Integrated Resource Planning

Roundtable 18-1
Day 1

February 14, 2018

Meeting Logistics

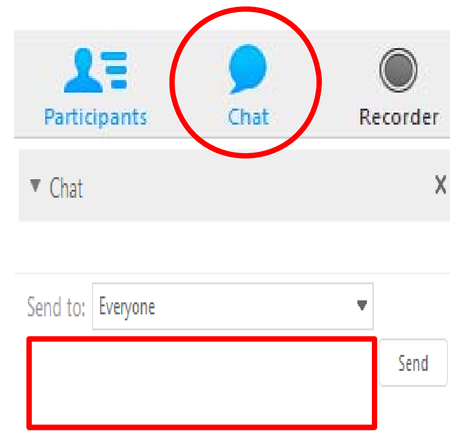
Local Participants:

- World Trade Center facility
- Wireless internet access
  - Network: 2WTC_Event
  - Password: 2WTC_Event$
- Sign-in sheets

Virtual Participants:

- Ask questions via 'chat' feature
- Meeting will stay open during breaks, but will be muted
- Electronic version of presentation: *portlandgeneral.com/irp*

>> Integrated Resource Planning



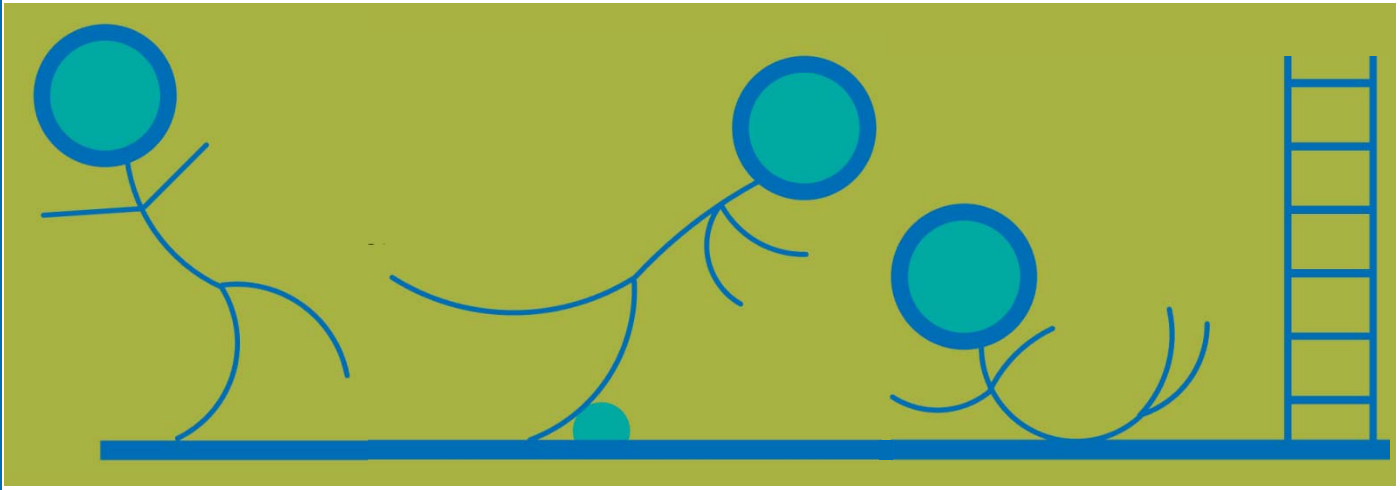
First things first…

The Power of Love!

Source: primarygames.com

Safety Moment

Slips, Trips, and Falls



Today's Roundtable Topics

- ❑ Welcome / Safety Moment
- ❑ 2019 IRP
- ❑ Portfolio Construction

  Break (15 minutes)

- ❑ Futures and Uncertainties
- ❑ Flexibility Assessment Methodology

  Lunch (30 minutes)

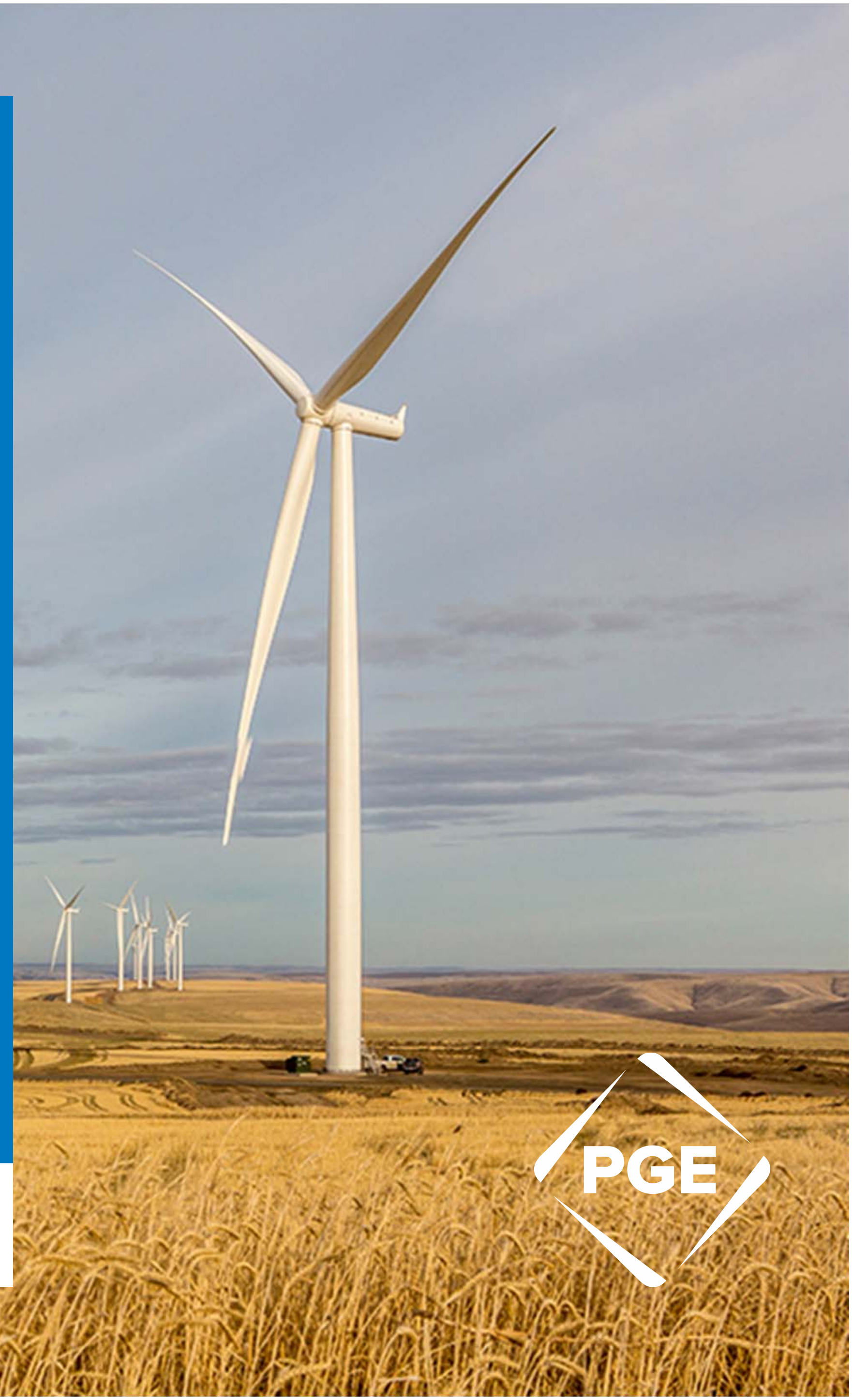
- ❑ Decarbonization Study
- ❑ Market Study

  Break (15 minutes)

- ❑ Customer Insights
- ❑ Next Steps/Wrap-up

2019 IRP Kick-Off

Elaine Hart



Integrated Resource Planning

The purpose of the IRP process is embedded within the OPUC IRP Guidelines

- **OPUC Order No. 07-047**

  Guideline 1(c)

  - “The primary goal must be the selection of a portfolio of resources with the best combination of expected costs and associated risks and uncertainties for the utility and its customers.” pp. 1-2.

- **OPUC Order No. 17-386**

  - “Our IRP guidelines and policies continue to provide the necessary framework to address these new challenges… How utilities characterize need and assess risk and uncertainty within their IRPs and how we integrate that analysis into our review, however, must evolve.” p. 14

Details from OPUC Order 17-386

Resource Adequacy

- Treatment of market capacity
- Flexible capacity and curtailment metrics
- Risks associated with Direct Access

Renewable Resources

- Incorporate a glide path analysis
- Conduct a decarbonization study
- Assess resources from Montana and hold workshop to explore transmission issues

Energy Efficiency

- "PGE will make available the Energy Trust's energy efficiency forecast data and provide an explanation of their model in the company's next IRP." p. 8

Demand Response

- "hire a third party to conduct a study for demand response specific to PGE's service territory with results in time to inform PGE's subsequent IRP" pg. 9

Other

- Load forecasting methodology improvements and workshops
- Scoring metrics workshops
- Distributed energy resource forecasting
- Customer Insights Study

Stakeholders' Values

Raw expressed Values from RoundTable 17.3 – Word Cloud

Stakeholders' Values

Sorted expressed Values from RoundTable 17.3 – Word Cloud

Stakeholders' Values

Categorized Values

Fairness & Transparency

- Authentic concern
- Sincere consideration of all feedback
- No duplicative metrics
- Transparency in development and process
- Accountability
- Early determination of metrics weighting as part of the Stakeholder process

Sustainability

- Sustainable, Healthy and Safe future for all generations
- Long Term vision anticipating sustainability requirements
- Climate impact
- Keeping fossil fuels, nuclear and biomass out of the mix
- Consistent with Portland's 100% renewable goals
- A clear path to Decarbonization

Cost and Risk

- Least cost, least risk
- Balancing cost, risk and benefits
- Lowest cost to customers
- Leveraging customer capabilities
- Leveraging AMI assets
- Fuel mix
- Fuel price stability
- Effective in differentiating portfolios

Stakeholders' Values

Categorized Values

Reliability & Resiliency

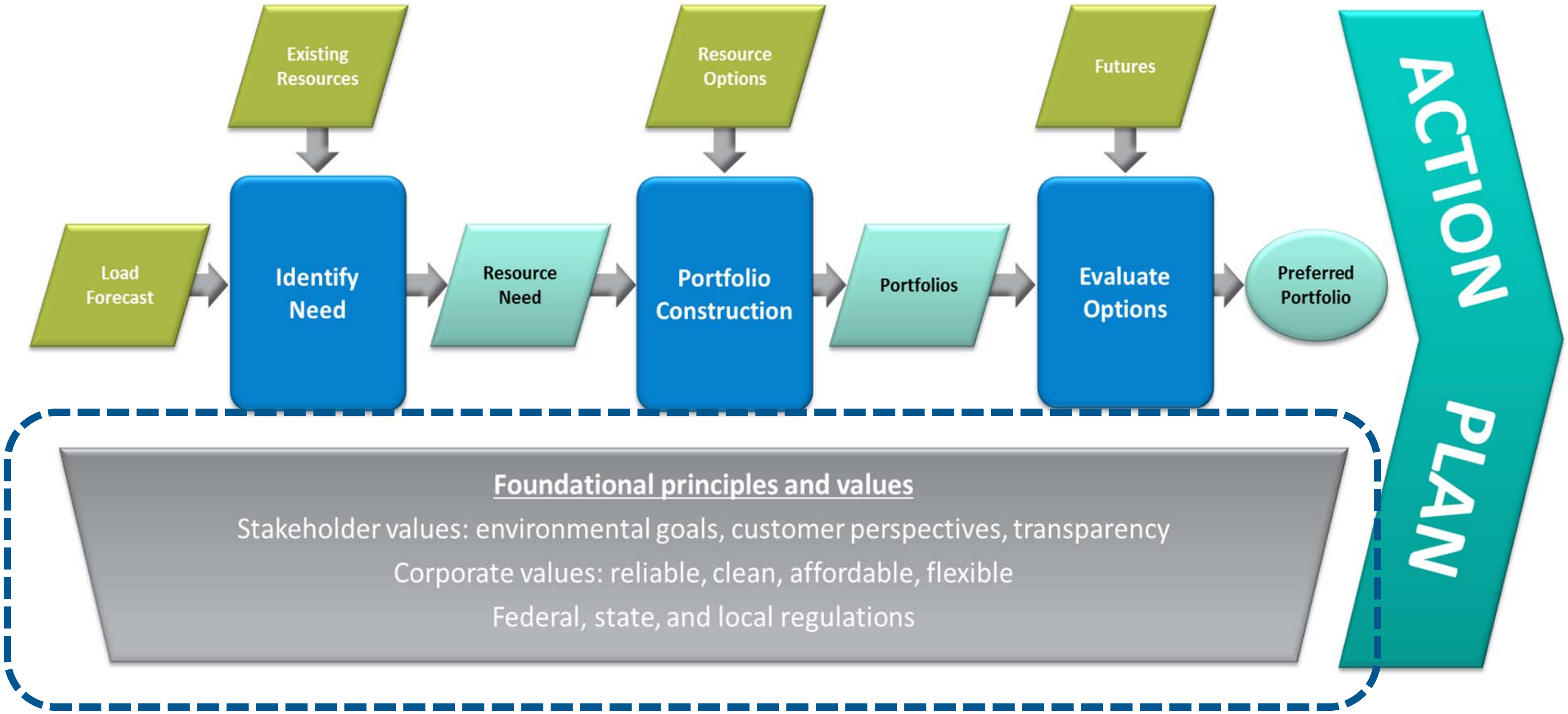
- Consider NERC definition of Resiliency
- Reliability is Assumed as foundational

Incrementalism & Optionality

- Flexibility for the future
- Optionality for the future

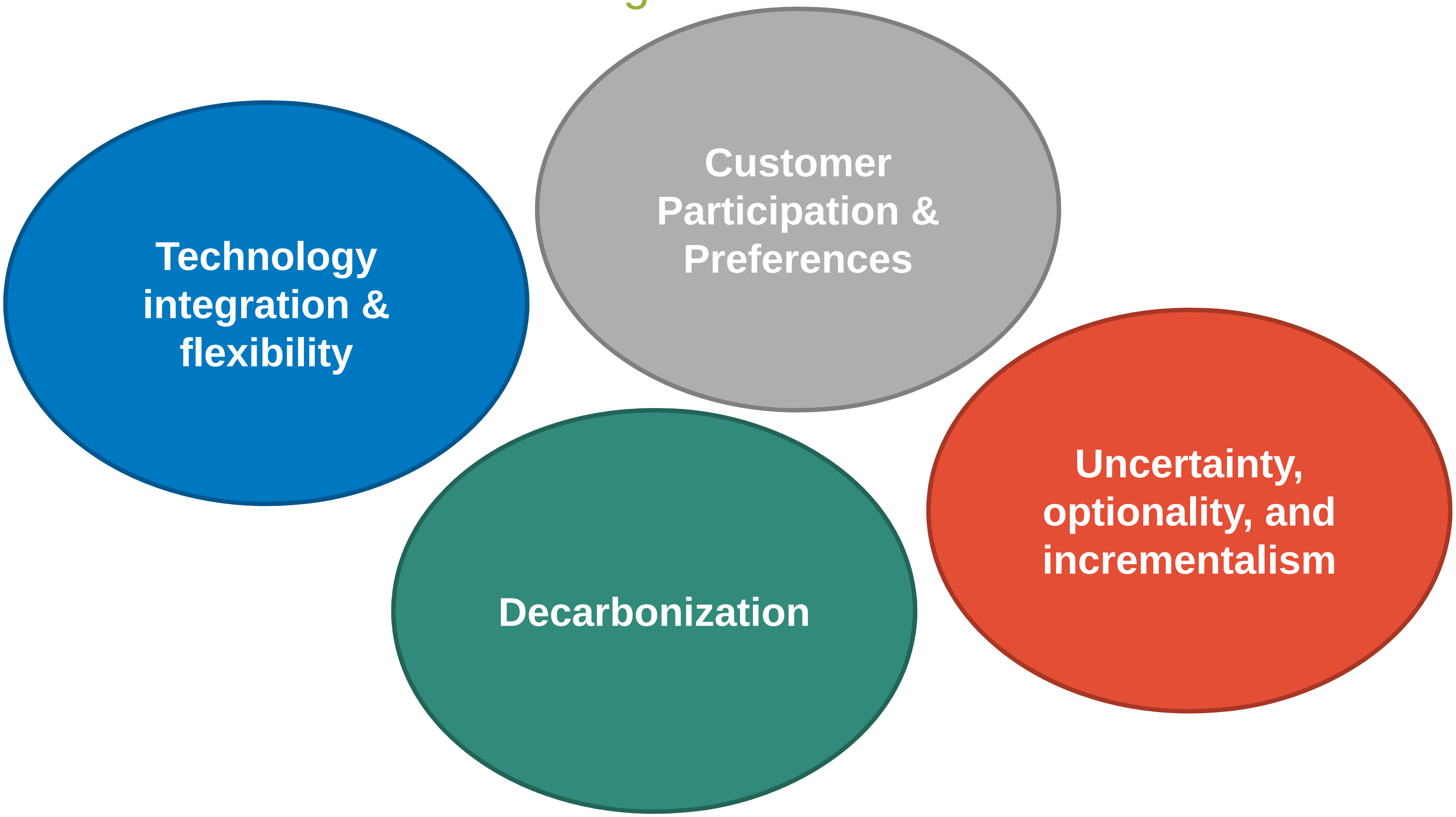
Stakeholders' Values

Your Values are embedded in our Process



Key Themes

Outcome of PGE brainstorming



Key Themes

Outcome of PGE brainstorming

Consumer Technology Adoption
(Behind-the-meter solar, storage, electric vehicles)

Distributed resources
(Distributed solar, storage, Demand response)

Customer Participation & Preferences

Community Goals
(City of Portland & Multnomah County Resolutions)

Customer Options
(TOU rates, Green Tariffs, Direct Access)

Key Themes

Outcome of PGE brainstorming

Technology integration & flexibility

Renewable Integration
How much does it cost to integrate renewables?

Flexible Resource Value
How much do we value flexibility from storage and other flexible resources?

Flexibility Adequacy
How much flexibility does the system need?

Infrastructure support for distributed resources
How much DER can the grid handle?
What will be needed to integrate new technologies like electric vehicles?

Key Themes

Outcome of PGE brainstorming

Economy-wide decarbonization
How might decarbonization of other parts of the energy economy (e.g., electric vehicle adoption) impact the PGE system?

Community Goals
(City of Portland & Multnomah County Resolutions)

Decarbonization

PGE’s 2050 goal
How should PGE treat its greenhouse gas goals in long-term planning?

Customer Goals
How should PGE plan for customers who may choose to decarbonize faster?

Key Themes

Outcome of PGE brainstorming

Types of uncertainty
Uncertainty in cost, price (technology change, policy uncertainty)
Uncertainty in need (load forecast, QFs, Direct Access)

Treatment of uncertainty
How can proposed near-term actions better address long-term uncertainties?

Optionality
How can portfolios be designed to value optionality?

Incrementalism
Is there inherent value to incrementalism?
How should the IRP consider year-on-year cost impacts?

Uncertainty, optionality, and incrementalism

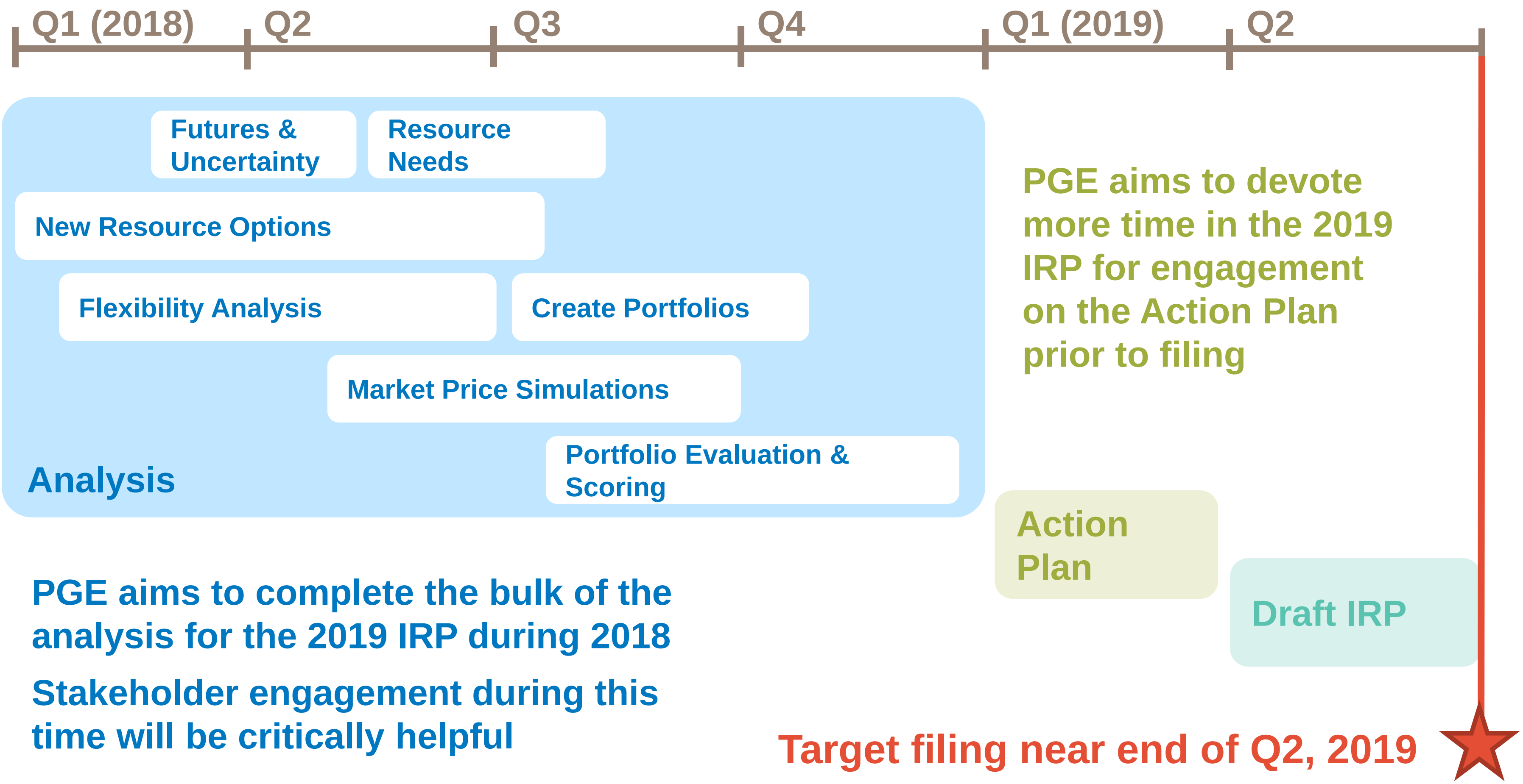
Stakeholder Feedback

What are your top priorities for the 2019 IRP?

- Methodological focus?
- Technology focus?
- Frameworks and communication?

Draft 2019 IRP Schedule

Planning for the Plan…



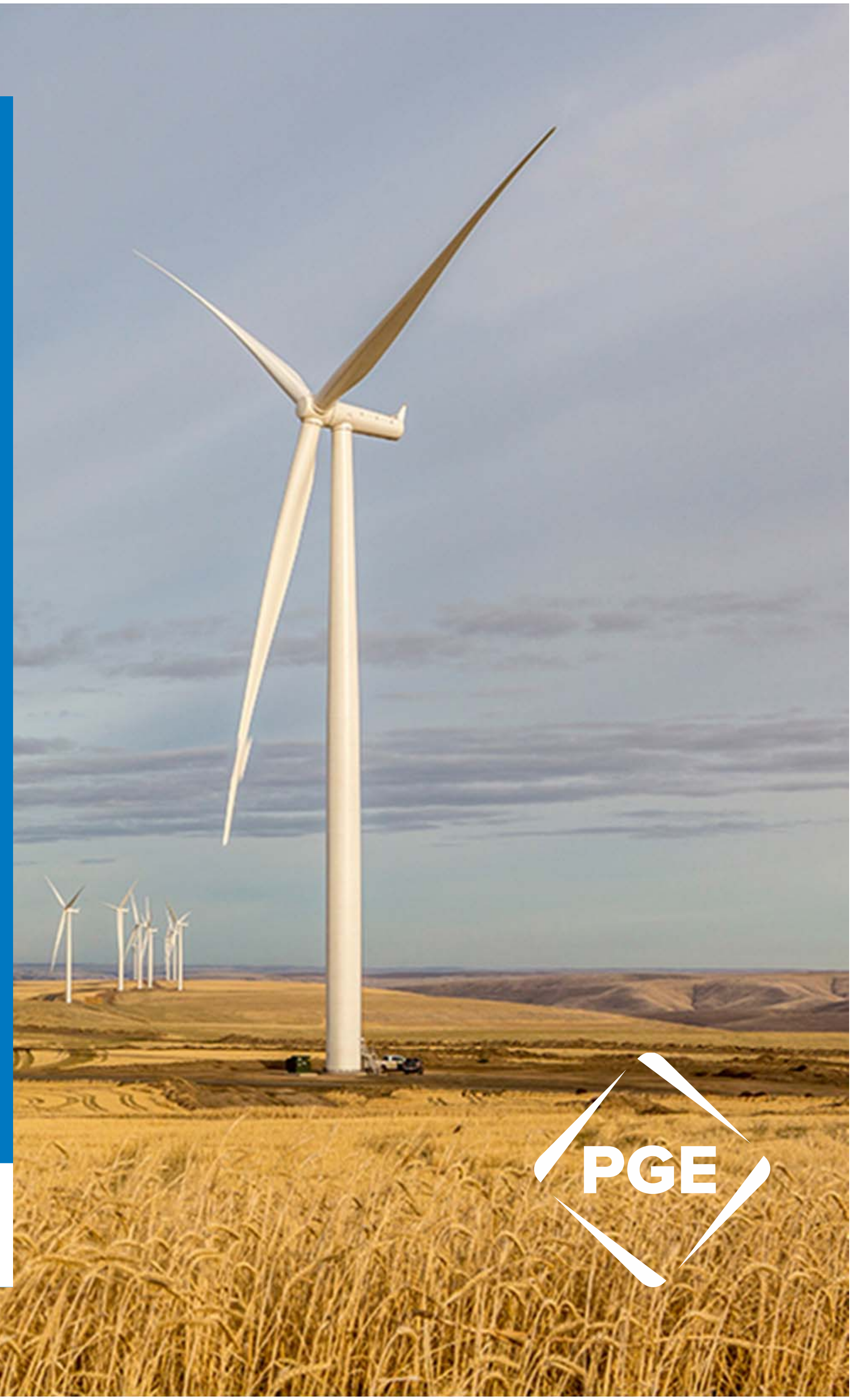
PGE aims to devote more time in the 2019 IRP for engagement on the Action Plan prior to filing

PGE aims to complete the bulk of the analysis for the 2019 IRP during 2018

Stakeholder engagement during this time will be critically helpful

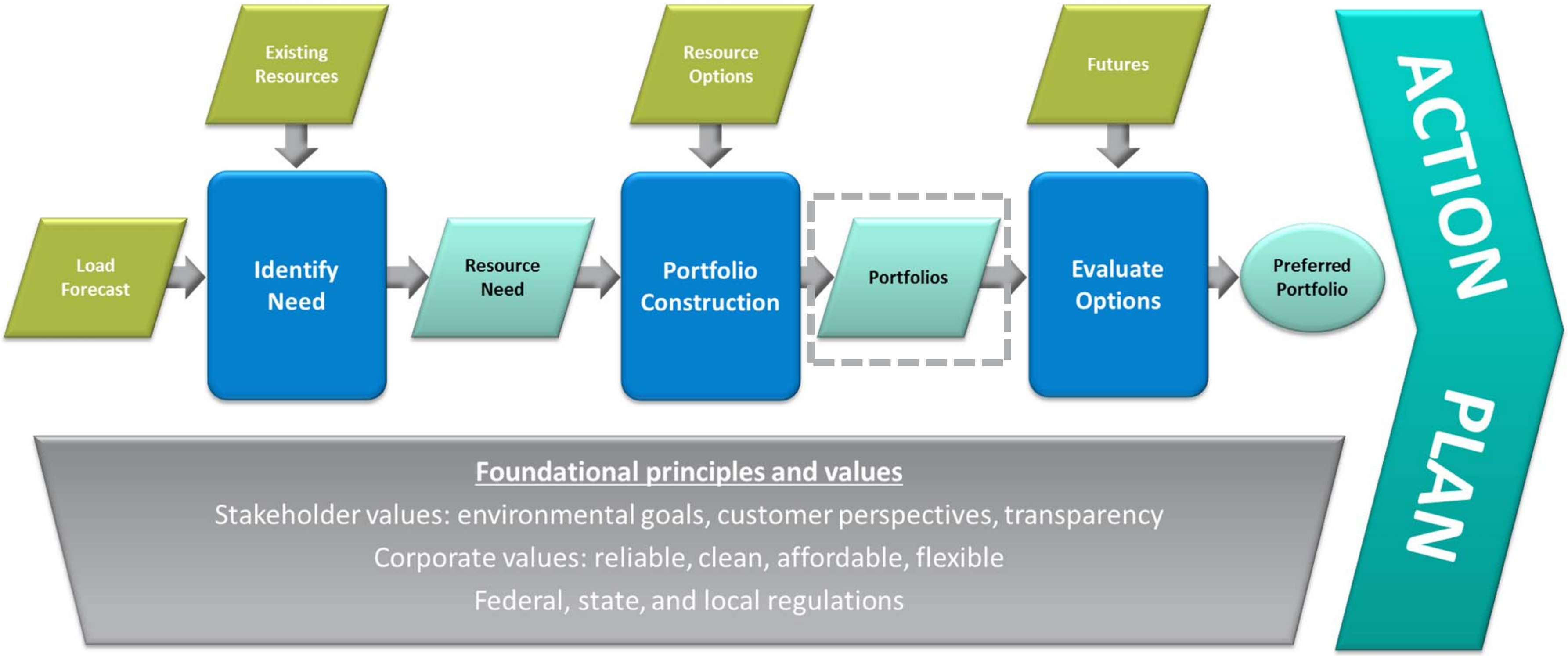
Portfolio Construction

Elaine Hart



IRP Modeling Process

- Portfolios are developed relatively late in the analytical process, but PGE is working to enhance the portfolio construction methodology now



Portfolio construction

The 2016 IRP revealed opportunities to improve upon PGE's methodology

2016 IRP methodology

- PGE hand-designed portfolios to investigate specific resource economic questions
  - Wind versus solar resources
  - Efficient Capacity versus high heat rate, low capital cost (Generic Capacity) resources
  - Value of Montana Wind relative to Gorge Wind
- Subject to resource need constraints
  - Resource adequacy requirement (2.4 loss of load hours per year)
  - RPS requirement & minimum REC bank requirement

Topics of discussion in 2016 IRP

- Incorporation of an optimal capacity expansion model to design portfolios?
- Consideration of portfolios that change with resource needs (i.e. different portfolios for low versus high load forecast futures)?

Capacity Expansion Modeling

Challenges	Potential Solutions
Capacity expansion models do not always yield sufficiently differentiated portfolios	Use capacity expansion to supplement, but not replace hand-specified portfolios. This will allow PGE to investigate portfolios that are not "economically optimal" to gain additional insights and to model some stakeholder portfolios
Capacity expansion models do not always account for PGE's specific design constraints (e.g., REC banking logic)	Incorporate AURORA dispatch solution into off-board optimal capacity expansion model that includes PGE's REC constraints.

PGE is in the process of building a simple off-board optimal capacity expansion model to use with AURORA and with hand-specified portfolio constraints to produce portfolios for 2019 IRP

ROSE-E generates optimized portfolios, automates portfolio design based on user-specified constraints, and simulates REC bank management

PGE's
Resource
Optimization
Strategy
EnginE!

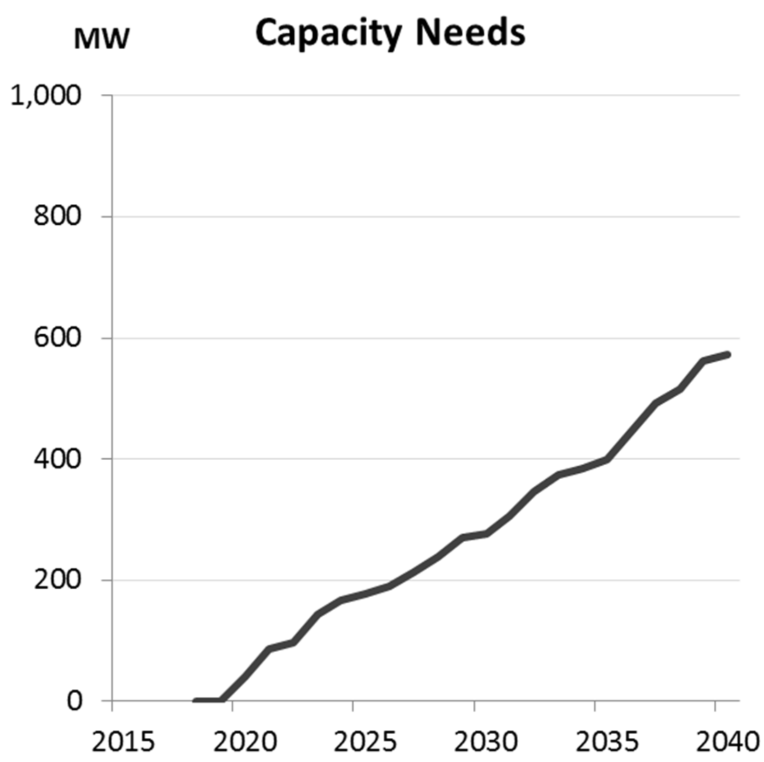
ROSE-E Formulation

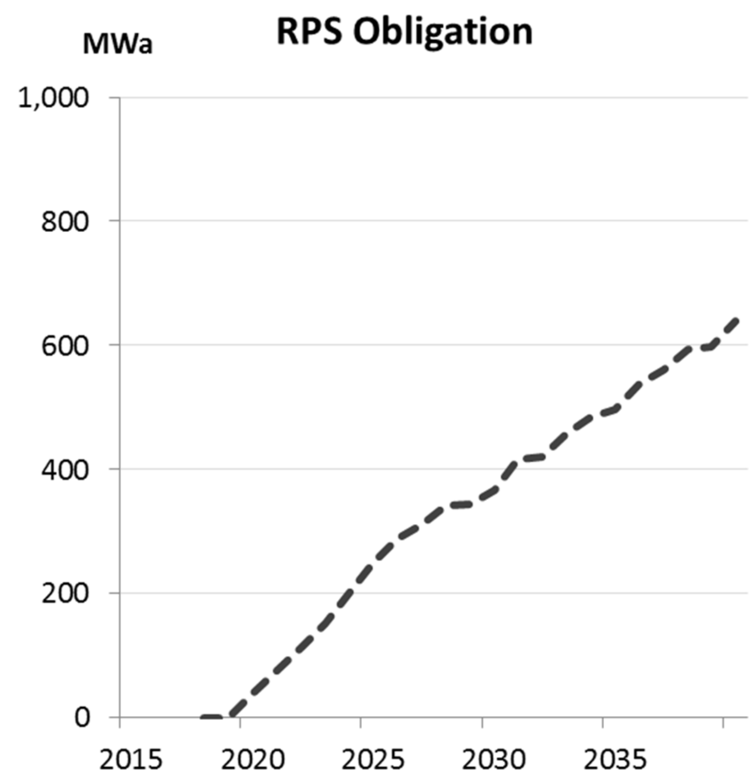
Linear Programming model, written in GAMS, with an Excel UI

- **Solves for:**
  - Resource build-out and REC retirement by year
- **Given:**
  - Resource needs (load, capacity, energy, RPS requirements)
  - Resource costs and dispatch from AURORA
  - ELCC curves from RECAP
- **Objective function**
  - Minimize NPVRR of portfolio costs in a given future (or)
  - Minimize Expected NPVRR across futures
- **Constraints**
  - Resource adequacy (capacity need and resource ELCCs)
  - RPS requirements
  - REC bank constraints (5-yr versus infinite-life RECs)
  - User-designed constraints to force in specific resources or test hypotheticals

ROSE-E Example

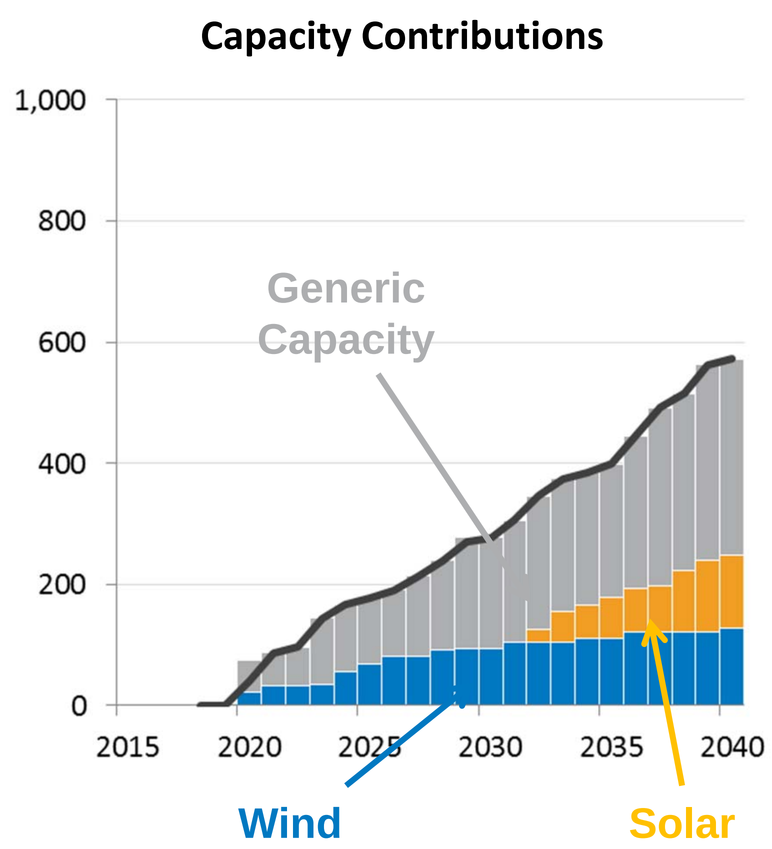
Optimal portfolio for randomly-generated system

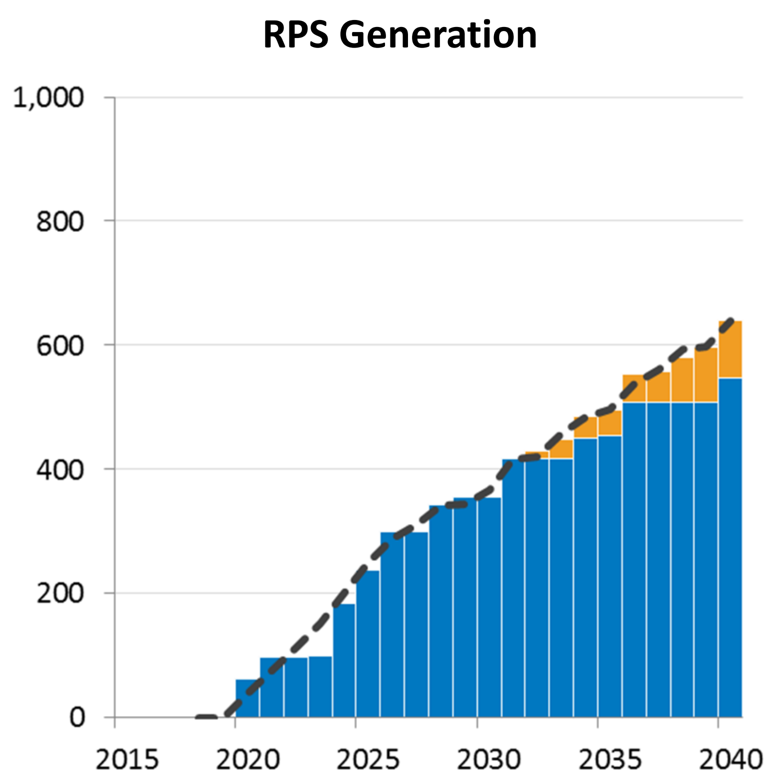




ROSE-E Example

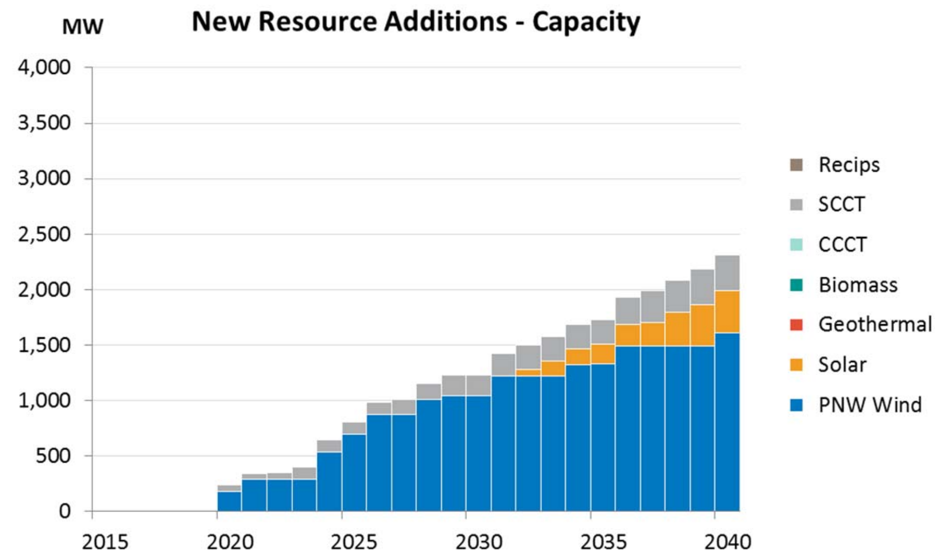
Optimal portfolio for randomly-generated system

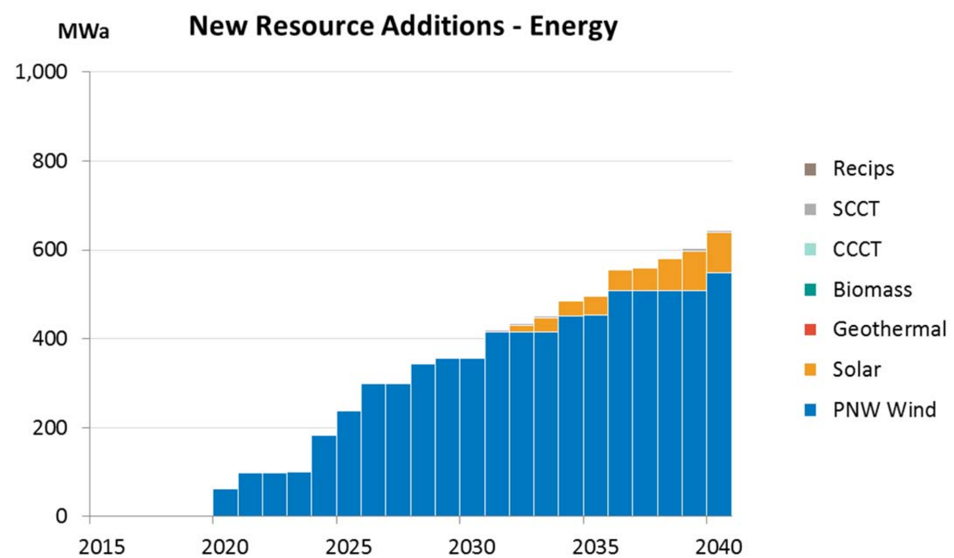




ROSE-E Example:

