Integrated Resource Plan

2016

Public Meeting #5

Thursday, December 17, 2015

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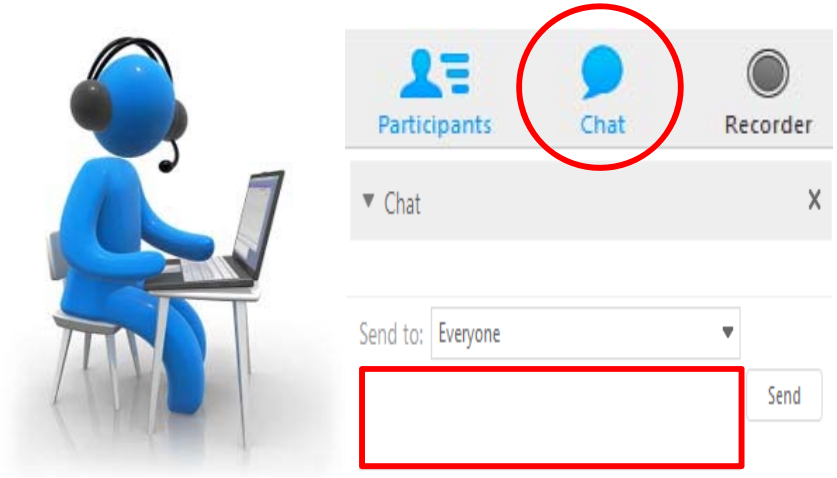
Welcome: Meeting Logistics

- Local Participants:
  - DoubleTree facility
  - Wireless internet access
  - Sign-in sheets
  - Parking

- Virtual Participants:
  - Ask questions via ‘chat’ feature
  - Meeting will stay open during breaks, but will be muted



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Welcome: Today's Topics

- Safety Moment
- Public Process
- 2013 IRP Update
- Integrated (Smart) Grid
- Energy Storage and HB 2193
- Demand Response (DR) Potential Study
- Planning Reserve Margin / Capacity Contribution
- Portfolios and Futures

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Safety Moment

Safety is a Core Value

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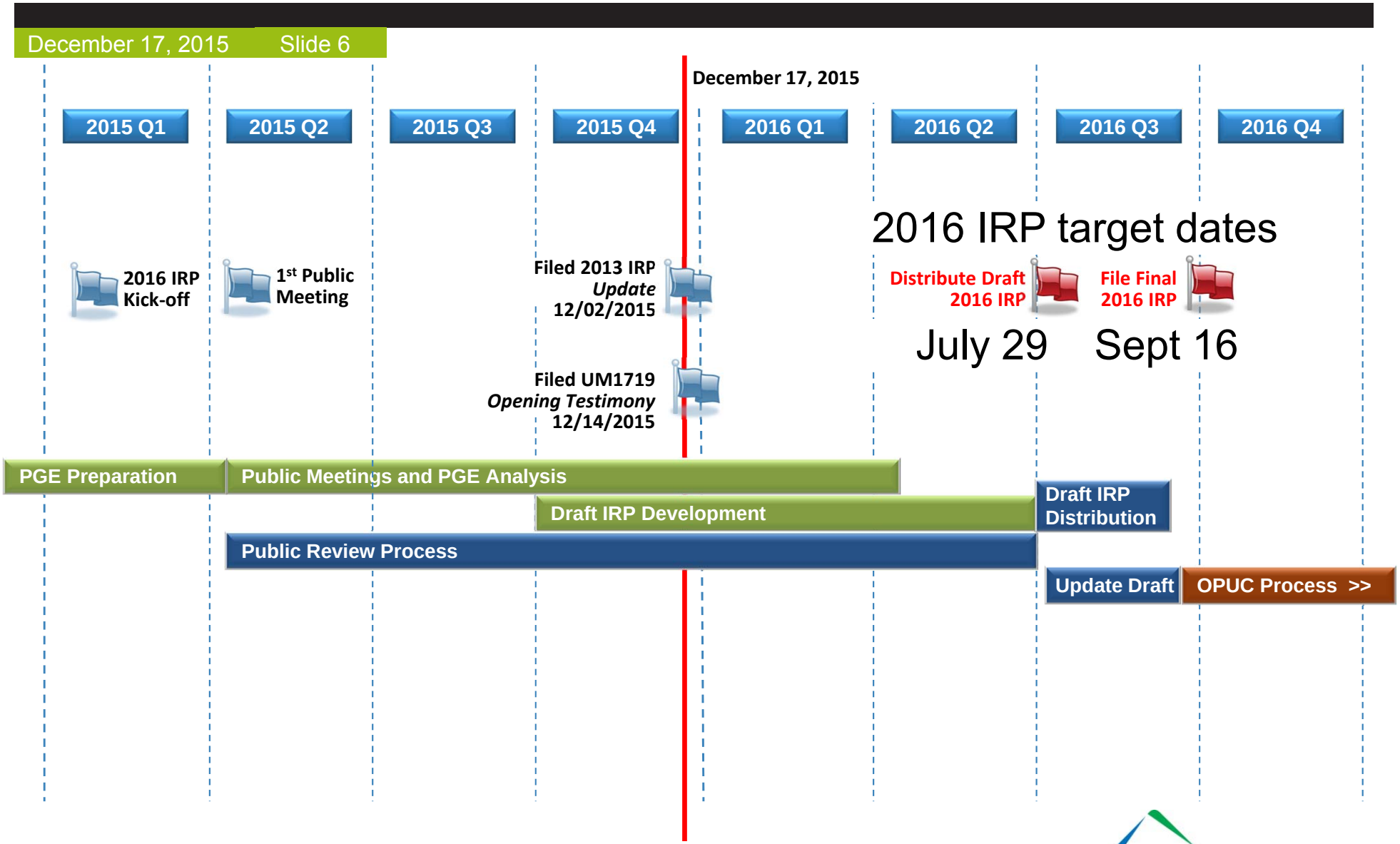
Public Process Overview

2016 IRP Timeline



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2016 IRP: Meeting Schedule And Planned Topics

Q4 2015 / Q1 2016

December 1, 2015

Workshop #2
Commission (Salem)

- *EIM Study*

December 17

Meeting #5
Public

- *Development*
  - *Integrated (Smart) Grid*
  - *Energy Storage*
- *Analysis*
  - *Portfolios and Futures*
- *Results*
  - *Planning Reserve Margin*
  - *Capacity Contribution*
  - *Demand Response*
- *General*
  - *2013 IRP Update*

Date

YY-#
Roundtable

- *Development*
  - *Topics*
- *Analysis*
  - *Topics*
- *Results*
  - *Topics*
- *General*
  - *Topics*

Public Meeting / Technical Workshop

Roundtables

Meeting with Commission Present

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2016 IRP: Meeting Schedule And Planned Topics

"For its next IRP planning cycle, we direct PGE to hold a series of workshops with stakeholders (with at least one attended by the Commissioners) to develop a wide range of multiple portfolios for meeting its incremental capacity and energy needs."

and

"PGE to work with Staff and stakeholders to explore options to model and perform analysis in its next IRP related to known, and expected, Section 111 (b) and (d) requirements, and to present its results at a workshop with Commissioners."

- Order No. 14-415

2016 IRP: Meeting Schedule And Planned Topics

2016 (Tentative)

February 10, 2016

16-1** (formerly Public Mtg #6) **Roundtable

- *Preliminary Results*
  - *Colstrip Portfolios*
  - *Variable Resource Integration*
  - *Trigger Points*
- *General*
  - *Transmission*

Dates Tentative

Additional Roundtables

- *16-2 on May 18*
- *16-3 on August 17*
- *16-4 on November 16*
- *Final Results*
  - *Colstrip Portfolios*
  - *Variable Resource Integration*
  - *Trigger Points*
- *Draft 2016 IRP*

Date and Location TBD

Meeting #3 Commission

- *Development*
  - *Portfolios and Futures Review*
  - *Reference Portfolio*
- *Results*
  - *Clean Power Plan*

2016 IRP target dates: July 29 – distribute draft; Sept 16 – file final

Roundtables

Meeting with Commission Present

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2016 IRP: Status

Item		Status	
Meetings	***Roundtables***	**9 Planned**	(5 Complete, 1 Scheduled, 3 Tentative)
Workshops		**4 Planned**	(3 Complete, 1 To Be Scheduled)
Feedback Forms		**4 Received**	(3 since last meeting)
2013 IRP Action Plan		**5 Actions (OPUC Order No. 14-415)**	
Supply Side		In progress	(Hydro contracts, portfolios, no major resources)
Demand Side		Completed In progress	(EE, DR) (CVR)
Enabling Studies		Completed In progress	(Load forecast, EE, DG, EIM, Capacity) (Biomass, Flexibility)
Transmission		In progress	
Other		In progress	(RPS, Clean Power Plan)
Related Topics		In progress	[UM1708 (DR); UM 1716 (VoS); UM 1719 (VER CC)]
2016 IRP Development		**~13 Chapters**	
Draft		Content outline under development	
Final		Not Started	

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2013 IRP Update

2013 IRP Update Topics

- Updates since the 2013 IRP
  - Load Forecast
  - Resources and Resource Costs
  - Fuel Prices and Carbon Costs
  - Load-Resource Balance
- Studies to inform the 2016 IRP
  - Progress on acknowledged and additional studies
  - Clean Power Plan overview
- RPS scenario analysis
- 2013 IRP Update presentation to OPUC planned for January 12, 2016

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2013 IRP Update

- **Load Forecast**
  - 2017 average energy decreases by 1.9 percent
  - 2017 winter peak increases by 1.1 percent
  - 2017 summer peak increases by 1.2 percent
  - Long-term growth rates are slightly lower than the 2013 IRP

2013 IRP vs. 2013 IRP Update Forecast

Reference Case Forecast	Energy		Winter Peak		Summer Peak	
	2017 MWa	2014-33 Growth	2017 MW	2014-33 Growth	2017 MW	2014-33 Growth
2013 IRP (December 2013 forecast)	2,422	1.3%	3,613	1.0%	3,523	1.3%
2013 IRP Update (June 2015 forecast)	2,377	1.2%	3,652	0.9%	3,564	1.1%
Change from 2013 IRP	(45)	(0.1%)	39	(0.1%)	41	(0.2%)

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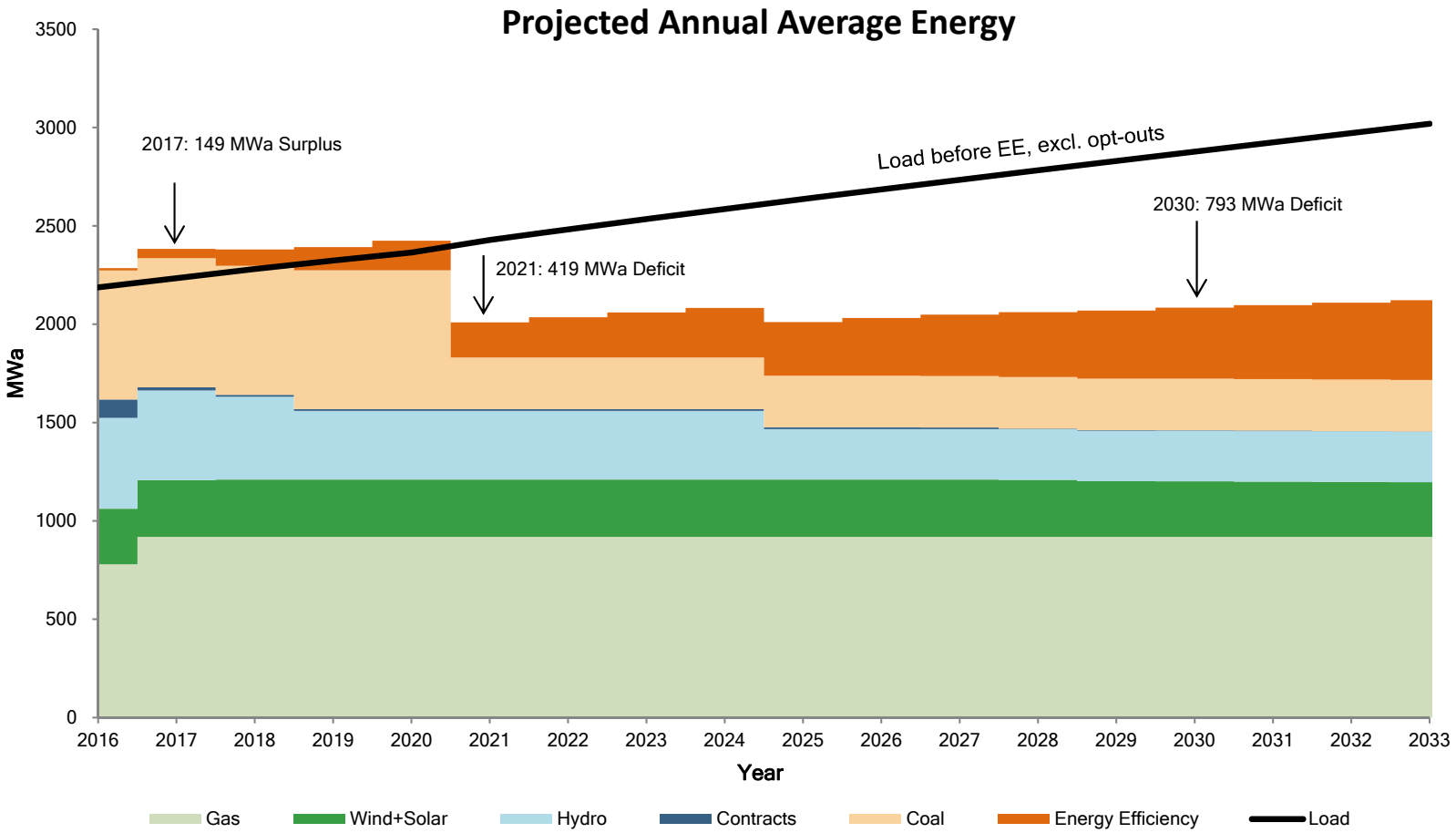
2013 IRP Update

- **Load-Resource Balance**



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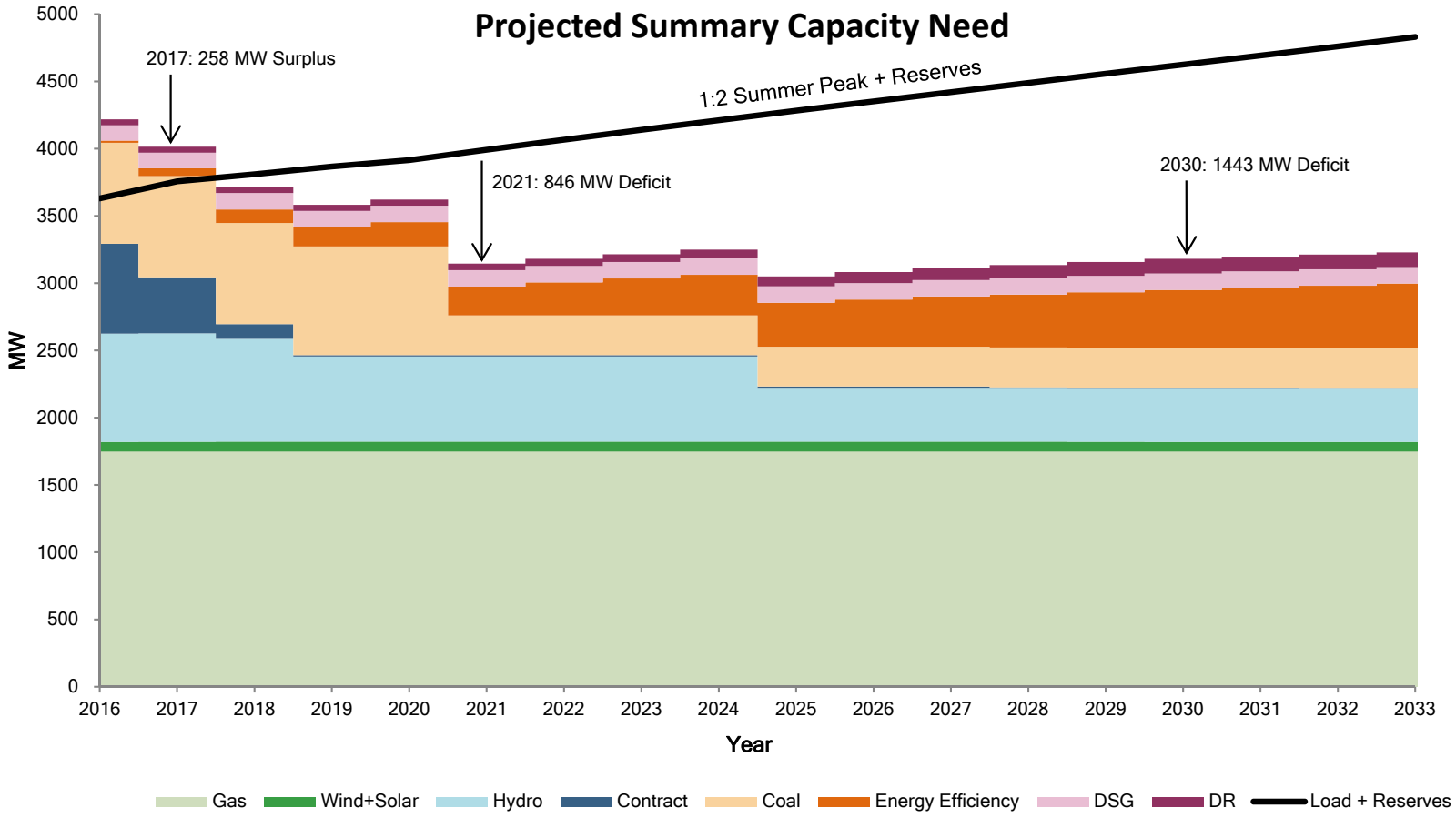
2013 IRP Update

