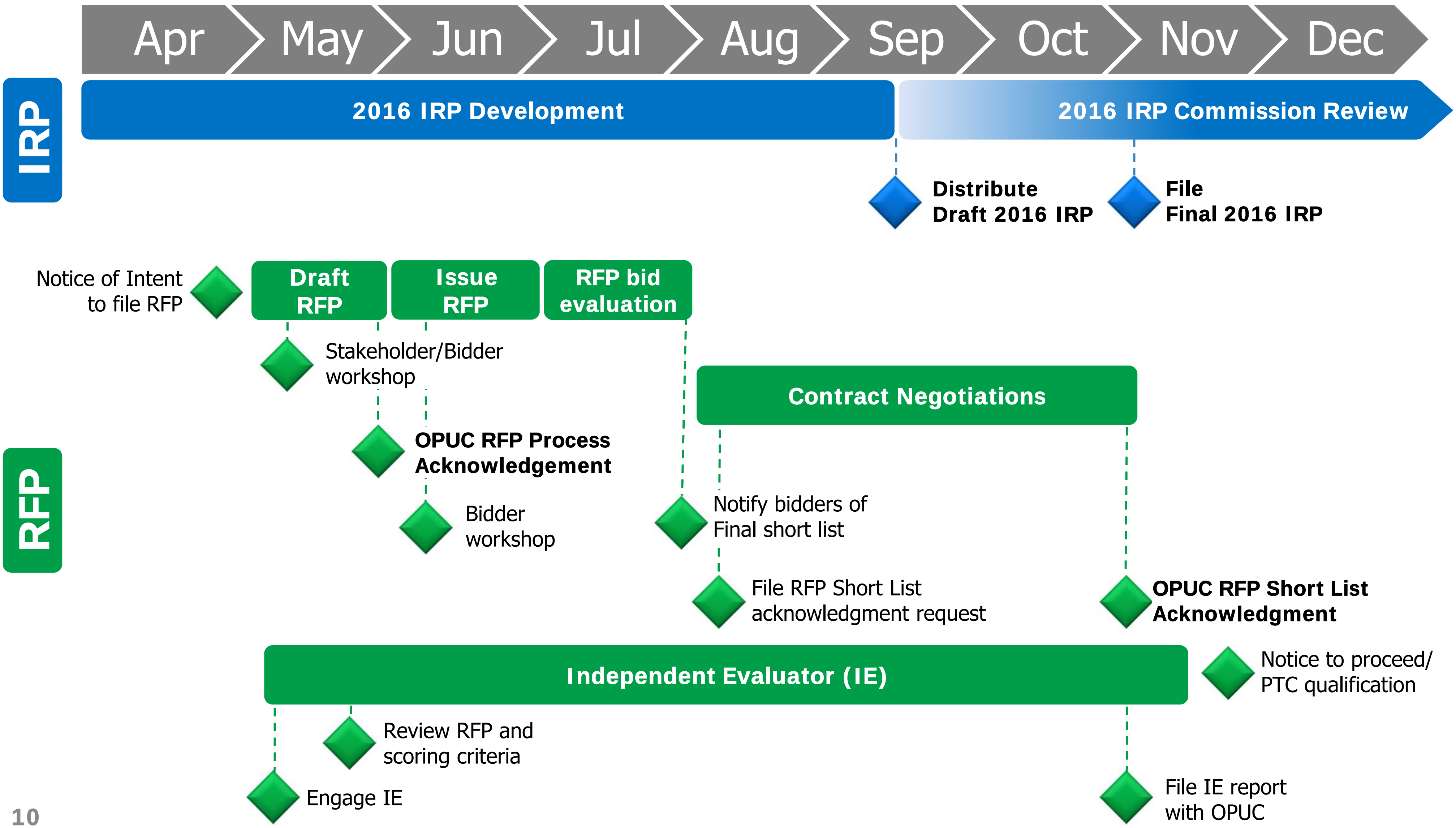
2016 IRP Timeline

The 2016 IRP evaluates a planning horizon through 2050 to inform actions through 2020



2016 Renewable RFP – Proposed Timeline

Parallel IRP and Renewable RFP timelines may affect distribution and filing dates for the 2016 IRP



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RPS Strategy

RPS Strategy– Framing Questions

- **Primary question:**

What RPS timing strategy should IRP employ as a common assumption and test through sensitivities?

- **Secondary question:**

Can PGE's identified RPS timing strategy be accomplished under established IRP and RFP procedure?

RPS Strategy– March 9th Review

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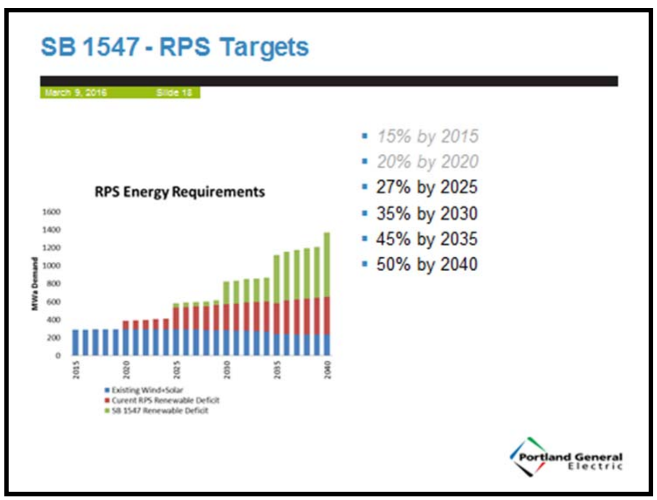
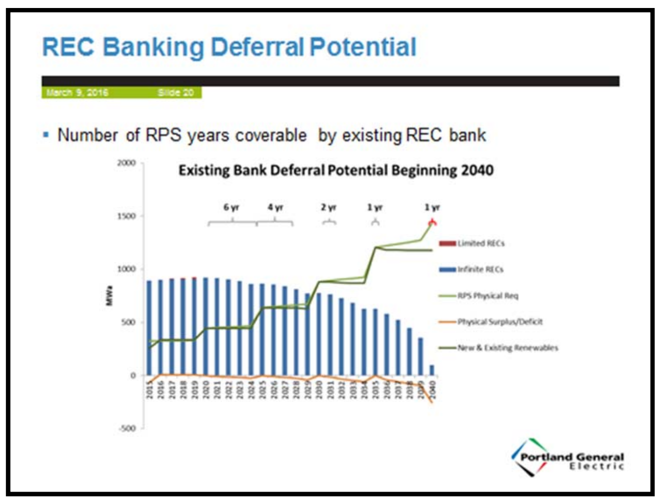
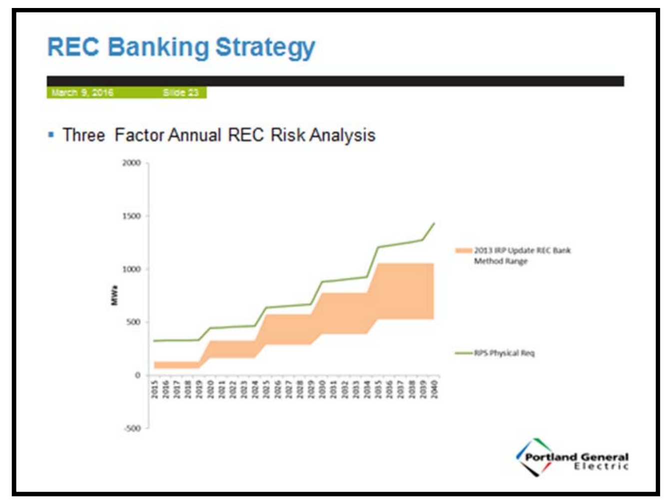
Primary takeaways from March 9th:

- SB 1547 has increased the RPS standard and changed REC banking rules
- The Production Tax Credit has been extended but begins to sunset after year end 2016
- PGE has identified an escalating REC banking target meant to address short term risk related to weather and procurement failure







RPS Strategy– Timing Analysis

Energy additions needed to meet the RPS standard:

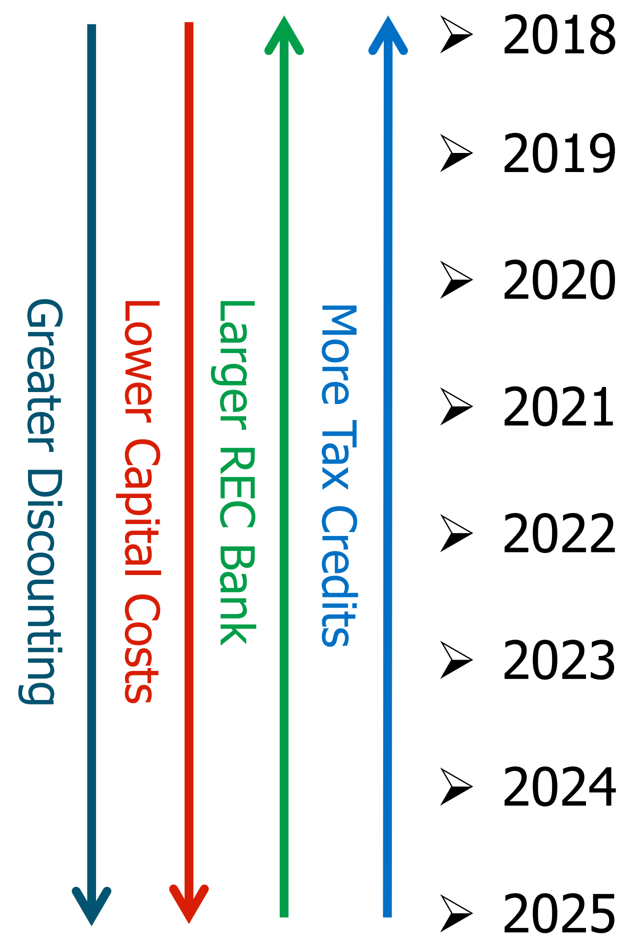
- 2020: 70 MWa
- 2025: 183 MWa (253 MWa cumulative)

Compliance opportunities include:

- Using banked RECs until 2025
- Resource procurement with 2018 COD
- All years between

Compliance considerations:

- Tax credit availability
- Expected wholesale power prices
- Targeted renewable energy credit banking levels
- The timing of long-term procurement
- The forecasted decline in technology capital costs
- Inflation and the time value of money

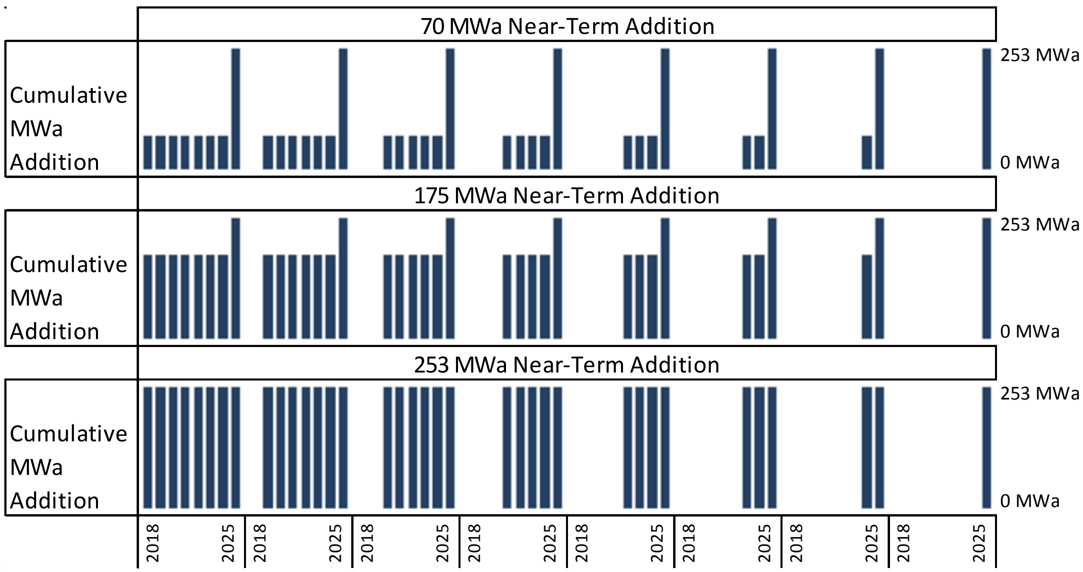


RPS Strategy– Timing Analysis

Renewable Portfolio Revenue Requirement Analysis -

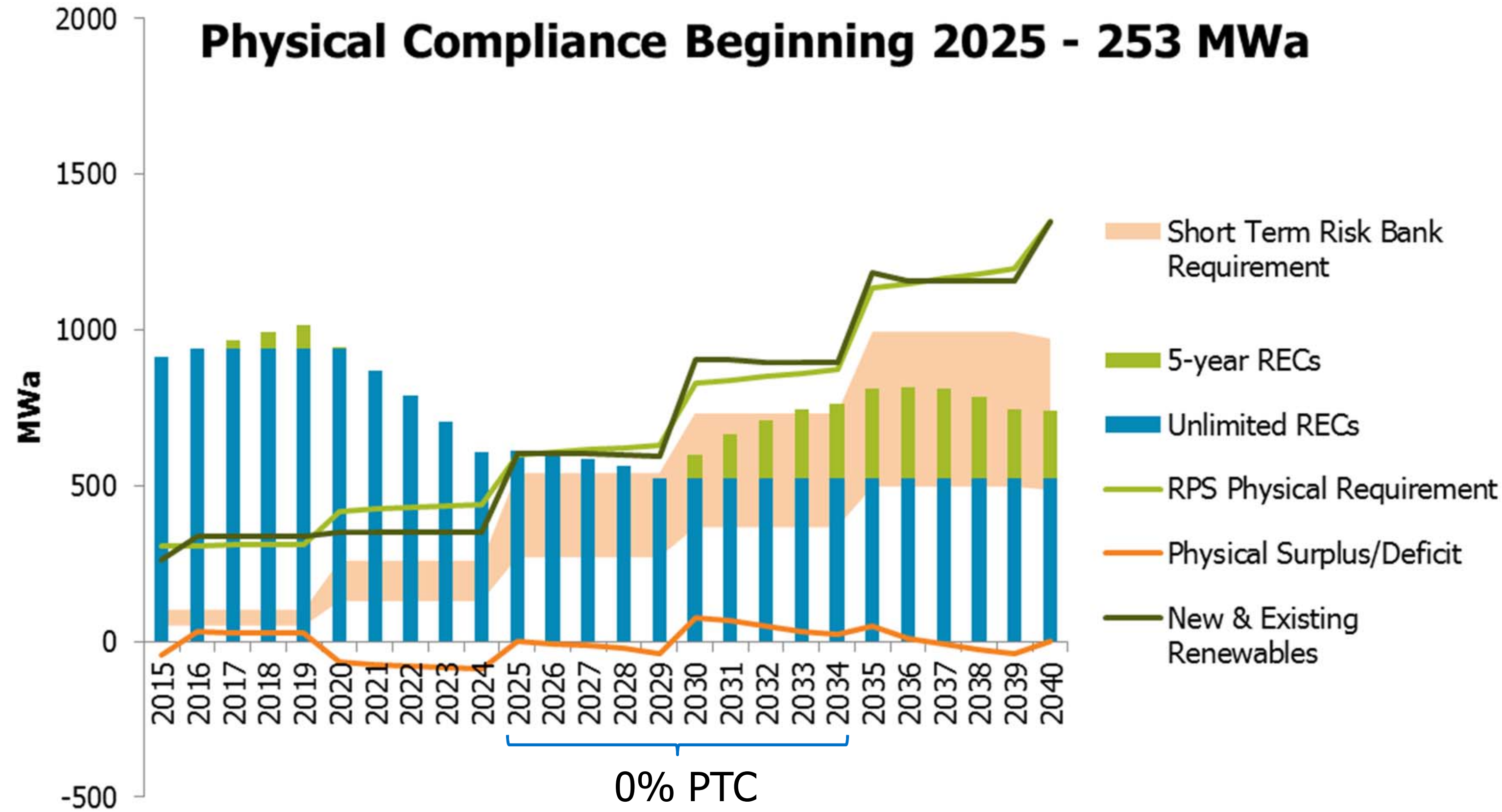
Studied 22 portfolios adding 70, 175, or 253 MWa in all years 2018-2025

All portfolios build 253 MWa cumulative by 2025



1. Gorge wind only - assuming a decline in capital costs
2. 2030 build adjusted to reach 2035 banked REC target, 2035 build adjusted to reach 2040 banked REC target, all portfolios physically compliant in 2040
3. Present value revenue requirement calculated for all portfolios less energy value

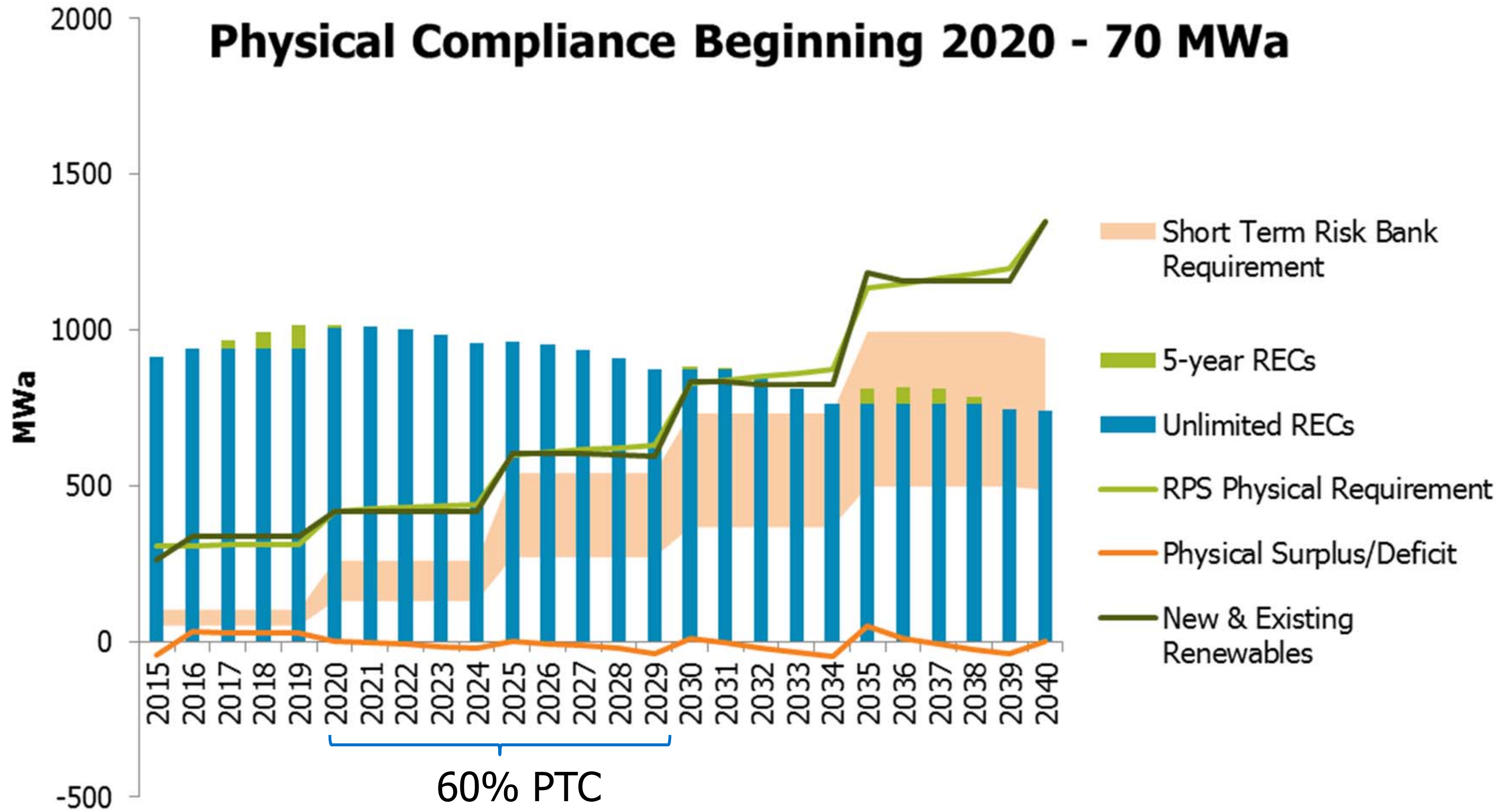
RPS Strategy - Results



Near-Team Addition	Reduction in NPVRR		
Year↓ Size→	70 MWa	175 MWa	253 MWa
2018 (100% PTC)			
2019 (80% PTC)			
2020 (60% PTC)			

Cost Reductions of Near-term Addition
Compared to a 253 MWa addition in 2025 (2016$).