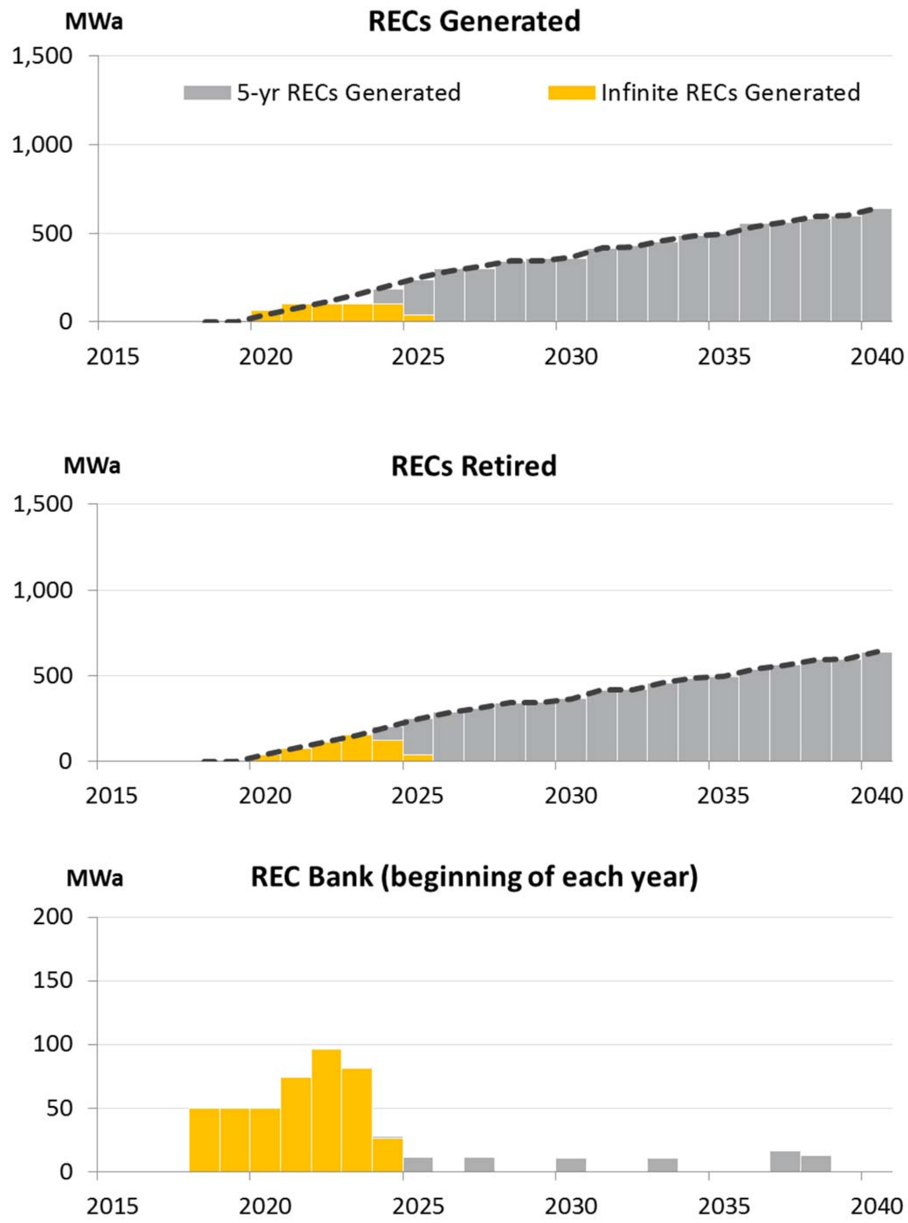
Capacity and Energy Additions





ROSE-E Example:

REC Accounting



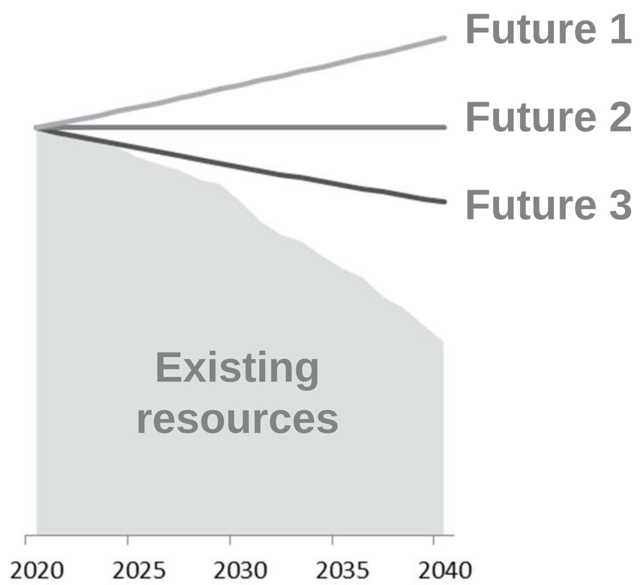
Future-Specific Portfolios

- In the 2016 IRP, all portfolios were designed to meet resource adequacy and RPS requirements under Reference Case conditions
- In the 2019 IRP, PGE may model portfolios that are specific to different futures

Challenges	Potential Solutions
Need to be careful to ensure that cost comparisons are appropriate (e.g., portfolio costs for a low load portfolio should not be directly compared to portfolio costs for a high load portfolio)	Address this issue in designing scoring metrics
Potentially increases problem size substantially	Consider future-specific portfolios in a way that prioritizes learning regarding impacts of uncertainty and optionality

Portfolios and Futures

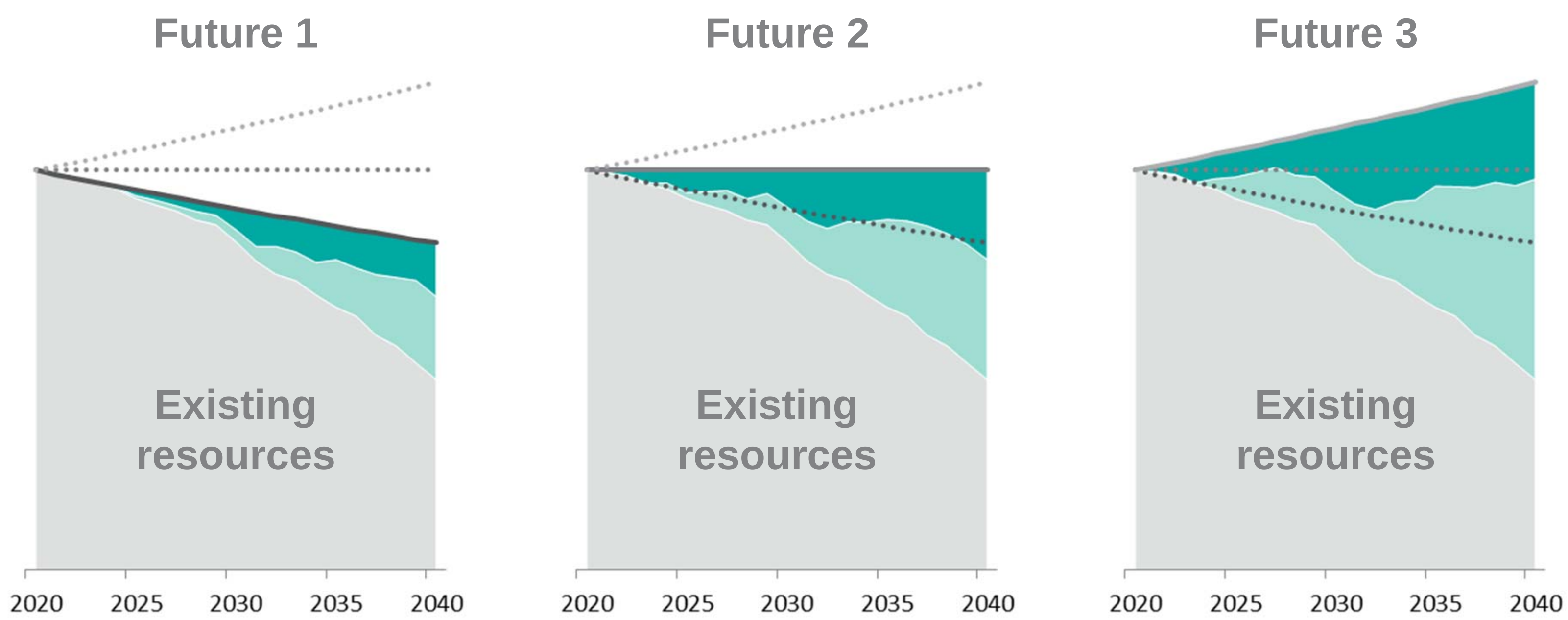
Portfolio design can incorporate futures in different ways



- Each future has different resource needs
- A capacity expansion model (like ROSE-E) can provide portfolios that account for this in different ways
    1. Simple future-specific portfolios
    2. Stochastic portfolios
    3. Flexible portfolios

1. Simple future-specific portfolios

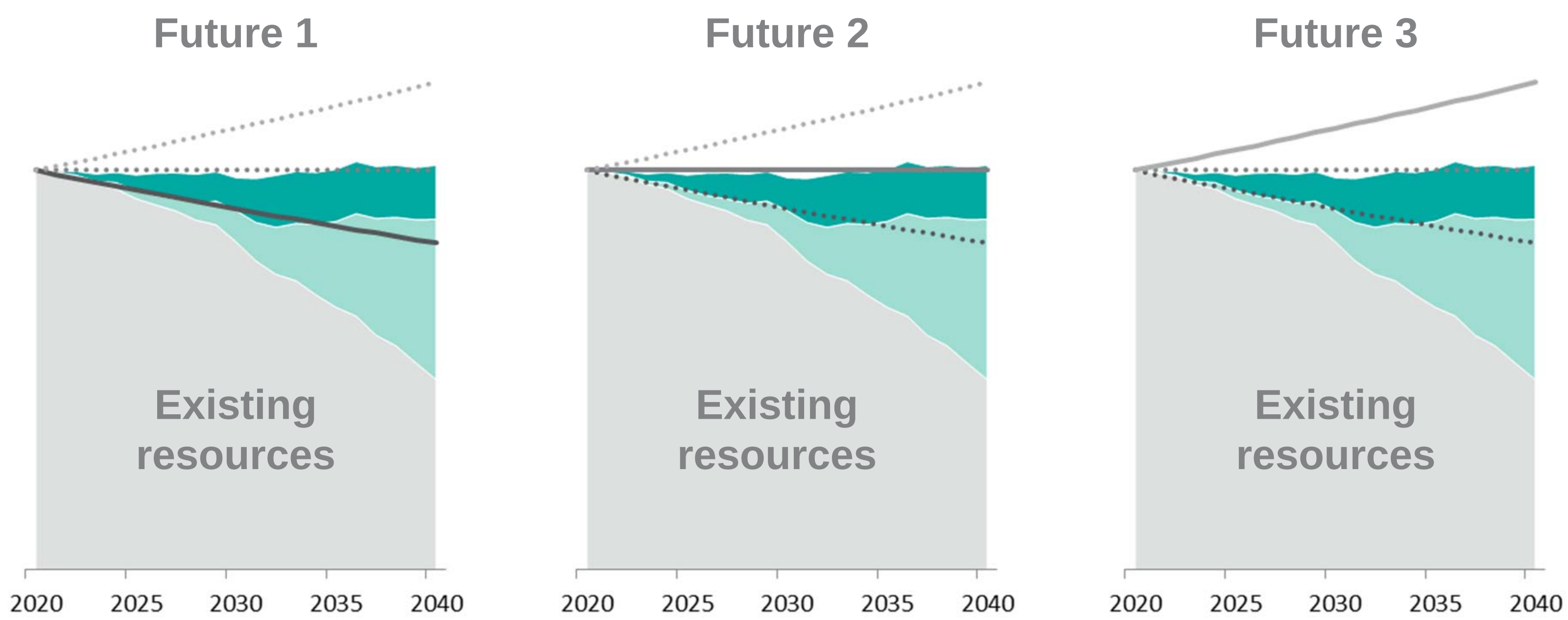
Find the optimal portfolio for each future



…okay, but how does this help inform the Action Plan?

2. Stochastic portfolios

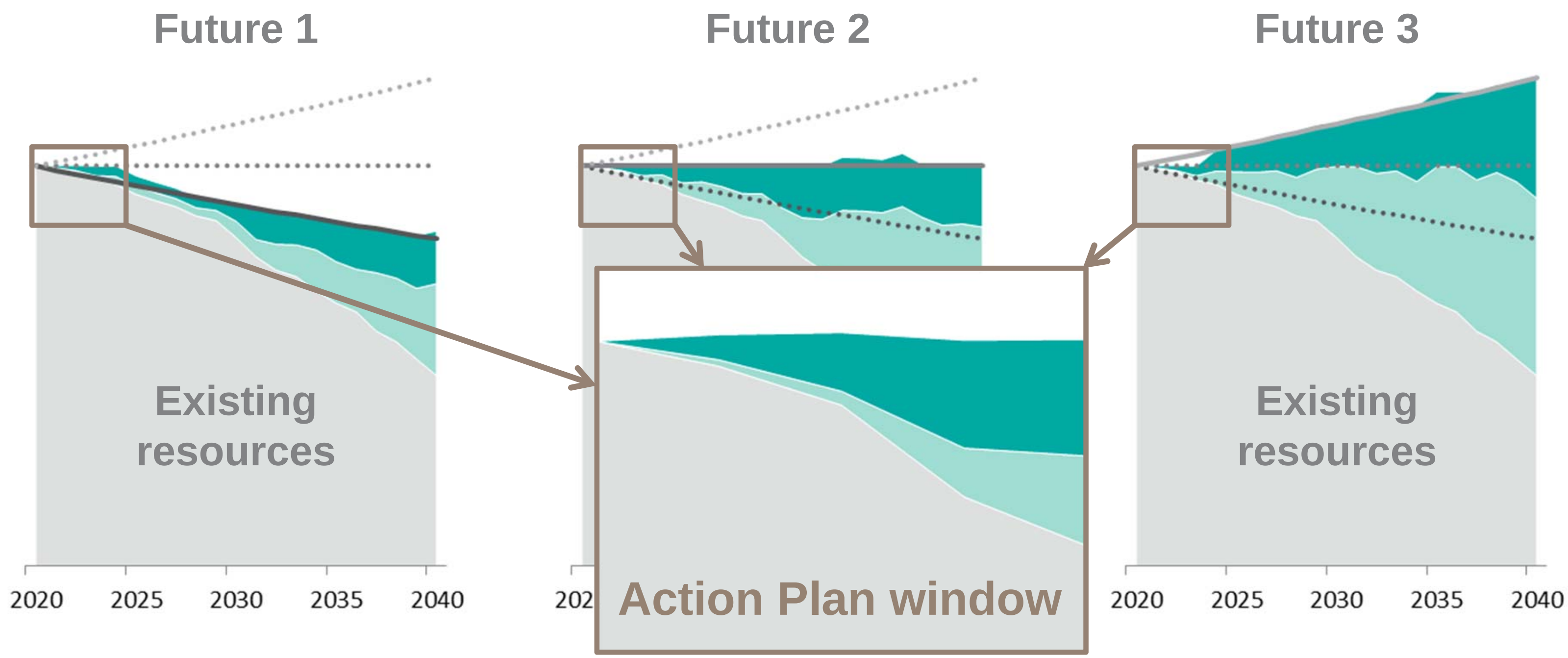
Find the optimal portfolio (on an expected basis) across a set of multiple futures



…but wouldn't we change course at some point if we end up in one of these futures?

3. Flexible portfolios

Find the optimal portfolio for the Action Plan years, allowing the portfolios to change in later years by future



This provides a single portfolio for the Action Plan window and inherently values optionality for future years.

The possibilities are endless…

…and yet we must complete the 2019 IRP

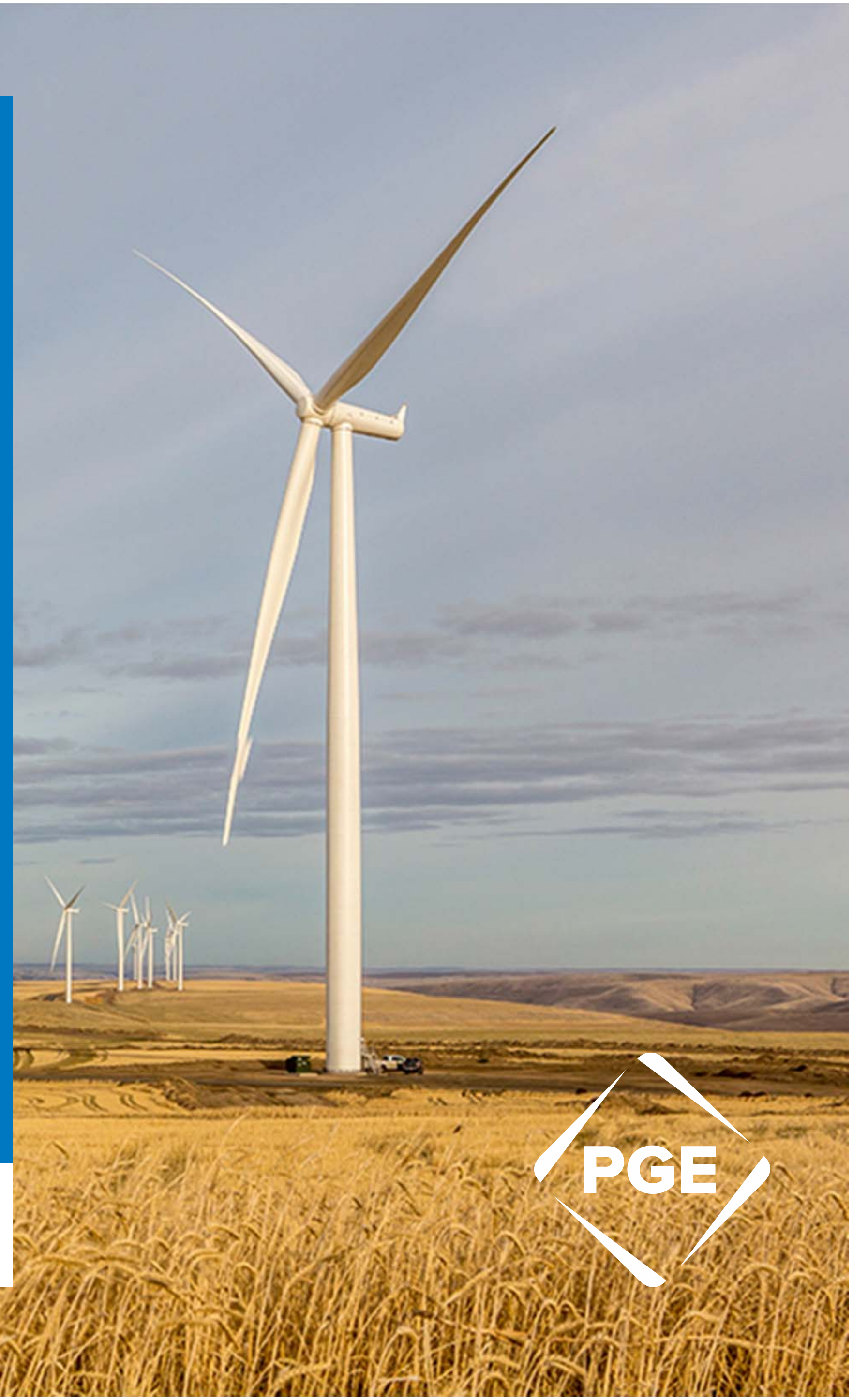
In the coming weeks, PGE will be drafting a framework for designing portfolios for the 2019 IRP that includes both hand-specified portfolios and optimized portfolios.

We'll need your help to:

- Identify key portfolios or questions of interest
- Provide feedback on our proposed framework
- Provide feedback on the use of ROSE-E to help design portfolios
  - Ex: Should we devote a more detailed Technical Meeting to describe and demonstrate ROSE-E?

Futures and Uncertainties

Kate, Sima, Jessie



Outline

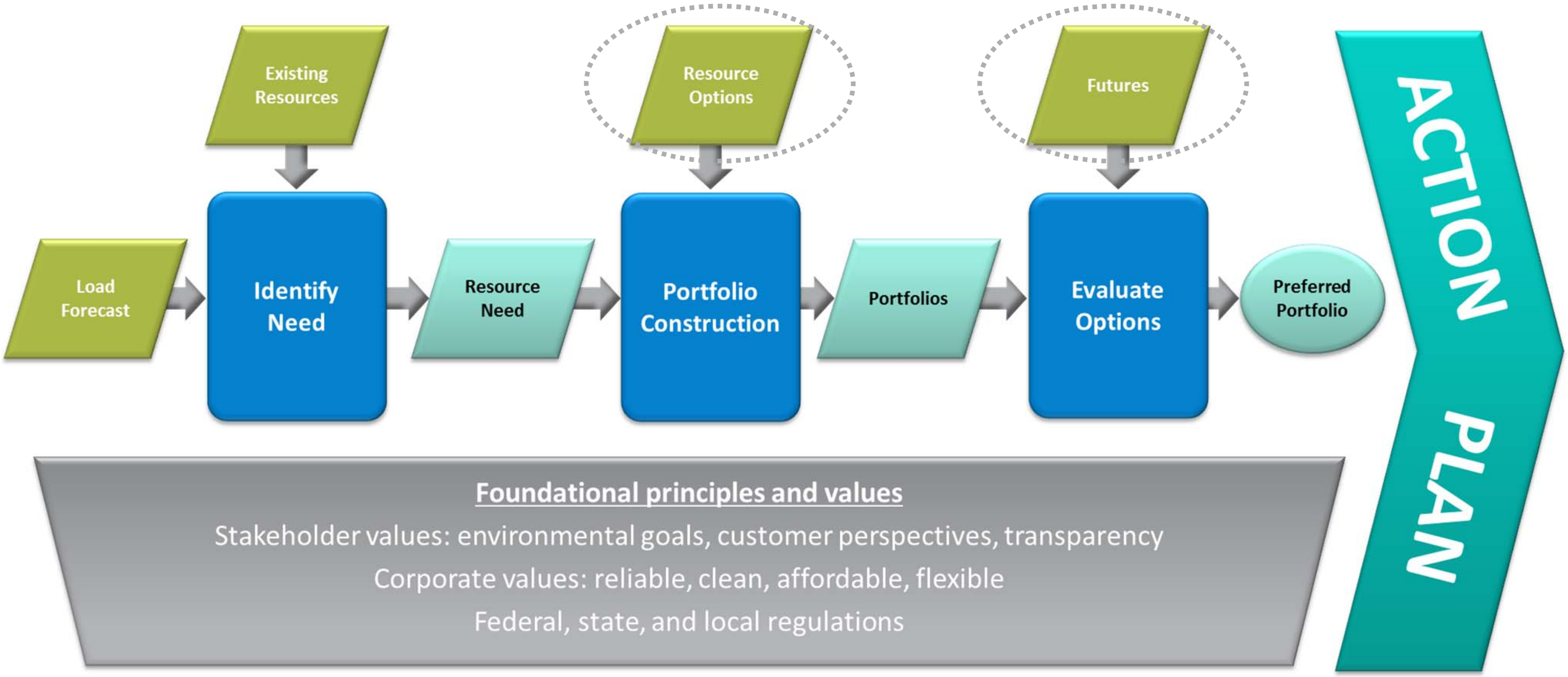
“Prediction is difficult, especially about the future.”

Niels Bohr and others

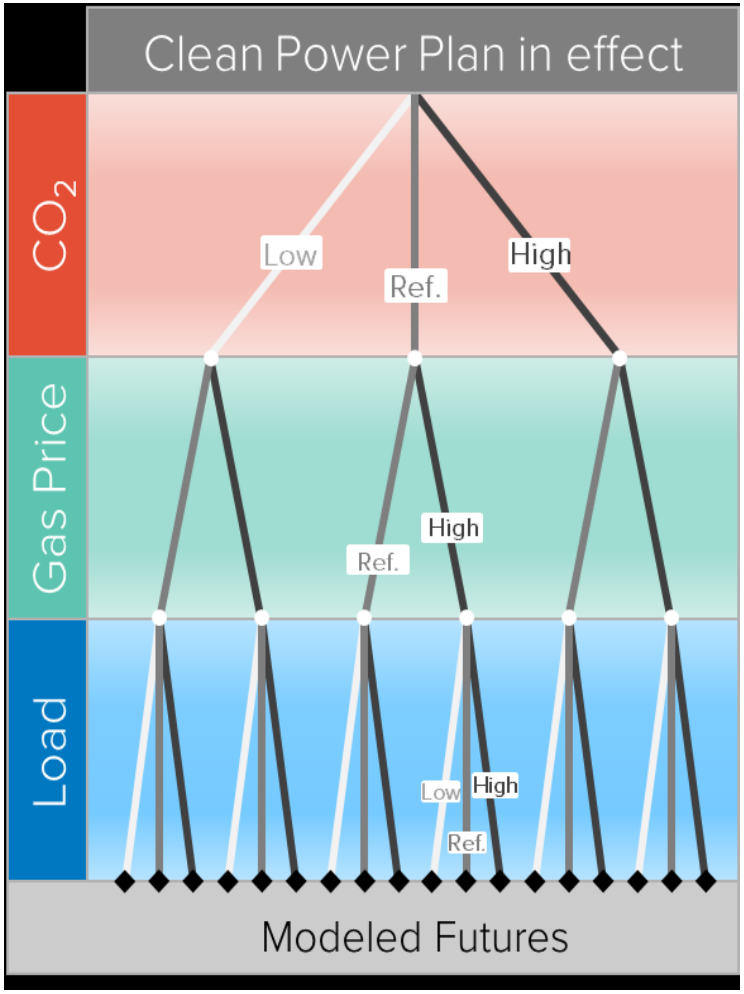
- ❑ **Review 2016 IRP Futures**
- ❑ **Feedback from 2016 IRP**
- ❑ **2019 IRP Uncertainties and Risk**
  - Need Assessments
  - Fixed Costs
  - Variable Costs and Energy Value
- ❑ **Feedback and Next Steps**

IRP Modeling Process

In the 2016 IRP, uncertainties were primarily factored in the Resource Options and Futures processes.



2016 IRP Futures



- ☑ WECC-wide CO_2 tax forecast by Synapse for **Reference and High carbon futures**
- ☑ **Low carbon future** based on existing programs only.
- ☑ **Low gas future** added in response to data request
- ☑ Varied **portfolio energy need**
- ☑ **Additional sensitivities:** capital costs, capacity factors, low hydro

2016 IRP Feedback

Need Assessment Uncertainties

- Load forecast methodology
- Distributed solar adoption
- Direct access assumptions
- Energy efficiency

Treatment of Existing Regional Resources

- Availability
- Cost

New Resource Cost

- Solar capital costs
- Economic life
- Planning horizon

Short-Term vs. Long-Term Uncertainties

- Balance of near-and long-term
- Assessment of long-term risks

2019 IRP – Uncertainty and Risk

Let's first brainstorm about uncertainties in the need assessment, then discuss some considerations . . .

Stakeholder thoughts regarding uncertainties in need assessments …

Uncertainties in Need Assessments

Resource Need:

- Capacity
- Energy
- RPS
- Flexibility

Uncertainties in Need Assessments

Load

- Economic factors
- Weather factors
- Customer choice

Resources

- Qualifying facilities
- Availability of existing regional resources
- Weather conditions
- Renewables RFP
- Energy storage

Adoption of Distributed Technologies

- Energy efficiency
- Demand response / smart load
- Distributed solar
- Distributed batteries
- Electric vehicles

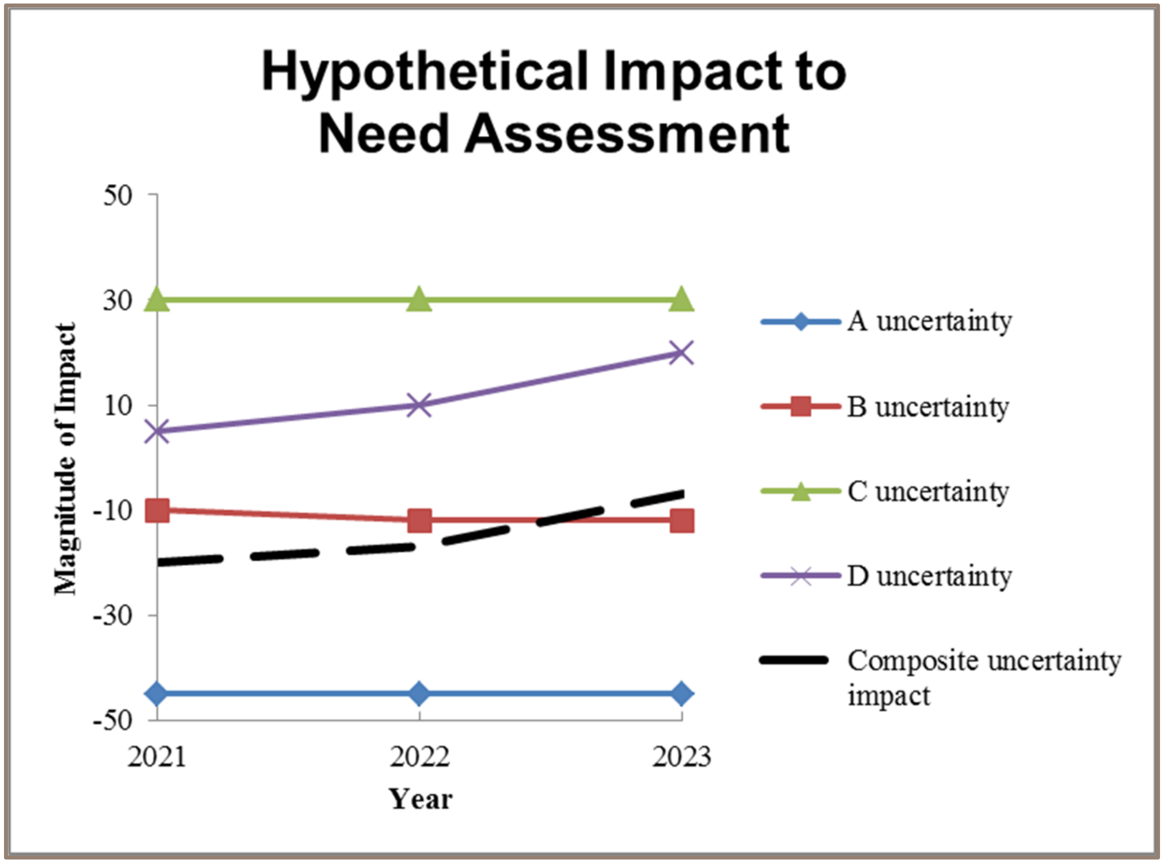
Regulation

- Environmental
- Resource adequacy requirements

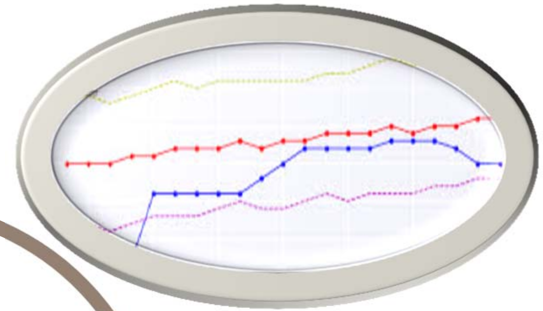
Uncertainty Considerations in Need Assessment

Uncertainty Considerations:

- Types of impact
- Magnitude
- Changing characteristics over time
- Correlations
- Impact in Action Window



Uncertainty Inputs in Portfolio Construction



Identify
- Multiple uncertainties

Learn
- Grouping
- Prioritize
- Boundaries

Portfolio Construction
- Upper/lower bounds
- Key cases

Stakeholder thoughts regarding uncertainties in estimated fixed costs…

Uncertainties in Fixed Costs

Fixed costs include **capital costs** and **fixed operating and maintenance costs**.

Uncertainties in Fixed Costs

- Overnight capital cost
- Maturity outlook
- Tech vs. Tech

Technology

- Inflation
- Taxes
- Cost of Debt
- Return on Equity
- Economic Life

Financial Parameters

- O&M
- Transmission
- Transportation
- Distribution system costs

Fixed O&M

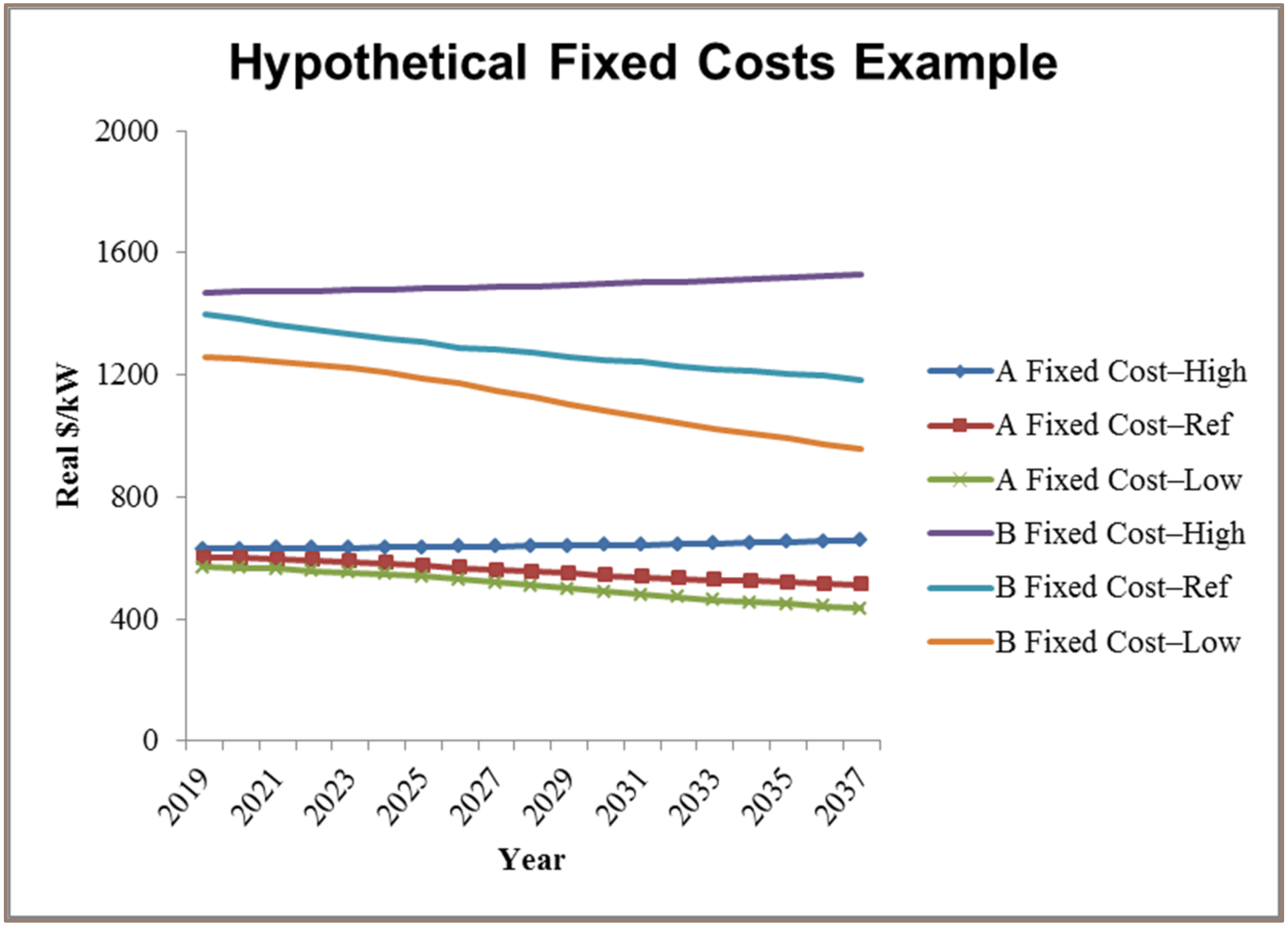
- Long-term cost
- Short-term / mid-term cost

Regional Resources

- Environmental costs
- Permitting costs

Regulation

Capital Cost Figures



Stakeholder thoughts regarding uncertainties in estimated variable costs and energy values…

Uncertainties in Variable Costs & Energy Value

Variable costs include **commodity costs**, **variable operating and maintenance costs**, and **environmental costs** that vary with dispatch

Energy value indicates the wholesale market value of a resource's generation

Uncertainties in Variable Costs and Energy Value

Commodity Costs
- Natural gas
- Coal

Environ-mental Costs
- CO_2
- Other (Water, SOx, NOx)

Variable Plant
- Cycling costs
- Start costs
- Other O&M
- Royalties

Weather
- Hydro
- Wind
- Solar

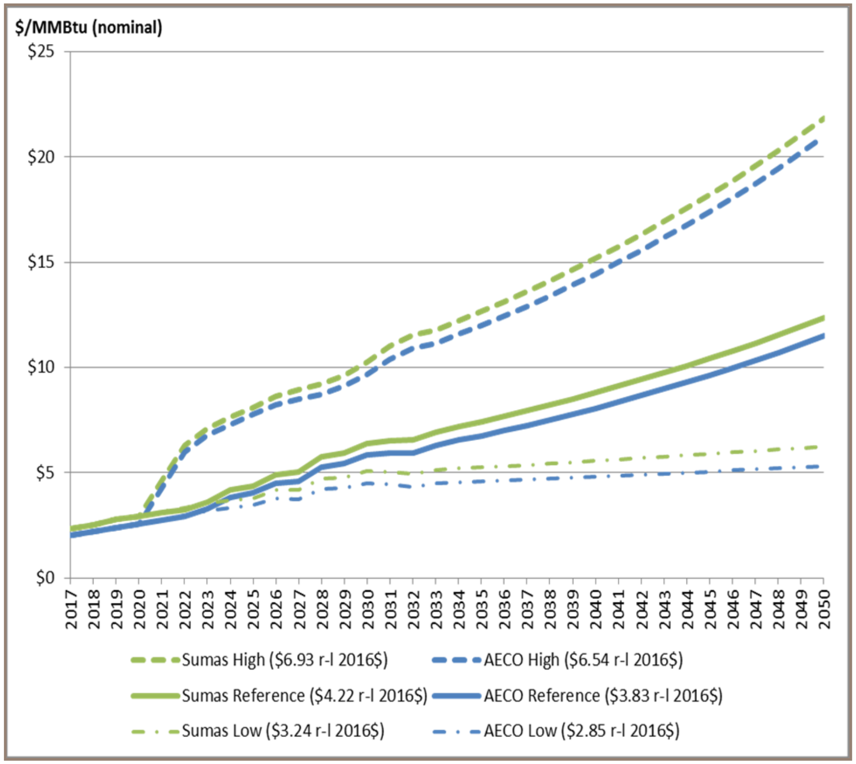
Regulation
- RPS
- Environmental
- Reliability Requirements

Markets
- Structures
- Curtailment
- Wholesale prices

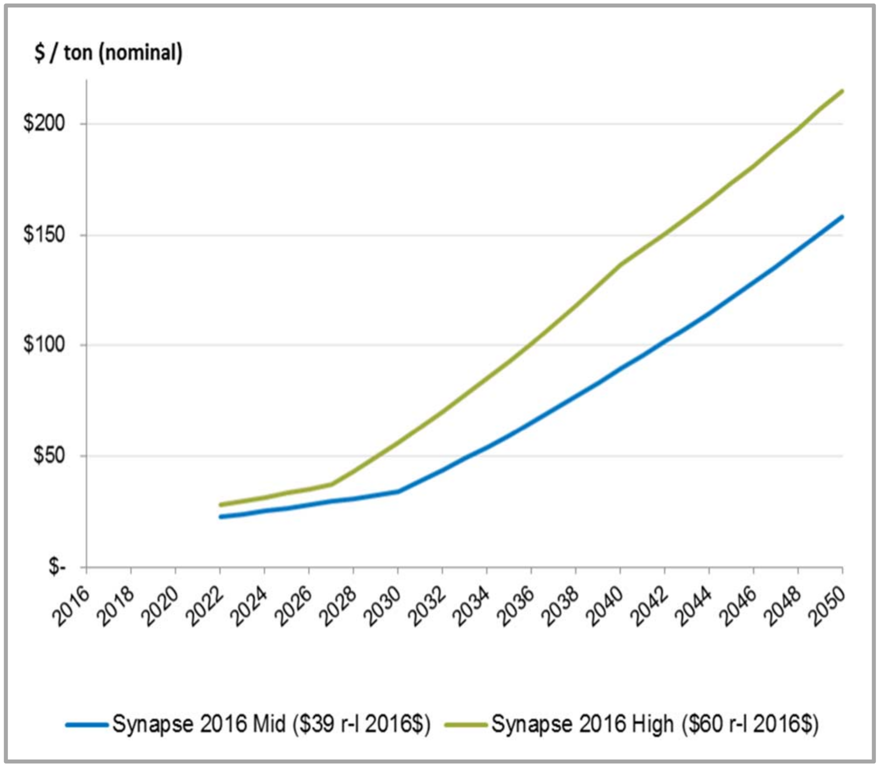
Gas and Carbon

Gas and CO_2 Price Forecasts from the 2016 IRP

Gas Price Forecast

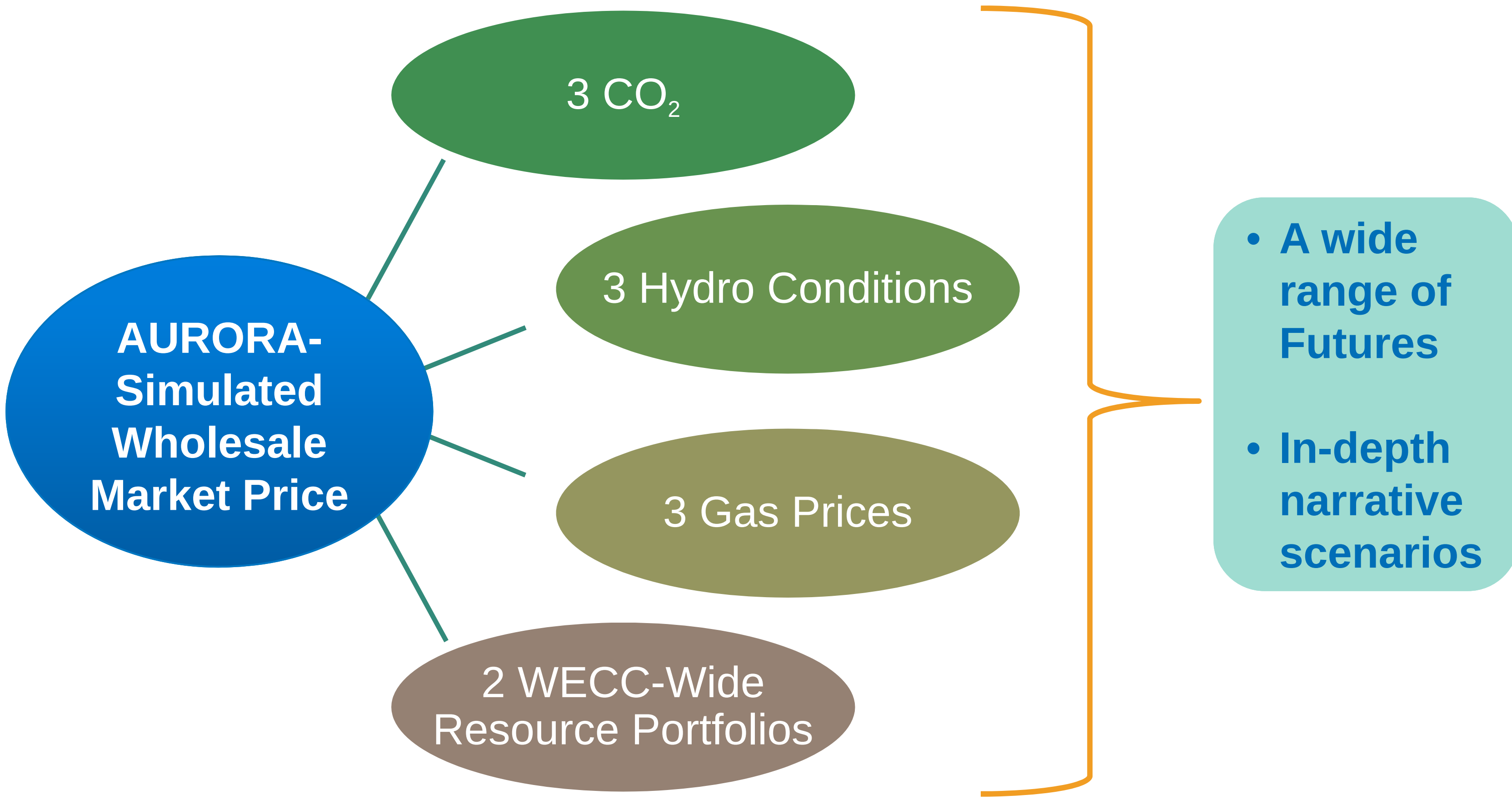


CO2 Price Forecast



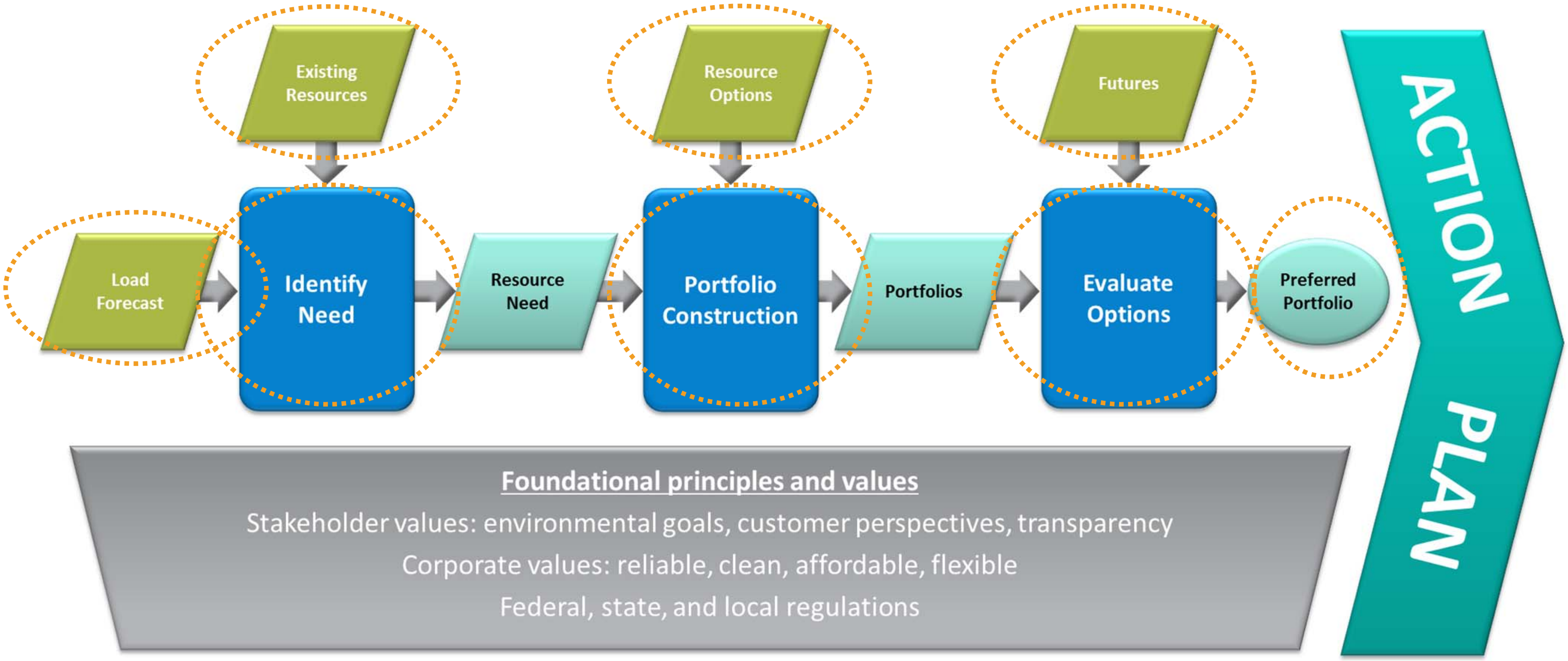
Wholesale Market Prices

Potential Uncertainties Captured in AURORA



IRP Modeling Process

In the 2019 IRP, uncertainties will be factored in a broader range of the IRP process.