- **Load-Resource Balance**



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2013 IRP Update

- **Renewable Portfolio Standard – Compliance Options**

  - Physical Compliance

  - Renewable Energy Certificates
    - Bundled
    - Unbundled (20% max annually)
    - Previously banked

  - Alternative Compliance Payments

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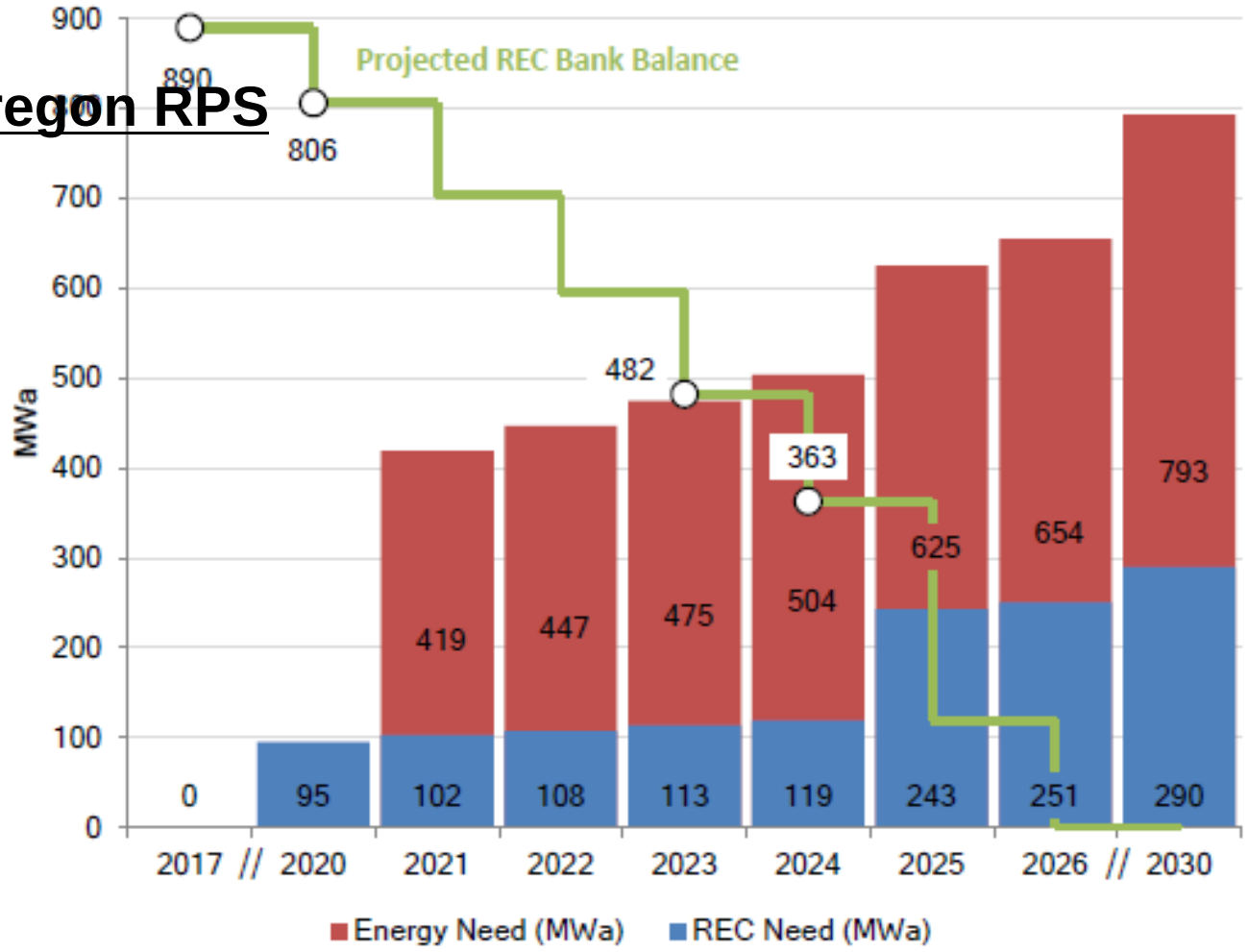
2013 IRP Update

- **Renewable Portfolio Standard**

Oregon RPS



15% by 2015

20% by 2020

25% by 2025

[1]Assumes no additional actions, i.e. baseline

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2013 IRP Update

- **Renewable Portfolio Standard**
  - 2017 projected REC bank balance ≈ 890 MWa[1]
  - 2025 projected REC bank balance ≈ 0 MWa[1]

Risk Factor	2015-2019	2020-2024	2025-2029	2030+
RPS resource in-service date	-	95	148	47
Generation < forecast	59	80	112	120
Future RPS increase	-	111	118	126
Load growth > forecast	6	10	12	12
Total Risk (MWa)	**65**	**296**	**390**	**304**

- Based on a minimum REC bank balance of 300–600 MWa, PGE concluded a physical renewable resource addition in 2024, balanced by reliance on banked RECs through 2023, enables PGE to delay costs of physical compliance in 2020.

[1]Assumes no additional actions, i.e. baseline

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2013 IRP Update Summary & Conclusion

Key Observations from 2013 IRP Update

- PGE continues to work toward the actions of the 2013 IRP
- PGE made refinements to the load forecast methodologies
- The energy load-resource balance forecasts a resource surplus through 2020 and a resource deficit beyond 2020
- The capacity load-resource balance forecasts a resource surplus in 2017 and a resource deficit beyond 2018
- Resource cost projections have decreased since the 2013 IRP
- Natural gas price projections have fallen further since the 2013 IRP
- The Clean Power Plan will be robustly modeled in the 2016 IRP

2013 IRP Update Conclusion

- When considered in total, the changes and revised assumptions in the IRP Update continue to support moving forward with the acknowledged Action Plan

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Integrated (Smart) Grid

Overview

- Integrated (Smart) Grid Update
- Current Strategy & Looking Forward
- Questions

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Integrated (Smart) Grid Update

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Grid Optimization Leadership

- More than 850,000 digital smart meters installed (2010)
- 5 MW lithium-ion battery and high reliability zone operational in Salem (2014)
- 76% of PGE substations have SCADA (up from 70% in 2013)
- 768 MWh saved through Conservation Voltage Reduction pilot (2015)
- Synchrophasors installations at 3 substations by end of 2015
- T&D Analytics pilot launched (2015)

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Customer Engagement Leadership

- Over 165,000 customers have accessed Energy Tracker[SM] (up from 80,000 in 2012)
- 25 MW demand response available (up from 16 MW in 2012)
- 106 MW dispatchable stand-by generation by end of year (up from 74 MW in 2012)
- 45 MW customer-owned renewables (up from 29 MW in 2012)
- Approximately 5,000 electric vehicles in PGE service territory (up from 600 electric vehicles in 2012)
- Approximately 1,100 public charging stations in Oregon (up from 688 in 2012)

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Spotlight: Salem Smart Power Center

The Salem Smart Power Center was a Smart Grid Demonstration Grant project developed as part of a regional transactive energy demonstration with Pacific Northwest National Laboratory.

- 5 MW/1.25 MWh lithium ion battery
- High reliability zone
- Transactive control capabilities
- Renewables integration
- Demand response capabilities
- Frequency regulation (Feb. 2015)

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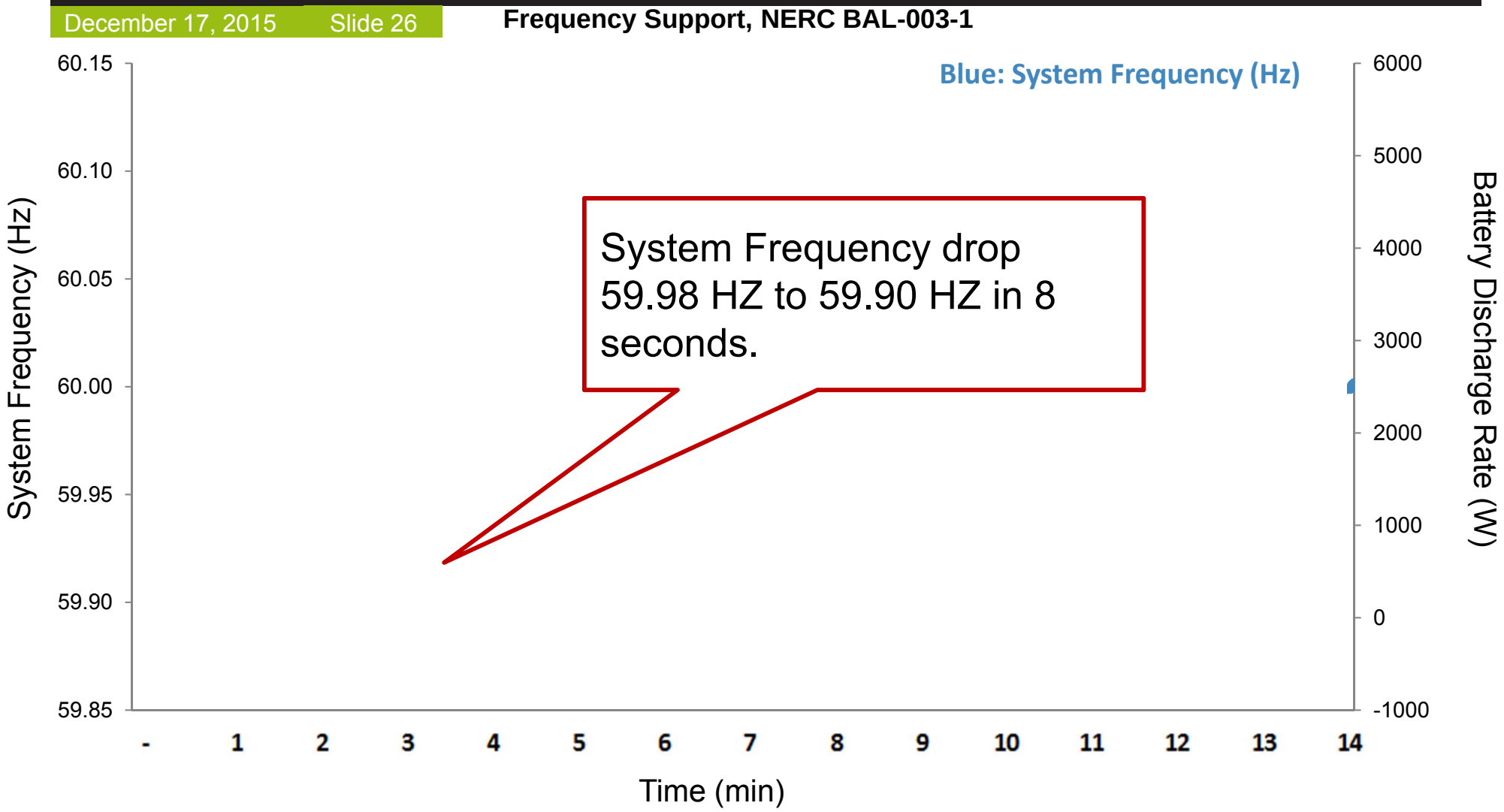
Spotlight: Salem Smart Power Center (cont.)



Feb 22, 2015, 8:44 am 660 MW of Generation Lost

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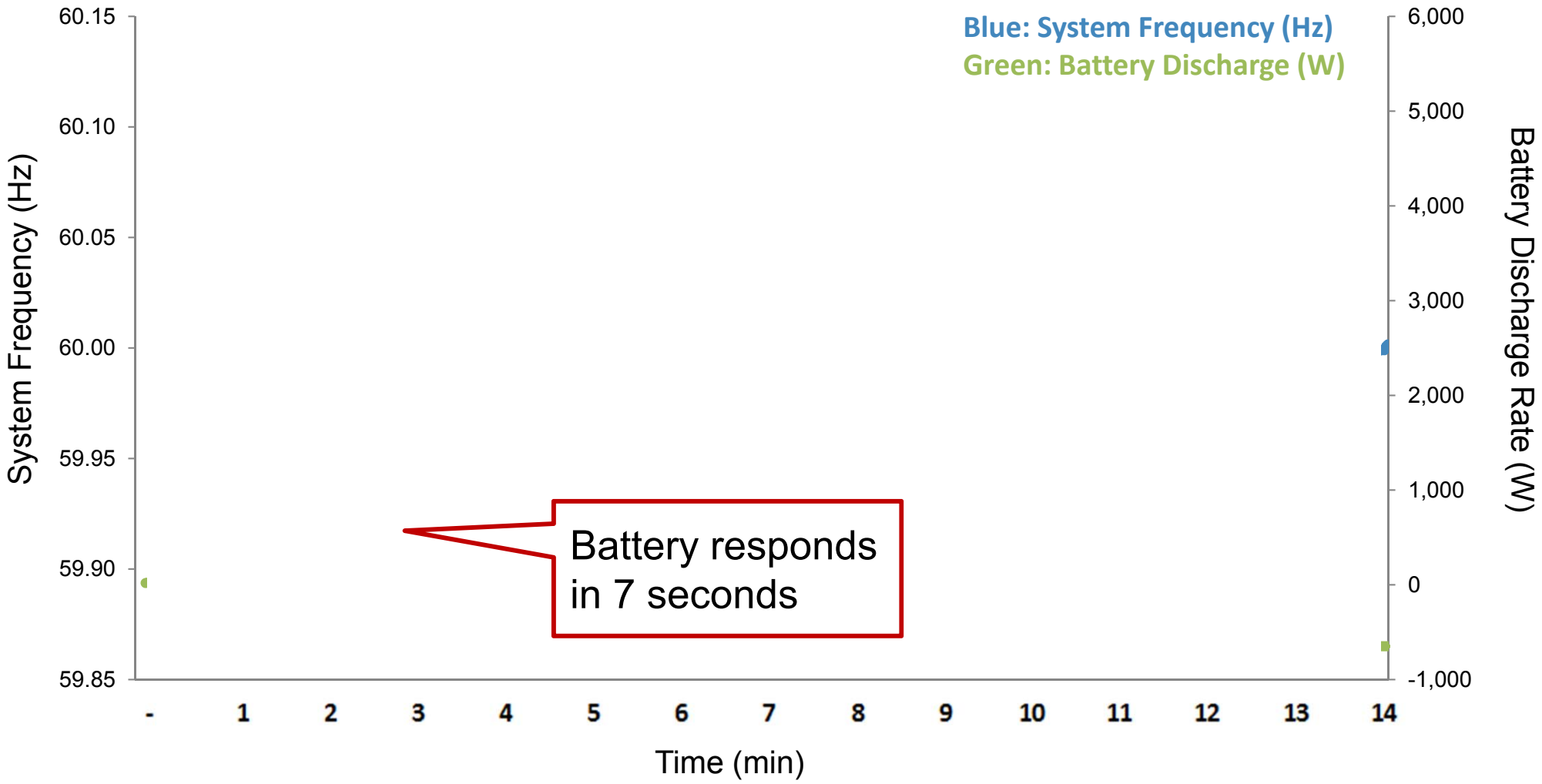
Spotlight: Salem Smart Power Center (cont.)



