Integrated Resource Plan

2016

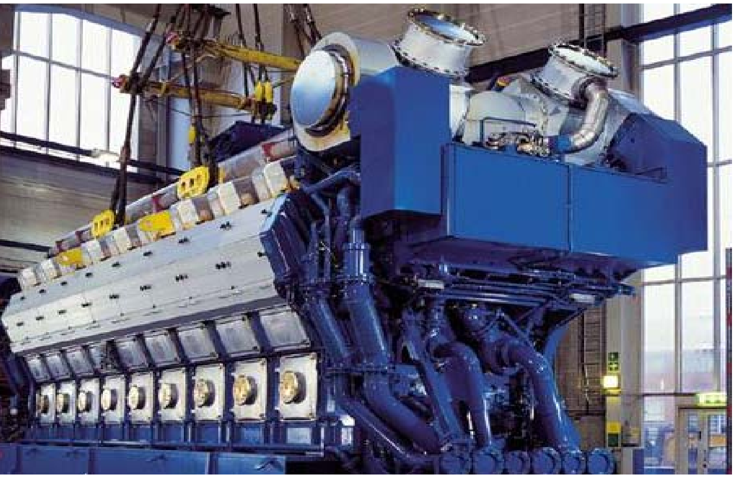
Public Meeting #1 – Revision 1

Thursday, April 2, 2015

© 2015 Portland General Electric. All rights reserved.

Portland General Electric

Welcome



Welcome: Meeting Logistics

April 2, 2015 Slide 3

- Local Participants:
  - World Trade Center facility
  - Please wait for microphone to ask questions

- Virtual Participants:
  - Place phones on mute to prevent background noise
  - Please do not use the ‘hold’ feature on your phone
  - Ask questions via ‘chat’ or ‘raise hand’ feature
  - Meeting will stay open during breaks, but will be muted

Sorry Officer, I didn’t follow the rules of the road.

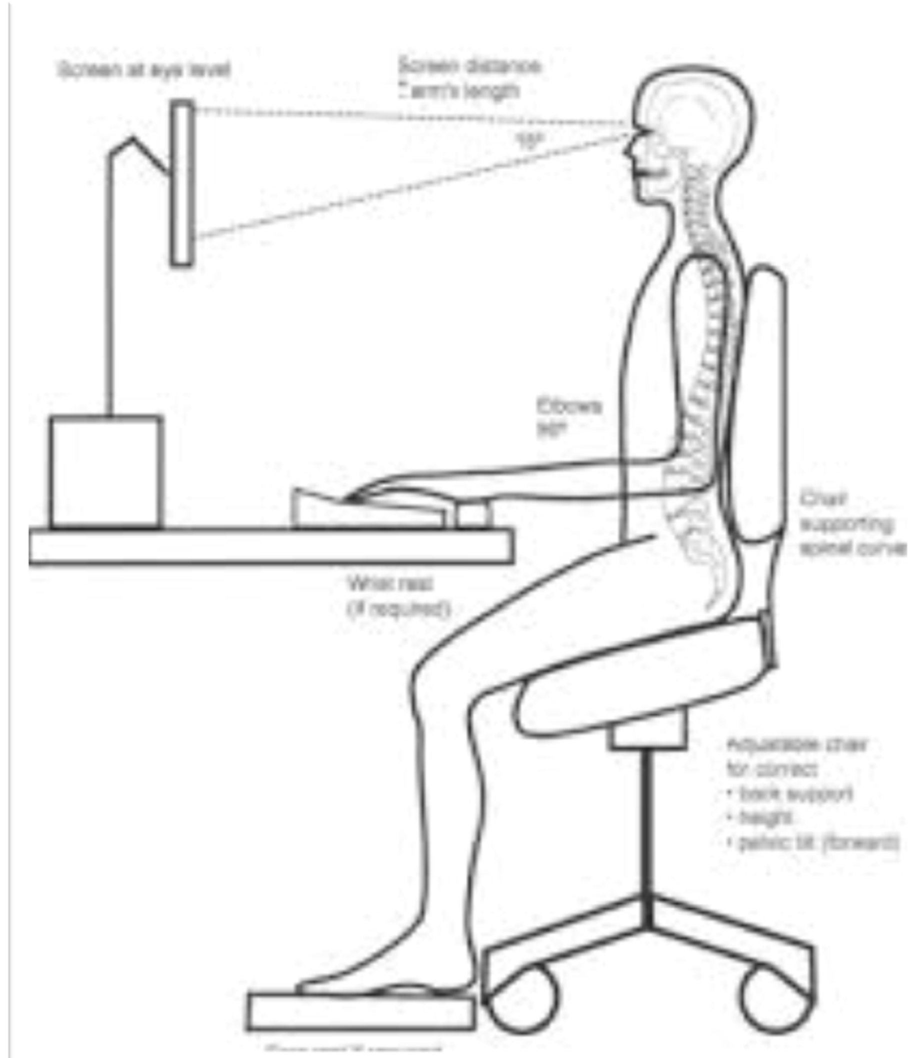
Portland General Electric

Welcome: Today's Topics

- Welcome and Safety Moment
- 2009 IRP and 2011 RFP Resource Update
- Public Process Overview
- 2013 IRP Order
- Load Forecast
- Preliminary Load Resource Balance
- Load Forecast Methodology
- Environmental Policy

Welcome: Safety Moment

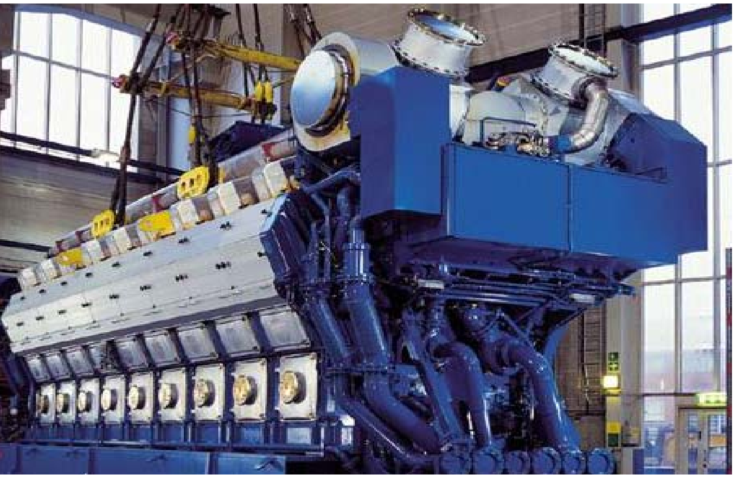
- Sit up straight
- Do not lean forward
- Keep feet flat on the floor
- Relax shoulders
- Keep arms close to sides



Portland General Electric


Portland General Electric

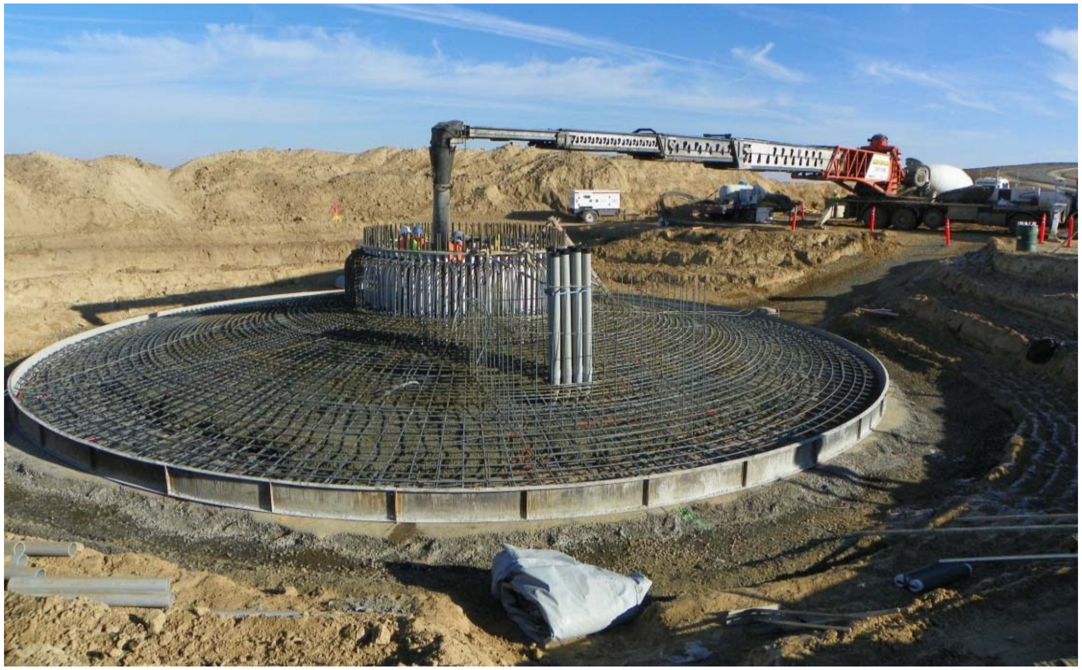
2009 IRP and 2011 RFP Resources




Resource: Renewable Generation

April 2, 2015 Slide 7

Tucannon River Wind Farm	
Project Location	Columbia County, WA
Capacity / Fuel	267 MW / Wind
Technology	116 2.3 MW Siemens Turbines
EPC Contractor	RES Americas
In-Service Date	December 2014



Portland General Electric

Resource: Capacity Generation

April 2, 2015 Slide 8

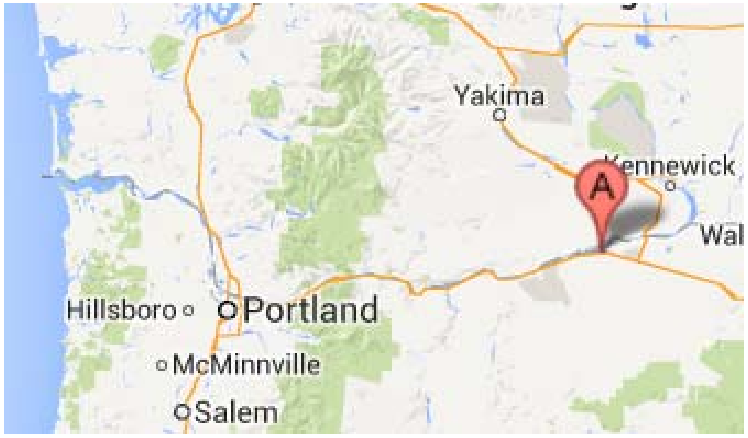
Port Westward Unit 2	
Project Location	Clatskanie, OR
Capacity / Fuel	220 MW / Natural Gas
Technology	12 Natural Gas Wärtsilä Reciprocating Engines
EPC Contractor	Black & Veatch, Harder Mechanical
In-Service Date	December 2014

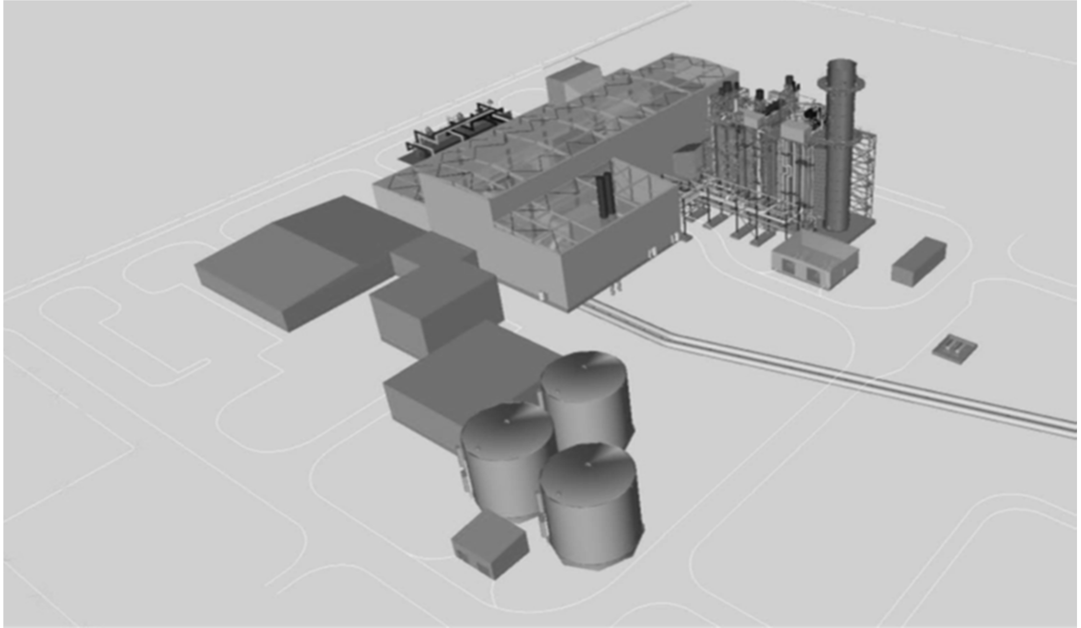
Portland General Electric

Resource: Energy Generation

April 2, 2015 Slide 9

Carty Generating Station	
Project Location	Boardman, OR
Capacity / Fuel	441 MW / Natural Gas
Technology	Mitsubishi Turbine
EPC Contractor	Abener/Abengoa
Estimated In-Service Date	Q2 2016



