Deep Decarb Study Update: Summary Report

EVOLVED ENERGY RESEARCH

Prepared for: Portland General Electric

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Contents

- Background
- Modeling approaches and assumptions
  - Modeling framework
  - Scenarios
- Results
- Summary

Background

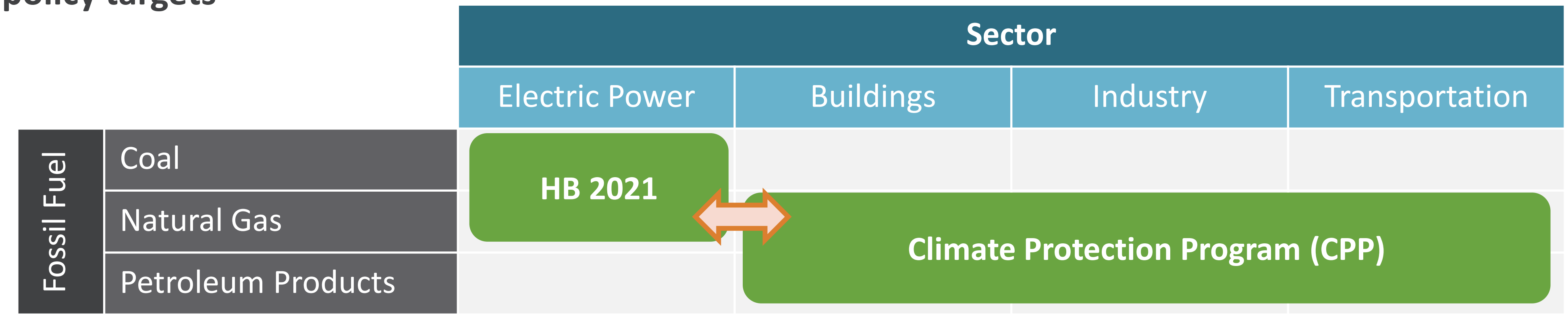
Motivation and context

- In 2017, Portland General Electric (PGE) commissioned Evolved Energy Research (EER) to undertake an independent study exploring pathways to deep decarbonization for its service territory (“Deep Decarb Study”)
  - Study evaluated an economy-wide reduction in GHG emissions of 80 percent below 1990 levels by 2050
- Since then, Oregon has adopted two keynote environmental policies limiting greenhouse gas (GHG) emissions
  1. **House Bill (HB 2021**) establishes emissions reduction targets for PGE’s electricity mix; and
  2. **Climate Protection Program (CPP)** limits GHG emissions associated with the use of fossil fuels in buildings, industry and transportation