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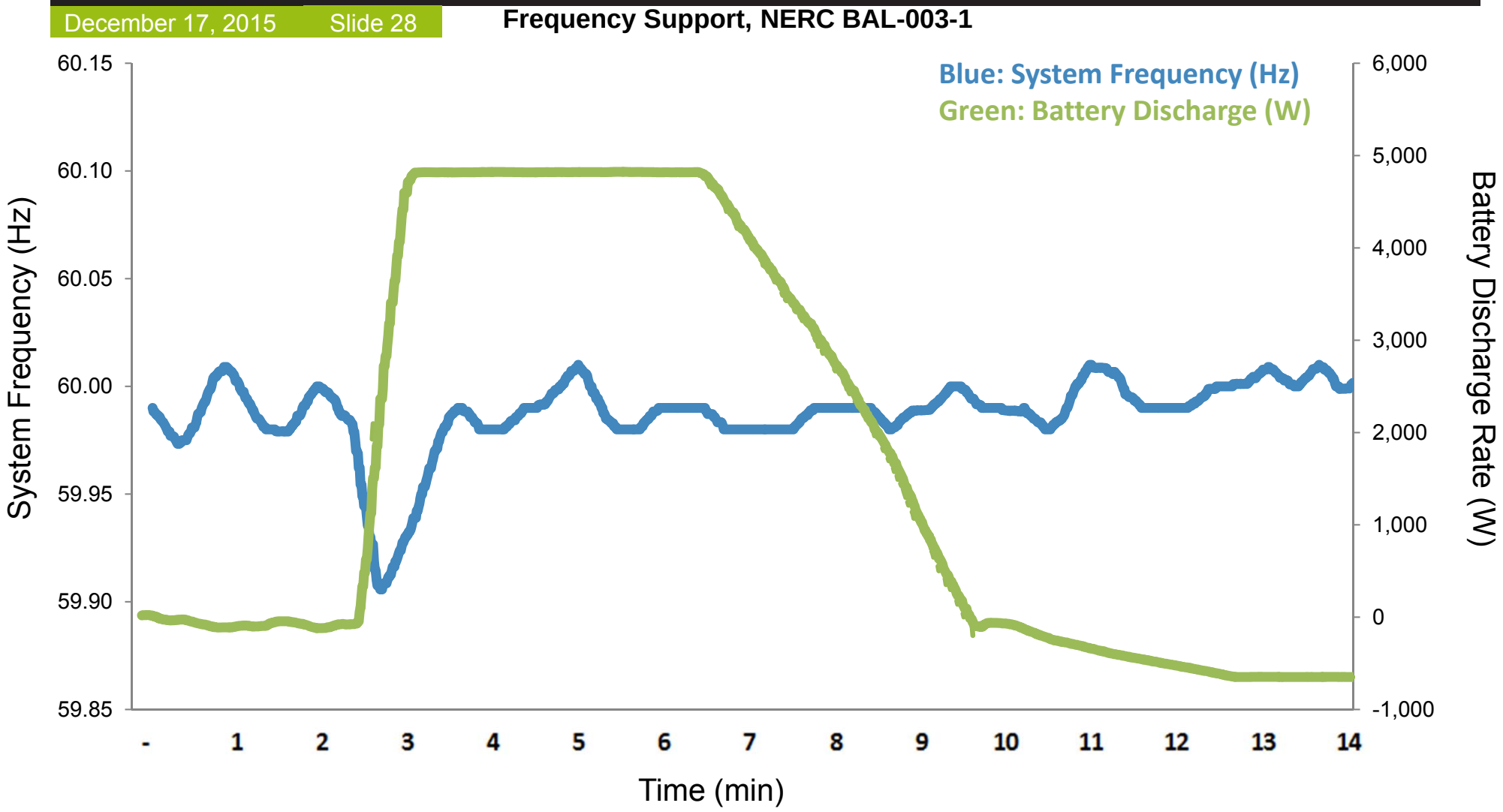
Spotlight: Salem Smart Power Center (cont.)



Feb 22, 2015, 8:44 am 660 MW of Generation Lost

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Spotlight: Pricing and Demand Response Pilots

Rush Hour Rewards Pilot

- Tests the impact of Smart Thermostat control on summer and winter peak energy usage
- Launch partner for **Nest's first winter program**
- **Goal:** enroll 3,500-5,000 customers and deliver 0.4-1kW reduction per household
- **Target Launch Date:** November 2015

Pricing Pilot

- Demand response pilot identifying the system benefit of targeted peak energy usage education, various time of use structures, and peak time rebate
- **Goal:** enroll 3,500-7,000 customers
- **Target Launch Date:** March 2016

Pilot Variant	Tentative Hours * Winter only
Schedule 7 Educated	No Change
Day and Night TOU	Day: 6am -10 pm Night :10pm -6 am
Peak only	Peak: 7am-10am*/3pm-8pm Off Peak: all other times
Three Tier	Peak:7-10am*/3-8pm Mid: 10am-3pm Off: 8pm-7am

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Spotlight: Energy Partner^{SM} Pilot

"The Energy Partner^{SM} Program is great….you start looking at (your system) from an eye of efficiency."

- Alpenrose Dairy

Automated Demand Response

- Launched August 2013
- **28** participating customers
- **10** MW enabled
- Goal of reaching **25 MW**

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Our Strategy

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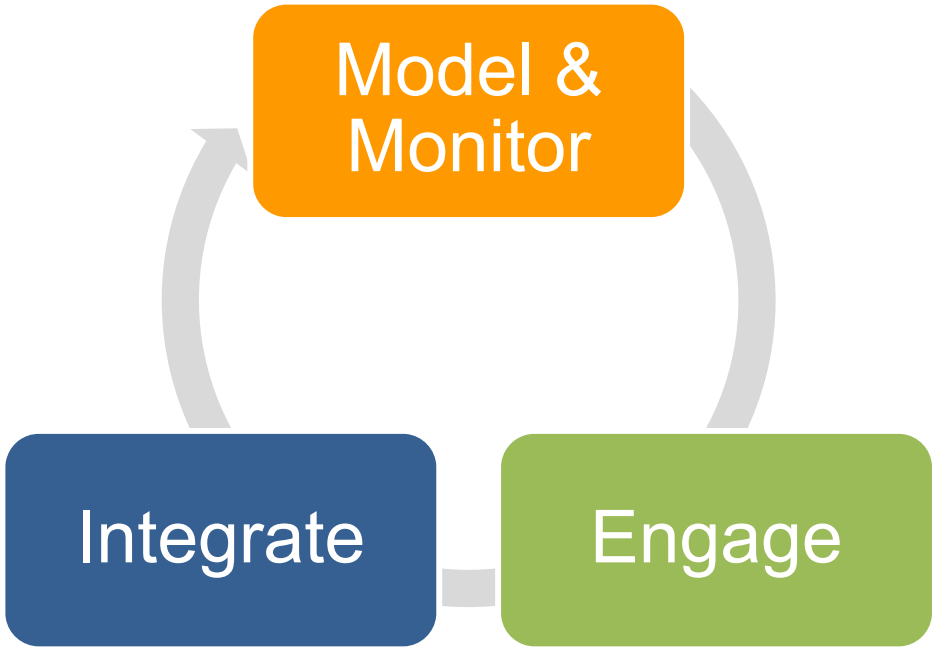
Our Strategic Approach

PGE will advance the intelligent and integrated operation of our grid by leveraging technologies that deliver customer value and system benefits in a changing landscape



Approach

Model & Monitor: leverage customer trends, data, policies, and modeling, to plan ahead by identifying potential pilots, demonstrations and programs

Engage: incorporate customer and stakeholder feedback as we start small in our deployment and testing of new technologies and programs

Integrate: build upon our foundation as we move to scale on proven technologies that drive new customer value

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Integrated (Smart) Grid Initiatives: Current Status

1 Model & Monitor
(Plan Ahead)

Monitor Industry Landscape
- Microgrid market assessment

Emerging Technologies
- Energy storage* (HB 2193)
- Electric vehicle smart charging/DR
- Smart water heaters

Potential Studies
- Demand response potential*

Real Time System Analysis

Integrated Resource Plan

2 Engage
(Successfully Pilot)

Pilots
- Energy Partner*
- Smart Thermostats*
- Pricing pilot*
- Conservation Voltage Reduction*
- Distribution Automation
- Salem Smart Power Center
- Communications Upgrades
- Strategic Asset Management
- T&D Analytics

3 Integrate
(Move to Scale)

Programs
- Smart meters
- Energy Tracker
- Energy Expert
- Dispatchable Standby Generation*

**Evaluating in partnership with Integrated Resource Planning*

Integrated (Smart) Initiatives: 2020 View

1 Model & Monitor (Plan Ahead)	2 Engage (Successfully Pilot)	3 Integrate (Move to Scale)
Monitor Industry Landscape **Emerging Technologies** **Potential Studies** **Real Time System Analysis** **Integrated Resource Plan**	**Pilots/Research** • Electric vehicle smart charging/DR • Smart Water Heaters • Microgrids **Systems** • Distribution management system	**Programs** • Smart meters • Energy Tracker • Energy Expert • Dispatchable Standby Generation • Demand Response • Pricing Portfolio • Conservation Voltage Reduction • Distribution Automation • Strategic deployment of distributed storage • Strategic Asset Management • T&D Analytics • Communications network

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Looking Forward and Closing Thoughts

- Have made significant strides to take advantage of integrated (smart) grid technologies, but there is more to be done.
- Are committed to leveraging the power of integrated (smart) grid technologies to deliver customer value and system benefits.
- Will continuously improve the operation of our business by pursuing integrated (smart) grid technologies where it makes sense.

Questions

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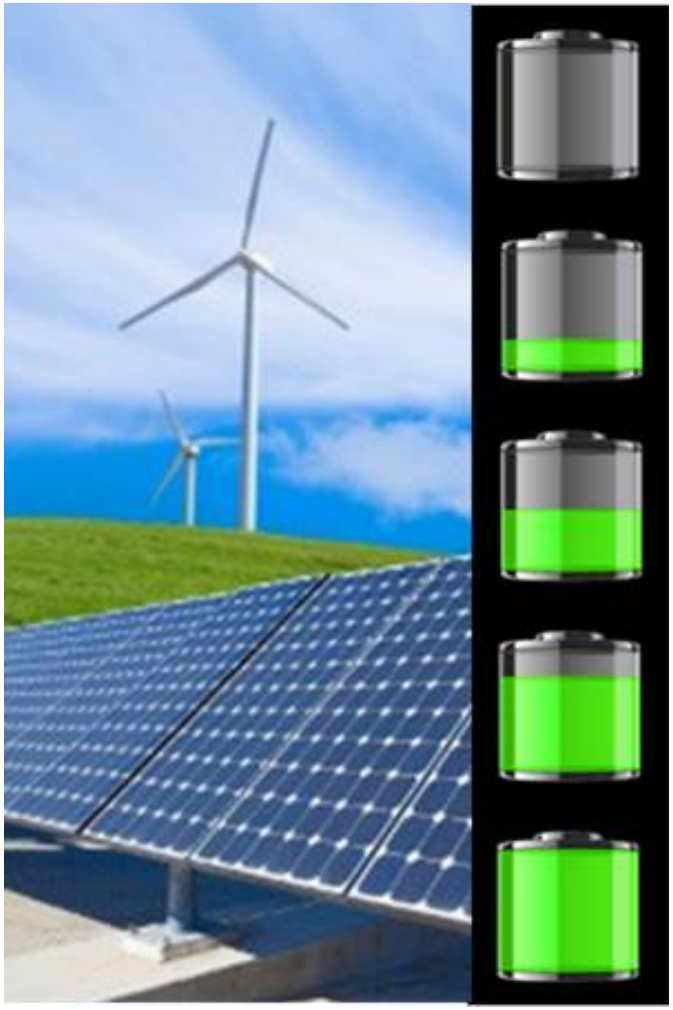
Energy Storage (HB 2193)

Overview

- HB 2193 Background
- Current Strategy
- Questions



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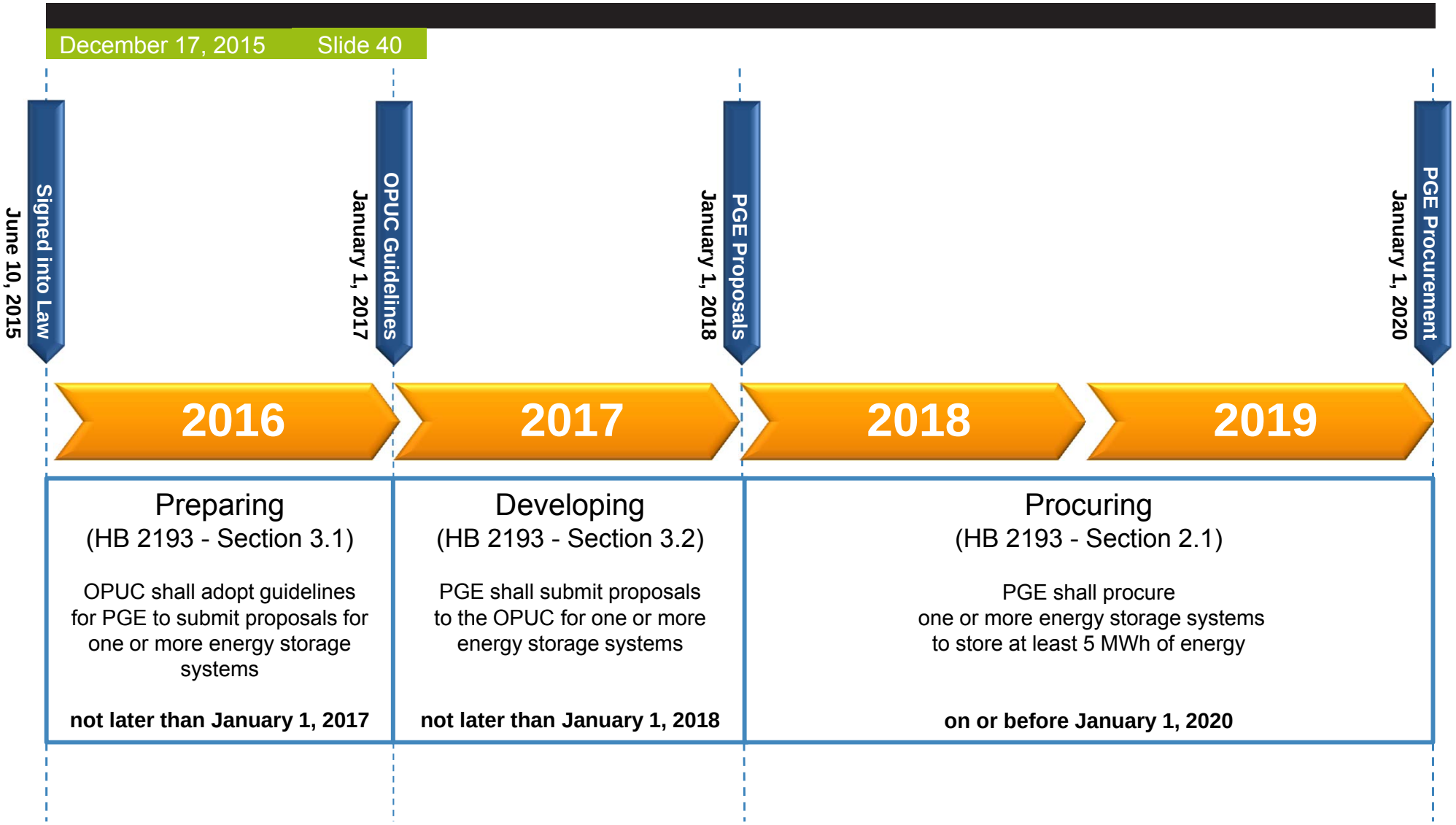
HB2193 Relating to Energy Storage

- PGE shall procure:
  - One or more energy storage systems
  - At least 5MWh of energy
  - May not exceed one percent [39MW] of 2014 peak load

- Includes an analysis of:
  - Current operations and system data
  - Data related to existing energy storage systems
  - How the addition of an energy storage system would complement proposed integrated, least-cost combination of resources to meet the expected needs of the electric company's customers.

Proposed Legislative Timing



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Regulatory Process

- OPUC to establish guidelines that examine potential value for:
  - Deferred investment in generation, transmission or distribution of electricity;
  - Reduced need for additional generation of electricity during times of peak demand;
  - Improved integration of different types of renewable resources;
  - Reduced greenhouse gas emissions;
  - Improved reliability of electrical transmission or distribution systems;
  - Reduced portfolio variable power costs; or
  - Any other value reasonably related to the application of energy storage system technology.