Next Steps

Stakeholder Inputs

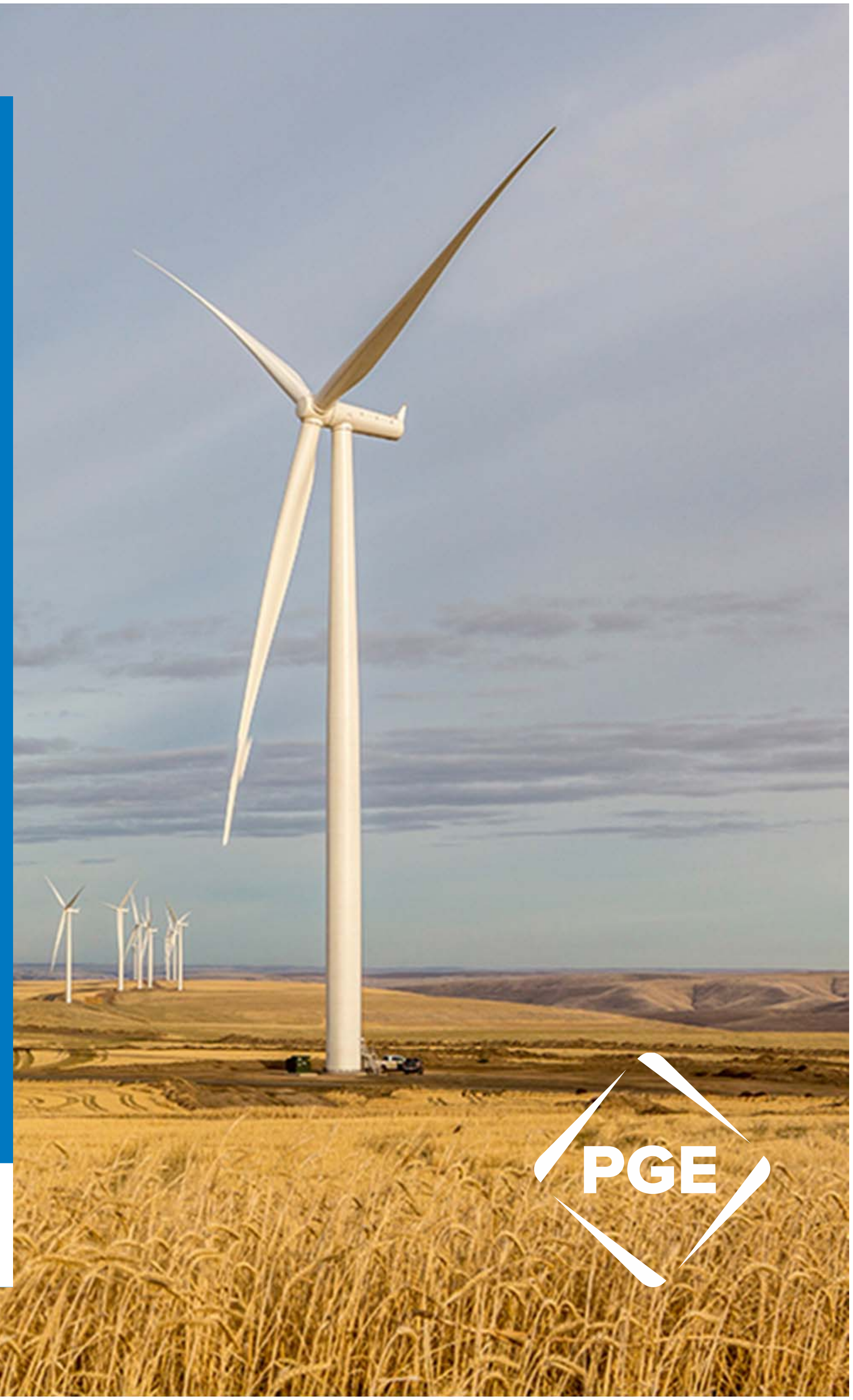
- Stakeholders **provide inputs** regarding their consideration of uncertainties
- **Examples**: priorities, suggestions for treatment in analysis

PGE Analytical Steps

- Apply sensitivities to **need assessments**
- Continue to develop treatment of uncertainties **in portfolio construction**
- Define cost inputs to Aurora to develop **price futures**
- Develop **portfolio evaluation process** across uncertainties

Flexibility Assessment Methodology

Vijay



Mid-term flexibility needs are moderate, but increase as the renewable penetration increases.

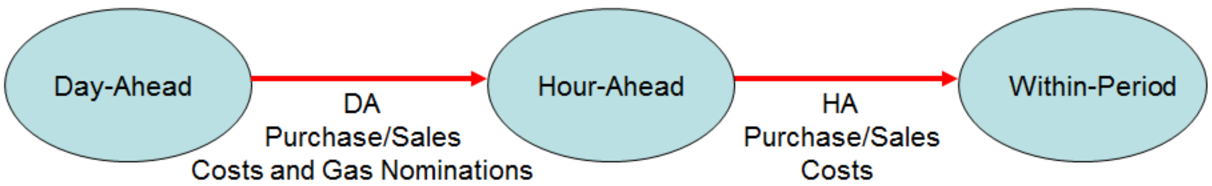
-2016 IRP

Background

- Intermittent nature of renewables coupled with their large forecast errors stress utility system operations, increasing the need for fast ramping and quick start/stop units
- As PGE's portfolio continues to incorporate more renewable resources and capacity contracts to meet state RPS mandate and action plan directives, there is a need to analyze the new flexibility need of PGE portfolio.
- While there is no industry standard methodology for flexibility analysis, PGE intends to build on the learnings from 2016 IRP and make use of internal models to study the flexibility need.

Resource Optimization Model

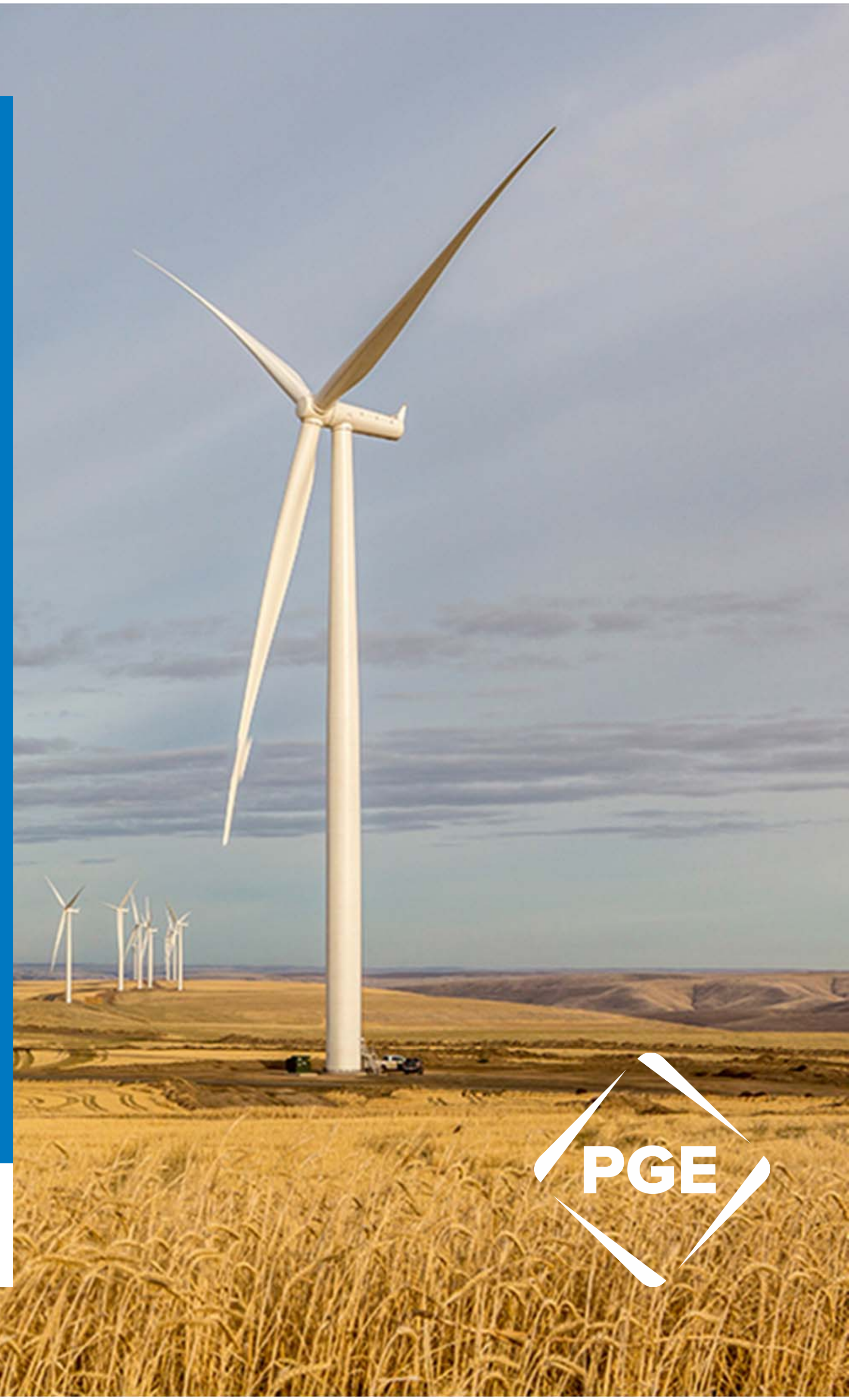
- Originally developed to study wind integration costs as a result of 2009 IRP
- Several iterations with a technical review committee oversight
- A multi-stage unit commitment and economic dispatch model



- Used to support IRP, General Rate Case/Annual Update Tariff proceedings, conduct internal economic analysis.
- Currently scoping the flexibility adequacy analysis , which includes defining
  - Flexibility Metrics
  - Portfolios
  - Market Access

Decarbonization Study

Evolved Energy Research



PGE is interested in understanding multiple pathways to a lower carbon future

Decarbonization Study

- In the 2016 IRP, stakeholders expressed interest in seeing portfolios that meet more aggressive long term GHG targets
  - State of Oregon economy-wide goal: 75% below 1990 levels by 2050
  - City of Portland and Multnomah County resolutions: 100% clean & renewable electricity by 2035; 100% economy-wide clean & renewable energy by 2050
- PGE has engaged a consultant (Evolved Energy Research) to develop three scenarios that meet aggressive carbon emissions targets in PGE's service area by 2050
  - High Electrification
  - Low Electrification
  - High Distributed Energy

Key Questions

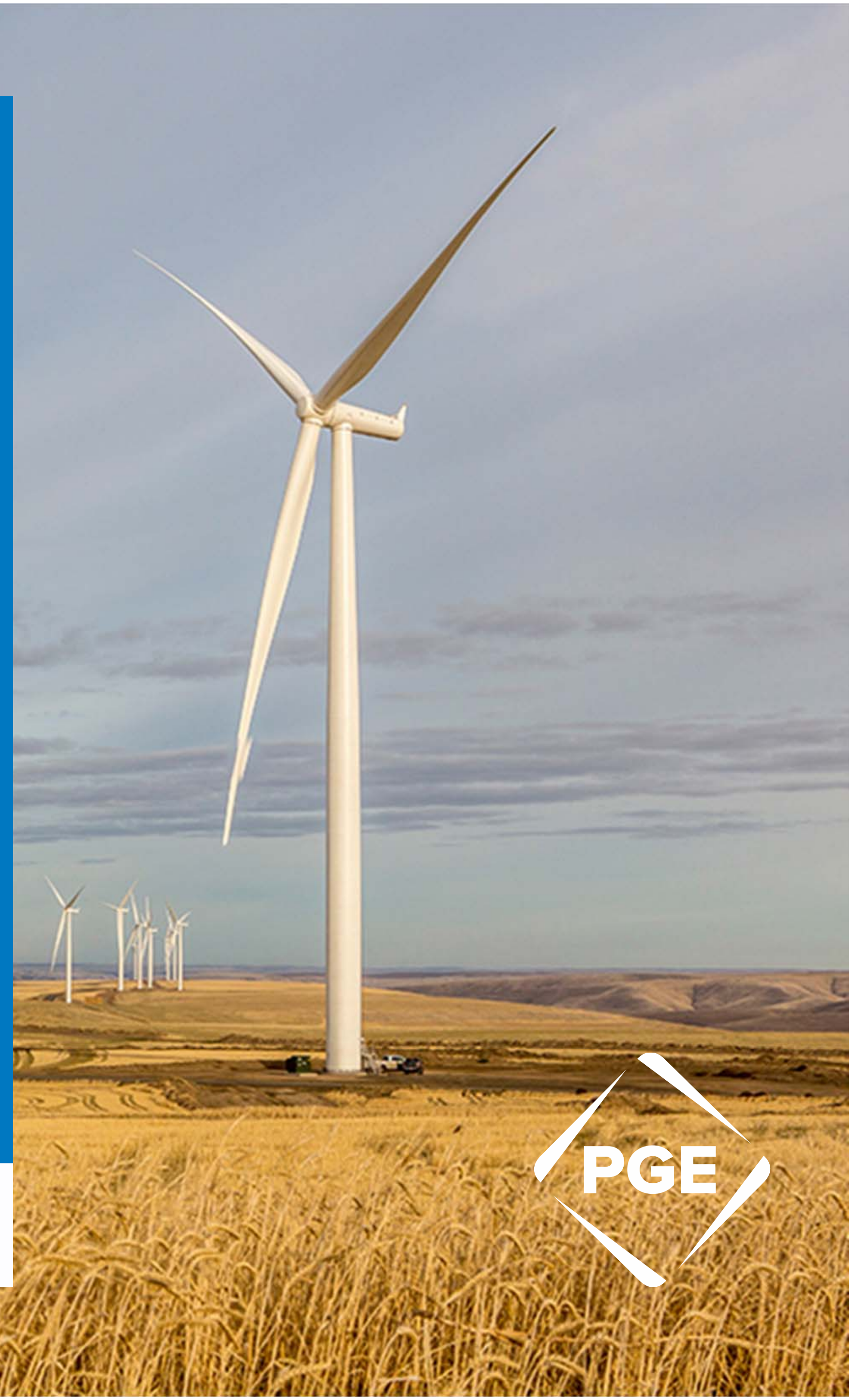
- How might energy services be met in PGE's service area in a decarbonized future?
- What are the potential implications for future electricity demands?
  - Both magnitude and shape of demand
- How much renewable infrastructure will be needed to support economy-wide decarbonization?
- What are the high level balancing challenges and solutions that may be relevant in a highly decarbonized future?
- What are the potential costs to our customers given today's technological outlooks?

Stakeholder Engagement

Consultant to present draft findings to stakeholders <u>today</u>

PGE will seek input from stakeholders regarding how the study findings could be incorporated into the next IRP in <u>a future roundtable meeting</u>

Portland General Electric Decarbonization Study: Summary of Draft Findings



Portland General Electric Decarbonization Study: Summary of Draft Findings

EVOLVED ENERGY RESEARCH

Presented To:
PGE Integrated Resource Planning Roundtable Meeting

Presented By:
Gabe Kwok and Ben Haley

February 14, 2018

Draft

Agenda

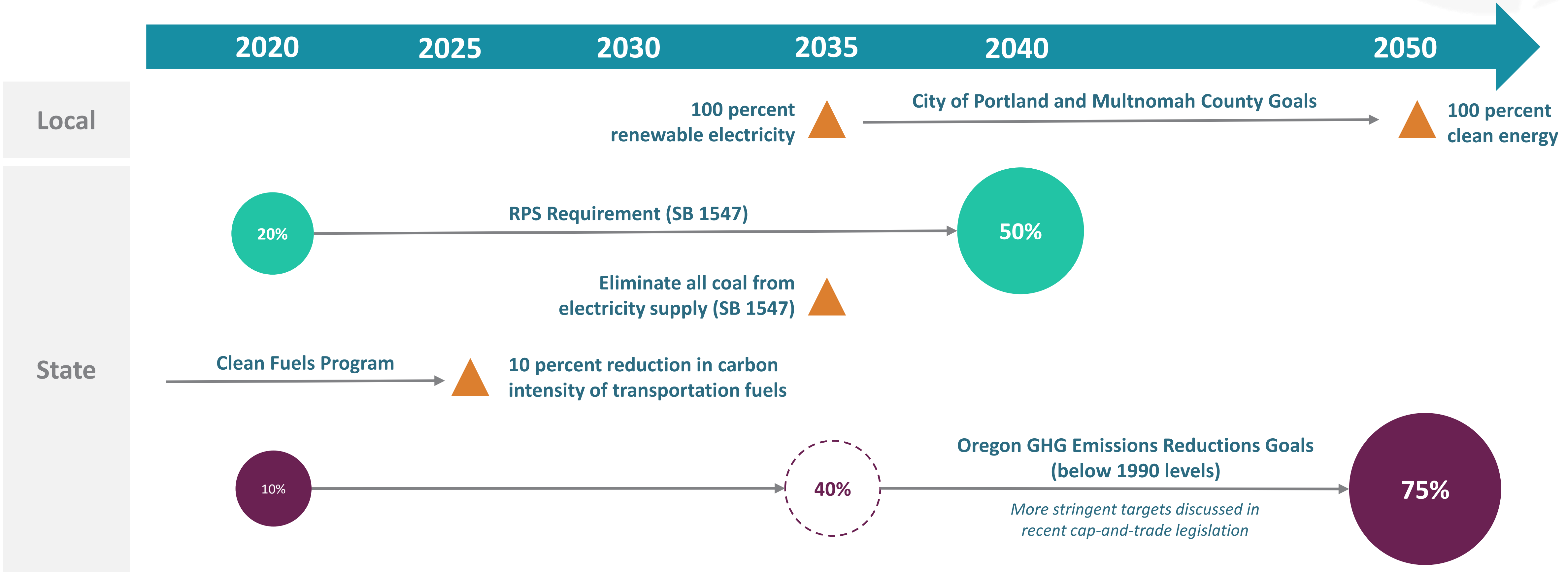
- Study Purpose and Scope
- Assumptions and Approach
- Scenarios
- Results
  - Energy Economy
  - Electricity System
- Study Conclusions

Study Purpose and Scope

Motivation

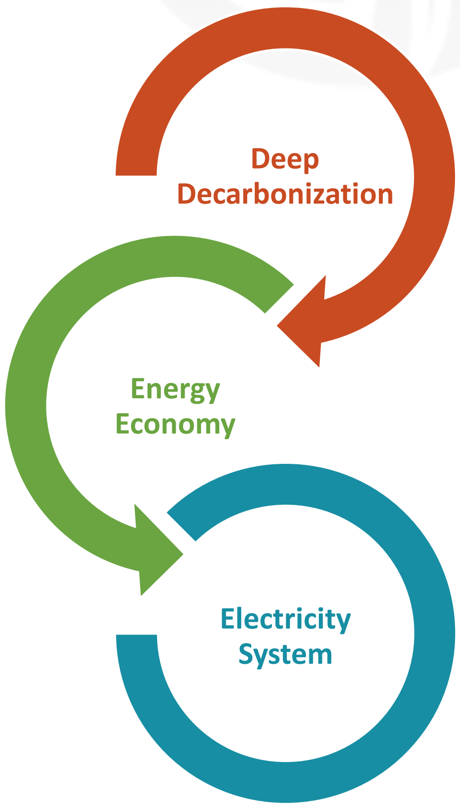
Decarbonization Timeline

Customer and stakeholder feedback, alongside a broad spectrum of goals and policies at all levels, is driving an interest in how to achieve economy-wide decarbonization



Purpose

- Portland General Electric (PGE) commissioned EER to undertake an independent study exploring pathways to deep decarbonization for its service territory
  - First deep decarbonization study for a utility service territory
- Questions posed:
  - What are the opportunities and challenges to achieve economy-wide deep decarbonization?
  - What are the implications on the electricity sector?
- Approach
  - We designed and evaluated three future energy scenarios that achieve steep reductions in energy-related CO_2 emissions



Scope

	Geography	Energy Types	GHG Emissions
✓	**PGE service territory**	**All energy types** (gasoline, hydrogen, etc.)	**Energy-related CO_2** (combustion of fossil fuels)
✗	**Rest of Oregon**	**N/A**	**Non-energy CO_2** (ex., ind. process emissions) **Non-CO_2 GHGs** (ex., CH_4 and N_20)

Interpreting Results: What the Study Is and Is Not

What the Study Is

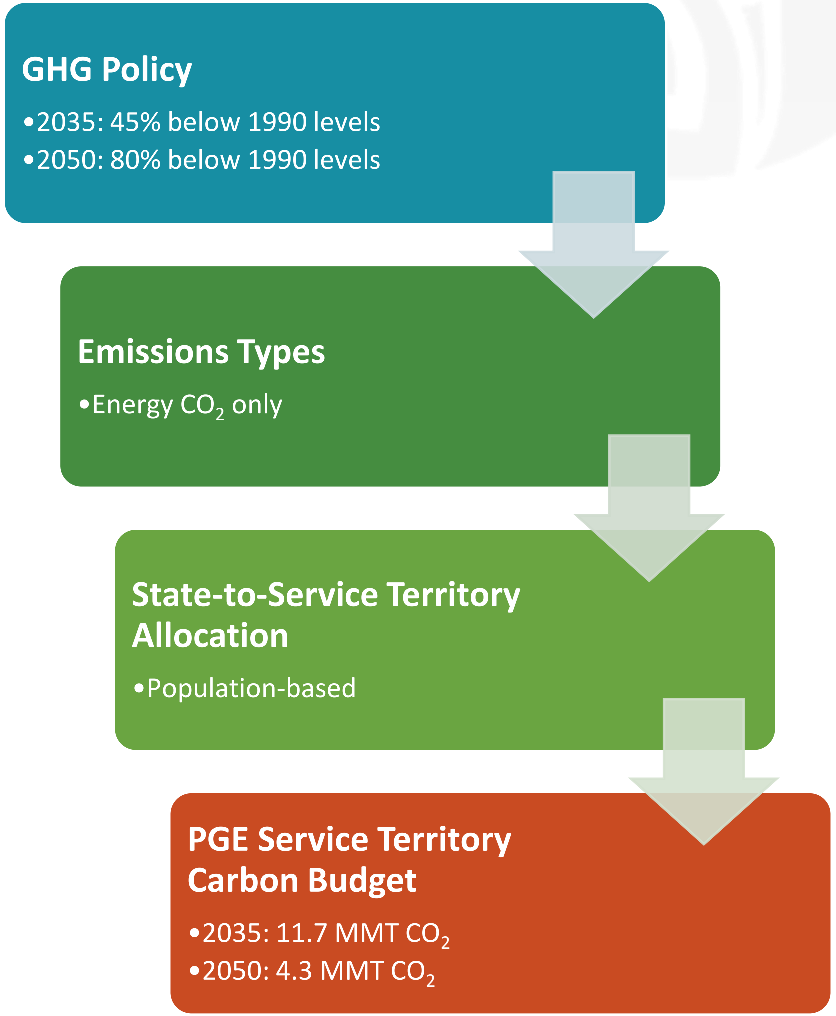
- Independent analysis exploring credible and plausible future energy scenarios
- Study is based on scenario (what-if) analysis
  - Scenario design is a user input
- Scenarios outline potential sources and demands for energy types over time
- Results illustrate different approaches to achieve deep energy-related CO_2 emissions reductions
- Provides insights into how economy-wide change affects electricity planning and operations

What the Study Is Not

- Scenarios are not a forecast of the future
  - We are not predicting future outcomes or assigning probabilities to scenarios
- Scenarios are not prescriptive
  - We are not recommending specific pathways
- Scenarios included in the study are not exhaustive
  - Thousands of plausible alternatives exist
- Scenarios do not reflect PGE's business plan or future resource acquisitions
- Study's modeling approach and results do not replace existing tools or processes used in IRP, cost-effectiveness evaluation, etc.

Study Emissions Targets

- Context is Oregon's on-going GHG cap-and-trade discussions
  - **45% reduction** below 1990 levels by 2035
  - **80% reduction** below 1990 levels by 2050
- Applied emissions reductions only to energy CO_2
- Allocated state-wide budget to PGE service territory using its share of state's population (45-47% of total)
- PGE service territory's carbon budget
  - **11.7** million metric tons (MMT) by 2035
  - **4.3** MMT by 2050
- → Between 1990-2050, per capita energy CO_2 emissions decrease from 16.0 tCO_2 to 1.6 tCO_2/person



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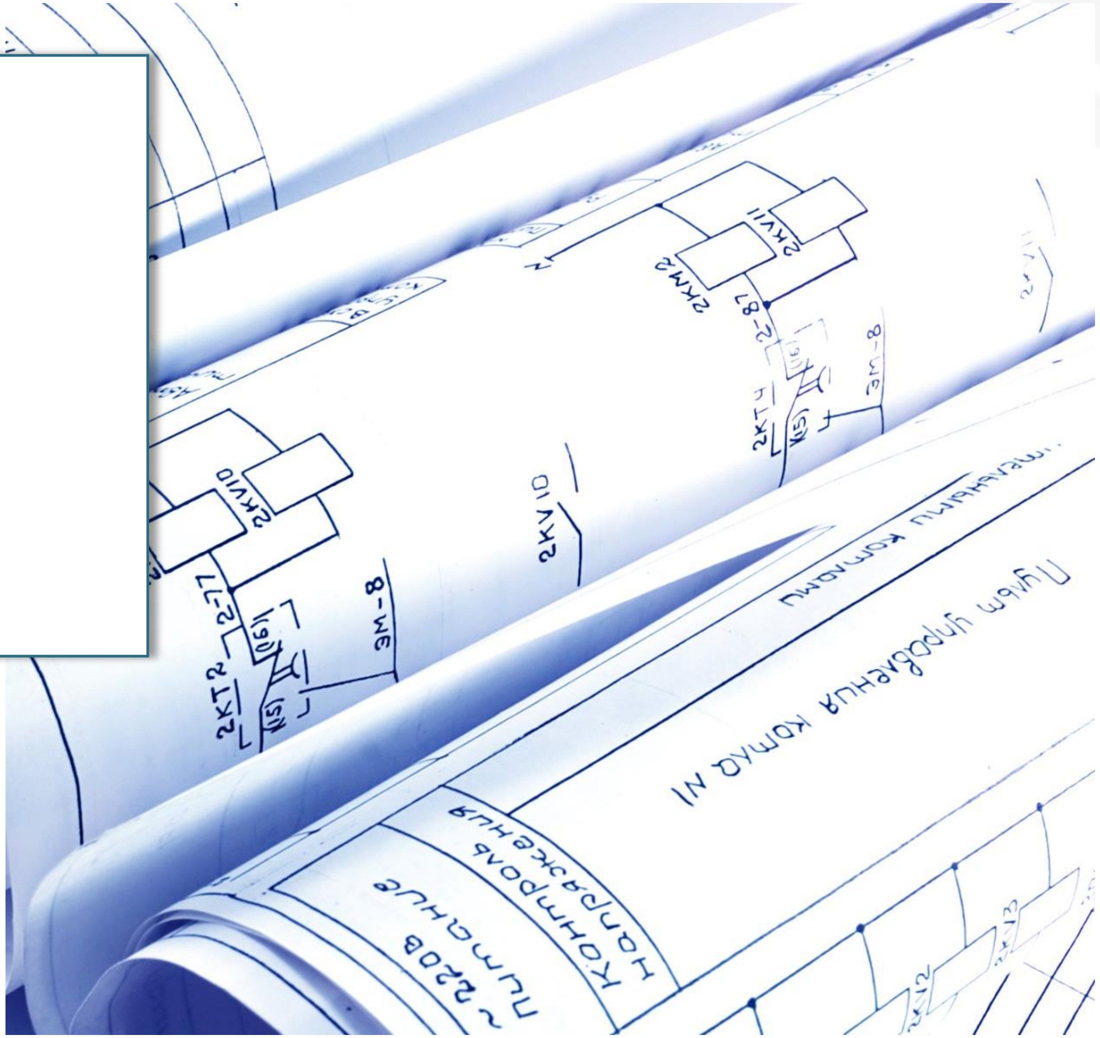
Study Approach and Assumptions

What are Pathways?

Pathway:
Plan or blueprint to achieve deep decarbonization of the energy system

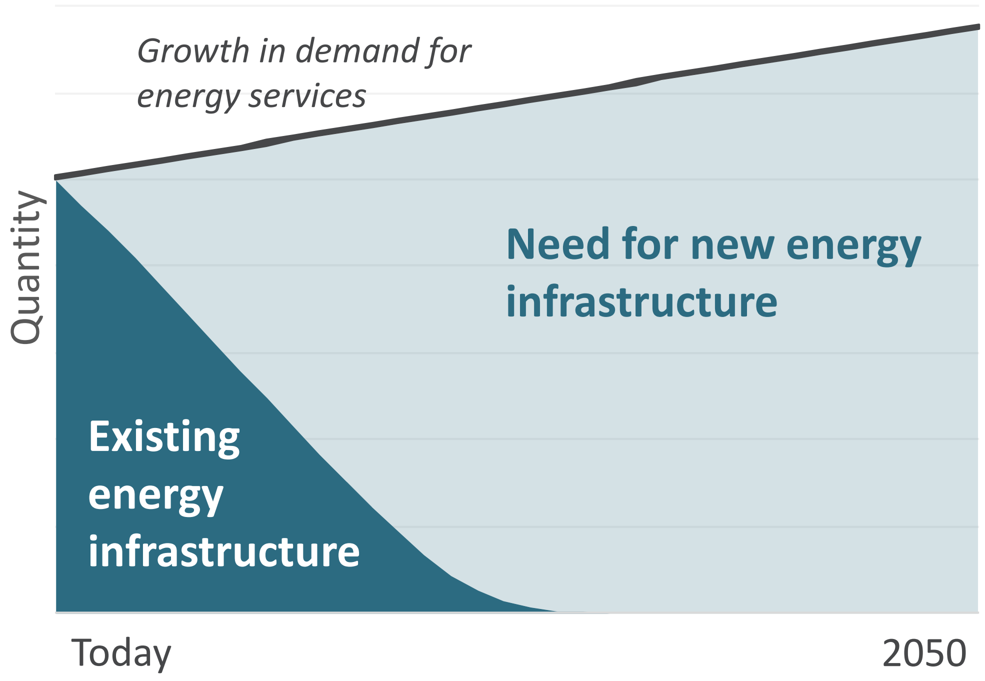


Modeling Approach

- **EnergyPATHWAYS model**
  - Economy-wide energy model that tracks all energy infrastructure, including its demand, emissions and costs
  - Characterizes rollover of infrastructure over time
  - Estimates energy demand from the "bottom-up"
- **Approach to reduce emissions**
  - Specify new low-carbon and efficient infrastructure to replace retiring infrastructure and meet growth in energy service demand
- Model and approach have been used to analyze deep decarbonization for the U.S., Washington State and other jurisdictions

Energy Infrastructure

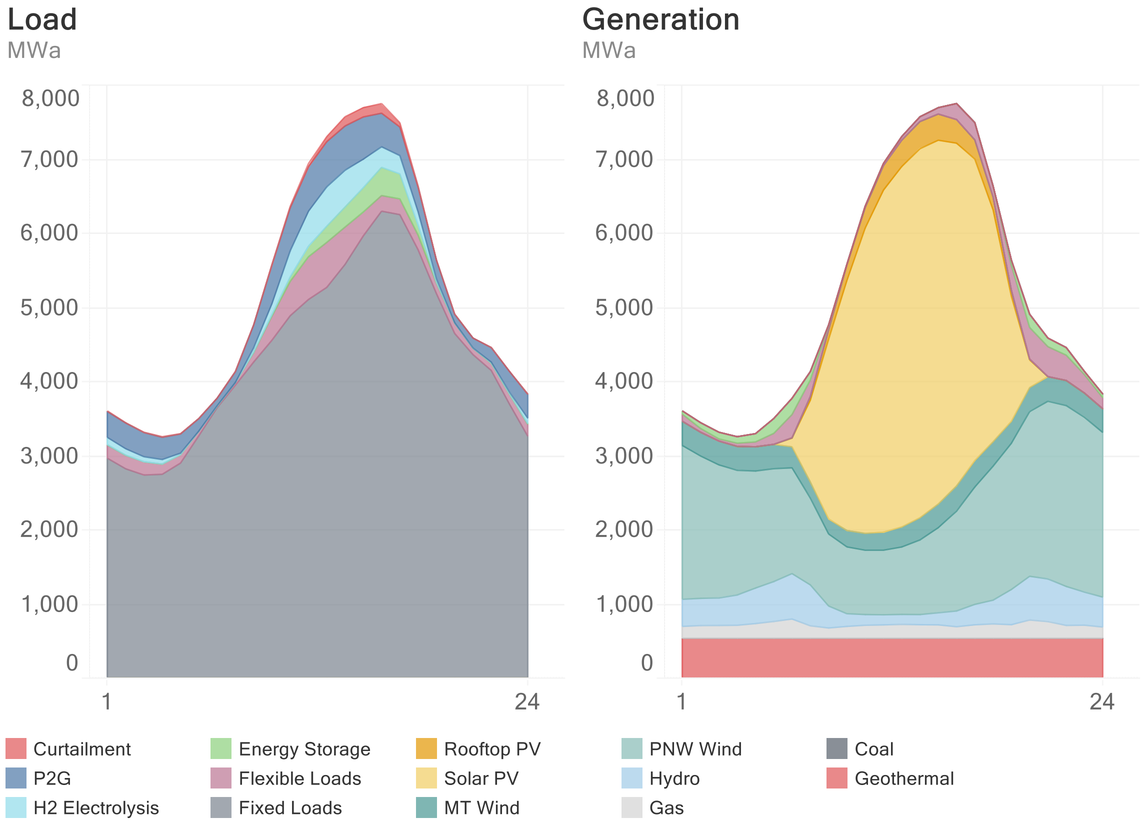
(includes energy supply and distribution equipment, buildings and end-use equipment)



EnergyPATHWAYS Electricity Dispatch

- **Bottom-up load shape**
  - Accounts for electrification
- **Hourly electricity dispatch**
  - Thermal resources
  - Dispatchable hydro resources
  - Energy storage
  - Flexible end-use demand
    - Automated load shifting
    - Examples: smart EV charging and water heating
  - Flexible electric fuel production
    - Load from electrolysis to produce hydrogen and power-to-gas facilities to produce SNG

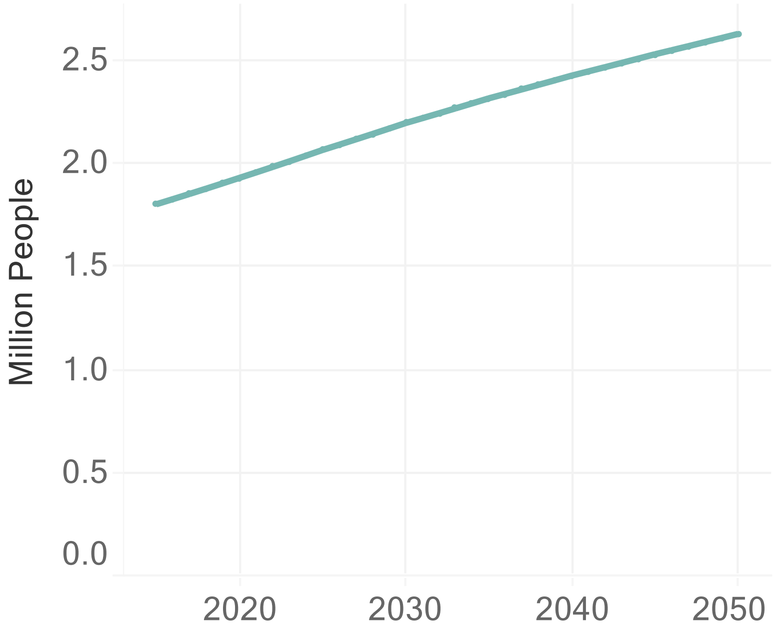
Illustrative Dispatch



Key Assumptions

- **Consistent activity levels**
  - Population and economic activity continue to grow
  - Deliver the same level of energy services
- **Natural stock rollover**
  - Energy infrastructure and equipment is replaced at the end of its natural life
  - There are no early retirements
- **Realistic technology deployment**
  - Use commercial or near-commercial technologies
- **Power system reliability**
  - Hourly dispatch to ensure adequate capacity
- **Environmental sustainability**
  - Limit the supply of biomass for energy use

Projected Population of PGE's Service Territory



Bioenergy for Liquid Fuels and Pipeline Gas

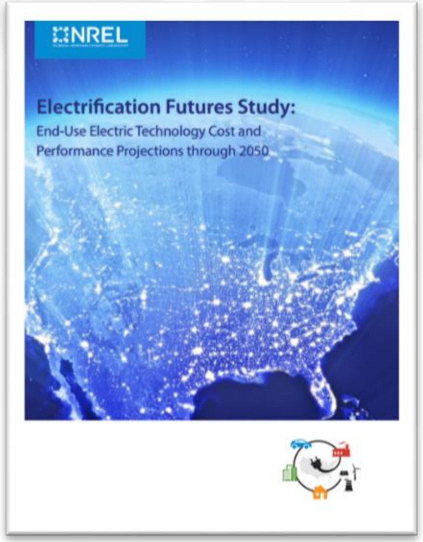
- Biomass is key to deep decarbonization due to its versatility
  - Can directly replace fossil fuels
- Supply of net-zero carbon biomass is scarce
  - Source for availability and cost of sustainable biomass is U.S. DOE's 2016 Billion-Ton Report

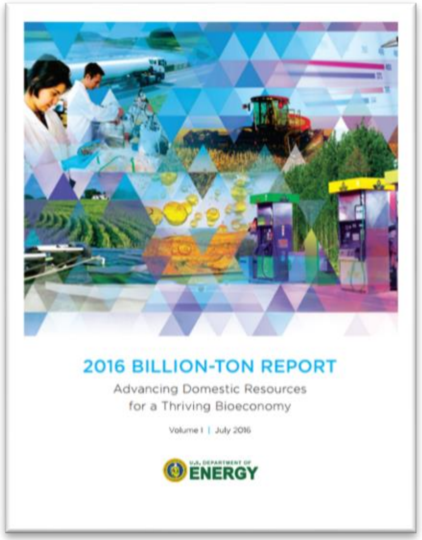
Assumption	Implication
• PGE service territory's allocation of net-zero biomass is its population-weighted share of national supply	• Biomass limit is 7.3 million dry tons (MDT), which is ~450 million gallons diesel fuel
• Biomass feedstock is net-zero carbon	• Biofuels have very low emissions rates, with some emissions from non-bioenergy use in conversion/refining
• Other jurisdictions in the U.S. pursue similar biomass-related actions	• Cost of producing and consuming biofuels reflects movement up the supply curve

Data Sources

Compiled data from recent publicly-available sources

Category	Source(s)
Electricity Resource Technologies	• PGE Integrated Resource Plan (DNV GL) • NREL Annual Technology Baseline 2017 • EIA Form 923
End-Use Technologies	• Input data for EIA's National Energy Model System (NEMS) used to produce Annual Energy Outlook (AEO) • NREL Electrification Futures Study: End-Use Electric Technology Cost and Performance Projections
Existing Building Stock	• PGE Residential Appliance Saturation Study • Northwest Energy Efficiency Alliance (NEEA) Residential and Commercial Building Stock Assessment reports
Fossil Fuel Prices	• EIA AEO 2017
Miscellaneous	• System load profiles: FERC Form 714 • Oregon vehicle miles traveled: 2017 Oregon Highway Cost Allocation Study • Population projection: Oregon Office of Economic Analysis • Bioenergy supply cure: DOE 2016 Billion-Ton Report