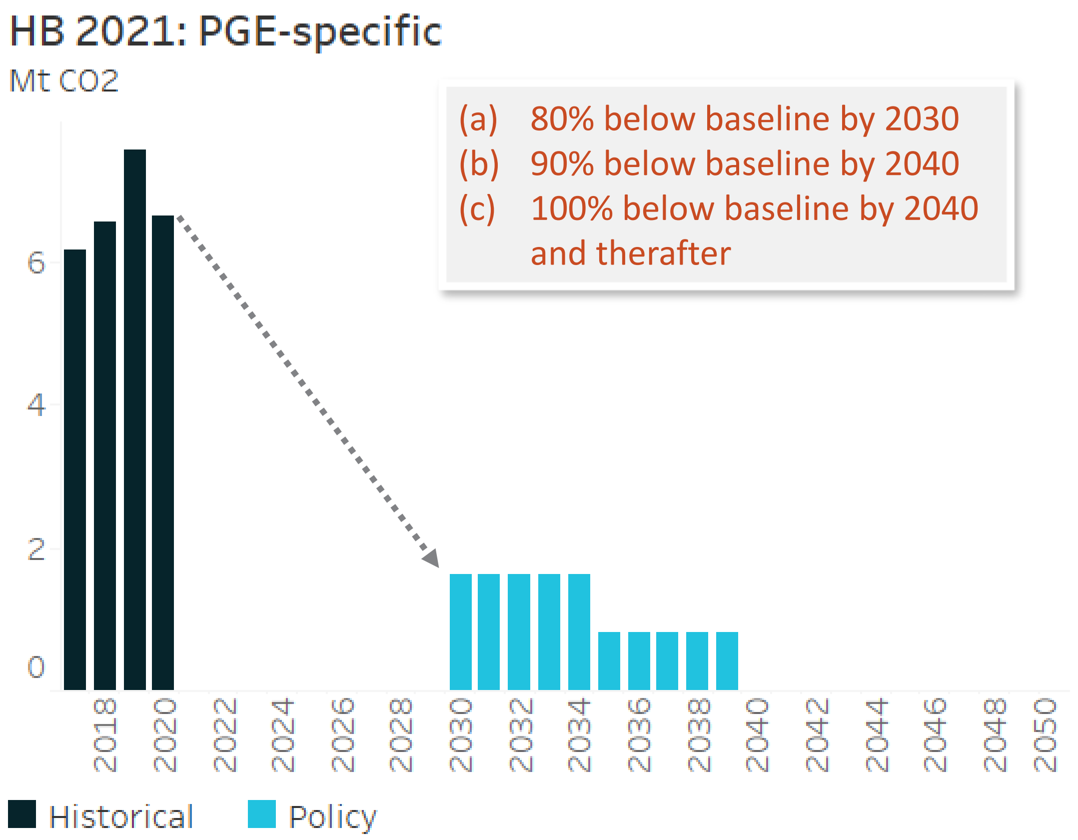
Purpose and scope

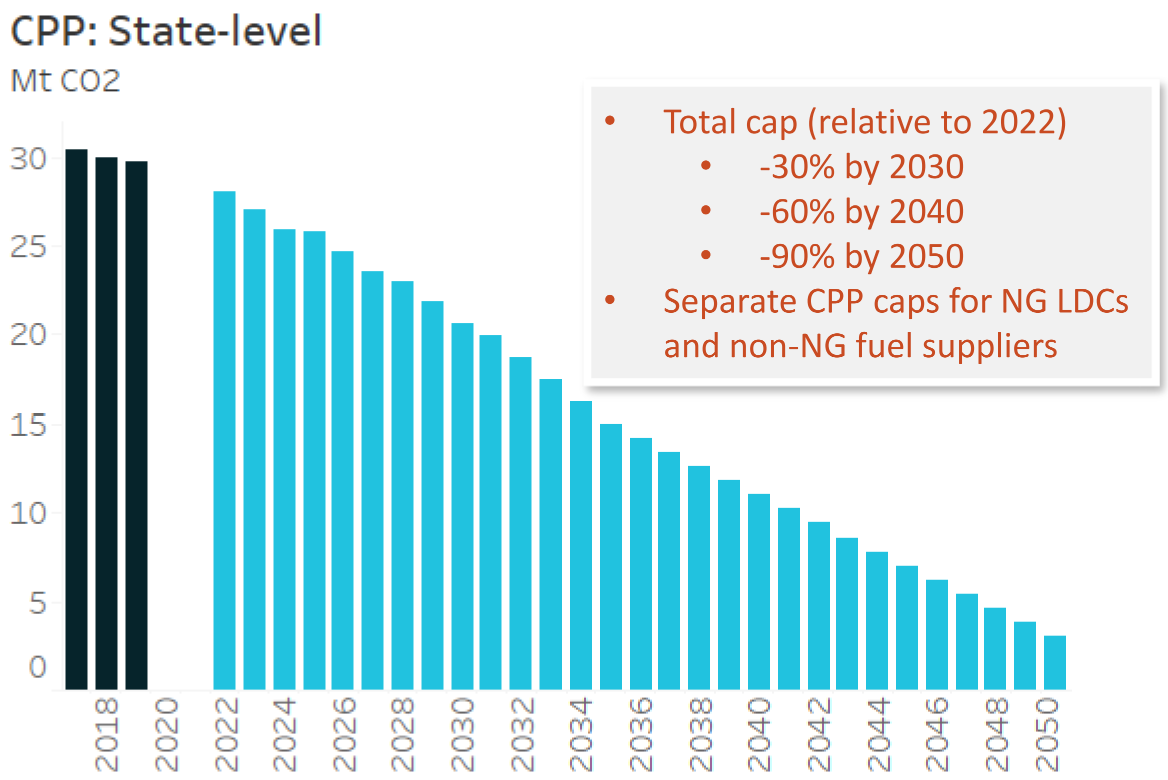
- The *Deep Decarb Study Update* explores pathways that achieve the HB 2021 and CPP emissions targets (“study policy targets”) for PGE’s service territory
- Questions posed:
  - What are the opportunities and challenges of achieving the study policy targets?
  - What are the result implications for electricity system operations and planning?
  - What are the cross-sectoral impacts of the two policy targets?

Study policy targets



Study policy targets





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Modeling Approaches and Assumptions

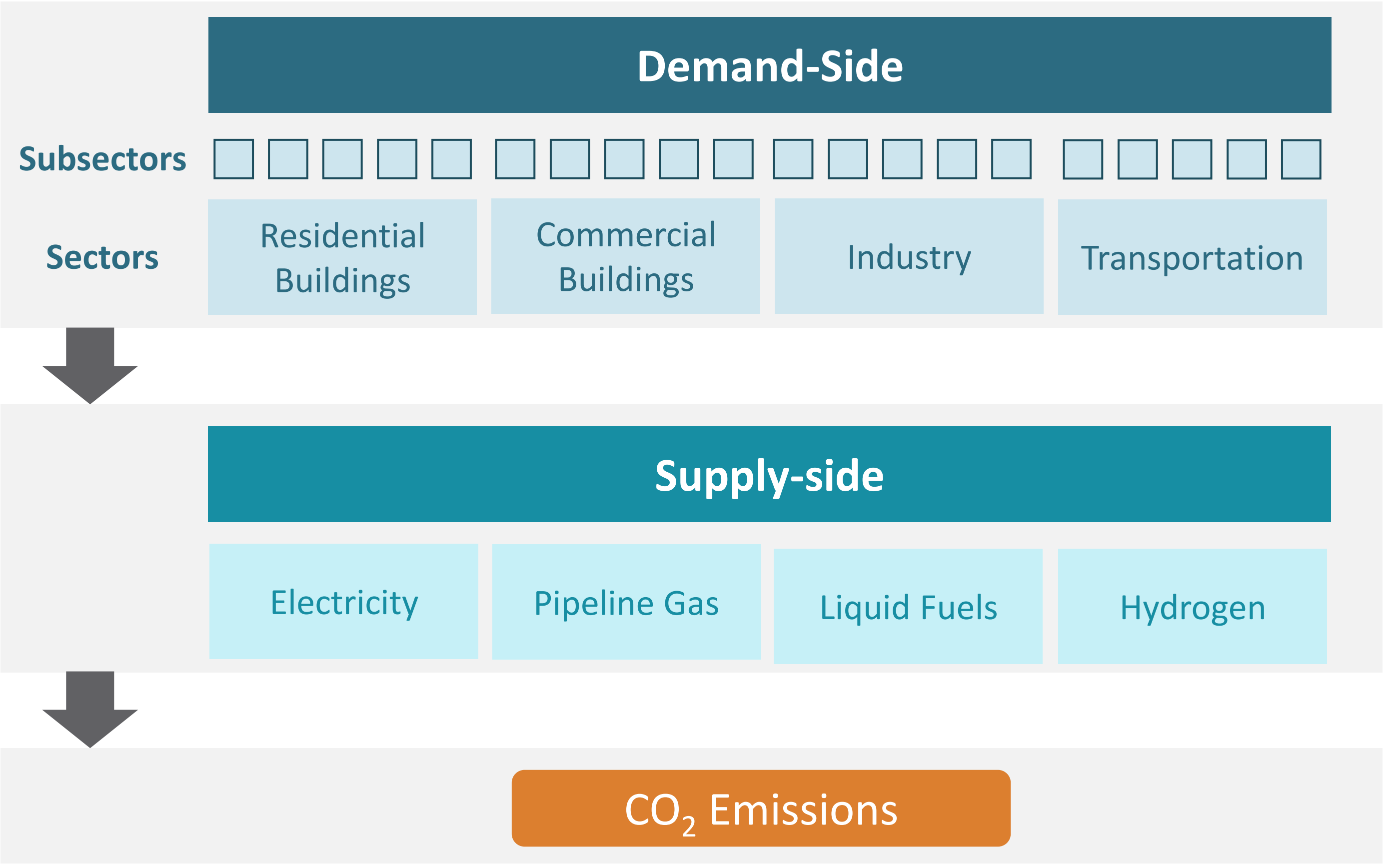
High-level description of modeling approach