PGE's Approach

Near Term

Identify and confirm:

- Grid operational needs and required resource characteristics
- Grid operational constraints
- Storage applications and opportunities

Define valuation methodologies and tools

Mid Term

Conduct feasibility screening

Identify and evaluate synergies with other planning and operation processes

Develop methodologies to analyze storage options

Long Term

Continue to integrate storage into long term system planning

Stakeholder engagement and coordination

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Questions?

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Demand Response Potential Study

Outline

- Background
- Potential Study Overview
  - Methodology
  - Programs Considered
  - Findings
- Portfolio Development
  - Methodology
  - Scenarios
  - Results
- Next Steps
- Cost-Effectiveness

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Background

- PGE recognizes the need for DR in its resource plan
- 2013 IRP included 45 MW of DR:
  - Energy Partner: 25 MW
  - Schedule 77: 20 MW
- Commissioned potential study from Brattle group to identify opportunity
- Based on study, PGE developed portfolios to be included in 2016 IRP

Potential Study Overview

- Brattle Group conducted an update of the 2012 potential study
- Estimates maximum achievable peak reduction and cost-effectiveness of various programs
- Assumes enrollment rates reach levels of successful DR programs around the country (75th percentile)
- Several factors suggest that PGE's customer base could reach these levels of participation
  - Success with energy efficiency programs
  - Environmentally conscious customer base
  - Rising adoption of energy management products (e.g., smart thermostats)
  - Growing summer peak demand
- Since PGE is starting from a point of relatively limited experience with DR, it will likely take time to reach these levels of participation
  - This has been the experience with the Energy Partner program

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Programs Considered

	Residential	Small C&I (<30 kW)	Medium C&I (30 to 200 kW)	Large C&I (> 200 kW)	Agricultural
Pricing Options					
Time-of-use (TOU)	X	X			X
Peak Time Rebate (PTR)	X	X			
PTR w/tech	X	X			
Critical Peak Pricing (CPP)	X	X	X	X	
CPP w/tech	X	X	X	X	
Conventional Non-pricing Options					
Direct load control (heating/cooling)	X	X			
Direct load control (water heating)	X	X			
Curtailable tariff			X	X	
Third-party DLC			X	X	X
Emerging DR Options					
Bring-your-own-thermostat (BYOT)	X				
Electric Vehicle (EV) charging load control	X				
Smart water heating	X				
Behavioral DR	X				

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High Level Findings

1. The most attractive DR opportunities are in the residential and large C&I customer segments
2. Residential pricing programs present a large and cost-effective opportunity to leverage the value of PGE's AMI investment
3. The incremental benefits of coupling enabling technology with pricing options are modest and perhaps best realized through a BYOT program
4. BYOT programs offer better economics than conventional DLC programs but lower potential in the short- to medium-term

High Level Findings, cont.

5. Residential water heating load control is an attractive opportunity with a broad range of potential benefits
6. Small C&I DLC has a small amount of cost-effective potential
7. DR is highly cost-effective for large and medium C&I customers and the potential can be realized through a number of programs
8. Agricultural DR programs are small and uneconomic
9. The economics of some programs improve when accounting for their ability to provide ancillary services

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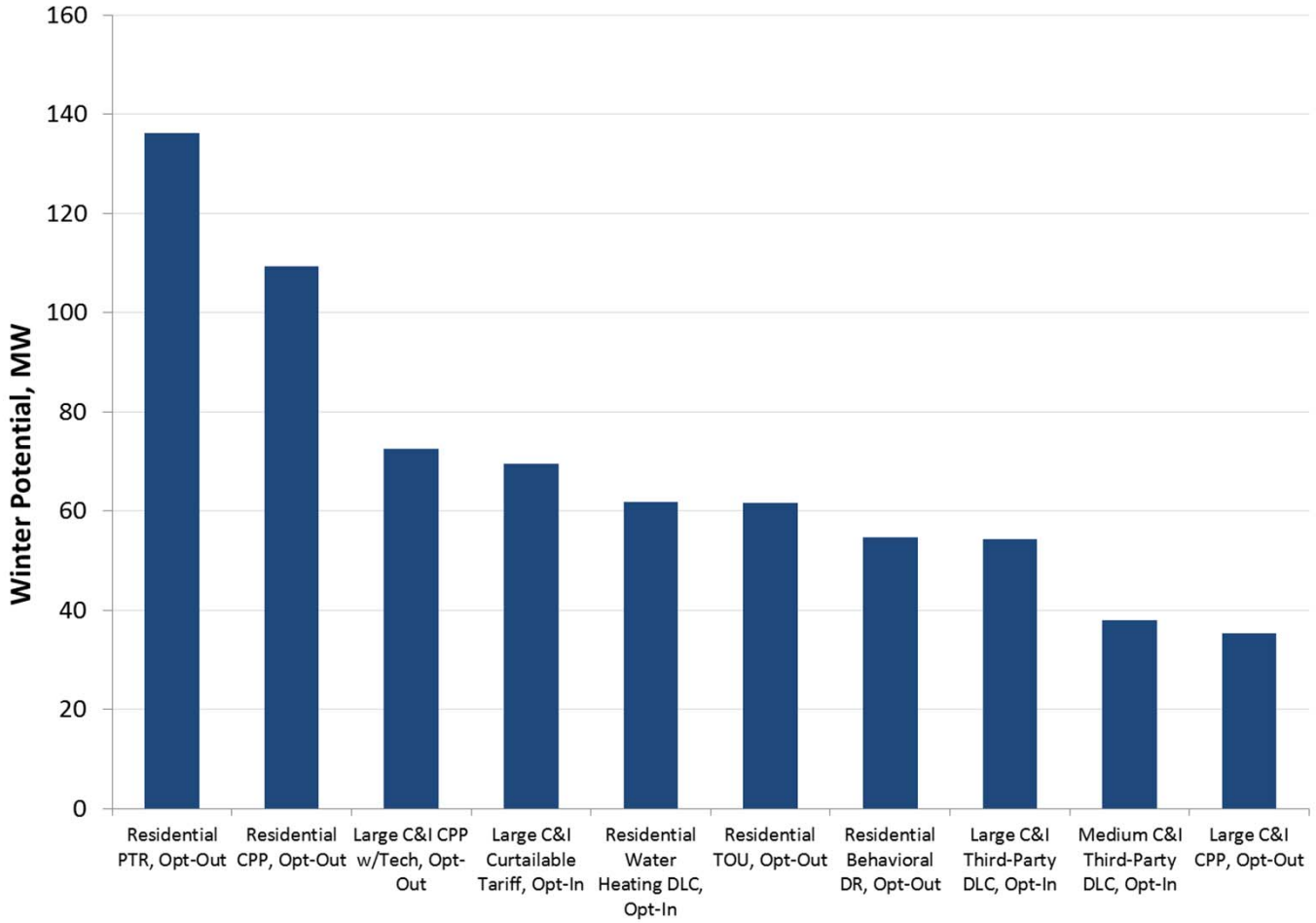
Potential Study Overview

Winter Potential



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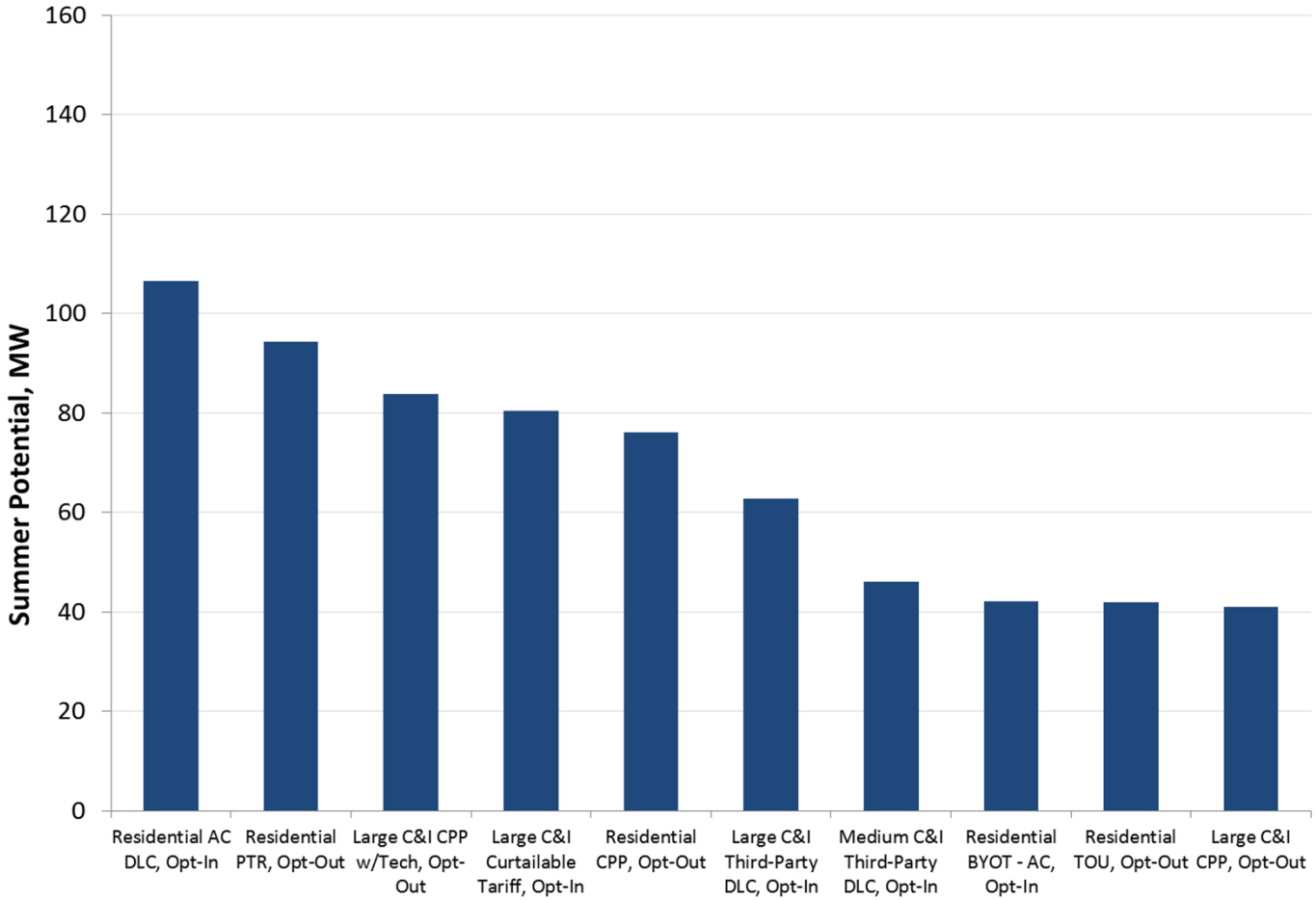
Potential Study Overview

Summer Potential



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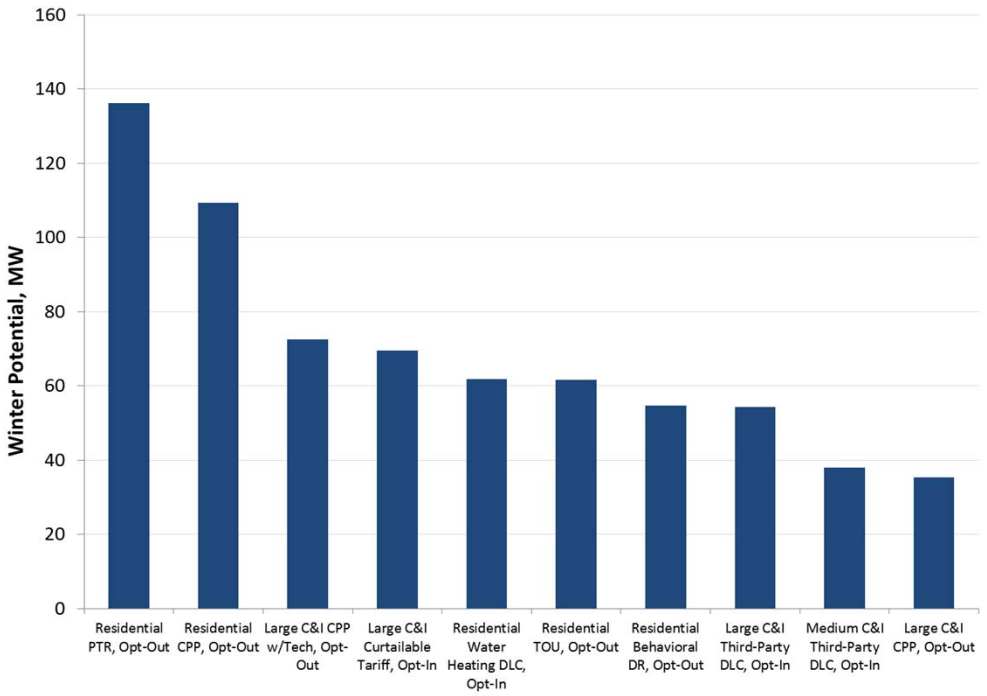
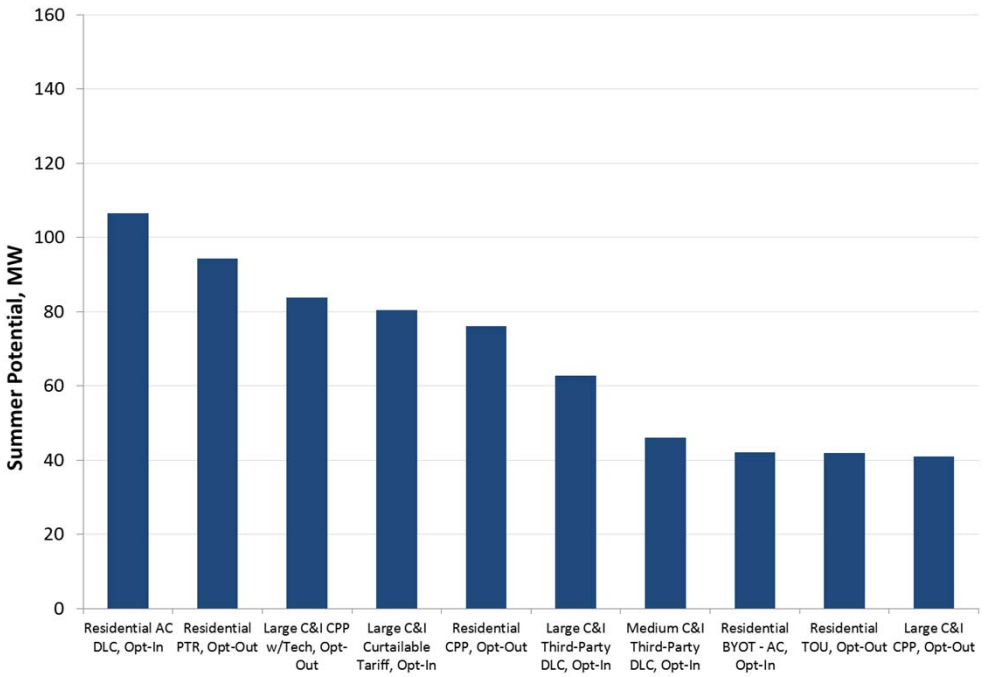
Potential Study Overview

Winter Potential



Summer Potential



- The largest programs are in the industrial and residential sectors
- Opt-out dynamic pricing generally provides the largest aggregate impacts due to high expected enrollment rates