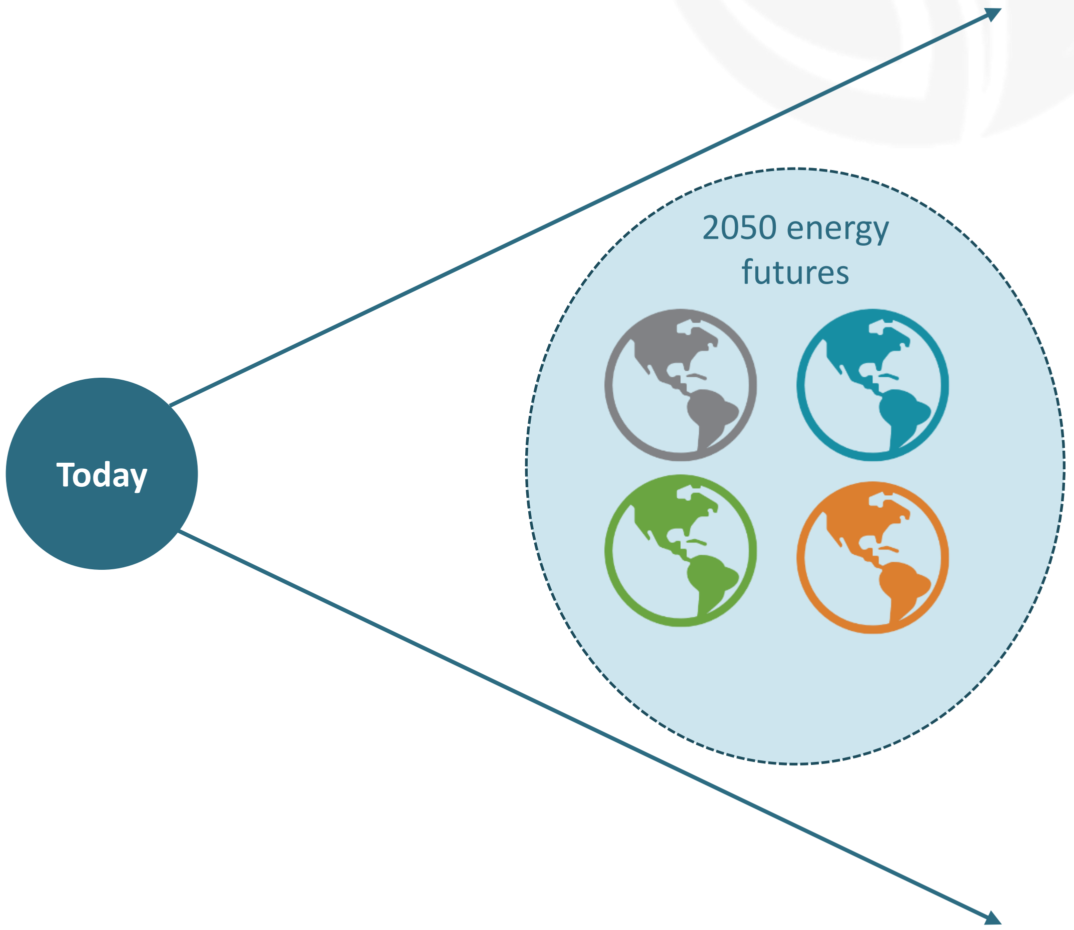




Scenarios

Overview

- Designed three energy scenarios that transition towards a low carbon future
  - These scenarios are referred to as **deep decarbonization pathways**
- Key objective of scenario design is to reflect broad range of outcomes for the electricity system
- Also developed a Reference Case to compare the three pathways against



Scenarios

Reference

A continuation of current and planned policy, and provides a benchmark against the deep decarbonization pathways

High Electrification

Fossil fuel consumption is reduced by electrifying end-uses to the extent possible and increasing renewable electricity generation

Low Electrification

Greater use of renewable fuels, notably biofuels and synthetic electric fuels, to satisfy energy demand and reduce emissions

High DER

Distributed energy resources proliferate in homes and businesses, which also realize higher levels of electrification

Electricity Resource Assumptions

Values by 2050 Unless Specified Otherwise

<table>
<tr><th></th><th></th><th>High Electrification</th><th>Low Electrification</th><th>High DER</th></tr>
<tr><td rowspan="6">Electricity Supply</td><td>Coal</td><td colspan="3">Boardman ceases operations by end of 2020; Colstrip 3&4 out of resource mix by 2035</td></tr>
<tr><td>Gas</td><td colspan="3">Maintain current fleet</td></tr>
<tr><td>Hydro</td><td colspan="3">Extend projected hydro contracts through 2050 (933 MW); additional 23 MW of small hydro</td></tr>
<tr><td>Geothermal</td><td colspan="3">500 MW addition</td></tr>
<tr><td>Utility-scale Wind and Solar PV</td><td colspan="2">75% electricity generation; includes onshore wind in PNW and Montana & solar PV in central OR; MW varies with load requirements</td><td>67% electricity generation</td></tr>
<tr><td>BTM Solar PV</td><td colspan="2">405 MW_{ac}</td><td>2,550 MW_{ac}</td></tr>
<tr><td rowspan="4">Balancing Resources</td><td rowspan="2">Energy Storage</td><td colspan="3">Proposed energy storage resources (36 MW / 160 MWh)</td></tr>
<tr><td>1,000 MW of bulk 8-hour storage</td><td>No additional</td><td>2,550 MW of dist. 6-hr storage</td></tr>
<tr><td>Flexible Electric Fuel Loads</td><td>Excluded</td><td>Hydrogen (H2) electrolysis & power-to-gas (P2G) production facilities</td><td>Excluded</td></tr>
<tr><td>Flexible End-use Loads</td><td colspan="3">Portion of electric load from select end-uses is flexible (ex., smart EV charging and water heating)
Capability varies depending on the level of end-uses that are electrified</td></tr>
</table>

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Summary of Key Scenario Assumptions

Primary Technology or Approach by 2050

		High Electrification and High DER	Low Electrification
Energy Supply	**Pipeline Gas**	No change	Decarbonized with renewable natural gas (RNG), hydrogen (H2) and synthetic natural gas (SNG)
	Liquid Transportation Fuels	Renewable diesel and jet fuel	Renewable diesel and jet fuel
Buildings	**Space Conditioning**	Air source heat pump	High efficiency gas furnace High efficiency air conditioner
	Water Heating	Heat pump water heater	High efficiency gas water heater
	Lighting	LED	LED
	Other Appliances (clothes washer, refrigerator, etc.)	Best available technology	Best available technology
Industry	**Process Heat**	Partial electrification	No change
Transportation	**Passenger Vehicles**	90% battery electric vehicle (BEV); 10% plug-in hybrid electric vehicle (PHEV)	90% battery electric vehicle (BEV); 10% hydrogen fuel cell vehicle (HFCV)
	Freight Trucks	50% electric 50% hybrid diesel truck	50% electric 50% liquefied & compressed gas (LNG/CNG)

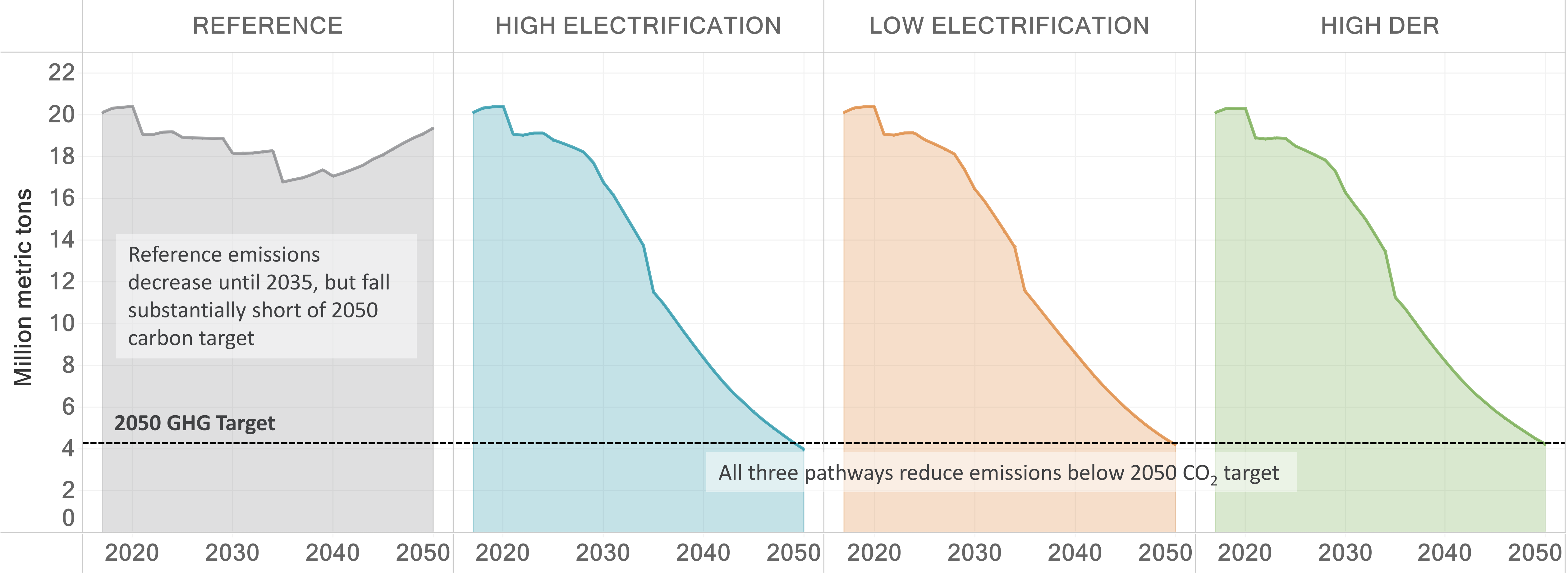
Results

Energy Economy

Energy-related CO_2 Emissions

Million metric tons

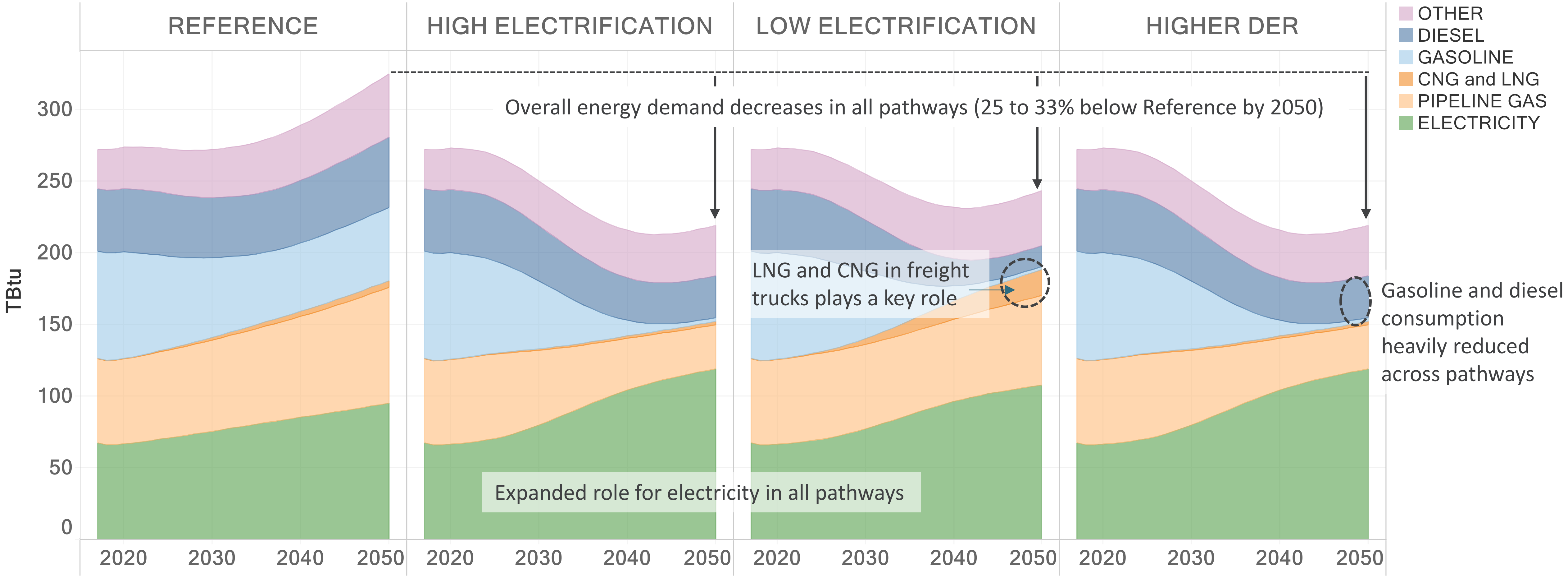
Includes emissions for the entire energy system and is not limited to power generation



Final Energy Demand

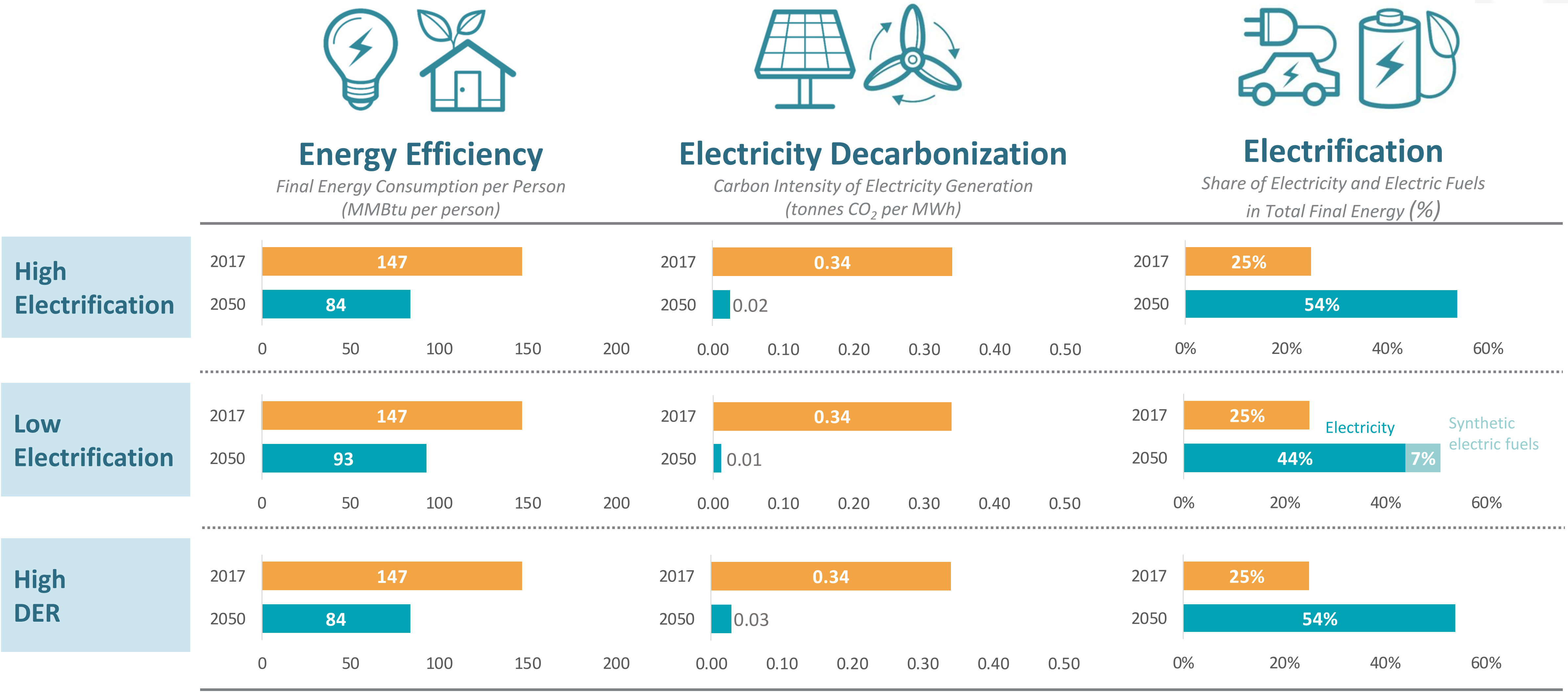
Trillion Btu (TBtu)

Final energy: energy used in the delivery of services such as heating or transportation and excludes energy consumed in converting to other forms of energy



Note: "Other" includes final energy types such as jet fuel, liquefied petroleum gas (LPG), biomass, steam, etc.

Three Pillars of Deep Decarbonization



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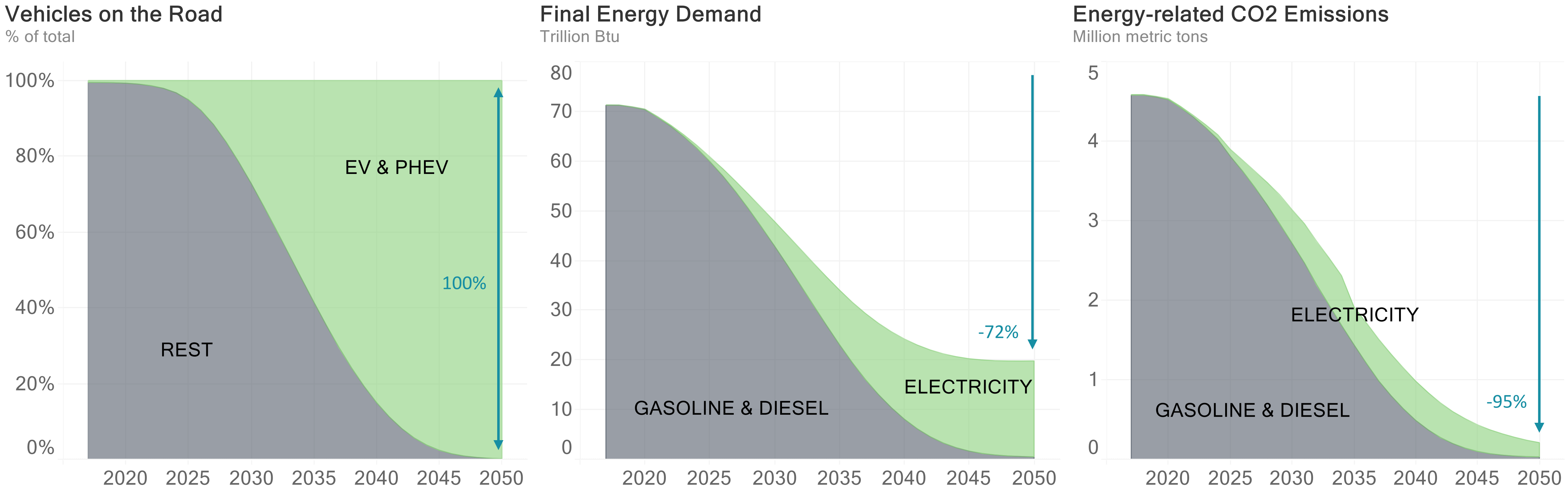
Three Pillars in Action: Passenger Transportation

High Electrification Pathway

Pillar: Electrification
Transition vehicles on the road from gasoline-powered internal combustion engine to battery electric and plug-in hybrid electric vehicles

Pillar: Energy Efficiency
70 percent decrease in energy consumption since battery electric powertrains are more efficient than an internal combustion engine

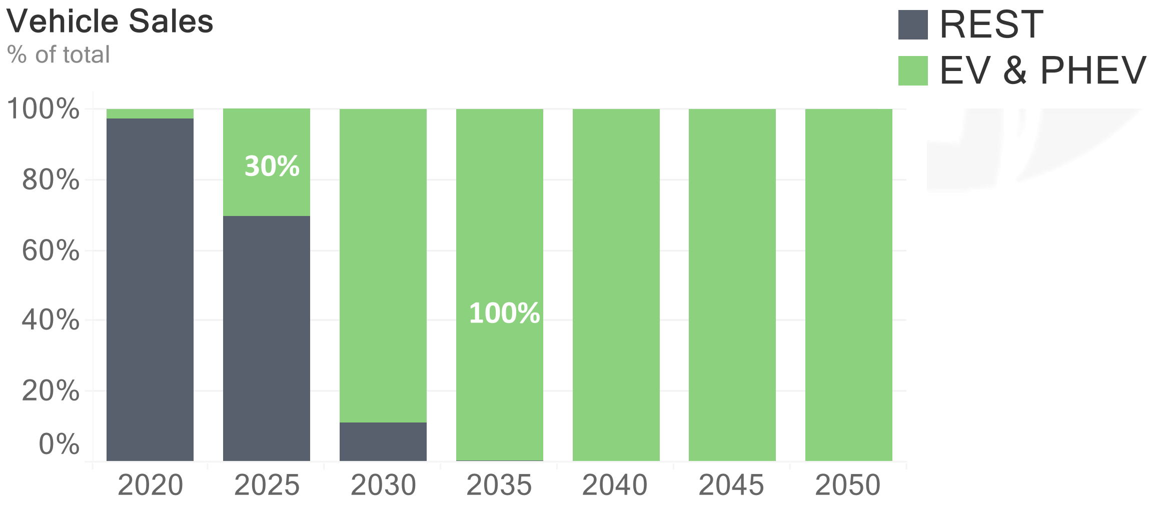
Pillar: Electricity Decarbonization
Charging electric vehicles on a low carbon electricity grid decreases overall passenger transportation emissions by 95 percent

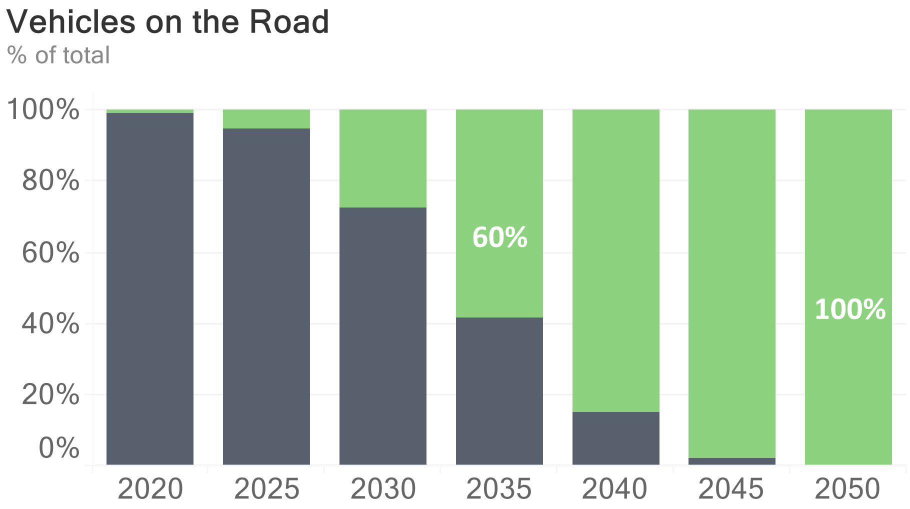


Passenger Transportation Electrification

High Electrification Pathway

- Our pathways assume **100 percent of vehicle sales** are zero emissions vehicles (ZEV) **by 2035**
  - 90 percent battery electric vehicle (BEV) in all pathways
  - Remaining 10 percent is plug-in hybrid electric vehicle (PHEV) or hydrogen fuel cell vehicle (HFCV)
- Vehicle fleet turnover lags sales
  - Share of vehicles on the road is not 100 percent until 2050





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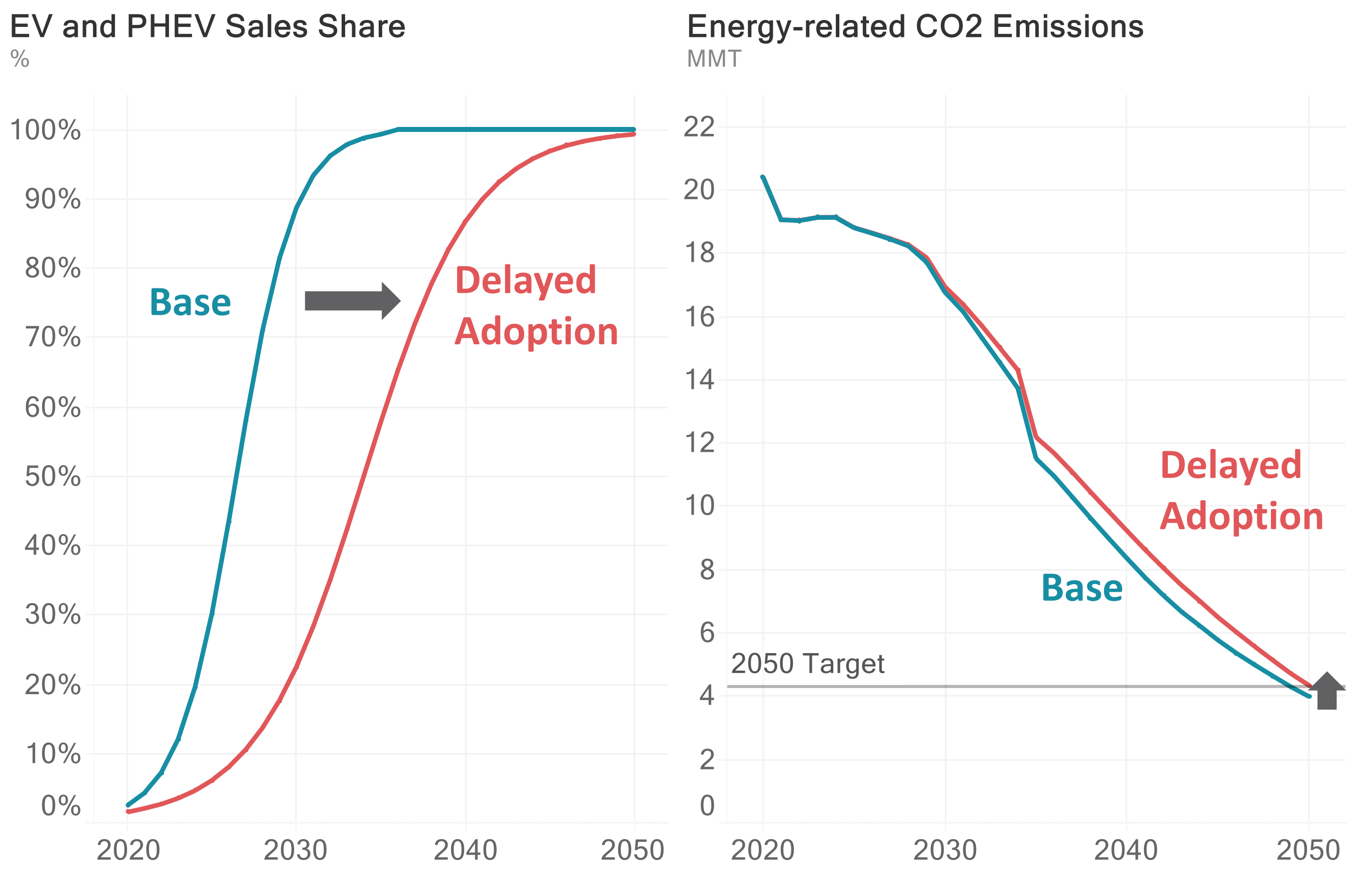
Impact of Delayed Adoption

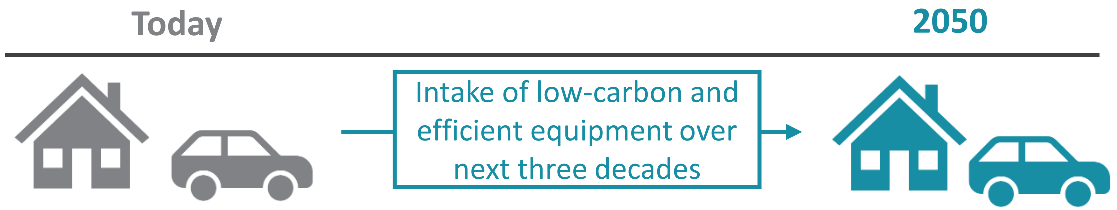
High Electrification Pathway Sensitivity

- We assessed the impact of delaying the assumed year of 100 percent ZEV adoption from 2035 to 2050
- Pathway no longer complies with the study's GHG targets
  - More than 10 percent of cars/trucks on the road in 2050 still consume petroleum

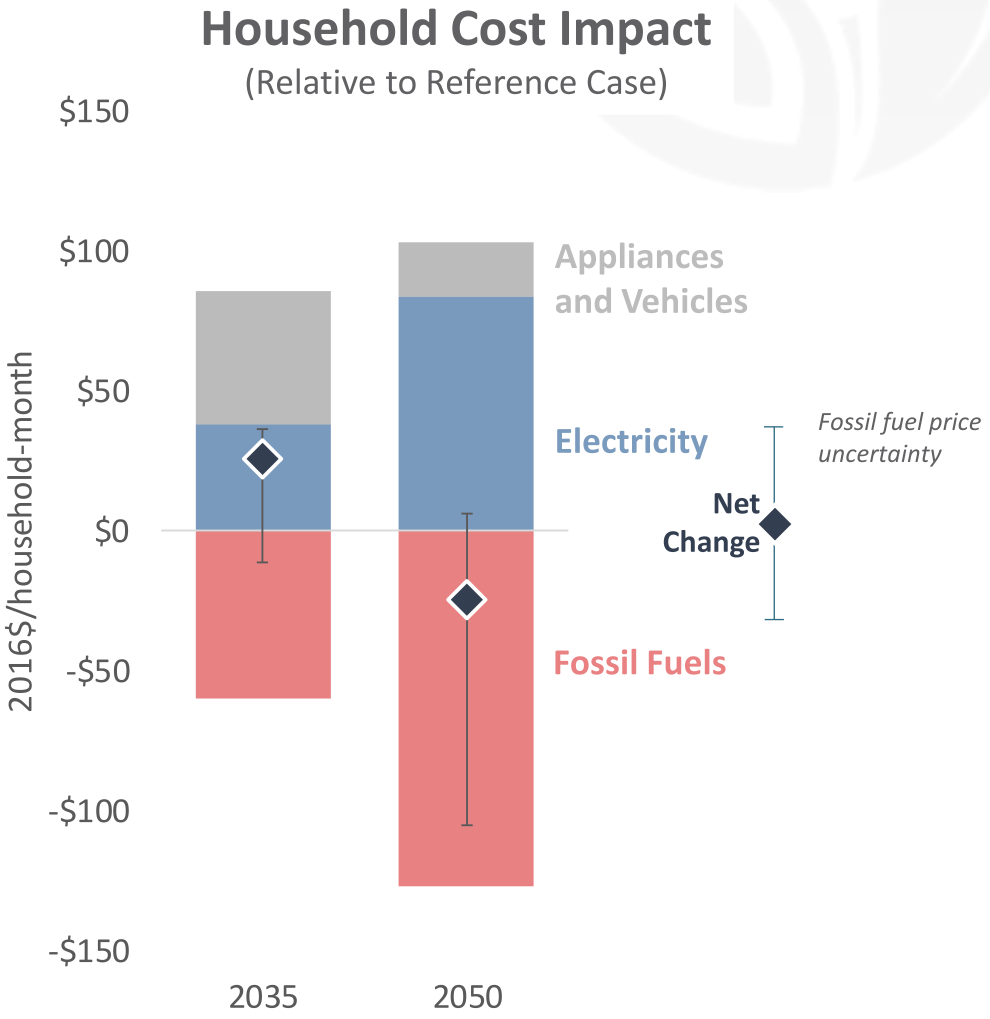


Structure of Household Energy Costs Changes

High Electrification Pathway, 2016$ per household per month



- Estimate of the change in average household costs per month
  - Includes appliances, light-duty vehicles, and home energy costs
  - Excludes economic benefits from avoiding climate change and air pollution
- Change in spending reflects energy system transformation: more on technology, less on fossil fuels
- Error bars reflect range in net cost from fossil fuel price uncertainty



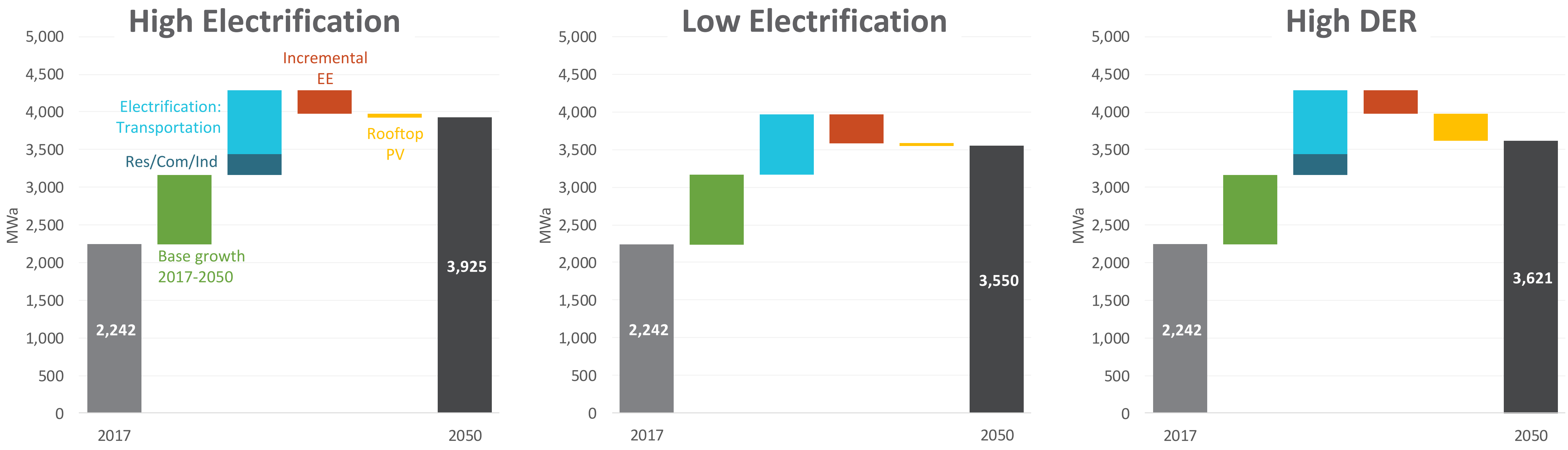
Results

Electricity System

Evolution of Retail Electricity Sales from Today to 2050

Average Megawatts (MWa)

- Retail sales increase by **60-75%** relative to today
- Transportation electrification is responsible for **50-60%** of the net increase



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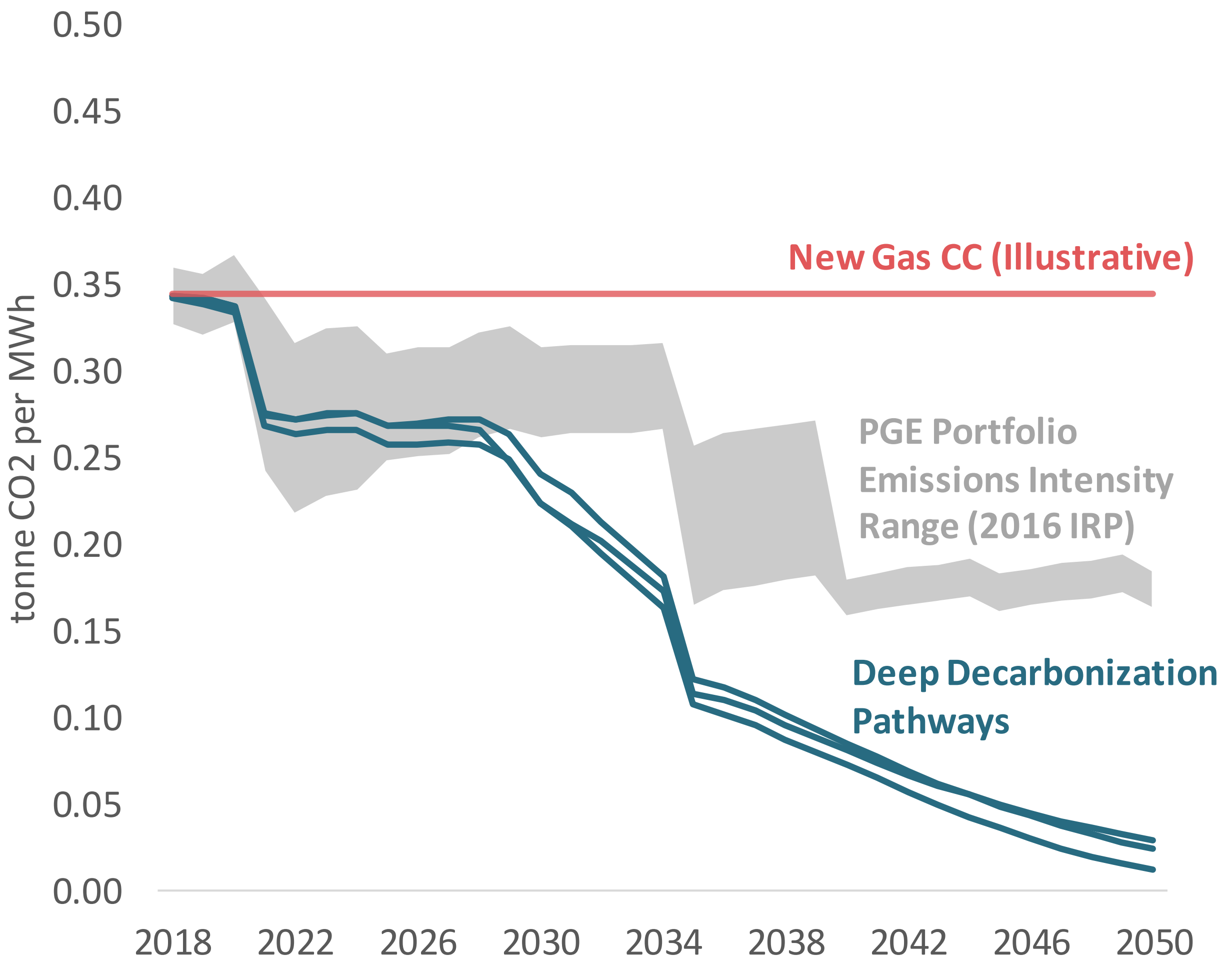
Emissions Intensity of Electricity Generation

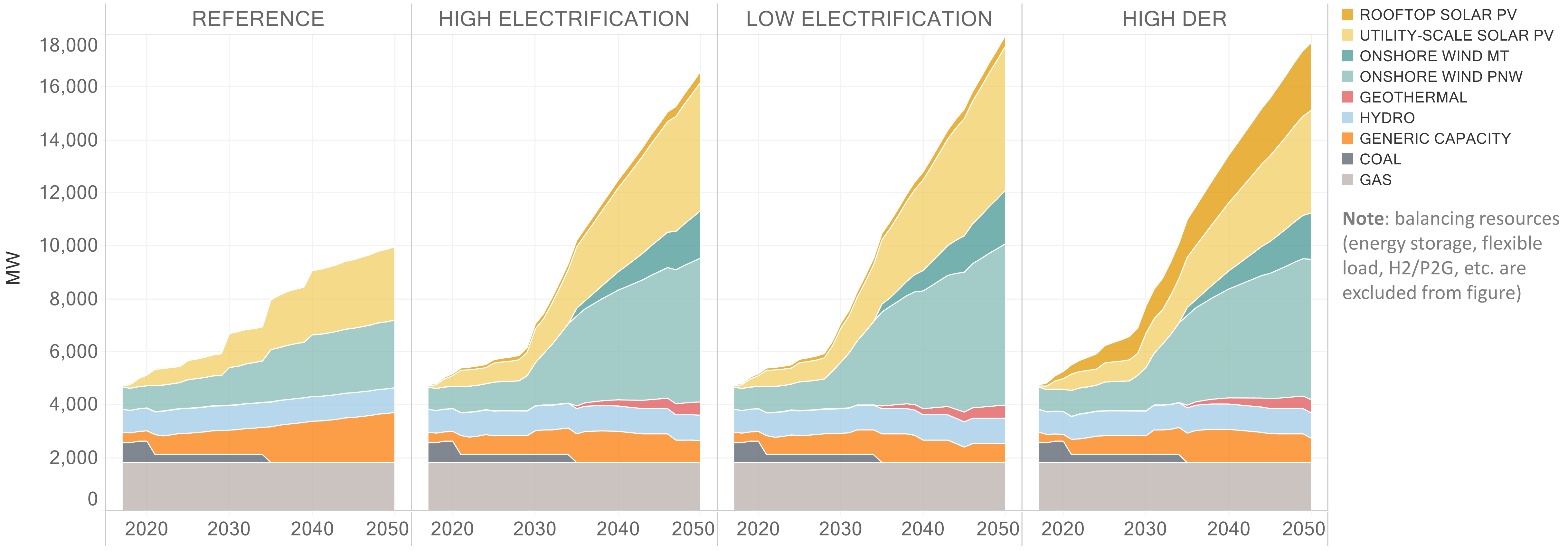
Tonnes CO_2 per MWh of generation



Installed Generation Capacity

MW

Capacity of renewables is 1.5x Reference Case levels by 2035 and more than 2.0x by 2050



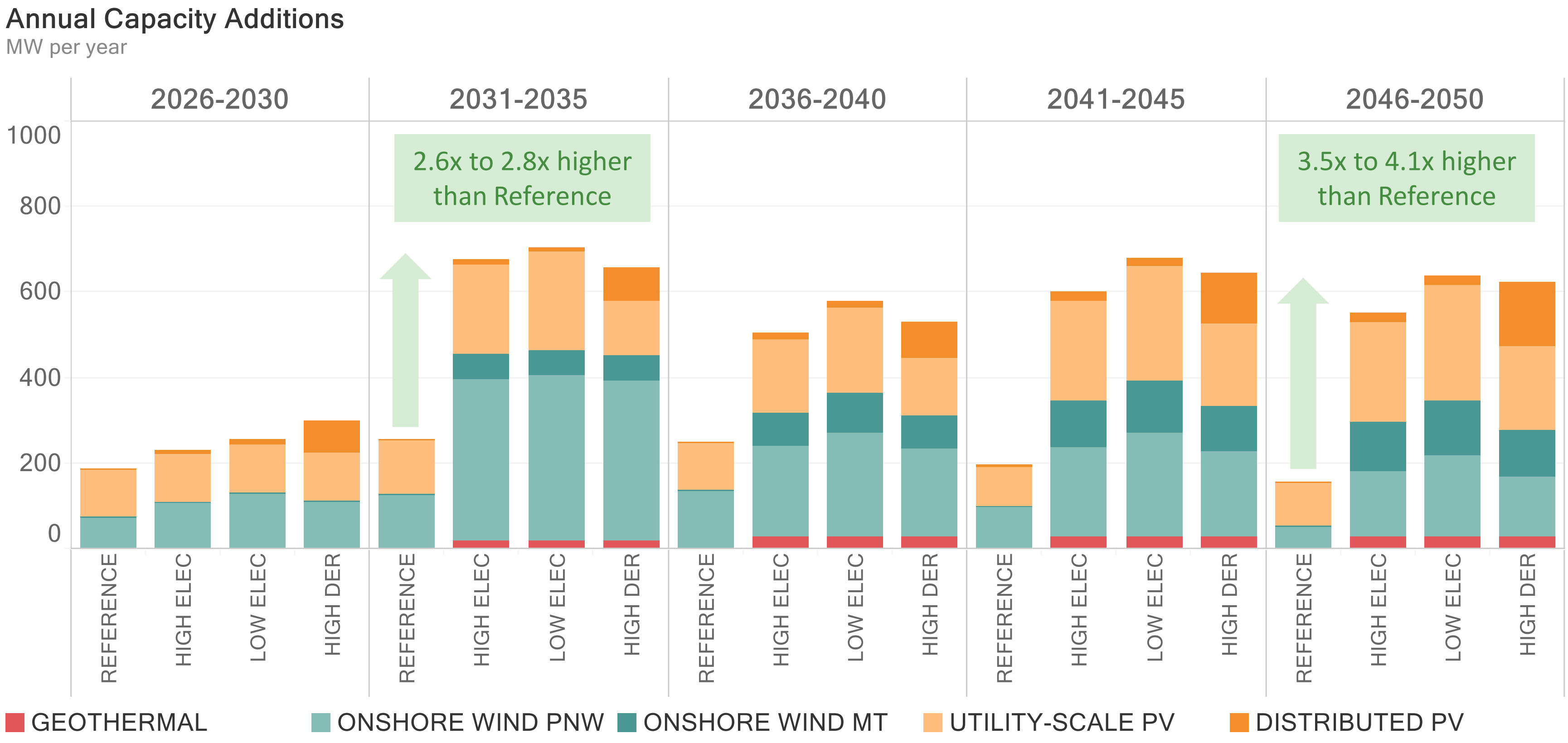
Note: balancing resources (energy storage, flexible load, H2/P2G, etc. are excluded from figure)