- Modeling projects energy demand for PGE's service territory and the least-cost way to provide that energy under policy constraints

Model of PGE's service territory	PGE service territory's energy needs	Supply energy reliability at least cost
Residential Commercial Industrial Transportation	Electricity Pipeline Gas Liquid Fuels	Generation Delivery Storage Fuel Supply

Analysis covers energy system for PGE's entire service territory

- Study includes a detailed representation of the PGE service territory's energy system, including infrastructure stocks and energy demands for buildings, industry and transportation
- Cost-optimal portfolios for electricity and fuels are developed to achieve policy goals at least-cost



Modeling result considerations

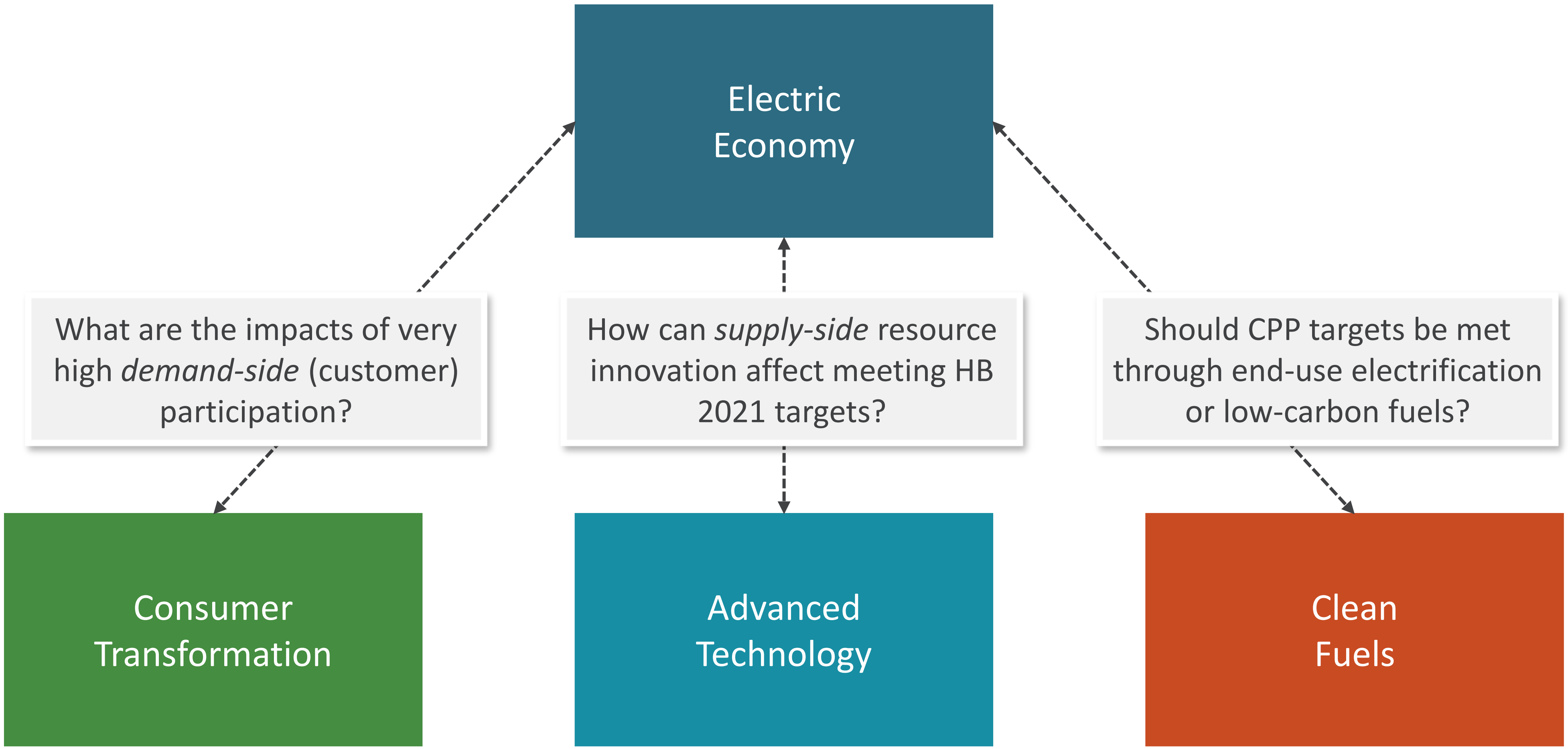
- Our modeling results may differ from PGE’s IRP and DSP due to the use of alternative models and the inclusion of direct access loads in our scope
- Scenarios do not reflect PGE’s business plan or future resource acquisitions
- This study’s modeling approach and results do not replace existing tools or processes used by PGE, such as defining “need” for resource adequacy or identifying optimal portfolios