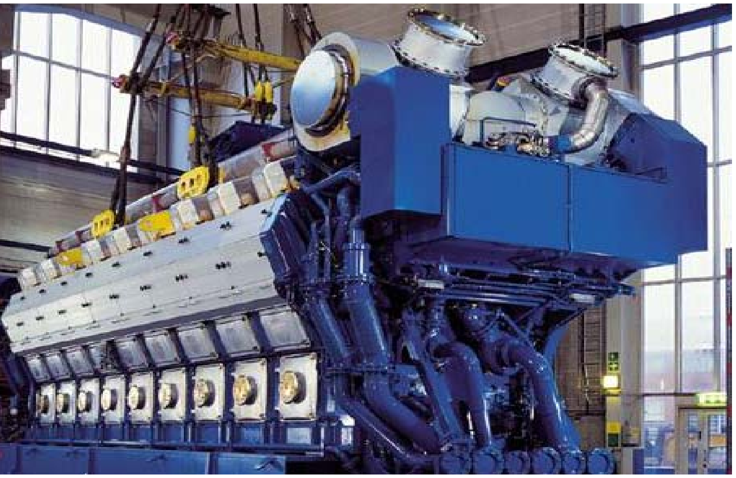


Portland General Electric

Portland General Electric

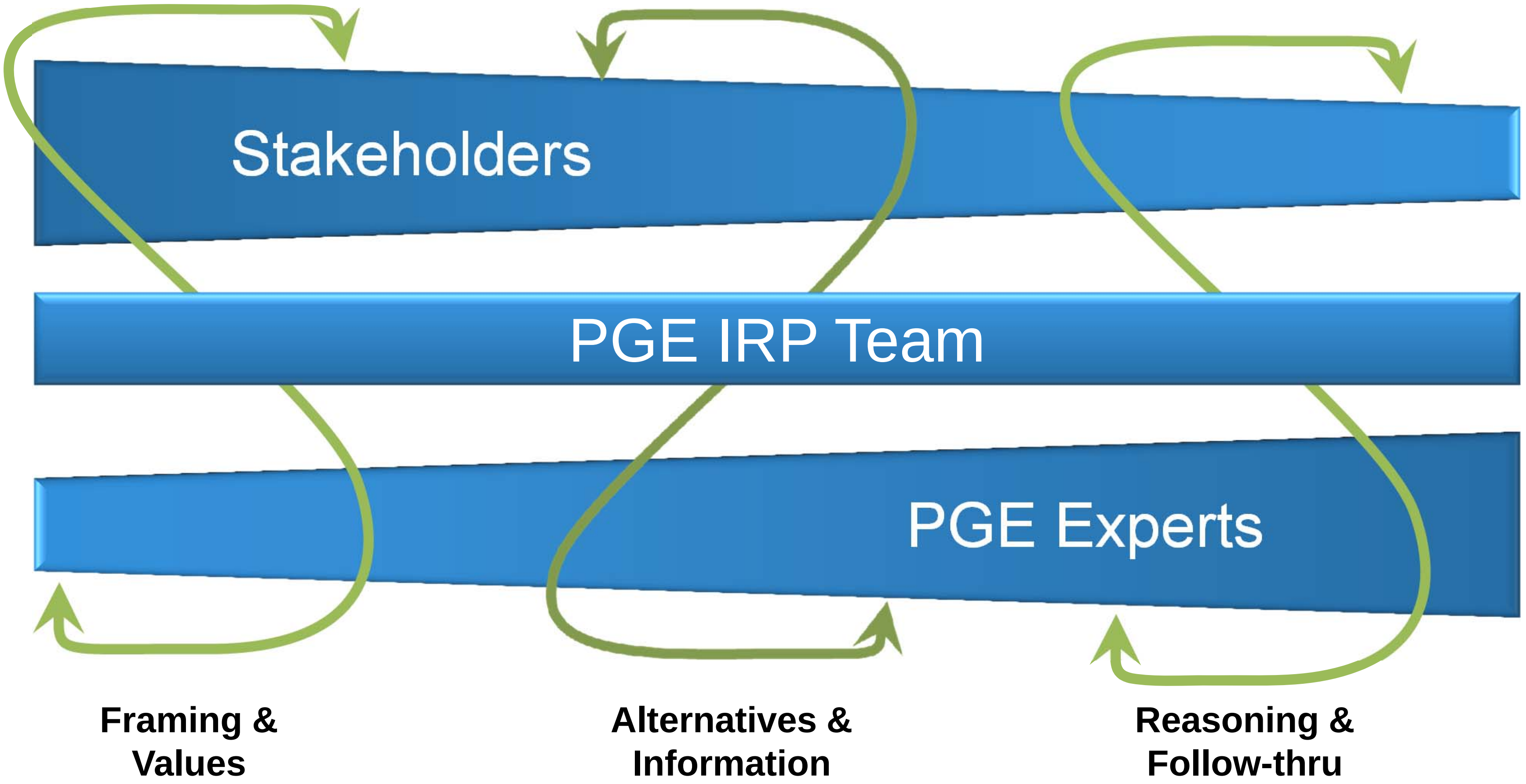
2016 Integrated Resource Plan

Public Process Overview



2016 IRP: Dialogue Process

Communication enhances the IRP process



2016 IRP: IRP Team Org Chart and Contacts

Robert Brown
Analyst, IRP

Kate von Reis Baron
Analyst, IRP

Sima Beitinjaneh
Analyst, IRP

Jimmy Lindsay
Analyst, IRP

Franco Albi
Manager, IRP

Brett Sims
Director, Rsrc Strategy

Maria Pope
VP, Pwr Ops & Rsrc Strtgy

PGE

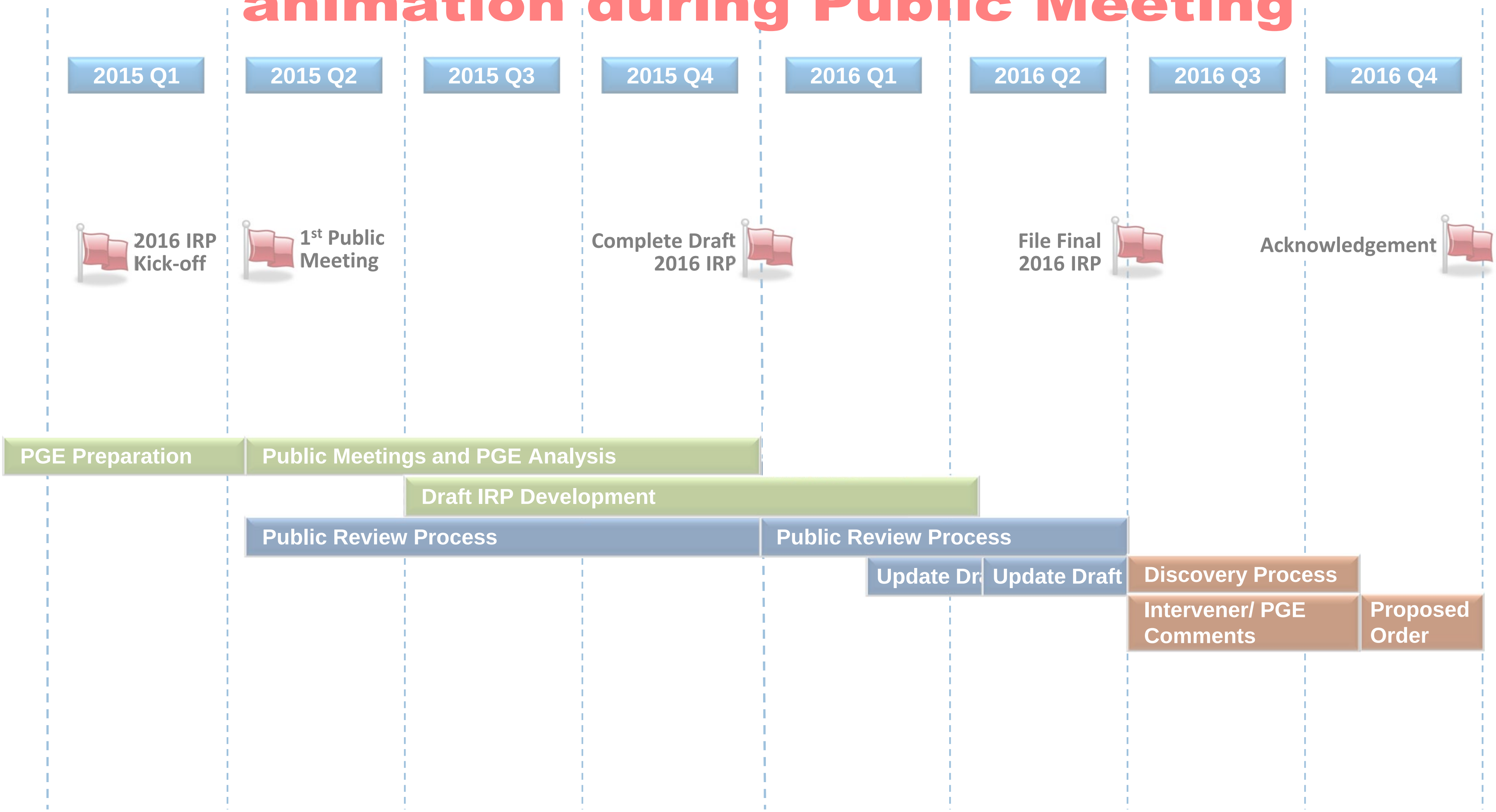
portlandgeneral.com/irp

IRP@pgn.com

Portland General Electric

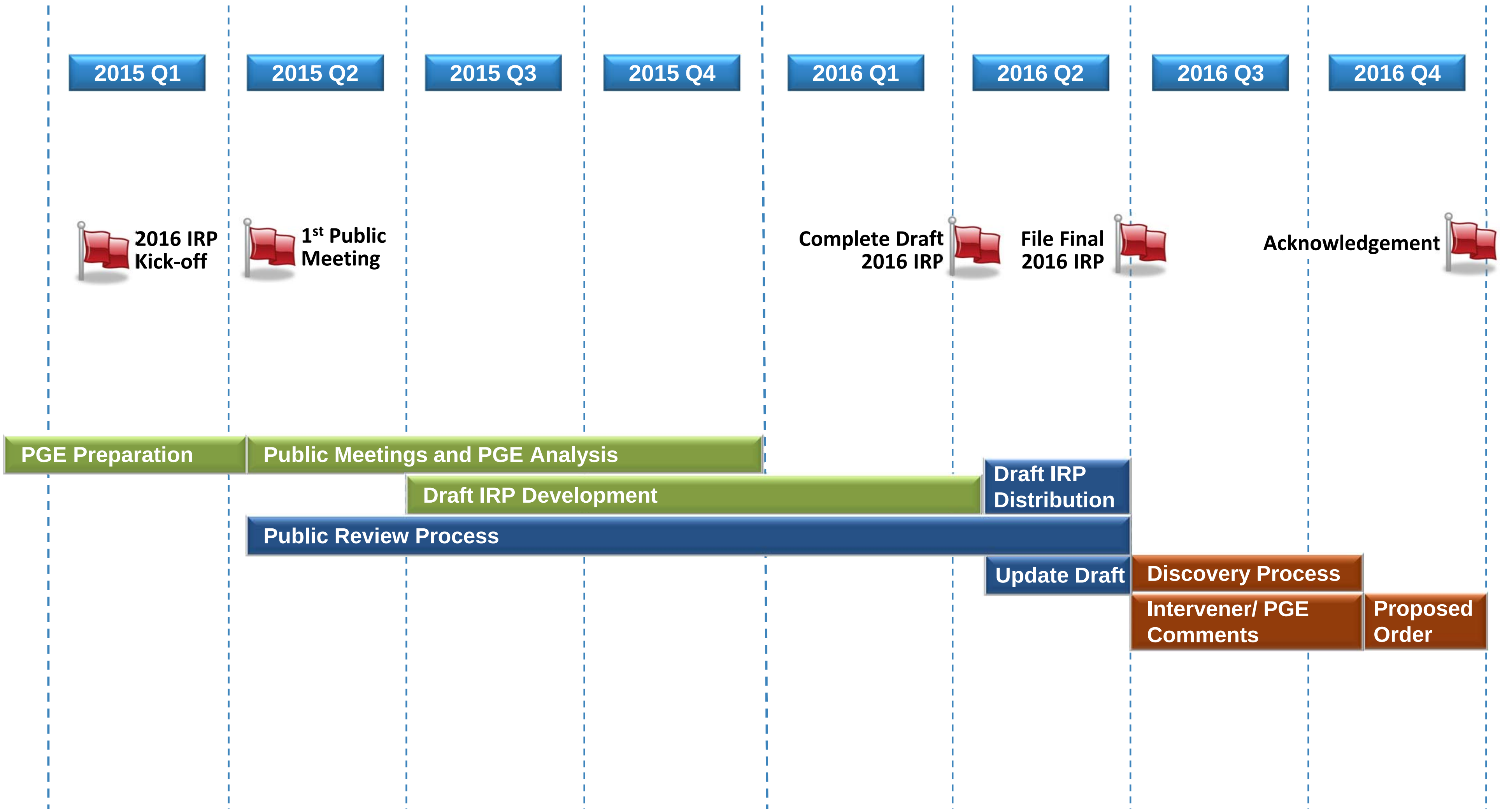
2016 IRP: Indicative Timeline

Slide 13 used only to facilitate animation during Public Meeting



Portland General Electric

2016 IRP: Indicative Timeline



Portland General Electric

2016 IRP: Meeting Schedule And Planned Topics

Q2/Q3 2015

April 2 — Meeting #1 Public

- Welcome
- Load Forecast Methodology
- Load/Resource Balance
- Environmental Policy

June 30 — Workshop #1 Technical

- Load Forecast Methodology Implementation
- Load Forecast Results

July 6 — Workshop #1 Commission (Salem)

- EIM Study Update
- 111(d) Representation
- VER Capacity Contribution

July 16 — Meeting #2 Public

- Energy Efficiency Forecast
- Demand Response Update
- Solar/Dist. Generation Study Presentation
- Supply-side Resource Assumptions

Public Meeting

Technical Workshop

Technical Workshop with Commission Present

Portland General Electric

2016 IRP: Meeting Schedule And Planned Topics

Q3 2015

August 13 — Meeting #3 Public
- Load Forecast Summary Results
- Flexibility Analysis Results
- Variable Resource Capacity Value Methodology
- Proposed Portfolios

September 24 — Workshop #2 Commission (Salem)
- Updated Proposed Portfolios
- Colstrip Portfolio Representation
- EIM Study Update

September 25 — Workshop #2 Technical
- Updated Proposed Portfolios
- Portfolio Analytics Methodology
- Variable Resource Integration Methodology

Public Meeting
Technical Workshop
Technical Workshop with Commission Present

Portland General Electric

2016 IRP: Meeting Schedule And Planned Topics

Q4 2015

October 21
Workshop #3
Technical
- Final Portfolios
- 111(d) Demonstration

October 22
Meeting #4
Public
- Natural Gas Forecast
- Conservation Voltage Reduction Update
- 111(d) Rule Update
- Transmission

November 20
Meeting #5
Public
- Results
  - Colstrip Portfolios
  - Variable Resource Integration
  - Trigger Point Analysis
  - Scenarios

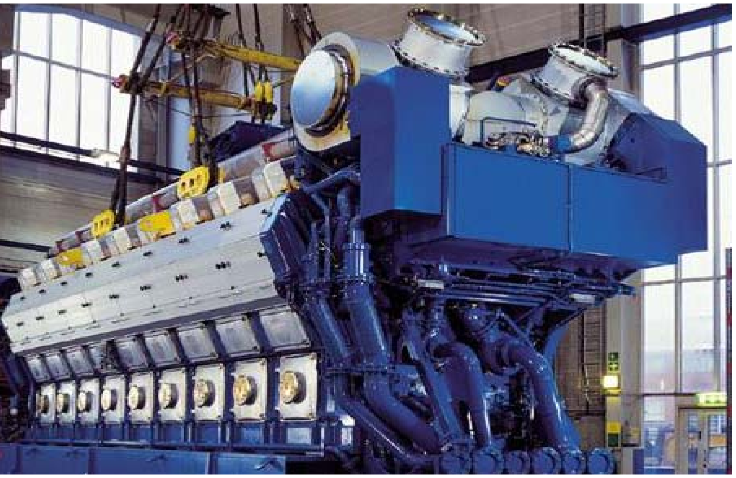
Public Meeting
Technical Workshop
Technical Workshop with Commission Present

Portland General Electric

Portland General Electric

2013 Integrated Resource Plan

Review Of Acknowledged Order



2013 IRP: OPUC Order No. 14-415

Resource actions (2017)

- Renew cost-effective hydro contracts
- Add 23 MW DSG
- Acquire 114 MWa of EE
- Continue ADR Pilot for 25 MW

Future resources / portfolios

- Develop wide range of resource portfolios
- Assess Colstrip

Enabling studies

- Distributed generation study
- Load forecast review
- Flexibility need/mix
- EIM cost-benefit

Other

- RPS compliance strategies
- VER capacity contribution
- Climate change

Portland General Electric

EIM Comparative Analysis Activities

- ✓ Develop an Advisory Committee and Charter
- ✓ Develop a Technical Review Committee and Charter
- ✓ Interviewed six vendors and chose E3 Consulting to conduct the modelling of benefits for both the NWPP and CAISO footprint
- ✓ Coordinate with peer utilities on base case assumptions and modelling scenarios
- o Assess PGE's internal costs to enter an EIM
- o Assess the external costs to join the NWPP or CAISO EIM
- o Conduct scenario analysis
- o Facilitate workshops to review assumptions, qualitative analysis and modelling results
- o Present final results

EIM Advisory and Technical Review Committees

Advisory Committee

- Steve Beuning – Excel Energy
- Jim Shetler – Balancing Authority of Northern California (BANC)
- Michael Goggin – American Wind Energy Assoc. (AWEA)
- Scott Kinney – Avista
- Tess Park – Idaho Power Company
- Scott Downey – Peak Reliability
- Doug Larson – Western Interconnection Regional Advisory Board
- Cameron Yourkowski – Renewables Northwest
- Mark Rothleder – California ISO
- Carl Monroe – Southwestern Power Pool
- John Crider – OPUC Staff
- Bob Jenks – Citizen's Utility Board (CUB)
- Joe Lawlor – Pacific Gas & Electric (PG&E)
- Rachel Dibble – Bonneville Power Administration

Technical Review Committee

- Michael Milligan – National Renewable Energy Laboratory (NREL)
- Brendan Kirby – Consultant to NREL
- Bart McManus – Bonneville Power Administration
- John Ollis – Northwest Power and Conservation Council
- Ron Schellberg – Idaho Power Company
- Ted Brekken – Oregon State University
- Eduardo Cotilla-Sanchez – Oregon State University

Portland General Electric

Dynamic Dispatch Program

PI Consolidation Project

Cycling Costs Studies Project

AGC Equipment Install Project

Real Time Dispatch Tool Project

Plant Data System (pi) Consolidation: Completed
- Optimizes the PGE plant data systems for reliability requirements, system constraints, and economic dispatch of the plants

Cycling Cost Studies: Completed on Thermal Plants
- Informs Operations of wear/tear costs and cycling restriction to improve dispatch logic via Real Time Dispatch Tool

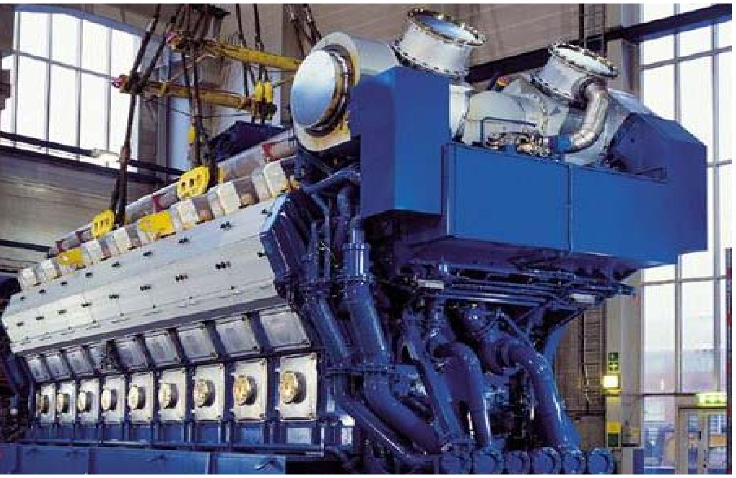
AGC Equipment Project: Completed on Thermal Plants
- Increased dispatch communication efficiency and allows remotely controlled dispatch for load following

Real Time Dispatch Tool: Q2 2015
- Increases efficiency and coordination of plant dispatch.
- Facilitates hybrid integration strategy for VERs

We will go live this spring with the Real Time Dispatch Tool.

Portland General Electric

Load Forecast



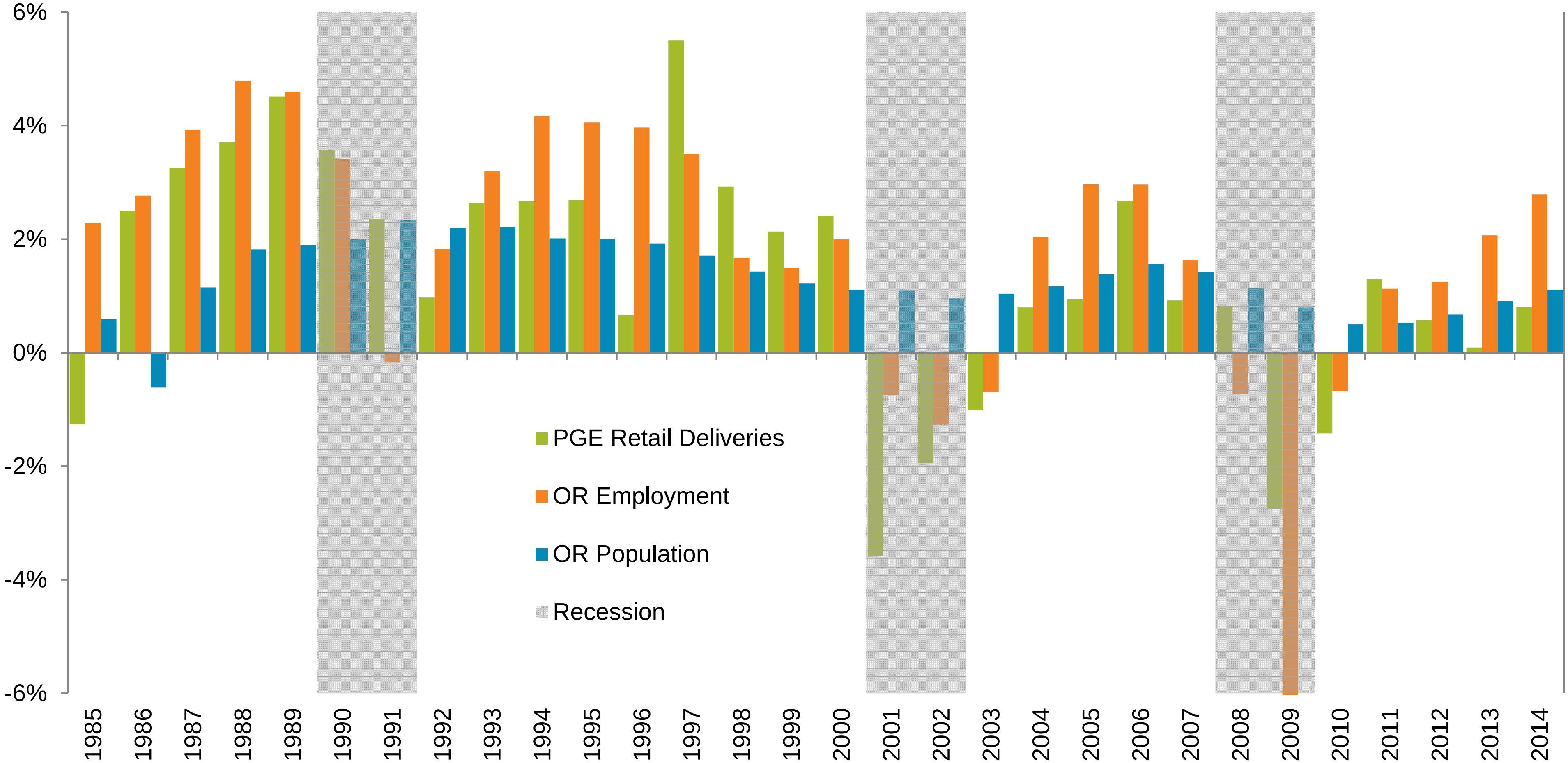
Load Forecast – Fundamental Drivers

Near-term: business cycle affects the economy and electricity use

Long-run: economy and demographics drive electricity consumption

- Portland metro area economy has been growing faster than Oregon and the PNW region due in large part to strong in-migration and the prominence and growth of high-tech industry.
  - Growth in high-tech is expected to continue in the future
  - Energy deliveries to high-tech more than offsets resource-based industry's retrenchment

Population and job creation drive electricity use



Recent Trends

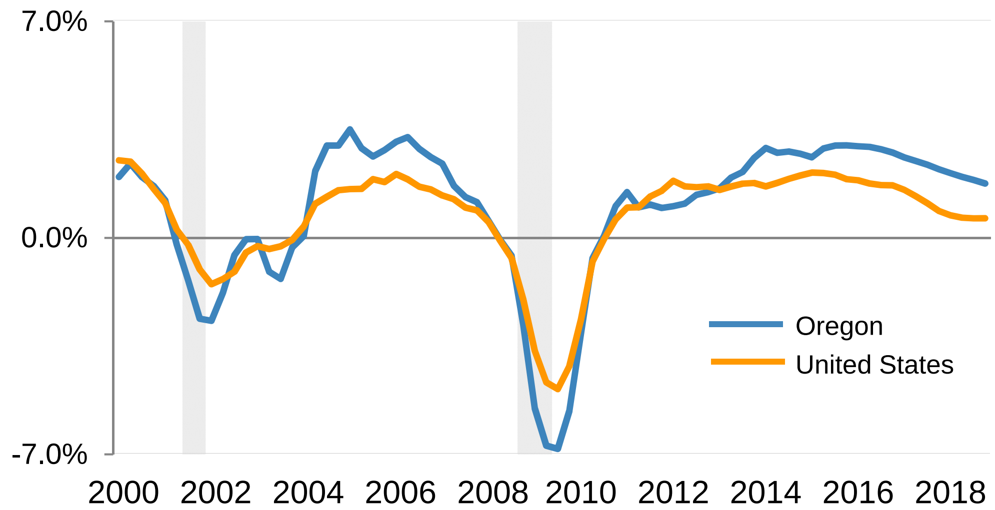
Economy & Population

- Economic and population indicators are strong
- Oregon employment is outpacing the US
- PGE 3-County service area recovered jobs lost in the recession at end of 2013

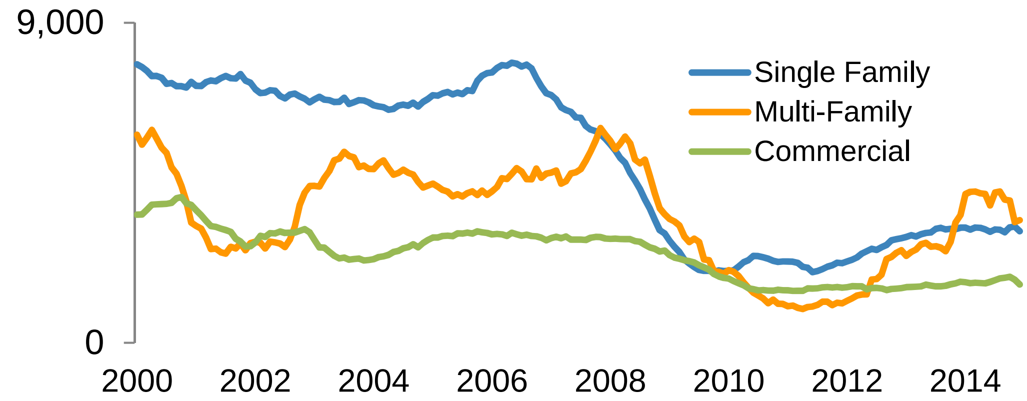
PGE Retail Energy Deliveries

- PGE retail energy deliveries continue to recover from 2008 recession.
- Load growth is being driven by industrial energy deliveries, particularly high tech expansion, though paper products manufacturing continues to show volatility.
- Residential deliveries have been flat since the decline in 2010, largely due to historically low number of connects.

Oregon Employment Growth Strengthening



Multi-Family Construction Leading Housing Recovery



Portland General Electric

Population & Employment Growth Forecasts

Population Trends	Growth Rate	Period
PGE 4-County Population (OEA)	1.2%	2015-2034
Oregon Population (OEA)	1.1%	2015-2034
US Population (Global Insight)	0.7%	2015-2034

- Western U.S. growing faster than the US average
- Oregon continues to be a leading state for in-migration, PGE service territory growing faster than the Oregon state average due to higher population growth in urban areas

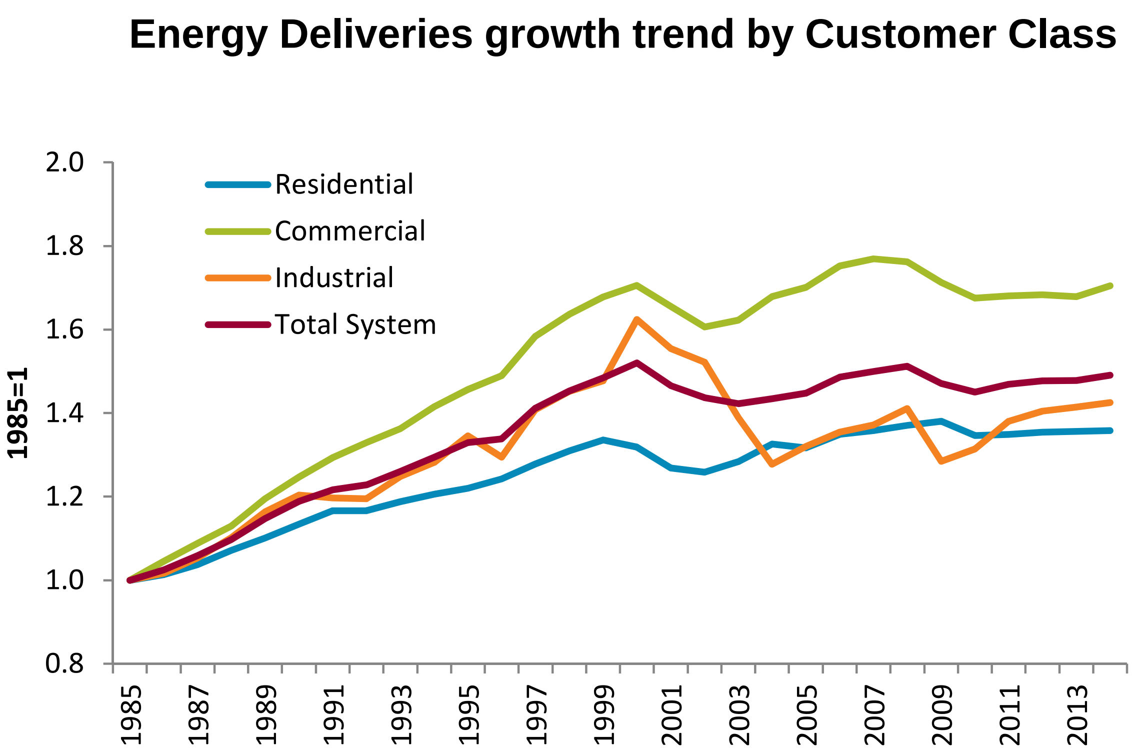
Employment Outlook*	Growth Rate	Period
Oregon Employment (OEA)	1.8%	2015-2024
US Employment (Global Insight)	1.1%	2015-2024

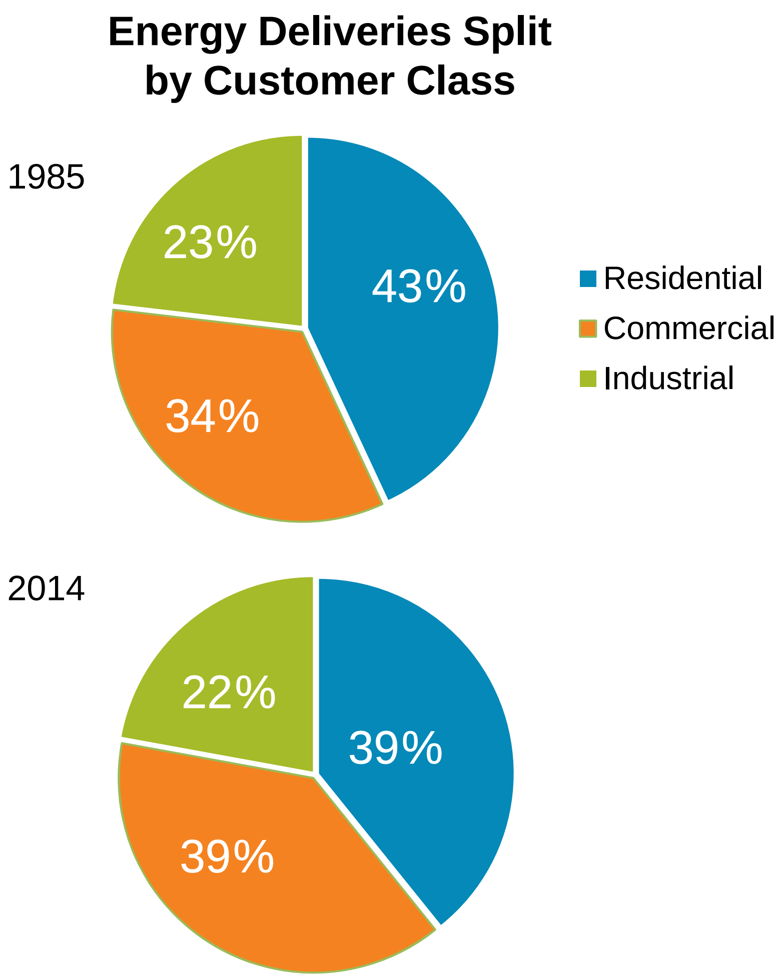
- In Oregon, job growth is expected to be most rapid in the Portland metro area due to concentration of business activities
- Businesses associated with high-tech industry are typically energy intensive

Source: Oregon Office of Economic Analysis, Economic Forecast, March 2015.
Global Insight U.S. Economic Forecast, March 2015.
* Oregon Employment forecasts only available to 2024

Portland General Electric

PGE Energy Deliveries Growth By Class





Portland General Electric

Sector-level Fundamentals: Residential

Customer growth is driven by economic conditions

- Strong population growth due to in-migration
- Population growth is fastest in urban areas
- Growth varies by region

Average usage continues to decline

- Long term trend of declining use per customer:
  - Federal codes and standards increase the energy efficiency of new appliances and newly constructed homes.
  - Other technological and behavioral changes (conservation)

Change in Appliance Stock

- Declining electric space heat penetration and increasing A/C penetration changing seasonal energy needs and peak demand
- Households are reaching full saturation for common, large appliances (e.g., washing machines, dish washers, refrigerators, etc.)