RPS Strategy - Results



Near-Team Addition	Reduction in NPVRR		
Year↓ Size→	70 MWa	175 MWa	253 MWa
2018 (100% PTC)			
2019 (80% PTC)			
2020 (60% PTC)	***$ 30 M***		

Cost Reductions of Near-term Addition
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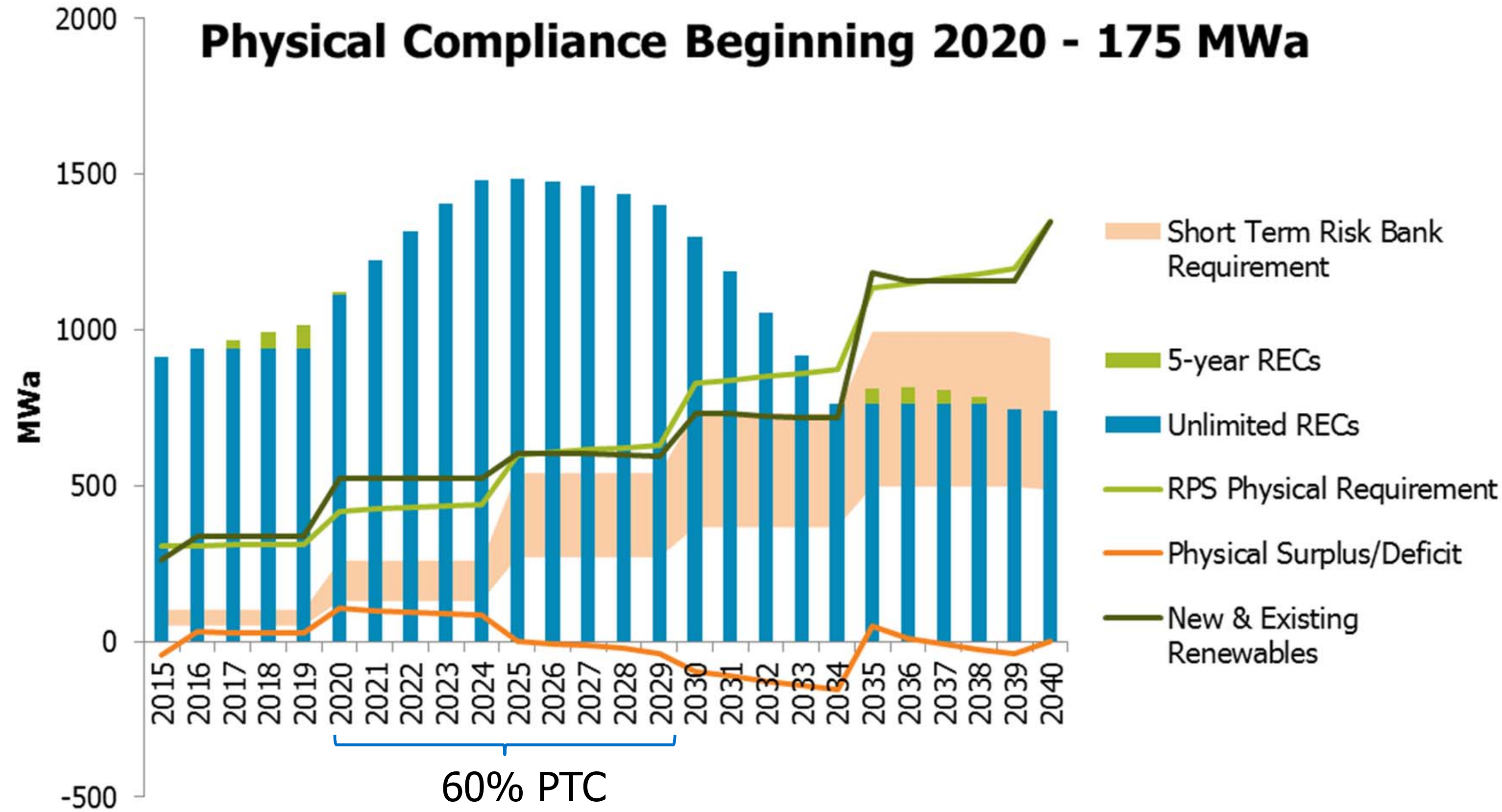
RPS Strategy - Results



Near-Team Addition	Reduction in NPVRR		
Year↓ Size→	70 MWa	175 MWa	253 MWa
2018 (100% PTC)			
2019 (80% PTC)			
2020 (60% PTC)	$ 30 M	***$ 70 M***	

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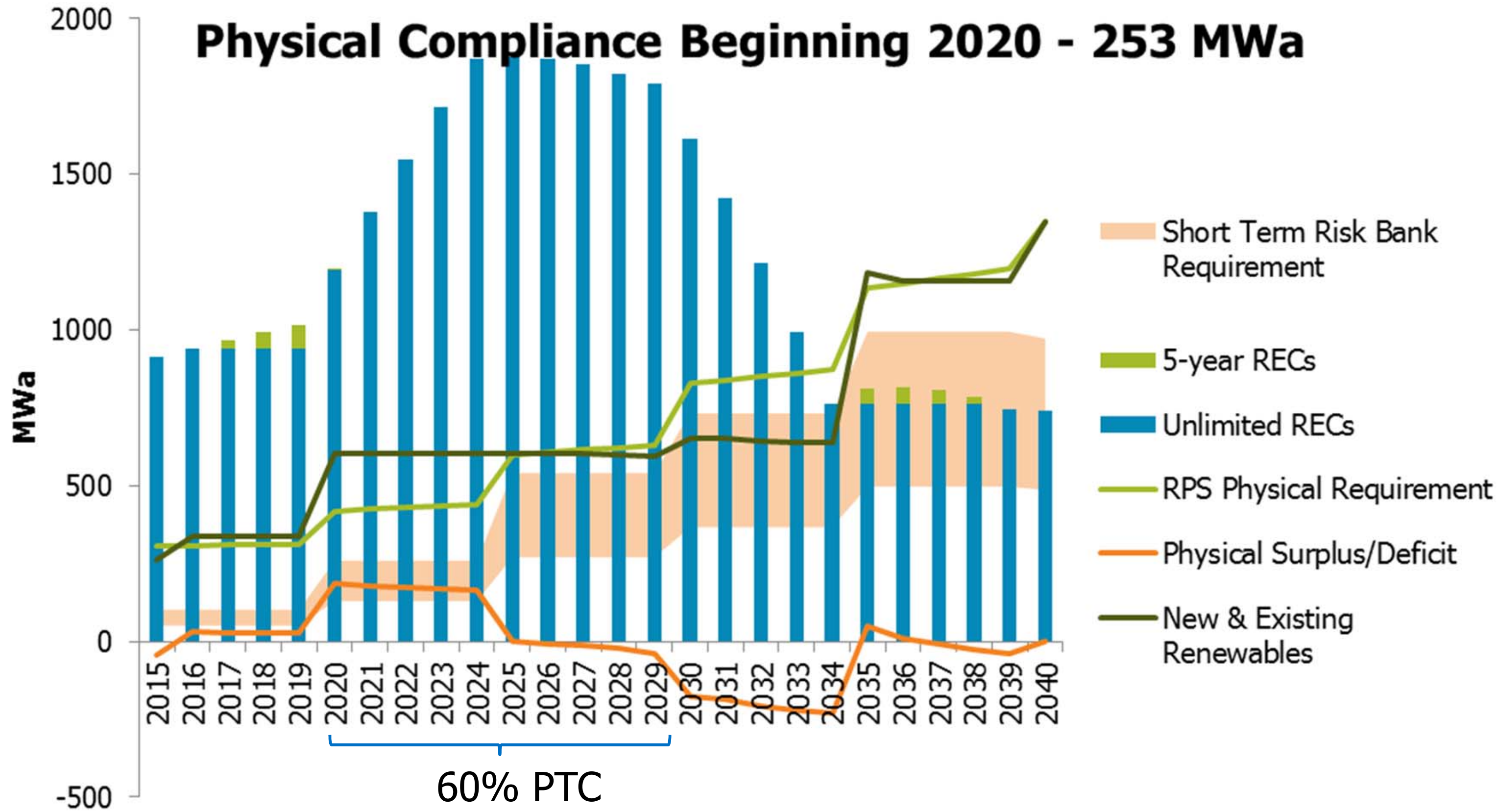
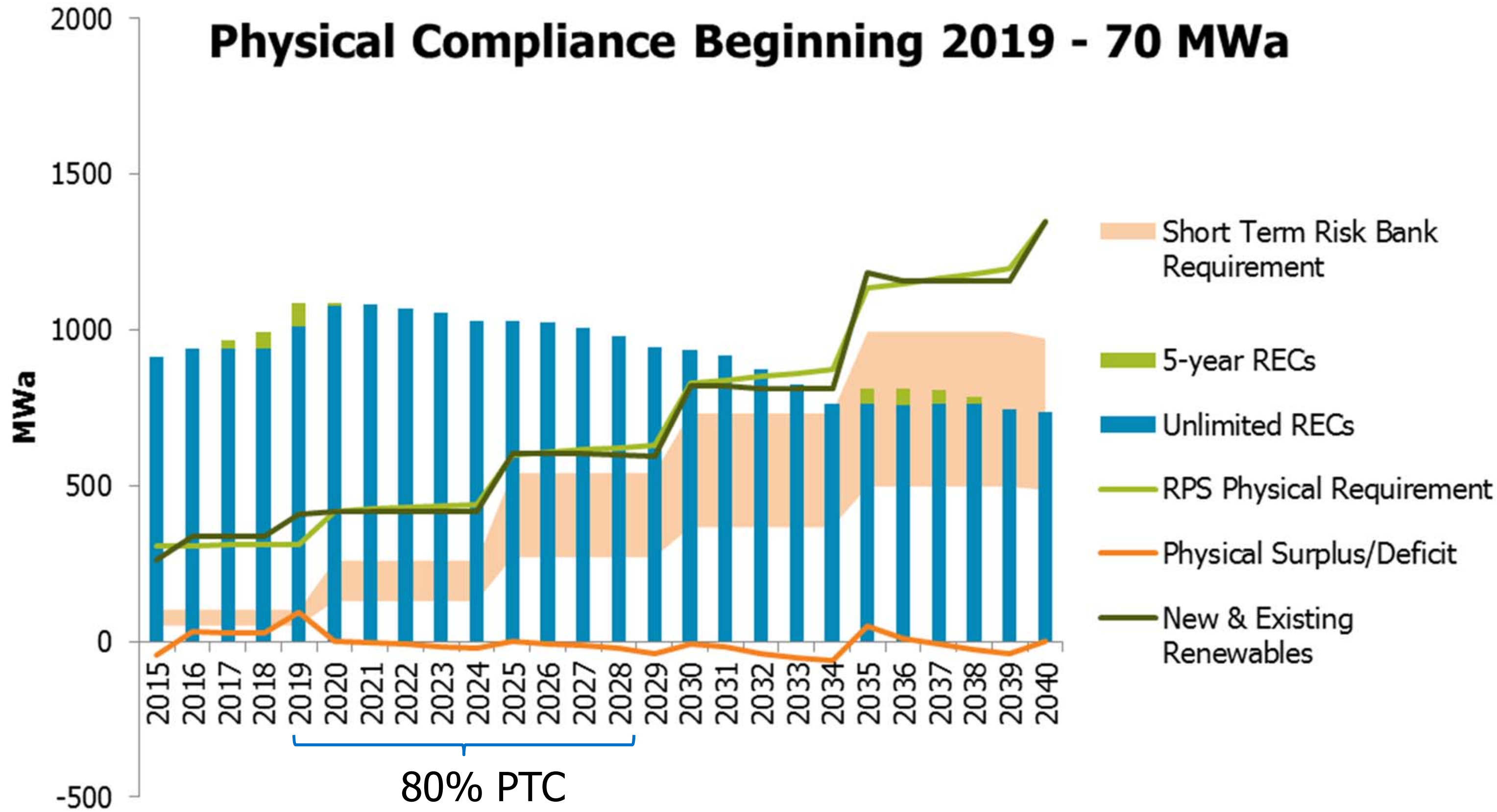
RPS Strategy - Results



Near-Team Addition	Reduction in NPVRR		
Year↓ Size→	70 MWa	175 MWa	253 MWa
2018 (100% PTC)			
2019 (80% PTC)			
2020 (60% PTC)	$ 30 M	$ 70 M	***$ 105 M***

Cost Reductions of Near-term Addition
Compared to a 253 MWa addition in 2025 (2016$).

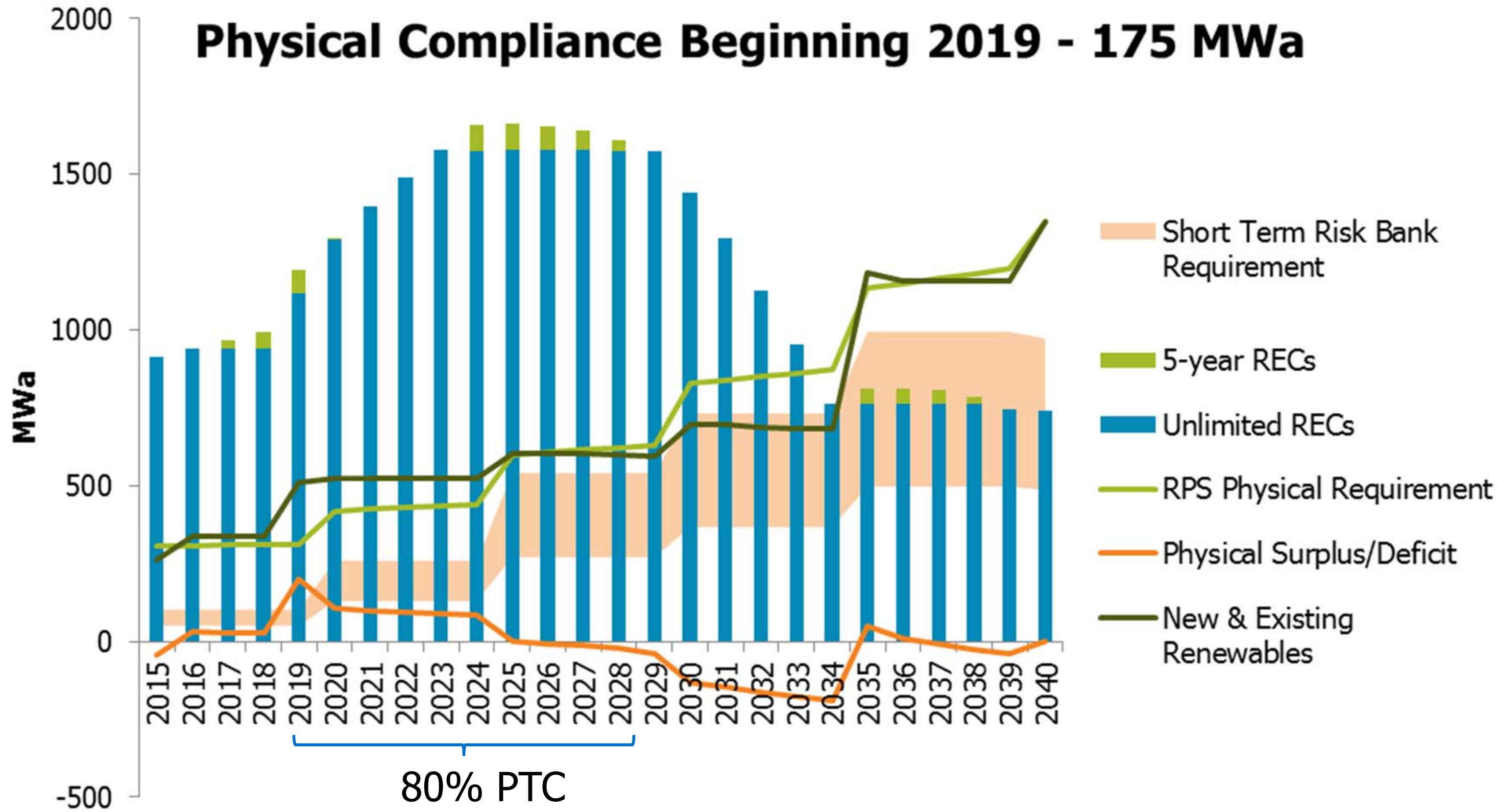
RPS Strategy - Results



Near-Team Addition	Reduction in NPVRR		
Year↓ Size→	70 MWa	175 MWa	253 MWa
2018 (100% PTC)			
2019 (80% PTC)	***$ 50 M***		
2020 (60% PTC)	$ 30 M	$ 70 M	$ 105 M

Cost Reductions of Near-term Addition
Compared to a 253 MWa addition in 2025 (2016$).

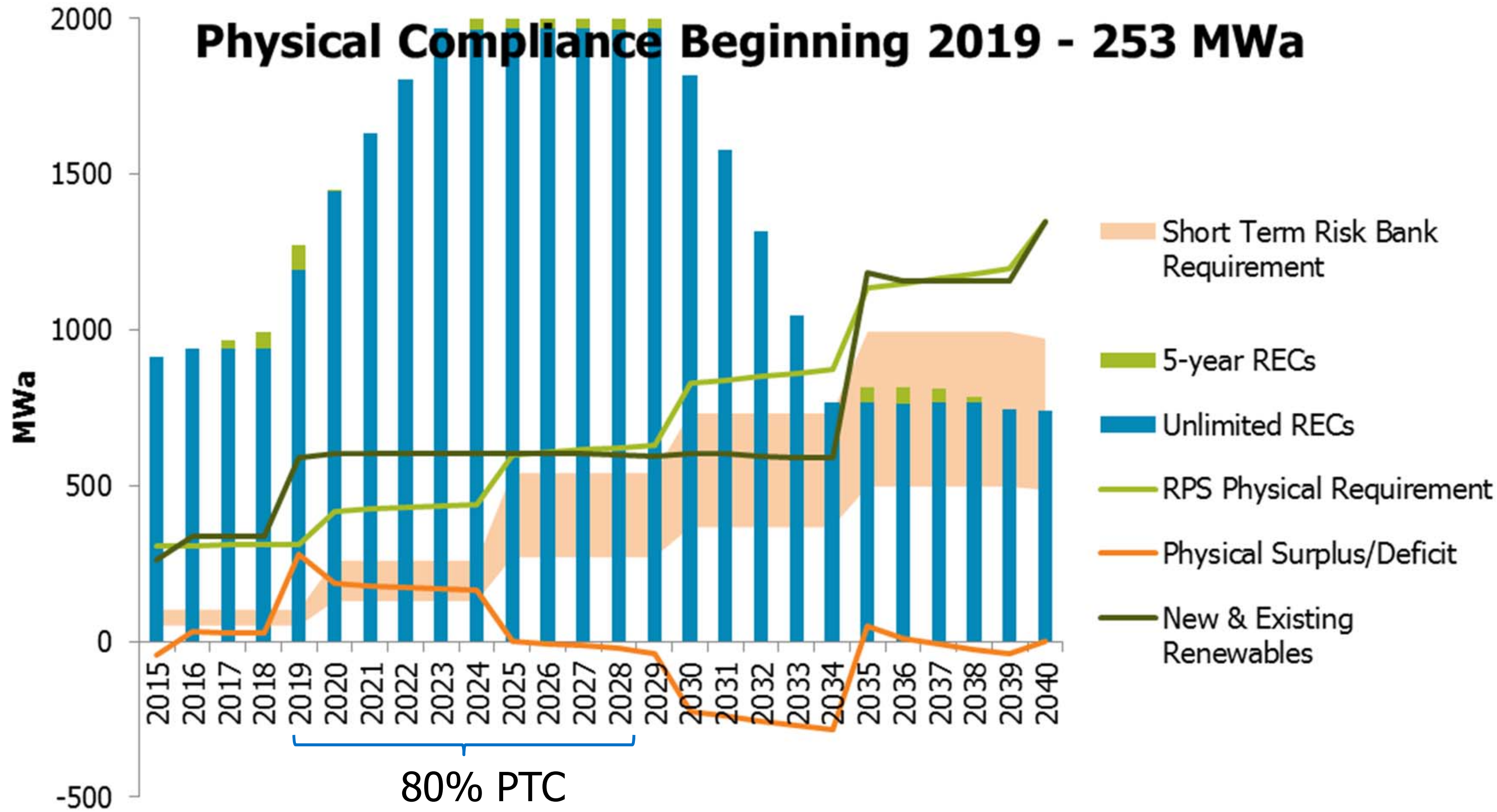
RPS Strategy - Results



Near-Team Addition	Reduction in NPVRR		
Year↓ Size→	70 MWa	175 MWa	253 MWa
2018 (100% PTC)			
2019 (80% PTC)	$ 50 M	***$ 125 M***	
2020 (60% PTC)	$ 30 M	$ 70 M	$ 105 M

Cost Reductions of Near-term Addition Compared to a 253 MWa addition in 2025 (2016$).

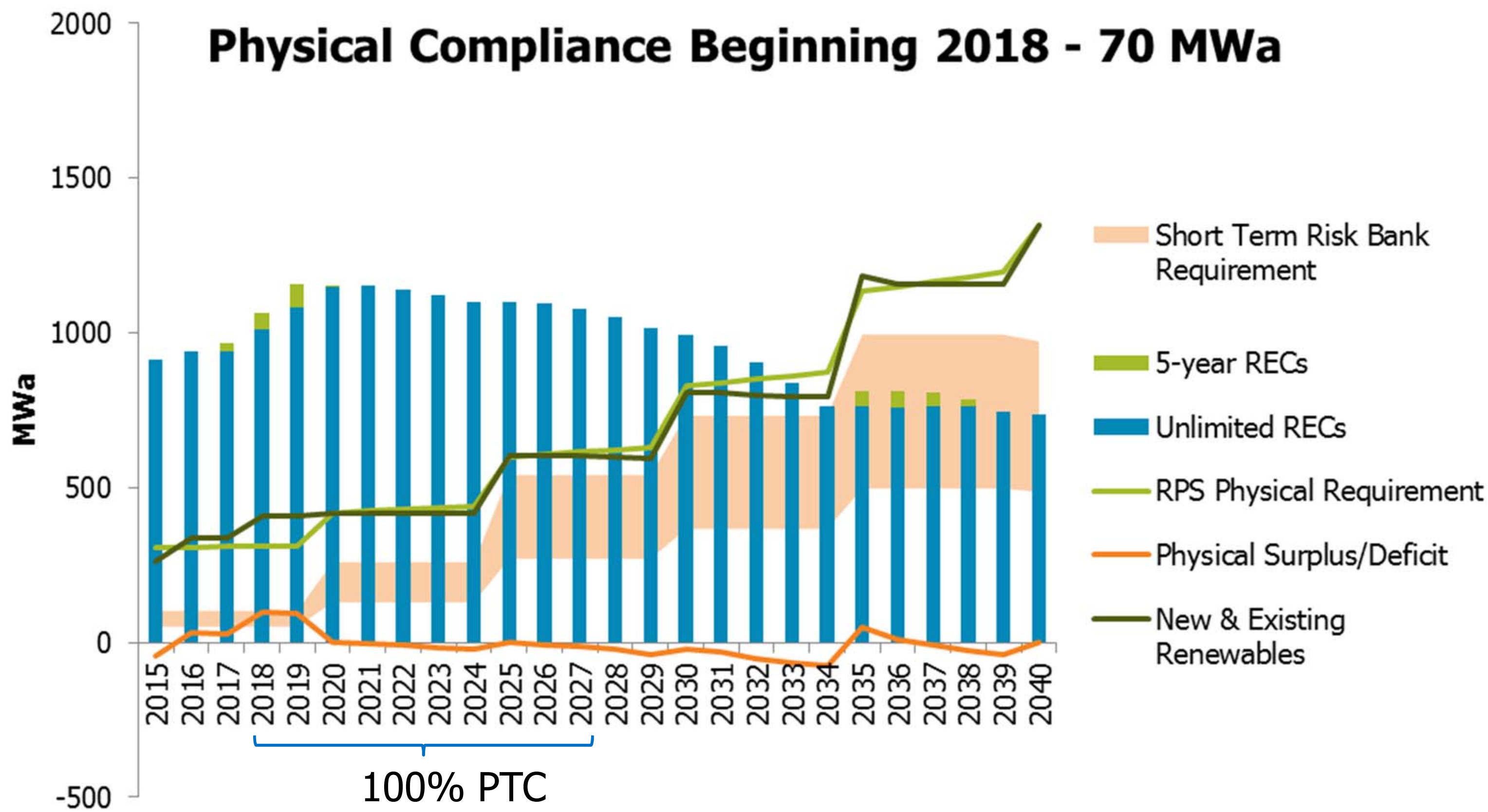
RPS Strategy - Results



Near-Team Addition	Reduction in NPVRR		
Year↓ Size→	70 MWa	175 MWa	253 MWa
2018 (100% PTC)			
2019 (80% PTC)	$ 50 M	$ 125 M	***$ 185 M***
2020 (60% PTC)	$ 30 M	$ 70 M	$ 105 M

Cost Reductions of Near-term Addition
Compared to a 253 MWa addition in 2025 (2016$).