Scenarios

Four pathways designed to meet the study policy targets

1. **Electric Economy**
   - Electrify buildings, industry & transportation to the extent possible to meet CPP targets
   - Deploy primarily transmission-sited (supply-side) resources to meet HB 2021
2. **Consumer Transformation**
   - Electrify homes & businesses, while consumers actively participate to provide flexibility
   - Very high customer-sited solar and storage adoption, plus end-use load flexibility
3. **Advanced Technology**
   - Assess the impact of nascent clean energy technologies
   - Understand broad impacts of offshore wind and hydrogen use in power generation
4. **Clean Fuels**
   - Maintain gas use in buildings and decarbonize fuel supply
   - Prolific use of hydrogen in transportation and industry

Scenario framework answers key questions



High-level assumptions table

Values are for 2050 unless specified otherwise

		Electric Economy [S1]	Consumer Transformation [S2]	Advanced Technology [S3]	Clean Fuels [S4]
Demand side	**End-use electrification**	High Electrification			Low Electrification
	Load Flexibility	Base	Aspirational	Same as S1	Same as S1
Electricity Supply	**Customer-sited resources**	Base	Aspirational	Same as S1	Same as S1
	Supply-side resources	Onshore wind, solar PV and energy storage		Allow offshore wind and H_2 turbines	Same as S1
	Existing thermal resources	-**Colstrip**: planned exit -**Existing gas-fired resources**: burn NG and then ZCF as needed (100% ZCF by 2040)			
Fuel Supply	**Zero-carbon fuels**	Minimal deployment since emissions reductions are primarily from demand-side reductions			High RNG and H_2 use

Results

Structure of results

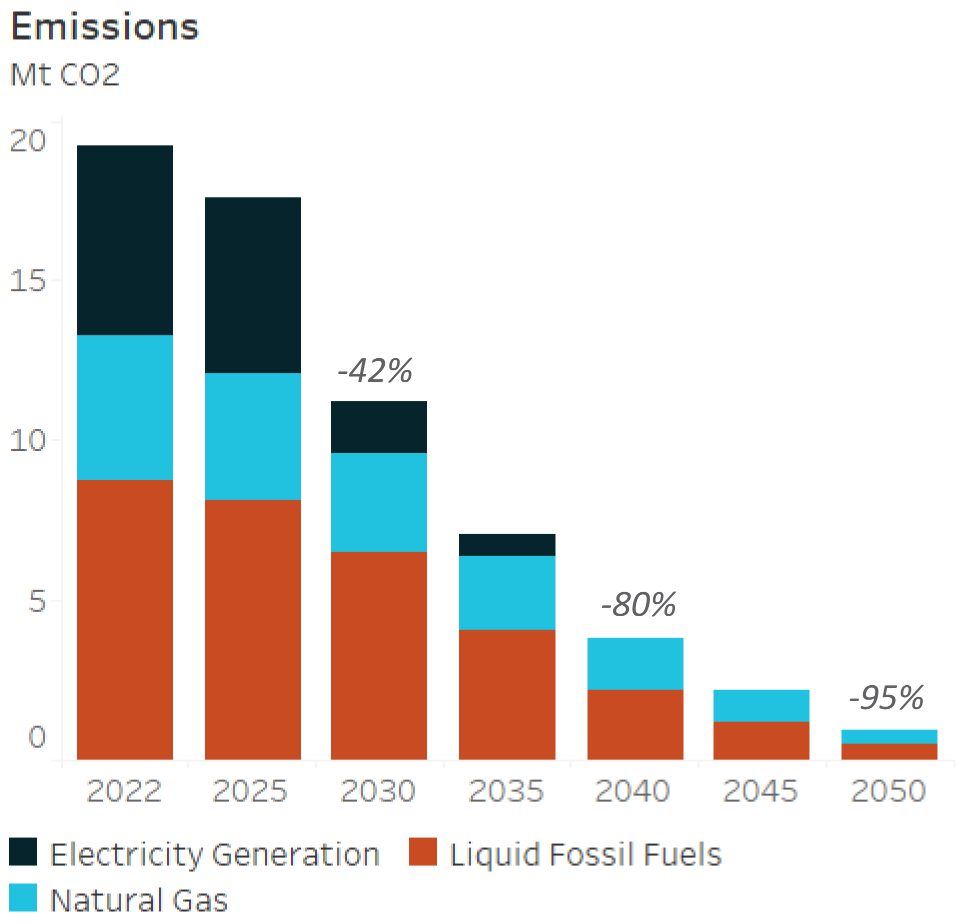
- The results in this section are presented as follows
- The **Electric Economy** scenario is presented first with an in-depth focus on how the PGE service territory energy system transforms to meet the study policy targets
- Next, the **Consumer Transformation, Advanced Technology** and **Clean Fuels** pathways are presented in the context of how the results differ relative to the **Electric Economy** scenarios