Portland General Electric

Sector-level Fundamentals: Non Residential

Commercial sector growth is expected to continue

- Economy is becoming more cooling-intensive, expect growth to be driven by cooling-related load
- Population growth leads to growth in commercial services, businesses, government services & other amenities

Strength in high tech to lead manufacturing output

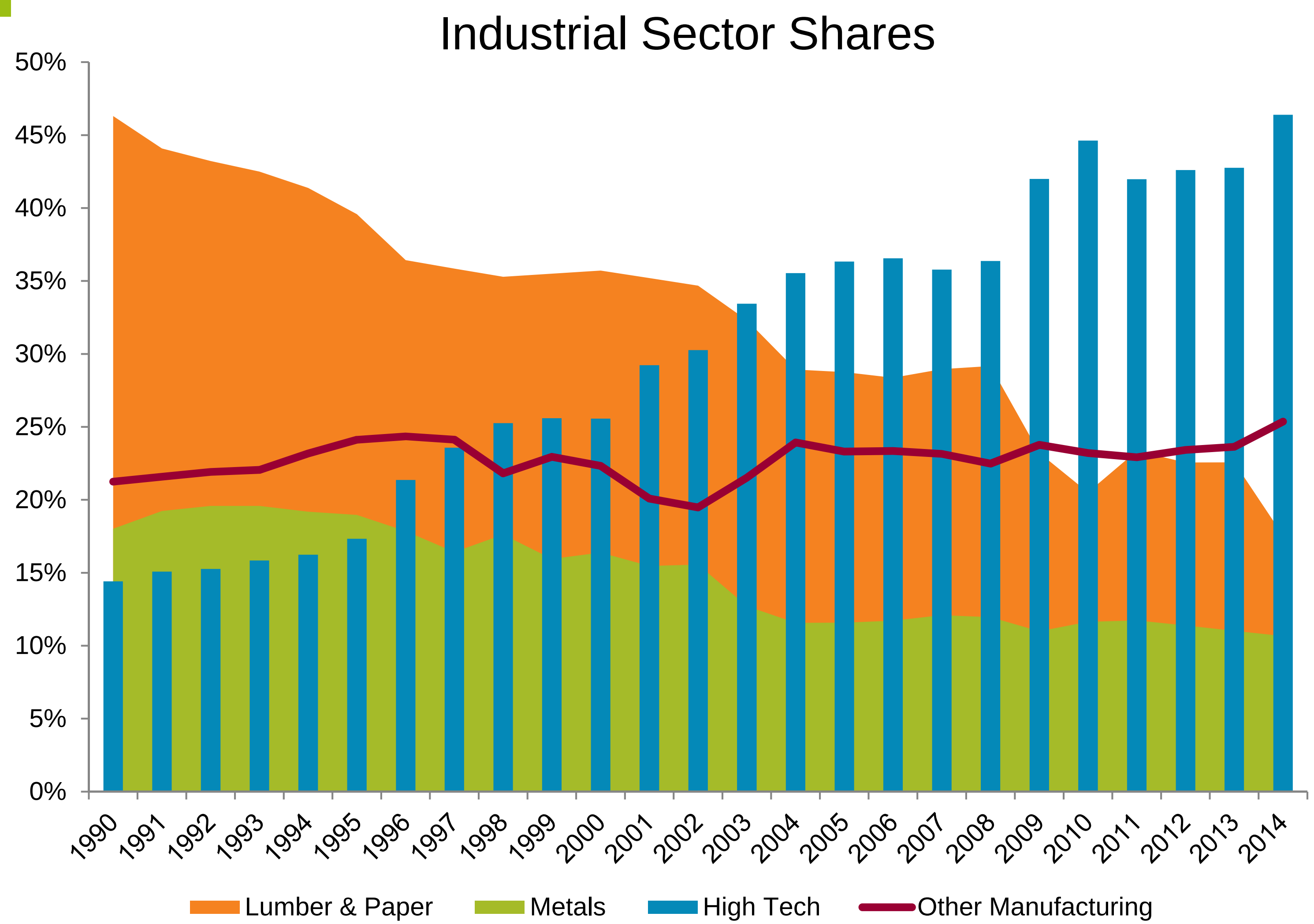
- Strong growth in high tech manufacturing
- Shifting share to high tech from wood products/natural resource industries
- Oregon high tech industries are concentrated in PGE service area

PGE manufacturing sector remains highly concentrated and thus volatile

- Top 20 industrial customers account for ~70% of total manufacturing load
- Creates difficult forecasting environment, can lead to variance

Industrial Deliveries

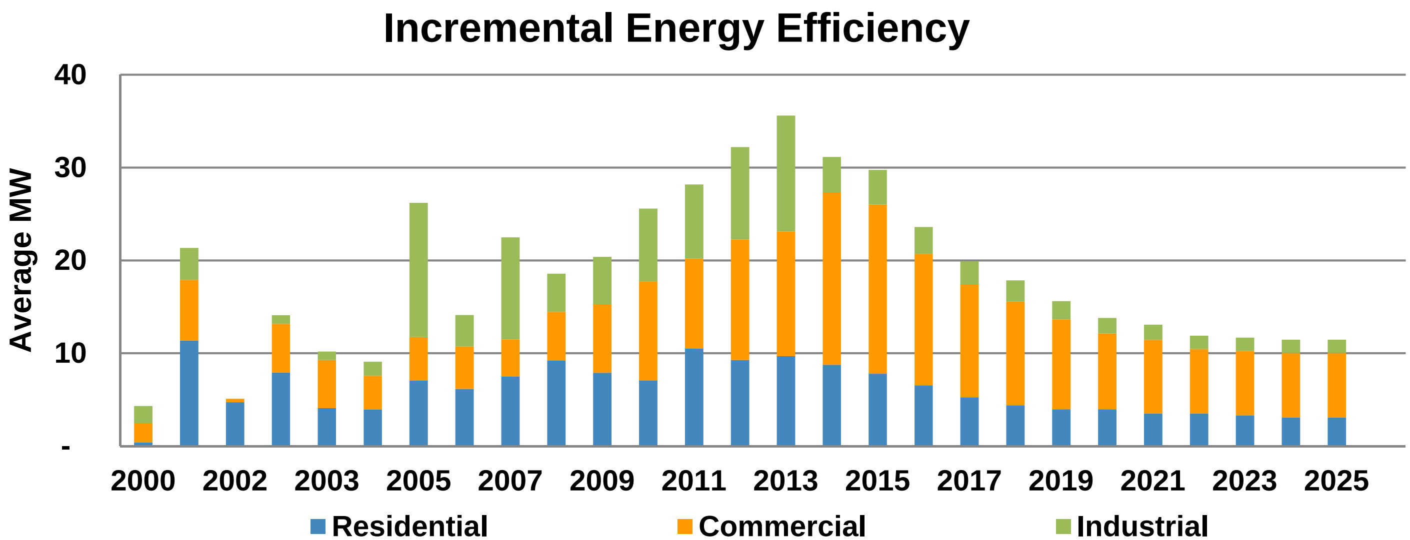
- Industrial customer mix has shifted over time from forest products to high tech manufacturing



Portland General Electric

Energy Efficiency

- Strong history of EE savings reducing average growth rates.



Residential

- New building savings
- Weatherization
- Energy-efficient TVs
- High-efficiency lighting (like LEDs)
- High-efficiency appliances (washers, dryers, freezers, and refrigerators)

Commercial

- Custom "whole-building" approaches
- Energy audits for schools
- High-efficiency lighting (like LEDs)
- Building controls and HVAC improvements
- Grocery equipment

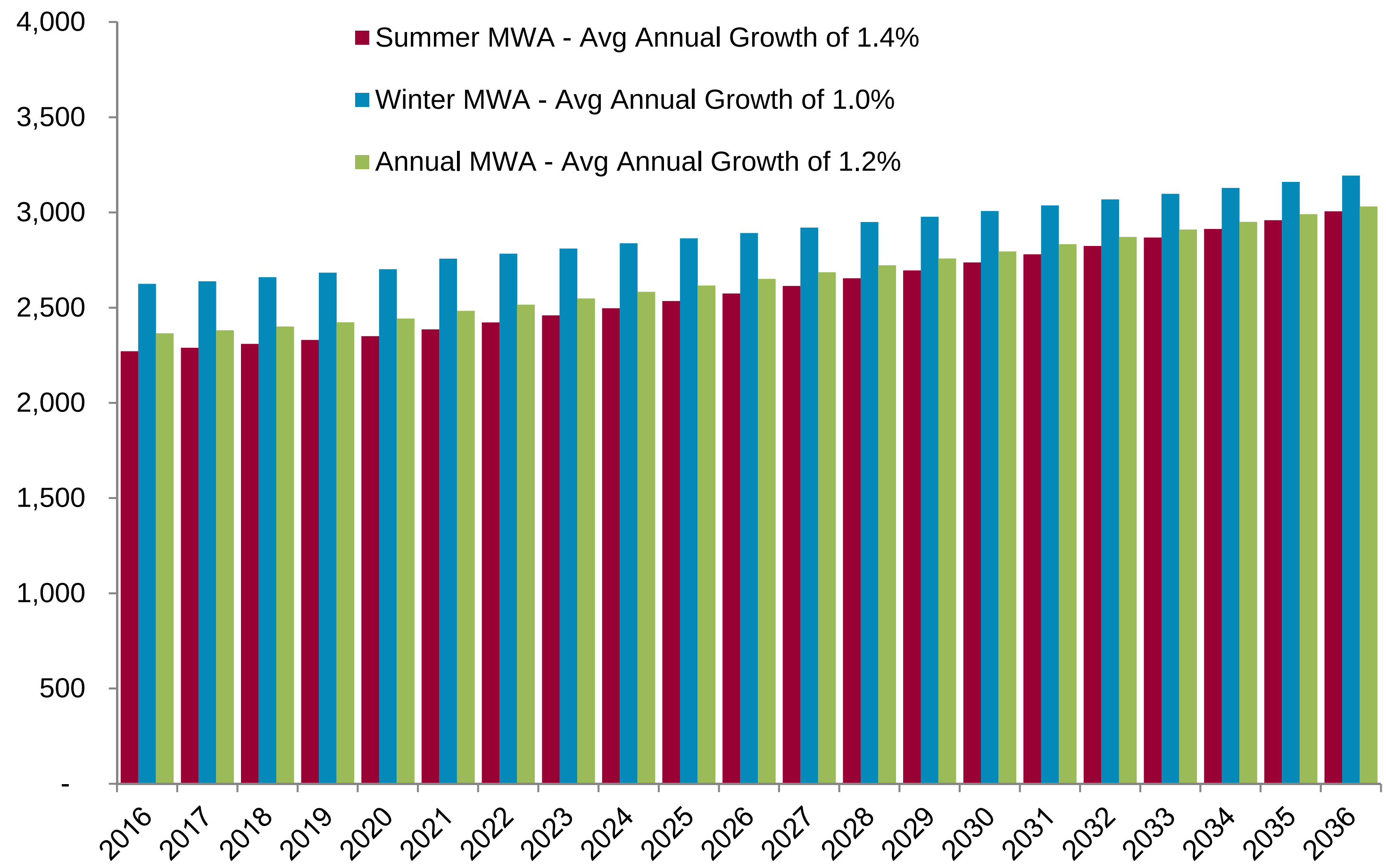
Industrial

- Small industrial and agricultural measures: irrigation, small compressed air, variable frequency drives
- No-cost/low-cost operational steps
- High-efficiency lighting (like LEDs)

Portland General Electric

Preliminary Energy Forecast, MWa
2017-2036

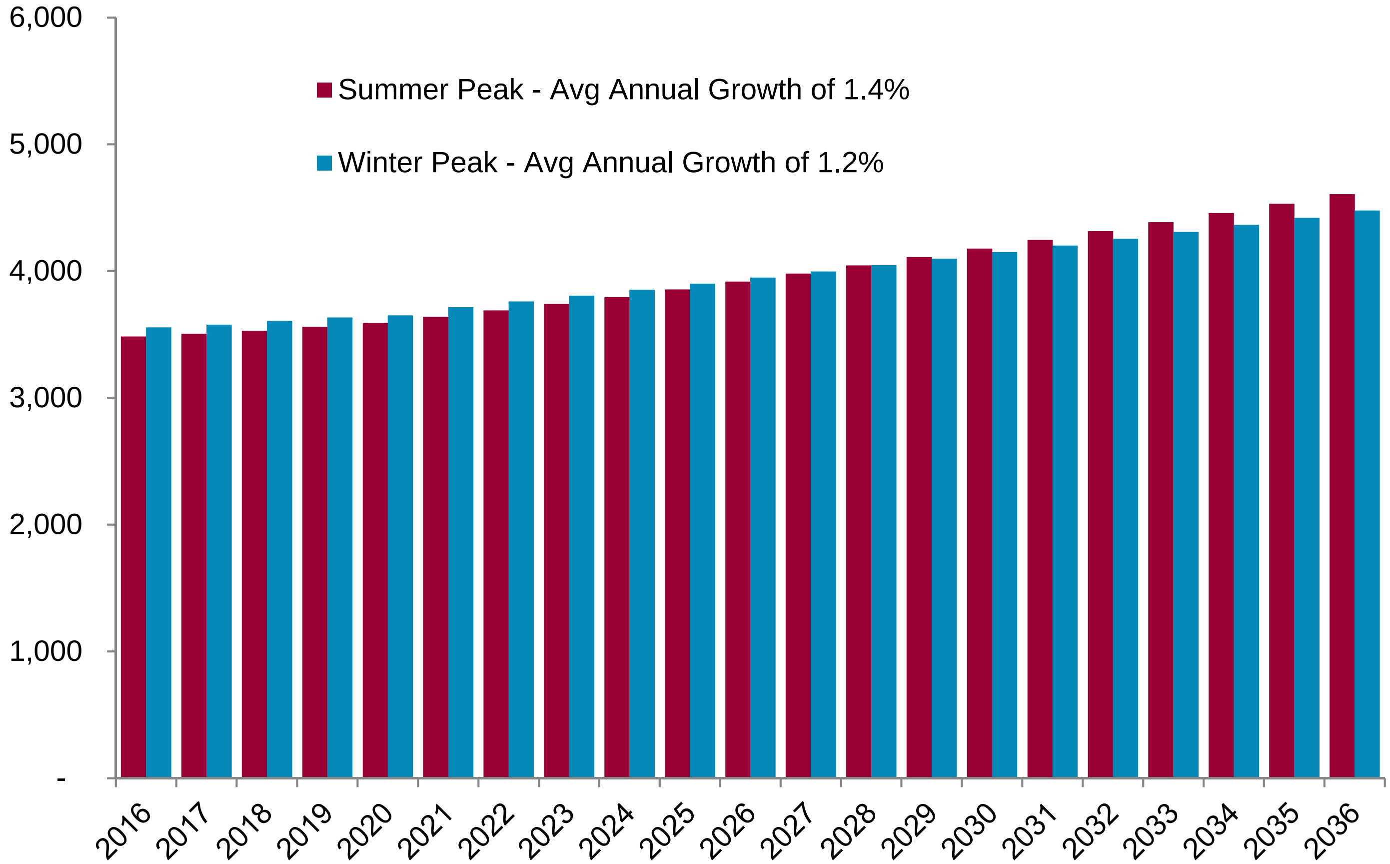
April 2, 2015 Slide 33



Source: PGE Net System Load Forecast, PGE December 2014 Load Forecast.

Portland General Electric

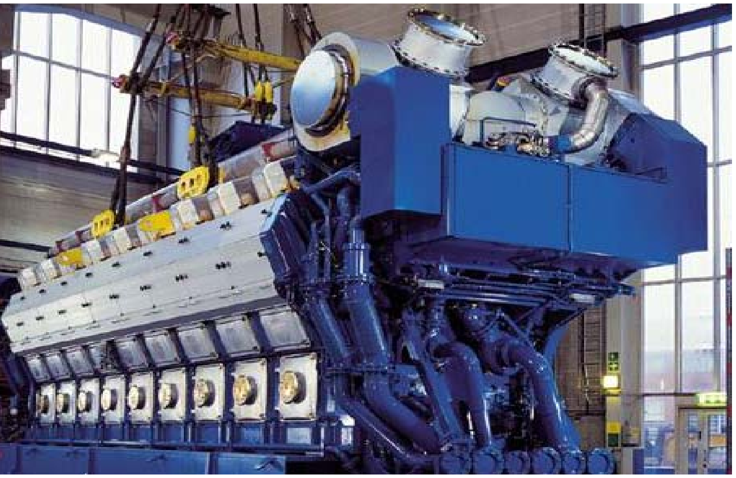
Preliminary Peak Demand Forecast, MW 2017-2036



Source: PGE Net System Load Forecast, PGE December 2014 Load Forecast.