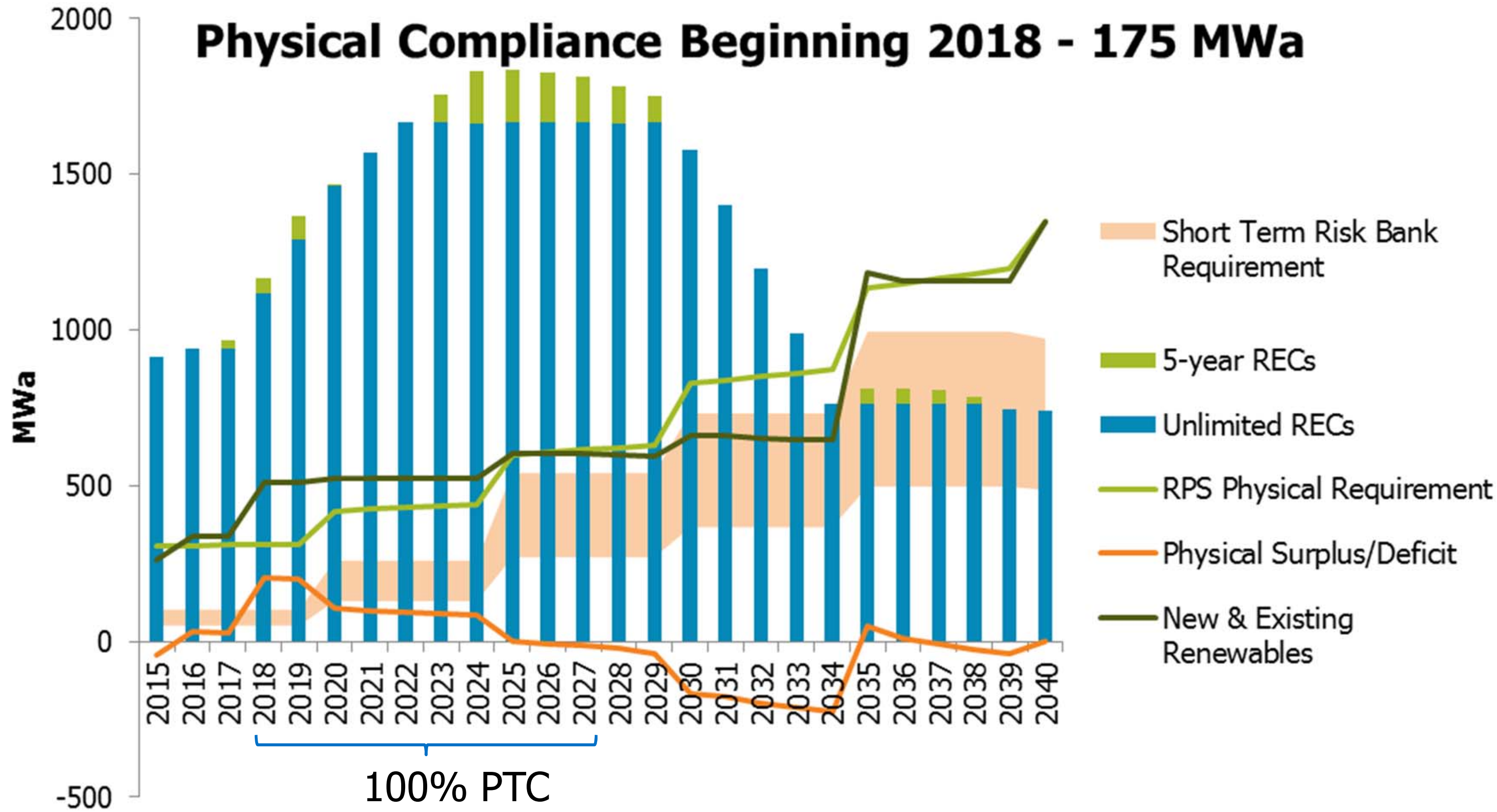
RPS Strategy - Results



Near-Team Addition	Reduction in NPVRR		
Year↓ Size→	70 MWa	175 MWa	253 MWa
2018 (100% PTC)	***$ 75 M***		
2019 (80% PTC)	$ 50 M	$ 125 M	$ 185 M
2020 (60% PTC)	$ 30 M	$ 70 M	$ 105 M

Cost Reductions of Near-term Addition Compared to a 253 MWa addition in 2025 (2016$).

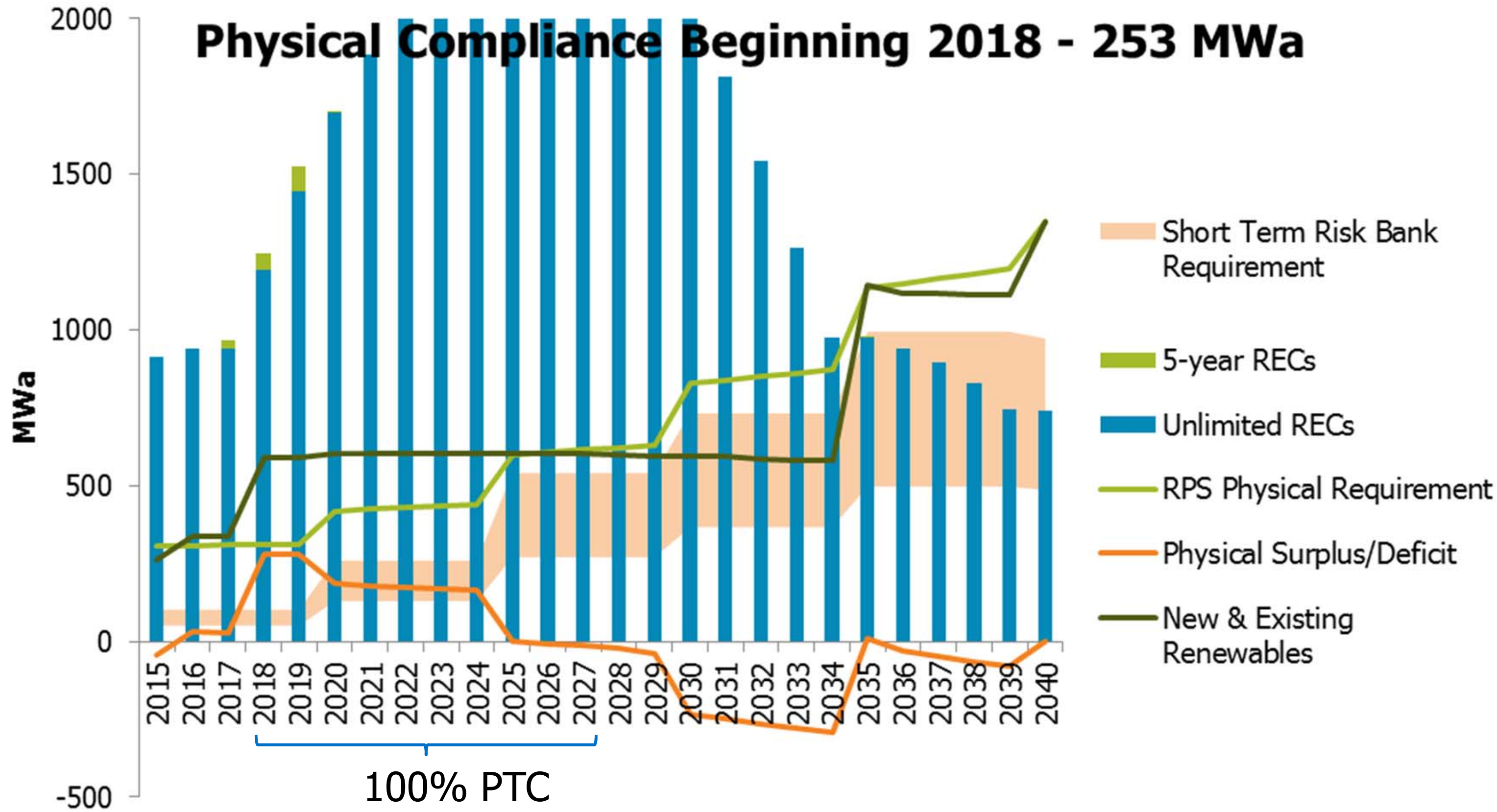
RPS Strategy - Results



Near-Team Addition	Reduction in NPVRR		
Year↓ Size→	70 MWa	175 MWa	253 MWa
2018 (100% PTC)	$ 75 M	***$ 185 M***	
2019 (80% PTC)	$ 50 M	$ 125 M	$ 185 M
2020 (60% PTC)	$ 30 M	$ 70 M	$ 105 M

Cost Reductions of Near-term Addition
Compared to a 253 MWa addition in 2025 (2016$).

RPS Strategy - Results



Near-Team Addition	Reduction in NPVRR		
Year↓ Size→	70 MWa	175 MWa	253 MWa
2018 (100% PTC)	$ 75 M	$ 185 M	***$ 265 M***
2019 (80% PTC)	$ 50 M	$ 125 M	$ 185 M
2020 (60% PTC)	$ 30 M	$ 70 M	$ 105 M

Cost Reductions of Near-term Addition
Compared to a 253 MWa addition in 2025 (2016$).

RPS Strategy - Results

1. **Expected revenue requirement is lowered by capturing PTC as early as feasible**

2. **Bringing more resources forward from the 2025 RPS obligation increases potential savings to customers**

3. **Approximately 175 MWa in 2018 targets a balance between demand uncertainty and reduction of NVPRR**

Near-Team Addition	Reduction in NPVRR		
Year↓ Size→	70 MWa	175 MWa	253 MWa
2018 (100% PTC)	$ 75 M	$ 185 M	$ 265 M
2019 (80% PTC)	$ 50 M	$ 125 M	$ 185 M
2020 (60% PTC)	$ 30 M	$ 70 M	$ 105 M

Cost Reductions of Near-term Addition
Compared to a 253 MWa addition in 2025 (2016$).

RPS Strategy - Results

RPS results confirmed by sensitivity analysis

- Near-term additions (i.e., projects with PTC benefit) result in cost reductions irrespective of REC bank benefit to long term compliance
- Parallel analysis demonstrates that near-term additions result in savings when considering the potential for alternative renewable resource technologies, associated capacity benefits, alternative long term procurement flexibility.

2018 175 MWa renewable resource strategy to be included as common IRP portfolio assumption. Additional RPS timing sensitivities will identify portfolio effects related to RPS strategy.

RPS Strategy - Timing

Preferred RFP strategy requires immediate action

- 100% PTC qualification requires commence construction or safe harbor by year end 2016
- 80% PTC qualification requires commence construction or safe harbor by year end 2017
- Neither strategy will allow for IRP acknowledgment before required notice to proceed

Given the quantity of cost reductions made available by identified RPS strategy, PGE has initiated a process for a 2016 Renewable RFP

First stakeholder and bidder workshop Wednesday May 18

RFP - Schedule

RFP Process	Date
Notice of Intent to issue RFP	5/2/2016
Petition for partial waiver submitted to OPUC	5/4/2016
Engage Independent Evaluator (IE) (same IE as prior RFP)	5/4/2016
Draft RFP issued to interested parties and OPUC	5/13/2016
Conduct Bidder/Stakeholder workshop on draft RFP	5/18/2016
Submit final draft RFP to OPUC (include redline to draft RFP)	5/23/2016
Obtain Commission approval of RFP	6/7/2016
Issue final renewable RFP	6/8/2016
Conduct bidder workshop on final RFP	6/9/2016
RFP proposals from bidders due	6/24/2016
RFP evaluate complete	7/14/2016
Final shortlist notification	7/15/2016
IE Report filed with OPUC	7/22/2016
File OPUC RFP shortlist acknowledgment and motion	7/29/2016
OPUC RFP acknowledgment	9/16/2016
Notice to Proceed (if necessary)	Nov-Dec 2016

Portfolios

PGE Resource Portfolios: Components

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Common Assumptions

- SB 1547:
  - RPS obligations
  - Colstrip serving Oregon customers
- ETO energy efficiency deployment
- Demand response
- Short-term/mid-term market procurement
- Conservation voltage reduction
- Dispatchable standby generation

Available Resources

- Spot market open position
- Flexible combined-cycle combustion turbine
- Wind and Solar PV
- Biomass and Geothermal
- Simple-cycle combustion turbine
- Energy storage (side case)
- Additional energy efficiency

PGE Resource Portfolios: Design

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- Spot Market vs. Resource (Portfolios 1 and 2)
  - Cost and reliability of market reliance
- CCCT vs. Wind (Portfolios 3 through 5)
  - Renewable resource economics relative to natural gas-fired
- PNW Wind vs. Diverse Wind (Portfolios 4 through 7)
  - Renewable resource locational diversification
- Wind vs. Baseload renewables (Portfolios 6 through 9)
  - Renewable resource capacity and variability
- Wind vs. Wind + Solar PV (Portfolios 6, 7, 10, and 11)
  - Renewable resource technological diversification
- Base vs. additional EE (Portfolios 13 and 14)
  - Portfolio cost / benefit of additional (“non-cost effective”) energy efficiency

PGE Resource Portfolios: Spot Market vs. Resource

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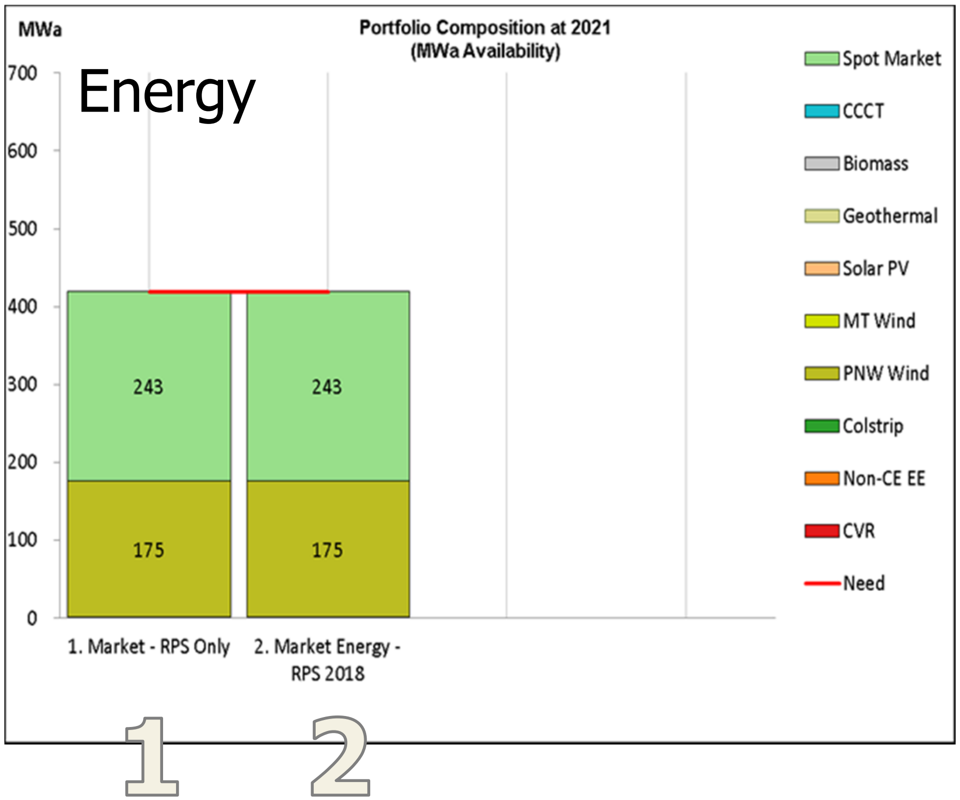
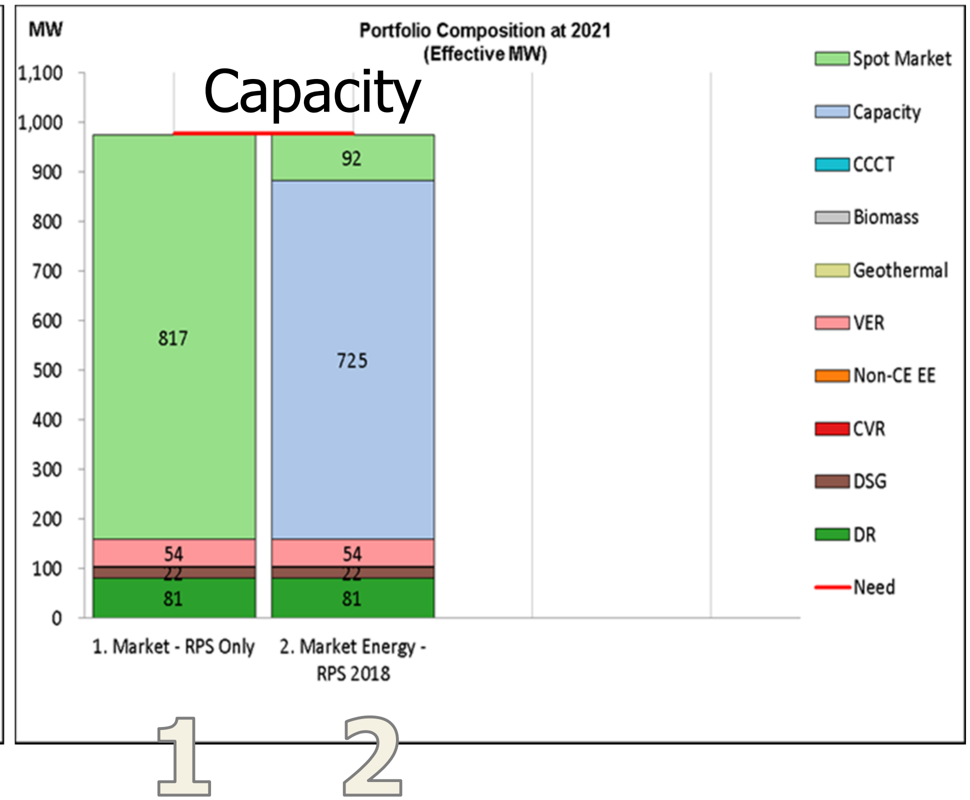
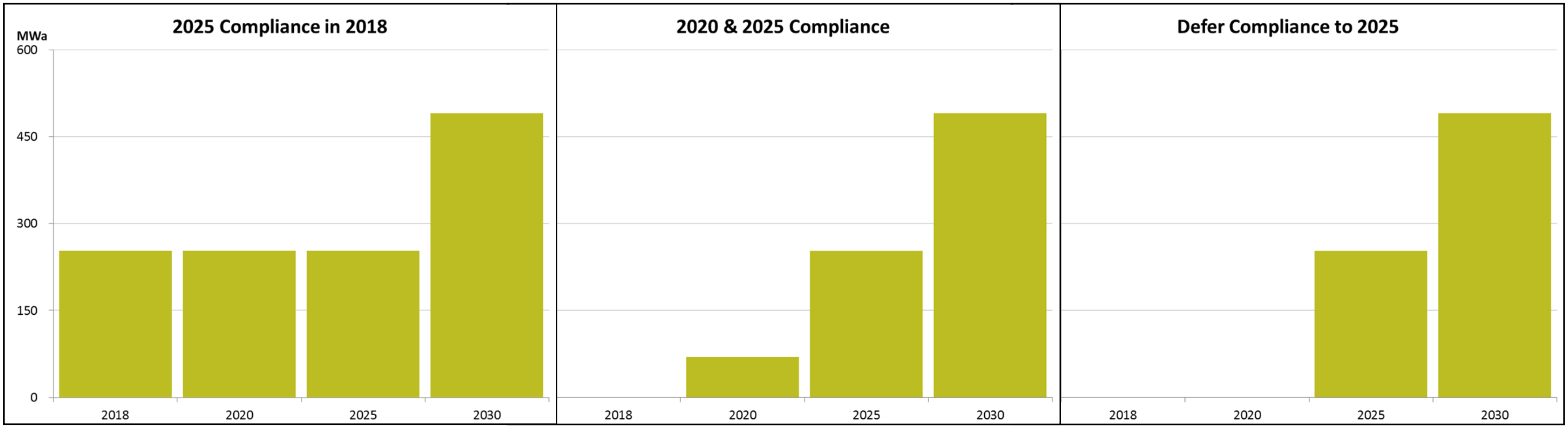




Cost and reliability of market reliance

PGE Resource Portfolios: RPS Timing

Utilize Portfolio 2 to assess effect of RPS resource timing on portfolio performance



PGE Resource Portfolios: SB 1547 Timing

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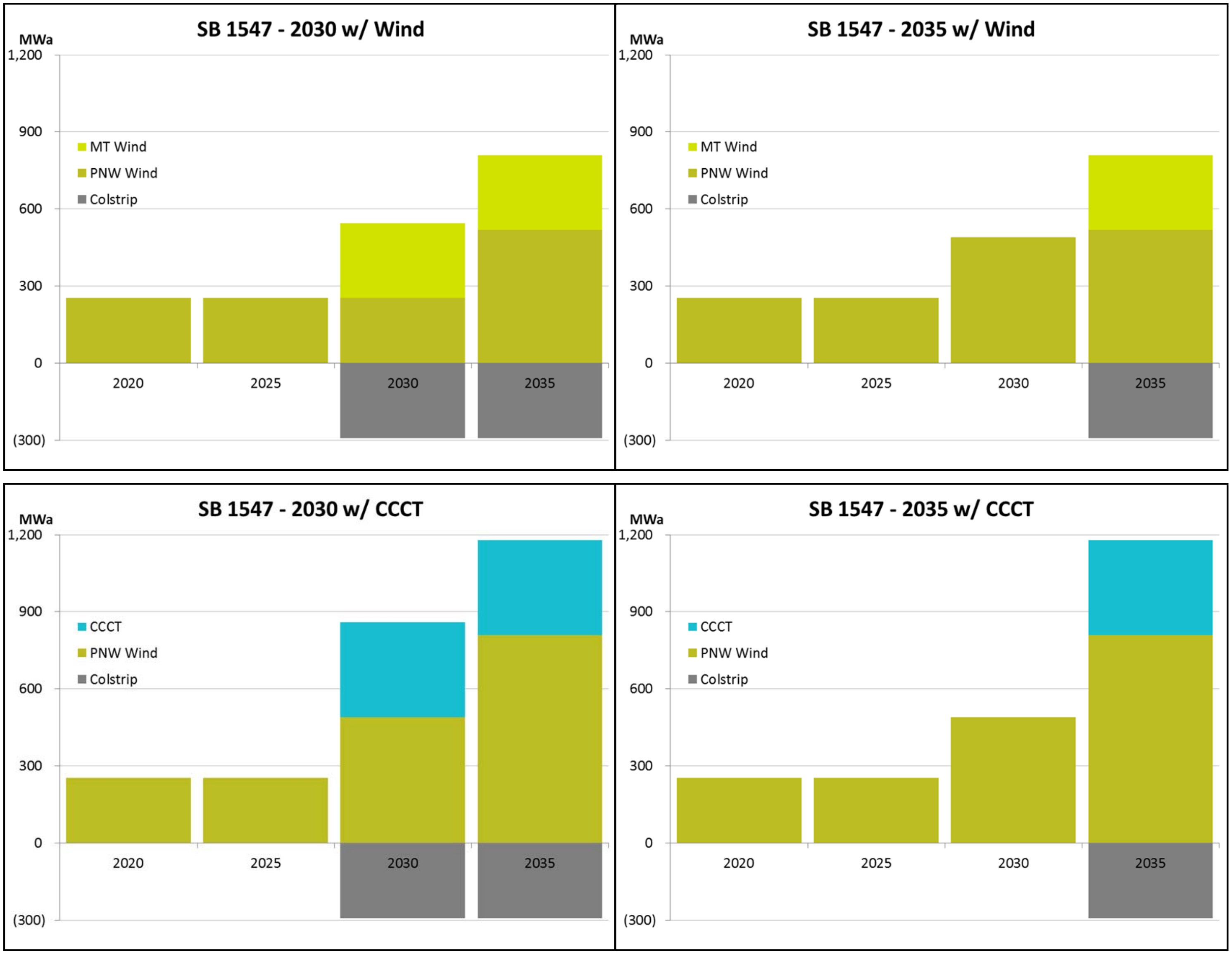
Utilize Portfolio 2 to assess potential effect of SB 1547 timing on portfolio performance