Annual Average Renewable Capacity Additions

MW per year

Average renewable capacity additions are approximately **600 MW per year** between 2030 and 2050

Starting in 2030, the quantity of new onshore wind is equivalent to **one to two Tucannon River (267 MW)** wind power plants installed *each year*



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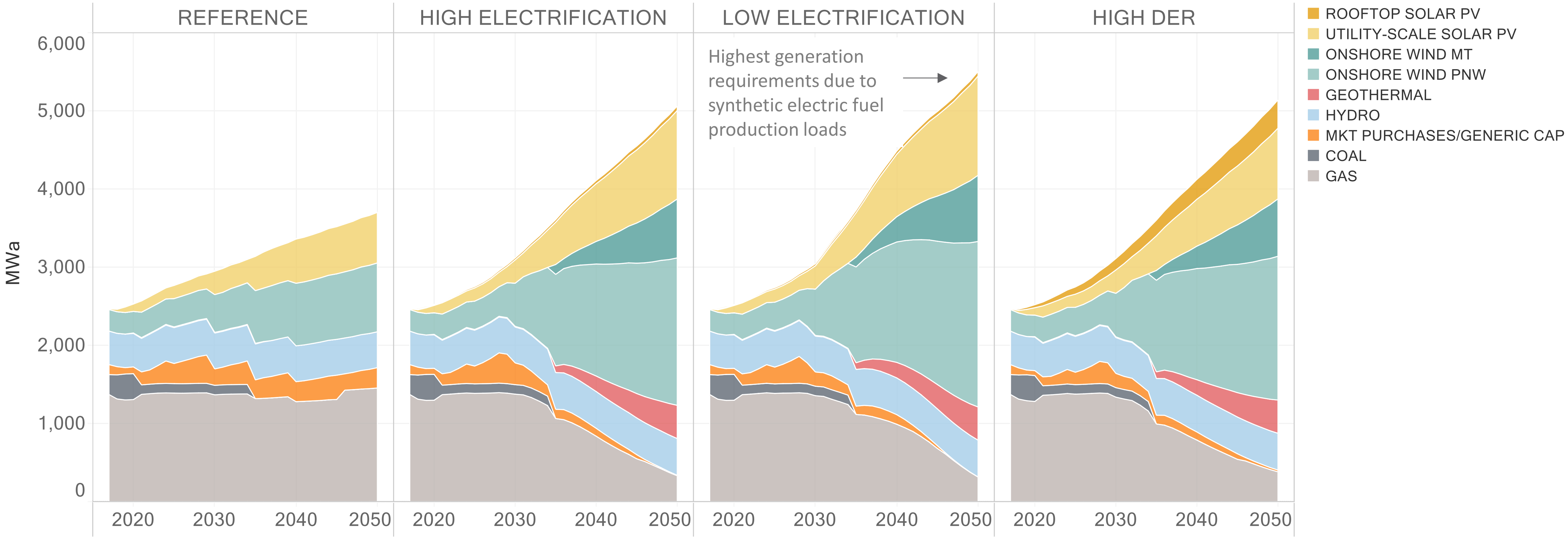
Electricity Generation

MWa

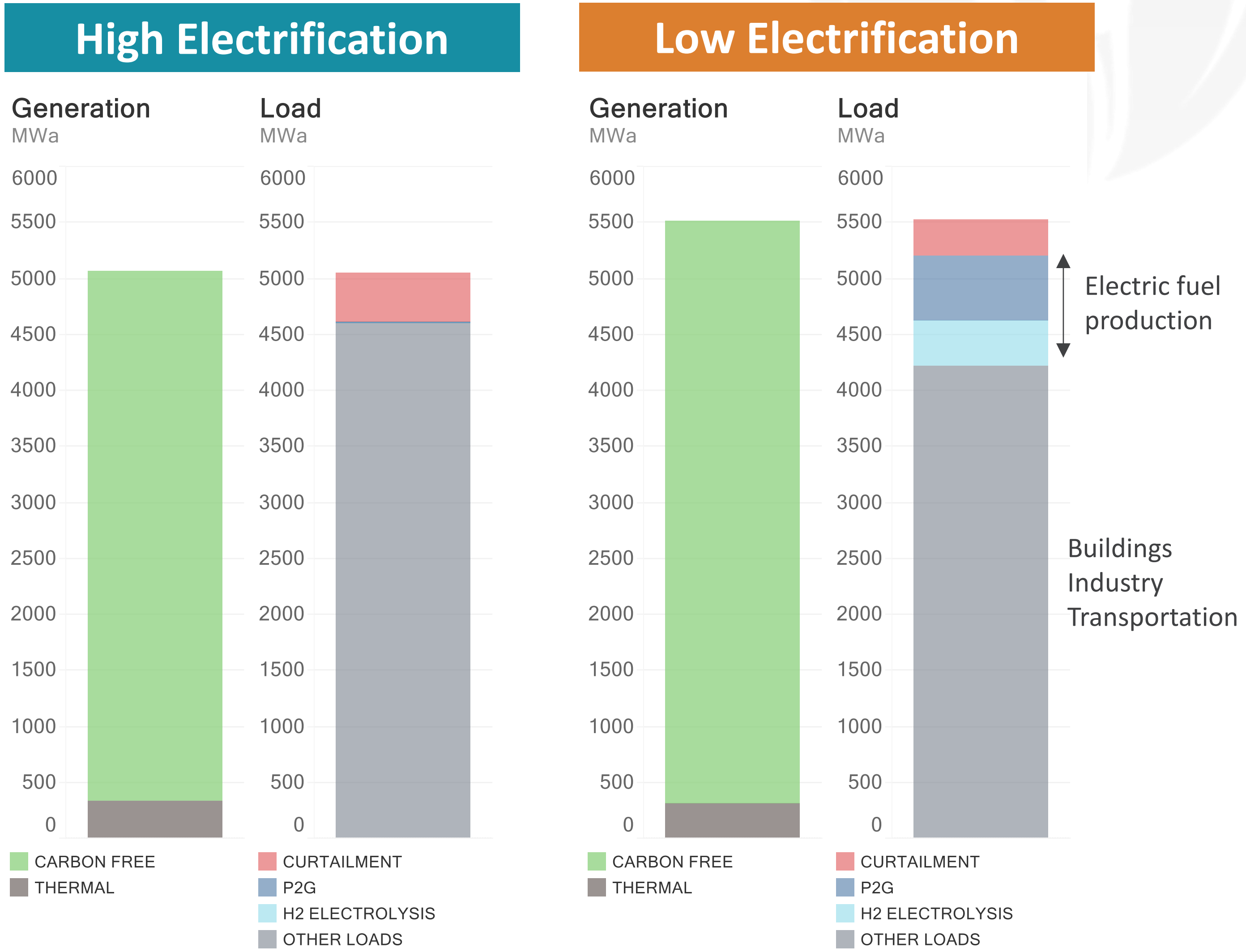
Generation requirements double relative to today
Two-thirds carbon-free by 2035 and 90%+ by 2050



Energy Balance in 2050: Where Electricity Generation is Consumed

Average Megawatts (MWa)

- Low Electrification pathway
  - Lowest retail energy deliveries
  - Highest electricity generation requirements to supply transmission-connected electrolysis and P2G facilities
- For illustration, the portion of generation that is curtailed is accounted for as a “load” to balance supply and demand



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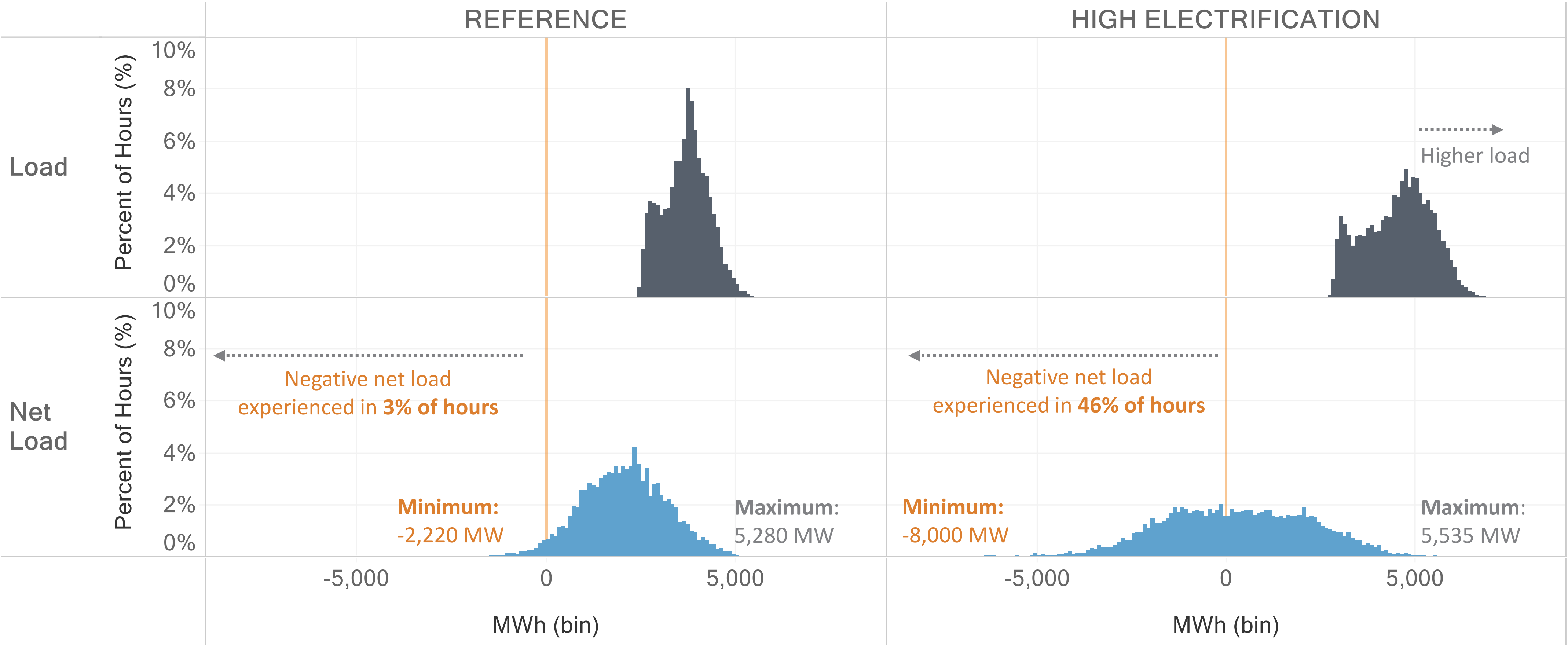
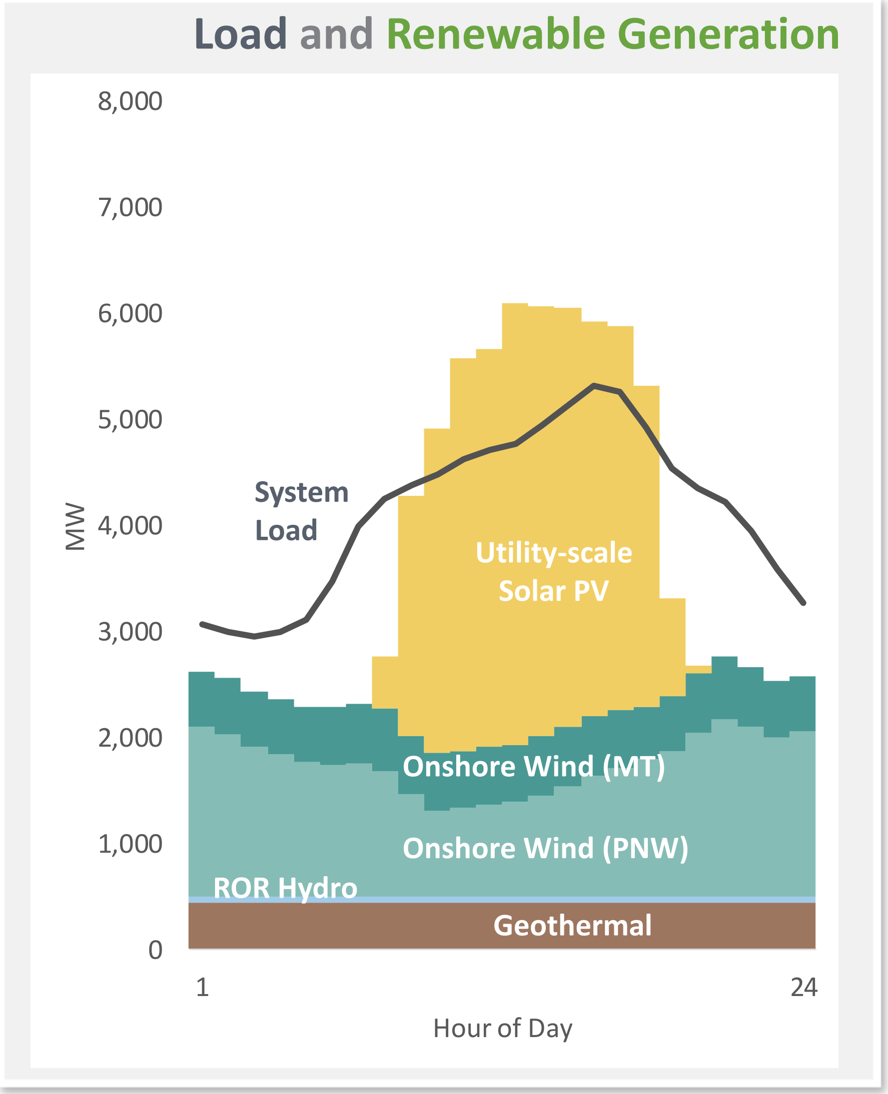
Distribution of Hourly Load and Net Load in 2050

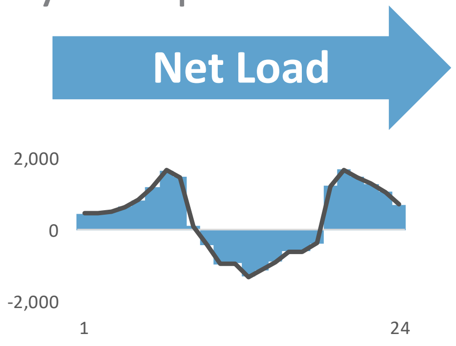
Net Load = Load − Wind/Solar/Geothermal/ROR Hydro

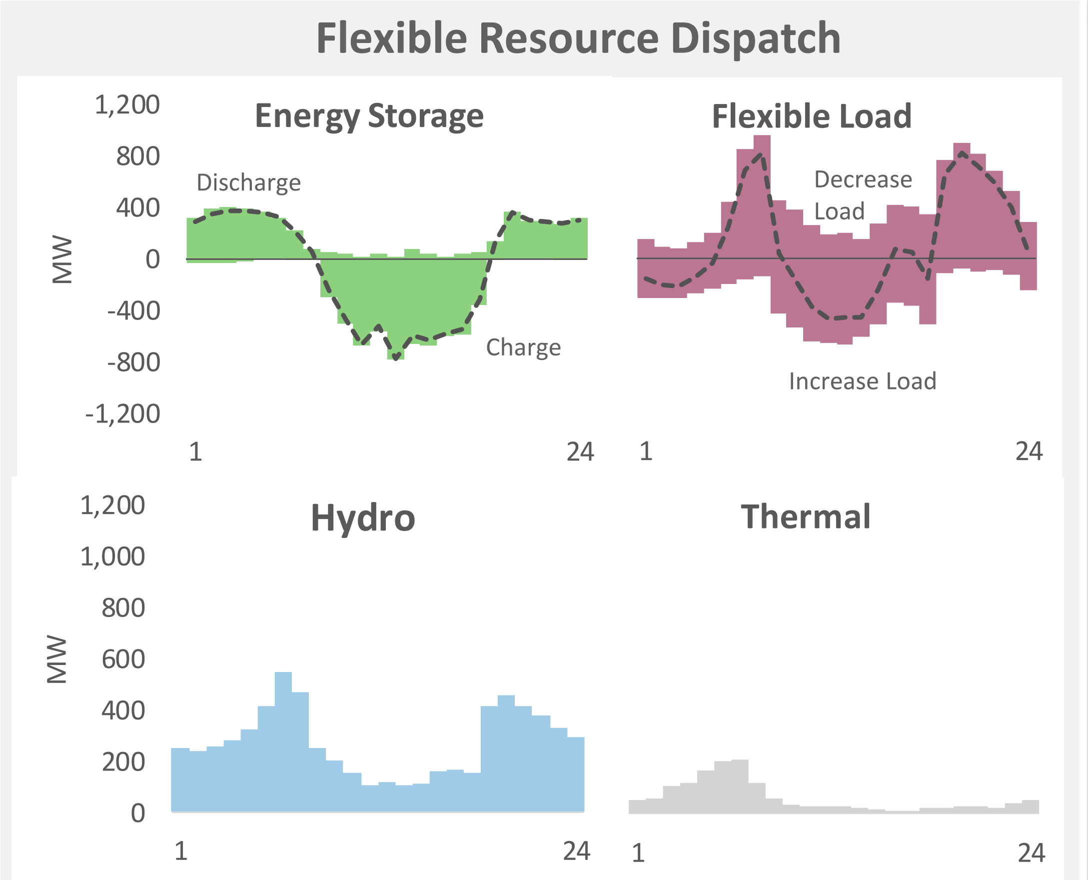


Balancing Electricity Supply and Demand

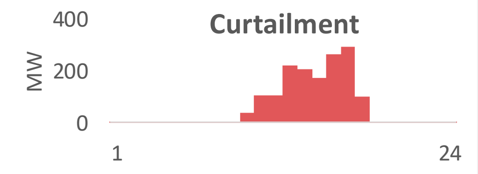
High Electrification Pathway, Average Day in September 2050







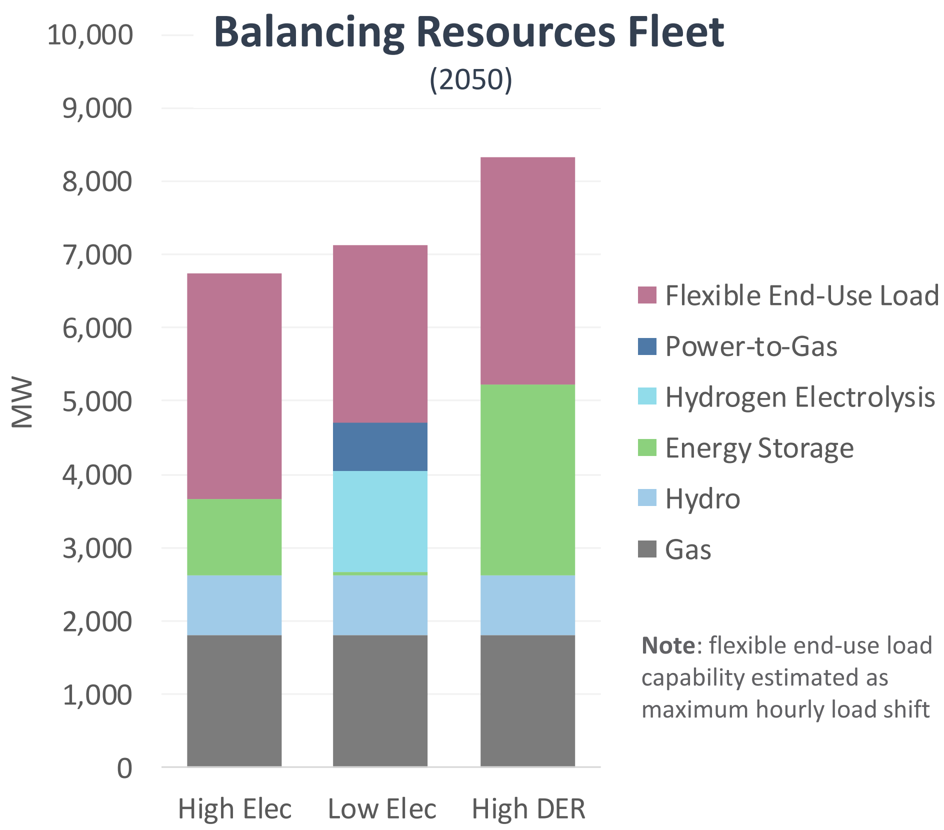
Note: H2 and P2G loads are key flexible resources in alternative pathways



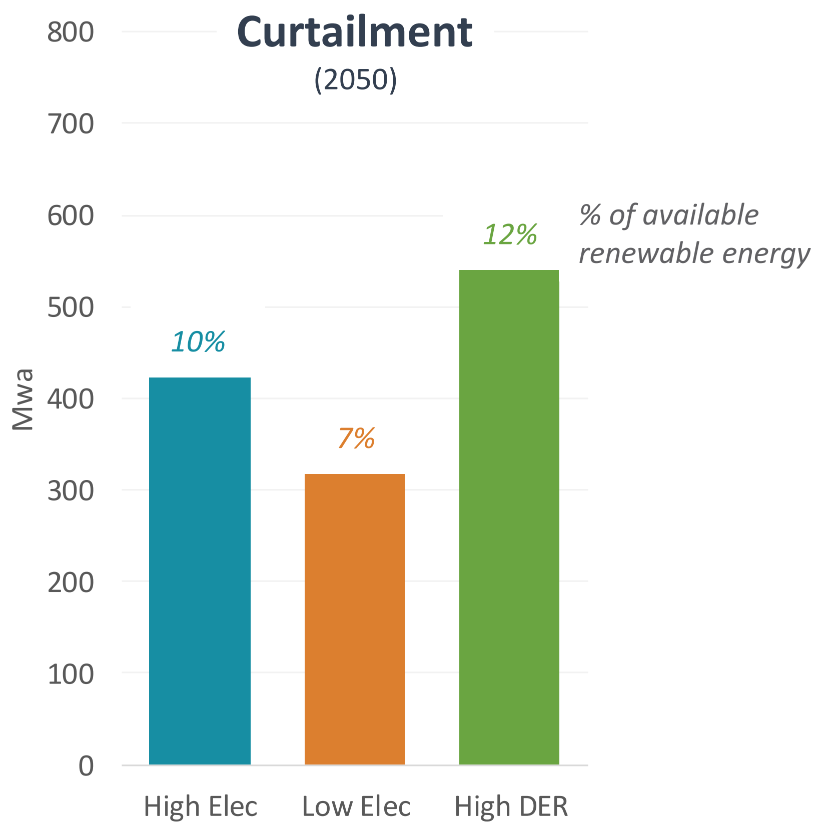
Balancing Resources and Generation Curtailment

Diverse mix of balancing resources to integrate renewables and avoid curtailment & emissions

After accounting for these resources, 7 to 12 percent of available RE generation is curtailed



Note: flexible end-use load capability estimated as maximum hourly load shift



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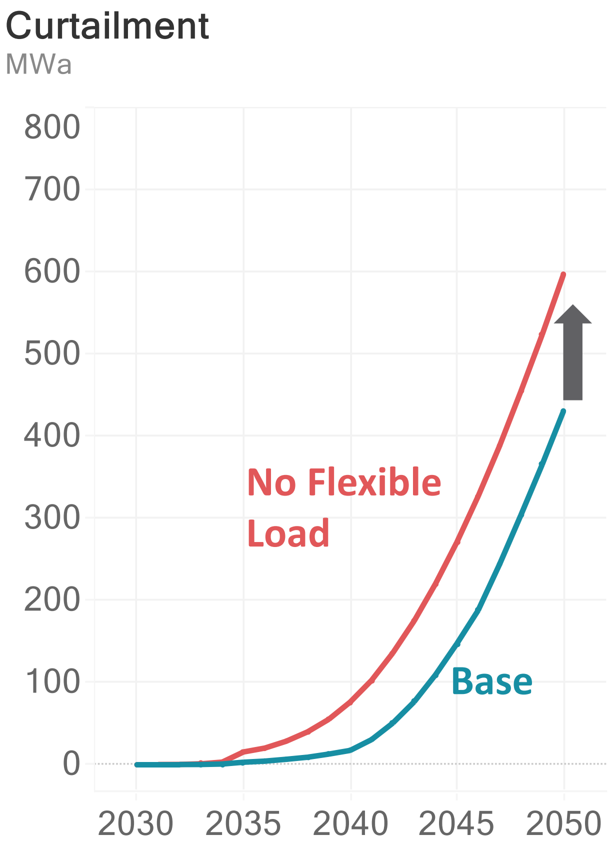
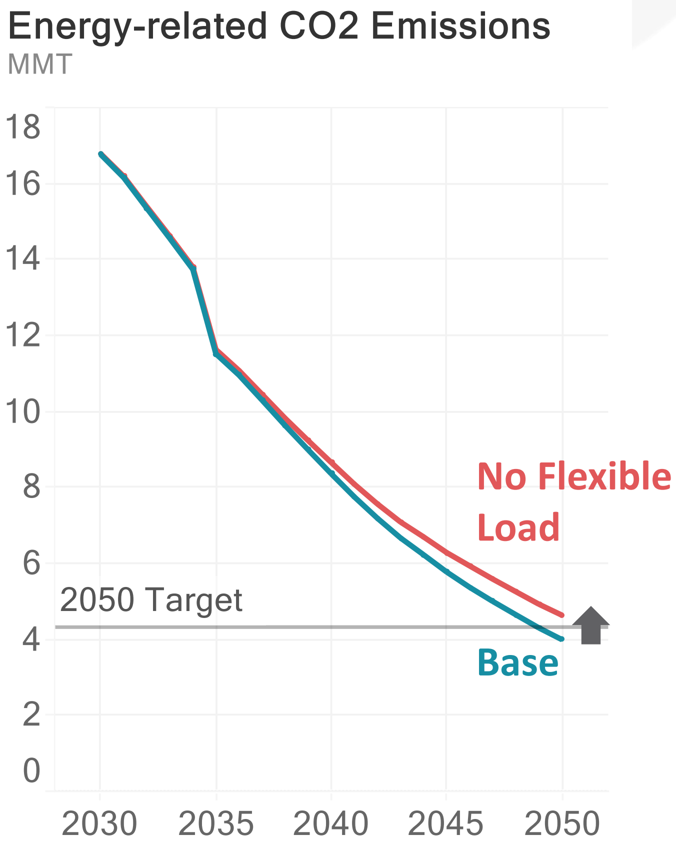
Value of Flexible End-Use Load

High Electrification Pathway Sensitivity

- **Sensitivity**: no flexible end-use load
  - Curtailment experienced sooner and increases by 166 MWa by 2050
  - Emissions increase and pathway is no longer compliant with 2050 target
- Economic benefit to incentivize and enable flexible load
  - All pathways are electricity *growth* scenarios and flexible load provides an opportunity to moderate peaks
  - Analysis finds that flexible end-use loads included in base case reduce electricity-related costs by ~10% by 2050 relative to no flexible load sensitivity





Study Conclusions

Study Findings

- Deep decarbonization of the PGE service territory's energy economy is possible and can be achieved using a variety of technologies and strategies
- Depends on a set of **three pillars** that are consistent with many studies examining decarbonization in the U.S. and abroad
  1. Energy efficiency;
  2. Decarbonization of electricity generation; and
  3. Increasing share of electricity and electric fuels
- Change evaluated in this study is transformational instead of incremental, and requires:
  - Both consumer and producer participation
  - New energy infrastructure
  - Timely planning to account for investment opportunities between now and 2050
- Transitioning to a low-carbon economy will change the composition of our energy bill, with more money spent on technology and less on fossil fuels

Insights on Deep Decarbonization and the Electricity Sector

- Economy-wide decarbonization will profoundly change the way electricity systems are operated and ideally planned for
- Power System Operations
  - In many hours of the year, renewable generation exceeds load
  - New sources of flexibility (energy storage, end-use load, H2/P2G) can complement traditional sources of flexibility (hydro and thermal) to ensure renewables are successfully integrated
- Integrated Resource Planning
  - Overall load requirements, shape of electric load and a highly renewable resource mix all affect resource adequacy
  - Scale of renewable capacity additions and demand-side participation exceeds historical levels
  - Proactive planning can facilitate a smooth transition
- Customer Participation
  - PGE’s customers play a key and active role to achieve a low-carbon economy
  - Smart charging of EVs and water heaters (among others) is highly valuable

Thank You

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About Evolved Energy Research

- Energy consulting firm focused on addressing key energy sector challenges posed by climate change
- Lead developers of EnergyPATHWAYS, a bottom-up energy system model used to explore the near-term implications of long-term deep decarbonization
- We advise clients on issues of policy implementation and target-setting, R&D strategy, technology competitiveness and impact investing

Supplementary Slides

Electrification of Space Heating

Overview

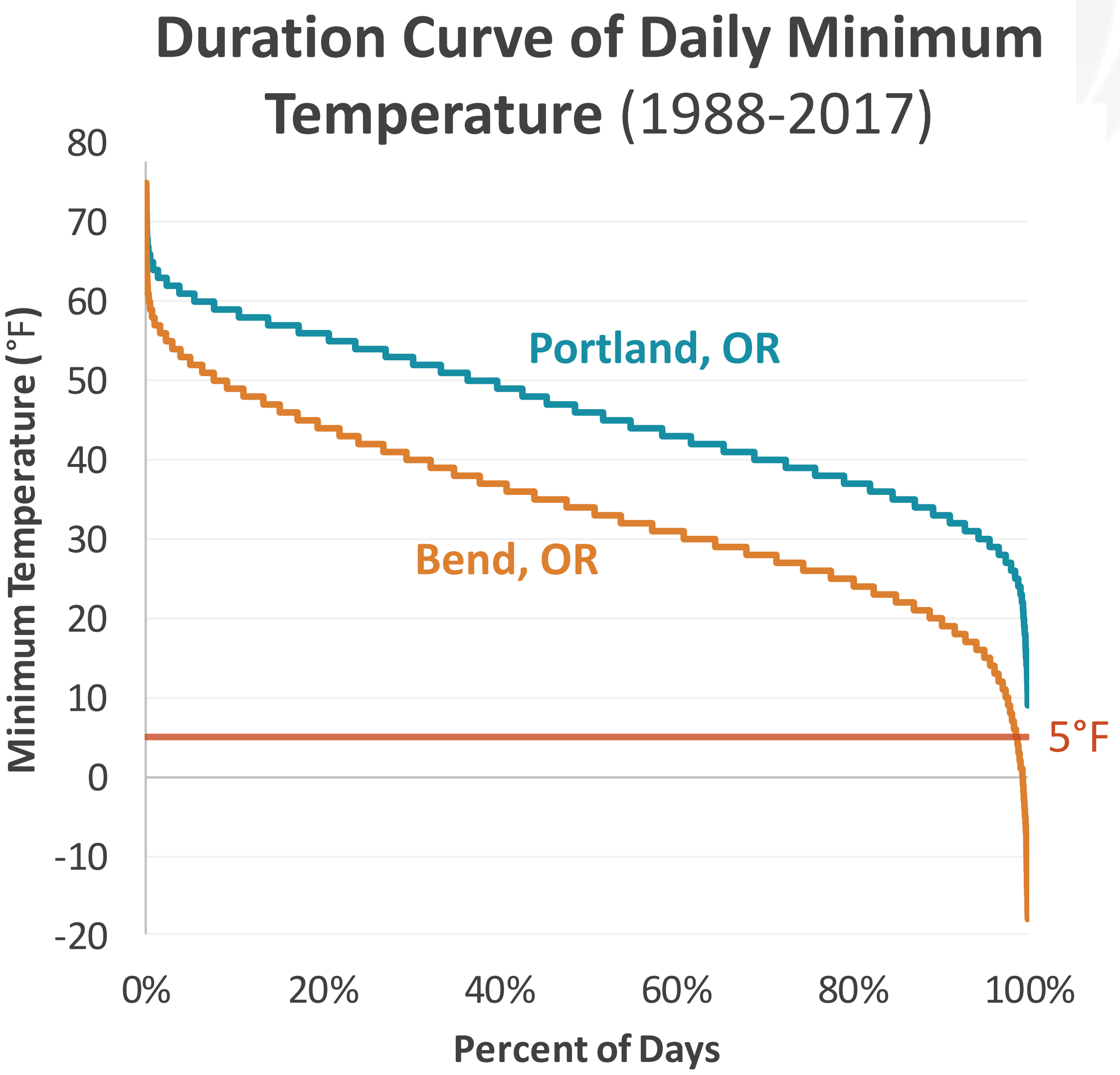
- **Problem Statement**
  - Space heating, a significant source of energy use and emissions, will need to be decarbonized in order to meet economy-wide GHG goals
  - Electrification of heat in buildings using **air source heat pumps (ASHP)** has been identified as a promising decarbonization strategy in numerous studies
    - ASHP efficiency is 2-4 times greater than electric resistance heaters, and also provides cooling
  - However, concerns have been raised about the efficiency of ASHPs when outdoor temperatures decrease, and backup (auxiliary) electric resistance systems are used
  - Concerns include whether distribution and system peak demands will sharply increase, requiring new electric generation, transmission and distribution infrastructure
- We address these concerns in the context of ASHP technology in general and the characteristics of PGE's service territory

ASHP Technology

- The issue of ASHP performance during very cold weather and reliance on (inefficient) backup electric resistance systems was identified many years ago, and has attracted considerable investment in research, development and deployment by both public and private institutions
  - For example, the U.S. Department of Energy's High Efficiency Cold Climate Heat Pump program started in 2010
- ASHP technology has advanced and new models perform at high levels of efficiency even at very cold temperatures
- Northeast Energy Efficiency Partnerships (NEEP) lists currently available cold climate ASHP systems with a coefficient of performance (COP) at 5°F of 2-3
  - 2-3 times more efficient on a site-energy basis than the best available electric heater or gas furnace

Climate

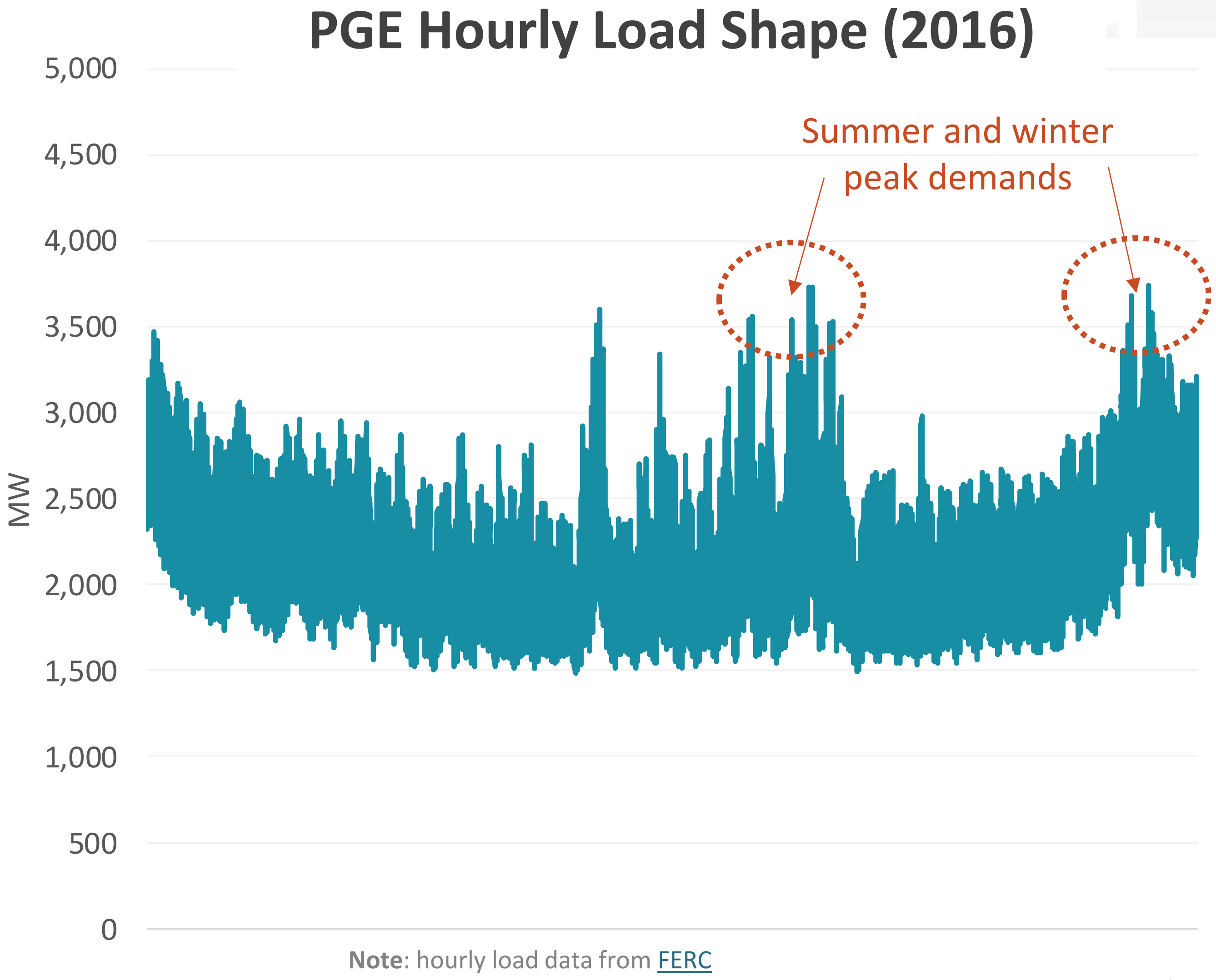
- Very cold weather conditions are experienced less frequently in PGE's service territory relative to other parts of Oregon
- Comparison of daily minimum temperature in Portland against Bend, Oregon (outside PGE's service territory) across the past 30 years shows less extreme cold weather
- Minimum temperate in Portland was never below 5°F, the benchmark for cold climate ASHPs in New England



Note: daily temperature data from NOAA

Nature of Electricity Demand

- Winter electricity demand is not the only concern, since PGE's system peaks in both the winter and summer
- Since ASHPs provide both heating and cooling, technology adoption also facilitates more efficient space cooling relative to air conditioners



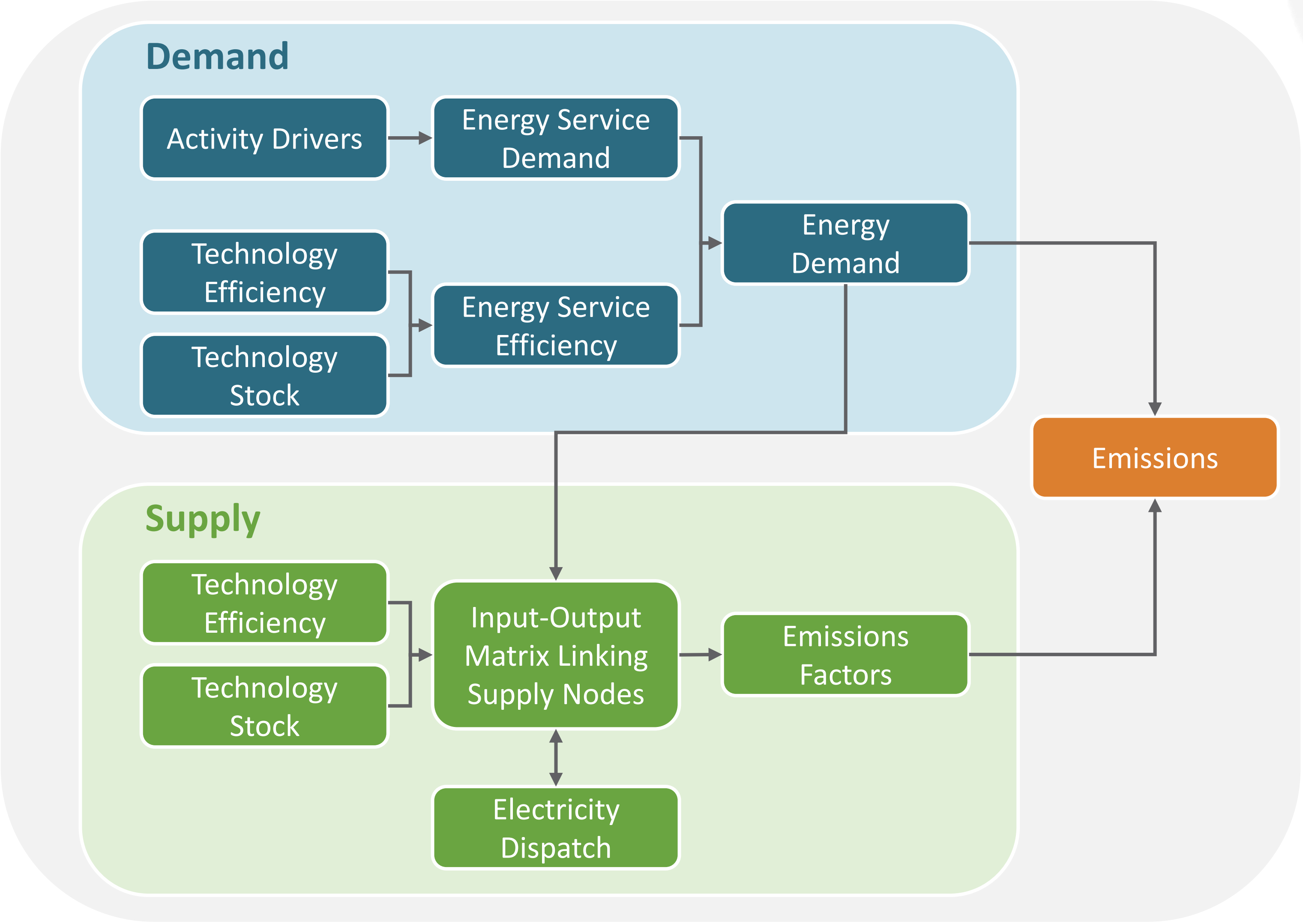
EVOLVED ENERGY RESEARCH

Additional Considerations

- Potential electric peak demand (local and system) increases from electrifying heat can be mitigated by:
  - Insulating homes
  - Pre-heating homes
  - Deploying distributed energy storage (i.e., discharge during peak heating load)
  - Adopting other energy efficient electric equipment
- In a carbon constrained environment, the tradeoff of not electrifying heat is to decarbonize pipeline gas, which also requires substantial new infrastructure
  - New central-station electrolysis and power-to-gas facilities
    - Significant efficiency losses from conversion to useful energy
  - Renewable resources (e.g., wind and solar PV power plants)
  - Transmission network upgrades for the renewable resources