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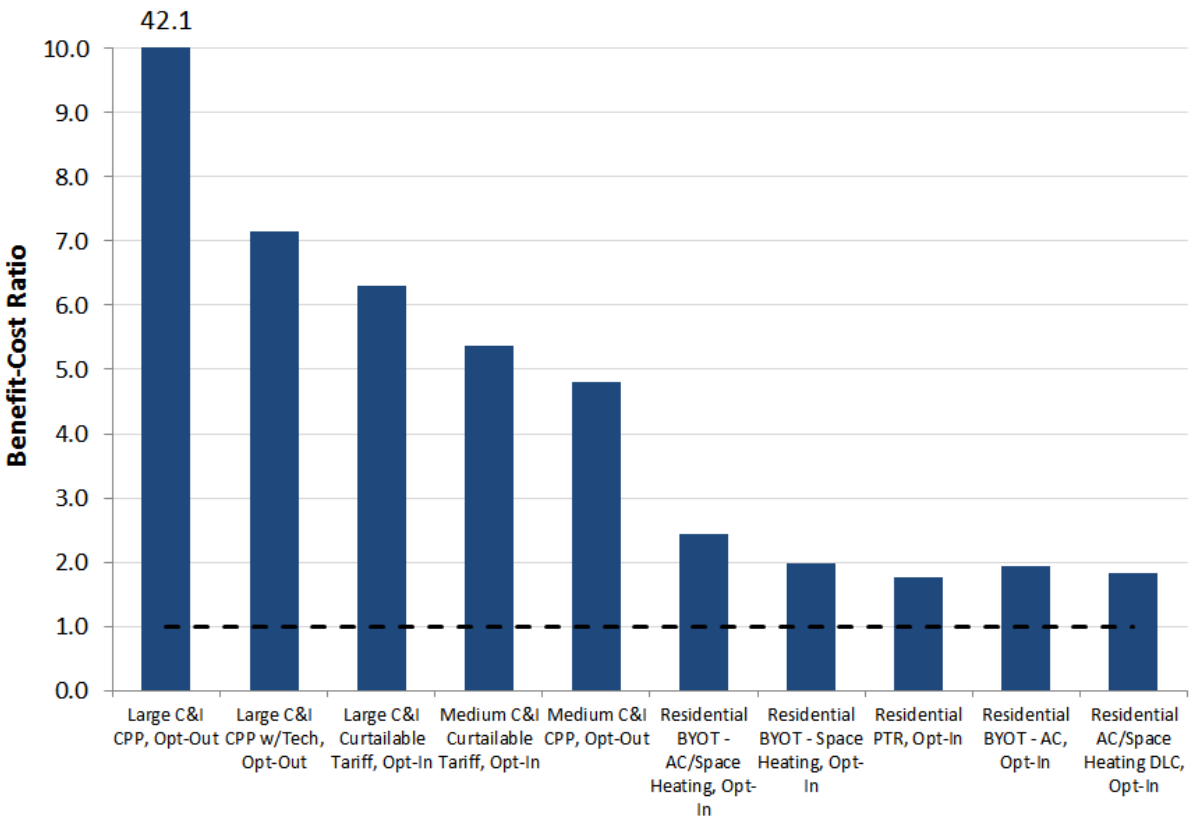
Potential Study Overview

Benefit-Cost Ratios



Comments

- Several large C&I and residential programs are highly cost-effective
- The most cost-effective programs tend to be pricing programs and curtailable tariffs

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Portfolio Development

- Results from the potential study were then modified to account for various factors:
  - Allow for pilot periods
  - Interactions between programs
  - Pragmatic participation rates/time-to-saturation
  - Timing aligned with other initiatives (CET)
  - Evaluation requirements (control group holdouts)
- Programs selected based on:
  - Achievable MW
  - Cost-effectiveness
  - Lessons learned from pilots
- Created three scenarios to account for uncertainty:
  - Low, Reference, High
  - Differing assumptions on adoption rate, maximum participation, and programs considered

Portfolio Development: Results (2021 MW)

- **Low: 36 MW (Winter), 40 MW (Summer)**
  - Time of Use Pricing (Opt-in)
  - Peak Time Rebate (Opt-in, Residential and Small C&I)
  - Traditional Direct Load Control (Water Heat)
  - Smart Thermostats (Residential and Small C&I)
  - Energy Partner
  - Restructured Curtailable Tariff
- **Reference: 78 MW (Winter), 74 MW (Summer)**
  - All Above
  - Behavioral Demand Response (Residential)
- **High: 191 MW (Winter), 162 MW (Summer)**
  - All Above
  - Default Time-of-Use and Peak Time Rebate
  - Smart Water Heaters
  - Smart EV Charging

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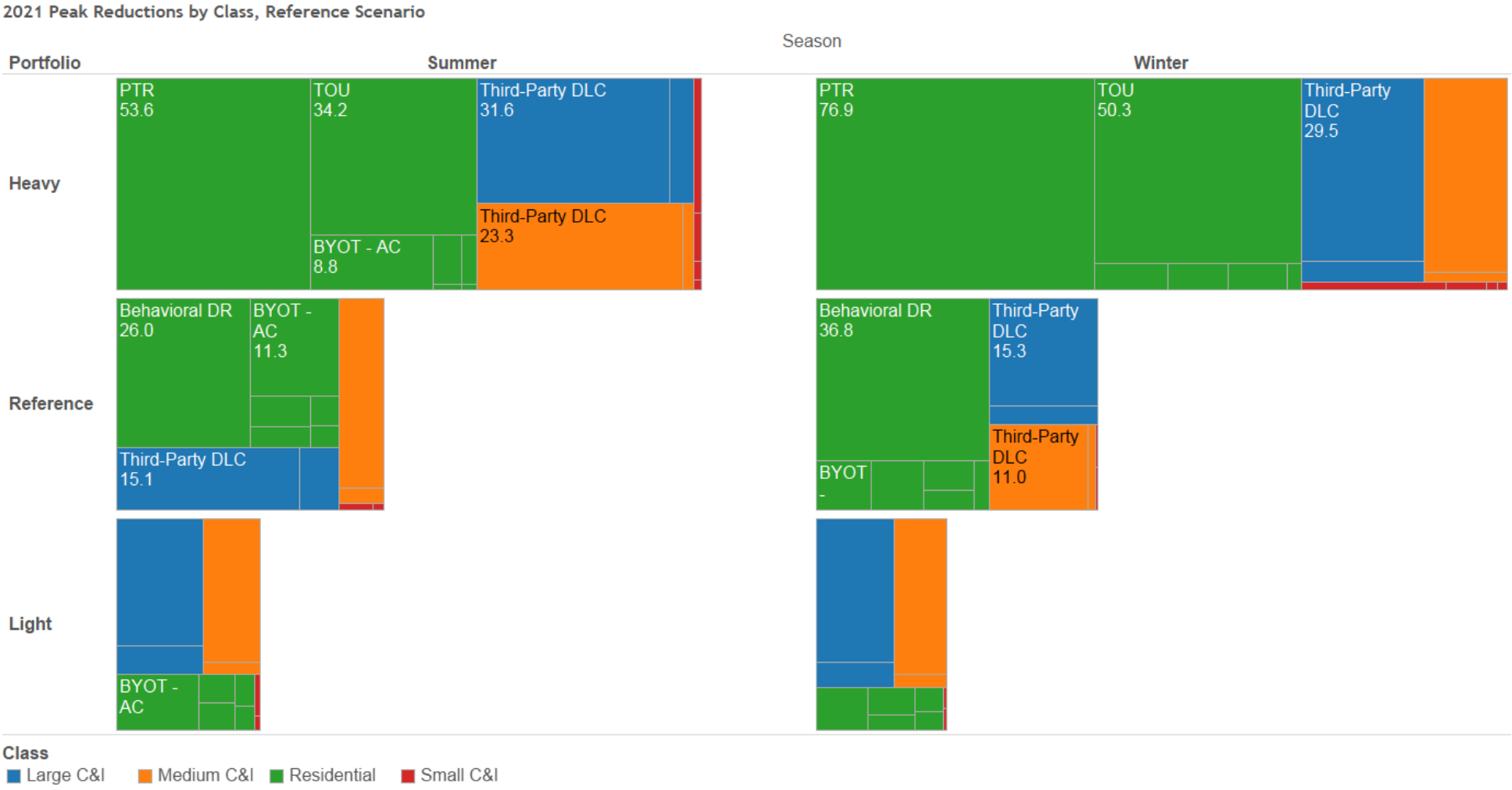
Portfolio Development: Results (2021 MW)



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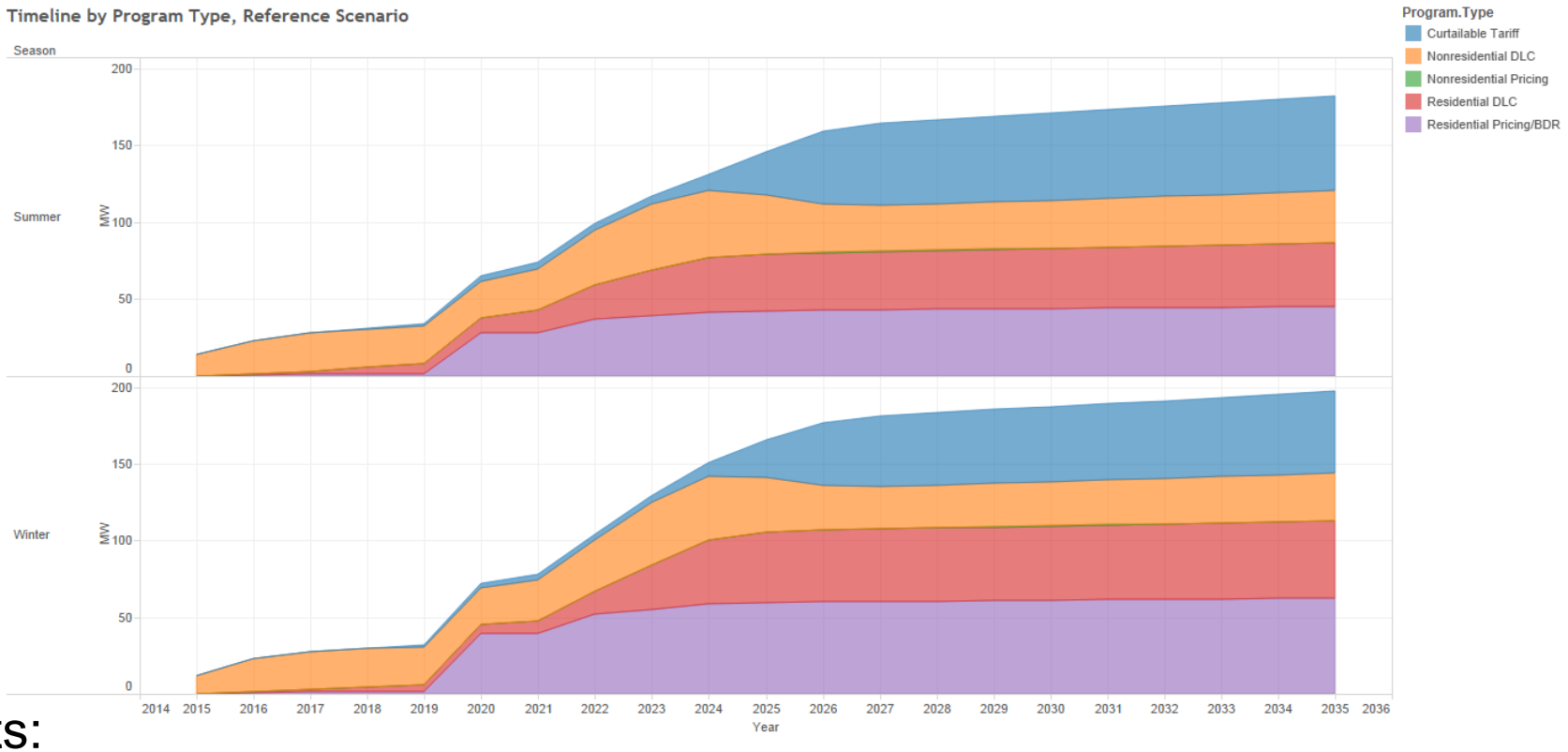
Portfolio Development: Timeline

- Major factor affecting 2021 impacts is that most programs are not deployed until 2020



- 2035 targets:
  - Low: 145 MW (Winter), 136 MW (Summer)
  - Reference: 197 MW (Winter), 182 MW (Summer)
  - High: 296 MW (Winter), 258 MW (Summer)

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Next Steps

- Smart Thermostat and Energy Partner pilots deployed
  - Ongoing M&V will inform full-scale program design
- Residential pricing pilot being developed for 2016 deployment
- Residential DLC pilot will be developed for 2017 deployment
- PGE will continue to monitor key metrics to inform full scale programs:
  - Peak impacts
  - Enrollment rates
  - Customer experience

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Cost-Effectiveness Methodology

- As part of UM 1708, PUC requested PGE develop cost-effectiveness methodology for demand response
- At a high level, PGE plans to follow CA demand response cost-effectiveness protocols
  - Will look at four B/C tests, with primary metrics being TRC and UCT
- We see this fitting into larger conversation on integrated (smart) grid metrics, storage, and planning of distributed resources
  - Will discuss in more depth with PUC staff at February meeting on integrated (smart) grid metrics
  - Also engaging in discussions with Energy Trust staff to ensure consistency and avoid double-counting while acknowledging full value

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Resource Adequacy (PRM) and Capacity Contribution

Resource Adequacy and Capacity Contribution

- Review 2013 IRP capacity needs and contribution methodologies
- 2016 IRP Study
  - Review E3 survey info
  - Review RECAP modeling
  - Results of capacity needs assessments
  - Results of capacity contribution assessments
  - Summary of improvements
- Potential items for next IRP cycle

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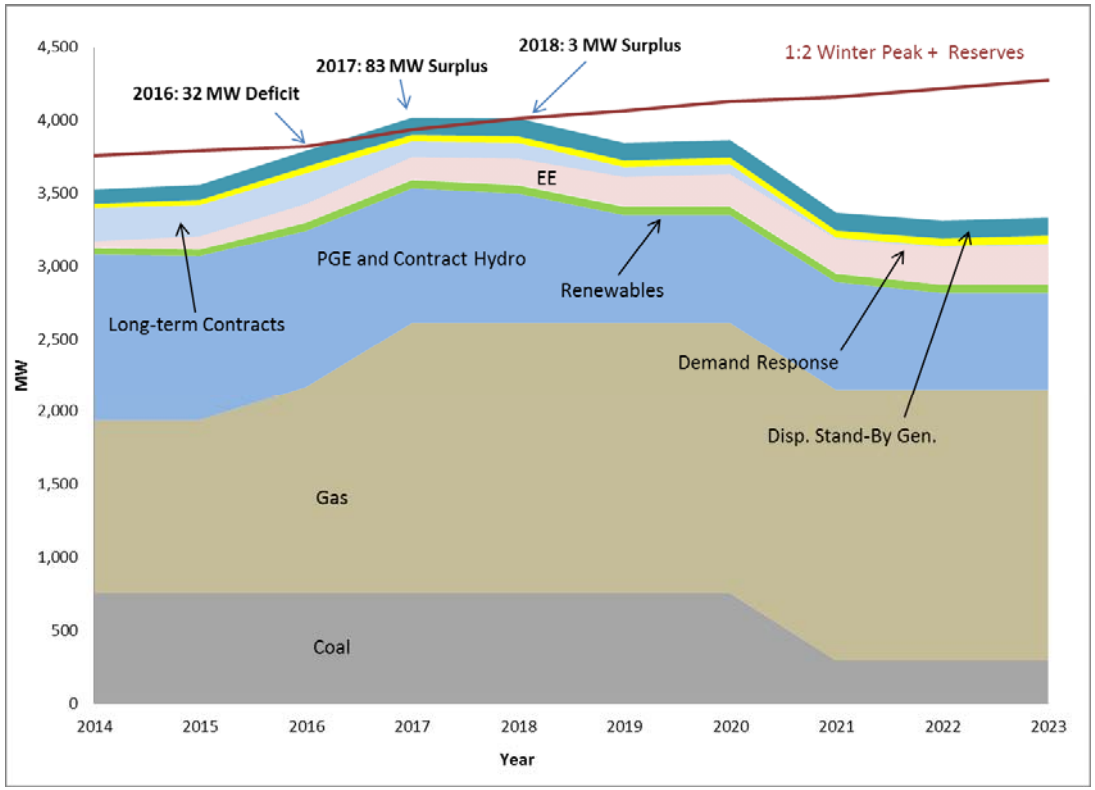
Resource Adequacy Assessment: 2013 IRP

- Seasonal capacity load-resource balances (LRBs) were used in the 2013 IRP to determine capacity needed to achieve resource adequacy.
- Resource need was determined by the seasonal peak load plus 6% for contingency reserves and approximately 6% for operating reserves (spinning and supplemental).