- Wind as replacement resource
- CCCT as replacement resource

PGE Resource Portfolios: CCCT vs. Wind

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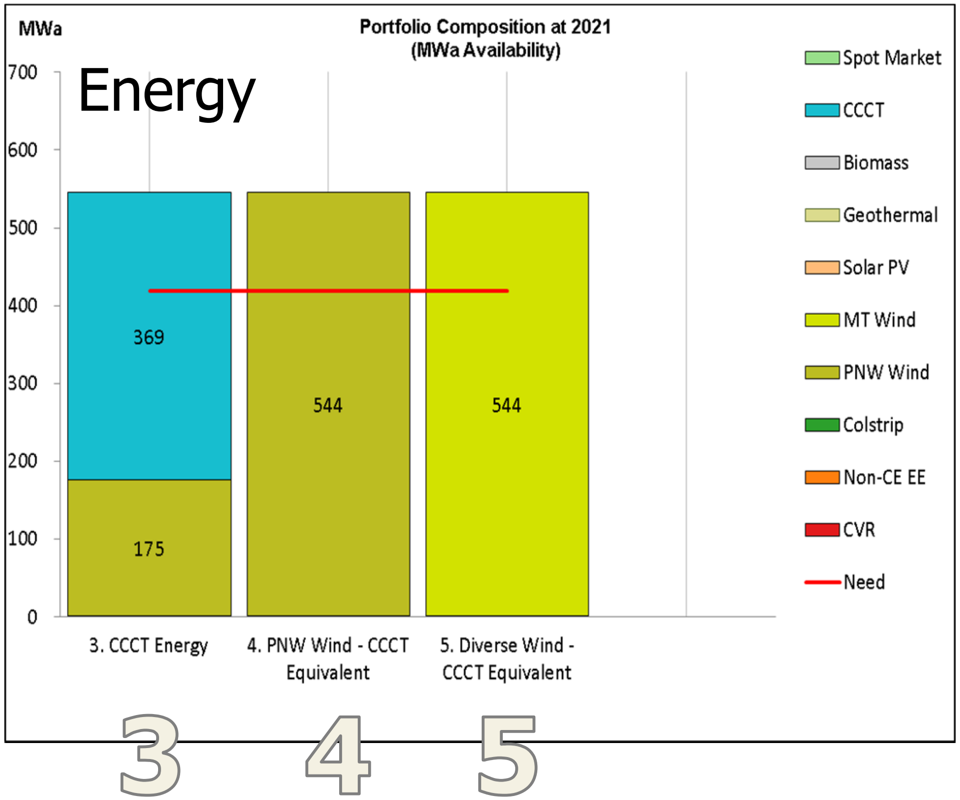
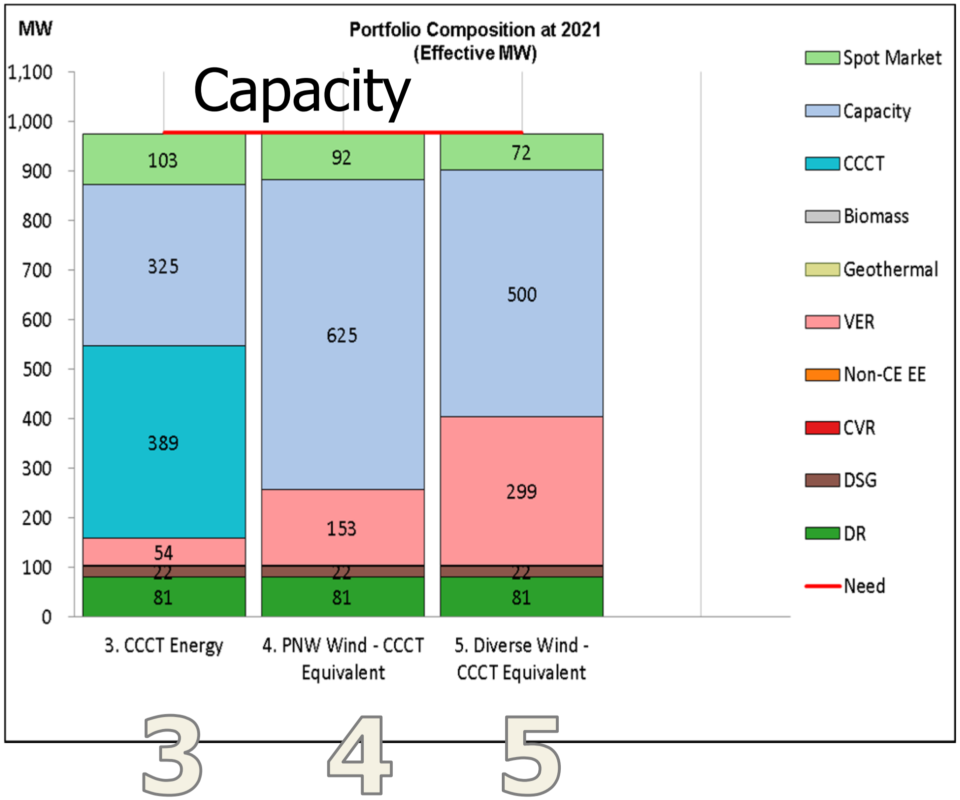
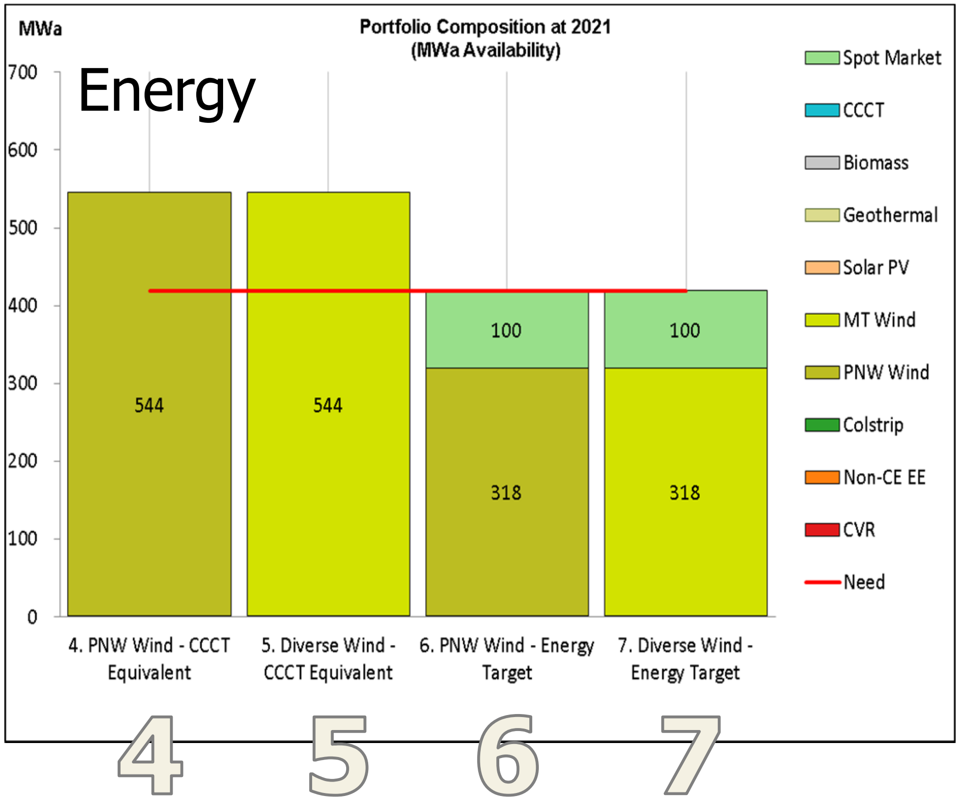
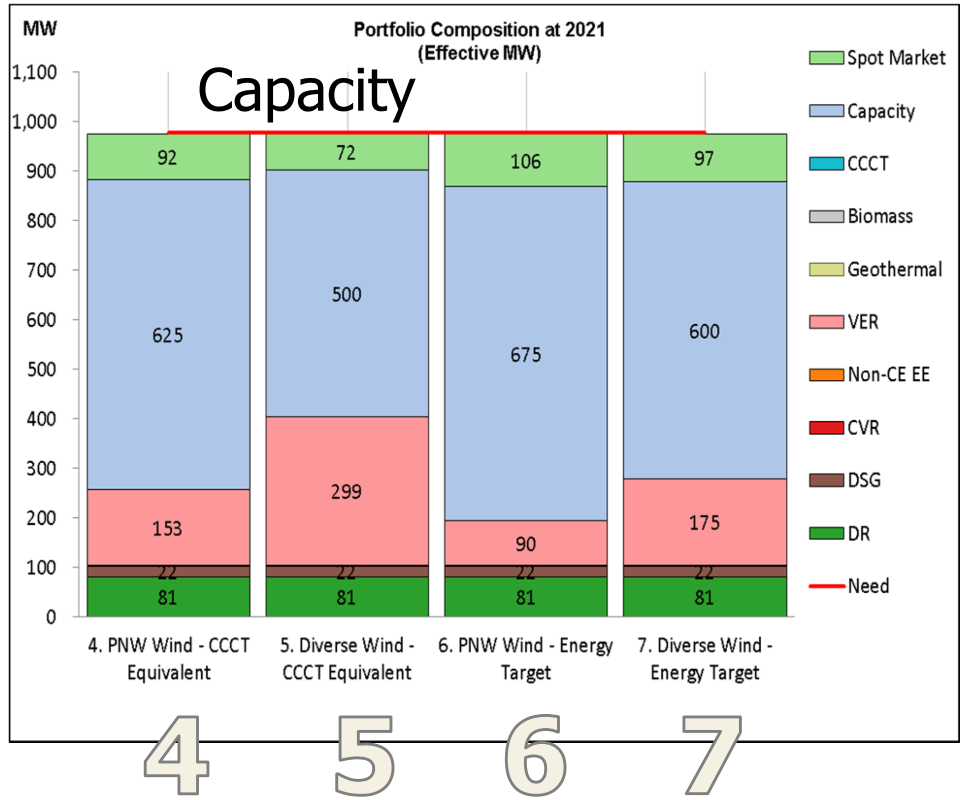




- Renewable resource economics relative to natural gas-fired

PGE Resource Portfolios: PNW Wind vs. Diverse Wind





- Renewable resource locational diversification

PGE Resource Portfolios:
Wind vs. Baseload renewables

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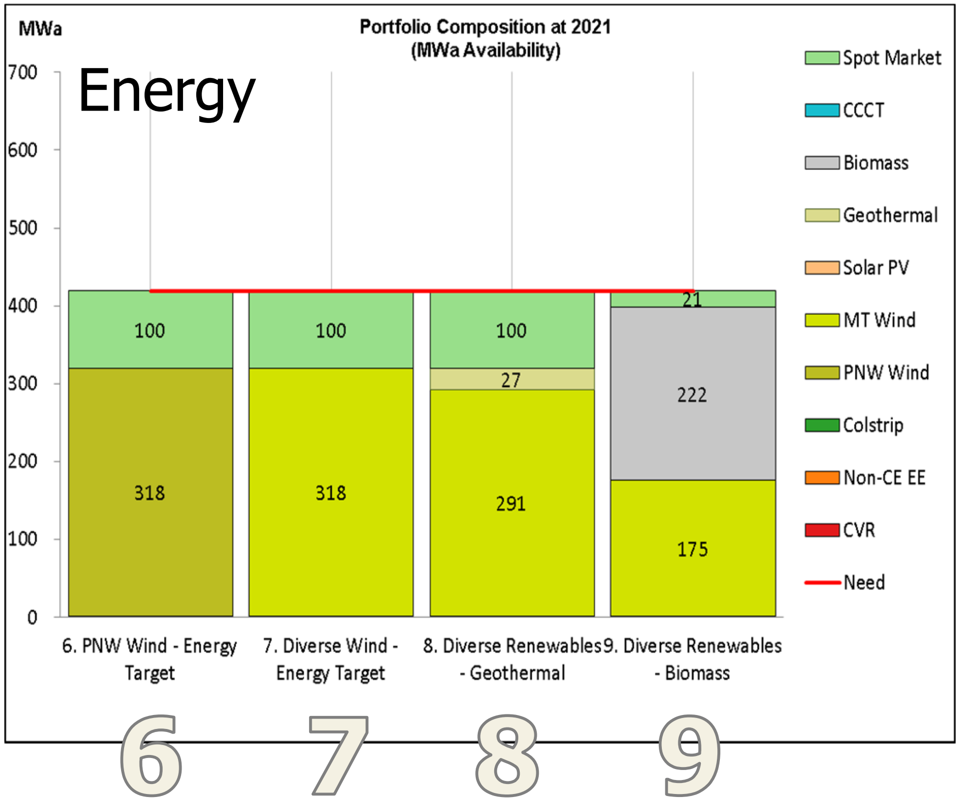

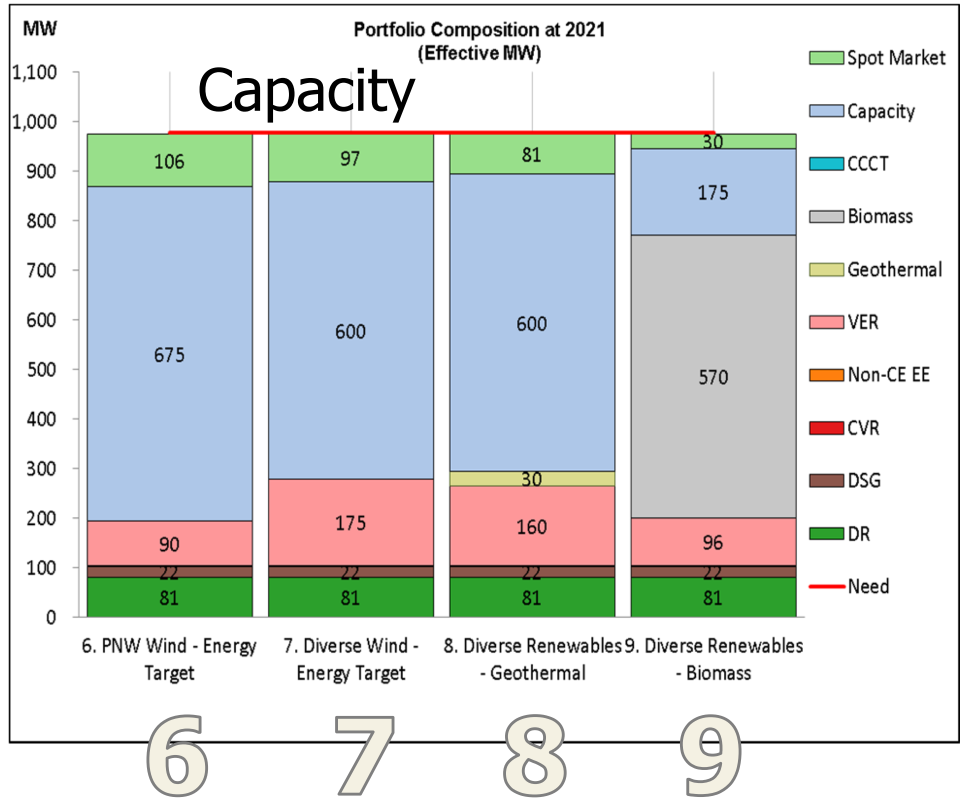

- Renewable resource capacity and variability

PGE Resource Portfolios: Wind vs. Wind + Solar

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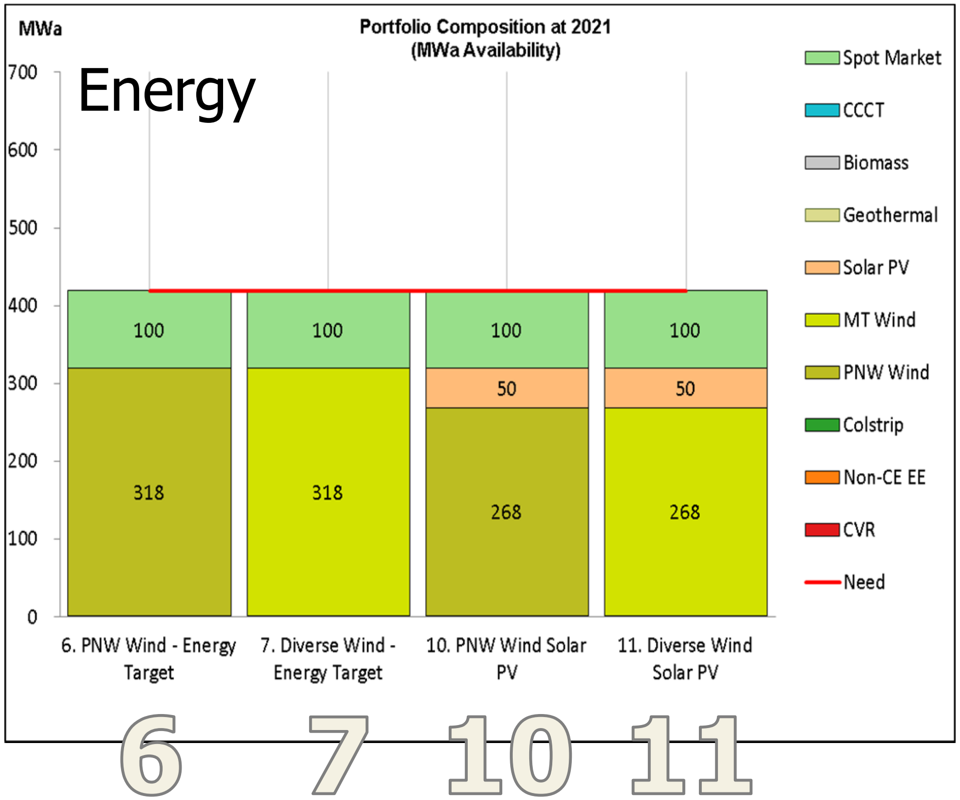
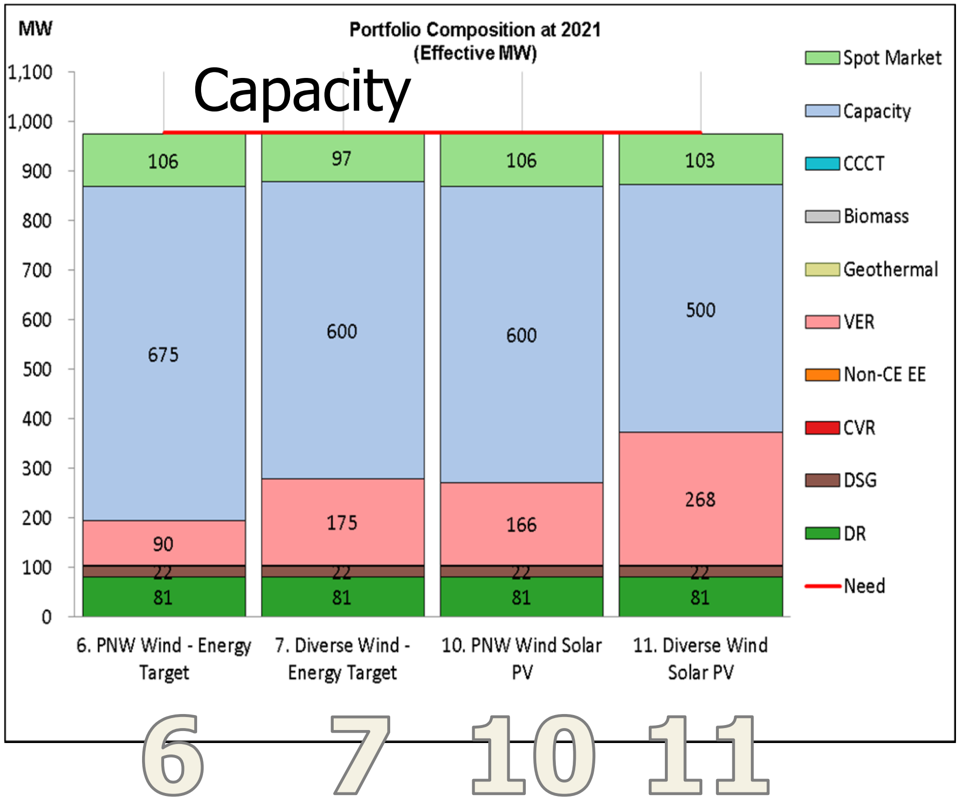
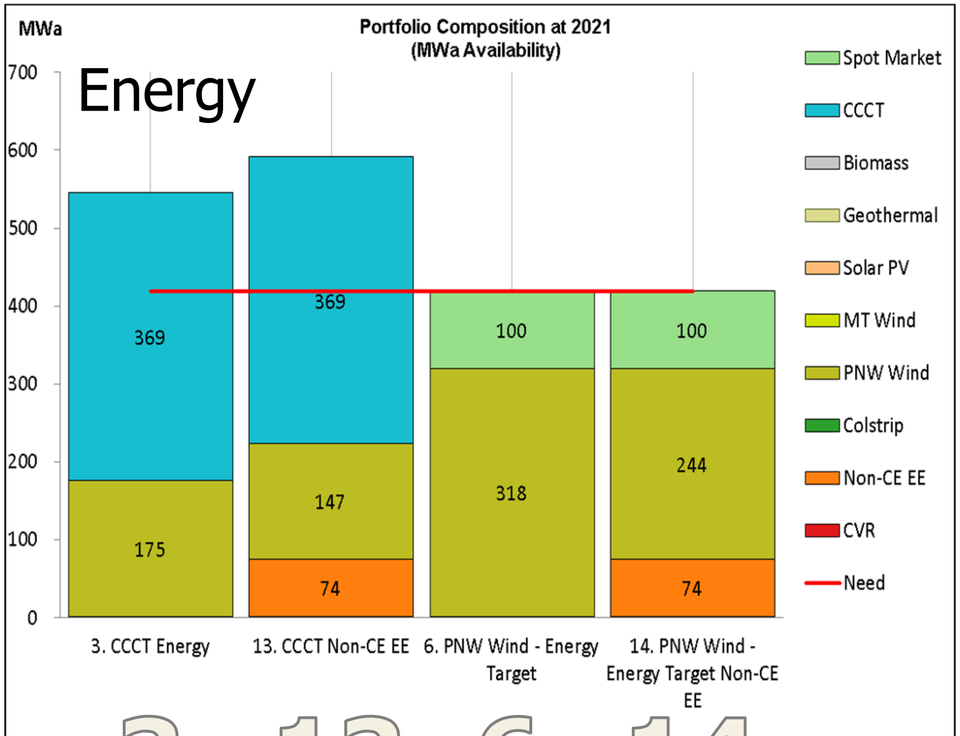
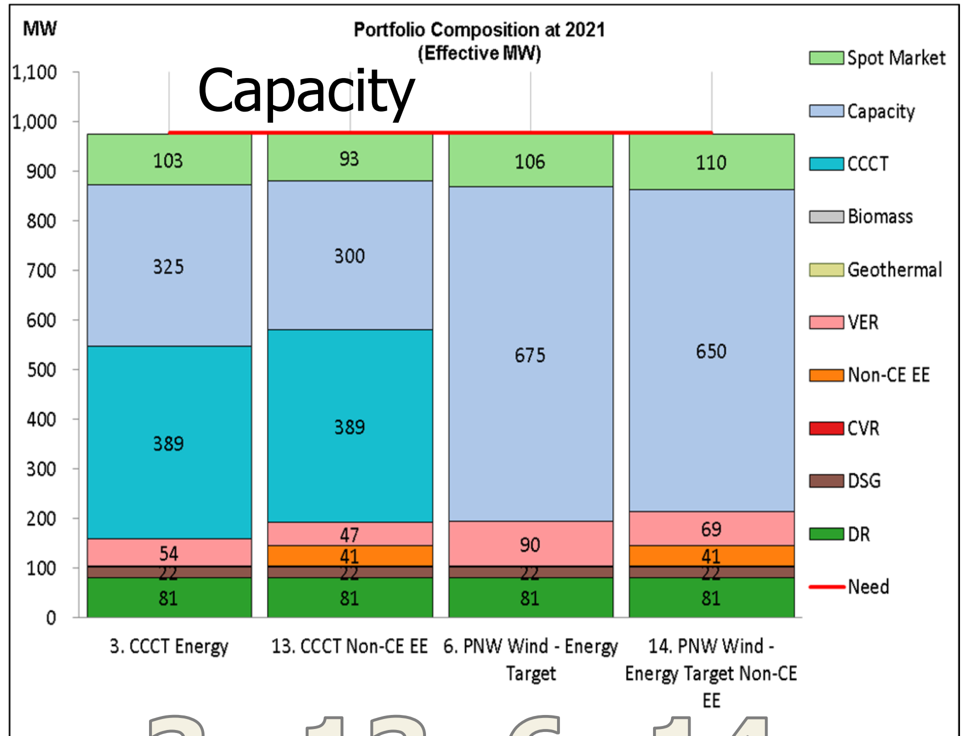