Emissions and Energy demand

Electric Economy

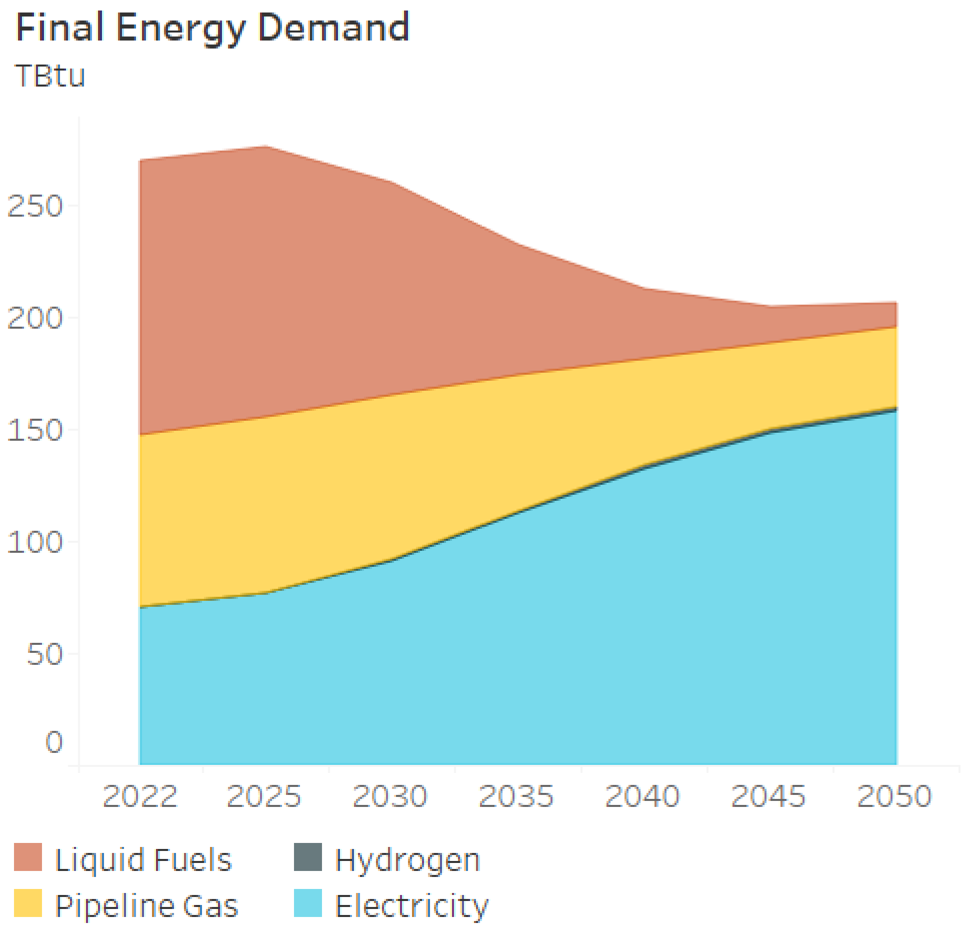
Covered CO_2 emissions

- Emissions covered by HB 2021 and CPP are approximately 20 Mt CO_2 today
  - Emissions associated with liquid fuel consumption, overwhelmingly found in transportation, make up almost half of all emissions
- Abatement is front-loaded during the first decade primarily due to HB 2021's 2030 carbon target
- Emissions decline to under 1 Mt by 2050



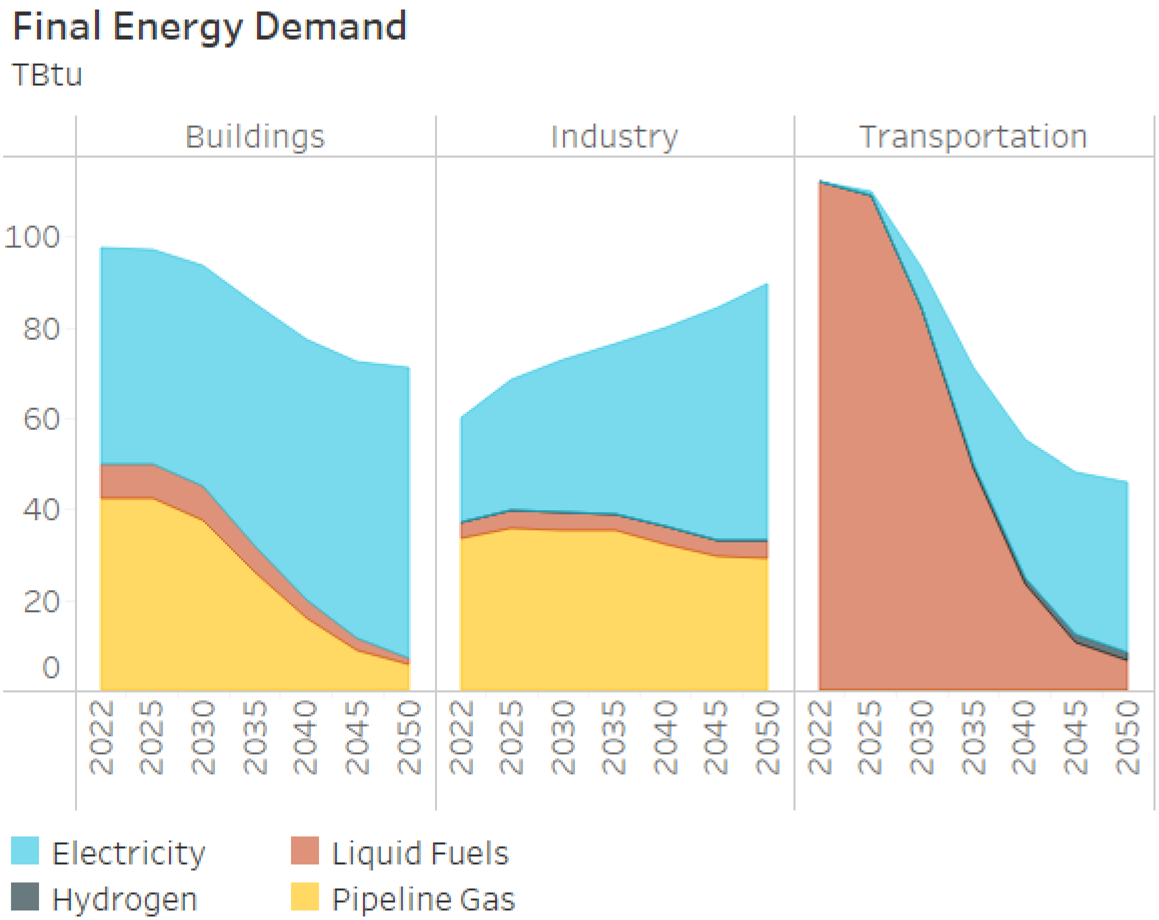
Final energy demand

- Final energy demand defined
  - Includes: energy used in the delivery of services such as heating or transportation (e.g., includes pipeline gas consumed in a furnace to provide heat)
  - Excludes: energy consumed in converting to other forms of energy (e.g., excludes pipeline gas consumed in a power plant and electricity consumed in electrolysis)
- Aggressive electrification in the building, industrial and transportation sectors results in large declines in demand for pipeline gas and liquid fuels
  - Electricity consumption more than doubles