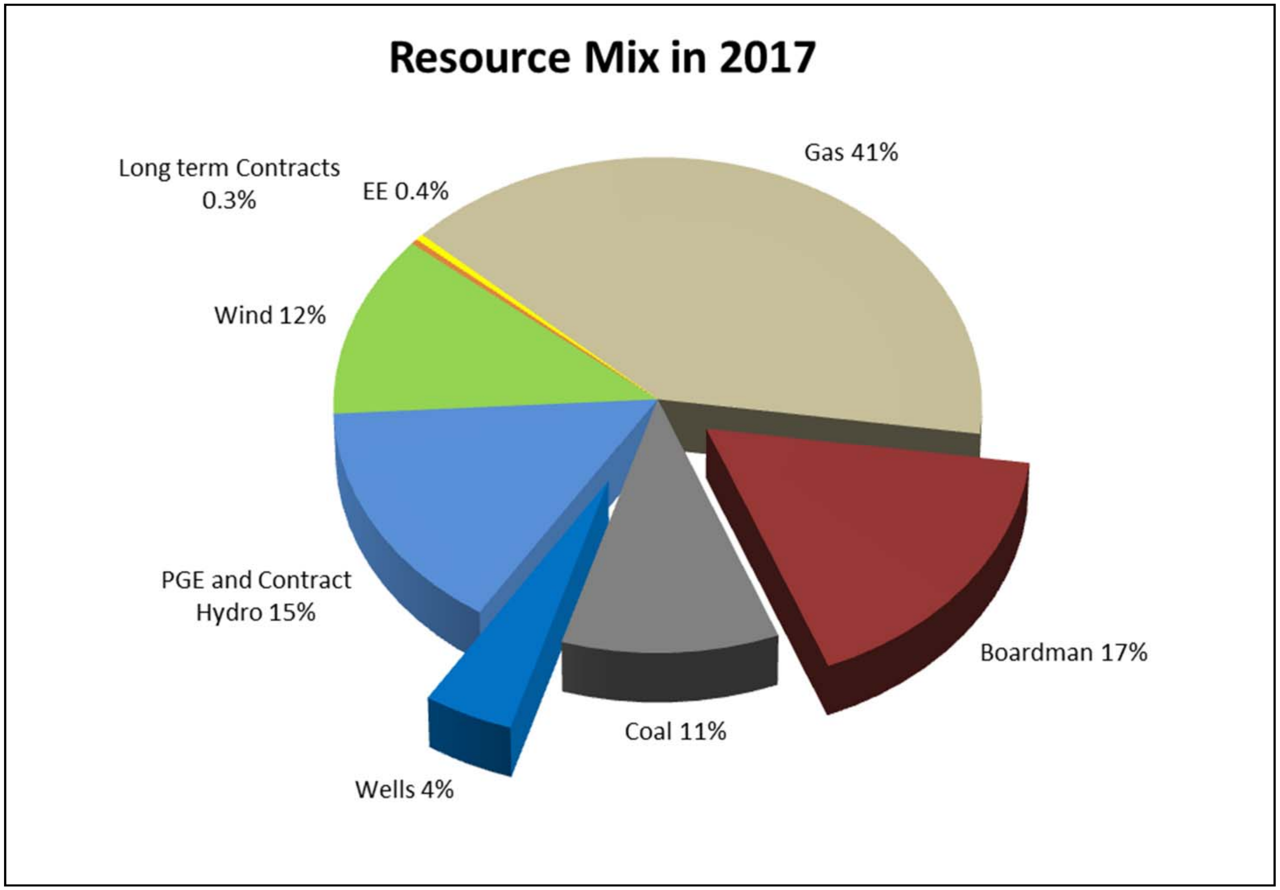
Portland General Electric

Preliminary Load Resource Balance



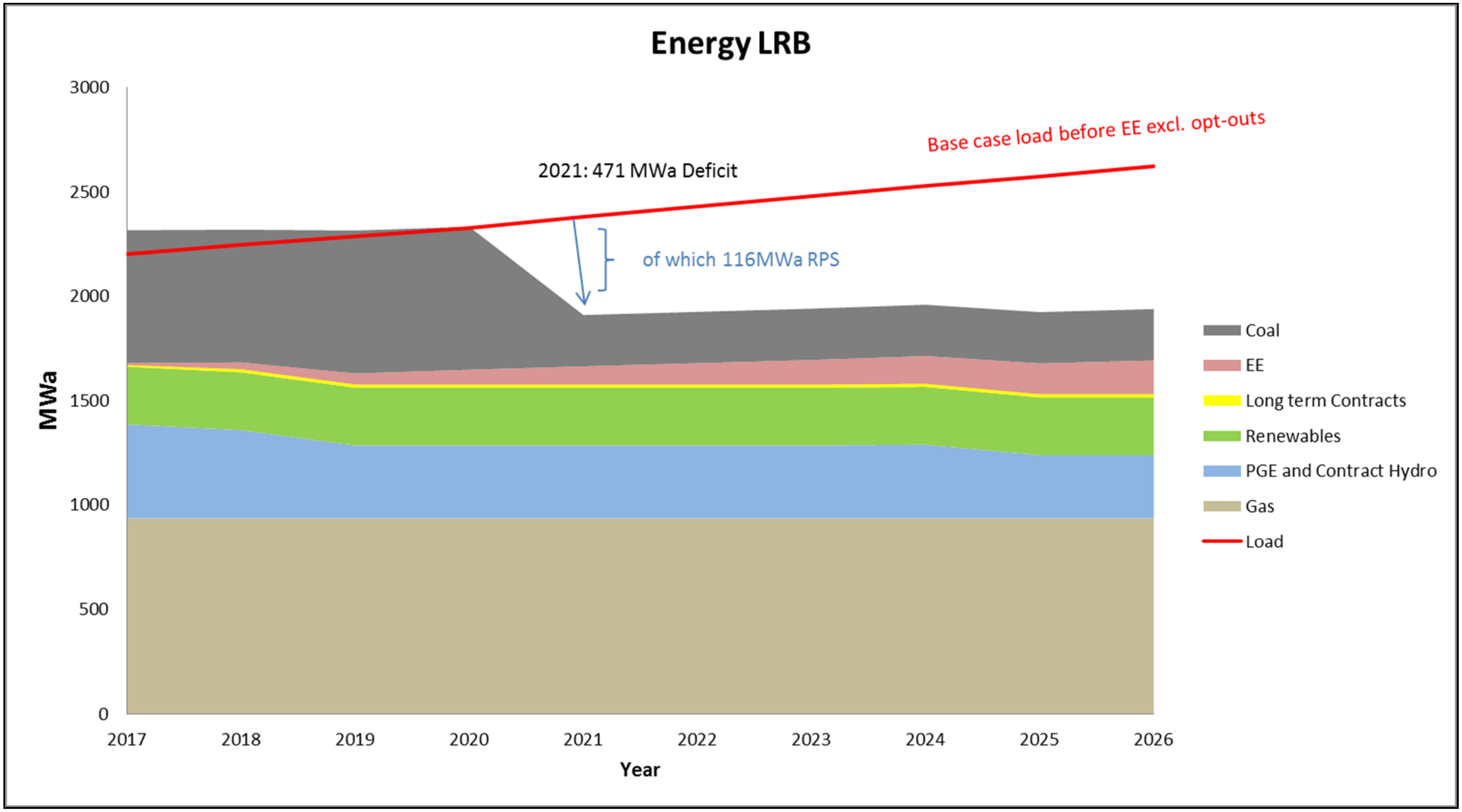
Preliminary Load Resources Balance (LRB)

PGE's resource mix is changing



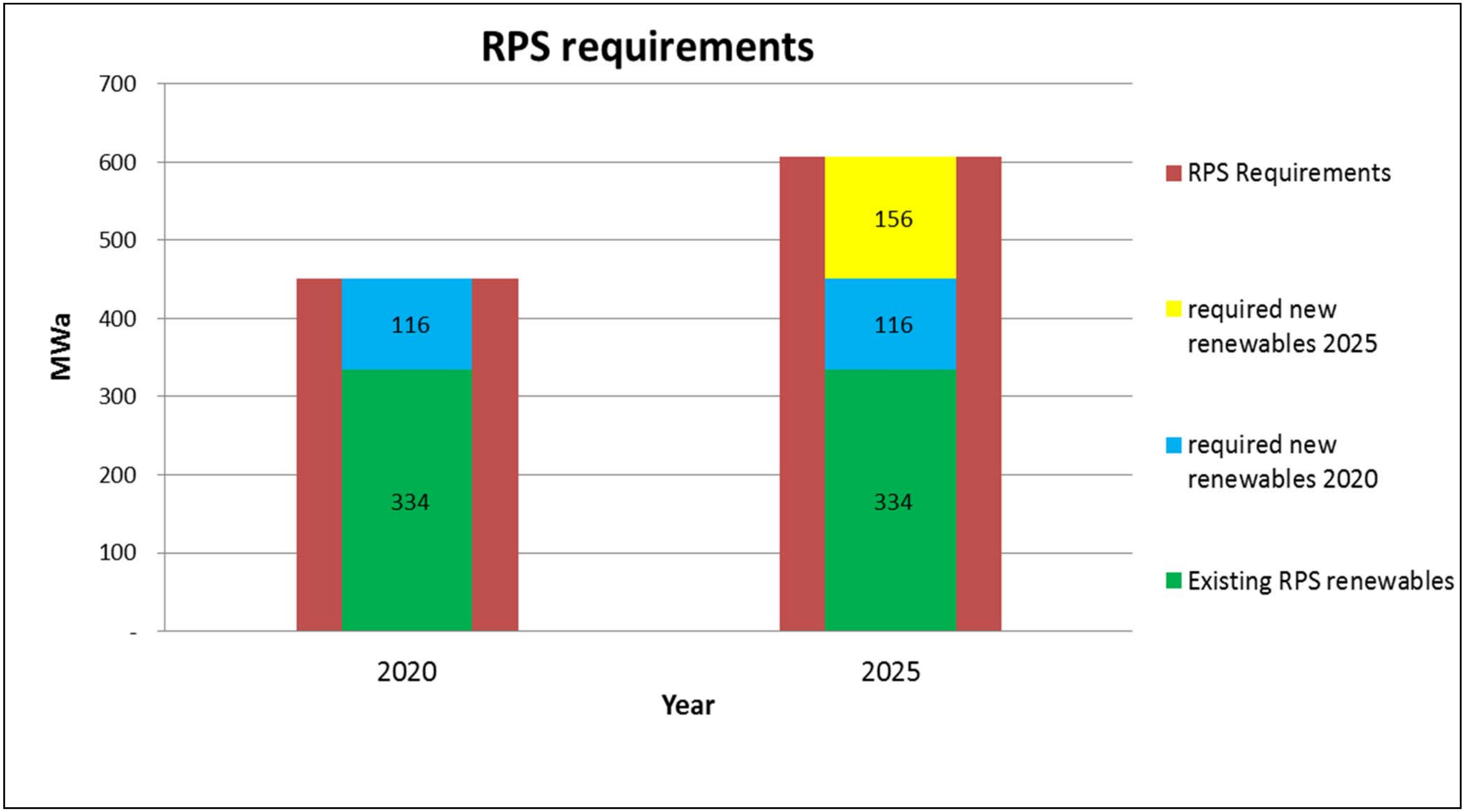
- Available resources average annual energy
- Hydro contract expires in 2018
- Boardman ceases coal-fired operations in 2020

Preliminary LRB: Energy



Portland General Electric

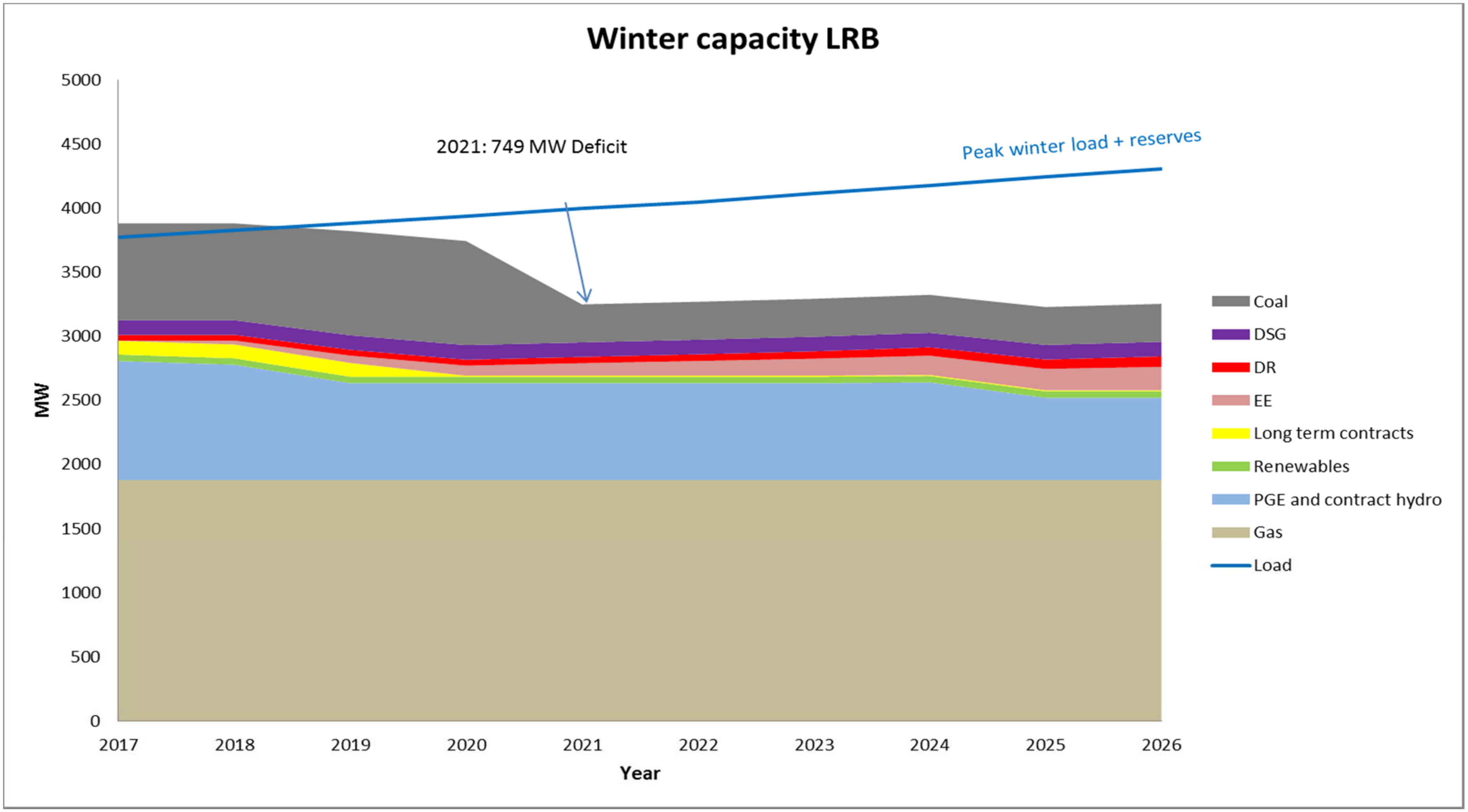
Preliminary LRB: Renewable Portfolio Standard



Portland General Electric

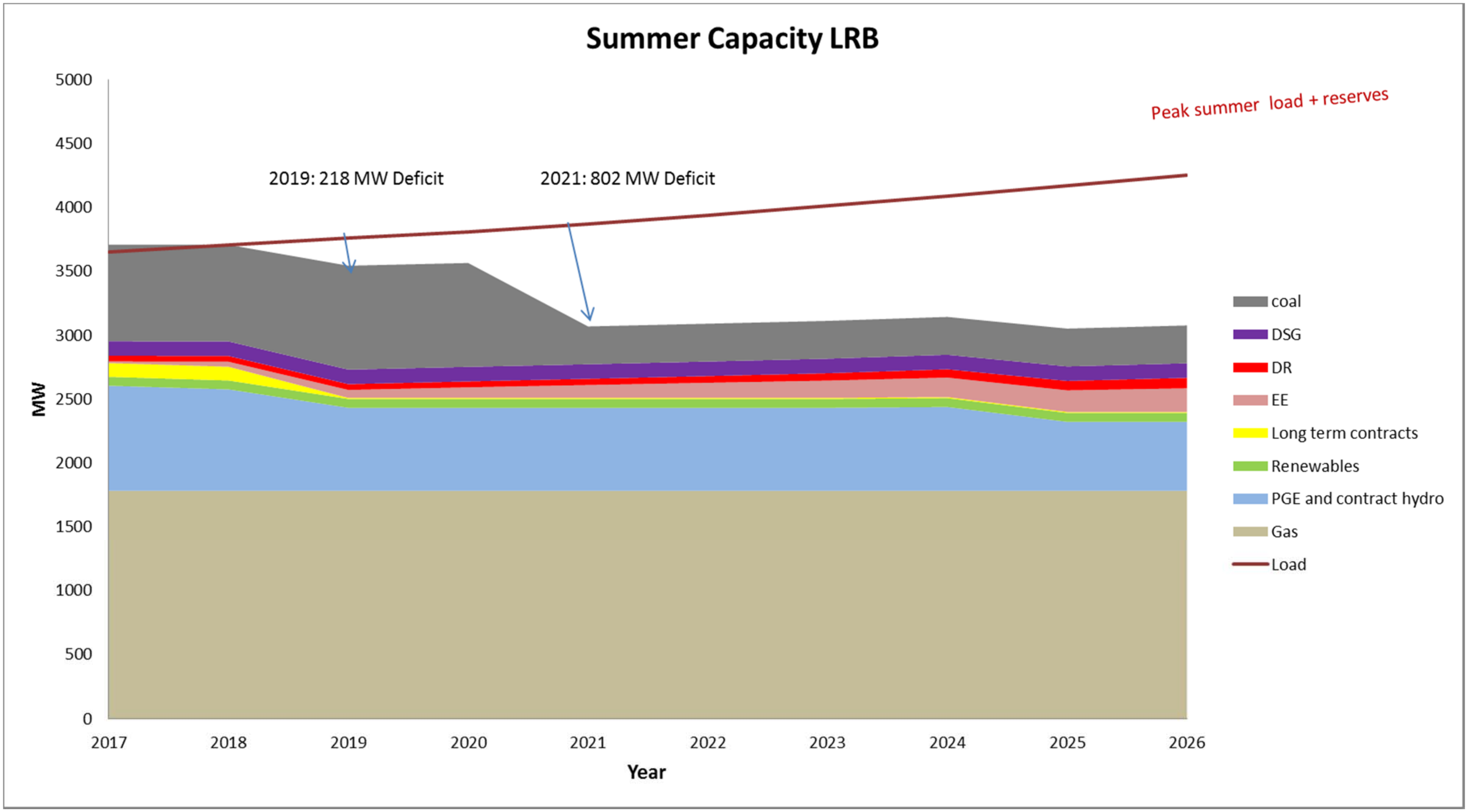
Preliminary LRB: Capacity – Winter

April 2, 2015 Slide 39



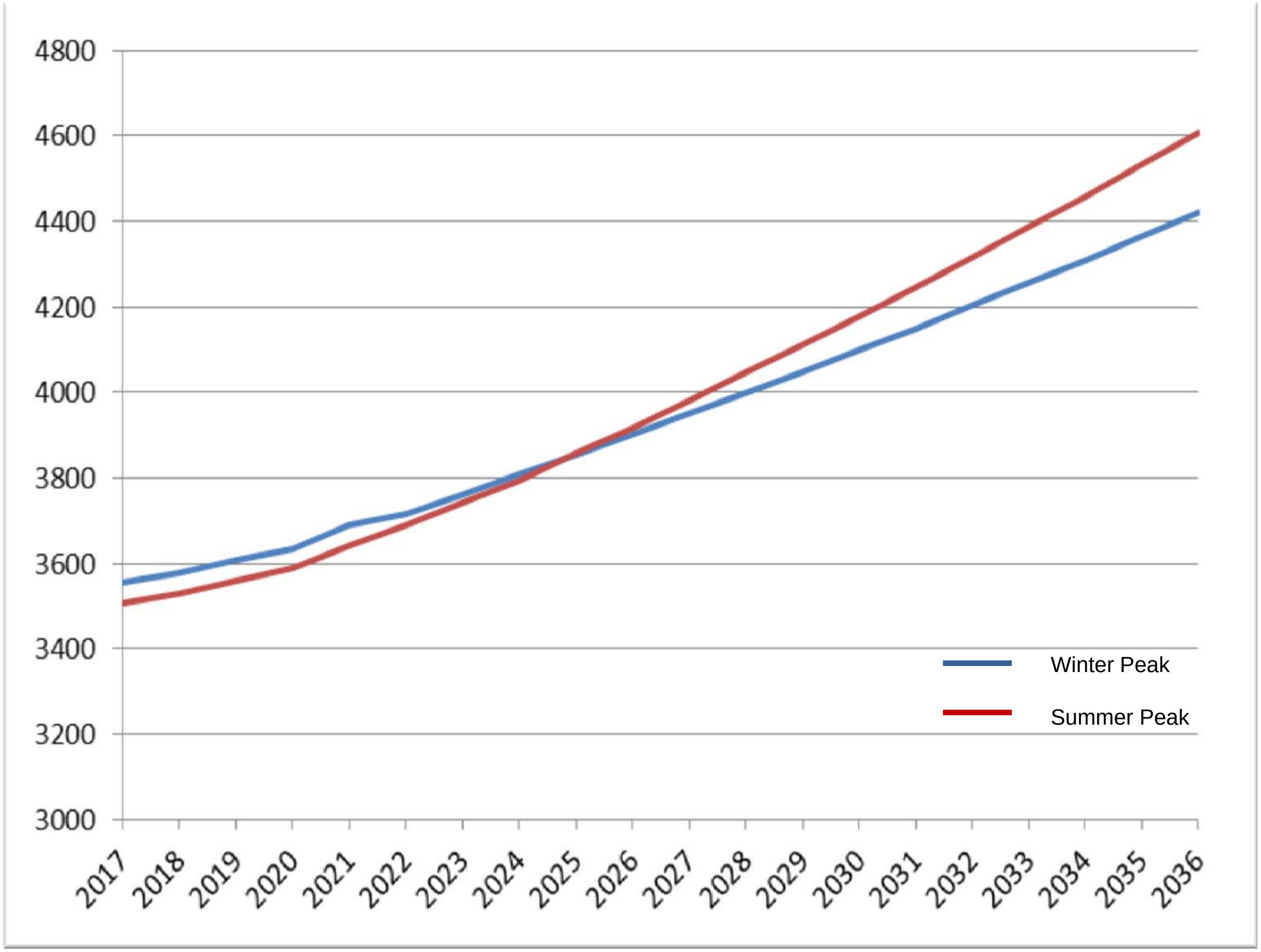
Portland General Electric

Preliminary LRB: Capacity – Summer



Portland General Electric

Preliminary LRB: Peak Load Trends

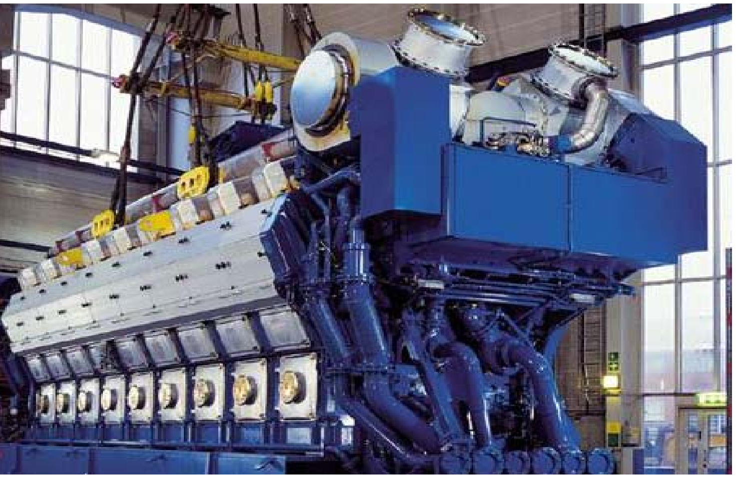


- Summer peak load growing faster than winter peak
- Gas and hydro resource shapes: lower capabilities in summer
- Shortage more pronounced in summer, more in the outer years

Portland General Electric

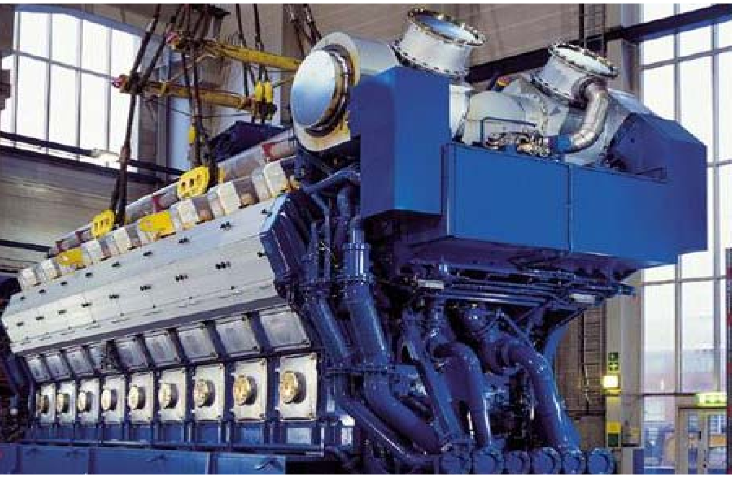

Portland General Electric

Load Forecast Methodology



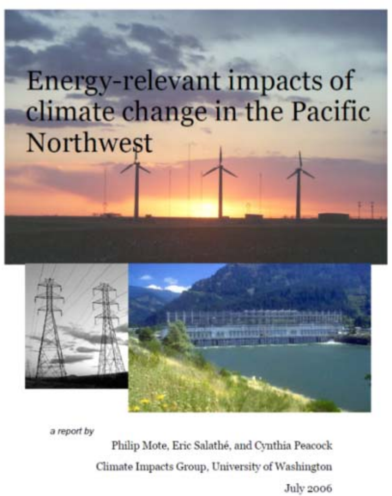

Portland General Electric

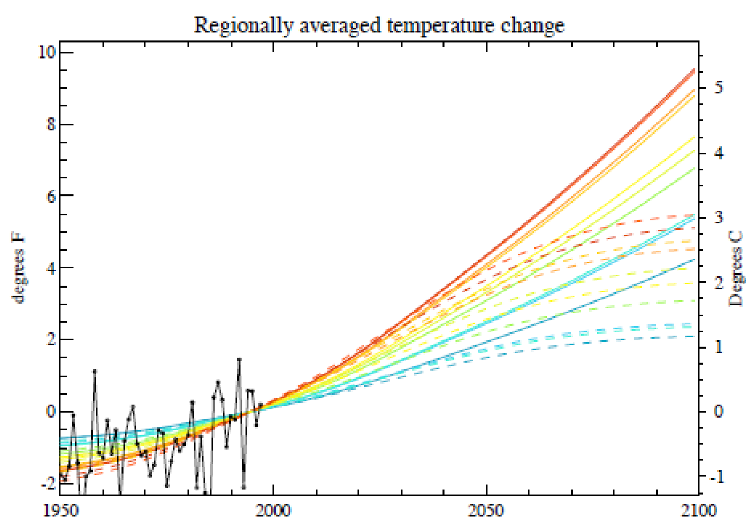
Climate Change: Planning



Climate Change: Planning

- Staff's Report for the 2013 IRP: "Climate change… is a matter that utilities should consider in their IRPs. [Staff recommends] developing the scope of an analysis of climate change impacts on system resources and operations."
- PGE last visited climate affected planning variables in its 2007 IRP by soliciting 'Energy-relevant impacts of climate change in the Pacific Northwest' authored by the Climate Impacts Group at UW.