PGE 2013 IRP Report
Figure 3-5

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Resource Adequacy Assessment: 2013 IRP

- Thermal: Seasonal peak capacities. Not derated for forced outages or maintenance
- Hydro: 4-hr sustained capacity in average hydro year for most systems
- Wind and Solar: based on studies of alignment with peak load
  - Wind: Biglow Canyon generation (2011-2012)
  - Solar: Forecast generation
  - All wind and solar in LRB and candidate portfolios treated with same capacity contribution.
- Stochastic Loss of Load study based on a different model
  - Varied load, hydro, wind, plant forced outages
  - Hydro and wind independent from load

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Resource Adequacy Assessment: 2016 IRP

Key areas of focus for 2016 IRP:

- PGE indicated intent to revisit adequacy in 2013 IRP
  - Changes to load profile and significant changes to resource portfolio – need to reassess contingency reserves.
  - Prefer consistent methodology for resource adequacy, capacity contribution, and portfolio adequacy assessments.
- Wind and solar capacity contributions: improve data sets and ability to capture resource/location diversity benefits, load correlations, and impacts of increased saturation levels .

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Resource Adequacy Assessment: 2016 IRP

- PGE retained Energy and Environmental Economics (E3) to conduct a resource adequacy and capacity contribution study for PGE's system based on a forecast of 2021.
  - Survey of other utility's metrics and methodologies for resource adequacy and planning reserve margin (PRM)
  - Capacity needs assessment for 2021 (annual and seasonal assessments)
  - Capacity contribution of existing renewable resources
  - Marginal capacity contribution of candidate renewable resources
  - E3 presented preliminary results at the August 13 Public Meeting

E3 Study: Survey of Utilities

- **E3 investigated reliability criteria, planning reserve margins, and PRM accounting methodologies for several utilities**
  - Other utilities in the West and similarly-sized utilities throughout the country
- **High-level findings:**
  - No industry-standard method of determining acceptable reliability or PRM
  - No NERC or WECC requirements or standards
  - PRM accounting methodologies vary by utility
  - Planning Reserve Margins range from 12-20%

E3, Capacity and Flexibility Needs under Higher Renewables, Oct 1, 2015, Slide 8

E3 Study: Survey of Utilities

	Peak Demand in 2021 (MW)	Planning Criterion	PRM	Peak Season
Puget Sound Energy	7,000 MW	LOLP: 5%*	16% (2023 - 2024)	Winter
Avista	Summer: 1,700 MW; Winter: 1,900 MW	LOLP: 5%*	22% (14% + operating reserves)	Both
PacifiCorp	10,876 MW	LOLE: 2.4 hrs/ year	13%	Summer
Arizona Public Service	9,071 MW	One Event in 10 Years	15%	Summer
Tuscon Electric Power	2,696 MW	PRM	15%	Summer
Public Service Co. of New Mexico	2,100 MW	LOLE: 2.4 hrs/ year	Greater of 13% or 250 MW	Summer
El Paso Electric	2,000 MW	PRM	15%	Summer
Cleco	3,000 MW	LOLE = 1-day-in-10 yrs.	14.8%	Summer
Kansas City Power & Light	483 MW	Share of SPP**	12%**	Summer
Oklahoma Gas & Electric	5,500 MW	Share of SPP**	12%**	Summer
South Carolina Electric & Gas	5,400 MW	24 to 2.4 days/10 yrs	14-20%	Both
Tampa Electric	4,200 MW	PRM	20%	Both
Interstate Power & Light	3,300 MW	PRM	7.3%	Summer
Florida Power and Light	24,000 MW	PRM	20%	Both
California ISO	52,000 MW	LOLE: 0.6 hours/year	15-17%	Summer

* PSE and Avista use NWPCC criterion of 5% probability of shortfall occurring any time in a given year
** SPP uses 1-day-in-10 years or 12% PRM system-wide

E3, Capacity and Flexibility Needs under Higher Renewables, Oct 1, 2015, Slide 9

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E3 Study: Modeling

- E3 used their publicly available Renewable Energy Capacity Planning Model (RECAP) to model PGE's system in 2021.
- Resource adequacy target: Loss-of-Load Expectation (LOLE) of 2.4 hours per year.
- Adequacy defined as ability to meet load and required operating reserves for a given hour.
- This is a "pure" capacity study. It assesses resource ability and system needs on an hourly basis.
- Study is not a flexible capacity study. It does not assess all capacity needs or abilities (frequency response, regulating margin, following, ramping, commitment, etc.)

E3 Study: Modeling

- RECAP is a probability-based model. In order to understand the results of the model, it is important to understand the treatment of loads and resources in the model.

E3 Study: Load

- RECAP uses load shapes that capture 33 years of weather conditions (1980-2012) with today's economic conditions
- Pre-2006 shapes simulated with weather data and neural network model trained on 2007-2012 load and weather conditions
- Load shape scaled to match 2021 monthly and seasonal 1-in-2 peak and energy provided by PGE
- PGE 2008-2014 loads incorporated into E3's historical-weather-based load time series

E3, Calculating PRM and ELCC, Oct 1, 2015, Slide 26

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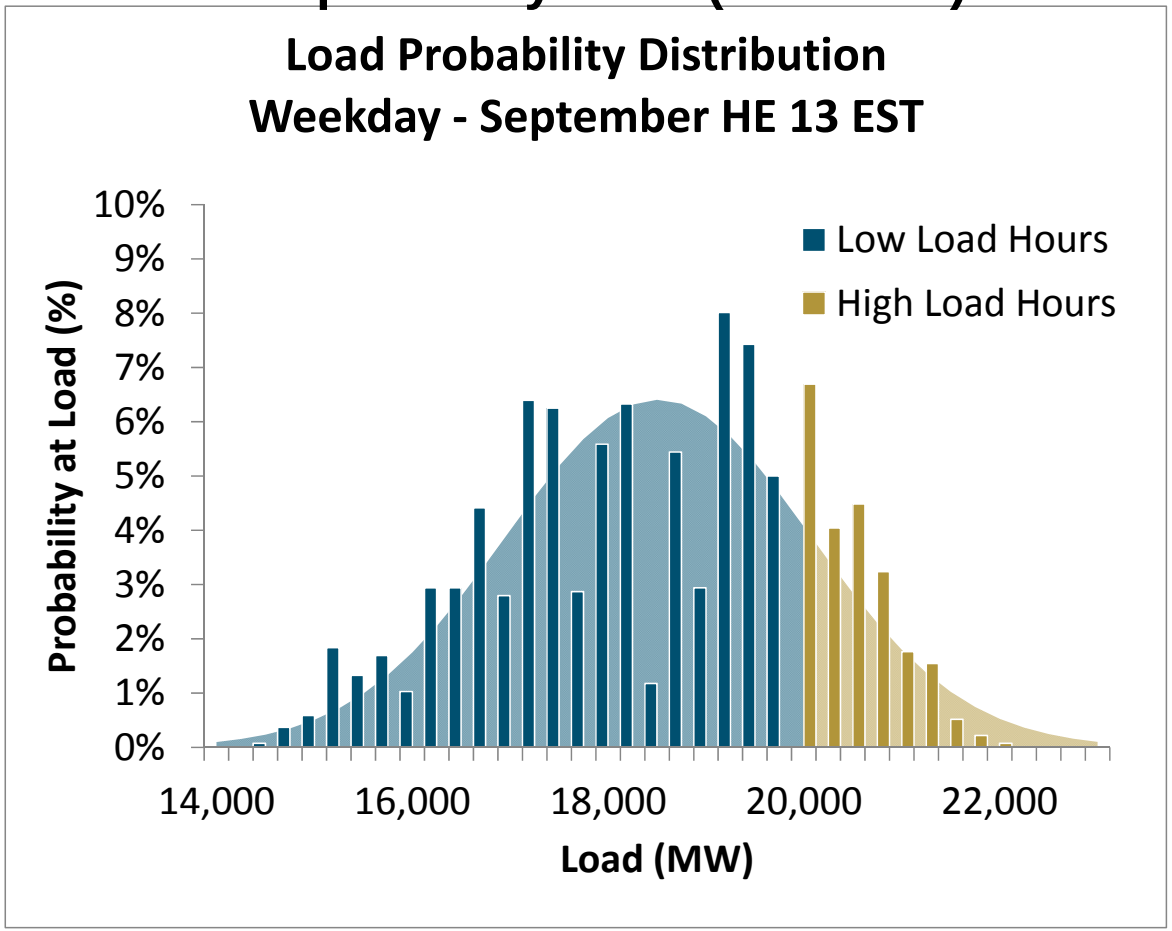
E3 Study: Load

- Probability distributions are created for each hour.
- Energy efficiency is included in the load forecast.

Sample Utility Hour (non-PGE)



E3, Calculating PRM and ELCC, Oct 1, 2015, Slide 16

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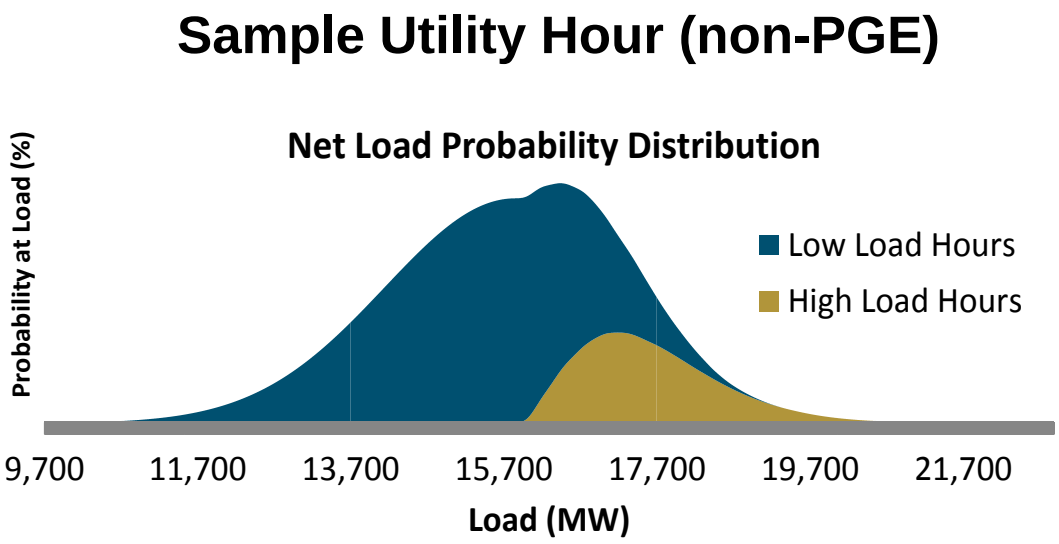
E3 Study: Wind and Solar

- Wind
  - Profiles based on simulated data from 2004-2006 and correlated with load.
  - Biglow Canyon profile also includes 2008-2014 historical shapes.
- Solar
  - Profiles based on simulated data from 2006 and correlated with load.

E3 Study: Wind and Solar



E3, Calculating PRM and ELCC, Oct 1, 2015, Slide 34

- Wind and solar probability distributions created for each hour based on relationship with load.
- Probability distributions calculated for each hour for load net of wind and solar.

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E3 Study: Hydro Capacity

- Clackamas, Pelton, and Round Butte: Monthly 4-hr sustained max capacity values in average hydro year from 2013 IRP.
- Mid-C Resources: E3 built a distribution of monthly max capacities from the average hydro year max capacities, NWPCC data relating capacity and energy, and historic hydro conditions.
- Small run-of-river treated as monthly average energy or zero (0) MW on a case-by-case basis.

E3 Study: Thermal Capacity

- PGE's 2021 thermal portfolio (Carty included, Boardman excluded).
- Monthly plant capacities based on monthly average temperatures.
- Forced outage rates included as stochastic variables.
- Maintenance outages not included.

E3 Study: Additional Resources and Requirements

- Additional resources included:
  - Energy Efficiency included in Load
  - Dispatchable Standby Generation
  - Demand Response
  - Existing contracts
  - Imports based on 2013 IRP Loss-of-Load Study levels with additional imports in summer Off-peak hours
- Additional requirements included:
  - Operating reserve requirements based on WECC BAL-002 spinning and supplemental (non-spin) reserves (approximated as 6% load)

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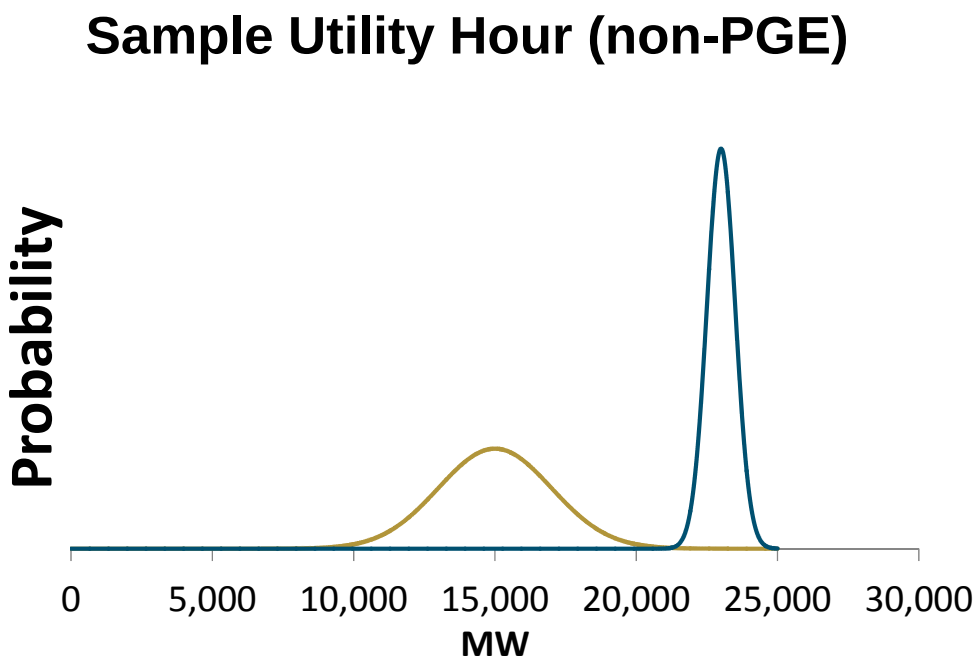
E3 Study: Loss of Load Potential

- Hydro, thermal, contracts, etc. combined to create a resource probability distribution curve for each month/day-type/hour.
- Net load distribution and resource distribution are combined to create a third probability distribution which is used to calculate the LOLP for the month/day-type/hour.
- These are combined to create an annual LOLE.
  - 332 hours in 2021



E3, Capacity and Flexibility Needs under Higher Renewables, Oct 1, 2015, Slide 15

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E3 Study: Modeling

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.007	0.005	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.004	0.024
2	0.001	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.006
3	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.005
4	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.006
5	0.004	0.005	0.003	0.002	0.000	0.000	0.000	0.000	0.000	0.001	0.005	0.016
6	0.095	0.085	0.049	0.020	0.000	0.000	0.001	0.006	0.011	0.015	0.132	0.221
7	0.616	0.466	0.327	0.046	0.001	0.001	0.009	0.029	0.045	0.087	0.517	1.326
8	2.288	1.212	0.576	0.088	0.005	0.005	0.054	0.157	0.148	0.168	1.149	2.971
9	3.735	2.105	0.782	0.053	0.011	0.024	0.212	0.673	0.208	0.142	2.083	4.669
10	3.277	1.663	0.625	0.039	0.025	0.079	0.782	1.599	0.354	0.102	1.872	4.506
11	2.724	1.237	0.450	0.028	0.050	0.188	1.846	3.001	0.586	0.079	1.517	4.063
12	2.160	0.958	0.292	0.021	0.083	0.384	2.982	4.435	0.866	0.068	1.262	3.450
13	1.920	0.687	0.146	0.015	0.137	0.658	4.363	5.794	1.358	0.060	1.052	2.787
14	1.553	0.443	0.091	0.012	0.179	1.004	5.653	7.225	1.931	0.068	0.865	2.143
15	1.247	0.309	0.064	0.009	0.233	1.222	6.626	8.347	2.430	0.071	0.756	1.658
16	1.142	0.299	0.053	0.008	0.269	1.476	7.254	8.844	2.858	0.077	0.884	2.156
17	1.710	0.462	0.084	0.008	0.295	1.521	7.295	8.897	3.037	0.140	1.446	3.991
18	3.803	1.020	0.173	0.012	0.274	1.250	6.316	8.263	2.835	0.279	3.072	6.586
19	5.858	1.962	0.417	0.014	0.196	0.761	4.706	7.171	2.365	0.441	4.662	8.323
20	5.693	2.176	0.618	0.026	0.126	0.410	3.234	5.619	2.064	0.348	4.120	7.589
21	4.231	1.469	0.416	0.023	0.074	0.209	2.058	4.266	1.555	0.144	2.979	5.584
22	2.457	0.778	0.133	0.008	0.023	0.072	0.229	1.012	0.135	0.021	1.572	3.261
23	0.882	0.253	0.019	0.001	0.001	0.005	0.021	0.194	0.008	0.003	0.553	1.052
24	0.119	0.030	0.001	0.000	0.000	0.000	0.001	0.012	0.000	0.000	0.084	0.179

E3, Capacity and Flexibility Needs under Higher Renewables, Oct 1, 2015, Slide 21

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E3 Study: Annual Capacity Needed

Unit	MW
Natural Gas	1,809
Colstrip	296
Hydro Projects	575
Mid-C Hydro Agreements	123
Other Contracts	9
DSG	85
DSM	41
Renewables	127
Imports	92
Total Available Dependable Capacity	**3,157**
1-in-2 Peak Load	3,525
Planning Reserve Margin	550
Total Dependable Capacity Needed	**4,075**
Dependable Capacity Shortage	**918**
PRM (%)	**15.6%**

- RECAP added conventional units (CU) of 100 MW with a 5% forced outage rate until the target LOLE of 2.4 hr/yr was met.
- Capacity shortage in CU = 918 MW.
- This table displays a summary of resources based on a mixture of views, including annual capacities and effective load carrying capability (ELCC) values. It does not represent the treatment of the resource in the model used to determine the shortage.
  - The PRM values are in the context of the view of the table.