Final energy demand by sector

- The largest transformation takes place in the buildings and transportation sectors, driven by aggressive end-us electrification
  - Heat pumps shift pipeline gas consumption to electricity in buildings
  - BEVs shift liquid fuel consumption to electricity in transportation
- Industrial sector demand continues to grow due to baseline growth embedded in PGE’s load forecast and assumed switching from gas to electricity



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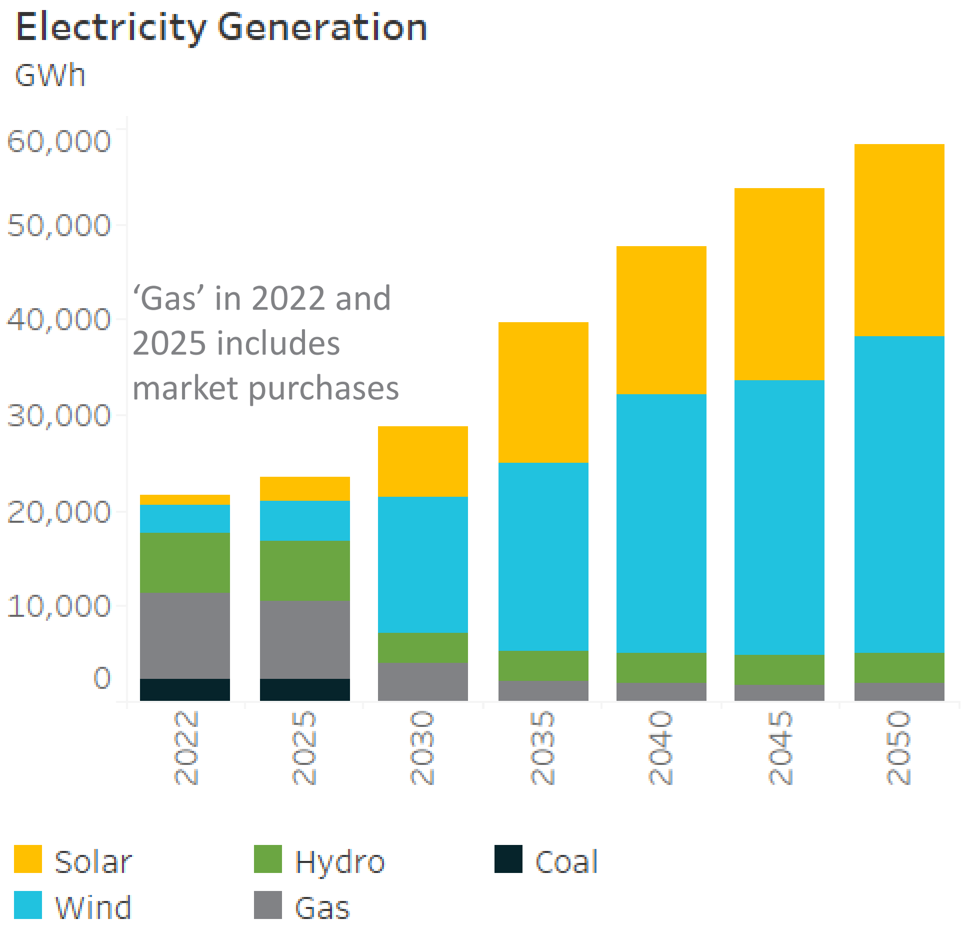
Electricity Sector Results