- Renewable resource technological diversification

PGE Resource Portfolios: Base EE vs. additional EE





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Portfolio cost / benefit of additional ("non-cost effective") energy efficiency

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Modeling Methodology

2016 IRP: Modeling Tools

Revenue requirements model:

- A PGE-developed spreadsheet model for calculating detailed, resource-specific, life-cycle, revenue requirements
- Ownership and fixed costs from this model are input to AURORA, along with resource variable costs and operating parameters

- Financial parameters (inflation, cost of capital)
- Resource cost estimates
- Other fixed cost inputs

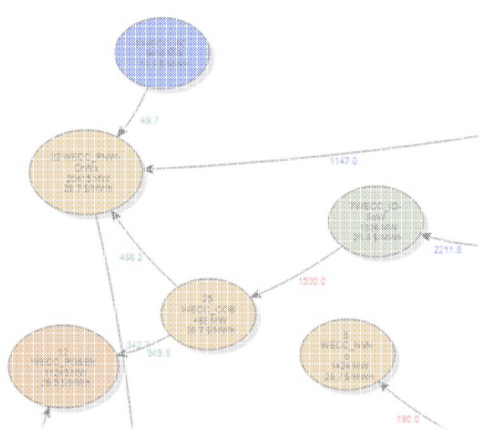
Revenue requirements model

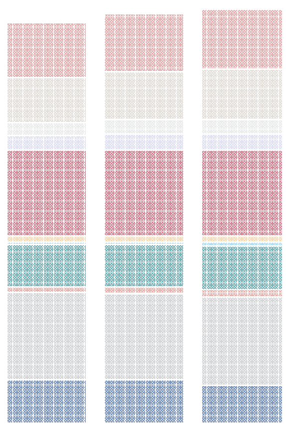
- Fully-allocated fixed cost of resource

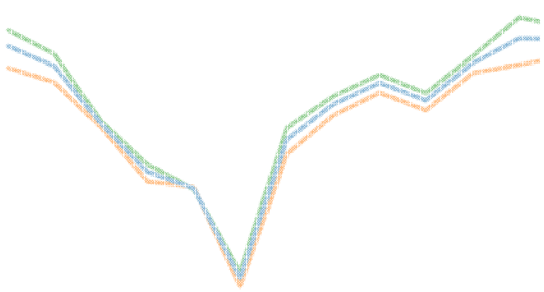
2016 IRP: Modeling Tools

AURORA:

- Third-party vendor (EPIS) software
- Two purposes: 1) regional capacity expansion, 2) resource/portfolio dispatch
- 1) Regional capacity expansion:
  - Given topology, existing resource stack, state RPS targets, fuel, CO_2 cost, loads, etc. (EPIS, Wood Mackenzie, Synapse)
  - Model resource additions/retirements through 2050 based on expected resource costs and parameters (PGE, Wood Mackenzie)
  - Results in a regional resource stack; dispatch produces simulated wholesale regional electricity prices for various points in the WECC







2016 IRP: Modeling Tools

AURORA:

- 2) Resource/portfolio dispatch:
  - PGE's resource portfolios dispatch within the market, resulting in portfolio net variable costs
  - Incorporate fully-allocated fixed costs from revenue requirements model
  - Perform the dispatch for each alternative portfolio for each given future, record the total costs

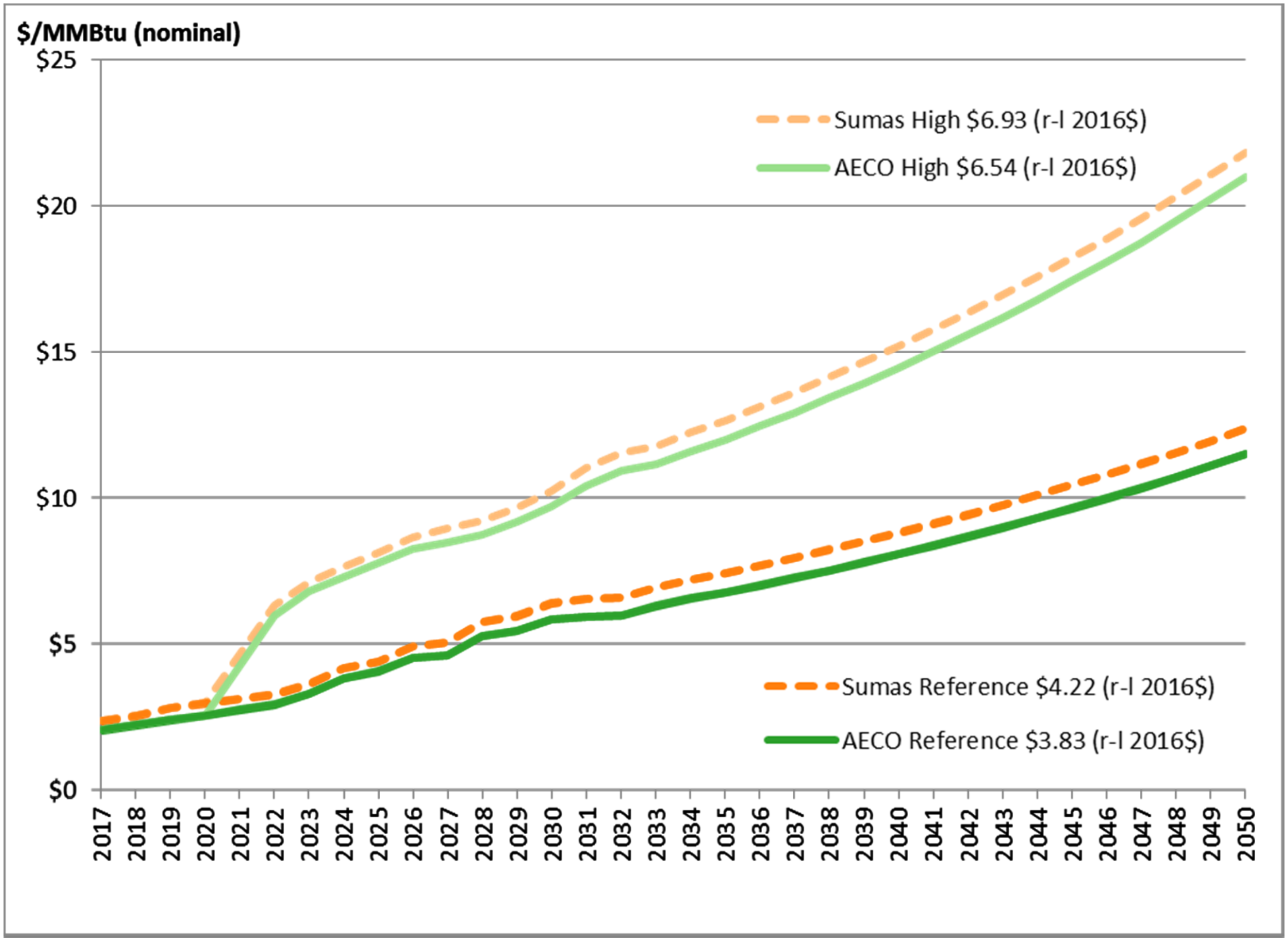
- Financial parameters
- Resource cost estimates
- Other variable cost inputs (fuel)

AURORAxmp

Simulate resource dispatch

- Resource and portfolio results for each future

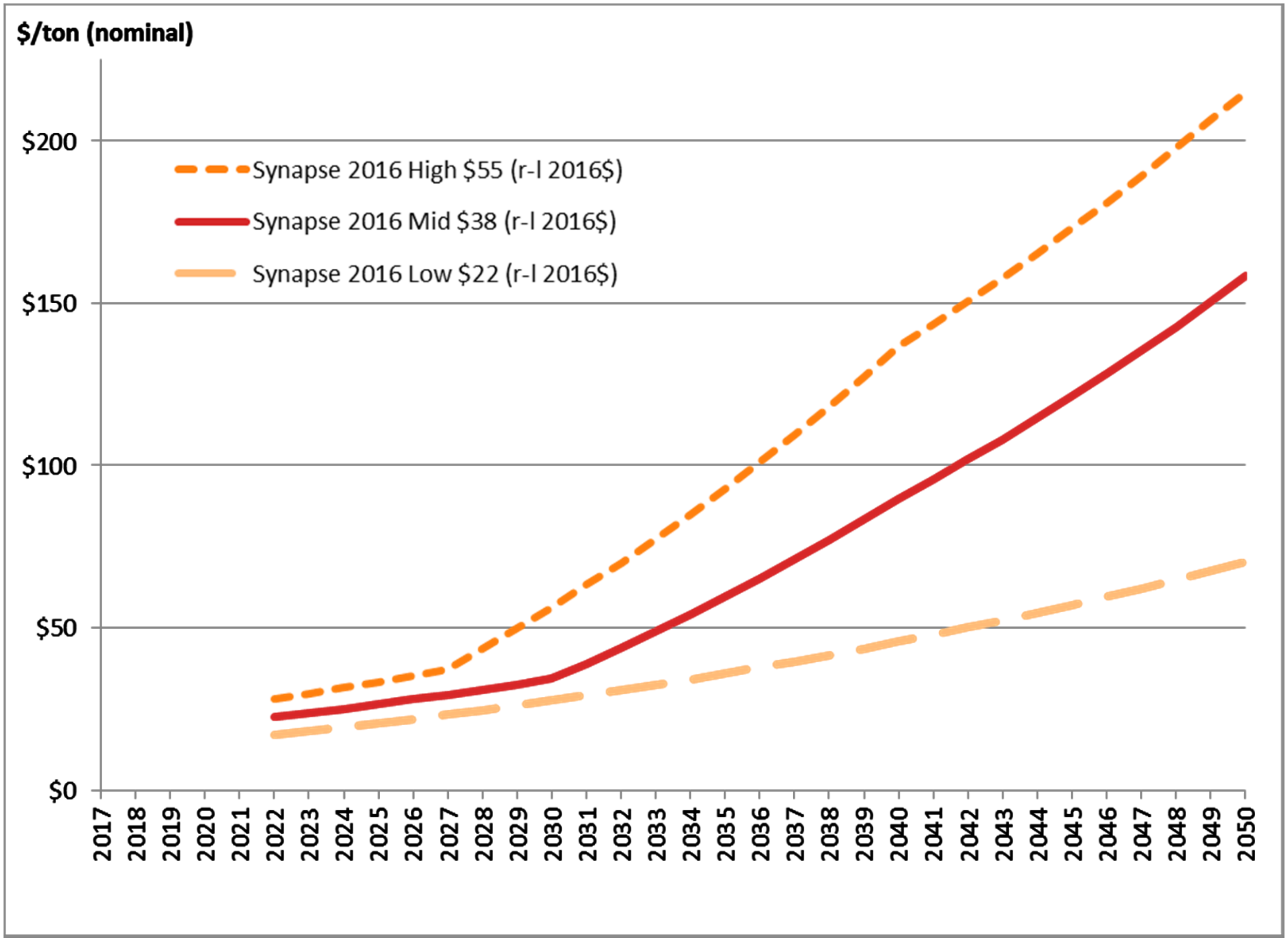
2016 IRP Natural Gas: Reference, High



- 2017-2020: PGE forward curve through
- 2021: blend forward curve and fundamentals forecast
- 2021-2035: Wood Mackenzie fundamentals forecast
- 2035-2050: extrapolation from fundamentals forecast
- Real-levelized (“r-l”) values 2017-2050 reported in 2016$

- High Gas case based on EIA “high oil price” scenario from 2015 Annual Energy Outlook for Henry Hub; basis differentials from Wood Mackenzie

2016 IRP CO_2: Reference, Low, High



- Synapse Spring 2016 National Carbon Dioxide Price Forecast
- Reflect "effective" prices
- Low case: CPP through 2050
- Mid case (PGE Reference Case): CPP + 80% below 2005 by 2050 actions in 2030
- High case: CPP + 90% below 2005 by 2050 actions in 2027

- Effective prices represent shadow costs of complying with the modeled policies
- PGE interprets as cost per unit of emission assuming national allowance trading

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Flexible Capacity

Flexible capacity analysis

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- PGE has been directed by the Oregon PUC to provide an "Evaluation of new analytical tools for optimizing flexible resource mix to integrate load and variable resources"
- PGE worked with Energy & Environmental Economics (E3) to conduct a study of potential flexibility challenges on the system under higher renewable penetrations

Goals of the study:

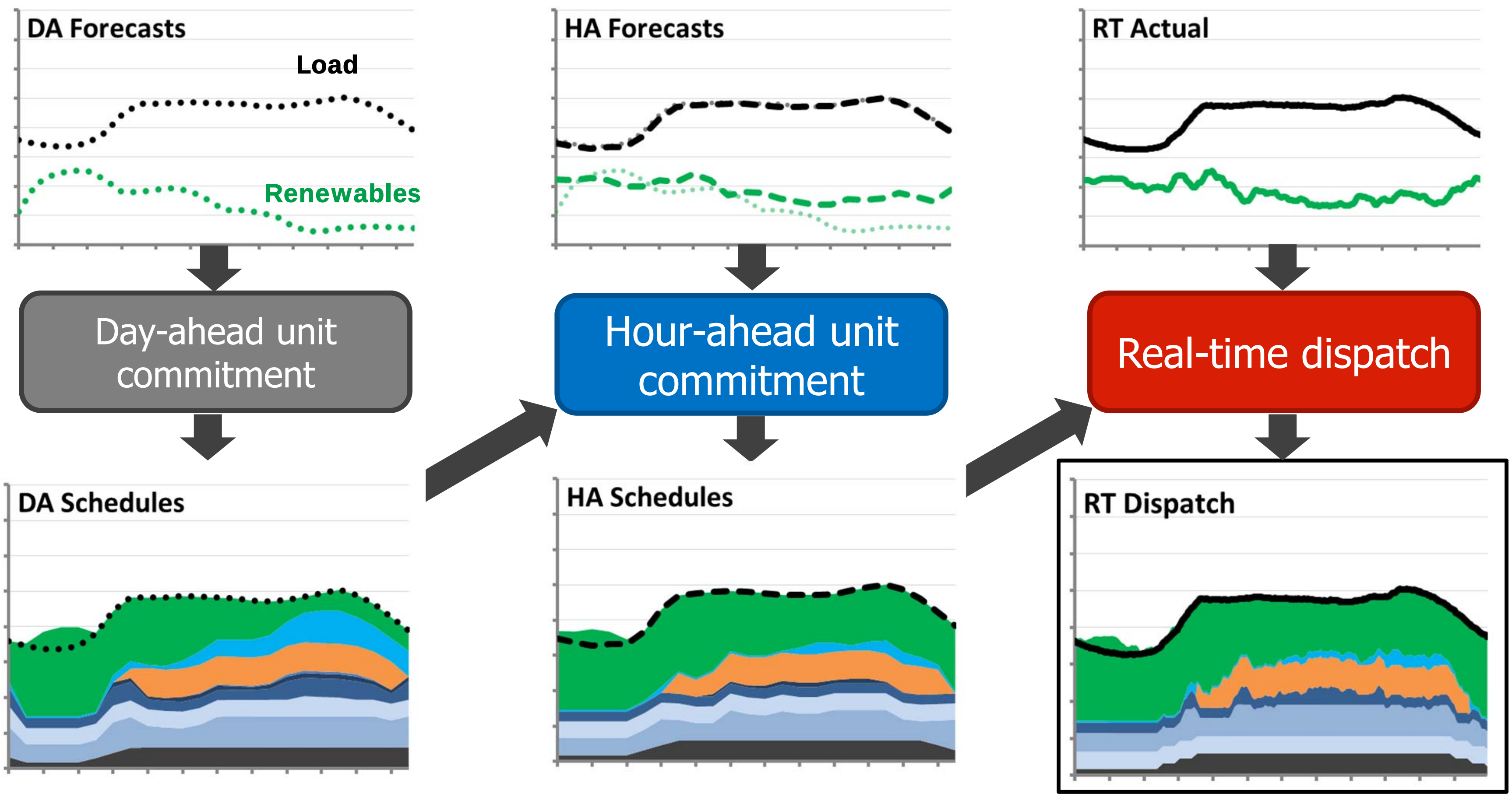
- Identify anticipated operational flexibility challenges on the system in 2021 on multiple time scales
  - Hour-ahead (HA)
  - Real-time (RT)
- Quantify the flexibility benefits of various procurement options
  - CCCT vs. Frame CTs vs. Reciprocating engines
  - Renewable portfolio diversity
- Preliminarily examine the impacts of higher penetrations of renewables

Summary of key findings

- **Near-term and mid-term flexibility needs are low, but increase as RPS increases**
- **Identified flexibility challenges are related to cost and operational strategy, not reliability**
- 25% RPS:
  - Upward flexibility challenges can largely be mitigated with additional capacity regardless of flexibility (thermal, market purchases, or contracts) in order to "free up" Beaver and Port Westward 2 to respond to forecast errors and large ramping events
  - Renewable oversupply up to 3.3%, depending on renewable portfolio and off-system sales
  - Renewable portfolio diversity shows flexibility and production cost benefits
- 50% RPS:
  - New flexible resources provide benefits over less flexible resources, suggesting more technology differentiation at higher renewable penetrations
  - Significantly larger forecast errors and ramping events observed for 50% RPS case relative to 25% RPS case
  - Renewable oversupply up to 18%, depending on renewable portfolio and off-system sales

REFLEX Modeling Methodology

- **REFLEX is a multi-stage production simulation model with 5-min resolution**
  - Commits and dispatch units in response to load, wind, solar, hydro, market conditions, generator operating parameters, subhourly variability, and forecast errors
  - Upward challenges quantified with Hour-ahead (HA) and Real-time (RT) products; Downward challenges quantified with priced renewable curtailment
  - **Considers adequacy of PGE resources to meet PGE loads (<u>excludes flexibility from the market</u>)**



Resource portfolios

- **Flexibility challenges were investigated in REFLEX for four renewable portfolios**
- **Incremental renewable build:**

MWa	Site Y1 (Gorge)	Site Y2 (Gorge)	Site Y Small (Gorge)	Utility PV	Montana Wind	RPS
Portfolio 6	116	150	-	-	-	25%
Portfolio 7	-	150	86	30	-	25%
Portfolio 9	116	-	-	-	150	25%
50% Portfolio (Doubles Portfolio 7*)	-	300	172	60	-	50%

- **Additional resources (tested with in-and-out runs of REFLEX)**

New Resources	Provides Reserves	Final Commitment Stage	Min Up/Down Time (hrs)	Max Ramp (MW/min)	Pmin (% of Pmax)	Min Load Heat Rate (Btu/kWh)	Full Load Heat Rate (Btu/kWh)
CCCT	Yes	Day-ahead	1.5	50	33%	8,318	6,503
Frame CTs	Yes	Real-time	0.5	2x40	38%	13,548	9,176
Recips	Yes	Real-time	0.5	22x5	7%	12,827	8,437

[Source: E3]

Scenarios

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- **Each renewable portfolio was run with a variety of new thermal resources to test the impact of thermal unit flexibility and its sensitivity to renewable portfolio composition**

Renewables	No New Thermal	CCCT	Frame CTs		Reciprocating Engines			
		400 MW	200 MW	400 MW	100 MW	200 MW	300 MW	400 MW
Portfolio 6 (25% RPS – Gorge Wind)	X	X	X	X	X	X	X	X
Portfolio 6 + 200 MW Imports (25% RPS – Gorge Wind)	X		X	X				
Portfolio 7 (25% RPS – Gorge Wind + Solar)	X		X	X				
Portfolio 9 (25% RPS – Gorge Wind + MT Wind)	X	X	X	X	X	X	X	X
50% RPS (double Portfolio 7)	X	X	X	X		X		

[Source: E3]

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Shown for Portfolio 6 (Gorge Wind)

Oversupply (MWa)

	HE1	HE2	HE3	HE4	HE5	HE6	HE7	HE8	HE9	HE10	HE11	HE12	HE13	HE14	HE15	HE16	HE17	HE18	HE19	HE20	HE21	HE22	HE23	HE24
Jan	34	56	74	89	90	72	39	16	7	4	1	0	0	0	0	1	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Feb	14	32	40	37	40	42	16	3	1	0	0	0	0	0	0	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mar	58	73	83	91	83	48	17	2	0	0	0	0	0	0	0	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Apr	56	77	63	50	45	31	15	9	5	4	4	6	9	10	12	9	8	7	4	1	2	0	9	25
May	62	69	73	85	85	50	19	6	1	0	0	1	1	0	0	0	0	2	2	1	0	1	8	20
Jun	70	82	93	107	107	61	14	1	0	0	0	0	0	0	0	1	0	1	1	2	2	0	1	16
Jul	23	31	34	38	32	18	6	3	0	0	0	0	0	0	0	0	0	0	0	1	2	0	5	23
Aug	25	37	37	37	35	24	12	2	0	0	0	0	0	0	1	0	0	0	0	0	1	0	2	10
Sep	49	68	78	77	61	38	25	18	13	6	4	4	3	2	2	3	4	3	3	1	1	8	24	45
Oct	96	120	145	129	107	63	17	3	0	0	1	0	0	1	1	1	0	0	1	0	1	3	12	37
Nov	38	56	63	55	56	59	37	21	10	2	0	1	1	1	0	0	0	1	0	0	0	1	5	19
Dec	28	55	75	83	79	64	34	15	8	1	0	0	0	1	1	0	0	1	1	0	0	0	0	2

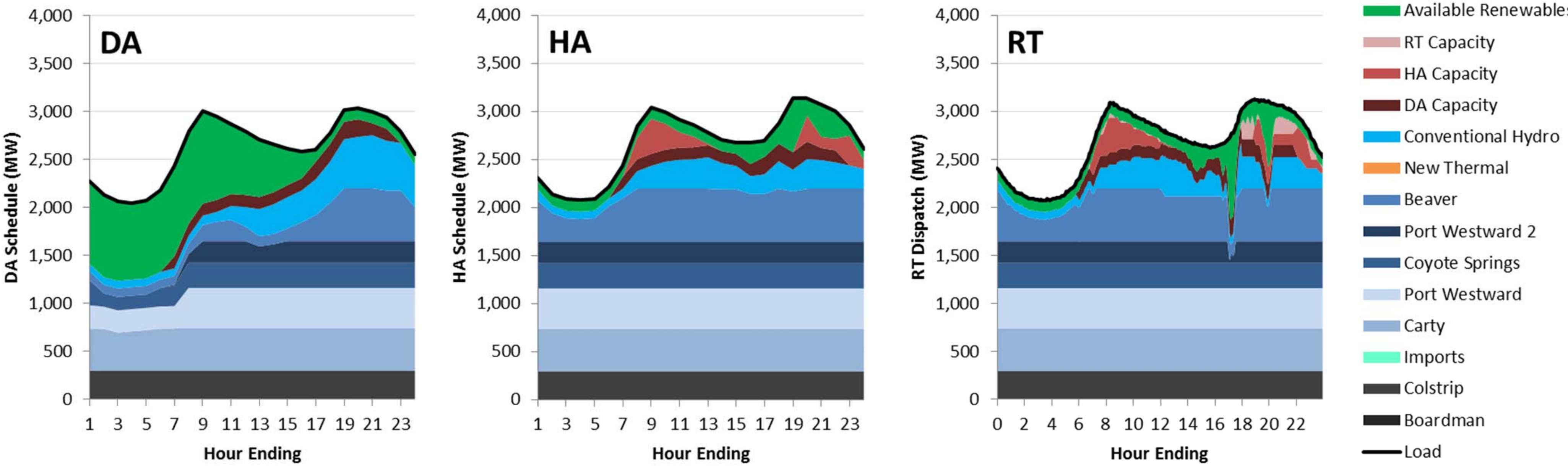
HA Capacity (MWa)