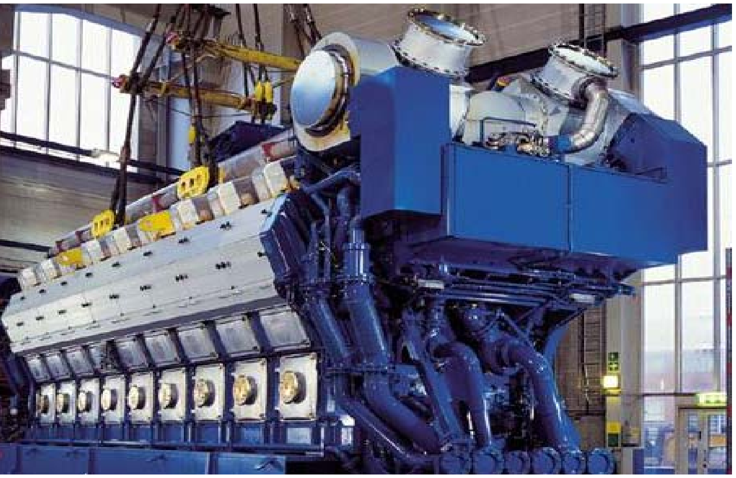
Climate Change: Planning

- For the 2016 IRP, PGE has partnered with Phillip Mote, PhD to update the 2006 study.
- Having surveyed possible climate related energy variables to study in further detail, the study will endeavor to identify how Portland area load forecasts (peak and energy) might be affected by global climate change.
  - Tracking BPA study on climate affected stream flows.
- Following a review and validation of the climate affected dataset, PGE will evaluate a climate affected load forecast future scenario.

Portland General Electric

Portland General Electric

Climate Change: Emission Trends

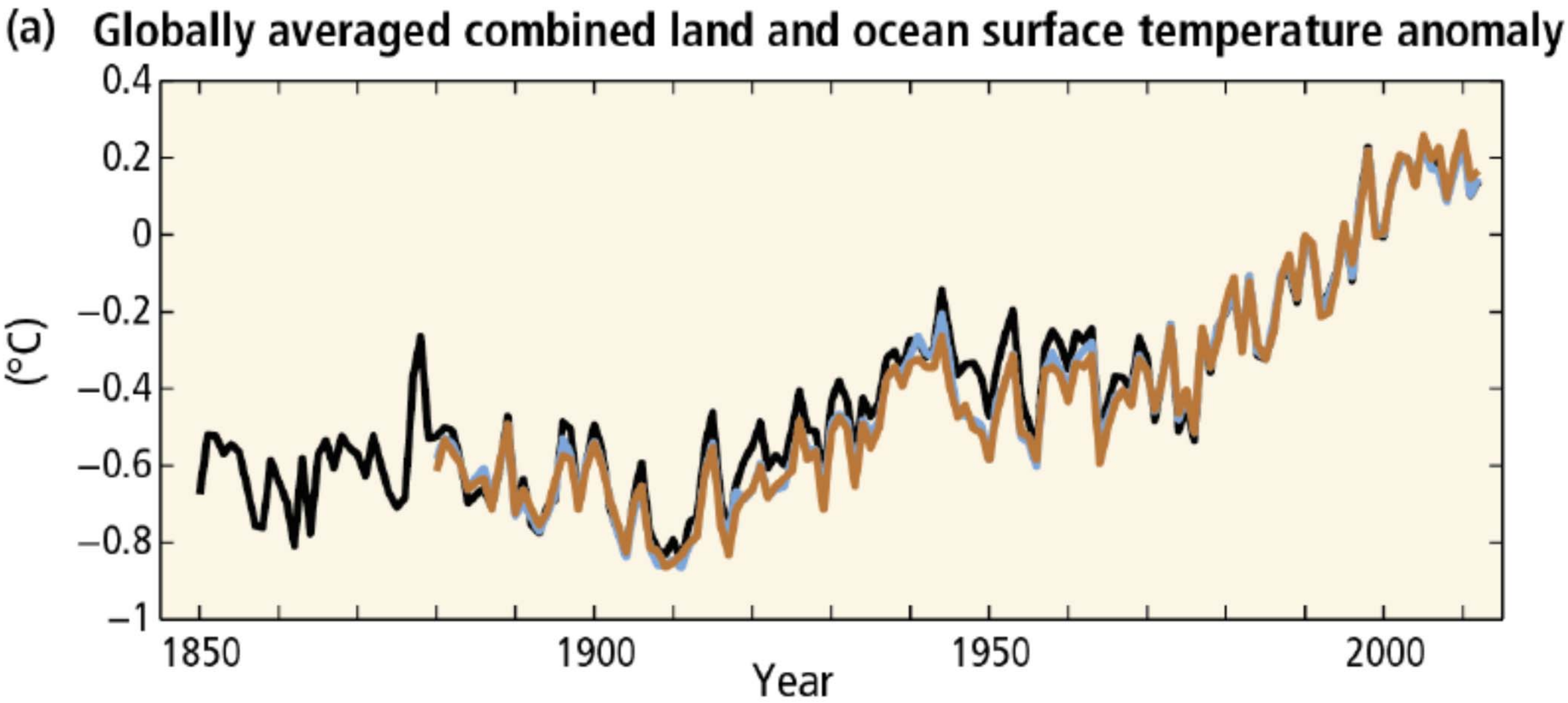


IRP Carbon Pricing: Two Rationales

- Climate change is real and it is happening now
  - Pricing carbon in a planning context is a way to include the societal costs of greenhouse gas emissions.

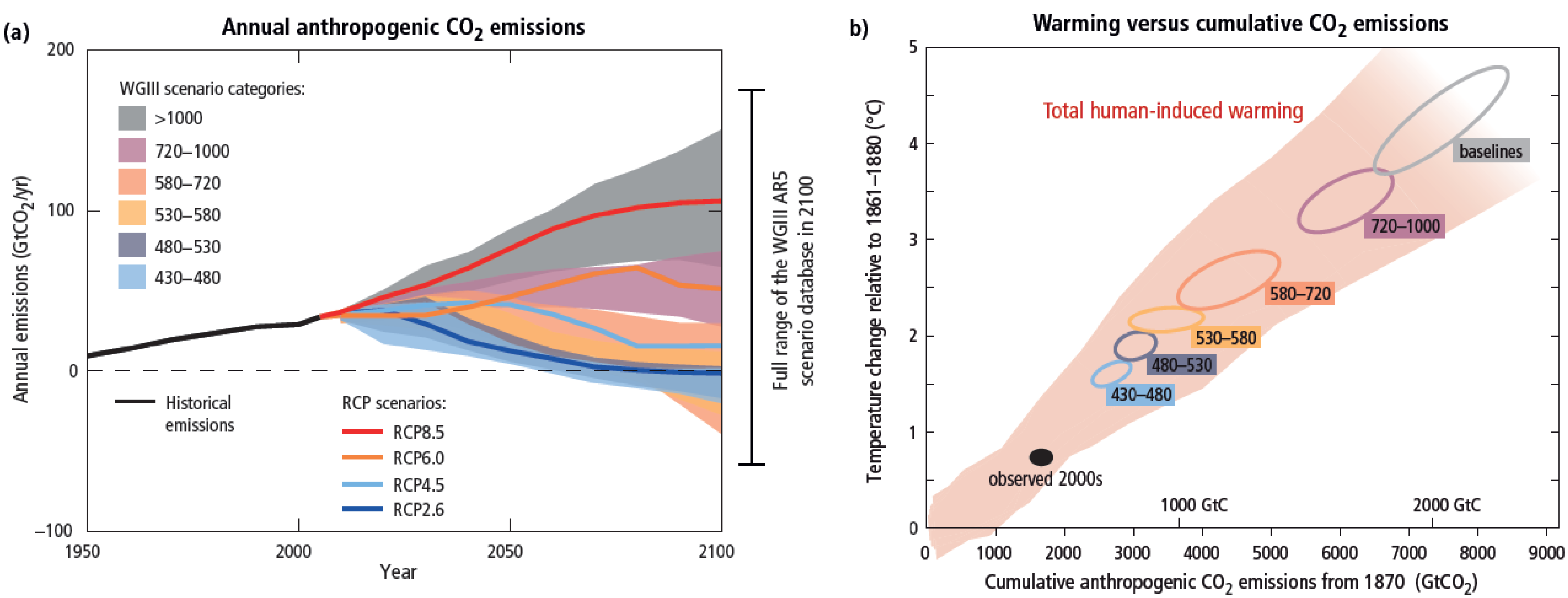
- Climate change *regulation* is real; it is happening now; it is likely to continue; and it may increase in stringency
  - Pricing carbon in a planning context is a way to account for the regulatory risk associated with carbon emissions.

Climate Change Is Real



Source: Inter-Governmental Panel on Climate Change, Fifth Assessment Synthesis Report, Summary for Policymakers, 2014

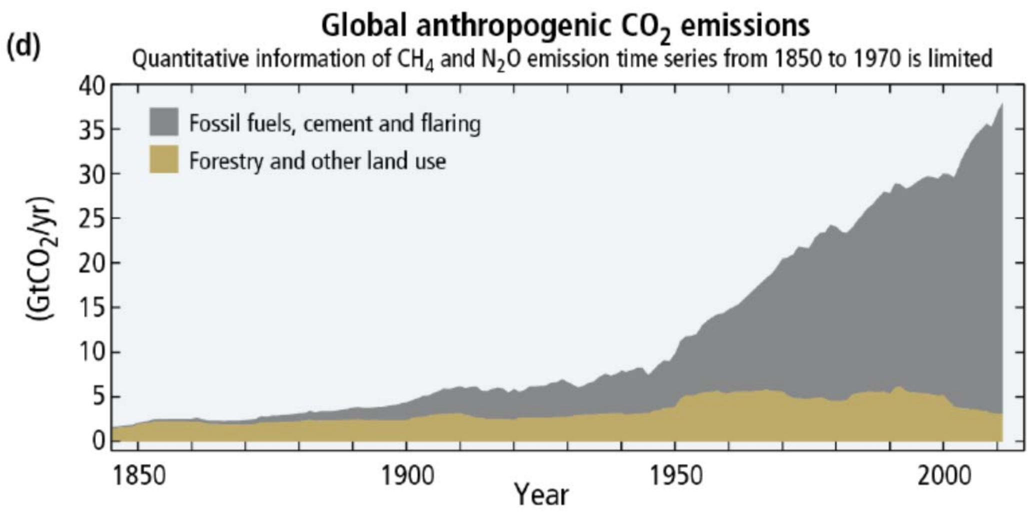
Climate Changes Dependent on Global Emissions

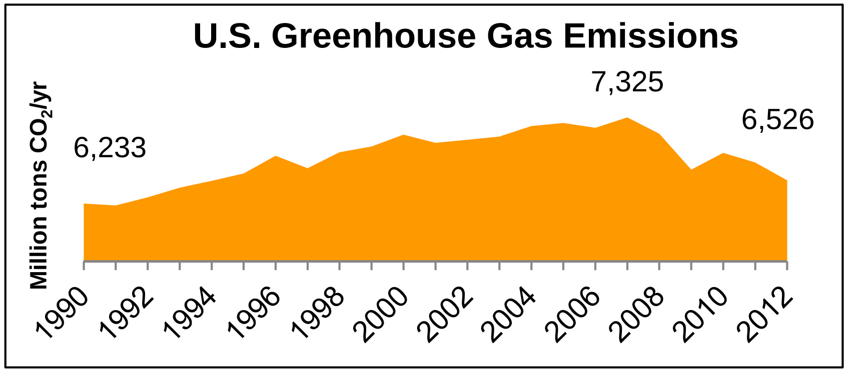


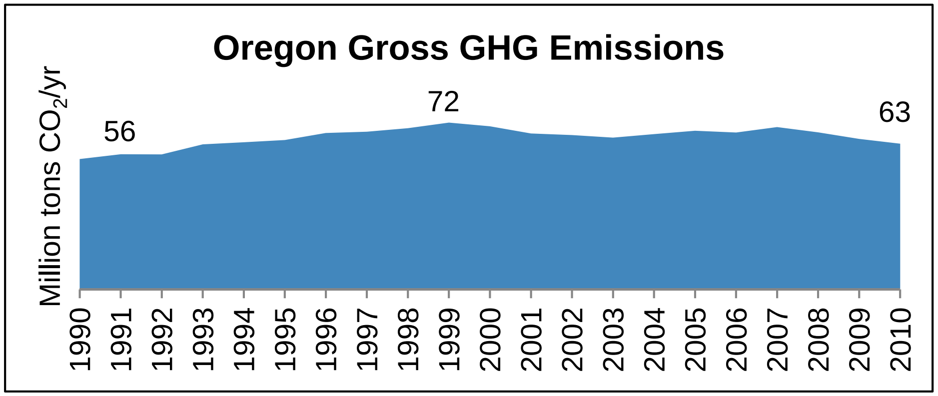
Source: Inter-Governmental Panel on Climate Change, Fifth Assessment Synthesis Report, Summary for Policymakers, 2014

Portland General Electric

Different Stories In Different Places







	Latest GHG emissions (million tons)
Oregon	63 (2010)
United States	6,526 (2012)
Global (CO_2 only)	38,000 (2010)

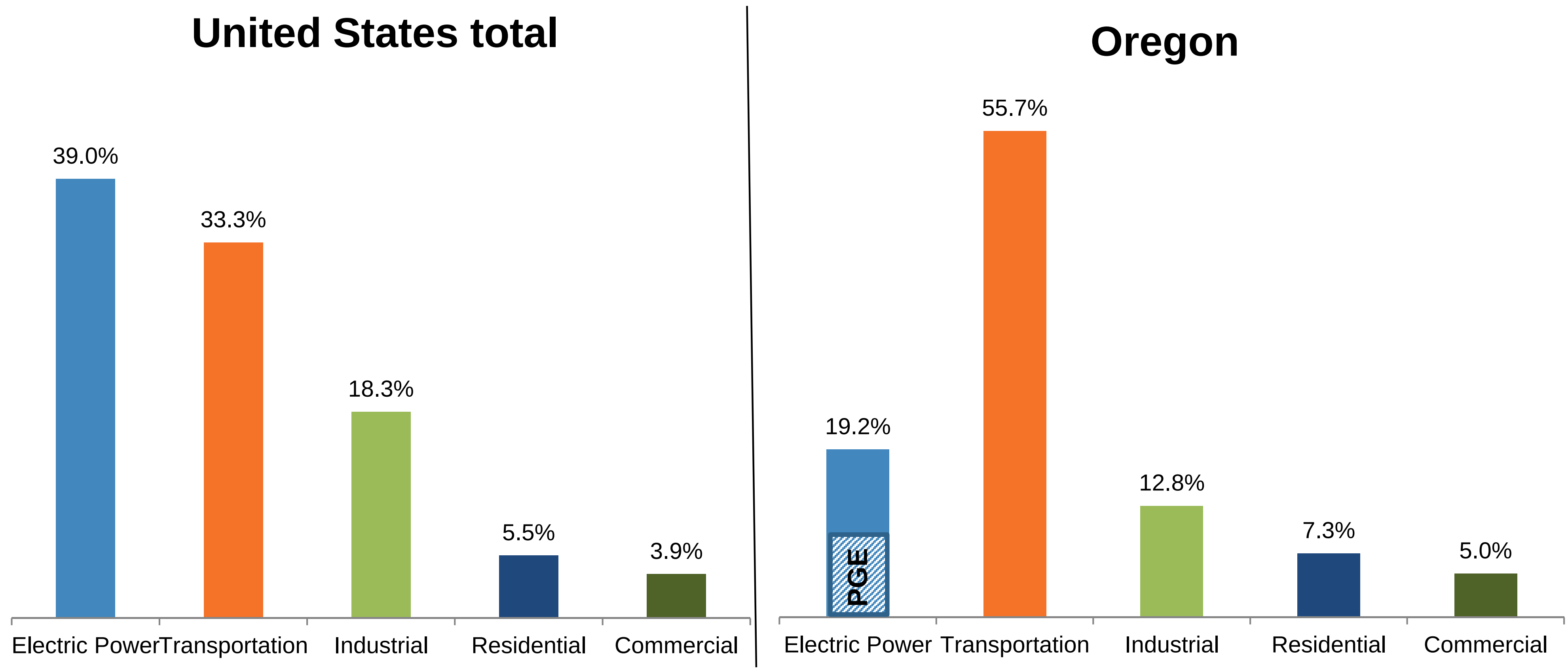
Sources: IPCC, Fifth Assessment Synthesis Report, Summary for Policymakers (2014)
EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012 (2015)
OGWC, Report to the Legislature (2013)

Portland General Electric

Emissions: CO_2 Sources

April 2, 2015 Slide 51

Electric power is a disproportionately small source of Oregon emissions

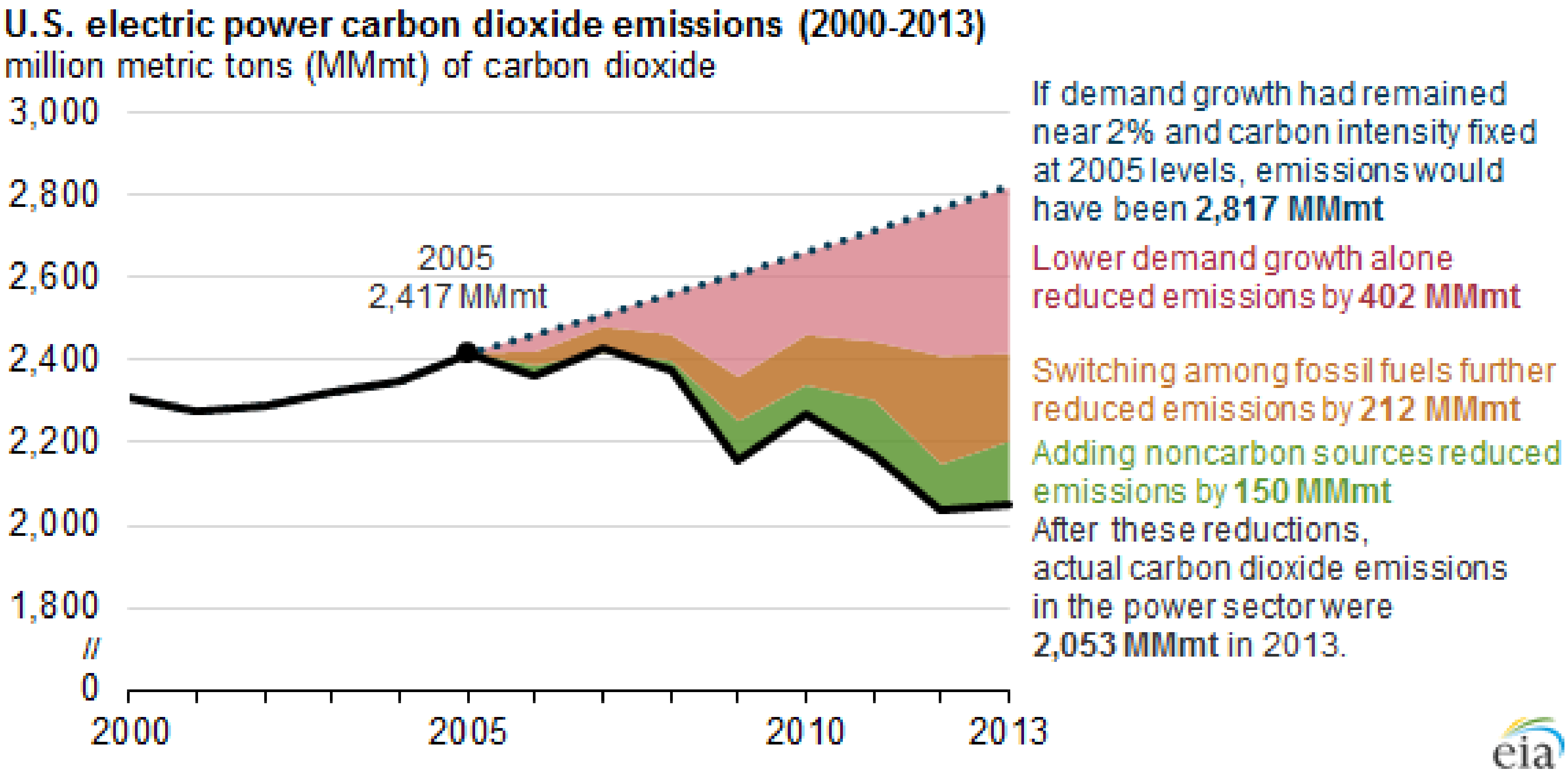


Source: Energy Information Administration, State CO2 emissions, March 4 2015 (2012 data)