Electric Economy

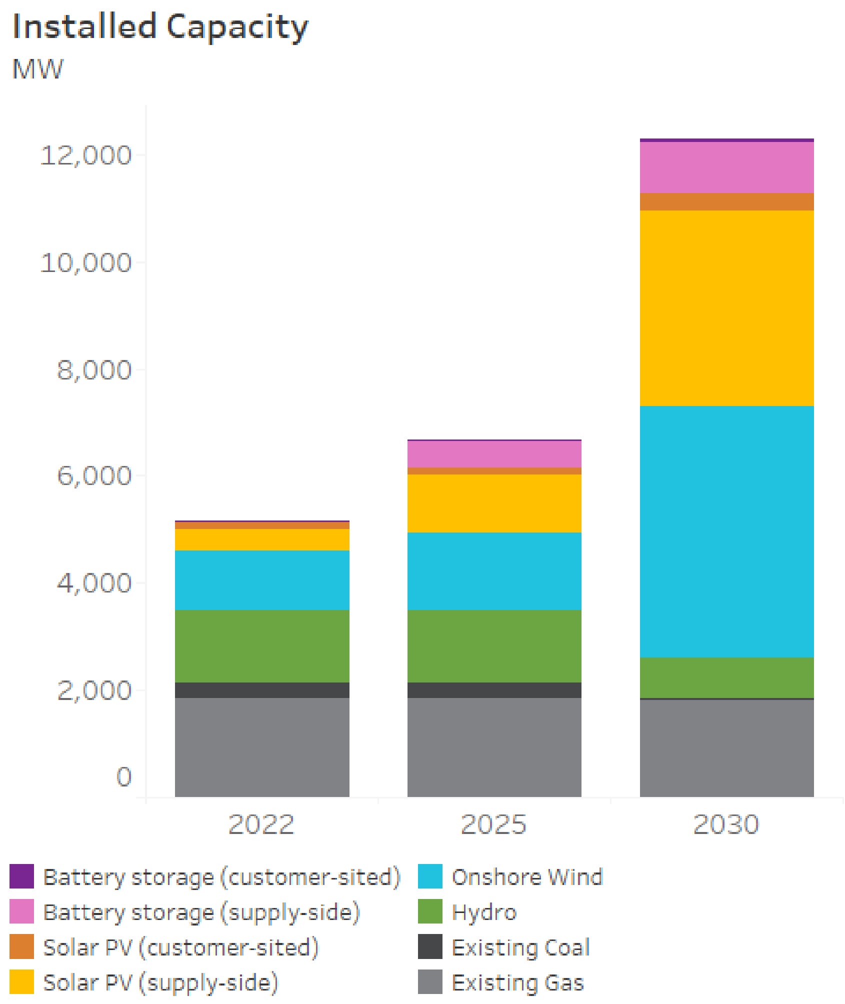
Electricity generation

- PGE's generation mix rapidly shifts from a hydro-thermal dominated mix to wind and solar-oriented
  - Gas generation decreases from 42% of total in 2022 to 14% by 2030
- Cost-optimal 100% clean generation mix (2040-2050):
  - Solar: 35%
  - Onshore wind: 55%
  - Hydro: 5%
  - Gas (zero-carbon): 5%

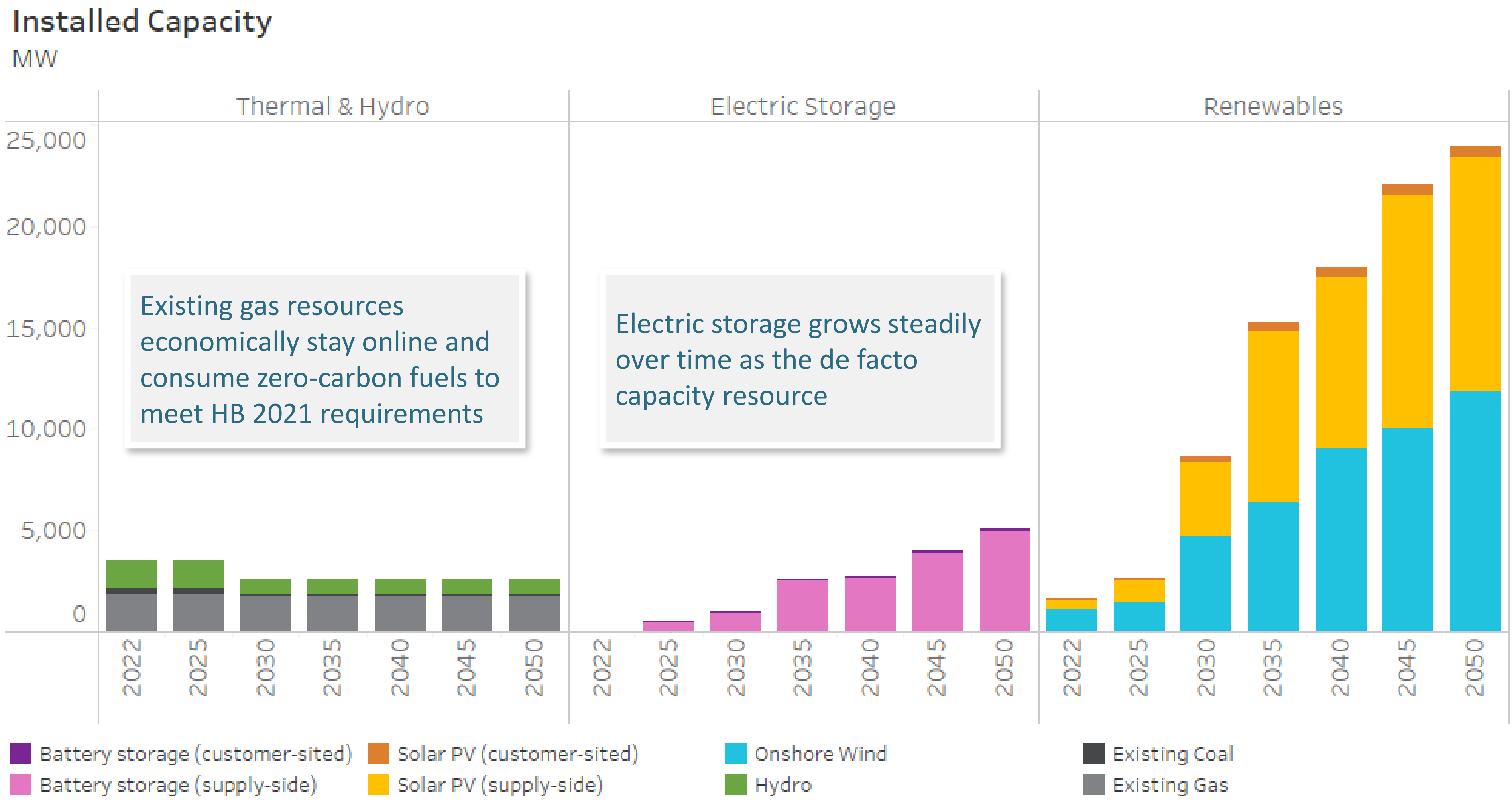


Installed capacity: today through 2030

- PGE's total installed capacity more than doubles by 2030 as energy, reliability and emission constraints bind
- Colstrip exit and expiration of contracts (e.g., PUD hydro) introduces a large capacity and energy gap that can only be met with renewables and storage
- Size of installed capacity is large since the incremental sources generally are low utilization (e.g., capacity factor 20-40%)