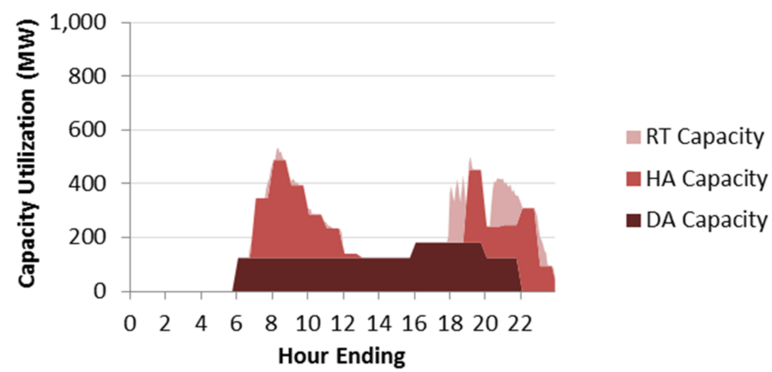
	HE1	HE2	HE3	HE4	HE5	HE6	HE7	HE8	HE9	HE10	HE11	HE12	HE13	HE14	HE15	HE16	HE17	HE18	HE19	HE20	HE21	HE22	HE23	HE24
Jan	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.7	6.0	5.5	7.5	6.5	3.2	1.5	1.4	1.3	2.0	6.1	16.8	15.7	10.7	4.6	2.8	0.1
Feb	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	16.5	42.1	34.5	26.3	20.6	10.8	6.8	5.4	4.4	4.7	7.7	20.3	40.9	29.8	21.0	14.1	5.2
Mar	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.1	3.3	3.5	2.7	1.5	0.1	0.3	0.0	0.0	0.0	0.0	0.2	3.7	3.4	2.1	1.0	0.0
Apr	0.0	0.0	0.0	0.0	0.0	0.0	0.5	6.3	9.3	11.7	9.9	5.1	3.7	3.8	4.3	4.1	4.6	6.3	4.9	1.7	8.2	3.7	0.5	0.0
May	0.0	0.0	0.0	0.0	0.0	0.0	0.6	9.2	8.3	5.1	3.4	3.1	1.9	1.3	0.0	0.0	0.7	2.1	1.3	0.3	3.7	6.7	1.6	0.0
Jun	0.5	0.0	0.0	0.0	0.0	0.0	0.1	2.2	11.3	10.5	13.6	17.0	17.4	13.3	8.3	8.2	5.9	6.0	5.2	12.4	19.6	20.7	20.4	2.5
Jul	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	9.3	7.5	5.8	4.1	3.8	4.5	6.4	7.7	13.7	18.6	24.1	13.1	6.2	3.6	6.1	1.1
Aug	1.0	0.0	0.0	0.0	0.0	0.1	0.5	3.6	5.8	7.5	10.1	13.1	20.3	27.7	28.2	24.9	34.8	45.2	38.0	27.2	22.7	14.4	6.8	2.5
Sep	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.8	1.3	0.7	1.5	3.5	6.6	12.0	16.5	22.5	23.4	16.3	13.3	12.3	3.4	2.8	0.7
Oct	0.0	0.0	0.0	0.0	0.0	0.0	0.3	4.8	1.7	2.1	2.8	3.1	1.3	1.2	1.2	0.5	0.5	1.1	6.2	9.9	9.7	2.5	1.4	0.0
Nov	0.0	0.0	0.0	0.0	0.0	0.0	0.1	2.3	6.5	2.8	2.2	0.6	0.0	0.0	0.0	0.0	0.1	2.8	14.2	12.1	6.8	1.9	0.0	0.0
Dec	0.2	0.0	0.0	0.0	0.0	0.0	0.8	14.3	40.6	34.0	27.9	25.5	15.1	11.0	10.7	6.5	2.1	9.9	40.0	50.5	37.1	24.1	29.8	5.0

[Source: E3]

Example dispatch on challenging day

December day with 25% RPS (Gorge Wind); Represents day with highest RT Capacity need among stochastic draws



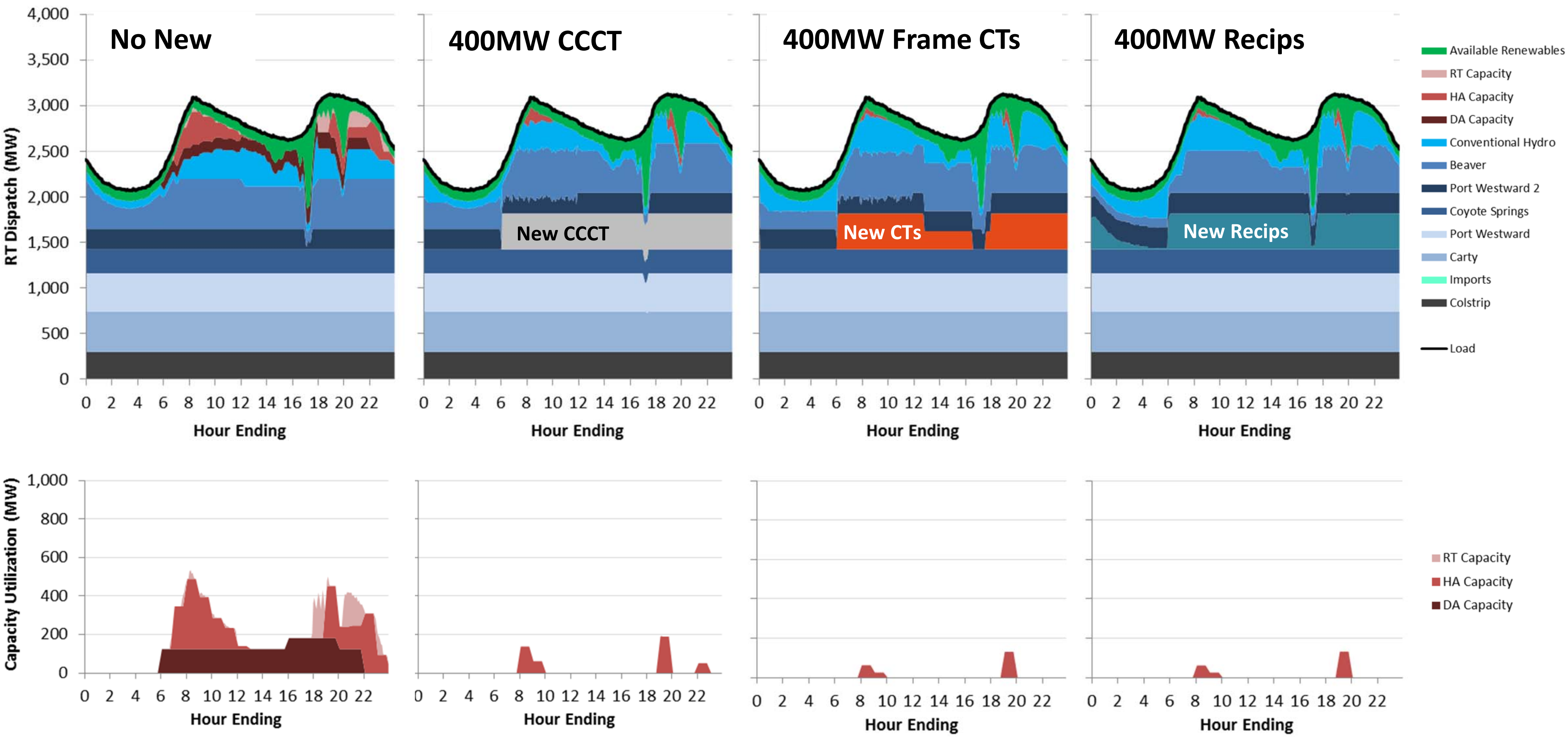


- RT Capacity needed to manage large real-time downward wind ramps
- Upward wind ramps mitigated largely by Beaver and Port Westward 2

[Source: E3]

New thermal resource impact on challenging day

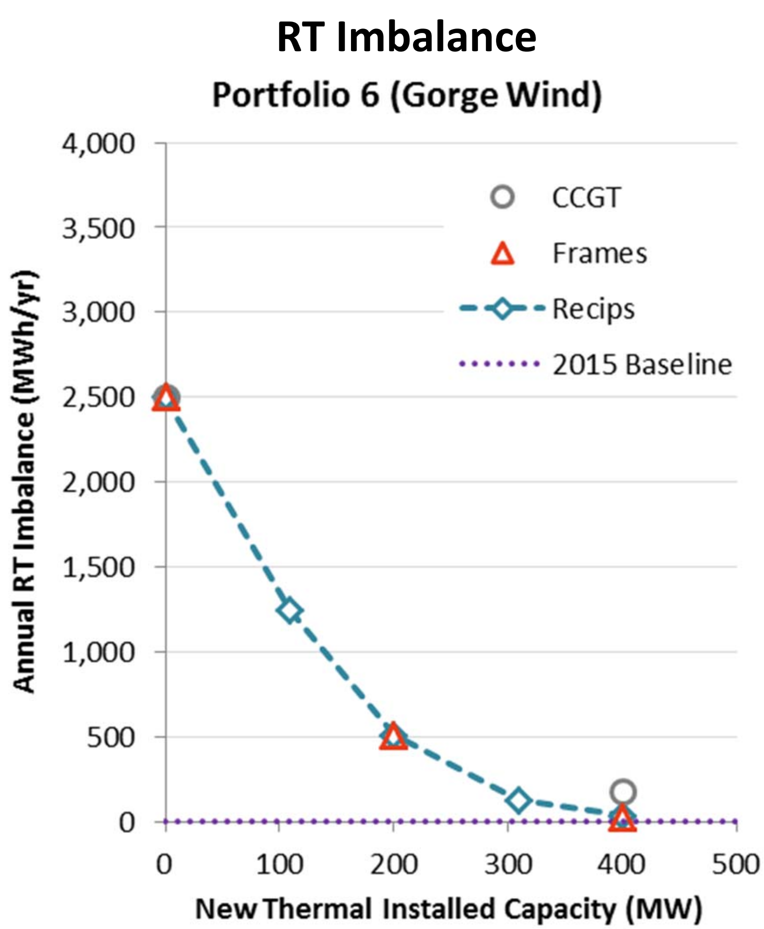
New thermal resources have similar impact on challenging day by either providing flexibility (Recips) or "freeing up" existing resources (PW2) to provide flexibility

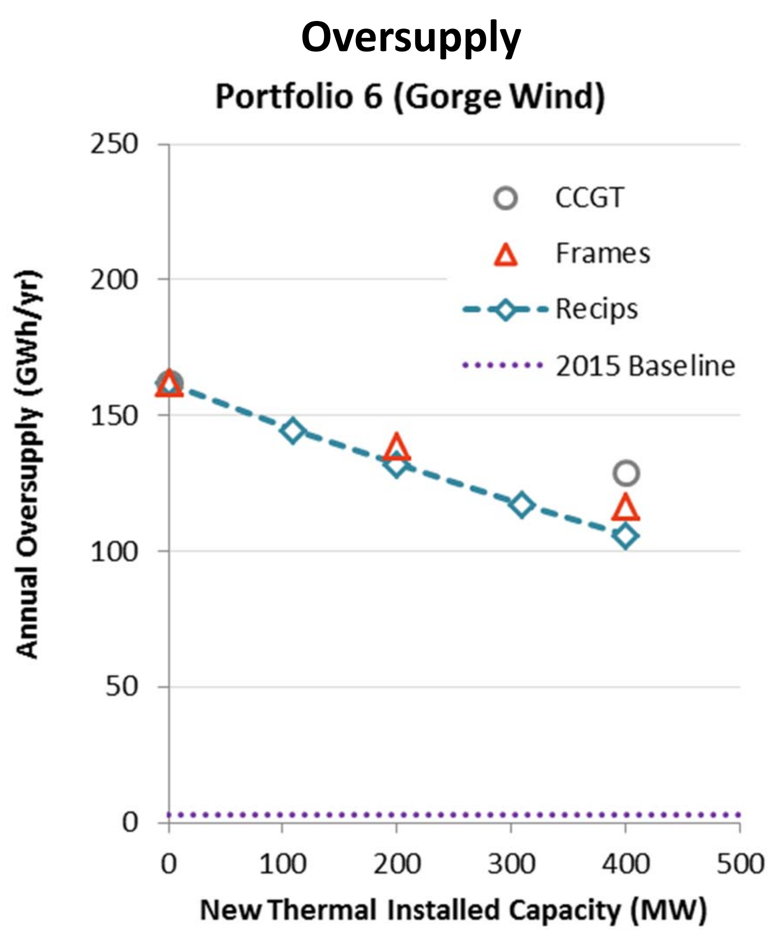


[Source: E3]

At 25% RPS, thermal resource additions mitigate both upward and downward flexibility challenges

Very little differentiation across representative technologies with respect to upward flexibility challenges

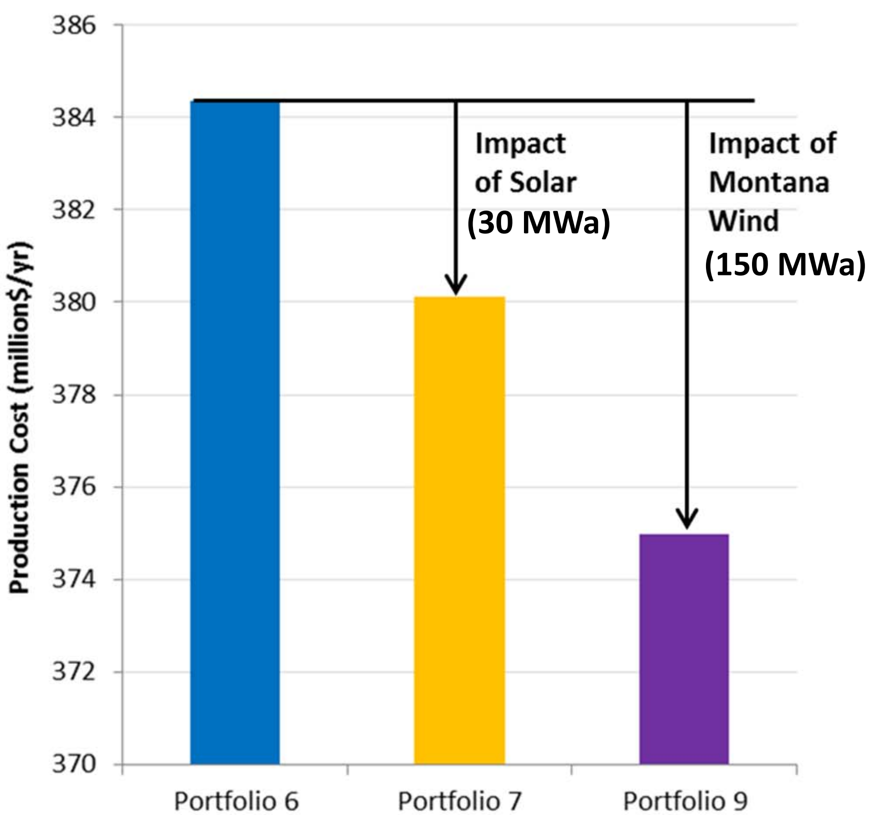


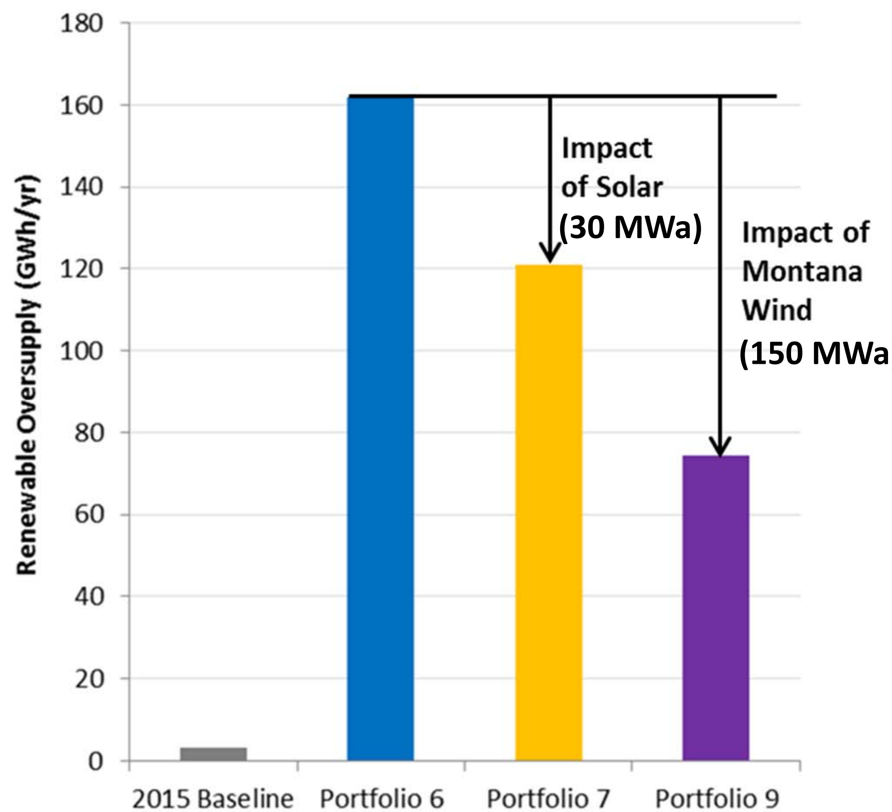


[Source: E3]

Impact of portfolio diversity on production cost and oversupply

- Portfolio diversity yields cost and integration benefits by improving the efficiency of thermal fleet utilization and reducing oversupply
  - Production costs include fuel, O&M, and start costs; exclude penalty costs





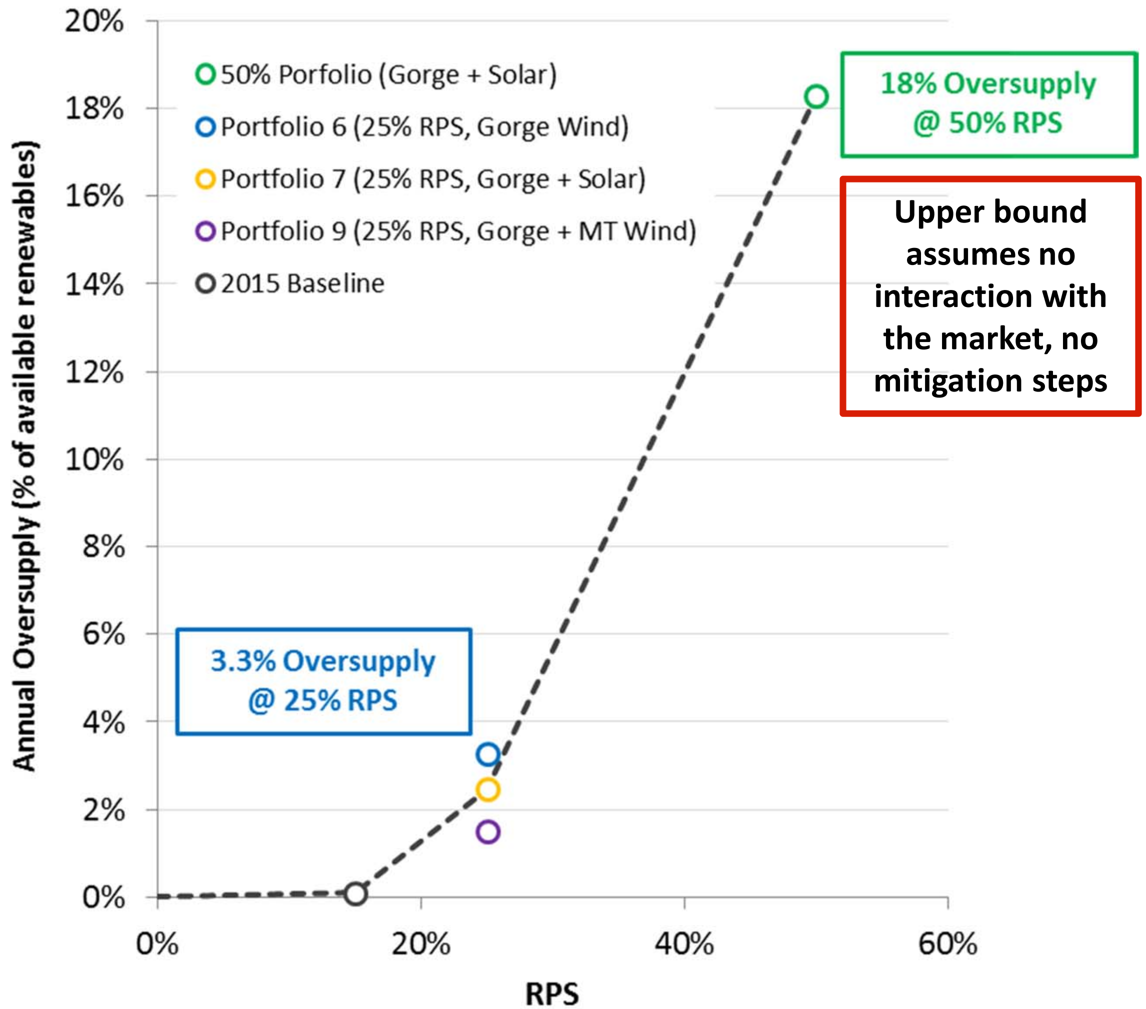
[Source: E3]

Potential impact of 50% RPS on renewable oversupply

- Without mitigation (interactions with the market, portfolio diversity, flexible resources), renewable oversupply could increase dramatically between 25% RPS and 50% RPS

- Greater technology differentiation identified at 50% RPS (not shown)

- Findings suggest that at higher RPS, PGE system will need diverse solutions, including:
  - Controls and communications to dynamically curtail renewables in real-time (capability assumed in all runs)
  - Evaluation tools for energy storage and DSM
  - Planning framework that accounts for the impacts of renewable oversupply on RPS compliance



[Source: E3]