Emissions: CO_2 Sources

April 2, 2015 Slide 52

Power Sector Emissions in the U.S. are Dropping



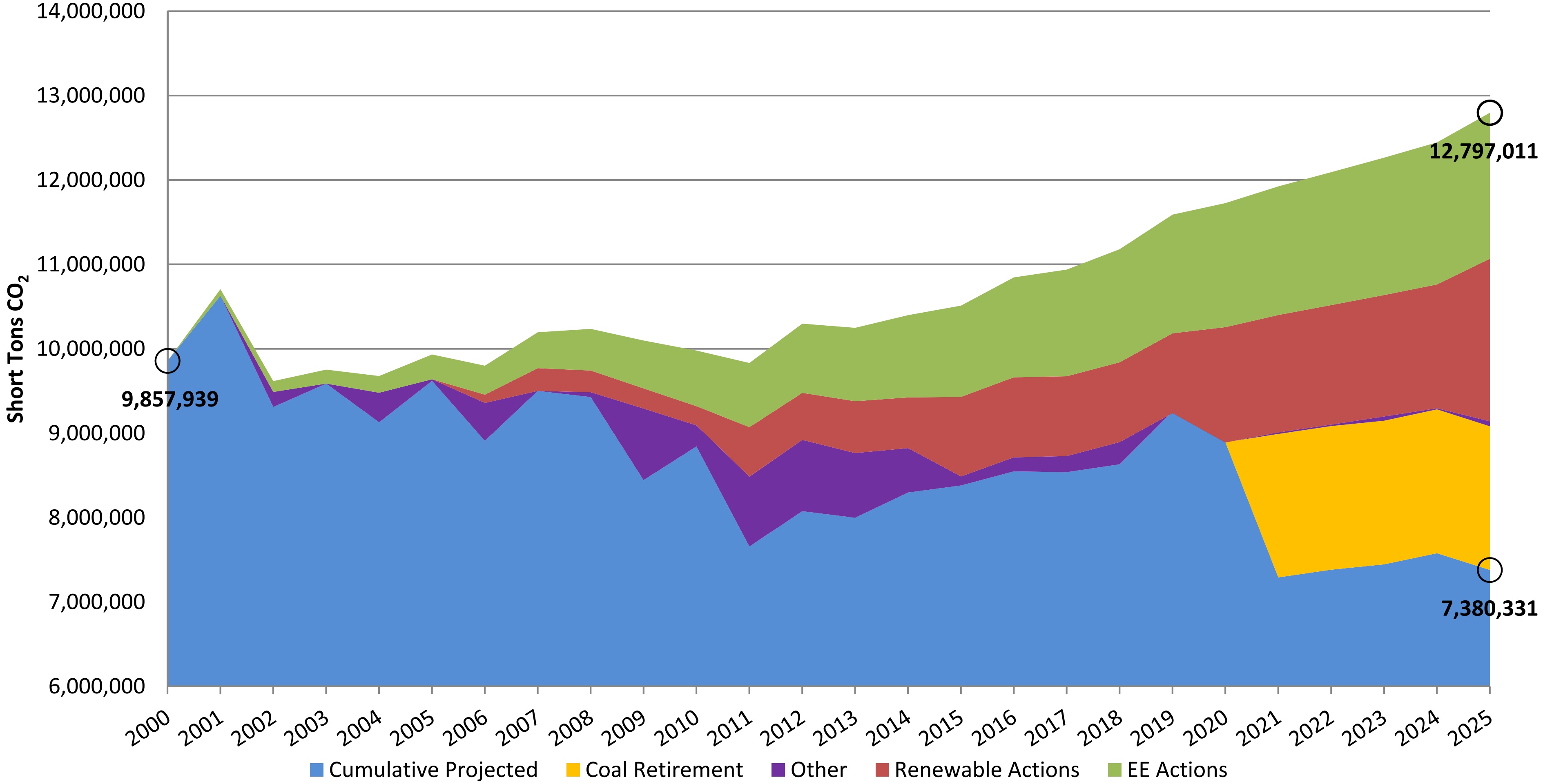
Source: Energy Information Administration, Annual CO2 Analysis, October 23, 2014

Portland General Electric

Emissions: CO_2 Sources

April 2, 2015 Slide 53

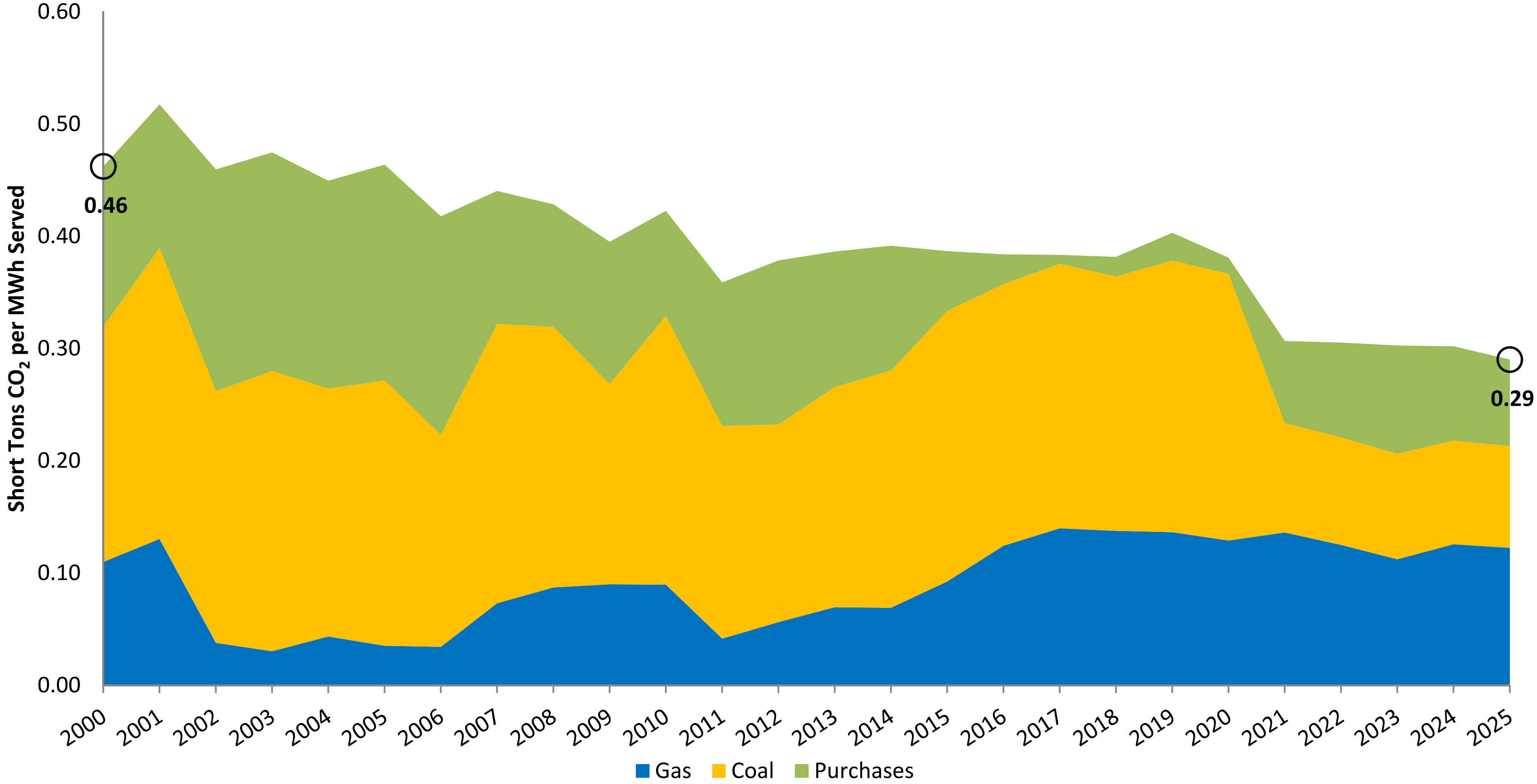
PGE CO_2 emissions are dropping



Portland General Electric

Emissions: CO_2 Sources

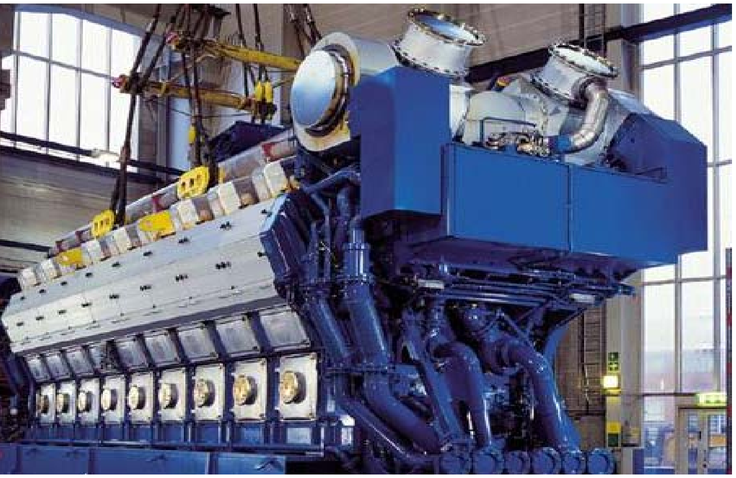
PGE Carbon Intensity Over Time is Dropping



Portland General Electric

Portland General Electric

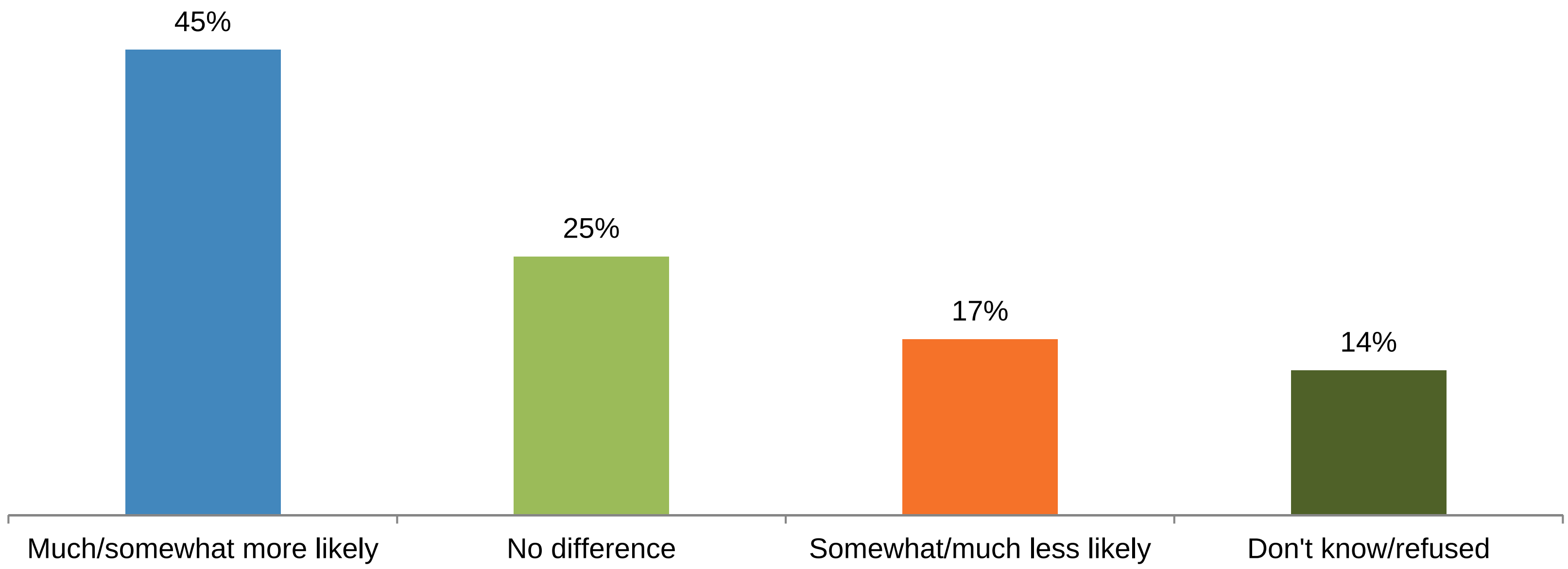
Climate Change: Policy Drivers



Climate Change: Policy Drivers

April 2, 2015 Slide 56

Americans are more likely to vote for a candidate who strongly supports acting on global warming



If a candidate for national office (such as the House of Representatives, the Senate, or president) strongly supports taking action to reduce global warming, would you be more or less likely to vote for the candidate?

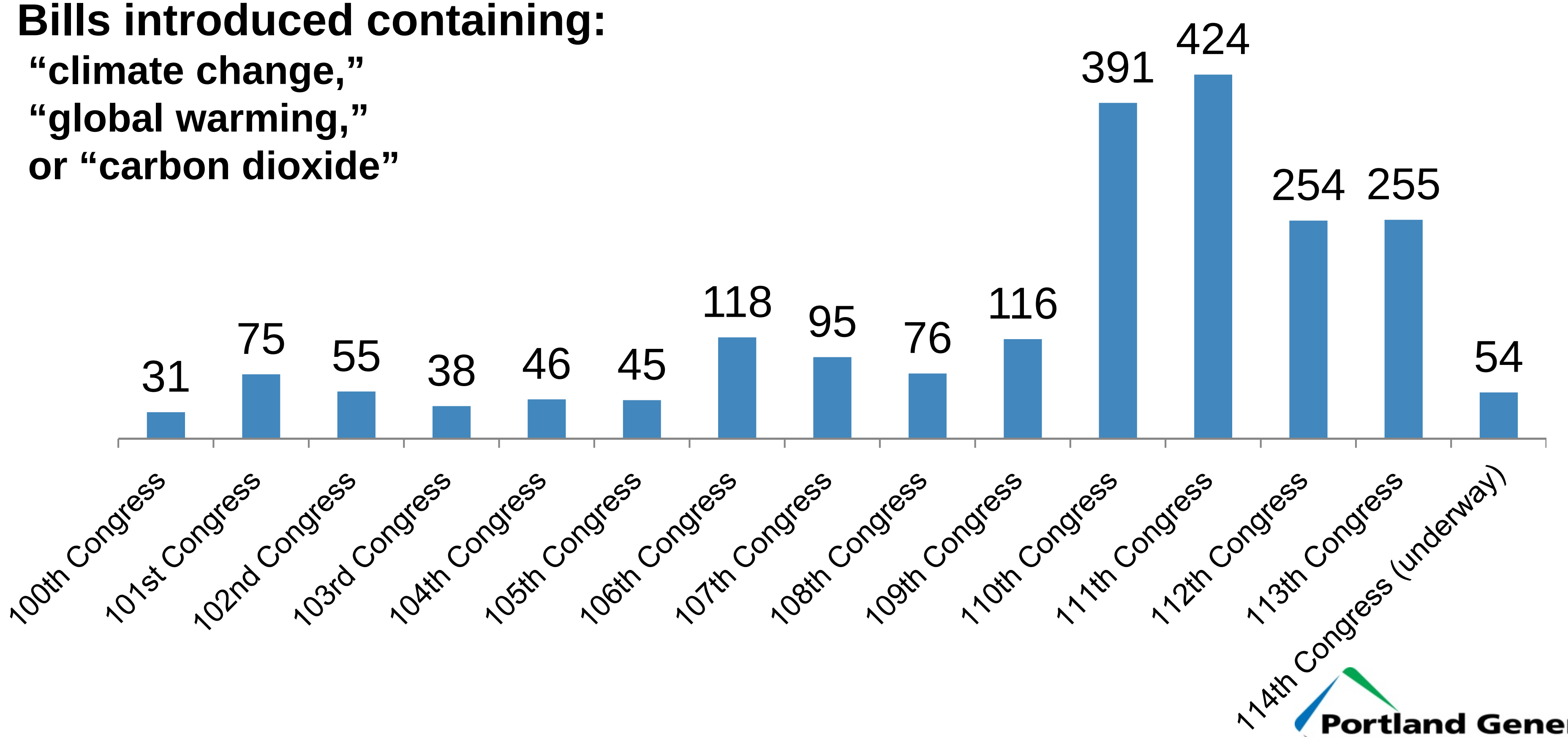
Base: Registered American Voters 18+. April 2015
Source: Yale Project on Climate Change, Politics & Global Warming, Spring 2014

Portland General Electric

Climate Change: Policy Drivers

Plenty of discussion in Congress, but a Congressional solution will likely remain elusive in the near-term

Bills introduced containing:
"climate change,"
"global warming,"
or "carbon dioxide"



Portland General Electric

Climate Change: Policy Drivers

The Courts have Spoken

- Massachusetts v. EPA (2007)
- EPA Endangerment Finding (2009)
- Utility Air Regulatory Group v. EPA (2014)

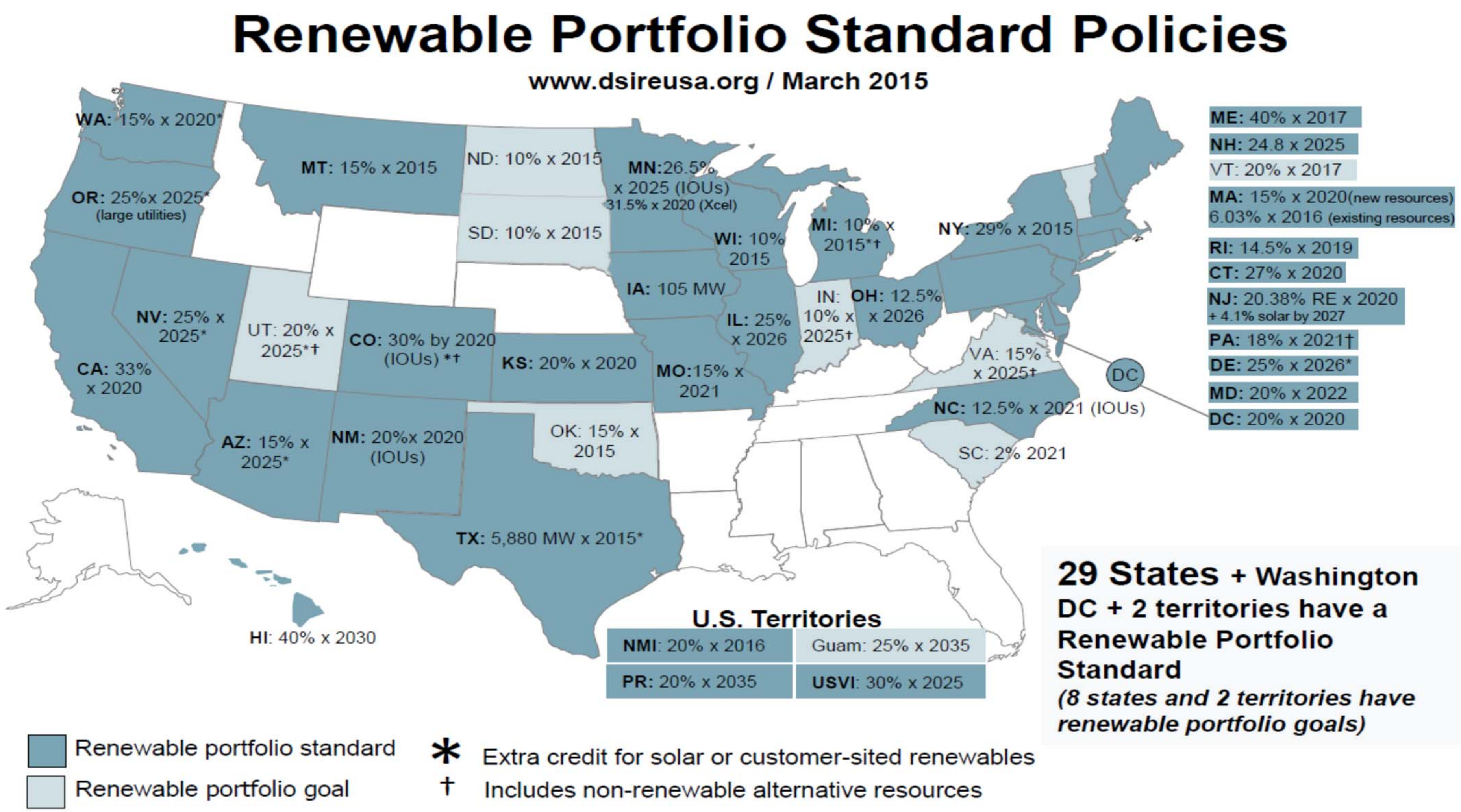
Climate Change: Policy Drivers

Actions taken by the Obama Administration on Climate Change

- The Clean Power Plan
- Vehicle and appliance efficiency standards
- Reducing hydroflourocarbons (HFCs)
- Emission reduction goals for the federal government
- Bilateral cooperation with China and other major emitters
- Working towards a global agreement in Paris 2015

Portland General Electric

Climate Change: Policy Drivers



Portland General Electric

Climate Change: Policy Drivers

April 2, 2015 Slide 61

Climate Change: Policy Drivers

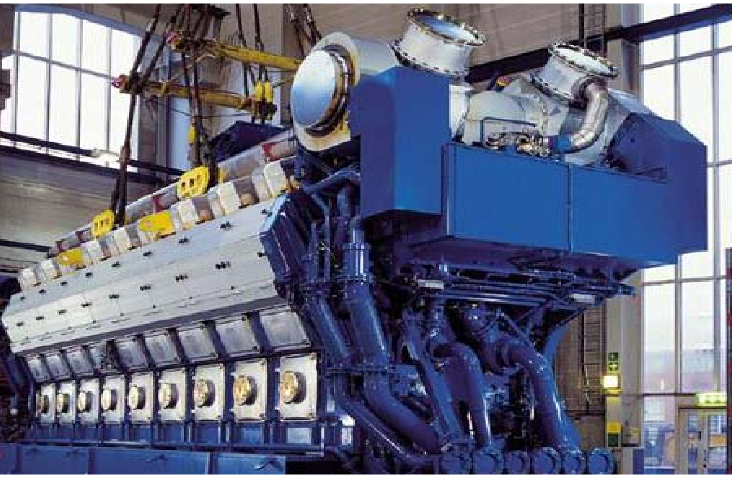
- Trends suggest that the question is WHEN, not if, Congress will act to determine an economy-wide approach to reducing CO2 emissions.
- Health care reform provides a useful comparison