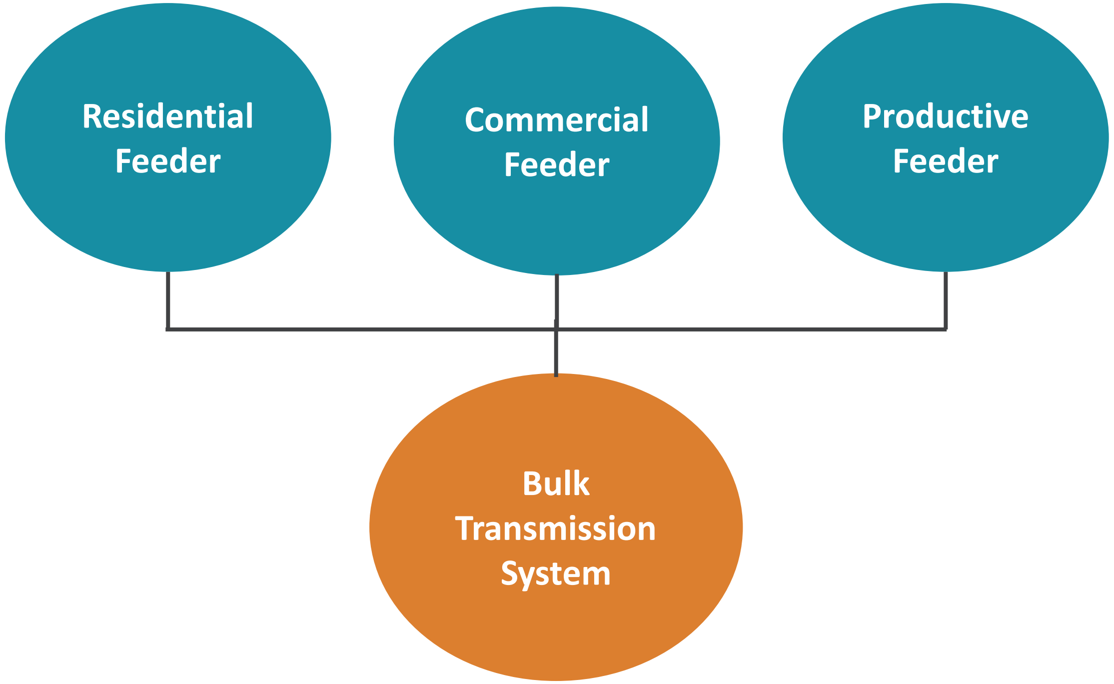
EnergyPATHWAYS

Modeling Framework



Electricity Dispatch: Overview

- Organizational structure of the electricity system in EnergyPATHWAYS



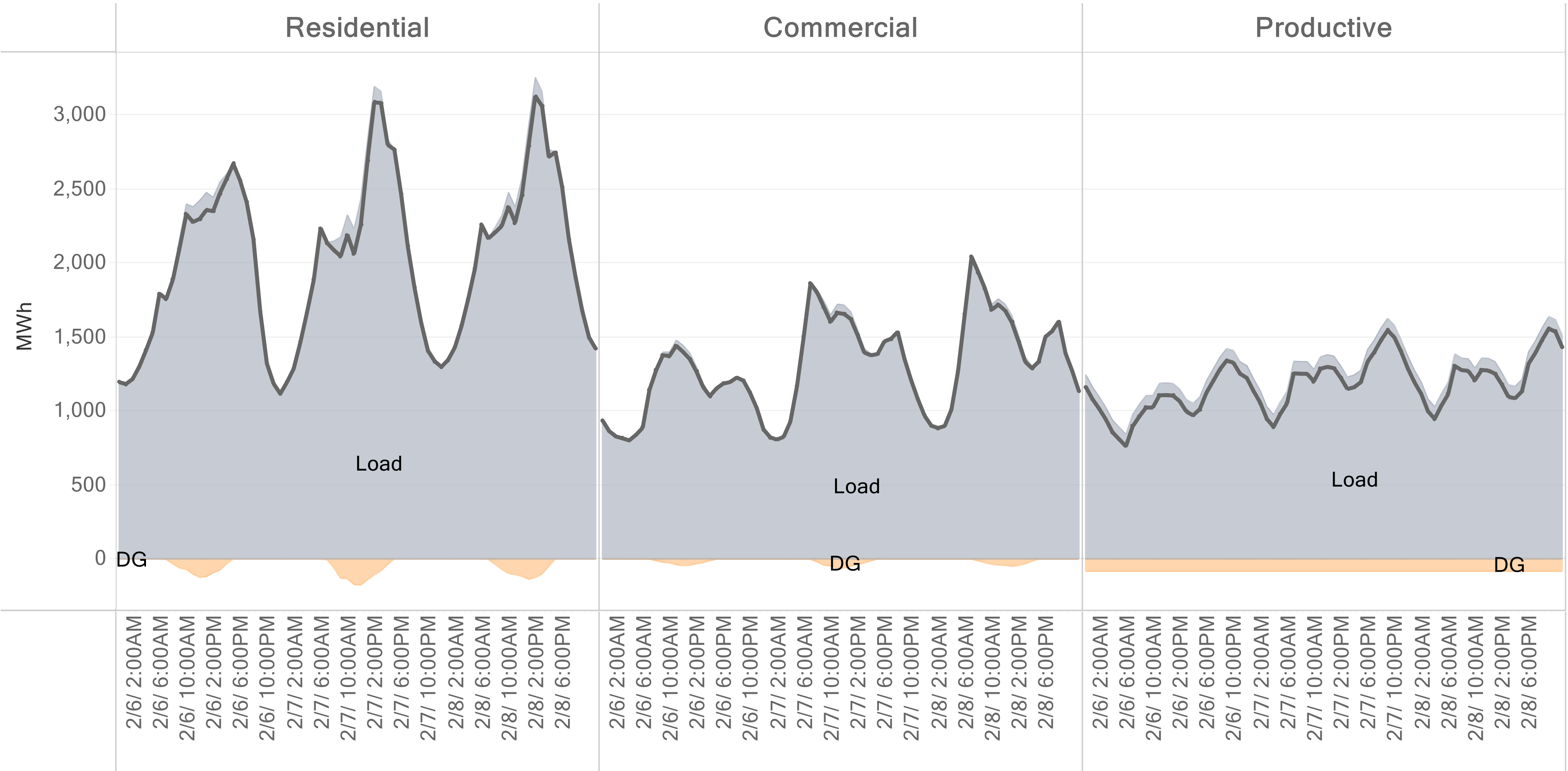
- Distribution and sub-transmission load
- Flexible load (smart water heaters, EV charging, etc.)
- Distributed generation (rooftop solar PV, combined heat and power)
- Distributed storage

- Transmission-level load
- Bulk storage (batteries, pumped hydro storage)
- Non-dispatchable generation (wind, solar, etc.)
- Dispatchable non-thermal generation and load (hydro, H2 electrolysis and power-to-gas
- Thermal resources

Electricity dispatch process is illustrated in the following slides for a three-day period (February 6-8, 2050)

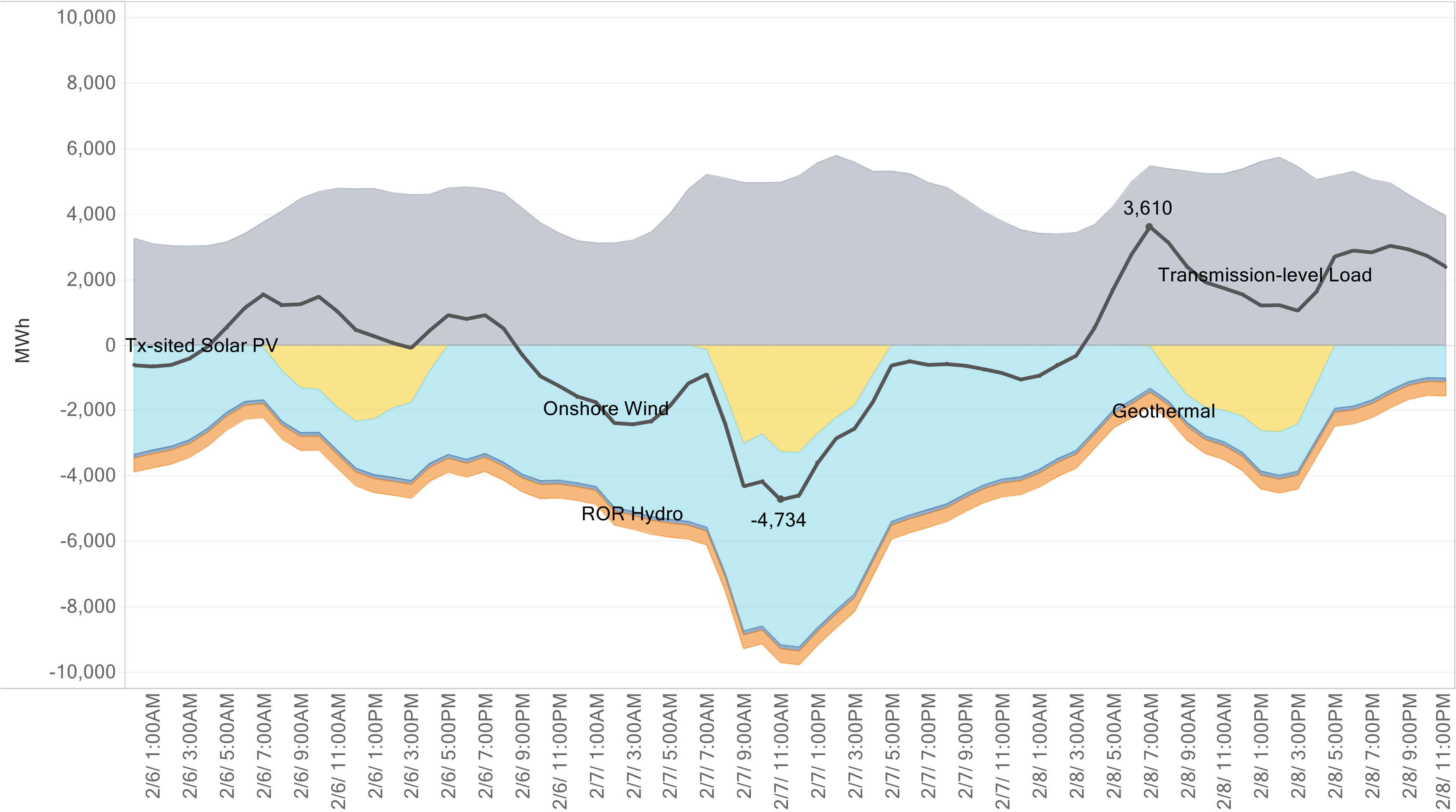
Electricity Dispatch: Distribution System Net Load

Illustrative - not a study result



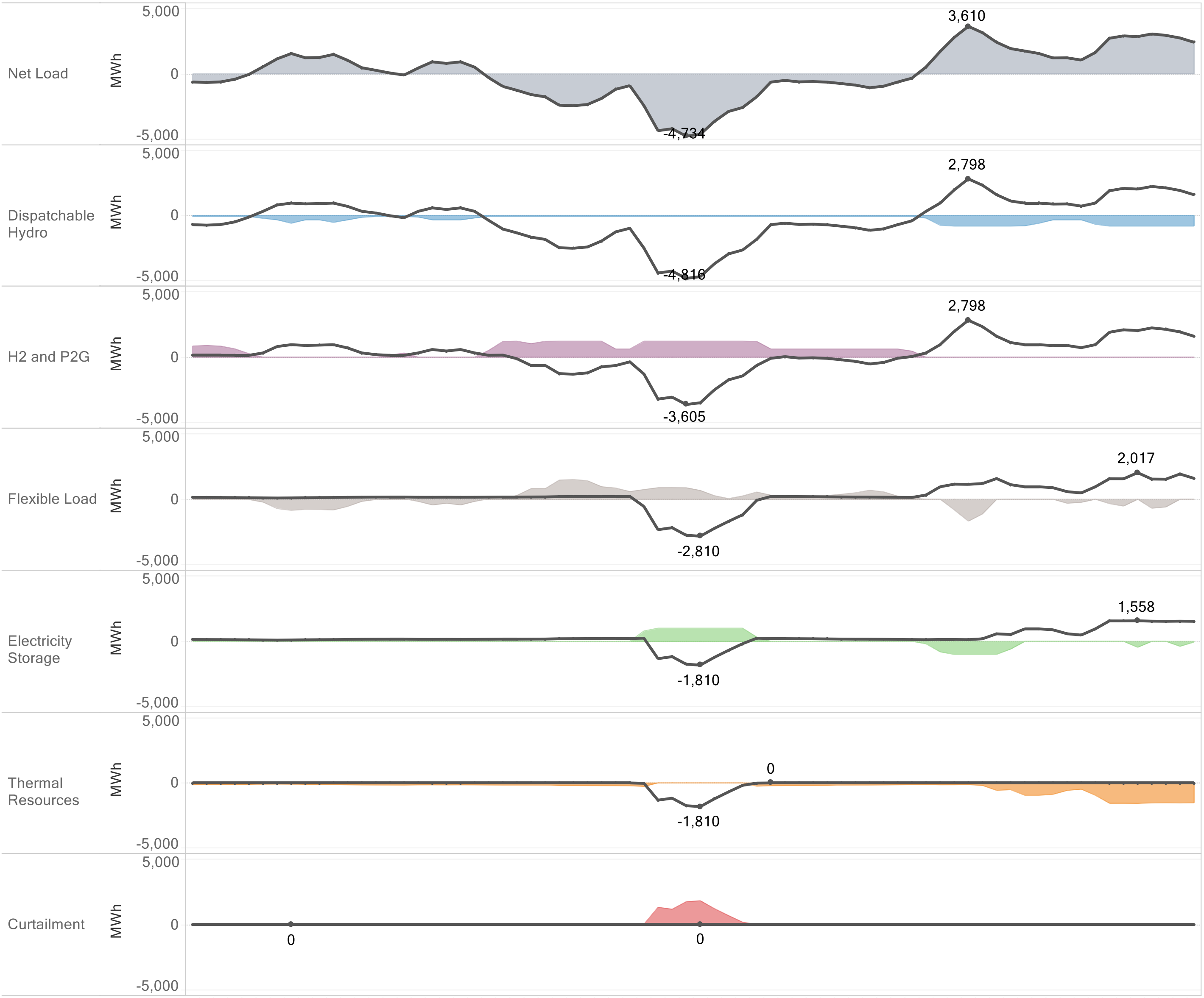
Electricity Dispatch: Transmission System Net Load

Illustrative - not a study result



Flexible Resource Dispatch

Illustrative - not a study result



Flexible resources reduce net load peaks and valleys

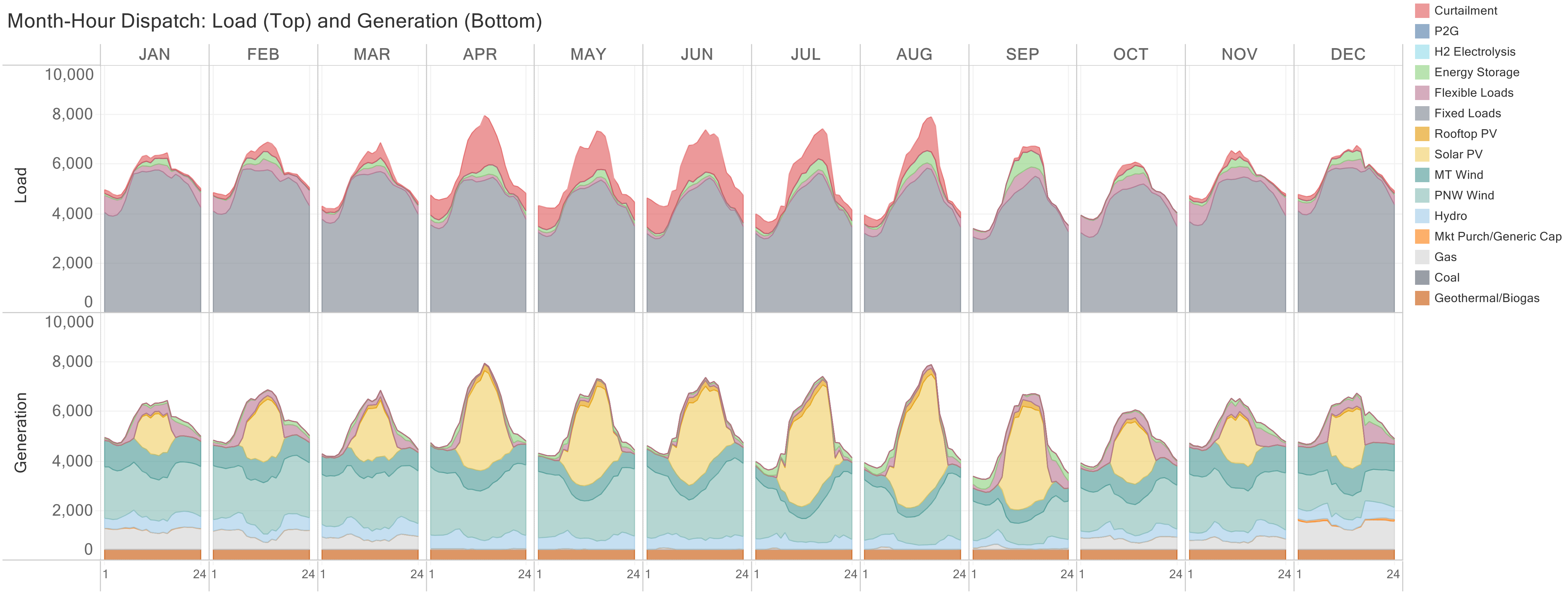
Thermal generators dispatched in order of short-run marginal cost to meet remaining positive net load

Remaining negative net load is curtailed to bring supply and demand in balance

Month-Hour Electricity Dispatch in 2050

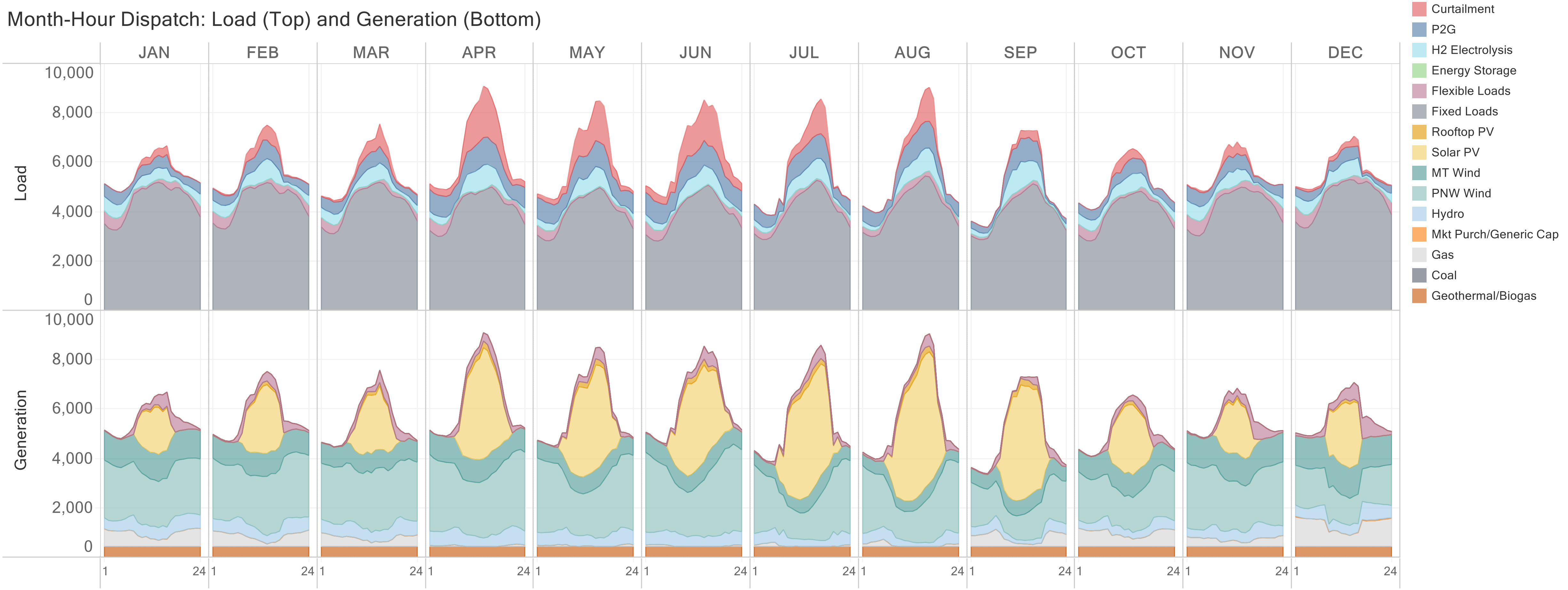
High Electrification Pathway: 2050

MWa



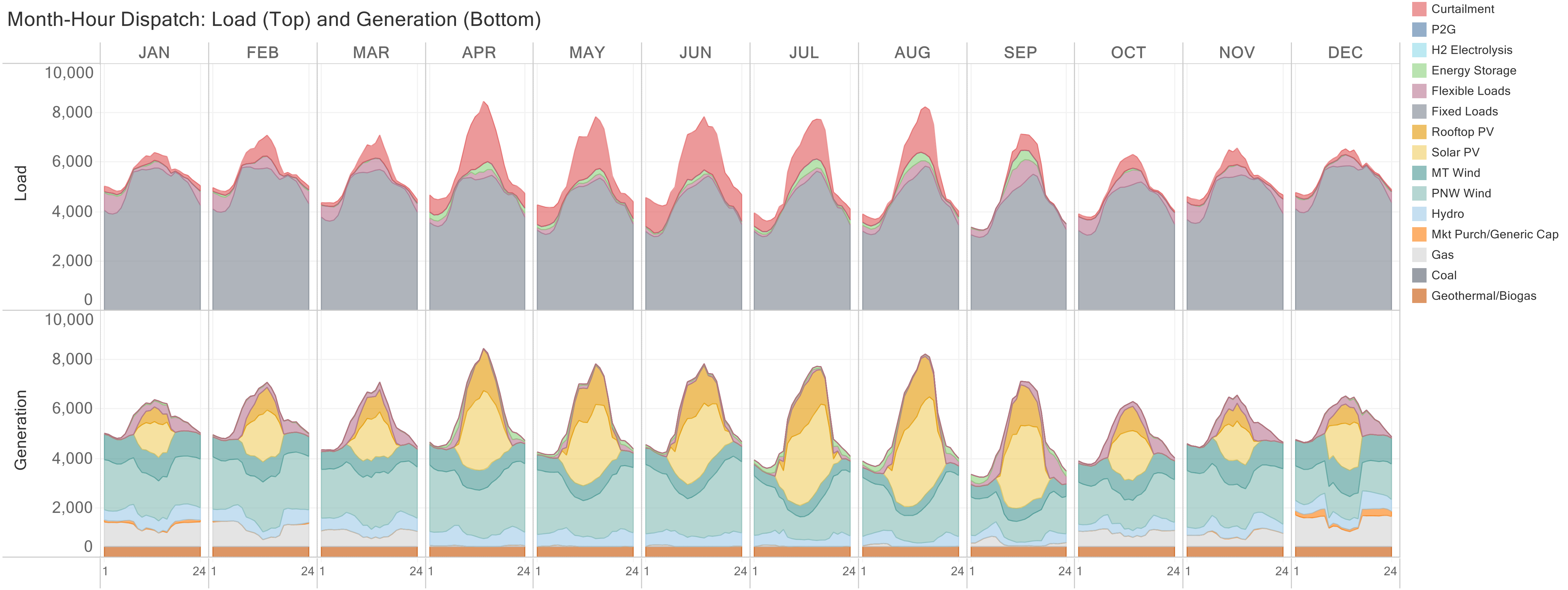
Low Electrification Pathway: 2050

MWa



High Distributed Energy Resources Pathway: 2050

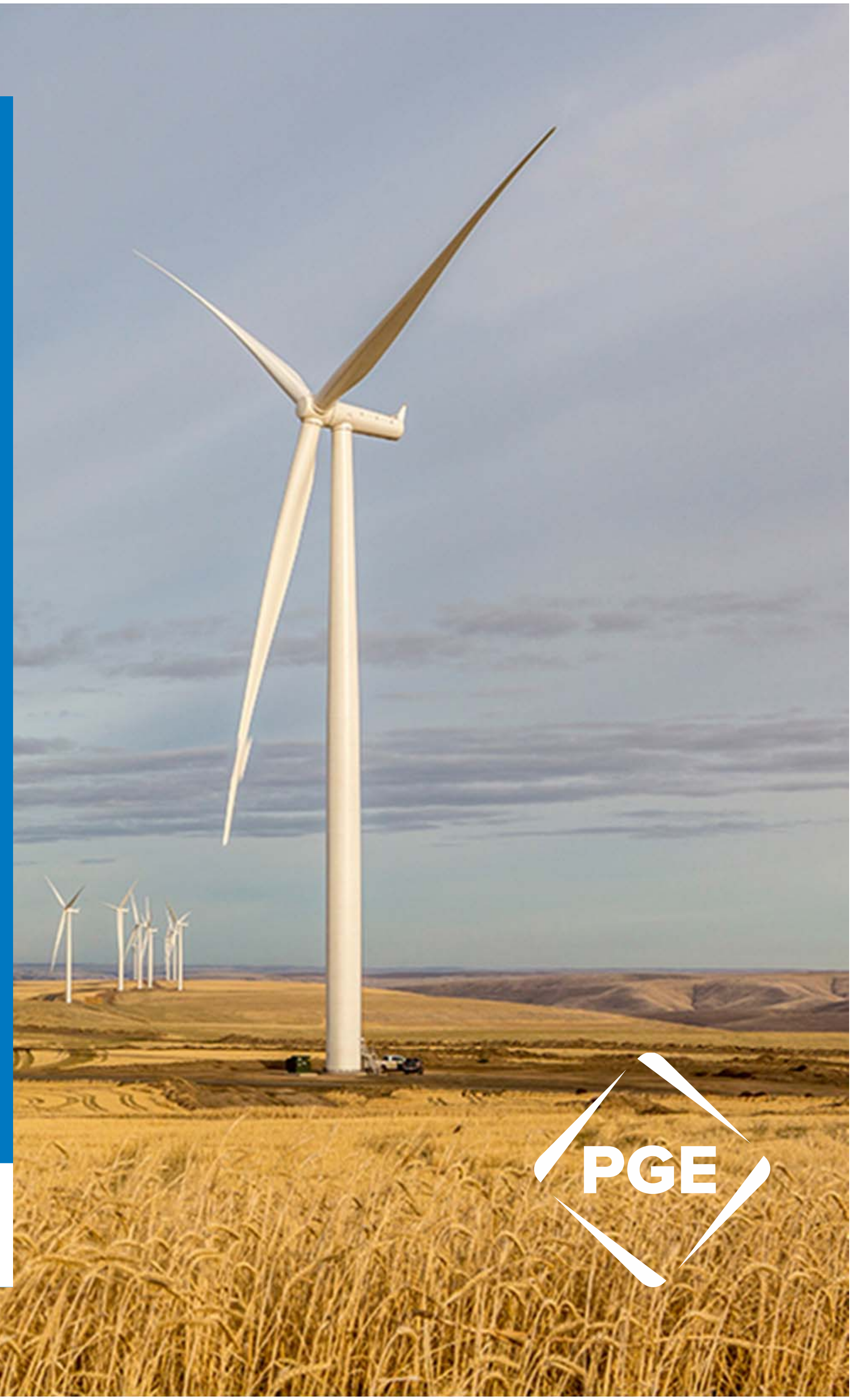
MWa



EVOLVED ENERGY RESEARCH

Market Study

Brad Carpenter



Goal Today: To share PGE's proposed scope for a Market Study and seek feedback from stakeholders.

Overview

- The LC 66 Order requires PGE to perform an Enabling Study that examines the treatment of market capacity ("Market Study").
- The Market Study will be utilized to inform the 2019 IRP.
- As the Pacific NW is expected to move from a capacity surplus to a deficit, PGE wants to examine its reliance on market capacity.
- The Market Study will focus on how PGE's access to regional resources is expected to change across various time frames.

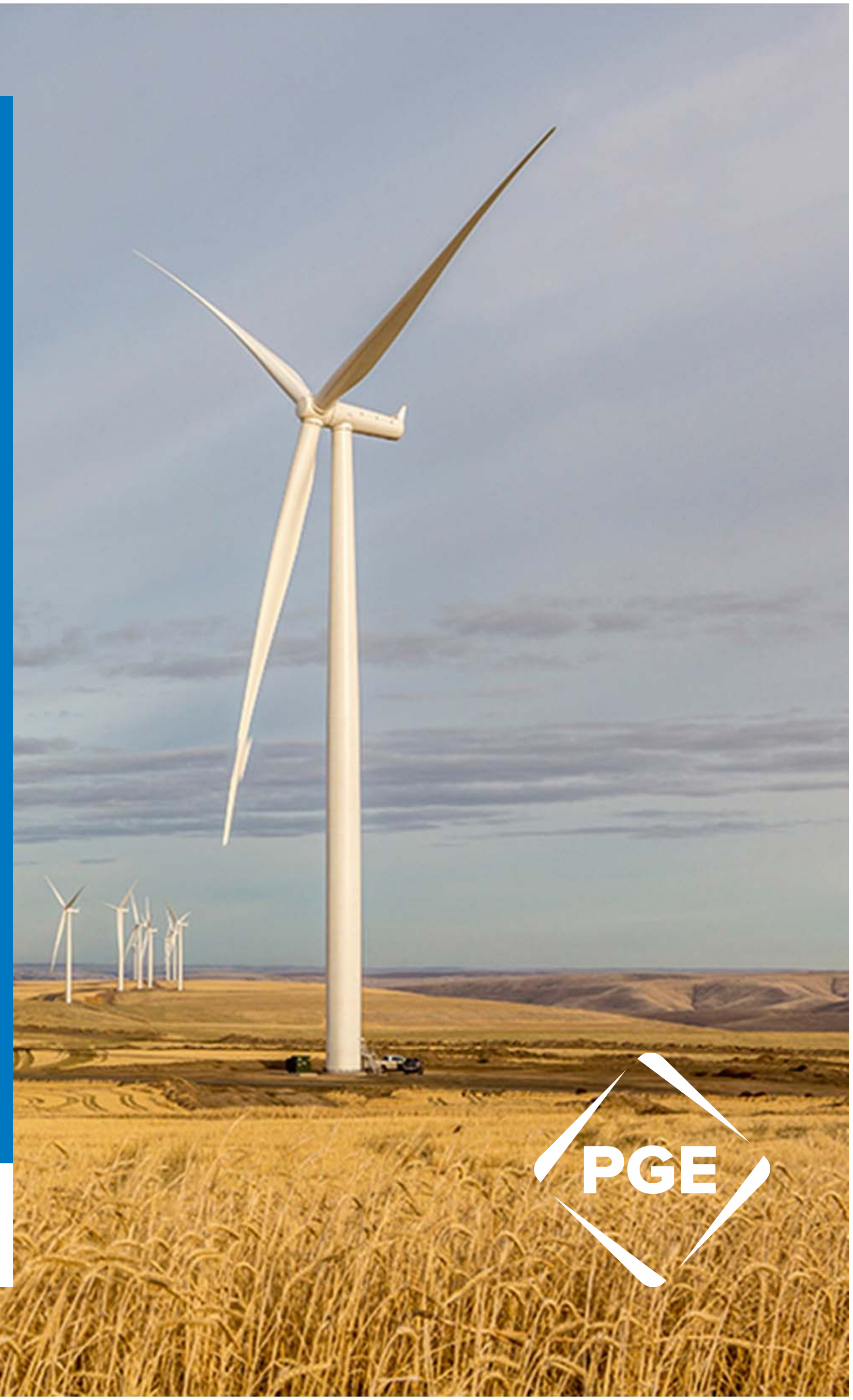
The Market Study will provide a broad look at the wholesale power market in the PNW and inform PGE's 2019 IRP.

Proposed Scope

- PGE plans to engage a third party consultant to perform a literature review and analysis of the NWPCC, PNUCC, and BPA regional market studies.
- Focal points of the Study include:
  - How much capacity is available now and how will that trend over time?
  - How much is PGE's "share" of capacity?
  - The analysis will be performed over several different time frames.
- The Market Study will not..
  - …provide insight into the economics of resources -- it will simply estimate whether the resources are expected to be available.
- PGE will then examine the seasonal quantities from the study in RECAP to help inform the 2019 IRP.

Customer Insights

Ron Newheiser
Market Strategies International



Portland General Electric
2017 Integrated Resource Plan Survey

Survey conducted: August-October 2017

ISO 20252 Certified

PGE

MARKETSTRATEGIES INTERNATIONAL

Contents

PGE 2017 Integrated Resource Plan (IRP) Survey Objectives

PGE has commissioned an updated IRP Survey in 2017 **to assess customers' resource preferences and cost expectations in order to inform PGE's long-term resource planning and the development of customer service plans and rates**, with the following specific objectives:

- Provide information on customer preferences to support the public process of Integrated Resource Planning.
- Understand customer concerns and preferences as they relate to Integrated Resource Planning.
- Quantify customers' (residential, general business, and key business customers) perceptions and receptivity to a variety of energy resource options, allowing PGE to assess individual resource options and resource mix options on a ratio scale of customer support.
- Determine which resource options customers would be most likely to support, and also the degree to which certain options would be supported over others, given differences in price and resource mix.

Market Changes Since the Most Recent 2012 PGE IRP Survey

Since conducting the most recent PGE Integrated Resource Plan (IRP) Survey in 2012:

- The state of Oregon has made an historic decision to **move away from coal** and **implement higher Renewable Portfolio Standards**
- The use of **renewable energy** and **demand side resources** have increased considerably, including:
  - Energy efficiency
  - Distributed generation (solar)
  - Energy storage
  - Electric vehicles
  - Smart thermostats
  - Energy management systems

Methodology

- Random samples of PGE Residential and General Business customers were screened and recruited to complete a web survey about PGE's future power supply.
- PGE's 2017 Integrated Resource Planning Survey was completed by:
  - n=**502** PGE Residential customers, screened as their household's any decision-maker.
  - n=**186** General Business customers, screened as a person responsible for making energy-related policy decisions for their company.
- After completing the screener, the main Integrated Resource Planning Survey took approximately 40 minutes to complete on average, via a self-administered web survey.

Detailed Findings

Portland General Electric

2017 Integrated Resource Plan Survey

Initial Electricity Resource Preferences

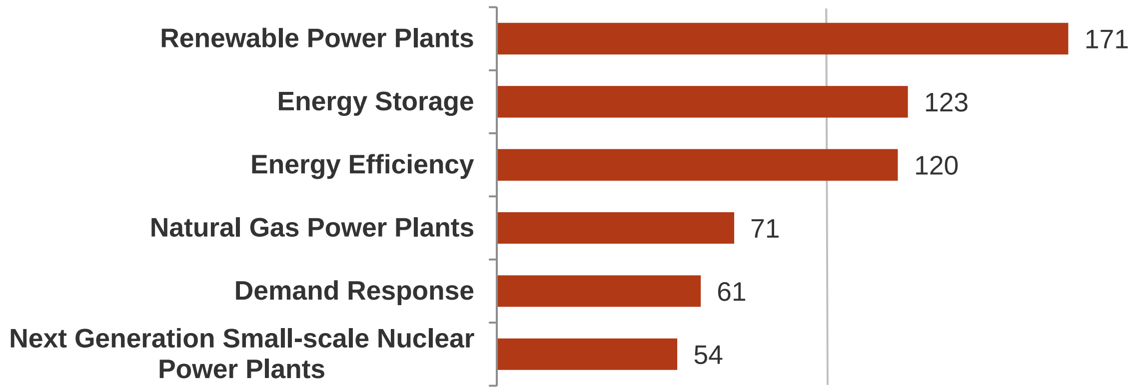
Before being provided with detailed information about each resource

Initial Electricity Resource Prioritization: Ranking of Resources PGE Could Use to Meet the Demand for Power in Oregon

> In the "Screening" section preceding the main IRP survey, customers were asked to rank their three most preferred resources for meeting the demand for power in Oregon, with Renewable Power Plants dominant as the first choice among most customers, and Next Generation Nuclear Power Plants cited most frequently as the "least preferred" option.

Among Residential Customers

Relative Preference Index*



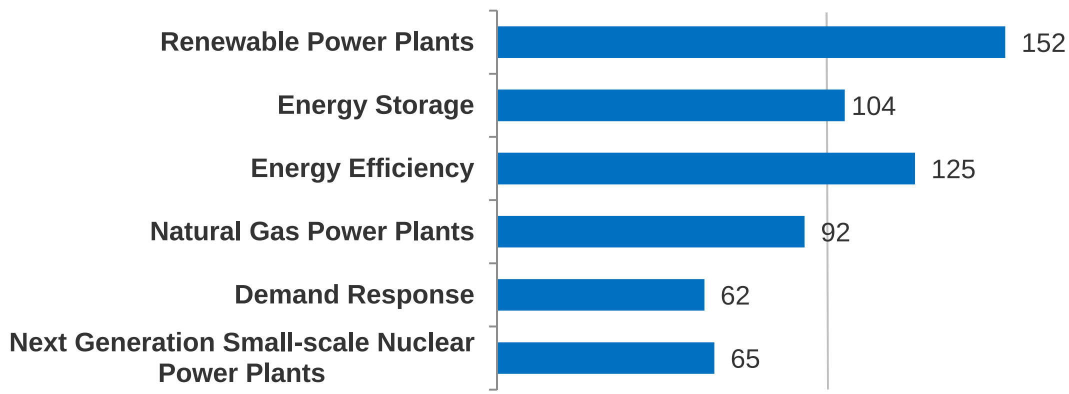
2012 Rank

2nd^
NA
1st^
3rd
NA
4th

Next Generation Coal Power Plants with Reduced Emissions ranked 5th in 2012.

Among General Business Customers

Relative Preference Index*



2012 Rank

2nd^
NA
1st^
3rd
NA
4th

Next Generation Coal Power Plants with Reduced Emissions ranked 5th in 2012.

*Relative Preference determined through Bradley-Terry Analysis. See slide notes for details.
^Wording and metric changed from 2012; use caution when interpreting trends.
S6-S9. Now, please think about the resources PGE might use to meet the demand for power in Oregon. Which of the following would be your first/second/third/last choice for how PGE meets this demand for power?

2012 Resource Descriptions:
Renewable Resources (Wind, Solar, Biomass, Geothermal, but not including Hydro-electric power plants)
Customer energy efficiency and energy conservation (i.e., CFL bulbs, more efficient appliances, lowering the thermostat)

Initial Electricity Resource Prioritization Comparison:
Customers Who Completed the IRP Survey *versus* Customers Who Completed Screening but Opted Not To Complete the Main Survey

	Among Residential Customers Who Completed the 2017 IRP Survey (n=502)		Among Residential Customers Who Completed the Screener, But Did Not Complete the 2017 IRP Survey (n=202)	
	Most Preferred	Least Preferred	Most Preferred	Least Preferred
Renewable Power Plants	**60%**	3%	**55%**	2%
Energy Storage	12%	4%	10%	4%
Energy Efficiency	10%	3%	16%	1%
Natural Gas Power Plants	4%	15%	4%	11%
Demand Response	2%	23%	3%	27%
Next Generation Small-scale Nuclear Power Plants	8%	**44%**	5%	**37%**

	Among General Business Customers Who Completed the 2017 IRP Survey (n=186)		Among General Business Customers Who Completed the Screener, But Did Not Complete the 2017 IRP Survey (n=254)	
	Most Preferred	Least Preferred	Most Preferred	Least Preferred
Renewable Power Plants	**47%**	8%	**41%**	4%
Energy Storage	7%	8%	3%	8%
Energy Efficiency	17%	1%	22%	2%
Natural Gas Power Plants	8%	11%	6%	14%
Demand Response	2%	18%	6%	18%
Next Generation Small-scale Nuclear Power Plants	16%	**50%**	13%	**48%**

S6-S9. Now, please think about the resources PGE might use to meet the demand for power in Oregon.
Which of the following would be your first/second/third/last choice for how PGE meets this demand for power?

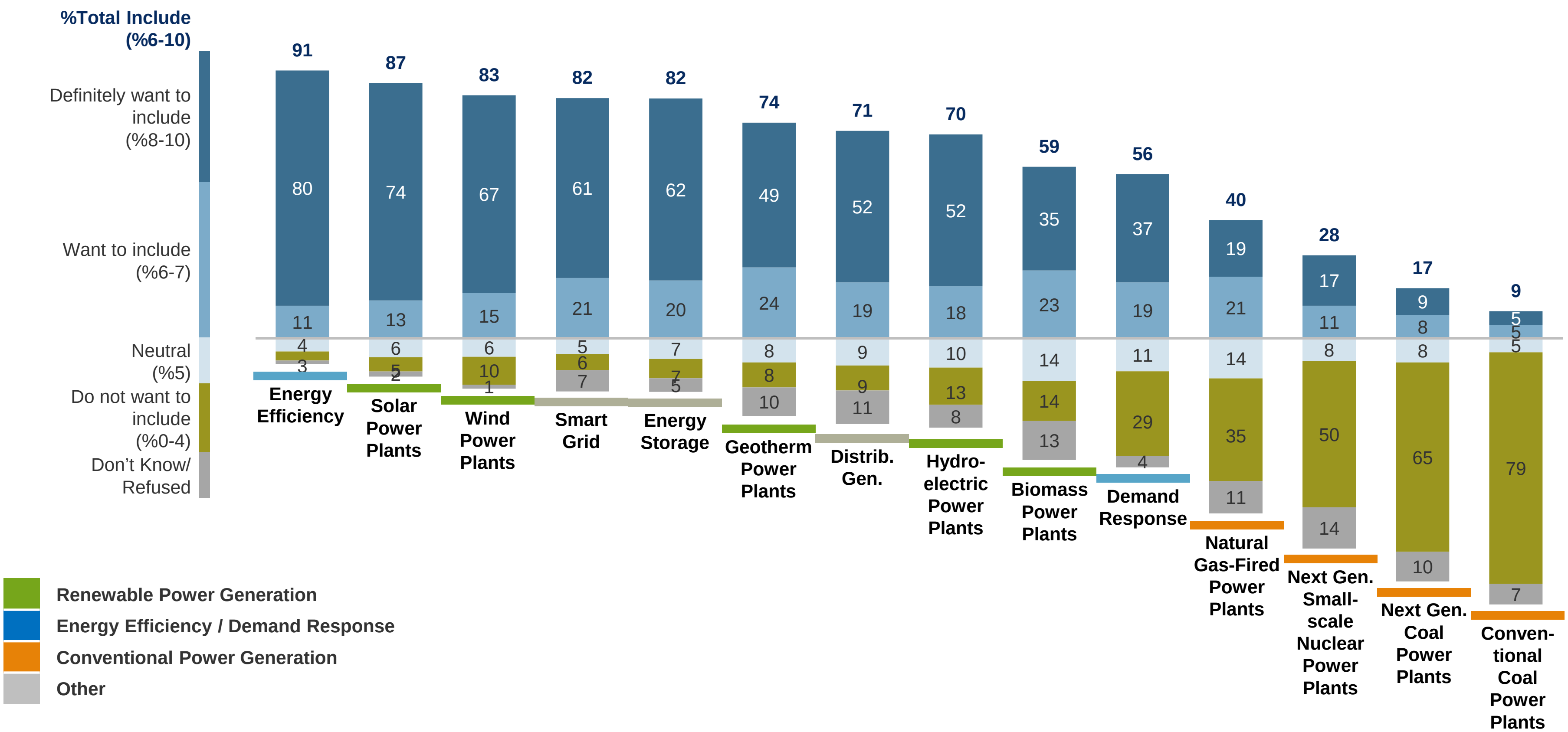
Initial Electricity Resource Preferences – *Residential*

(Prior to Seeing Detailed Information About Each Resource)

n=502

> Residential customers most prefer Energy Efficiency and Solar Power be included in future energy plans for Oregon with roughly nine in ten customers indicating these resources should be included (%6-10). More than eight in ten also prefer Wind Power, Smart Grid, and Energy Storage be included.

> Least preferred resource options among Residential customers includes Next Generation Small-scale Nuclear Power (28%), Next Generation Coal (17%), and Conventional Coal (9%).