E3, Capacity and Flexibility Needs under Higher Renewables, Oct 1, 2015, Slide 22

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E3 Study: Seasonal Capacity Needs

- RECAP was also used to look at winter and summer seasonal capacity needs.
- The seasonal views were based on a reliability target of 2.4 hours per season.
- Meeting the seasonal needs alone will not achieve the annual reliability target

E3 Study: Seasonal Capacity Needs

Winter Season

Unit	MW
Natural Gas	1,862
Colstrip	296
Hydro Projects	624
Mid-C Hydro Agreements	127
Other Contracts	9
DSG	85
DSM	41
Renewables	108
Imports	214
Total Available Dependable Capacity	**3,368**
1-in-2 Peak Load	3,525
Planning Reserve Margin	530
Total Dependable Capacity Needed	**4,055**
Dependable Capacity Shortage	**687**
PRM (%)	**15.0%**

Summer Season

Unit	MW
Natural Gas	1,756
Colstrip	296
Hydro Projects	526
Mid-C Hydro Agreements	119
Other Contracts	9
DSG	85
DSM	41
Renewables	138
Imports	20
Total Available Dependable Capacity	**2,989**
1-in-2 Peak Load	3,376
Planning Reserve Margin	498
Total Dependable Capacity Needed	**3,874**
Dependable Capacity Shortage	**884**
PRM (%)	**14.7%**

E3, Capacity and Flexibility Needs under Higher Renewables, Oct 1, 2015, Slides 28-29

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E3 Study: Renewable Capacity Contributions

- Dispatchable renewable resources (e.g. geothermal) are modeled like thermal plants (monthly capacity values, forced outage rates)
- Intermittent resources
  - Capacity contributions depend on the resource portfolio and the load profile.
  - Marginal contributions tend to decline as saturation levels of a resource type increase. Rates of decline can vary substantially by system and resource type.
  - It is important to capture correlations with load.
  - There can be portfolio diversity benefits where the sum is greater than the parts.
  - The quality and quantity of the data available are very important to the results.

E3 Study: Existing Renewable Resources

	Winter	Summer	Annual
Nameplate rating MW	902	902	902
Portfolio ELCC (MW)	108	138	127
Portfolio ELCC (% of nameplate MW)	12.0%	15.3%	14.1%

E3, Capacity and Flexibility Needs under Higher Renewables, Oct 1, 2015, Slide 46

- RECAP calculated the ELCC of the existing portfolio of renewables using the same process, but with resources removed.
- The ELCC value (127 MW) is in terms of CUs.

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E3 Study: Candidate Renewable Resources

- **Marginal ELCC measures the additional ELCC provided by adding new resources to the portfolio**
- **Sample portfolio includes two Gorge sites and PV**
  - The Gorge sites add little diversity to the existing portfolio and have relatively low ELCCs
  - Incremental PV resource has higher ELCC due to its high summer capacity factors

Resource	Nameplate Rating (MW)	Annual ELCC
Incremental Gorge Wind	609 MW	65 MW (11%)
Incremental Solar	168 MW	68 MW (41%)
Total Incremental Portfolio	777 MW	141 MW (18%)

E3, Capacity and Flexibility Needs under Higher Renewables, Oct 1, 2015, Slide 47

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E3 Study: Candidate Renewable Resources

- Gorge wind resources have higher ELCC in winter than in the summer
- Solar PV has high summer value due to coincidence of output with peak needs, but very low winter value due to nighttime peak loads
- Portfolio effects result in similar total incremental portfolio ELCC for all three tests

Resource	Nameplate Rating (MW)	Winter ELCC	Summer ELCC
Incremental Gorge Wind	609 MW	112 MW (18%)	55 MW (9%)
Incremental Solar	168 MW	12 MW (7%)	91 MW (54%)
Total Incremental Portfolio	777 MW	127 MW (16%)	148 MW (19%)

E3, Capacity and Flexibility Needs under Higher Renewables, Oct 1, 2015, Slide 49

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E3 Study: Candidate Renewable Resources

- **Montana wind has capacity factor and higher ELCC than the Gorge sites**
- **The Montana wind site exhibits strong portfolio effects with solar PV**

Resource	Nameplate Rating (MW)	Annual ELCC
Incremental Montana Wind	445 MW	91 MW (20%)
Incremental Solar	168 MW	68 MW (41%)
Total Incremental Portfolio	613 MW	171 (28%)

E3, Capacity and Flexibility Needs under Higher Renewables, Oct 1, 2015, Slide 48

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E3 Study: Candidate Renewable Resources

- **Montana wind resources have higher ELCC than the Gorge sites in both the winter and the summer**
- **Positive portfolio effects with solar PV result in similar incremental portfolio ELCC in winter and summer**

Resource	Nameplate Rating (MW)	Winter ELCC	Summer ELCC
Incremental Montana Wind	445 MW	192 MW (43%)	74 MW (17%)
Incremental Solar	168 MW	12 MW (7%)	91 MW (54%)
Total Incremental Portfolio	613 MW	208 MW (34%)	166 MW (27%)

E3, Capacity and Flexibility Needs under Higher Renewables, Oct 1, 2015, Slide 50

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E3 Study: Results for 2021

- Study values for resource needs and ELCCs are for a snapshot of 2021 and a set of candidate resources.
- E3 developed a workbook tool that calculates ELCC values for different combinations of a specific set of resources.
- Generalizations will be made for capacity needs and capacity contributions for other years and resource combinations.

Resource Adequacy and Capacity Contributions

Improvements from previous methodology:

- Consistent methodology for capacity needs and capacity contribution.
- Capacity needs assessment based on reliability target and 2021 resources and loads.
- Expanded and improved data sets, particularly for wind and load.
- Correlations between resources and load.
- Capture impacts of resource diversity.
- Capture portfolio effects.

Resource Adequacy and Capacity Contributions

PGE will continue to investigate modeling options for the next cycle. Possible areas for investigation:

- Additional data, improved correlations
- Time-sequential model
- Import assumptions

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Portfolios and Futures

Preliminary 2016 IRP Futures and Portfolios

- IRP Portfolio Analysis tests the performance of various combinations of resource alternatives ("Portfolios") across risk factors that may affect the resource plan ("Futures")

- Portfolios are dispatched under each Future
  - Portfolio performance typically based on NPVRR
  - Interested in the relative performance of Portfolios (against one another)
  - Portfolio Analysis framework will be presented at future IRP Public Meeting

- Given this, Portfolios should generally be designed to isolate one aspect relative to another Portfolio, for example:
  - Resource composition changes, but quantity and timing approximately equal
  - Resource timing differs, but quantity and composition are unchanged

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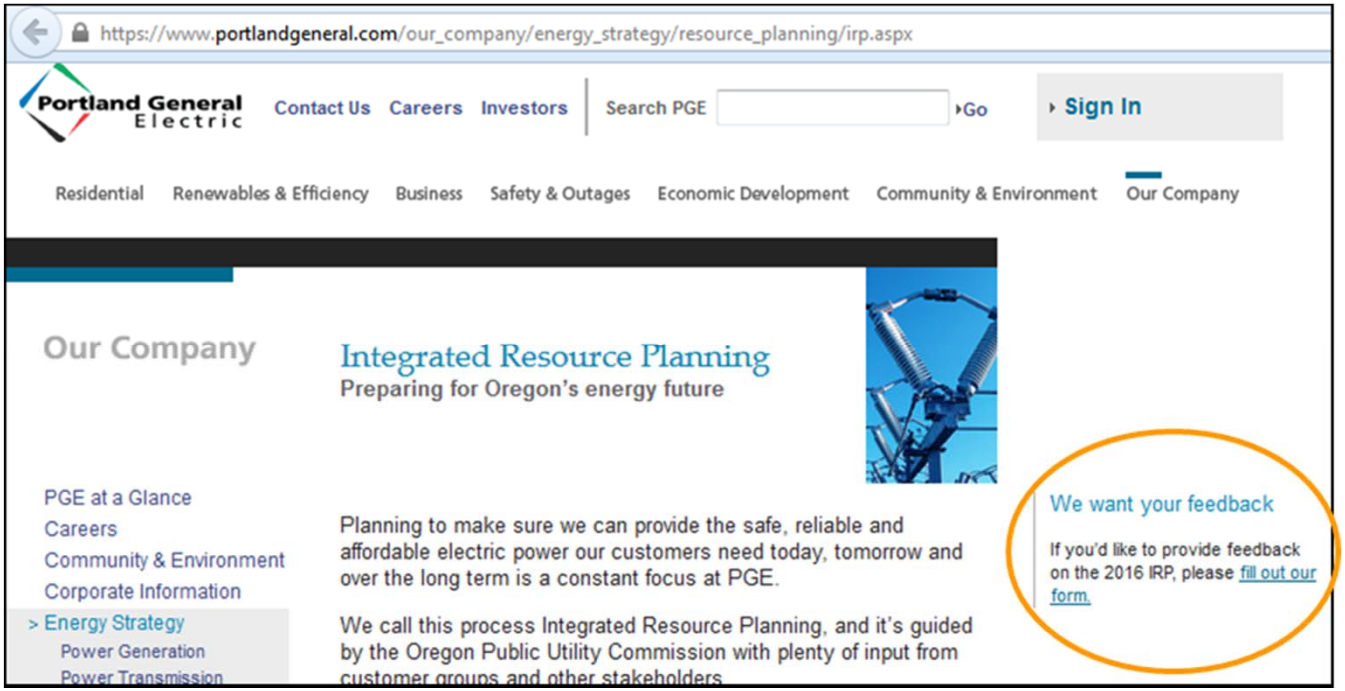
Futures and Portfolios: Feedback received

- Jess Kincaid (ODOE) – Synapse CO_2 price scenarios (06/15/15)
- Bill Pascoe (Absaroka) – Resource parameter considerations
  - Montana wind (CF, capacity contribution, flexibility, and transmission)
  - Pumped hydro storage
- Feedback form online: www.PortlandGeneral.com/IRP



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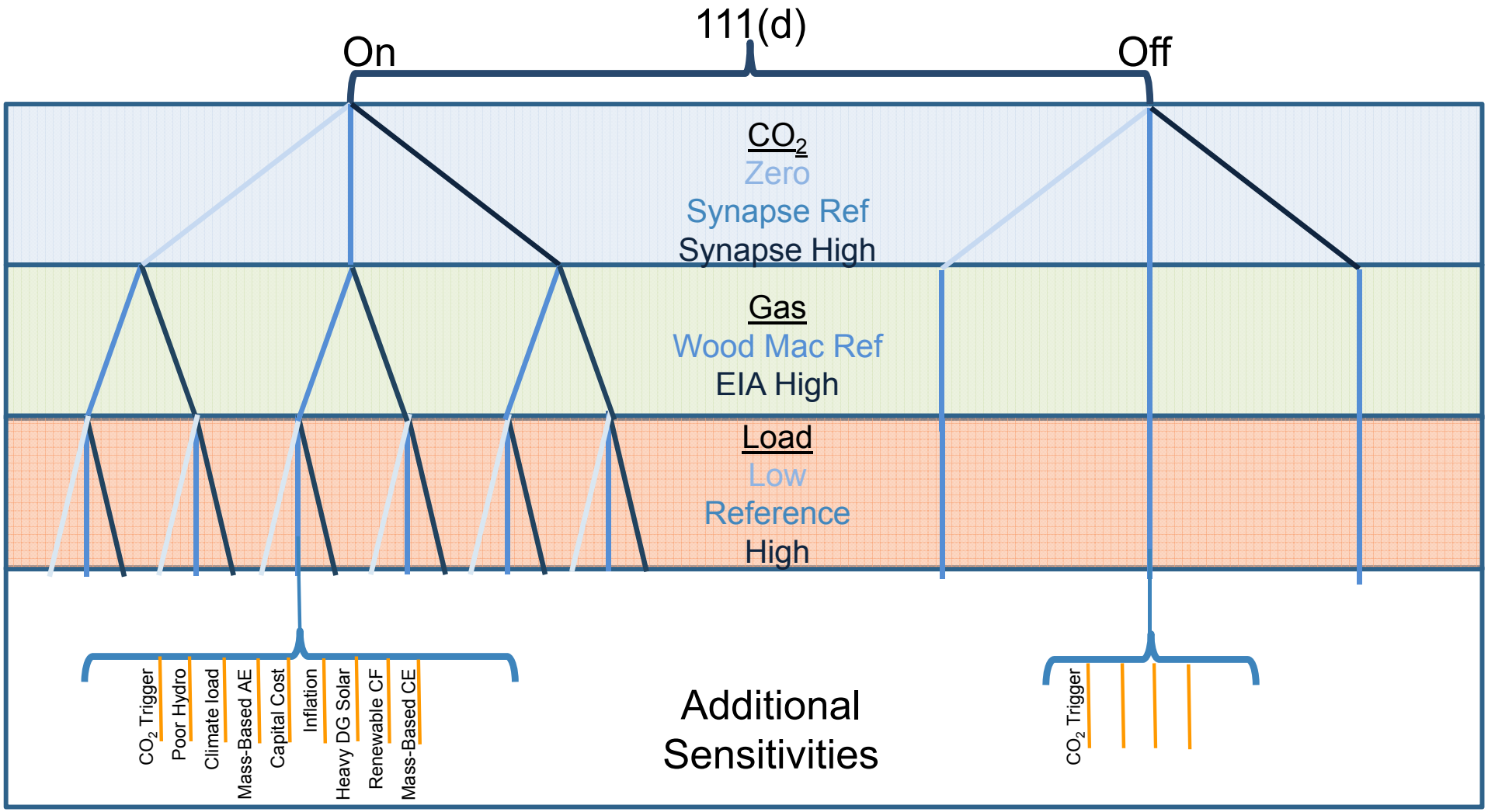
Futures: Preliminary Futures