Portland General Electric

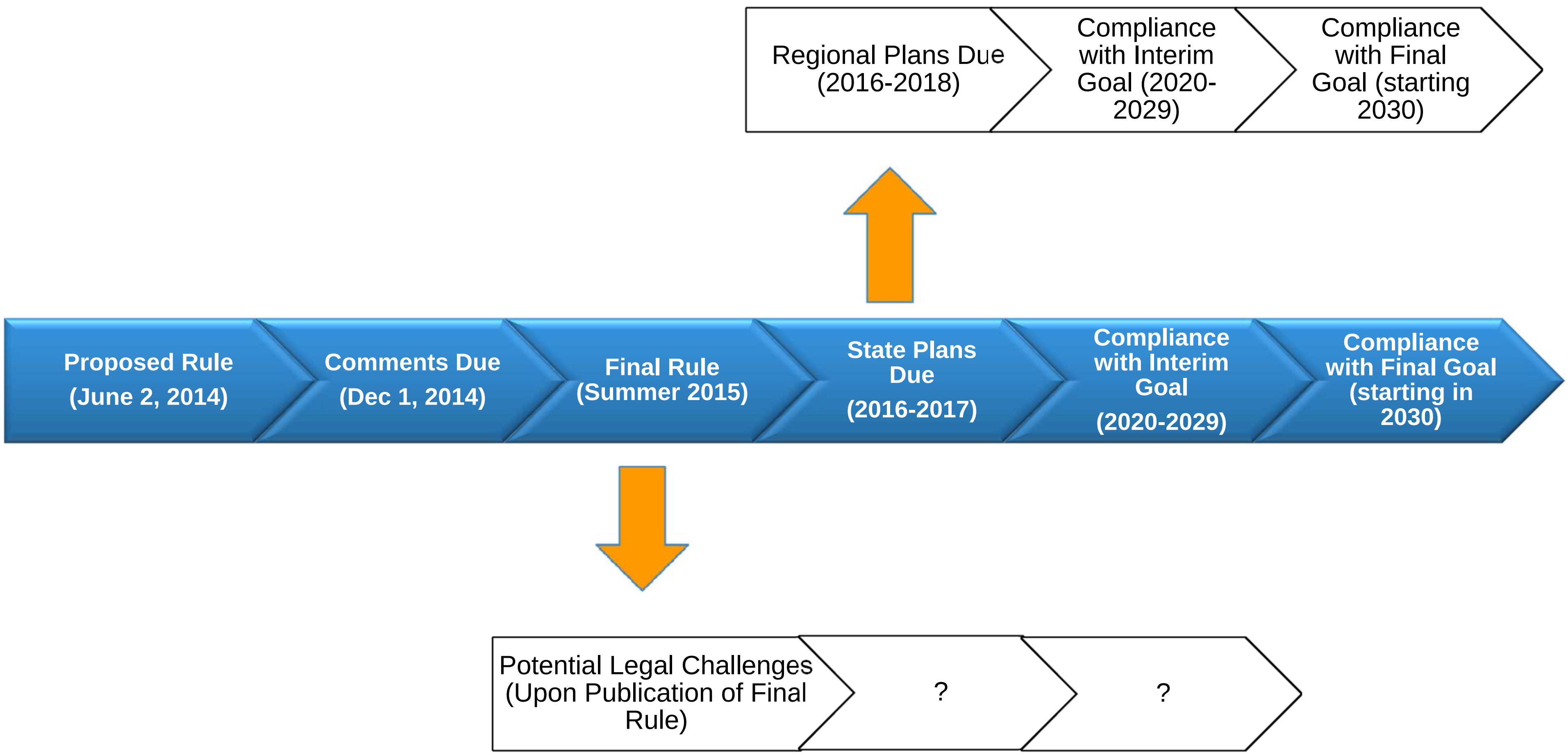
Portland General Electric

Clean Power Plan – 111(d)

Description And Framework



111(d): Proposed Timeline(s)



Portland General Electric

111(d): Architecture Of The Proposed Rule

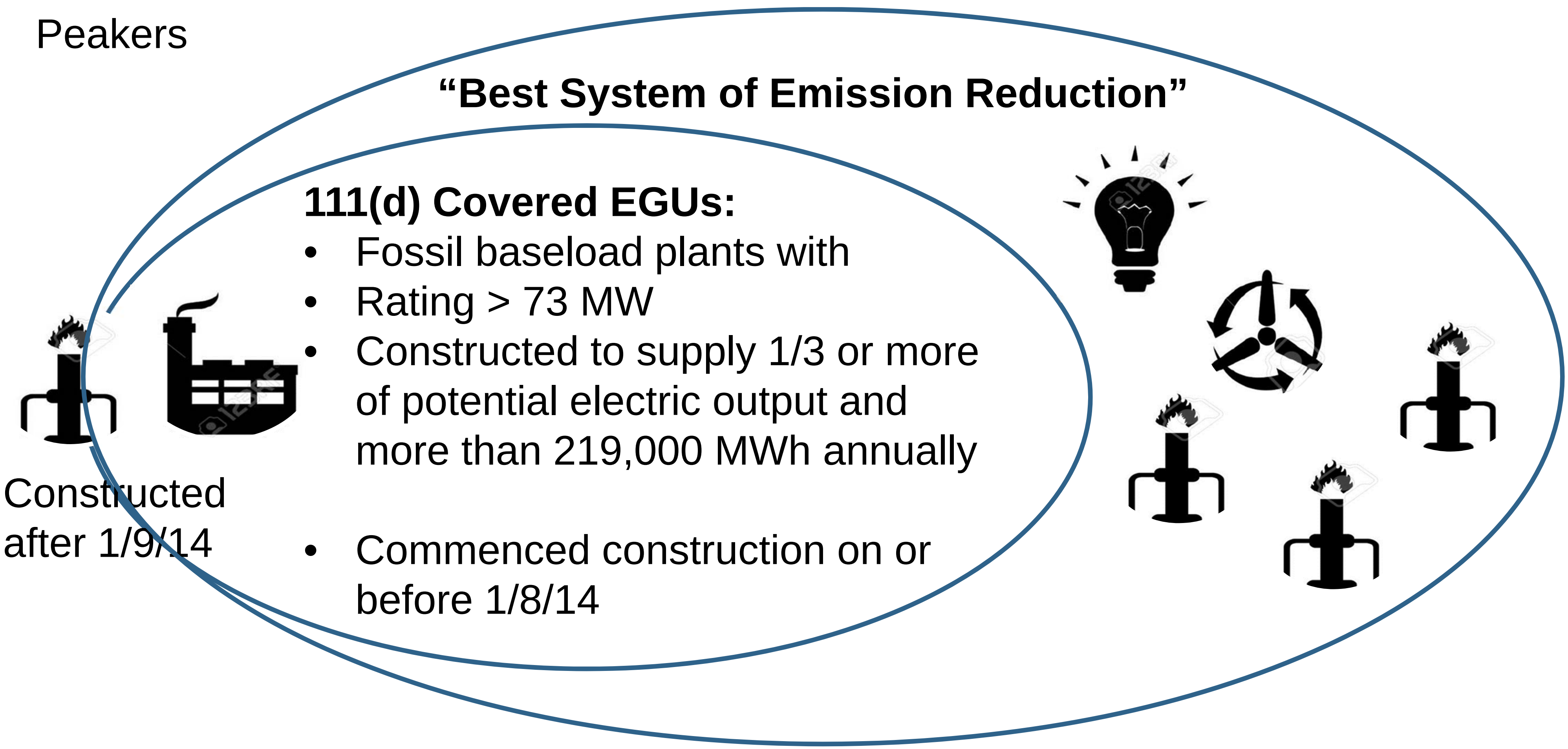
State-specific emission rate goals

- Set by EPA
- States must comply

State compliance plans

- States develop after EPA finalizes goals in 2015
- EPA approves
- Many possible variations
- Allocation of compliance burden within state unclear at this point

111(d): Covered sources and BSER

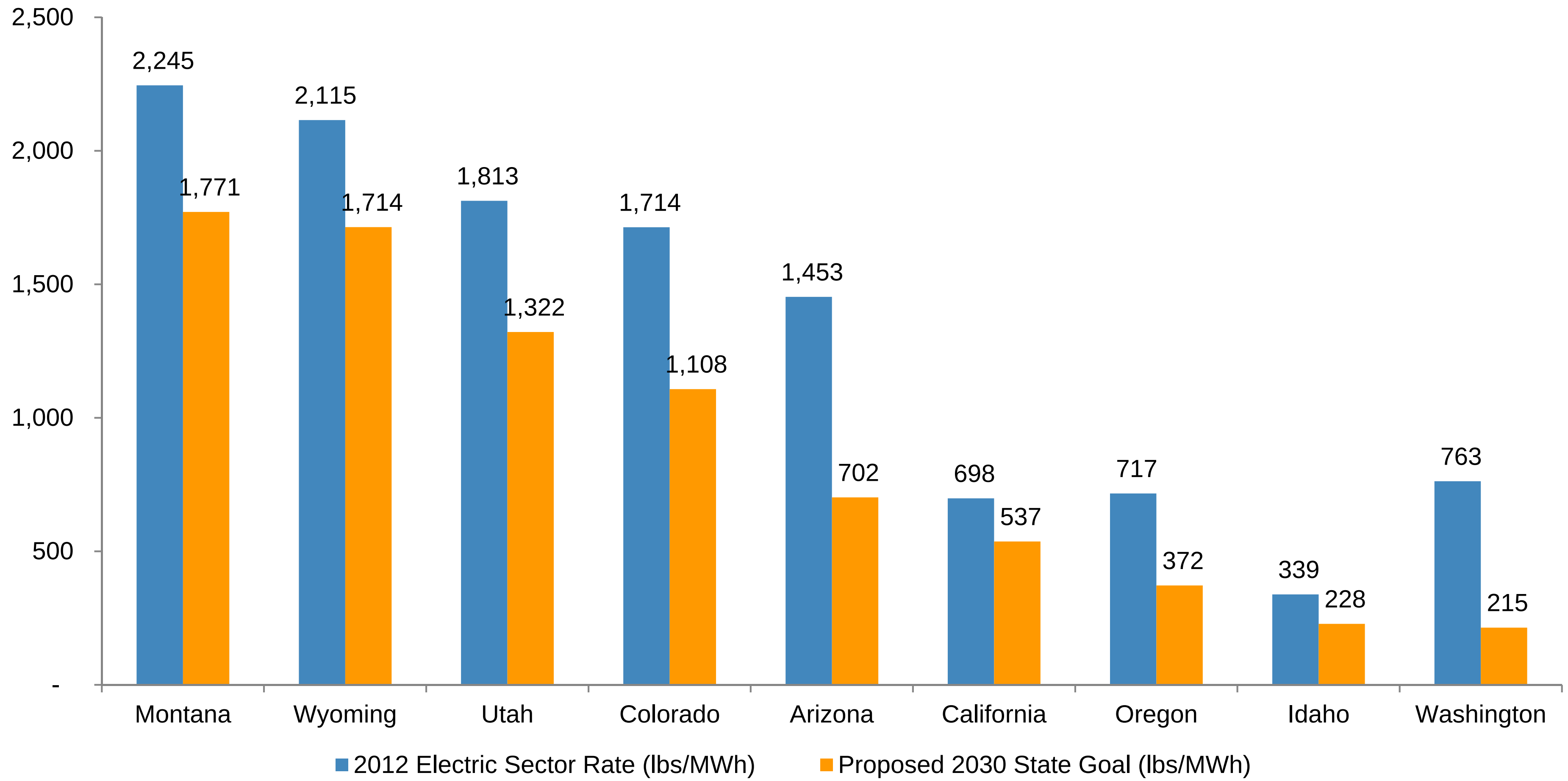


111(d): Four Building Blocks Applied To All States

- Coal plant heat rates improve 6%
- Natural gas combined cycle plants re-dispatched up to 70% capacity factor
- Increased renewable energy
- Increased energy efficiency

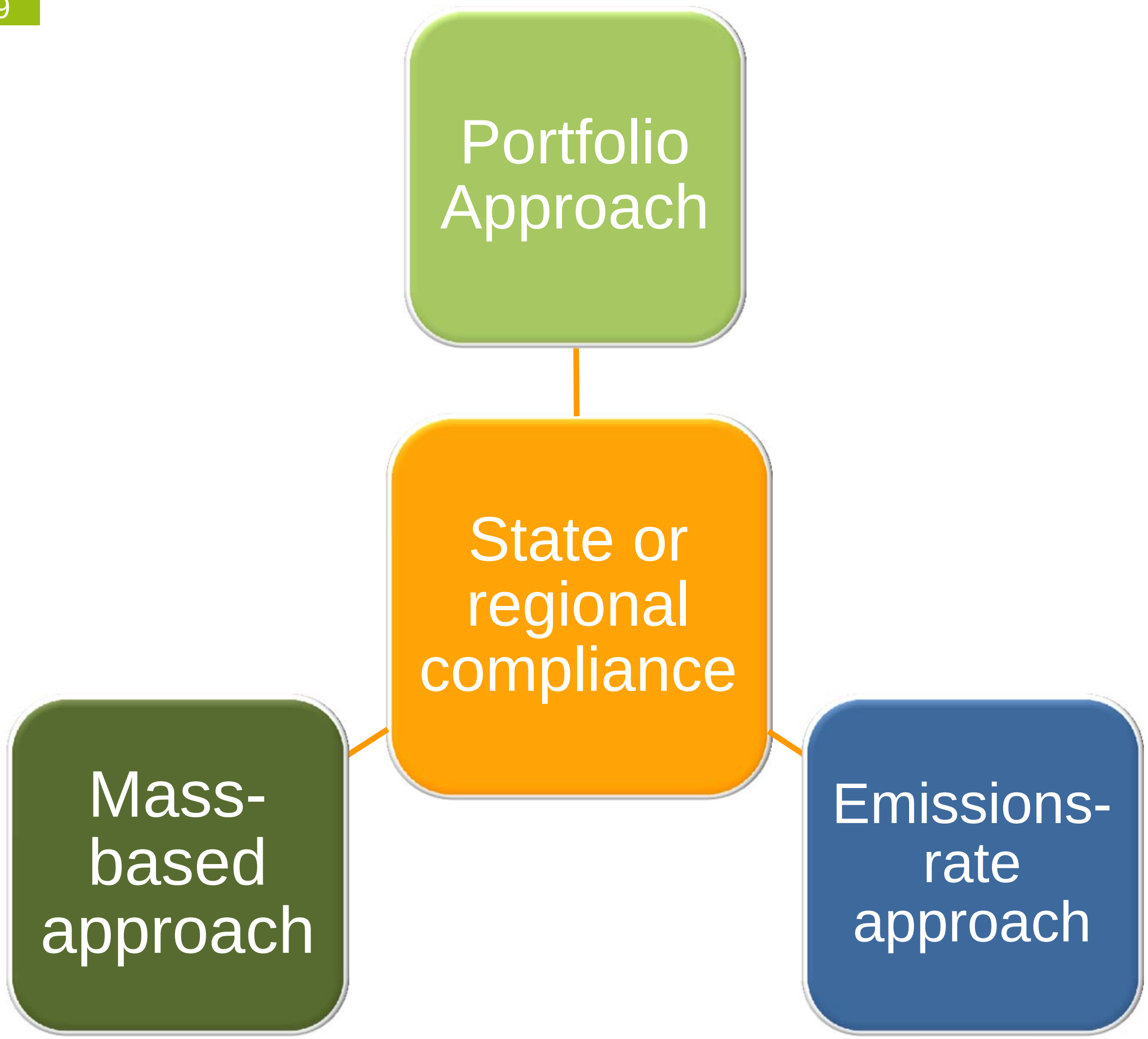
111(d): Proposed Goals

2012 CO_2 Emissions and Proposed 2030 Goals for Select Western States



Portland General Electric

111(d): Three Approaches To Compliance Plans



111(d): EPA Expects To Finalize Rule Summer 2015

Likely to be clarified

- Final and interim rate-based goals
- Use of renewable energy for compliance
- Use of energy efficiency for compliance
- Pre 2020 banking
- Dates for state and regional plan submission

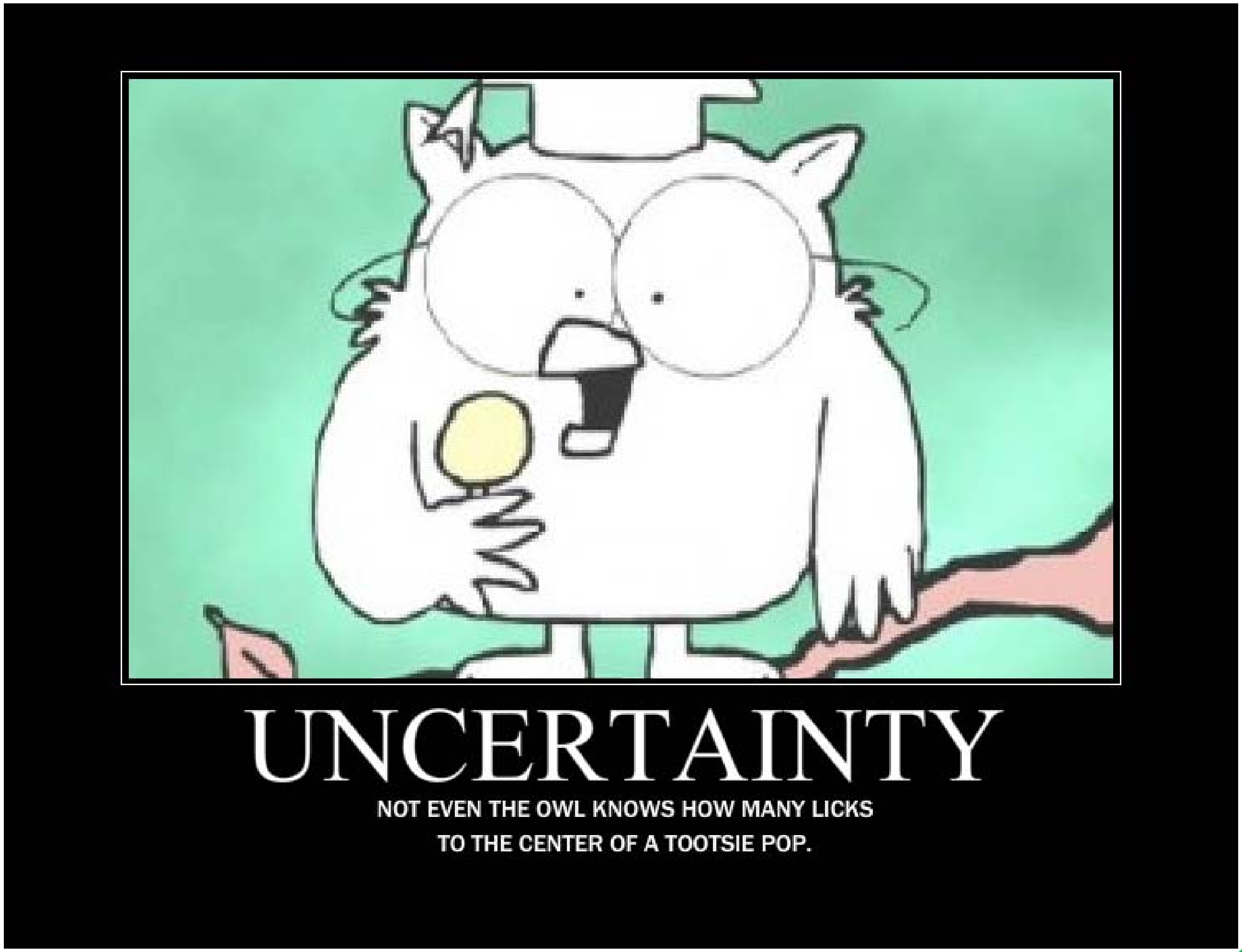
Unlikely to be clarified

- Final and interim mass-based goals
- Amount of cost-effective energy efficiency available
- Compliance approach (state v. regional); (portfolio, rate, mass)
- PGE's compliance burden
- Legality of EPA's approach

Treatment of Carty and role of new natural gas plants

Portland General Electric

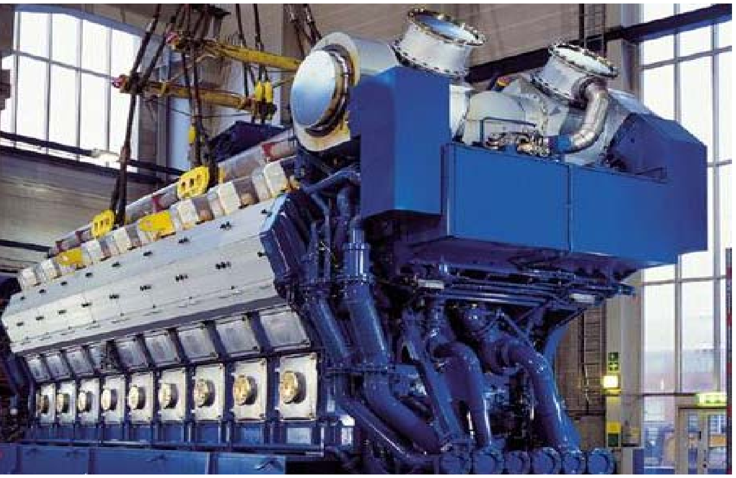
111(d): Summary



Portland General Electric

Clean Power Plan – 111(d)