	Definitely want to include (%8-10)	Want to include (%6-7)	Neutral (%5)	Do not want to include (%0-4)	Don't Know/ Refused	%Total Include (%6-10)
Energy Efficiency	80	11	4	3		91
Solar Power Plants	74	13	6	5	2	87
Wind Power Plants	67	15	6	10	1	83
Smart Grid	61	21	5	6	7	82
Energy Storage	62	20	7	7	5	82
Geotherm Power Plants	49	24	8	8	10	74
Distrib. Gen.	52	19	9	9	11	71
Hydro-electric Power Plants	52	18	10	13	8	70
Biomass Power Plants	35	23	14	14	13	59
Demand Response	37	19	11	29	4	56
Natural Gas-Fired Power Plants	19	21	14	35	11	40
Next Gen. Small-scale Nuclear Power Plants	17	11	8	50	14	28
Next Gen. Coal Power Plants	9	8	8	65	10	17
Conven-tional Coal Power Plants	5	5	5	79	7	9

Q4A-Q4N. Please indicate how much you would prefer that each type of resource be included in a future energy supply plan for Oregon.

^Wording changed from 2012; use caution when interpreting trends.

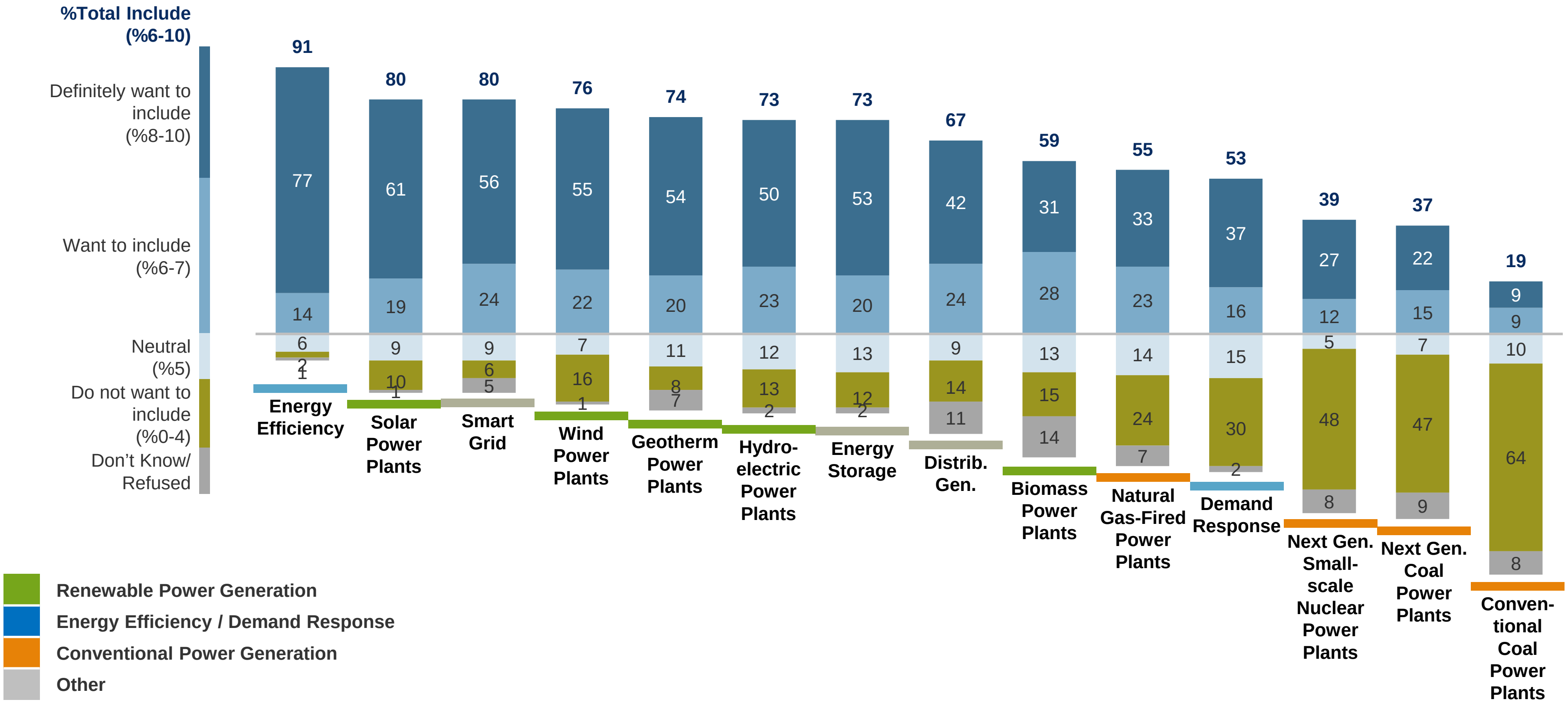
Initial Electricity Resource Preferences – *General Business*

(Prior to Seeing Detailed Information About Each Resource)

n=186

> General Business customers most prefer Energy Efficiency be included in future energy plans for Oregon with roughly nine in ten customers indicating this resource be included (%6-10). Eight in ten also prefer Solar Power and Smart Grid be included.

> Least preferred resource options among General Business customers are similar to Residential and include Next Generation Small-scale Nuclear Power (39%), Next Generation Coal (37%), and Conventional Coal (19%).



Q4A-Q4N. Please indicate how much you would prefer that each type of resource be included in a future energy supply plan for Oregon.

Informed Electricity Resource Preferences

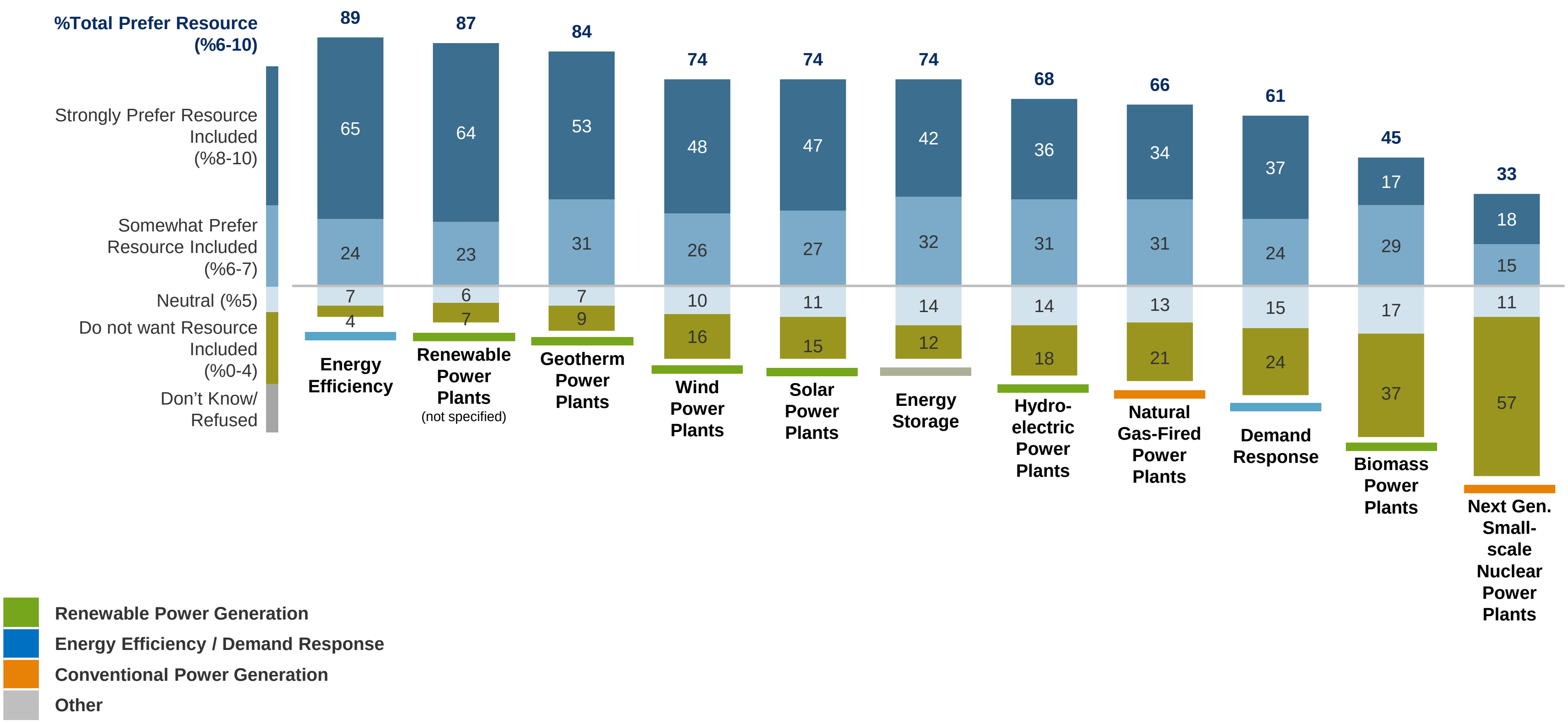
After being provided with detailed information about each resource

Electricity Resource Preferences for PGE's Long-Term Energy Plan

Residential (After Seeing Detailed Information About Each Resource)

n=502

> After seeing more detailed information about each resource, Residential customers indicate the most preference for *energy efficiency* (89% total prefer), *renewable power plants* (87%), and *geothermal power plants* (84%) to be included as part of PGE's long-term energy plan.



Given these factors, please rate [RESOURCE] in terms of the extent to which you would prefer that this resource be part of PGE's long-term energy supply plans.
REN_1, NG_1, NUC_1, EE_1, DR_1, ES_1, WIND_1, SOL_1, BIO_1, GEO_1, HYDRO_1.

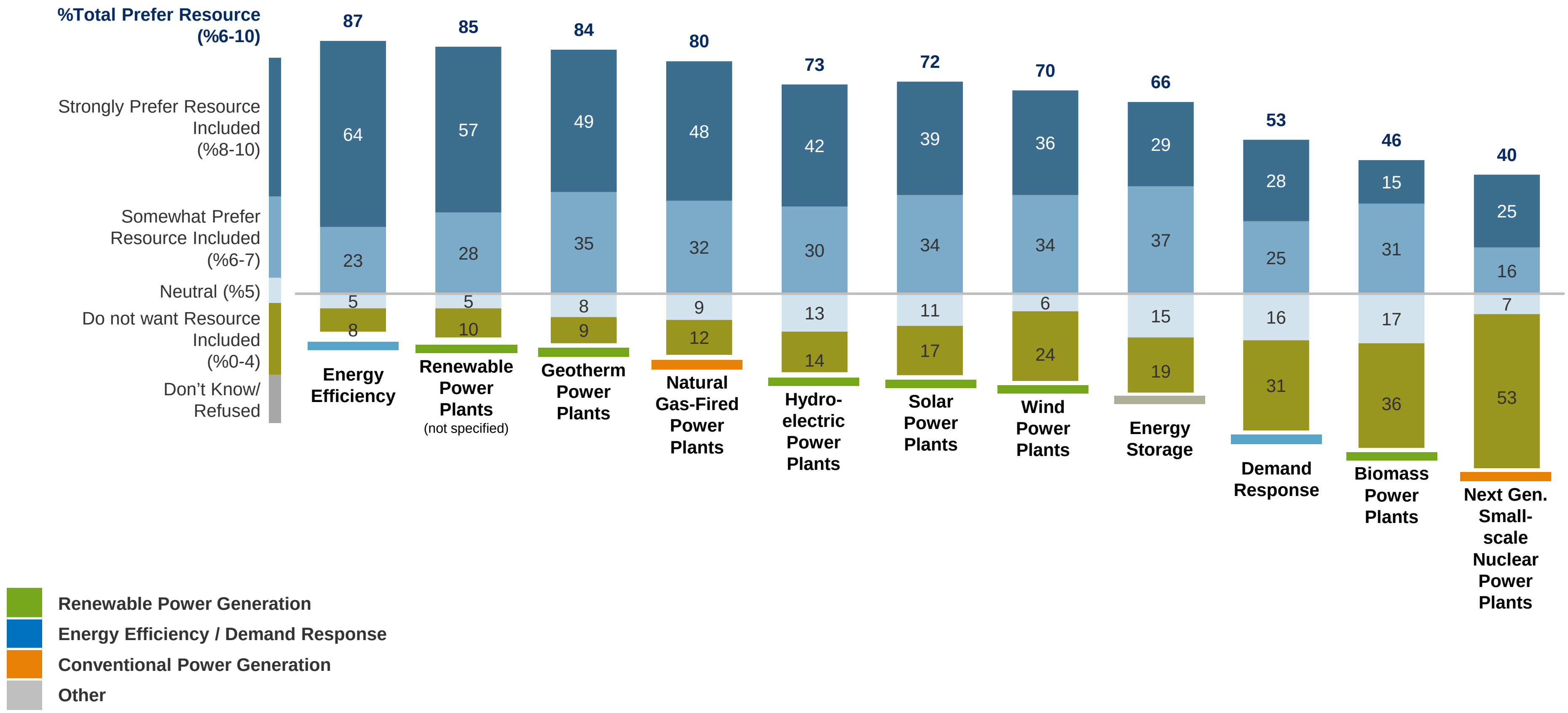
^ In 2006, Natural Gas was described as having "low" price stability, and "increasingly imported".

Electricity Resource Preferences for PGE's Long-Term Energy Plan

General Business (After Seeing Detailed Information About Each Resource)

n=186

> After seeing more detailed information about each resource, General Business customers indicate the most preference for *energy efficiency* (87% total prefer), *renewable power plants* (85%), *geothermal power plants* (84%), and *natural gas power plants* (80%) to be included as part of PGE's long-term energy plan.



Given these factors, please rate [RESOURCE] in terms of the extent to which you would prefer that this resource be part of PGE's long-term energy supply plans.
REN_1, NG_1, NUC_1, EE_1, DR_1, ES_1, WIND_1, SOL_1, BIO_1, GEO_1, HYDRO_1.

Renewable Resources, Environmental Issues

Customer support for increased renewable resources

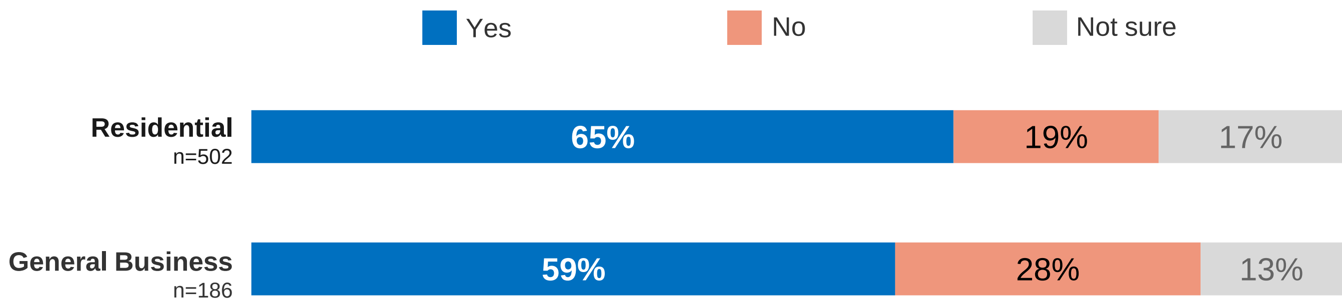
Expected timeframe for PGE’s transition to 100% renewable power

Prioritization of environmental concerns

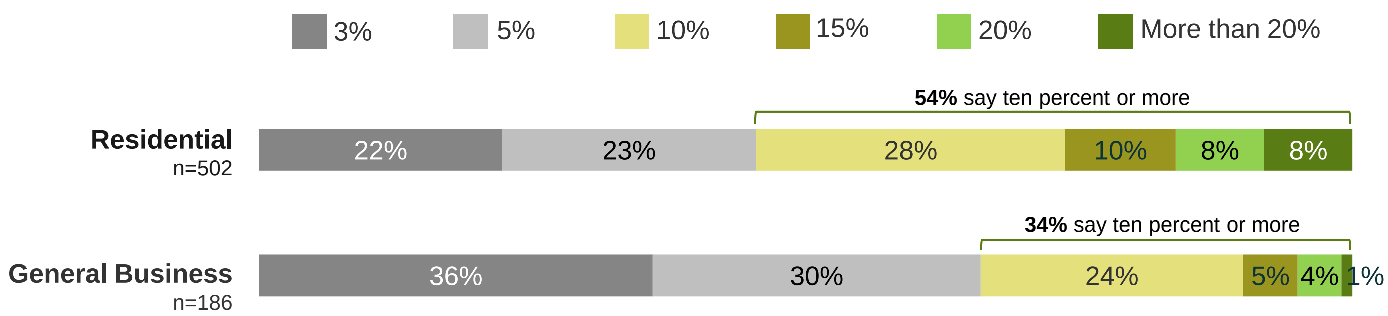
Support for Use of More Renewable Resources Even if All PGE Customers Would Need to Pay More for Electricity

> Nearly two-thirds (65%) of Residential customers and six in ten (59%) General Business customers think PGE should use more renewable resources even if customers would need to pay more for electricity.

Do you think that PGE should use more renewable resources even if this meant that all PGE customers would need to pay more for electricity?



What is the highest additional cost for renewable resources that you think PGE should ever consider paying?

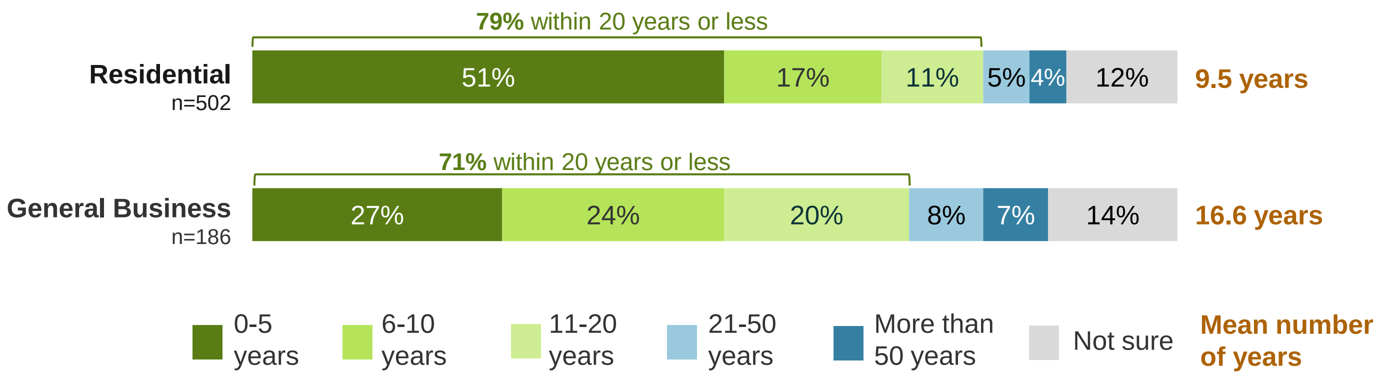


REN_2. Do you think that PGE should use more renewable resources even if this meant that all PGE customers would need to pay more for electricity?
REN_3. What is the highest additional cost for renewable resources that you think PGE should ever consider paying -- recognizing that all customers would ultimately have to bear this cost?

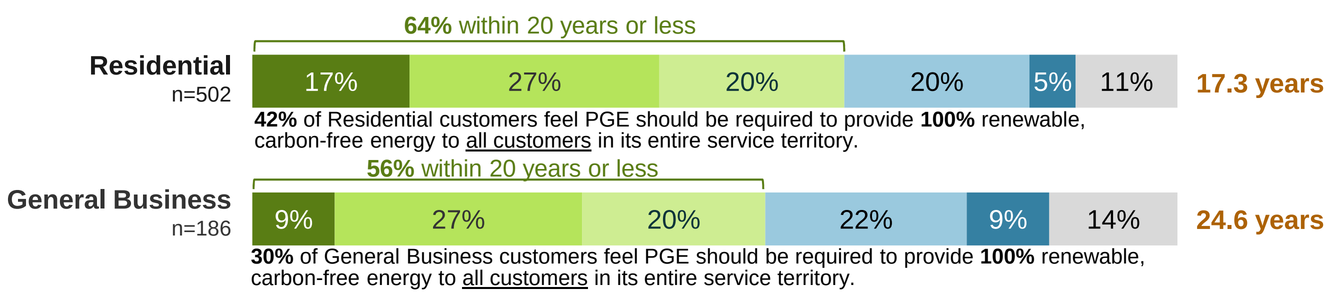
Expected Timeframe for PGE to Provide 100% Renewable Power

- Residential customers anticipate a quicker transition to 100% renewable energy than their General Business counterparts, with 51% of Residential customers expecting this to be available for their home within five years, versus 27% of General Business customers expecting this. (A portion of this 0-5 year response may be among those familiar with PGE's Green Source program.)
- Majorities of Residential (64%) and General Business (56%) customers feel that PGE should achieve 100% renewable energy across its entire service territory within 20 years.

Desired Number of Years for PGE to Provide Your Home or Business with 100% Clean and Renewable Energy like Wind, Solar, Geothermal, and Hydropower



Expected Number of Years for PGE to Achieve 100% Renewable Energy Supply for Its Entire Service Territory



REN_100A. By what year do you want the energy that powers your home/business to be produced by 100% renewable, carbon-free generation resources like wind, solar, geothermal and hydropower?
REN_100. Currently, customers can elect 100% renewable energy through purchase of certified Renewable Energy Certificates. Some cities and states are setting long-term goals to have 100% of their energy supplies produced from renewable, carbon-free sources [i.e. energy supply, not purchased RECs]. By what year do you expect PGE to achieve a 100% renewable, carbon-free energy supply for its entire service territory?

Concern Regarding Global / Societal Issues, Action Taken

Among Residential Customers

> Pollution of groundwater sources (18%), *pollution of rivers and streams* (16%) and *global climate change / global warming* (15%) are the most concerning environmental issue for Residential PGE customers.

Global / Societal Issues	Relative Concern (derived importance*)	Rank^ 2006	Rank^ 2012	Percent Indicating Changes Made in Response to Issue (8-10 rating on a 0-10 scale**) 2006 n=507	2012 n=502	2017 n=502
Pollution of groundwater sources	18%	2nd	2nd	27%	29%	30%
Pollution of rivers and streams	16%	1st	1st	30%	29%	31%
Global climate change / global warming	15%	6th	7th	18%	20%	28%
Air pollution	12%	7th	5th	21%	25%	27%
Preserving local fish and wildlife habitats	11%	3rd	3rd	20%	20%	23%
Disaster preparedness for events like major earthquakes, wildfires, and tsunamis	10%	NA	NA	-	-	23%
Deforestation in Oregon	10%	5th	6th	20%	21%	16%
Cyber threats to our energy distribution systems	8%	NA	NA	-	-	15%

^ Items and metric changed from 2006 and 2012; use caution when interpreting ranking trend.
PC. Which of these global / societal issues is of most concern to you as a resident of Oregon?
ENVCONC1-ENVCONC8. To what degree have you made changes in terms of how you behave/it operates in response to each of these global / societal issues?

* Relative Concern" is based on "derived importance" modeled from paired-comparison results across these eight global / societal issues.
** Scale for changes made in response to issue: 0=Little or no change, 10=A great deal of change

Concern Regarding Global / Societal Issues, Behavioral Changes

Among General Business Customers

- General Business customers prioritize *pollution of groundwater sources* (18%) and *pollution of rivers and streams* (17%) as issues of most concern to them.
- *Global climate change/global warming* (8%) is a lesser concern among General Business customers compared with their Residential counterparts.

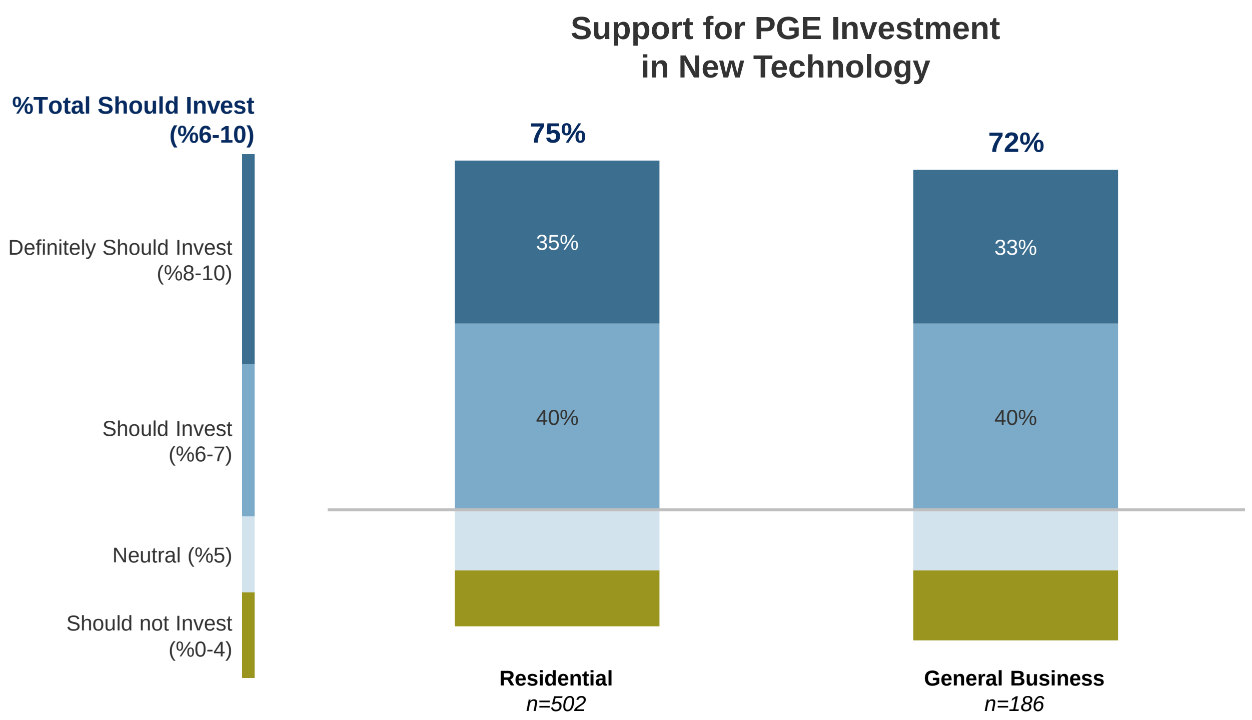
Global / Societal Issues	Relative Concern (derived importance*)	Rank^ 2006	Rank^ 2012	Percent Indicating Changes Made in Response to Issue (8-10 rating on a 0-10 scale**) 2006 n=200	2012 n=198	2017 n=186
Pollution of groundwater sources	18%	2nd	2nd	20%	27%	11%
Pollution of rivers and streams	17%	1st	1st	17%	28%	20%
Preserving local fish and wildlife habitats	13%	4th	4th	9%	16%	16%
Disaster preparedness for events like major earthquakes, wildfires, and tsunamis	13%	NA	NA	-	-	8%
Air pollution	12%	3rd	3rd	10%	20%	14%
Cyber threats to our energy distribution systems	12%	NA	NA	-	-	9%
Global climate change / global warming	8%	6th	7th	6%	12%	15%
Deforestation in Oregon	7%	7th	6th	9%	11%	19%

PC. Which of these global / societal issues is of most concern to you as a resident of Oregon?
ENVCONC1-ENVCONC8. To what degree has your facility made changes in terms of how you behave/it operates in response to each of these global / societal issues?

* Relative Concern" is based on "derived importance" modeled from paired-comparison results across these eight global / societal issues.
** Scale for changes made in response to issue: 0=Little or no change, 10=A great deal of change

PGE Investment in New Technology to Promote Energy Efficiency, Facilitate the Integration of Renewable Resources, and Make Operations More Efficient

> Approximately three-quarters of Residential (75%) and General Business (72%) customers feel that PGE should invest in new technologies (75% Residential, 72% General Business).



NEWTECH. Some electric utilities invest ratepayer money in research and development of new technologies that might promote energy efficiency, facilitate integration of renewable resources, or otherwise make their operations more efficient. Other utilities do not try to develop new technologies, but simply try to find and implement the best technologies that have already been developed.
To what extent do you think that PGE should be investing in developing new technologies?

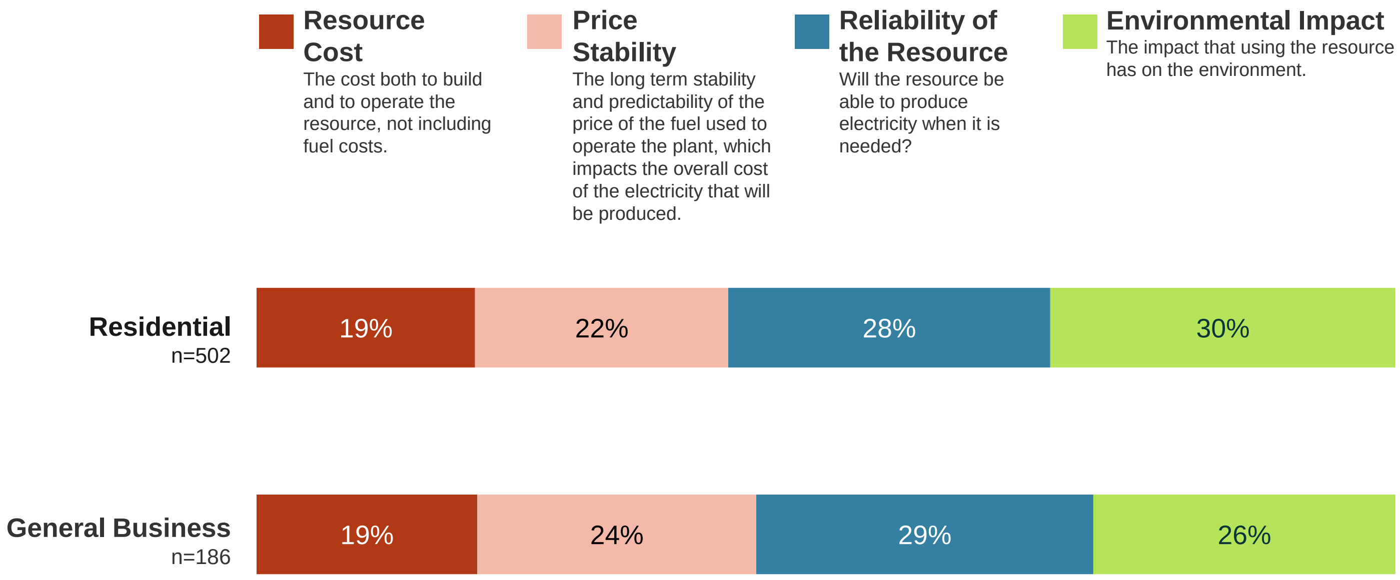
Resource Allocation Exercises

Customer-developed long-term energy resource plans

Relative Importance of Key Factors in Resource Evaluation

> For both Residential and General Business customers, *environmental impacts* and *reliability of the resource* are most important when evaluating resources. However, *price stability* and *resource cost* follow closely among both customer types.

Average Allocation of 100 Points Across Four Key Factors Used for Evaluating Each Energy Resource



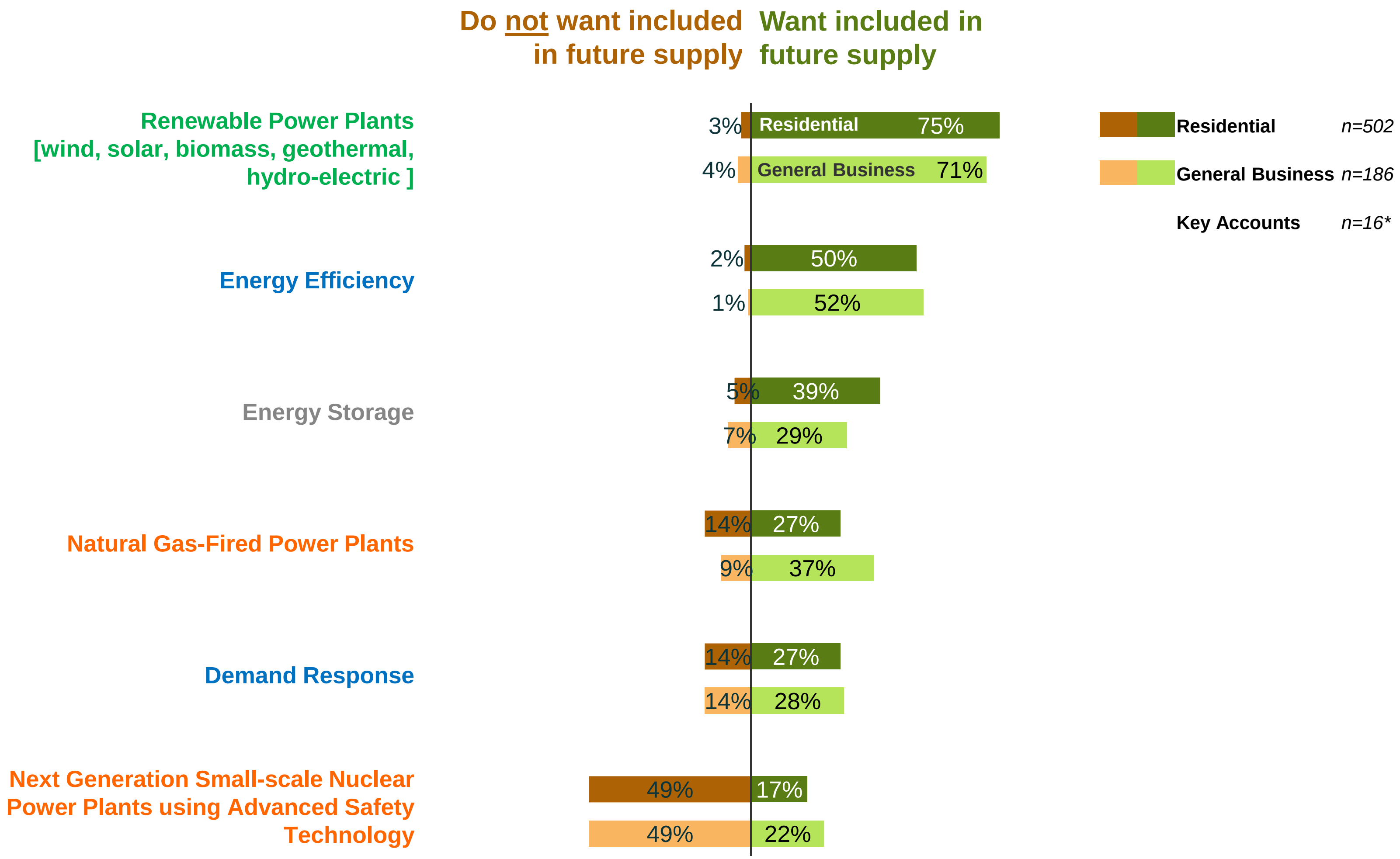
Note: "Factor Importance" percentages are means calculated for each factor from a 100-point allocation exercise.

FACTOR_1. **Resource Cost** – The cost both to build and to operate the resource, not including fuel costs.
FACTOR_2. **Price Stability** -- The long term stability and predictability of the price of the fuel used to operate the plant, which impacts the overall cost of the electricity that will be produced.
FACTOR_3. **Environmental Impacts** – The impact that using the resource has on the environment.
FACTOR_4. **Reliability of the Resource --** Will the resource be able to produce electricity when it is needed?

Resources to Include / Exclude in PGE's Future Electricity Supply Regardless of Price

> Three quarters (75%) of Residential customers and seven in ten (71%) General Business customers want *renewable power plants* included in the future electricity supply, with only 3% and 4% indicating that they do not want renewable power included.

> *Next generation nuclear* is the least desired resource for future energy supply with approximately one-half (49%) of both customer segments indicating they do not want it included.



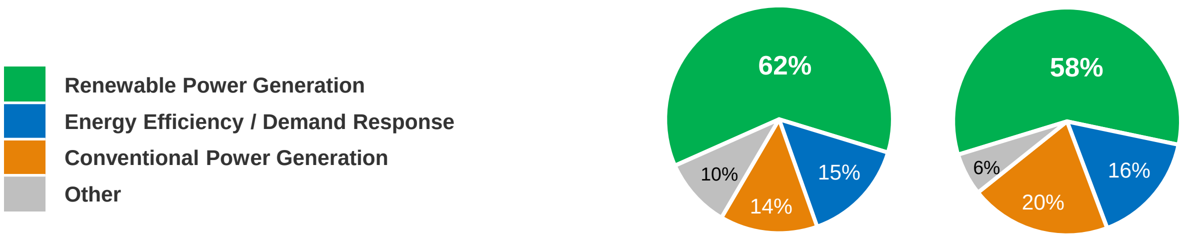
DEF_INCL. Which of these resources would you definitely want PGE to include in a future electricity supply plan regardless of how expensive it was relative to other options?
NOT_INCL. Which of these resources would you definitely NOT want PGE to include in a future electricity supply plan, regardless of how inexpensive it was relative to other options?

Prioritization of New Electricity Resources to be Developed Over the Next 10 Years

> When several specific types of renewable power plants are presented alongside the other options, Residential and General Business prioritization of resources to be developed over the next 10 years are similar, with four out of five specific renewable power plant types (all except Biomass) preferred over the other options.

Prioritization of New Electricity Resources to be Developed by PGE
(Average Allocation of 100 Points Across 10 Potential Resources)

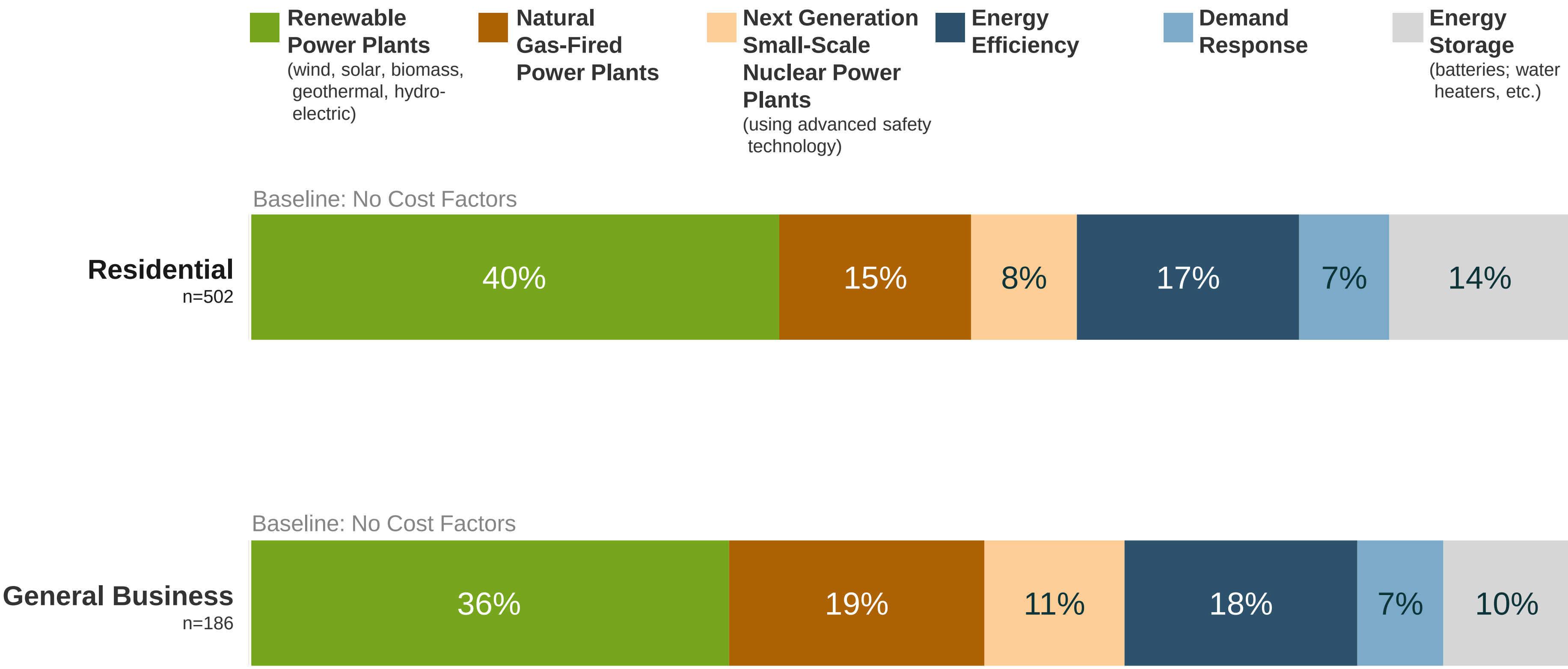
	Residential	General Business
n=	*502*	*186*
Solar Power Plants	17%	14%
Wind Power Plants	15%	13%
Geothermal Power Plants	13%	12%
Hydro-electric Power Plants	12%	14%
Energy Efficiency	11%	12%
Energy Storage	10%	6%
Natural Gas-Fired Power Plants	9%	13%
Next Generation Small-scale Nuclear Power Plants	5%	7%
Biomass Power Plants	5%	5%
Demand Response	4%	4%



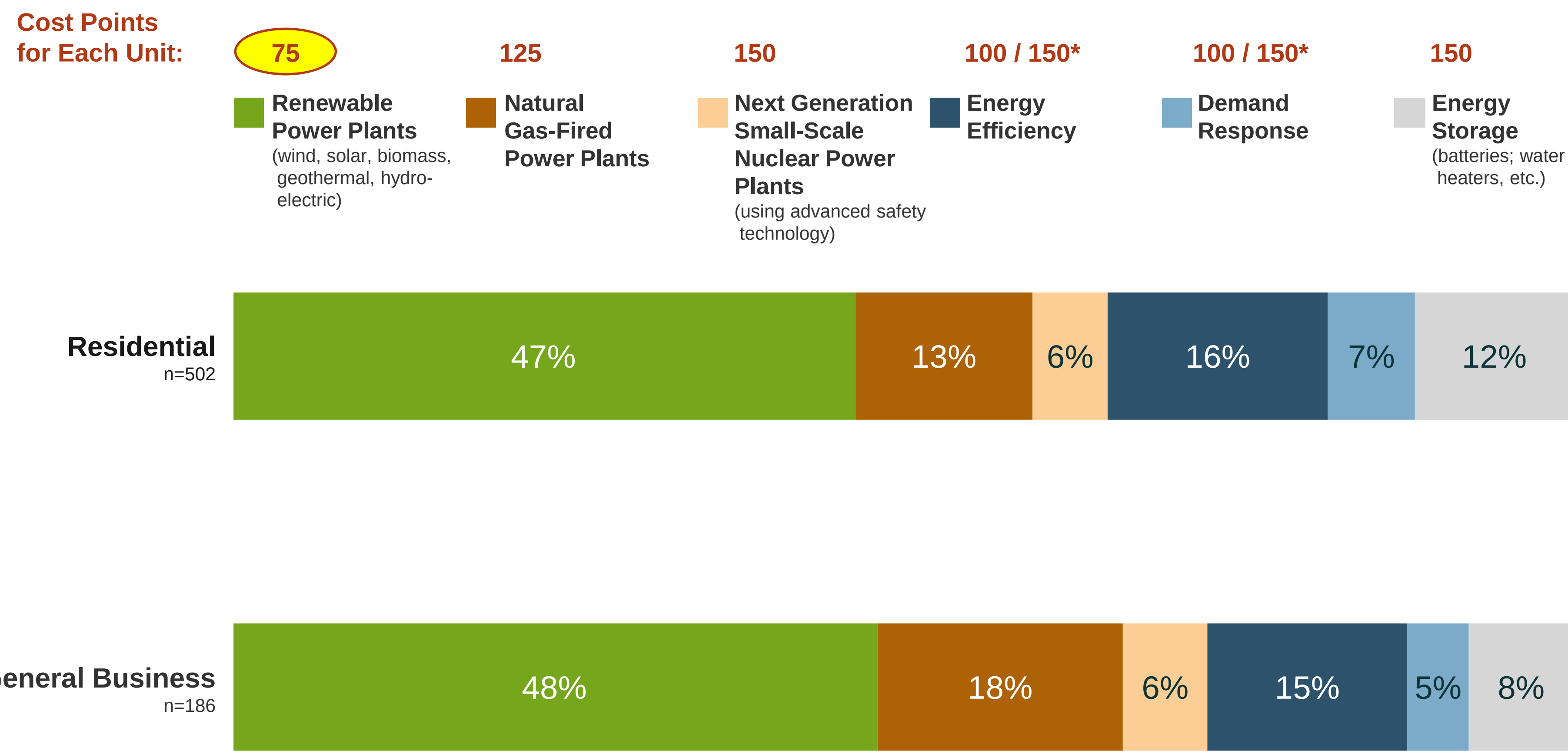
REN10YR. Please allocate those 100 points across the different energy resources in a way that indicates which resources you would <u>most like</u> to see developed, given what you now know about those resources.