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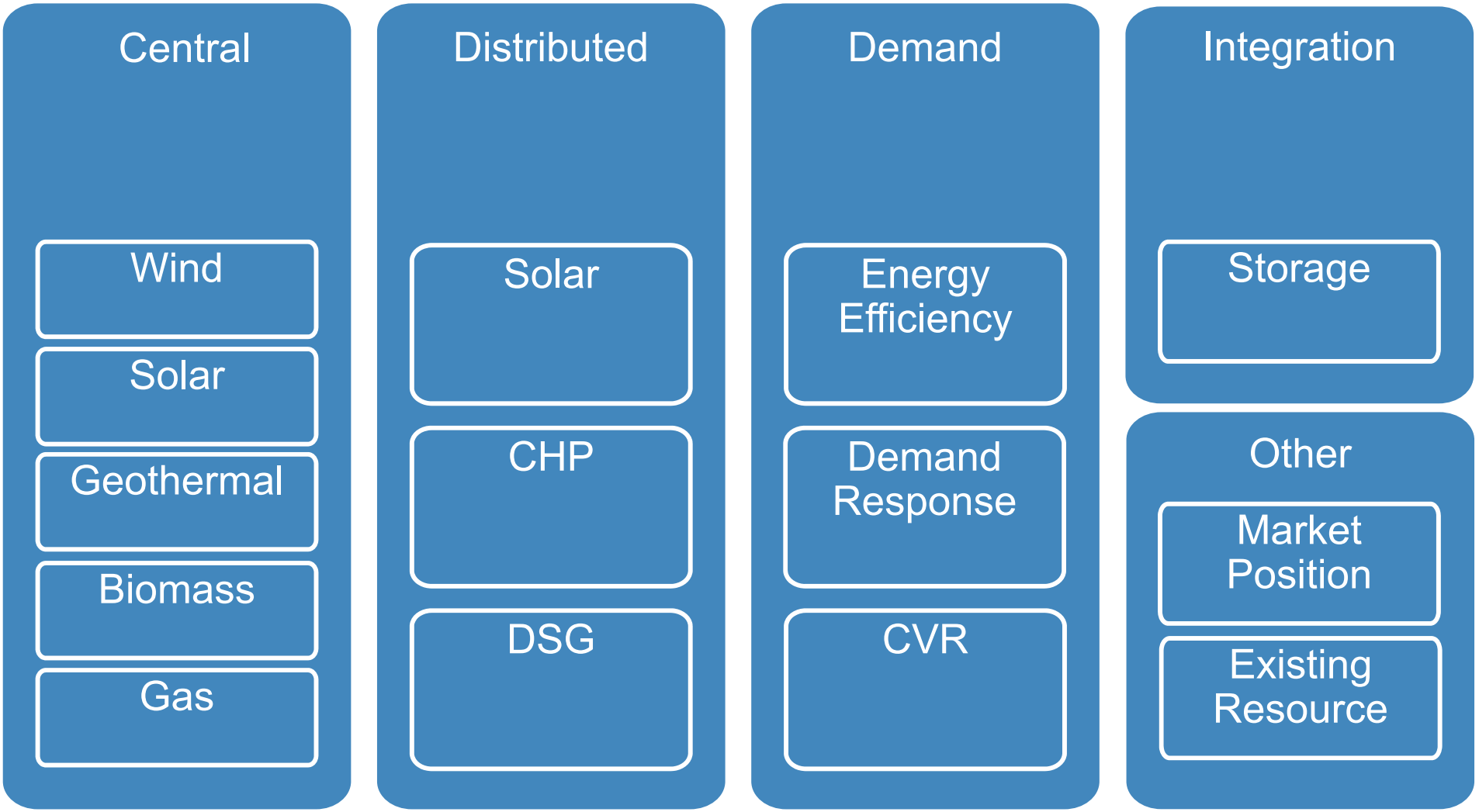
Portfolios: Resource alternatives



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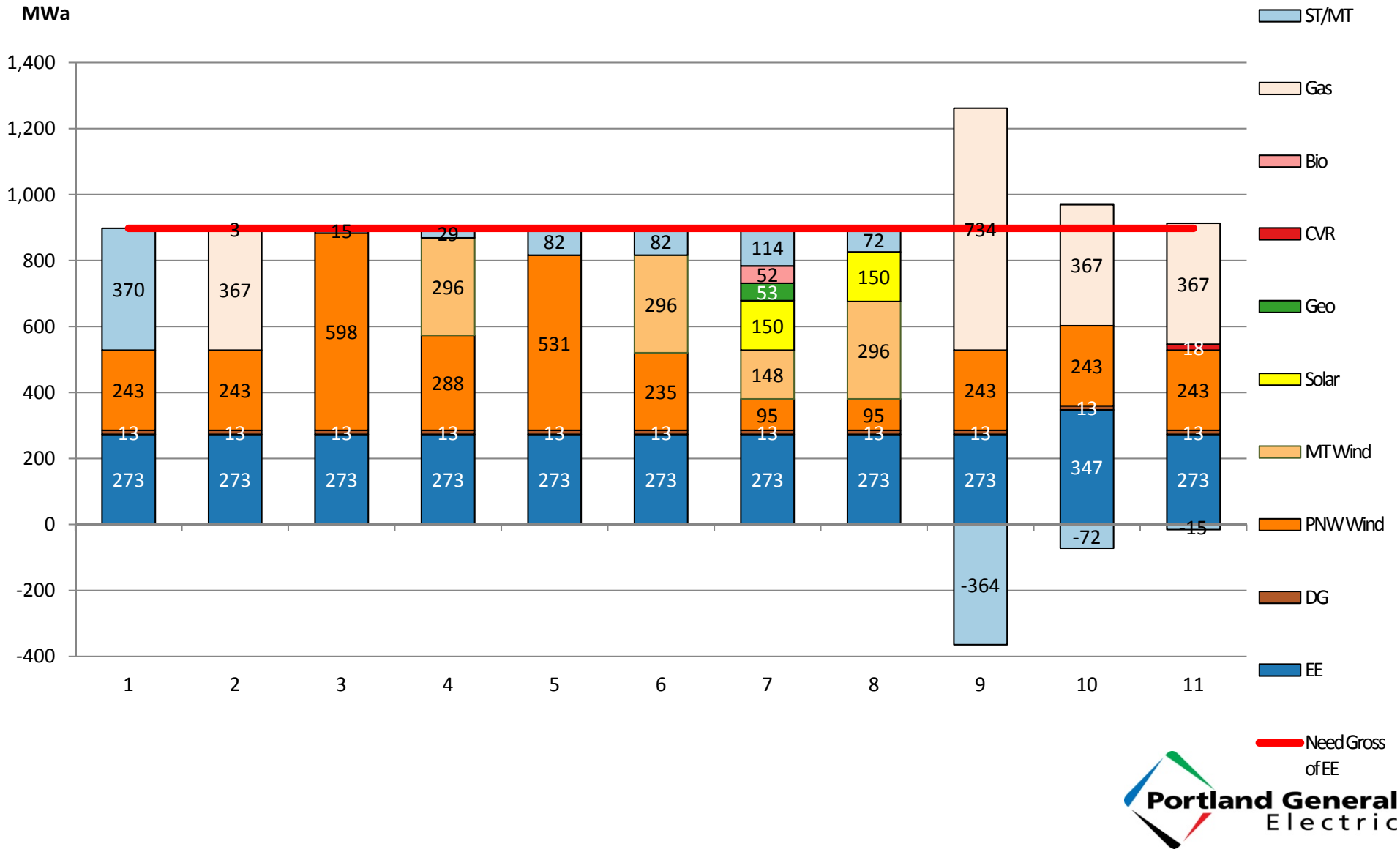
Portfolios: Common Assumptions

- RPS physical compliance by 2025
- ETO EE (base deployment)
- Distributed Generation (reference)
- Demand Response (reference)
- Short-term/Mid-term market procurement – Energy and Capacity

Portfolios: Representative Portfolios

2025 incremental resources (energy at availability)



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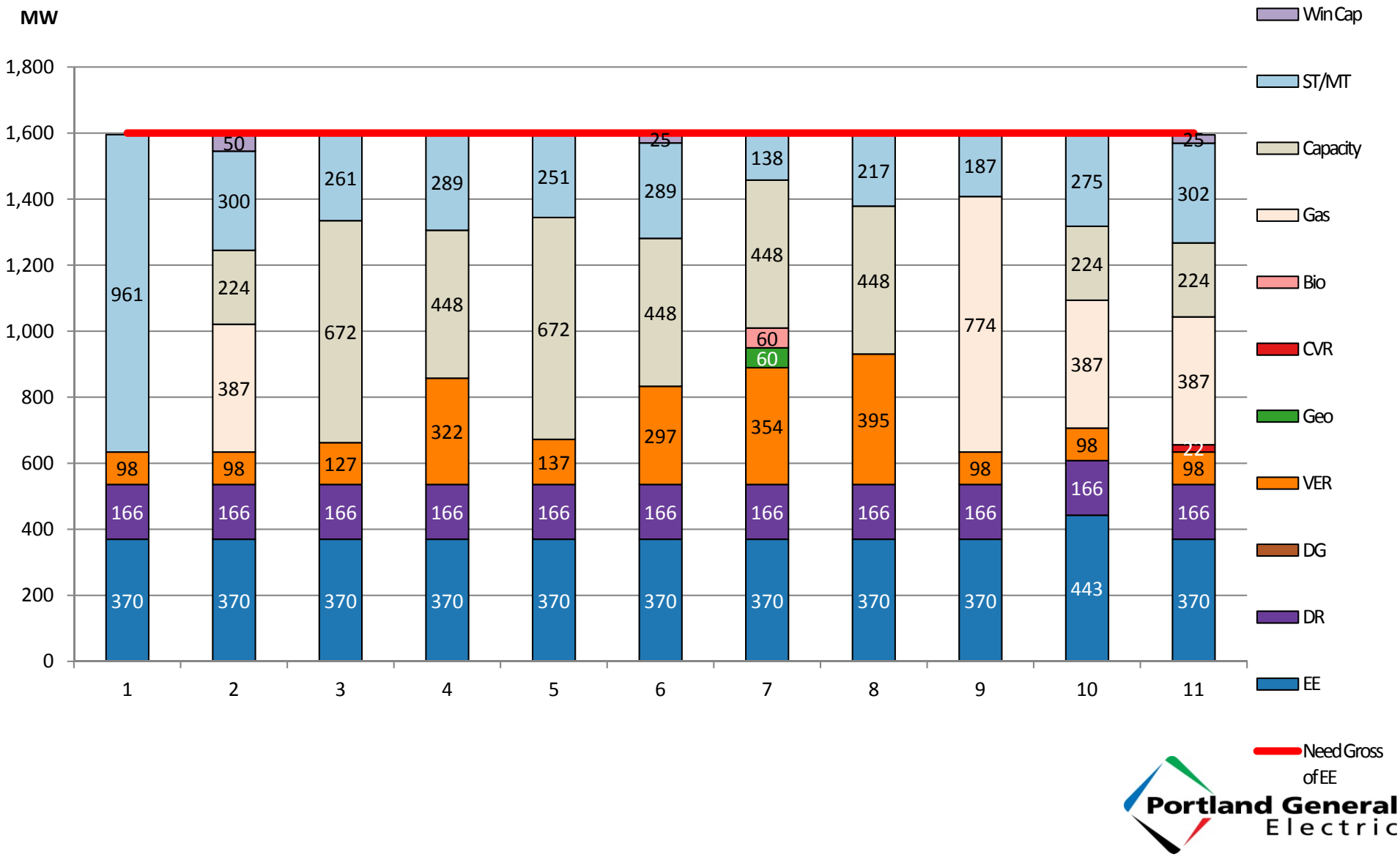
Portfolios: Representative Portfolios

2025 incremental resources (dependable winter capacity)



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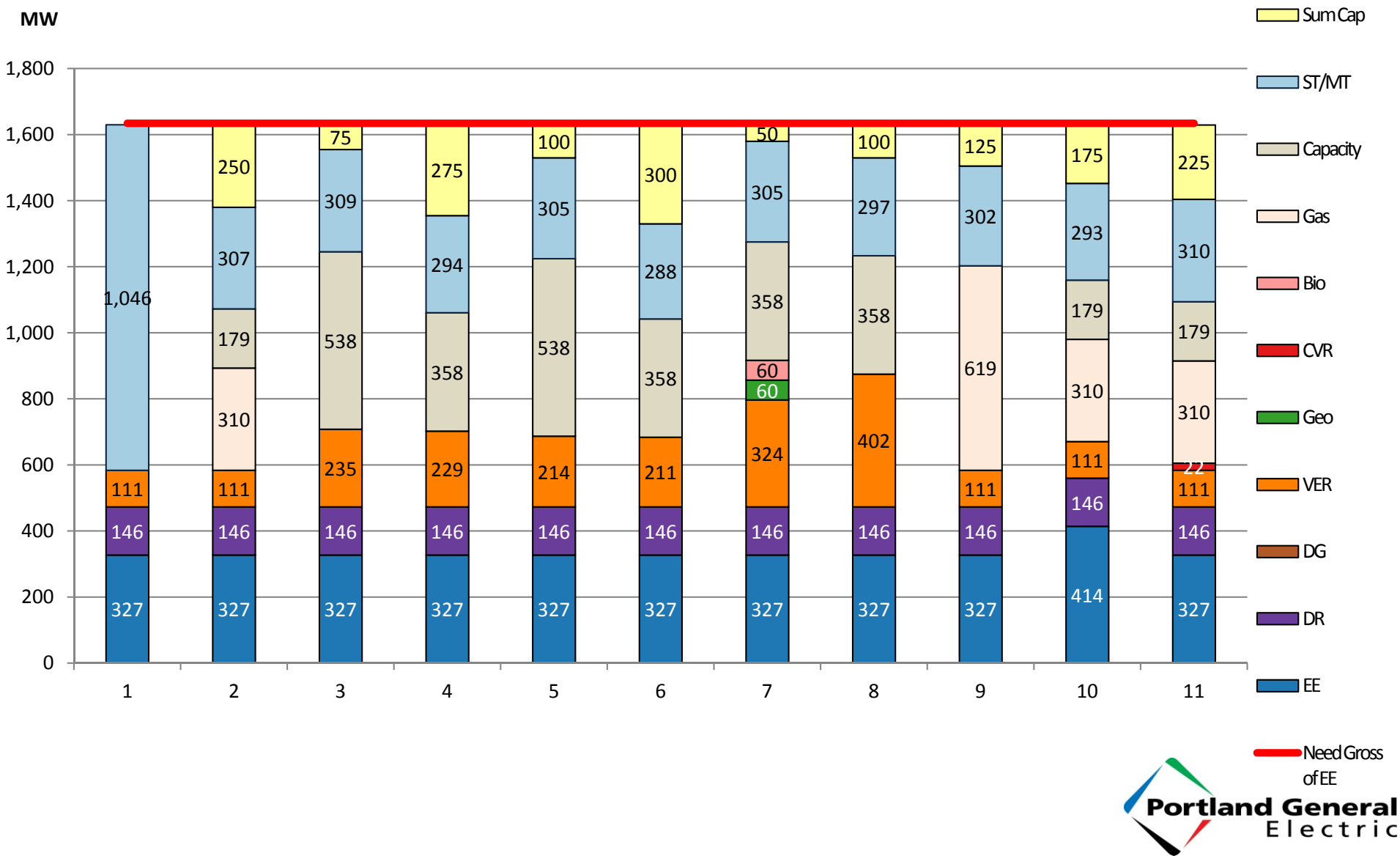
Portfolios: Representative Portfolios

2025 incremental resources (dependable summer capacity)



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Futures and Portfolios: Additional Factors

- Portfolios will test additional assumptions:
  - Additional resources: High DG, capacity resources, storage
  - RPS compliance strategy
  - Portfolio open position

- Other potential considerations
  - Various State RPS compliance requirements
  - Other Futures or Portfolios?

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Appendix

2016 IRP: Feedback Status

December 17, 2015 Slide 103

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.	
Environmental Policy	Does PGE place any type of weather weighting on load forecast?	PGE uses 15-year average weather, with rolling updates	

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2016 IRP: Feedback Status

December 17, 2015 Slide 104

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.	Est. 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.	Est. 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)

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2016 IRP: Feedback Status

December 17, 2015 Slide 105

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

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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)?	The report is currently under review. Our plan is to have this report finalized by the end of 2015.	Est. 12/31/15
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

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.	
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.	

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2016 IRP: Meeting Schedule And Planned Topics

Q2/Q3 2015

April 2 — Meeting #1 Public
- Welcome
- Load Forecast Methodology
- Load/Resource Balance
- Environmental Policy

July 6 — Workshop #1 Commission (Salem)
- EIM Study Update
- 111(d) Representation

July 15 — Workshop #1 Technical
- Load Forecast Methodology Implementation
- Load Forecast Results

July 16 — Meeting #2 Public
- Load Forecast
- Energy Efficiency Forecast
- Supply-side Resource Assumptions
- Solar/Dist. Generation Study Presentation

Public Meeting

Technical Workshop

Technical Workshop with Commission Present

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2016 IRP: Meeting Schedule And Planned Topics

Q3 2015

August 13

Meeting #3
Public

- *Development*
  - *Demand Response*
  - *Flexibility Study*
  - *Planning Reserve Margin*
  - *Portfolios and Futures Ideation*
- *Analysis*
  - *Load Forecast*
  - *Natural Gas Forecast*

September 25

Meeting #4
Public

- *Development*
  - *111(d) Rule update*
  - *Climate Study review*
  - *CVR Update*
  - *DSG Update*
- *Analysis*
  - *ROM Update*
- *Results*
  - *General Updates*

Public Meeting

Technical Workshop

Technical Workshop with Commission Present

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