Modeling



111(d) Modeling - Overview

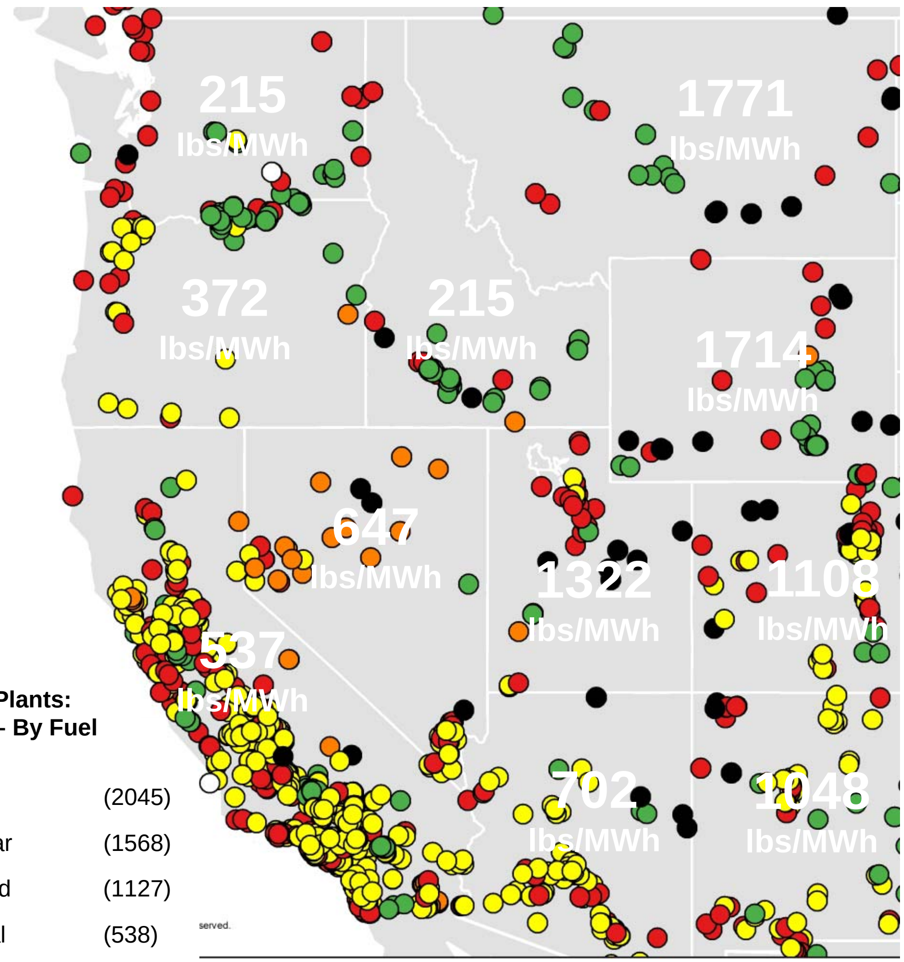
- General modeling structure
- Challenges
- Reducing rule uncertainty
- Deterministic scenario analysis
- Case studies
- Proposed analysis
- CO_2 policy interaction
- Environmental policy future framework
- Recap and discussion

111(d) Modeling: General Structure

April 2, 2015 Slide 74

1. Identify eligible units
2. Assign units to groups
3. Apply a new constraint to the appropriate group

Western Non-Hydro Resources (SNL)



Power Plants: Whole – By Fuel Type

Gas	(2045)
Solar	(1568)
Wind	(1127)
Coal	(538)
Geothermal	(65)
Nuclear	(55)

Portland General Electric

111(d) Modeling: Challenges

April 2, 2015 Slide 75

Poor Run-Time Performance

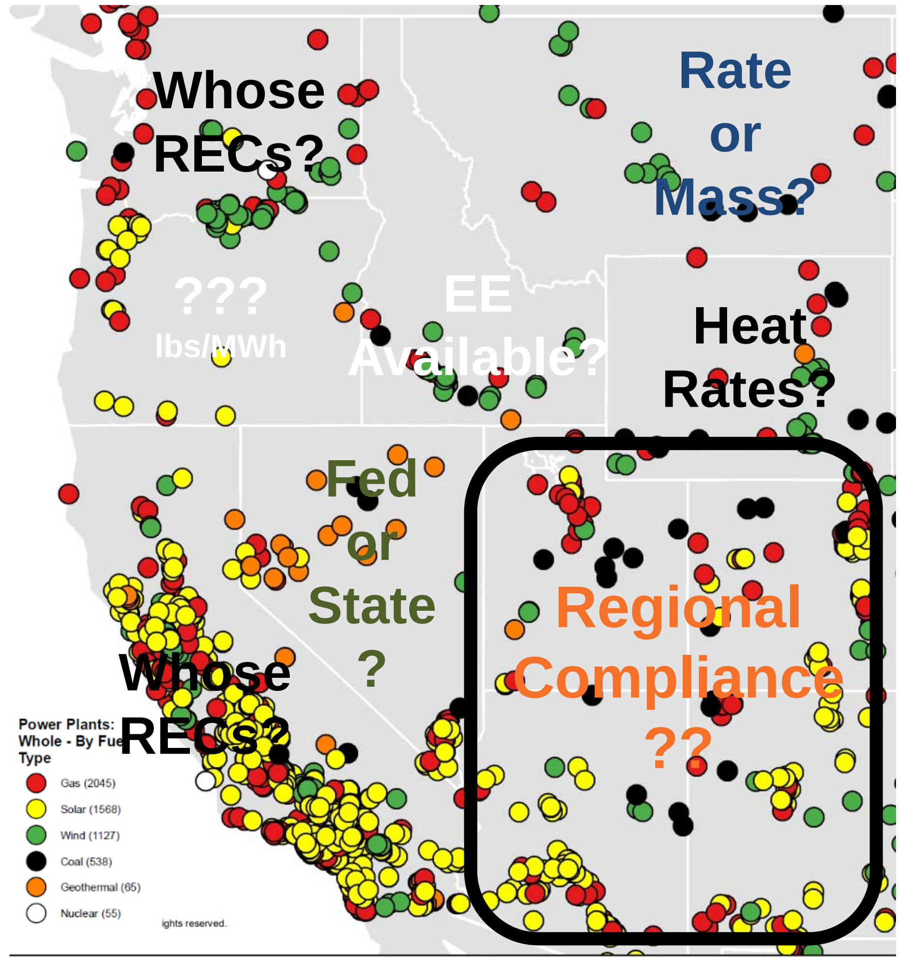
Rule Uncertainty

- Goal Stringency
- Goal Timing
- REC Ownership

Deterministic Variables

- Regional vs State
- EE Availability
- Rate vs Mass
- 111(b) vs 111(d)

Western Non-Hydro Resources (SNL)



Portland General Electric

111(d) Modeling: Rule Uncertainty

- Take advantage of timing to mitigate rule uncertainty
- Model 111(d) as written Sep ‘15
  - Take advantage of federal rule making to reduce goal uncertainty
  - Final rule expected by September 2015
- PGE anticipates final rule will provide additional certainty on:
  - The stringency of the final goal
  - The nature of the interim goal
  - Renewable ownership issues
  - NW hydro allocation concerns

Portland General Electric

111(d) Modeling: Deterministic Decisions

- **Scope of Constraint:**
  - State or Regional Plan?
- **Standard:**
  - Rate or Mass based standard?
- **EE Expectations:**
  - Available at EPA identified levels?
- **Heat Rate Improvements:**
  - Available at EPA identified levels?
- **New Resource Constraints:**
  - New resources constrained?

Deterministic Variables

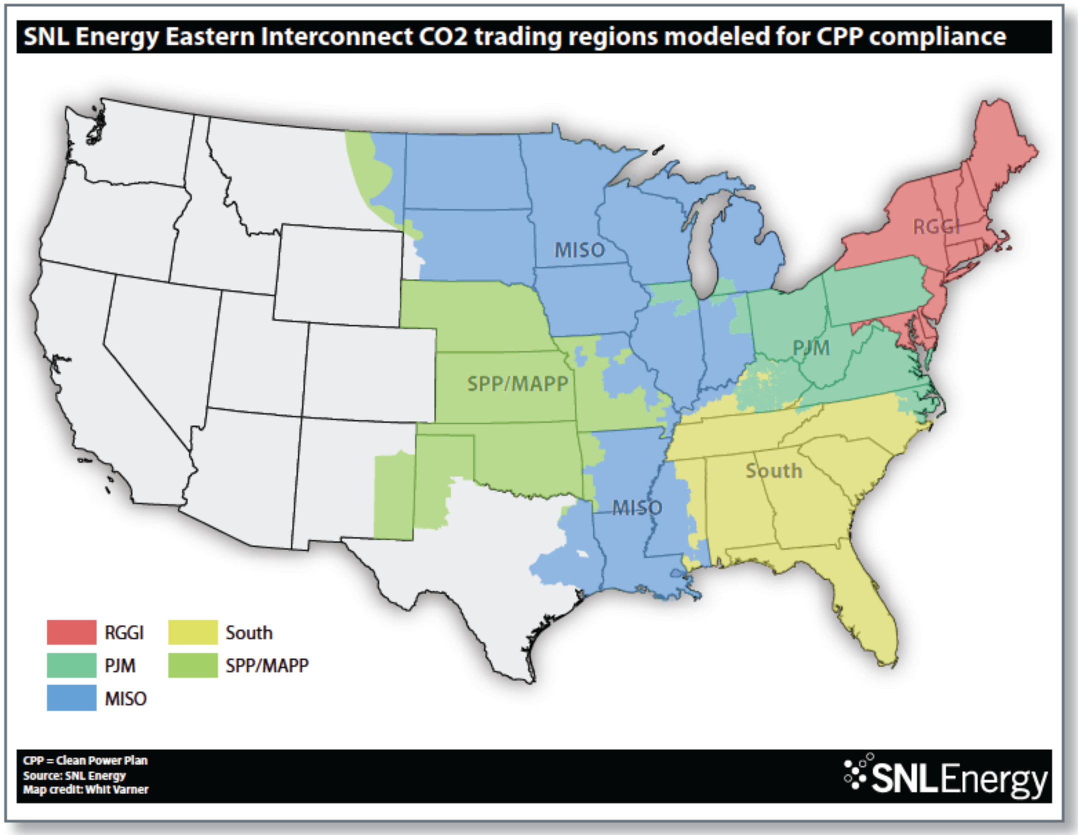
- Regional vs State
- EE Availability
- Rate vs Mass
- 111(b) vs 111(d)

Portland General Electric

111(d) Modeling: SNL Case Study

April 2, 2015 Slide 78

- **Scope of Constraint:**
  - Regional compliance
- **Standard:**
  - Mass based
- **EE Expectations:**
  - Available at EPA identified levels
- **Heat Rate Improvements:**
  - Not available
- **New Resource Constraints:**
  - New resources included in mass cap



Source: **Critical Mass: An SNL Energy Evaluation of Mass-based Compliance Under the EPA Clean Power Plan**

Portland General Electric

111(d) Modeling: Rhodium Group Case Study

- **Scope of Constraint:**
  - Regional & National scenarios
- **Standard:**
  - Rate based
- **EE Expectations:**
  - EPA & BAU Scenarios
- **Heat Rate Improvements:**
  - Not available
- **New Resource Constraints:**
  - New resources not constrained

	BAU EE	EXPANDED EE
NATIONAL	National with Limited EE	National with Expanded EE
REGIONAL	Regional with Limited EE	Regional with Expanded EE

Portland General Electric

111(d) Modeling: Energy Ventures Analysis Case Study

- **Scope of Constraint:**
  - State compliance
- **Standard:**
  - Mass based
- **EE Expectations:**
  - EE not available at EPA levels
- **Heat Rate Improvements:**
  - Not available
- **New Resource Constraints:**
  - New resources not constrained

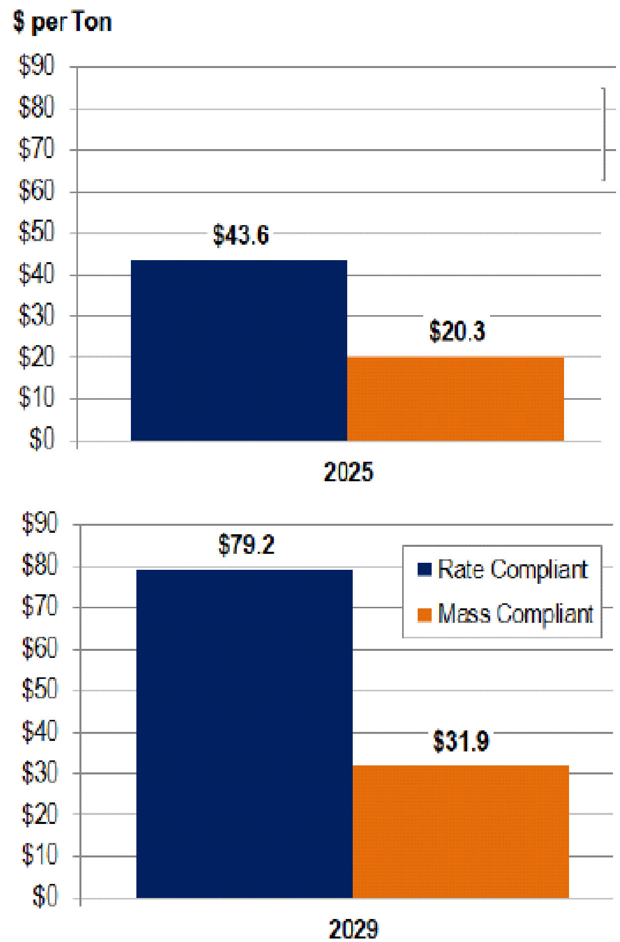
Source: Energy Ventures Analysis, Oct 14

Portland General Electric

111(d) Modeling: PJM Case Study

- **Scope of Constraint:**
  - State & Regional scenarios
- **Standard:**
  - Rate & Mass based scenarios
- **EE Expectations:**
  - EPA & BAU Scenarios
- **Heat Rate Improvements:**
  - Not available
- **New Resource Constraints:**
  - New resources constrained in mass cap

Rate vs Mass Compliance in PJM Region: CO2 Effective Price 2025 & 2029



Source: PJM, March 2015

111(d) Modeling: Lessons Learned

- From a modeling perspective, 111(d) is much more complicated than a CO2 price
- Scenario analysis shows how policy design affects compliance cost
  - EE availability affects cost of compliance Mass based standard may lower cost of compliance

	SNL	Rhg	EVA	PJM
State	-	-	+	+
Regional	+	+	-	+
Rate	-	+	-	+
Mass	+	-	+	+
EE Availability	+	+/-	-	+/-
Heat Rate Improvement	-	-	-	-
New resource constraints	+	-	-	+/-

111(d) Modeling: Proposed Analysis

- Use scenario analysis to address remaining deterministic uncertainty.
  - Energy efficiency availability both in Oregon and regionally affects the rule’s cost of compliance
  - Rate based vs mass based standards affect rule’s cost of compliance, especially for states with coal retirements

	SNL	Rhg	EVA	PJM	PGE
State	-	-	+	+	+
Regional	+	+	-	+	-
Rate	-	+	-	+	+
Mass	+	-	+	+	+
EE Availability	+	+/-	-	+/-	+/-
Heat Rate Improvement	-	-	-	-	-
New resource constraints	+	-	-	+/-	-

Portland General Electric

111(d) Modeling: 111(d) Scenario Analysis

- Four 111(d) Scenarios
  - BAU EE: Existing regional load forecasts from EIA AEO delivered in Aurora w/ ETO cost effective energy efficiency
    - Rate & Mass Standards
  - Expanded EE: Adjusted regional load forecasts w/ ETO all achievable energy efficiency
    - Rate & Mass Standards

	BAU EE	EXPANDED EE
RATE	A: State Rate Based Implementation Plan with Cost Effective EE	B: State Rate Based Implementation Plan with All Achievable EE
MASS	C: State Mass Based Implementation Plan with Cost Effective EE	D: State Mass Based Implementation Plan with All Achievable EE

111(d) Modeling: Building Block Treatment

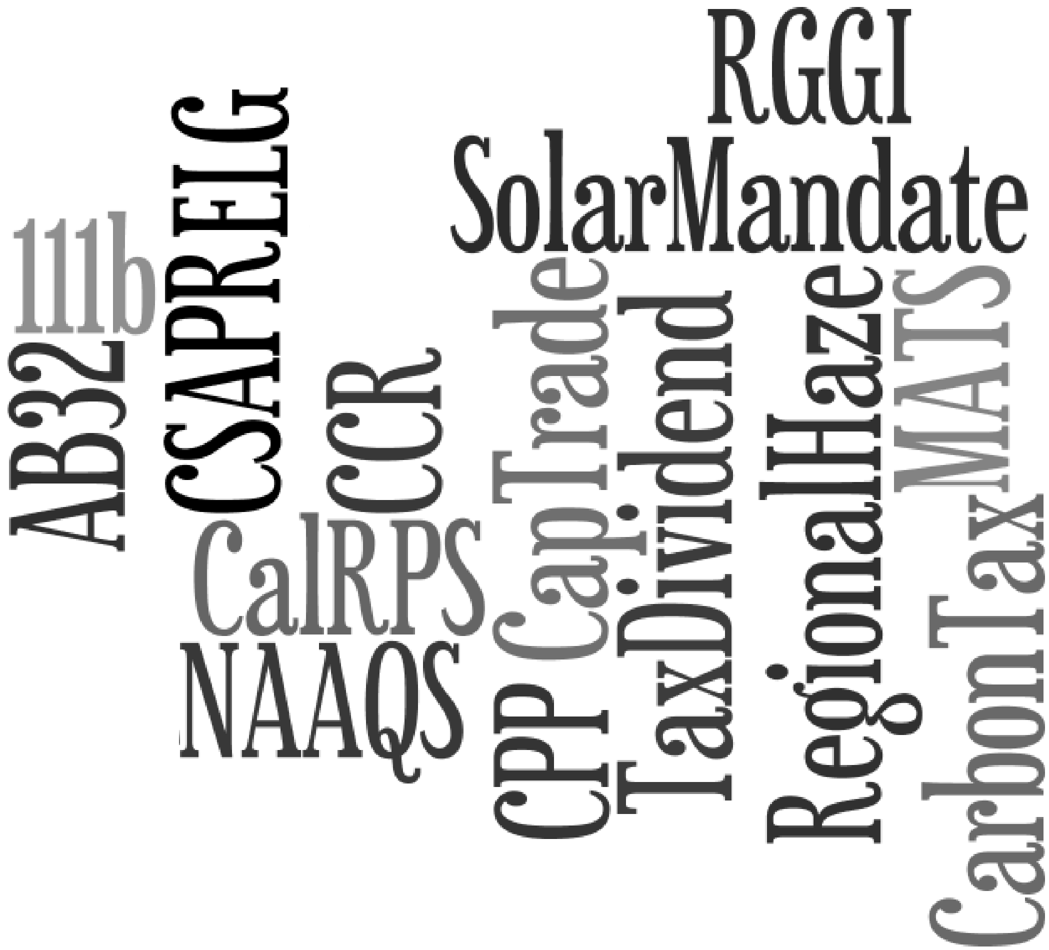
Building Block Treatment

EPA Proposed Rule	PGE's Proposed Analysis
All steam units' heat rates improved 6%	Unit heat rates unadjusted
CCCTs redispatched to 70% capacity factor	Model determines CCCT dispatch
2x new renewables nationally by 2029	No limit on new renewables
2.5x EE nationally by 2029	'Cost effective' EE and 'all achievable' EE scenarios

Portland General Electric

111(d): Interaction With Additional Policy

- 111(d) is an important constraint, but hardly the only environmental policy operative today or possible across the planning horizon.



111(d): Interaction With Additional Policy

- Existing policy modeled as written in law.
- Future policy risk accounted for through CO2 price scenarios
  - Despite diversity of mechanisms, environmental policy in the utility sector is generally designed to limit greenhouse gas emissions.
  - Employing effective cost of carbon price as a proxy allows a broad array of future policy outcomes to be captured in fewer scenarios.

111(d): Interaction With Additional Policy

- In an effort to sample the broad range of possible future environmental policies:
  - 2016 IRP will model scenarios where 111(d) is left final, replaced, or repealed while layered with…
  - High, medium, low, and zero CO2 future prices
- An appropriate number of environmental policy futures allows 2016 IRP to measure portfolio risk of uncertain environmental policy.

Eight Environmental Policy Futures Tested in 2013 IRP, Table 9-5

↓ Futures Risk Drivers→	Fuel Prices	CO_2
1 Reference Case		
Fuel/CO_2		
2 High Gas	X	
3 Low Gas	X	
31 Very High Gas	X	
4 High Coal	X	
5 Low Coal	X	
12 No Carbon Tax		X
13 Synapse low CO2		X
14 Synapse High CO2		X
30 CO2 trigger		X
33 16 dollars CO2 in 2023		X
34 High Capital Cost Wind and Solar/No CO2		X
25 High Gas and CO2	X	X
26 Low Gas and No CO2	X	X

Portland General Electric

111(d): Proposed Framework For Policy Futures

Policy Class	Climate Policy Scenario	111(d)		CO2 Price					111(b)	Existing Policy
		As Finalized	Repealed Replaced	None	Low	Mid	High	Trigger		
111(d) Scenario Analysis	CPP-A	X		X?	X?				X	X
	CPP-B	X		X?	X?				X	X
	CPP								X	X
	CPP								X	X

	BAU EE	EXPANDED EE
RATE	**A**: State Rate Based Implementation Plan with Cost Effective EE	**B**: State Rate Based Implementation Plan with All Achievable EE
MASS	**C**: State Mass Based Implementation Plan with Cost Effective EE	**D**: State Mass Based Implementation Plan with All Achievable EE

Portland General Electric

111(d): Proposed Framework For Policy Futures

Policy Class	Climate Policy Scenario	111(d)		CO2 Price					111(b)	Existing Policy
		As Finalized	Repealed Replaced	None	Low	Mid	High	Trigger		
111(d) Scenario Analysis	CPP-A	X		X?	X?				X	X
	CPP-B	X		X?	X?				X	X
	CPP-C	X		X?	X?				X	X
	CPP-D	X		X?	X?				X	X
Policy Interaction Analysis	CPP-A+ Low	X		X?	X?				X	X
	CPP-A+ Mid	X				X			X	X
	CPP-A+ High	X					X		X	X
	CPP-A+ Trig	X						X	X	X

Portland General Electric

111(d): Proposed Framework For Policy Futures

Policy Class	Climate Policy Scenario	111(d)		CO2 Price					111(b)	Existing Policy
		As Finalized	Repealed Replaced	None	Low	Mid	High	Trigger		
111(d) Scenario Analysis	CPP-A	X		X?	X?				X	X
	CPP-B	X		X?	X?				X	X
	CPP-C	X		X?	X?				X	X
	CPP-D	X		X?	X?				X	X
Policy Replacement Analysis	No CO2		X	X					X	X
	Low CO2		X		X				X	X
	Med CO2		X			X			X	X
	High CO2		X				X		X	X
	Trigger CO2		X					X	X	X

Portland General Electric

111(d) Modeling: Recap & Discussion

- Thirteen proposed environmental policy futures used to evaluate a broad range of policy outcomes.
- 111(d) scenario analysis used to prepare for unknown state implementation of the proposed rule.
- CO2 pricing used as a proxy for future state and federal environmental policy changes.
- Feedback requested on specific CO2 prices. Synapse, reference of 2013 IRP's forecast, released an update March 2015.