Customers' Long-Term Energy Resource Plans: Electricity Resource Allocation Block 1 – *All Resource Options*

- In the initial "baseline" Resource Allocation Exercise, customers were asked to allocate resource "units" across six different electricity resource options to create their long-term energy plan.
- Among both the Residential and General Business segments, Renewable Power Plants receive the highest percent allocation in Block 1, even when they are priced at a higher cost than other options.
- On average, Residential customers allocate slightly more to *Renewable Power Plants* compared with their General Business counterparts, while General Business customers allocate slightly more to *Natural Gas* and *Next Generation Small-Scale Nuclear* power plants.

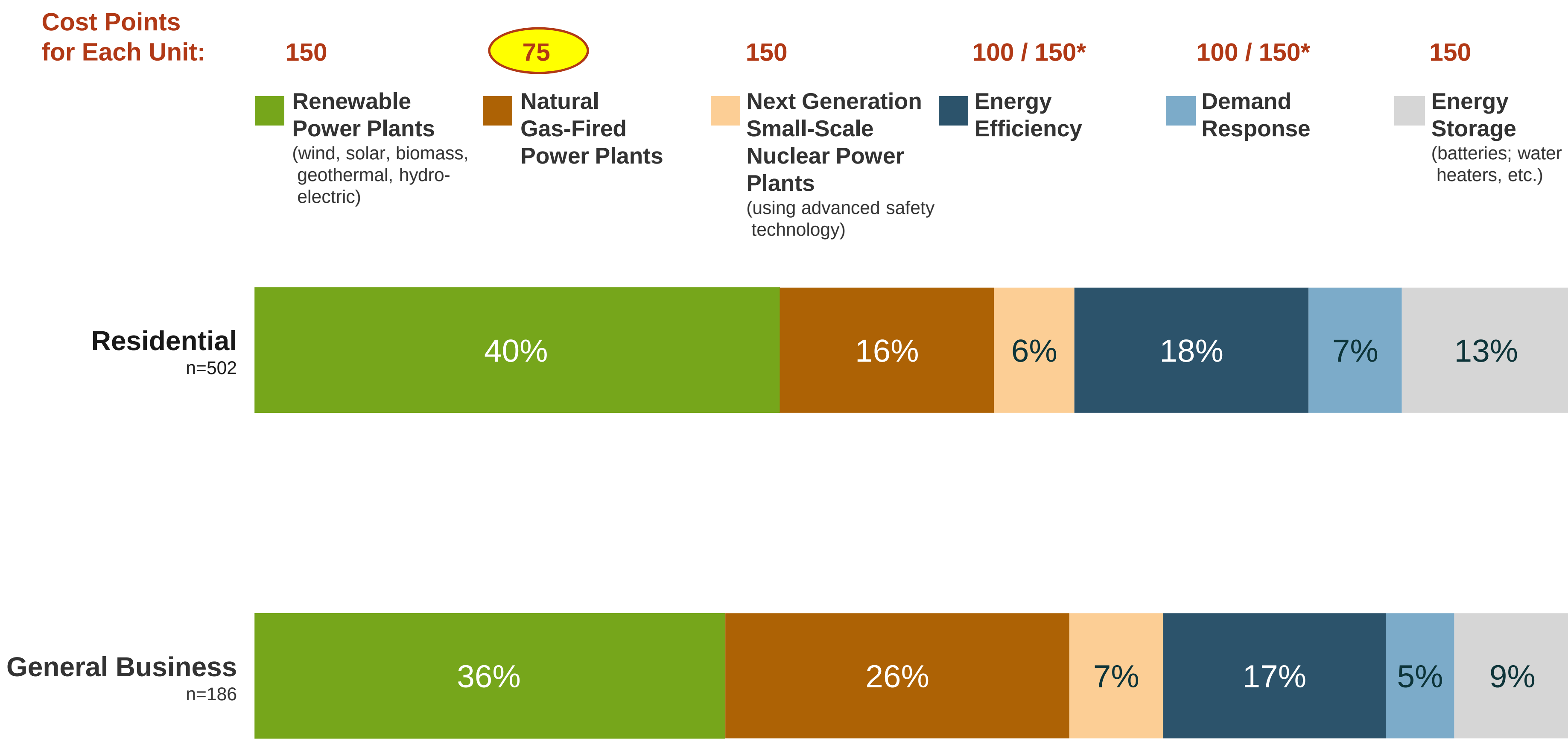


Customers' Long-Term Energy Resource Plans:
Electricity Resource Allocation Block 1 – *All Resource Options*
With Renewable Power Plants at Their LOWEST Cost / All Other Resources at Their HIGHEST Cost



* For Energy Efficiency and Demand Response, maximum cost points were 100 for 0=5 units, and 150 for 6-10 units allocated.

Customers' Long-Term Energy Resource Plans:
Electricity Resource Allocation Block 1 – *All Resource Options*
With Natural Gas-Fired Power Plants at Their LOWEST Cost / All Other Resources at Their HIGHEST Cost



* For Energy Efficiency and Demand Response, maximum cost points were 100 for 0=5 units, and 150 for 6-10 units allocated.

Key Takeaways

- Respondents indicated a desire to see more renewable energy sources in the PGE energy mix
  - Both residential and business customers expressed this desire and were consistently aligned with each other
- Customers support the effort to add renewables even if it costs them more
- Customers expect PGE to move to renewable energy sources quickly
- Customers are not exclusively concerned about cost factors when considering energy resources.
  - Environmental concerns actually score higher than cost concerns when customers are asked to allocate importance.
- Environmental concerns are important to customers
  - Climate change is an increasing concern among residential customers
- Low preference for Demand Response, relative to other energy sources, may be due to incomplete customer knowledge about the programs.
  - Increased communication about programs is important to improve public knowledge about them

Wrap up

Franco

Appendices

Appendix A: Detailed Methodology, Resource Definitions, Allocation Exercise Design

Appendix B: Knowledge of Current Resources Used for PGE’s Power Supply

Appendix C: Additional Resource Allocation Exercise Results

Appendix D: Respondent Profiles

Appendix A: Detailed Methodology, Resource Definitions, Allocation Exercise Design

Data collection methodology

Energy resource definitions

Resource allocation exercise design

2017 IRP Survey Data Collection Methodology

2017 IRP Survey Data Collection Methodology Overview			
	Residential	**General Business**	**Key Accounts**
Overall Quotas	**502** completed surveys	**186** completed surveys	**16** completed surveys
Additional Quotas and Weighting	Data weighted by gender, age, county, and PGE Residential Segments.	Medium ($6K - $24.9K annual PGE revenue): 135 Large ($25K+ annual PGE revenue): 51 Data weighted by revenue segment.	No additional quotas or weights applied.
Qualified Respondent	Adult, energy decision-maker for HH, industry screen	Responsible for making energy-related decisions for their company	Main contact identified in PGE's Key Business Customer database
Screening and Recruiting	Web-based screening and recruitment	Web-based screening and recruitment, supplemented with phone screening and recruitment	Web-based screening and recruitment
Screener Incentives	A drawing incentive for participating in the web Screener survey (chance to win one $500 grand prize, or one of five $100 cash prizes)		No Screener incentive; Pre-survey email from PGE encouraging participation
Main IRP Survey	Web survey (restricted to PCs, Macs, and large tablets due to survey layout – no mobile phones)		
Main IRP Survey Incentives (for completed survey)	**$25** check	**$40** check	**$100** check
Survey Length	**Screener**: 5 – 7 minutes / **Main IRP Survey:** 35+ minutes		
Survey Sample	Randomly selected customer records from PGE's customer database		All available Key Business Customer records (<100 provided)

Survey Screening: Initial Electricity Resource Prioritization

Now, please think about the resources PGE might use to meet the demand for power in Oregon. Which of the following would be your [first / second / third / least preferred] choice for how PGE meets this demand for power?

Renewable Power Plants (including Wind, Solar, Biomass, Geothermal, and Hydro-electric power plants)

Natural Gas Power Plants

Next Generation Small-scale Nuclear Power Plants using Advanced Safety Technology

Energy Efficiency (installation of energy efficient appliances, lighting, and weatherization)

Demand Response (asking customers to shift time of electricity use or reduce use via behaviors such as turning off lights and appliances)

Energy Storage (battery systems that store excess electricity generation, such as power produced by solar arrays during daytime hours, for use when needed)

Descriptions of Energy Resource Options for Initial Survey Questions

> More detailed descriptions of selected electricity resource options were provided later in the survey, preceding the resource allocation exercises.

Natural Gas-Fired Power Plants

Conventional Coal Power Plants

Next Generation Coal Power Plants with Reduced Emissions

Next Generation Small-scale Nuclear Power Plants using Advanced Safety Technology

Wind Power Plants

Solar Power Plants

Biomass Power Plants (using plant-derived material)

Geothermal Power Plants (using naturally occurring heat in the earth to generate energy)

Hydro-electric Power Plants

Energy Efficiency (installation of energy efficient appliances, lighting, and weatherization)

Demand Response (asking customers to shift time of electricity use or reduce use via behaviors such as turning off lights and appliances)

Distributed Generation (small-scale generation located at point of consumption. e.g. solar, microhydro, fuel cells, small wind)

Energy Storage (battery systems that store excess electricity generation, such as power produced by solar arrays during daytime hours, for use when needed)

Smart Grid (investments in new technologies and infrastructure to support more efficient management of electricity supplies)

Electricity Resource Allocation Exercises

> After being presented detailed information about each electricity resource, respondents were asked to complete several "resource allocation exercises" in which they allocated points across several potential resources to create their own long-term energy supply plans.

- *First, they completed an initial "baseline" resource allocation with no cost factors introduced.*
- *Then, they completed several additional resource allocation exercises with three different sets of resource options, and price factors for each resource which varied across the exercises.*

> *An example of one of the resource allocation exercises respondents completed is shown below.*

The table below provides several electricity resource options that are available to you to build an energy plan. It also tells you the cost "points" associated with each unit of electricity resource you select.

To complete this exercise you must:

- Select 10 units of electricity resource in total
- Select only one type of resource or a mix of resources
- Include only the resources you want in your plan

Please note: **The cost points associated with each type of resource may or may not reflect the actual costs that would be associated with acquiring each resource in the marketplace.** For the purposes of this exercise, however, please make your energy planning decisions assuming the relative costs reflected in the resource cost points indicated.

Creating a plan that totals 1000 costs points will result in no increase in PGE customers' bills. However, you DO NOT have to spend exactly 1000 cost points:

- For every 250 points your plan EXCEEDS 1000 cost points, the bills for ALL PGE customers will go up by 5%
- For every 250 points your plan costs LESS than 1000 cost points, the bills for ALL PGE customers will go down by 5%
- Please enter the number of units of each resource to be included in your plan in the table below. When you have selected the 10 units of electricity resource you want – recognizing the total cost impact of those resource selections – you are done.

Resource	Maximum Units of Each Resource Available	Cost Points for Each Unit (including cost to build, operate & cost of fuel)	Enter Number of Units of Each Resource Included in Your Resource Plan	Cost for Units of Electricity Selected for Each Resource
Renewable Power Plants (wind, solar, biomass, geothermal, hydro-electric)	10	(75-150)	[RECORD UNITS 0-10]	[DISPLAY TOTAL FOR RENEWABLES]
Natural Gas Power Plants	10	(75-125)	[RECORD UNITS 0-10]	[DISPLAY TOTAL FOR NATURAL GAS]
Next Generation Small-scale Nuclear Power Plants using Advanced Safety Technology	10	(125-150)	[RECORD UNITS 0-10]	[DISPLAY TOTAL FOR NUCLEAR]
Energy Efficiency	10	(75-100 for 0-5 units; 125-150 for 6-10 units)	[RECORD UNITS 0-10]	[DISPLAY TOTAL FOR EE]
Demand Response	10	(75-100 for 0-5 units; 125-150 for 6-10 units)	[RECORD UNITS 0-10]	[DISPLAY TOTAL FOR DEMAND RESPONSE]
Energy Storage (batteries, water heaters, etc.)	10	[100-150]	[RECORD UNITS 0-10]	[DISPLAY TOTAL FOR ENERGY STORAGE]
		Total Number of Units of Electricity Selected Must Equal 10 ➔	Click Here for Total [DISPLAY TOTAL NUMBER OF UNITS SELECTED]	Click Here for Total Cost of Energy Plan [DISPLAY TOTAL COST]

Summary of Resource Option Cost Scenarios

Resource Option	Energy Efficiency	Demand Response	Energy Storage	Natural Gas	Next Gen Nuclear	Renewables	Wind	Solar	Biomass	Geothermal	Hydro
COST POINTS RANGE	75-150	75-150	100-150	75-125	125-150	75-150	75-125	75-150	100-150	100-150	100-150
	BASELINE SCENARIO (no cost factors)										
Scenario 1 (Baseline)											
	SCENARIOS FOR BLOCK 1										
Scenario 2											
Scenario 3											
Scenario 4											
Scenario 5											
Scenario 6											
	SCENARIOS FOR BLOCK 2										
Scenario 7											
Scenario 8											
Scenario 9											
Scenario 10											
Scenario 11											
	SCENARIOS FOR BLOCK 3										
Scenario 12											
Scenario 13											
Scenario 14											
Scenario 15											

Appendix B: Knowledge of Current Resources Used for PGE's Power Supply

Familiarity with electricity resource options

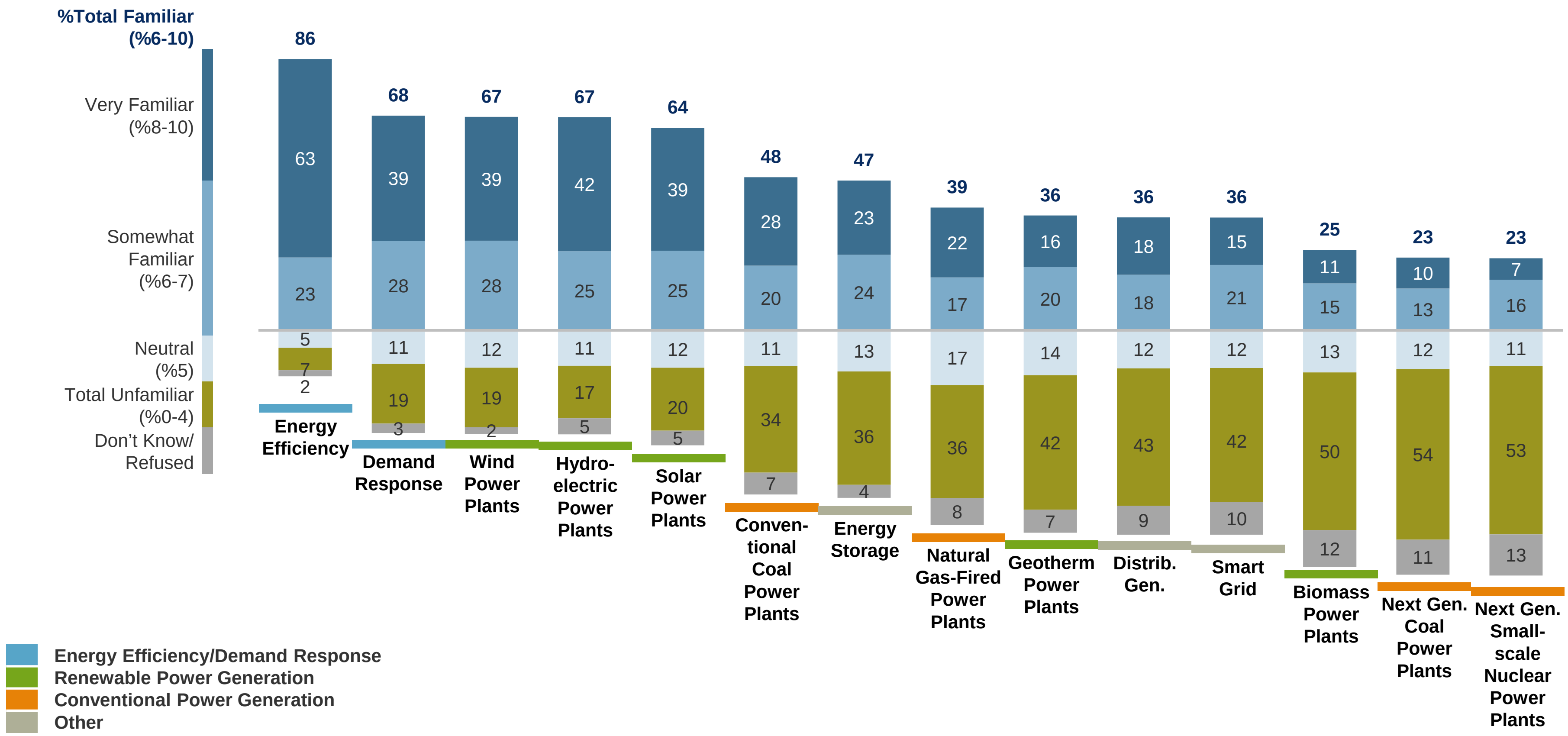
Knowledge of resources used for PGE's power supply

Awareness that electricity received from PGE is generated from renewable resources

Familiarity with Electric Resource Options – *Residential*

n=502

- Residential customers report being most familiar with Energy Efficiency, with more than eight in ten (86%) saying they are familiar with this energy resource option. Roughly two in three customers say they are familiar with Demand Response, Wind Power, Hydro-Electric, and Solar Power (64-68%).
- Familiarity is lowest with Biomass Power, Next Generation Coal, and Next Generation Small-scale Nuclear with approximately one in four customers reporting they are familiar with these options.



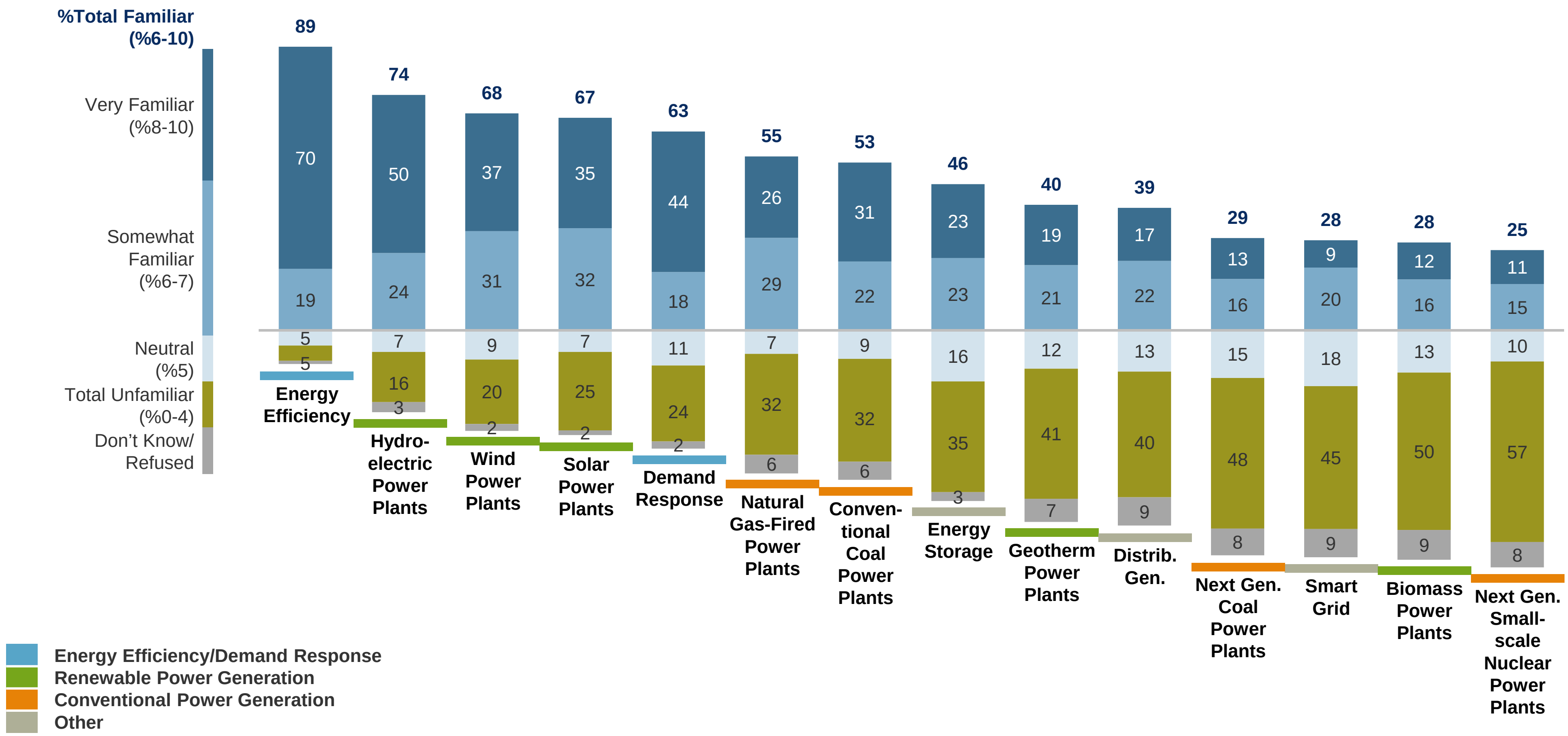
Q1A-Q1N. How familiar are you with each of the following electricity resource options?

^Wording changed from 2012; use caution when interpreting trends.

Familiarity with Electric Resource Options – *General Business*

n=186

- Similar to Residential customers, General Business customers report being most familiar with Energy Efficiency, with nearly nine in ten (89%) saying they are familiar with this energy resource option. More than six in ten customers say they are familiar with Hydro-Electric Power, Wind Power, Solar, and Demand Response (63-74%).
- Familiarity is lowest with Next Generation Coal, the Smart Grid, Biomass Power, and Next Generation Small-scale Nuclear with approximately one in four customers reporting they are familiar with these options (25%-29%).



Q1A-Q1N. How familiar are you with each of the following electricity resource options?

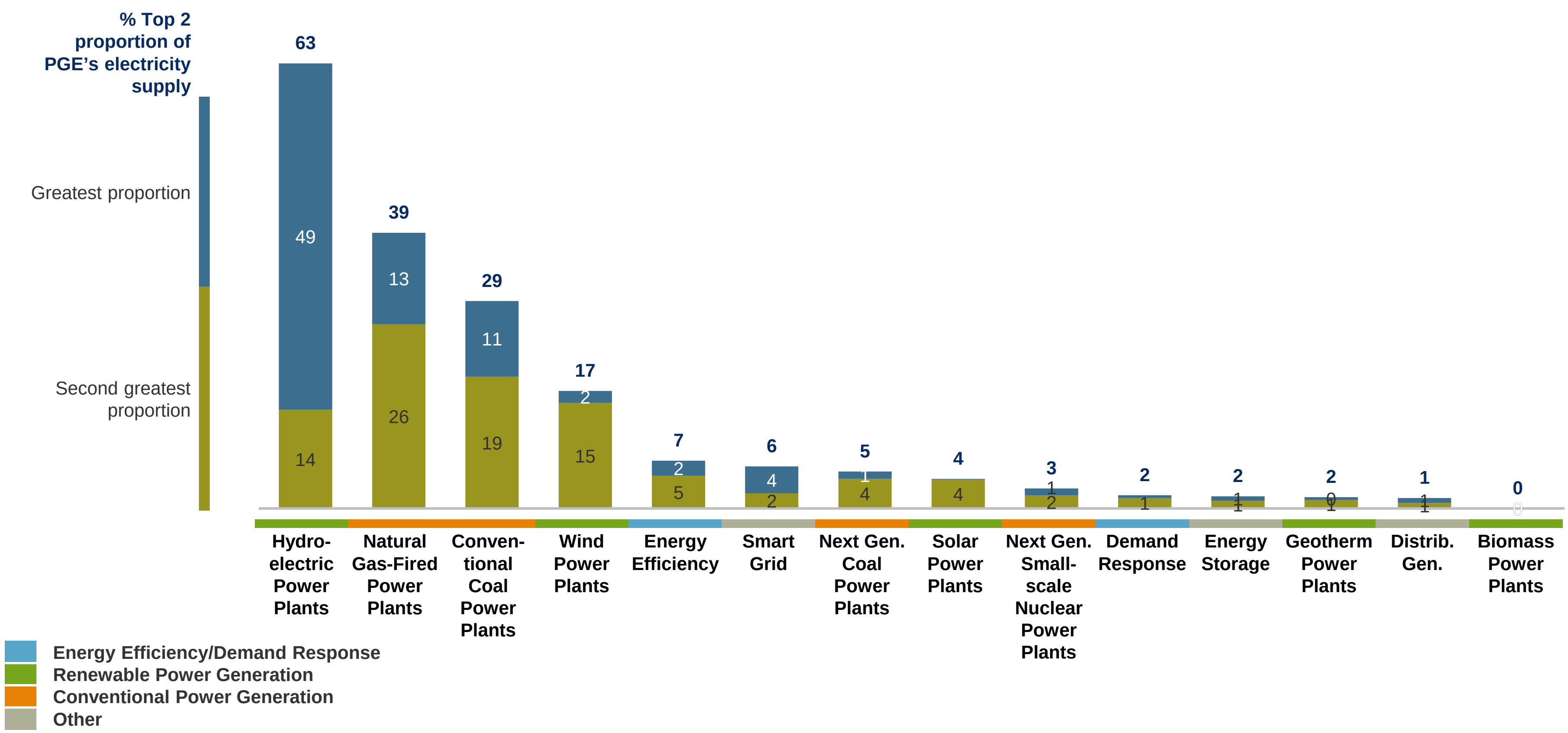
^Wording changed from 2012; use caution when interpreting trends.

Knowledge of Resources Currently Used for PGE's Power Supply

Among Residential Customers

n=502

- A majority of Residential customers identify Hydro-electric Power (63%) as one of the top two resources PGE uses to supply electricity, followed by Natural Gas (39%), Conventional Coal (29%) and Wind Power (17%).
- No other resource is believed to among the top two resources currently used for PGE's electricity supply by more than 7% of Residential customers.



Q5-Q6. Which one of these resources do you think currently accounts for the greatest / second greatest proportion of PGE's power supply?

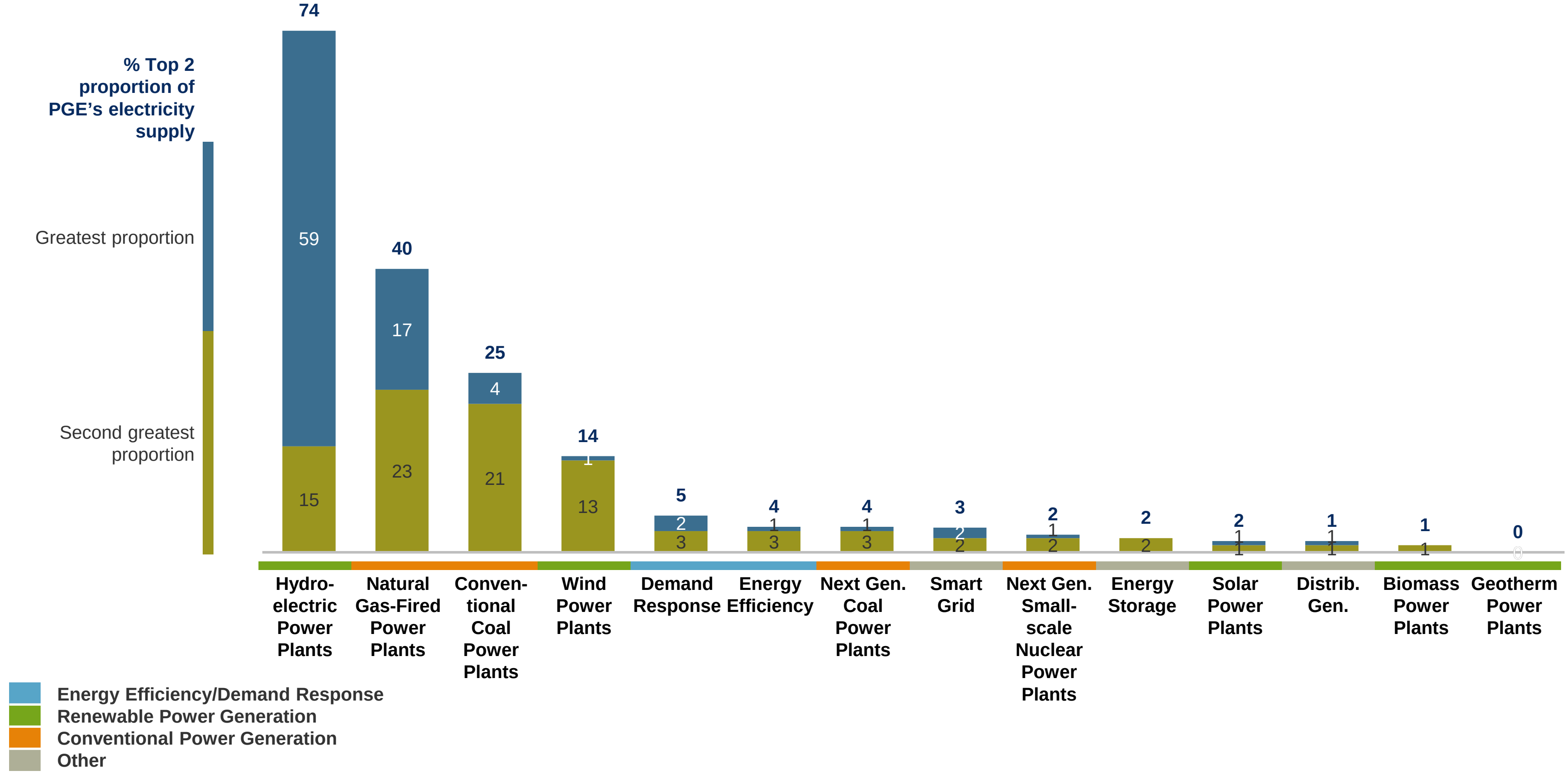
^List and item wording changes versus 2012; use caution when interpreting trends.

Knowledge of Resources Currently Used for PGE's Power Supply

Among General Business Customers

n=186

- A majority of General Business customers identify Hydro-electric Power (74%) as one of the top two resources PGE uses to supply electricity, followed by Natural Gas (40%), Conventional Coal (25%) and Wind Power (14%).
- No other resource is believed to among the top two resources currently used for PGE's electricity supply by more than 5% of General Business customers.



Q5-Q6. Which one of these resources do you think currently accounts for the greatest / second greatest proportion of PGE's power supply?

^List and item wording changes versus 2012; use caution when interpreting trends.

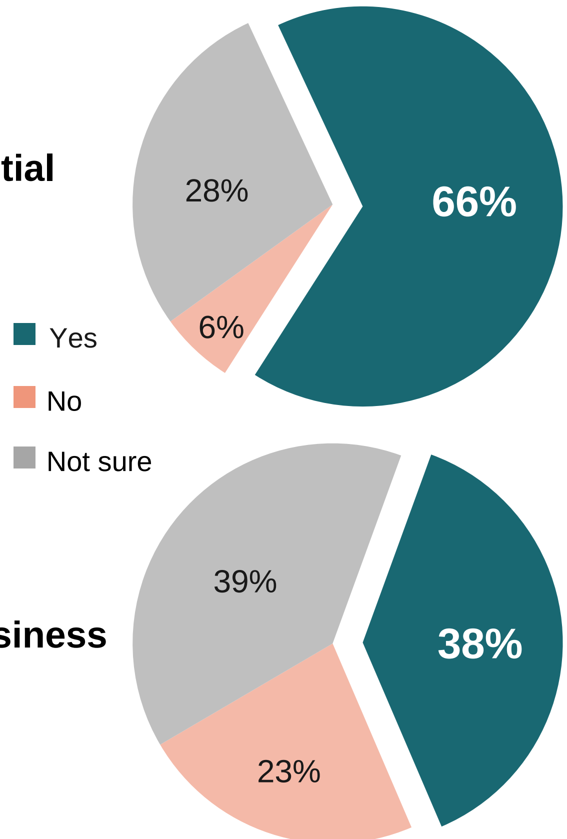
Awareness That Electricity Received from PGE is Generated from Renewable Resources (such as Wind, Solar, Biomass, Geothermal, or Hydro-electric)

- Two-thirds of Residential Customers believe that some portion of the power they receive from PGE is generated using renewable resources (66%).
- The proportion of General Business customers that believe their facility receives energy from renewable resources is much lower at 38%.

Awareness That Any Of The Electricity the Customer's Home or Business Receives from PGE Is Generated Using Renewable Resources Such as Solar, Wind, Biomass, Geothermal, or Hydro-electric Power

Residential
n=502

General Business
n=186



Estimated Percentage of PGE Electricity That Comes From Renewable Sources
(among customers who believe some energy is generated using renewables)

Residential: n=349

10% or less	19%
11% to 20%	21%
21% to 30%	18%
31% to 40%	9%
41% to 50%	8%
51% to 70%	5%
71% to 100%	5%
Not sure	15%
Mean	**29.4%**

General Business: n=70

10% or less	22%
11% to 20%	24%
21% to 30%	19%
31% to 40%	6%
41% to 50%	2%
51% to 70%	0%
71% to 100%	16%
Not sure	11%
Mean	**27.6%**

AWR_REN1. To the best of your knowledge, is any of the electricity you receive / your business receives from PGE generated using Renewable Resources?
AWR_REN2. To the best of your knowledge, approximately what percentage of PGE's electricity currently comes from Renewable Resources such as wind, solar, biomass, or geothermal?

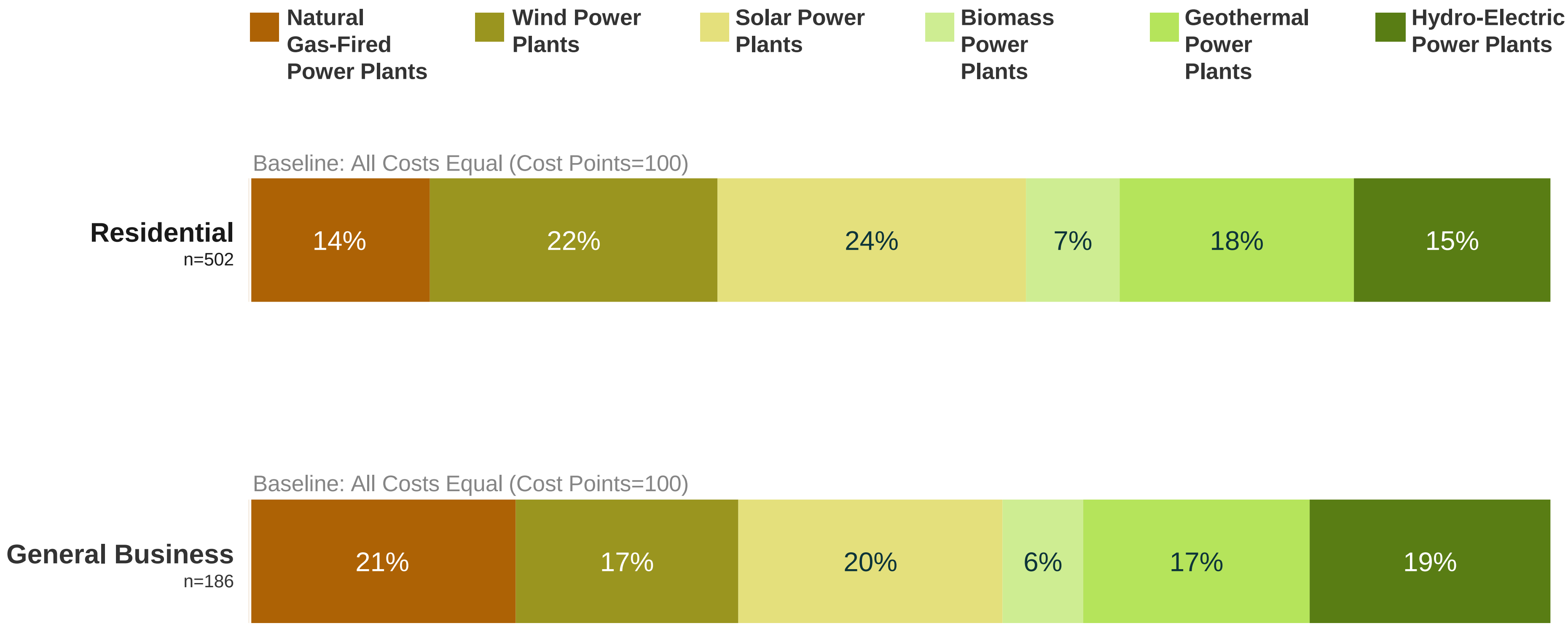
Appendix C: Additional Resource Allocation Exercise Results

Electricity Resource Allocation Block 2 – *Natural Gas and Specific Renewables*

Electricity Resource Allocation Block 3 – *Renewables Only*

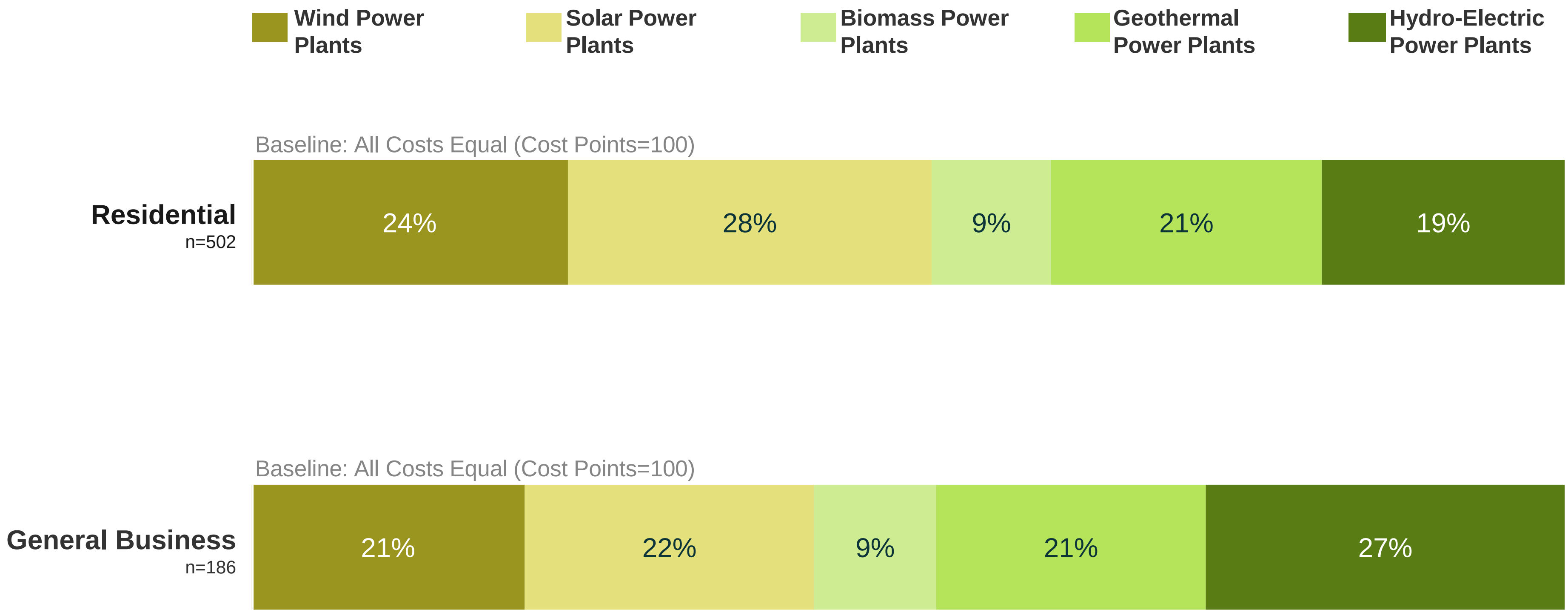
Customers' Long-Term Energy Resource Plans: Electricity Resource Allocation Block 2 – *Natural Gas and Specific Renewables*

> When presented with a menu of electricity resources consisting of Natural Gas Power Plants and five specific types of Renewable Power Plants, customers overwhelmingly prefer a mix dominated by renewable resources, even when Natural Gas is the least expensive option.



Customers' Long-Term Energy Resource Plans: Electricity Resource Allocation Block 3 – *Renewables Only*

- When presented with five specific Renewable Power Plant options only and all costs are equal, Residential customers allocate the most of their long-term power plan to Solar Power Plants (28%), while General Business customers give Hydro-Electric Power Plants their highest allocation (27%).
- Biomass is the least popular resource option among both segments in this scenario.



Appendix D: Respondent Profiles

Residential Demographics

General Business and Key Accounts Firmographics

Demographics by segment

	Total	Simply Service (A)	Totally Tech (B)	Innovative Investors (C)	Continually Connected (D)	Sensible Savers (E)
n=	*502*	*37*	*172*	*199*	*34*	*60*
Gender	*%*					
Male	47%	48%	53%	50%	35%	41%
Female	53%	52%	47%	50%	65%	59%
Homeowner or Renter						
Homeowner	63%	29%	71% ADE	91% ABDE	34%	56% AD
Renter	36%	71% BCD	29% C	8%	63% BC	44% BC
Education						
H. S. or less	3%	4%	3%	2%	2%	6%
Some college Voc./Tech. Sch.	33%	29%	29%	23%	47% C	47% BC
College graduate/ post graduate	63%	67% E	67% E	73% DE	51%	46%
Income						
Less than $25k	7%	11% C	5% C	1%	23% BCE	4%
$25K-$50K	14%	15%	12% C	6%	28% BC	15% C
$50K-$75K	21%	33% C	21%	17%	14%	23%
$75K+	58%	41%	62% AD	76% ABDE	34%	57% D
Age						
18-24	4%	12% C	6% C	0%	5%	1%
25-34	17%	31% CD	26% CD	6%	15%	11%
35-44	20%	20%	26% CD	16%	23%	11%
45-54	19%	14%	16%	22%	26%	16%
55-64	22%	14%	16%	25% B	21%	31% B
65 or over	18%	9%	10%	30% ABD	9%	29% ABD
Average Monthly Bill						
Less than $50	18%	19%	27% CD	16%	10%	18%
$50 to $64.99	18%	32% CE	20%	14%	14%	14%
$65 to $84.99	20%	19%	25%	19%	19%	17%
$85+	43%	30%	28%	51% AB	57% AB	51% B
Mean bill amount in dollars	$89.5	$72.4	$79.8	$97.2	$94.9	$99.7

Firmographics by Segment

	General Business	Medium Business (A)	Large Business (B)
n=	186	135	51
Length of Current Employment	%		
Less than 6 months	3%	3%	2%
6 months to less than 1 year	1%	1%	4%
1 year to less than 5 years	24%	25%	20%
5 years or more	70%	68%	75%
Proportion of Operating Costs Accounted for by Electricity Costs			
Less than 1%	11%	12%	10%
1% to less than 5%	36%	34%	43%
5% to less than 10%	23%	22%	25%
10% to less than 20%	13%	13%	12%
20% or more	6%	7%	2%
Number of Locations Served by PGE			
1	35%	36%	31%
2	23%	24%	18%
3	13%	14%	8%
4	23%	19%	33% A
Number of Years as Customer			
Less than 5 years	6%	6%	8%
5 to less than 10 years	10%	11%	6%
10 or more years	81%	80%	82%

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