Incorporation into 2016 IRP

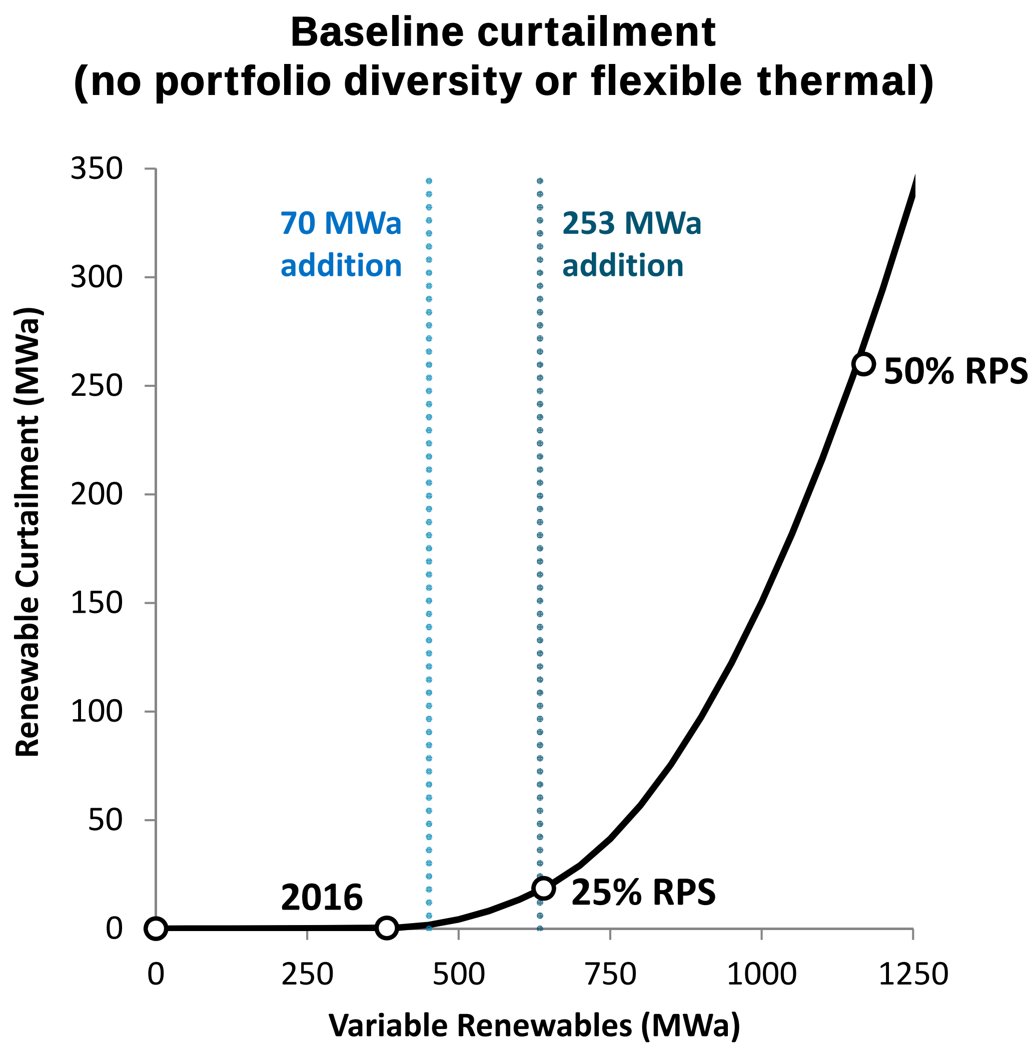
- **IRP will incorporate the three primary conclusions from the flexibility study:**
  1. Flexibility challenges are relatively limited through 25% RPS, but increase steeply between 25% and 50% RPS
  2. Renewable portfolio diversity has flexibility benefits
  3. Thermal technology differentiation is limited at 25% RPS, but increases at higher RPS

- **Renewable curtailment has been selected as the primary metric for quantifying flexibility costs/benefits between portfolios**
  - Renewable-driven upward challenges can always be mitigated by overcommitting thermal resources and experiencing renewable curtailment
  - Because REFLEX does not consider opportunities to sell excess generation in the market, curtailment-related penalties should be interpreted as upper bounds

1. Flexibility challenges depend on renewable penetration

- Based on the REFLEX results, a baseline curtailment curve has been calculated to approximate renewable curtailment assuming no portfolio diversity (all Gorge wind) and no incremental flexible thermal resources

- This curtailment baseline represents the maximum curtailment associated with a given portfolio



2. Renewable portfolio diversity has flexibility benefits

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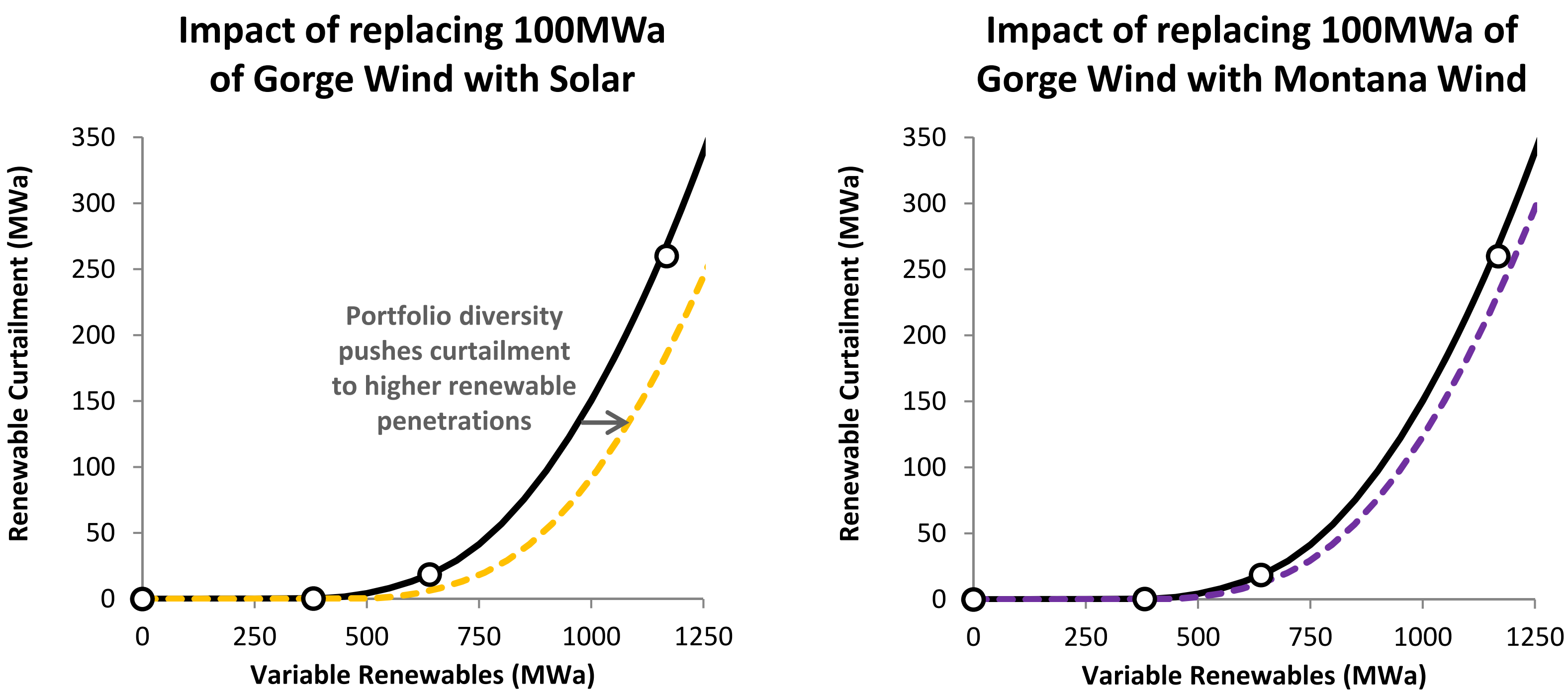
- Renewable portfolio diversity adjustments are then made based on the curtailment observed in Portfolio 7 (Gorge Wind + Solar) and Portfolio 9 (Gorge Wind + Montana Wind)



- Diversity impacts are based on 25% RPS simulations and extrapolated to 50% RPS; the impact of portfolio diversity at higher penetrations is an important topic for future investigation

3. Thermal technology differentiation depends on renewable penetration

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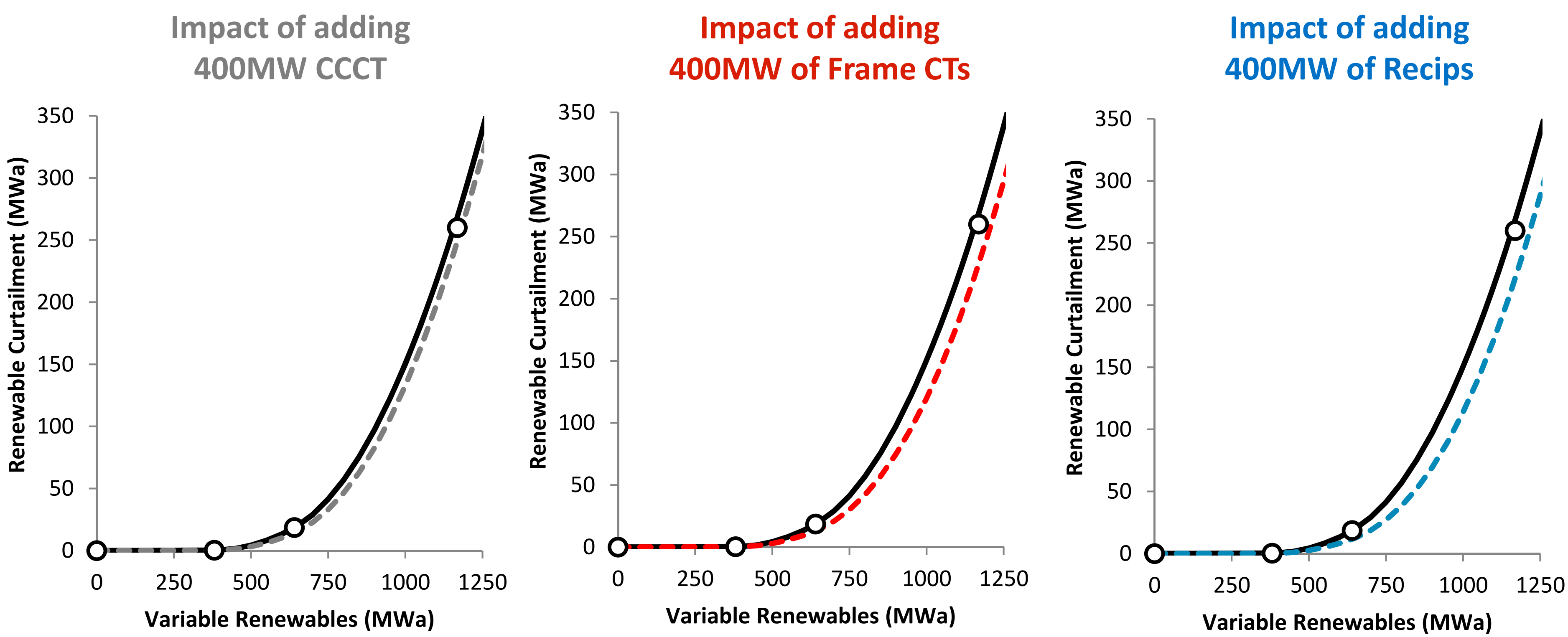
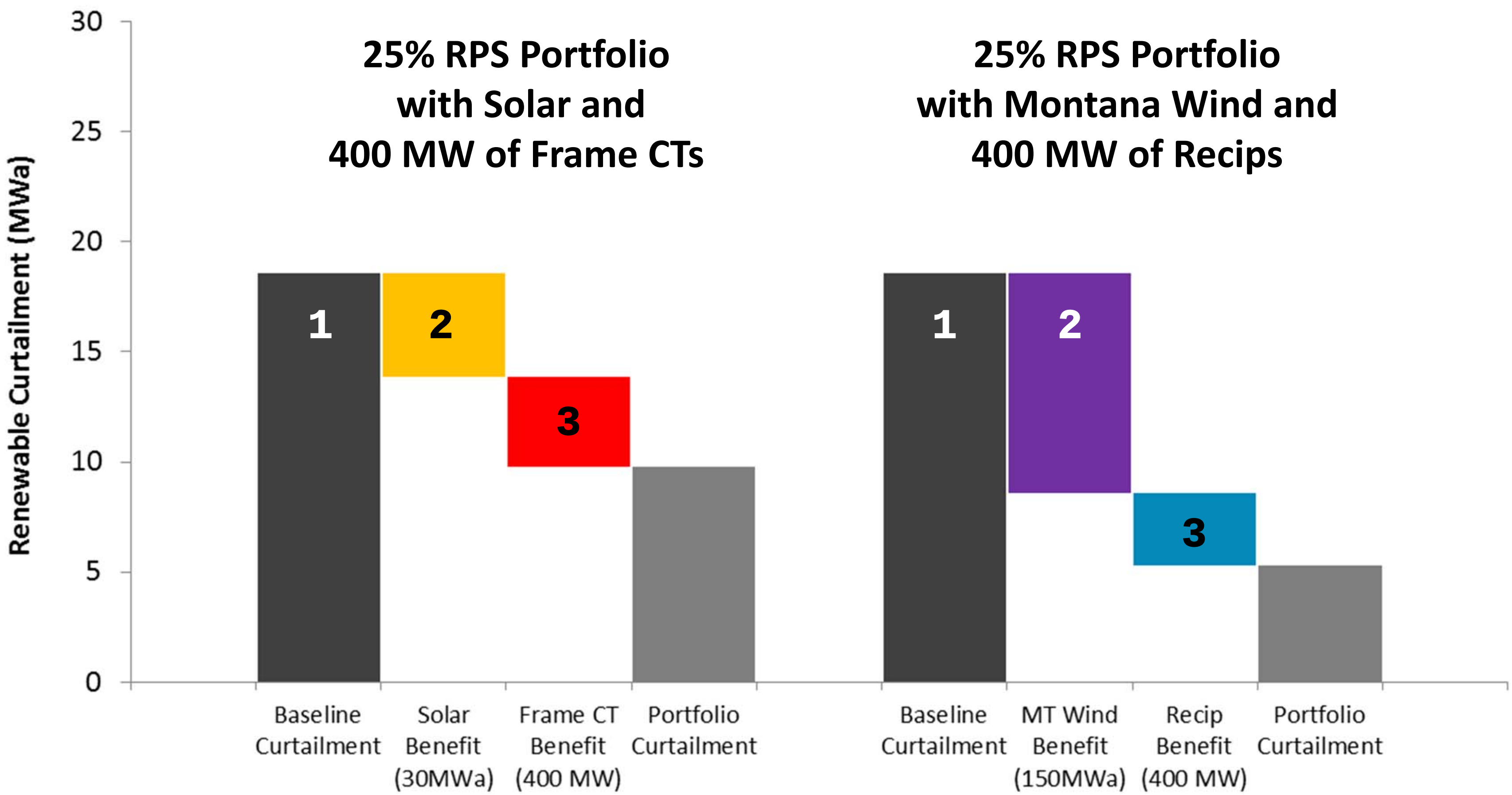
- Thermal resource impacts are approximated from both 25% RPS and 50% RPS runs to reflect technology differentiation and the impact of renewable penetration on technology differentiation



Portfolio Assessment

- Renewable diversity and thermal flexibility components can be combined to approximate upper bound on renewable curtailment for each portfolio
- While the upper bound on curtailment is used as a device for comparing flexibility challenges across portfolios, it is not anticipated that these levels of curtailment will be experienced on the system because opportunities to mitigate curtailment through market interactions are not modeled



Future modeling considerations

- Flexibility constraints will likely have much bigger impacts on the system as renewable penetrations increase above 25%, requiring ongoing evaluation of flexibility challenges
- Interactions with the market may have significant impacts on PGE's flexibility position, especially as PGE joins EIM
- Several of the demands of flexibility modeling are already incorporated into the ROM model, which has been developed for quantification of the renewable integration cost
- Future analytical efforts will seek to establish a more coordinated treatment of renewable integration costs and flexibility needs through a single modeling platform

	Priority	REFLEX	ROM
DA → HA → RT unit commitment and dispatch	**High**	Implemented	Implemented
Multi-day constraints	**High**	3-day	Weekly/flexible
Unit ramp rate constraints	**High**	Implemented	Implemented
Treatment of market interactions	**High**	Fixed prices	Supply curves
Energy storage models (PSH and batteries)	**High**	In progress	In progress
Hydro modeling	**High**	Fleet-wide constraints	Cascading system
Stochastic treatment of system conditions	**Low**	Implemented	None

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Energy Storage

Vibrant and Evolving Ecosystem

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From Energy Storage Technology Value Chain

	Power Electronics Vendors	Energy Storage Management System Vendors	Energy Storage System Vendors	Energy Storage System Developers
Residential Segment	Eguana Technologies, OutBack Power, SMA, Schneider Electric, Tabuchi Electric	Geli, OutBack Power, Sunverge	JLM Energy, peakNRG, Sonnen Batterie, Sunverge, Tabuchi Electric, Tesla	SolarCity, SunPower, Tesla
Non-Residential Segment	ABB, Bosch, Eaton, Ideal Power, Eguana Technologies, Parker, OutBack Power, S&C, Princeton Power Systems, Schneider Electric, SMA	1Energy Systems, ABB, Bosch, Coda, Demand Energy, Geli, Greencharge Networks, Greensmith, IG Intelligent Generation, OutBack Power, Stem, Sunverge, Viridity Energy, Younicos	ABB, Advanced Microgrid Solutions, Bosch, Demand Energy, Coda, Greensmith, EnSync, Greencharge Networks, peakNRG, PowerTree, Sharp, Solar Grid Storage, Sonnen Batterie, Stem, Tesla, Younicos	Advanced Microgrid Solutions, Coda, Demand Energy, Greencharge Networks, Greensmith, Sharp, SolarCity, Solar Grid Storage, Stem, Tesla, UGE
Utility-Scale Segment	ABB, Bosch, Eaton, Ingeteam, Parker, Princeton Power Systems, S&C, Schneider Electric, SMA	1Energy Systems, ABB, AES Energy Storage, Bosch, Demand Energy, Greensmith, IG Intelligent Generation, S&C, Younicos	ABB, AES Energy Storage, Bosch, BYD, Demand Energy, Greensmith, NEC Energy Solutions, Powin, Tesla, RES, S&C, Younicos	AES Energy Storage, Glidepath, NextEra Energy Resources, Invenergy, RES, SunEdison, Tesla

Source: GTM Research

Technology Range

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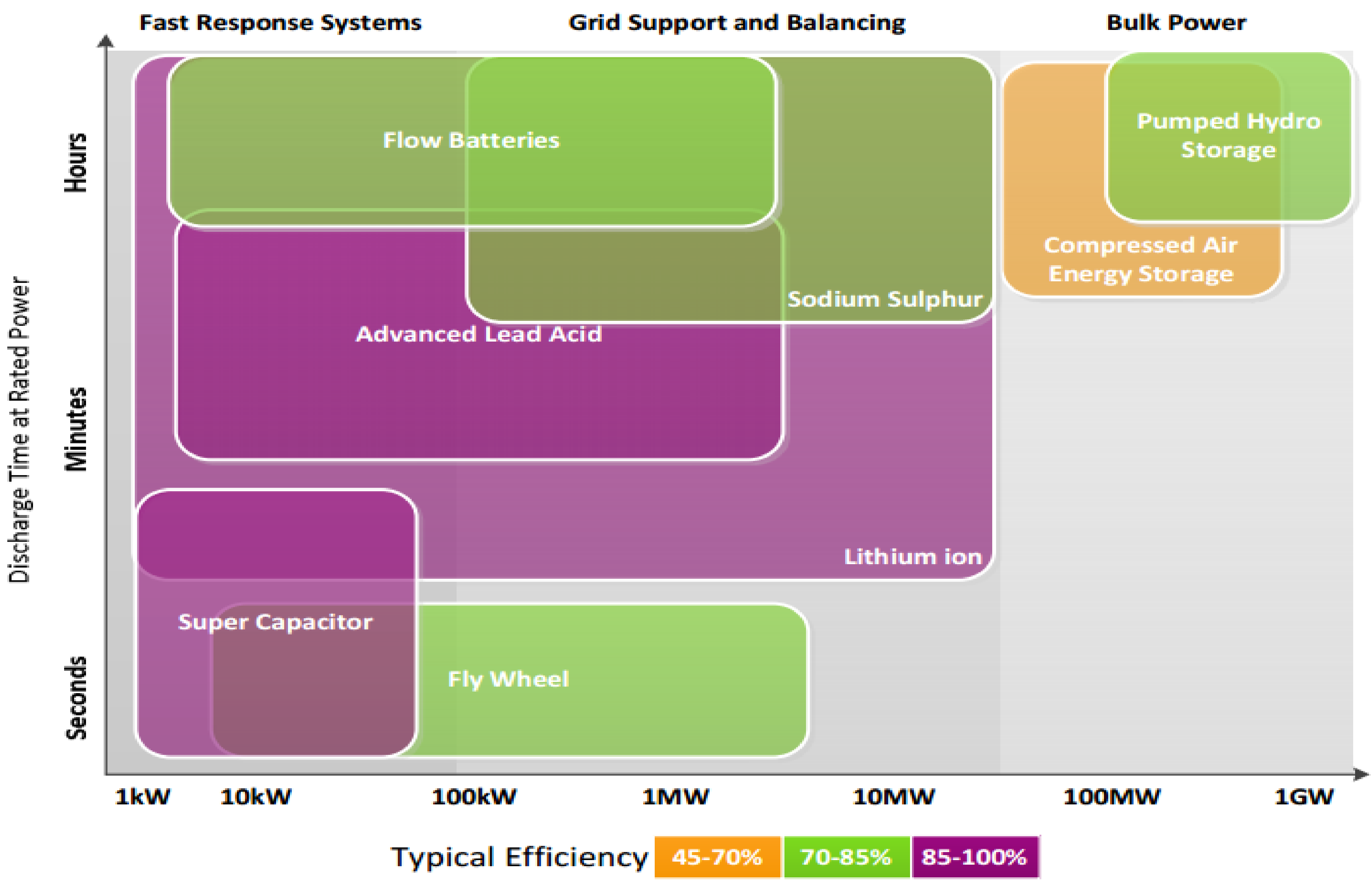
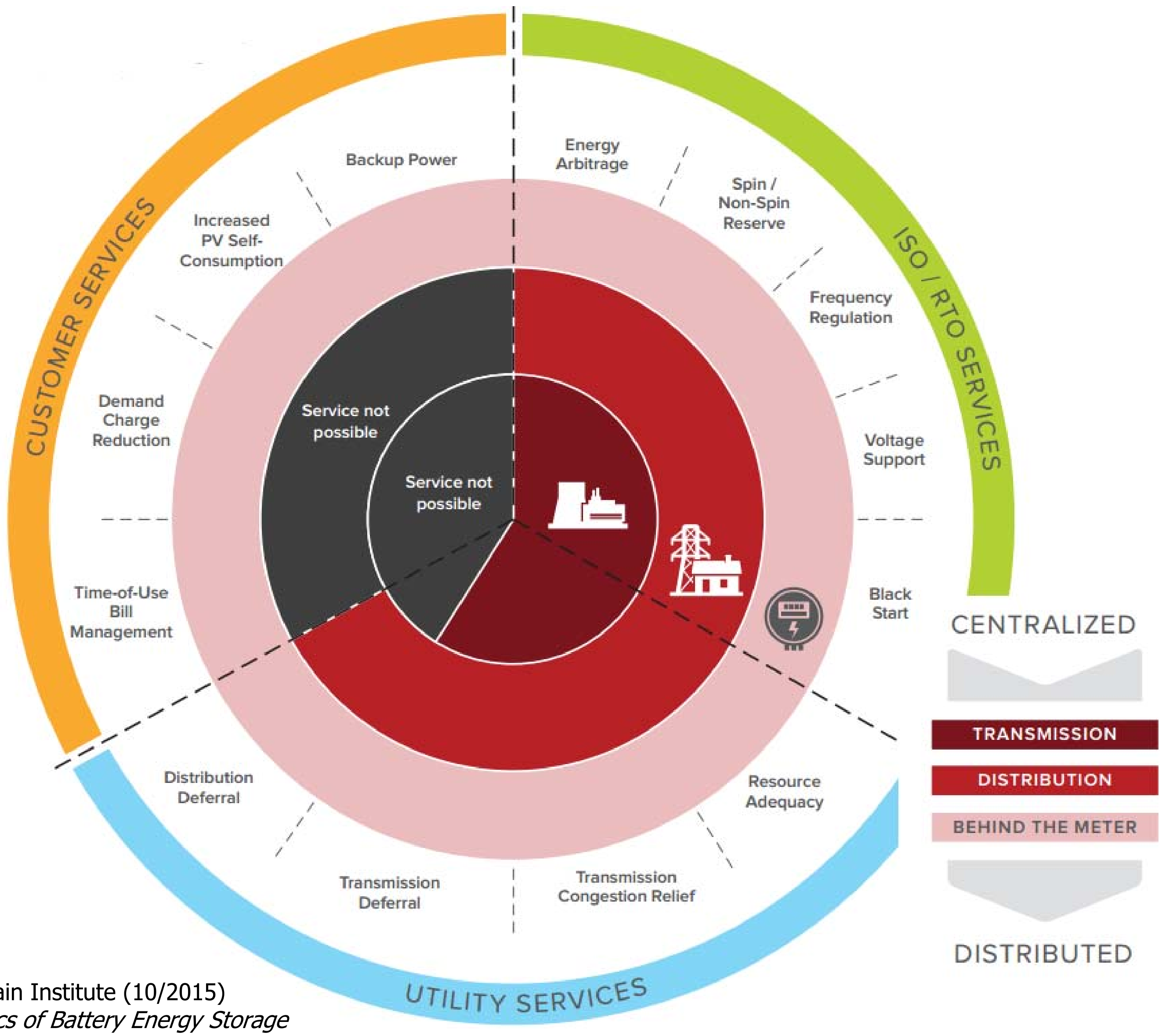
Technologies are available for a range of services and durations



Source: Australian Renewable Energy Agency (7/2015): *Energy Storage Study Funding and Knowledge Sharing Priorities*

Locational and Application Diversity

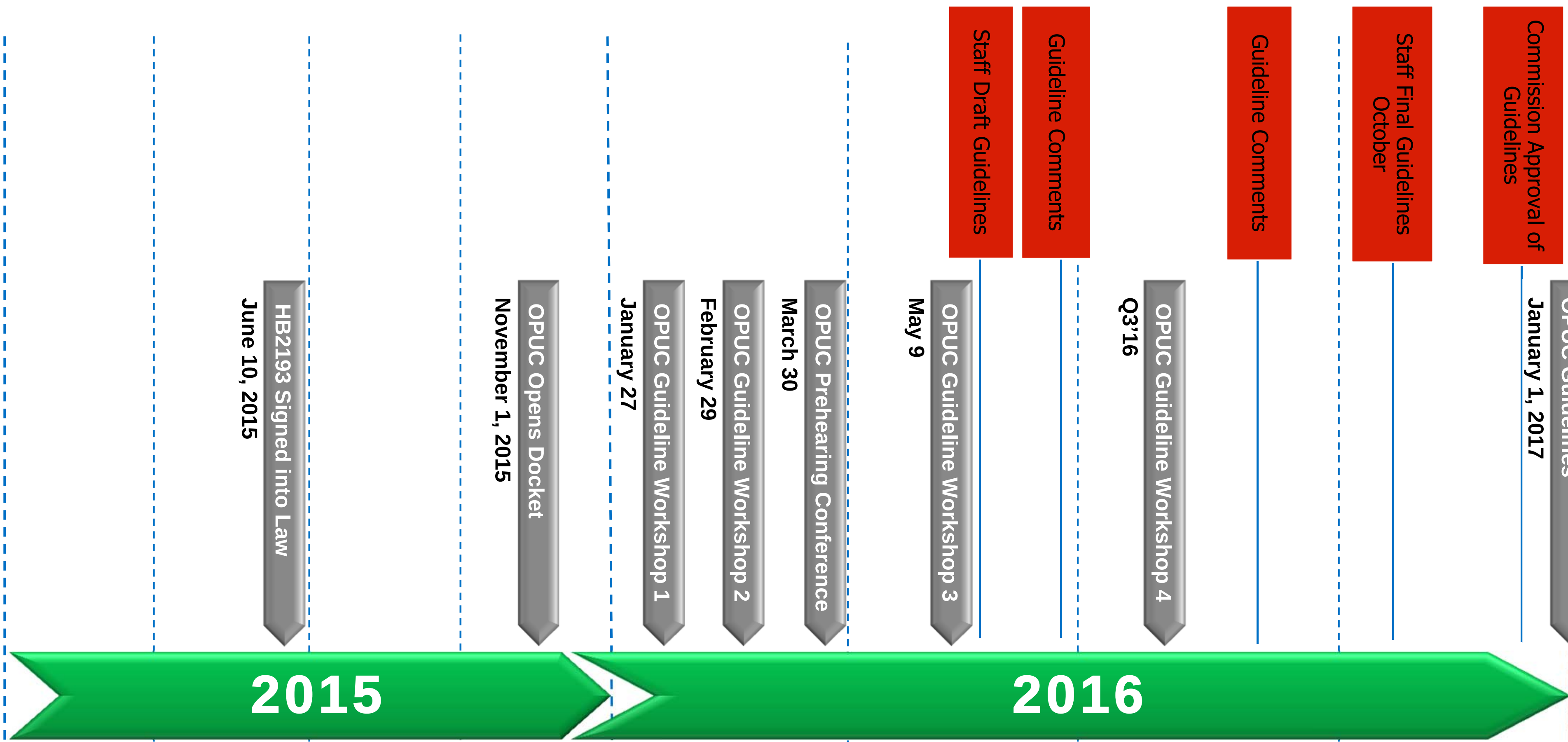
Energy storage can be used for multiple use cases, though not necessarily simultaneously



Source: Rocky Mountain Institute (10/2015)
The Economics of Battery Energy Storage

HB 2193 Guideline Development Schedule

PGE involvement in guideline development is critical to achieve a beneficial outcome for customers



Preparing

OPUC shall adopt guidelines for PGE to submit proposals for one or more energy storage systems **not later than January 1, 2017**

Energy Storage

Vision

Provide a diversified energy storage portfolio while integrating all resources through PGE system operations

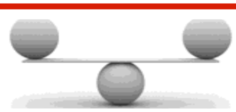
Principles. Energy storage…

is an integration resource serving as load or generation as required

provides a system benefit for all customers

integrates transmission and distribution with power operations

enables resource diversification and grid decarbonization efforts



helps balance cost and risk while maximizing reliability

Project Roadmap

Strategic objectives are linked with execution capabilities

Safety

- **Safety is a core value**
- **Integrate** physical testing and cyber security protocols early on

Strategy

- **OPUC regulatory process** to inform best practice implementation
- **Identify and mitigate risks** through planning and organizational structure

Execution

- **Align execution strategy** to deliver successful projects
- **Focus on core competencies** and follow the established roadmap

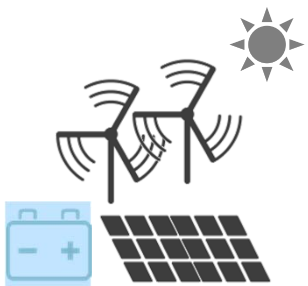
Energy Storage Road Map

Ensure Safety & Reliability			
Safety	Identify safety requirements for demonstration installations	Establish approaches for all projects & incorporate into safety best practices	Document standards, track incidents, & update as necessary
Testing	Identify vendor testing requirements & field test demonstration installations	Establish more formalized testing protocols and practices & perform independent engineering analysis	Integrate into standard practices
Cyber Security	Identify energy storage systems integration requirements	Develop best practices for operation, redundancy, and consistent implementation of security standards	Update processes and technology as needed
Prepare People & Business			
Organization	Focused storage team coordinated with other units and consultants support	Storage team shares learning, training is conducted & additional staffing ramps up	Storage team disbands & learning is entrenched
Resource Strategy	Metrics and evaluation methodologies developed	Metrics and methodologies merged with existing approaches & budgets planned	Standardized approaches used and maintained
Regulation and Customer Prices	Clarify immediate regulatory and customer price needs	Clarify regulatory and customer price needs tied to business models	Update as necessary
Best Practices Application	Summarize best practice from prior industry experience	Establish continuous improvement mechanisms & document methodologies	Maintain continuous improvement
Implement Projects			
Planning	Near-term needs and opportunity assessment & analytics with consulting support	Internal methodology & analytical capability developed & applied	Standardized planning & evaluation methods
Procurement	Demonstration-related, storage focused procurement	Individual installation-related, storage focused procurement & storage as a solution	Storage as a solution & larger-scale adoption
Installation & Integration	Install demonstration storage & determine standard integration, controls, and asset management	Establish installation practices for additional storage	Formalize with standard practices
Operations	Identify and confirm measurement & verification approaches and data collection & maintenance	Execute regular M&V and establish best practices per applications	Monitor assets & ensure ongoing learning

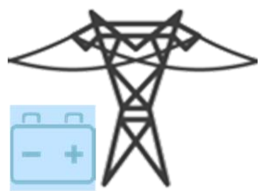
Project Scope

Energy storage can be deployed at diverse locations and be enabled to operate to support multiple use cases

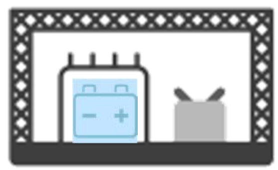
Generation Facilities



Transmission System



At Substation



Distribution Feeder

Salem Smart Power Center

Customer Premises

In front of the meter

Behind the meter

Future Investigation

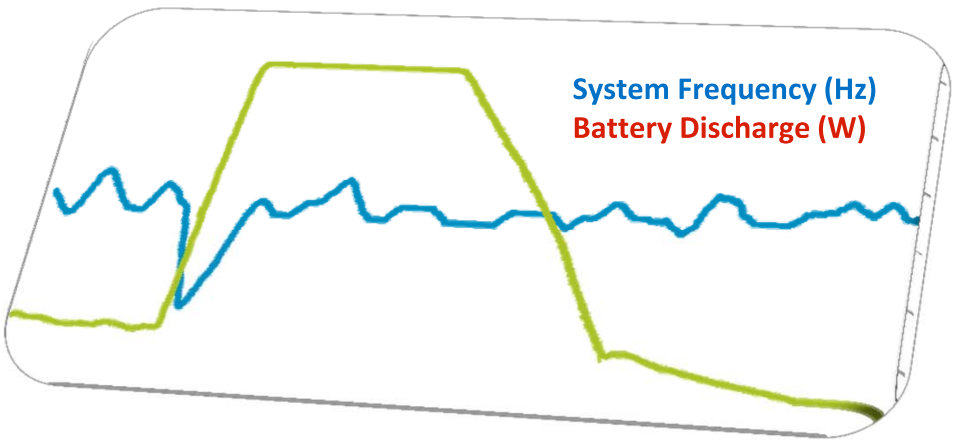
Investigating in UM 1751

Potential to store energy

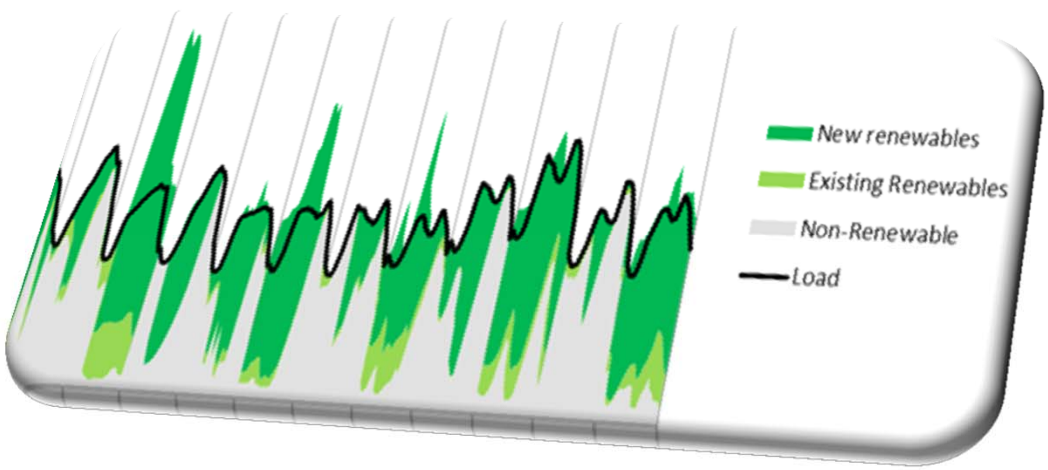
Potential to store energy is dependent on application, technology, and location

- HB 2193 requires that each proposal include "an evaluation of the potential to store energy in the company's system" @ 3.2.b.
- "Storage potential" is a broad phrase which needs to be contextualized
- PGE plans to assess storage potential through evaluation of applications, technology, and location
  - energy arbitrage and demand shifting
  - ancillary services
  - avoided renewable curtailment
  - generator capacity value
  - locational value
  - other use cases

Potential to store energy for Frequency Response



Potential to store energy to Avoid Renewable Curtailment



Commission evaluation of proposals

Portland General Electric

HB 2193 provides guidance on Commission review of proposals

- The Commission shall consider each proposal to determine whether the proposal:
  - is consistent with the Commission guidelines adopted
  - reasonably balances the value for ratepayers and utility operations
  - is in the public interest

Quantitative and qualitative metrics included in proposals could be used to inform Commission evaluation

- Project costs ($/kW)
- Project benefits ($/kW)
- Investment deferral value
- Peak demand generation reduction avoided cost
- Renewables integration savings
- Greenhouse gas emissions reductions
- Reliability metrics improvements
- Portfolio variable power costs reductions
- Additional value (if applicable)
- Commercial operation date (COD)
- Term (year)

- Technology type
- Self-discharge (MW/hour)
- Ramp rate (charge/discharge, up/down; MW/hour)
- Maximum capacity (charge/discharge, up/down at grid connection point; MW)
- Capital cost ($)
- Fixed O&M ($/kW-year)
- Variable O&M (for discharging, $/MWh)
- Roundtrip Efficiency (%)
- Maximum cycles (per lifetime, number of cycles)
- Maximum daily switches (charge/discharge; number of charges per day)

Portland General Electric

Boardman Biomass

100% Torrefied Biomass Test Burn – Boardman Plant

Portland General Electric

- Status of Boardman 100% Torrefied Biomass Test Burn
- Quick History
- Obtaining 8,000 tons of Torrefied Fuel
- Combustion Pre-Testing at Western Research Institute
- Production Quality Control and Assurance
- Costs and Test Considerations
- Summary and Outlook

Boardman – Using Renewable Biomass Fuel

Portland General Electric

Target: 600 MW at 40% Capacity
Amounts to: 240 MW annualized

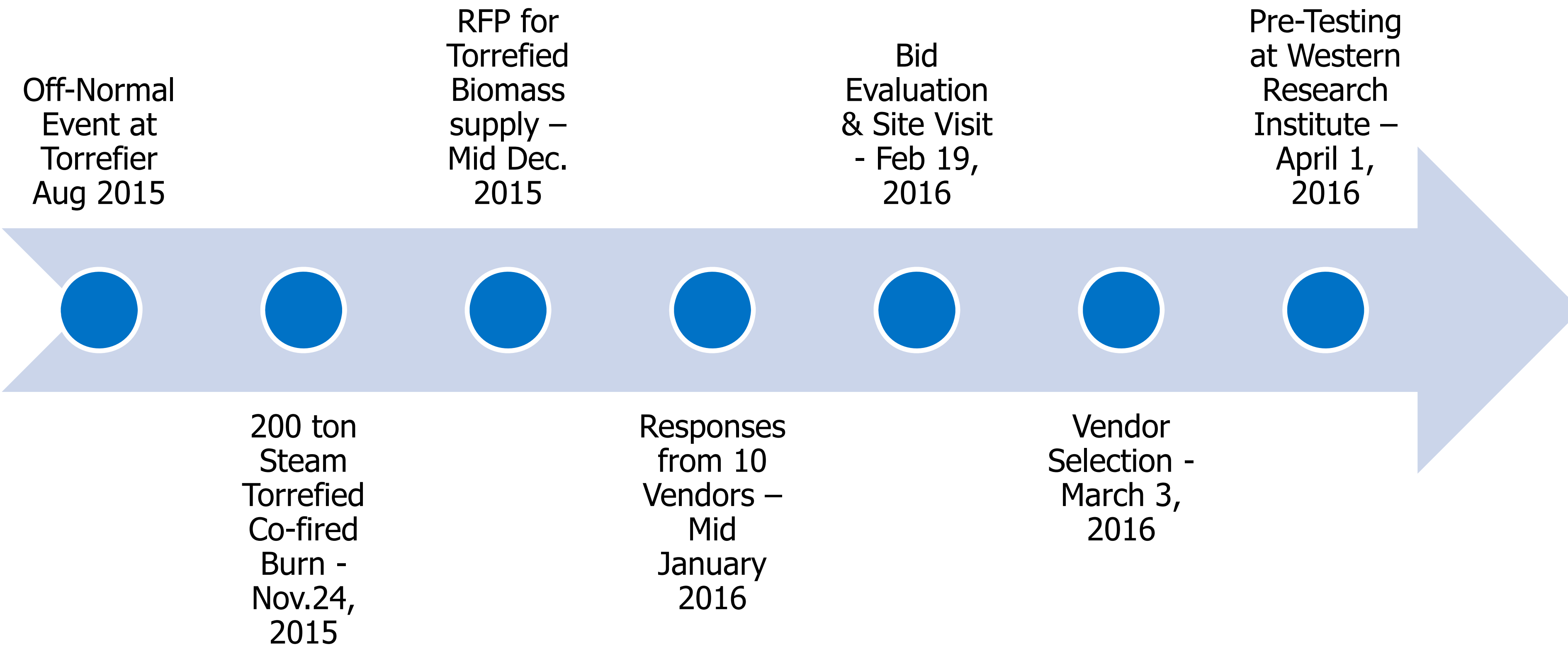
Baseload workhorse

- 600 MW capacity; PGE owns 90%
- Plant to cease coal operations by Dec. 31, 2020
- 100% operation on biomass may be an option with regulatory approval

Phase 1: Co-fire test burn
Phase 2: 100% Torrefied

- 1 full power day equivalent
- 8,000 tons of fuel

Timeline 100% Torrefied Biomass Test Burn



16 Sources Worldwide – All Comers

- Steam Torrefied
- Kiln Torrefied

10 Responses

One Response at close to Levelized Cost

Located in the Commonwealth of Virginia

- Heart of "Coal Country"
- Excess capacity in transportation, labor due to coal downturn

Selected Vendor – Vega Biofuels

Joint Venture with Nex-Gen Industries

HQ in Norcross, GA

Fabrication Shop in Richlands, VA

Nex-Gen builds a calciner type device

Rotary Kiln type torrefier

Typically operate at 450 °C for Char

Can operate at 300 °C for torrefying

Products

- Metallurgical (Met) Coal Hybrid
- Biochar
- Charcoal

NGI 14 Being Deployed in Alabama

Two Drive Motors, 8 Hp; Single Phase Power; ≈ 2 gal propane / ton

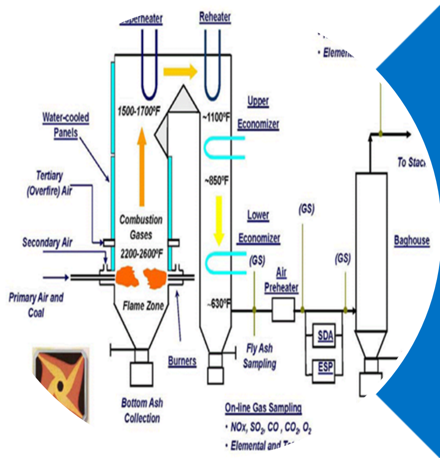
Operational Characteristics – 3rd Generation Design

Portland General Electric

- 7 + Tons / hour …. Four units deployed to field
- Propane or diesel fired
- Rotary Kiln (Calciner) design
- Manual Operation & Controls
- 2 Workers / 12 hour shift – Four days
- Charge Hopper – Biomass Feed
  - Heated with Exhaust Air
  - ≈ 10 to 15% Moisture Content
- Gravity Aided
- Exit Screw Auger, Length & Rate tuned for Cooling torrefied product
- Emissions
  - Cyclone removes organic condensibles – Natural Draft Exhaust
  - Saw Dust Filter removes escape fraction

Western Research Institute – Combustion Tests

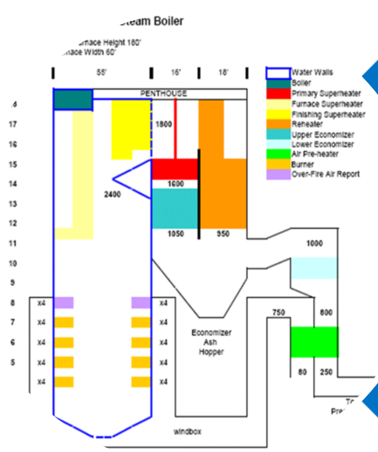
WRI



Upsides

- Can compare PRB Coal with "similar" solid fuels under same combustion conditions
- Has most of the Boardman Components but smaller scale
- Better than a wet thumb in the air or worse - Not Knowing

Boardman



Downsides

- Cannot fully predict what will happen in Boardman's Boiler
- Boardman's burners are more sophisticated
- Introduction of combustion air is different
- Flue gas at WRI is 500 °F cooler

Vega Torrefied Fuel Combustion Performance

Portland General Electric

Torrefied Fuel Milling was identical to PRB Coal

Vega 300 combusted well

- Almost identical to PRB coal
- Duplicate runs were similar – No Fluke

Vega 450 did NOT yield a good, stable burn

Ash Deposition for Vega 300

- Coloration is a little different
- Tends to deposit earlier in the system
- Needs further study on Boardman ESP for ash capture

Conclusion: Go with Vega 300; Decline use of Vega 450

Combustion and Storage Pre-Testing

Portland General Electric

Western Research Institute	250 lb combustion test of 450 C material	250 lb combustion test of 300 C material (in duplicate)	Baseline PRB combustion test
Storage (100 tons 300 °C)	Auto-Ignition	Dust creation and Re-suspension	Breathing Zone Industrial Hygiene
Explosivity Testing - Fike Corporation	Minimum Auto Ignition Temperature (Dust Cloud - MAIT)	Minimum Explosive Concentration (MEC)	20L Dust Explosibility

= Completed

Cost Schedule & Quality Control

Portland General Electric

8,000 tons Torrefied Fuel Delivered to Boardman's Gate by Rail

100 tons Torrefied at 300 °C for Observation Delivered by Truck

Likely Total Cost is in range of $1,500,000

For each 100 tons of Production:

During Production of 8,000 tons
- Extract 10 lbs per 10 tons
- The 10 lbs are combined and uniformly mixed

+

Standard Labs performs Fuel Spec Analysis
- If in spec – the 100 tons is accepted
- If Not in spec – the 100 tons is rejected

=

Accepted 100 ton piles are combined

Quality Assurance in Torrefied Fuel Production

Portland General Electric

Standard Labs will conduct 6 unannounced visits for additional sampling

As fuel is loaded onto train, every car is sampled, combined & analyzed for one final check

Fuel Spec Analysis for every sample is sent to Vega and to PGE

PGE will send a representative at least once to observe and sample

Summary and Test Considerations

Portland General Electric

Phase 1: Co-fire test burn [2015]

Phase 2: 100% Torrefied test burn [2016]

- One Full Power Day Equivalent
- 6 pulverizers for 24 hours
- 3 pulverizers for 48 hours

Item	Mitigating Action
Written notice DEQ & ODOE	Notify at least 15 days before test burn
Operational Power Ramp	Warm up; stepwise increases, w/ hold points

Boardman Power Plant – Breaking New Ground

Portland General Electric

Target: 600 MW at 40% Capacity
Amounts to: 240 MW annualized

Baseload workhorse

- 600 MW capacity; PGE owns 90%
- Plant to cease coal operations by Dec. 31, 2020
- 100% operation on biomass may be an option with regulatory approval

Some Notable Facts:
- Largest Conversion in US
- Largest Torrefied Fuel Order
- Sets 1st Market Price
- Largest Train Load Moved
- Largest Test Burn

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

Portland General Electric

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 CO_2 prices?	At this point, the flexible capacity modeling effort will likely not consider a range of CO_2 prices.	12/17/15

2016 IRP: Feedback Status

Portland General Electric

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

Portland General Electric

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

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

Portland General Electric

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

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

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

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

Portland General Electric

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

Portland General Electric

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

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

Portland General Electric

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