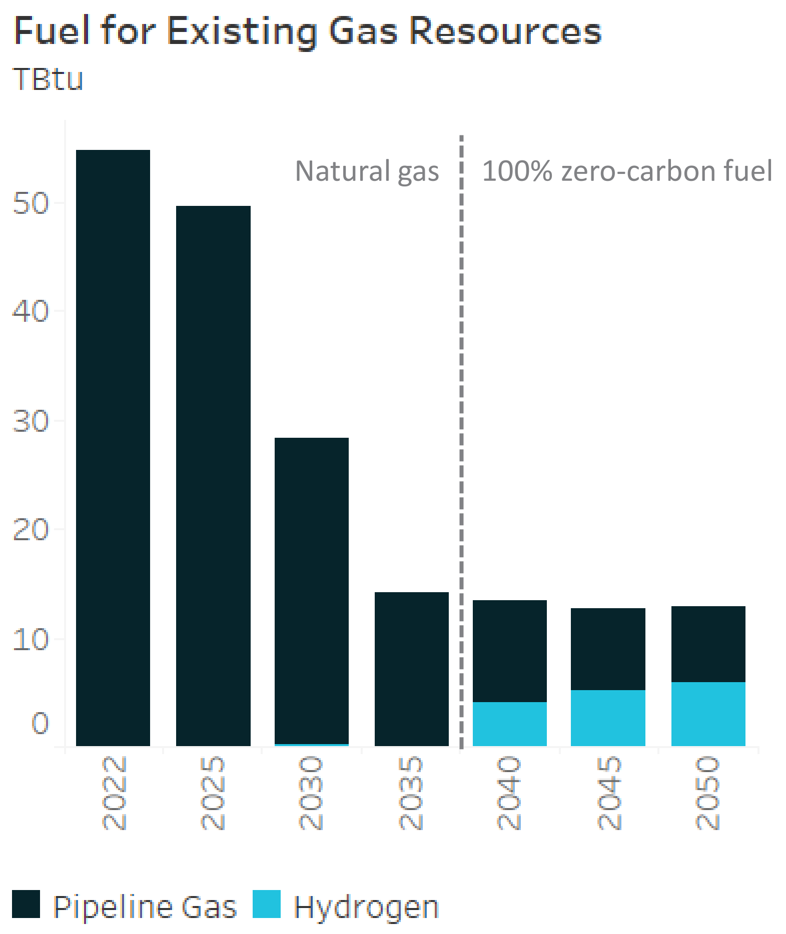


Installed capacity through 2050



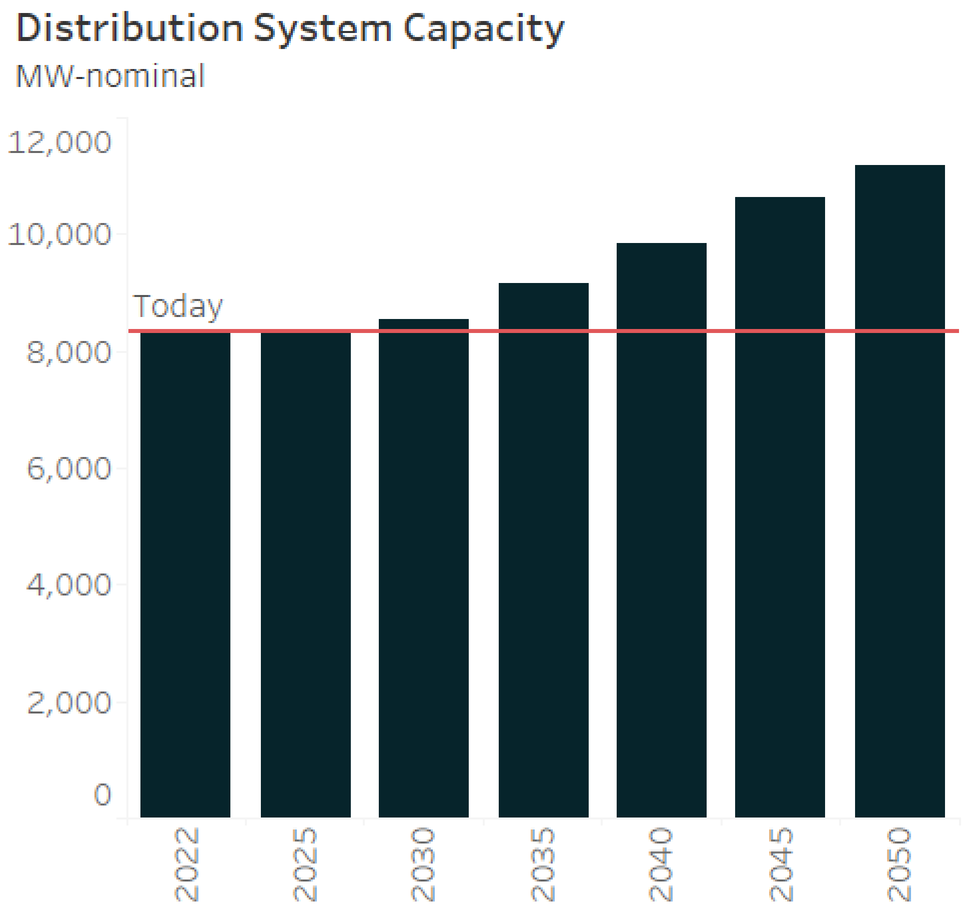
Fuel for existing thermal resources

- HB 2021 emission limits are met through 2035 by reducing thermal resource generation and natural gas use
- Starting in 2040, fuel supply is 100% decarbonized, including ~40% hydrogen and ~60% RNG (biomass-derived)



Distribution system

- We approximate total distribution system capacity by summing the capacity of each feeder archetype
  - Approximately equivalent to the sum of each individual feeder's weak link
- Most distribution capacity upgrades are triggered post-2030
- Total simulated distribution capacity grows by one third from today to 2050

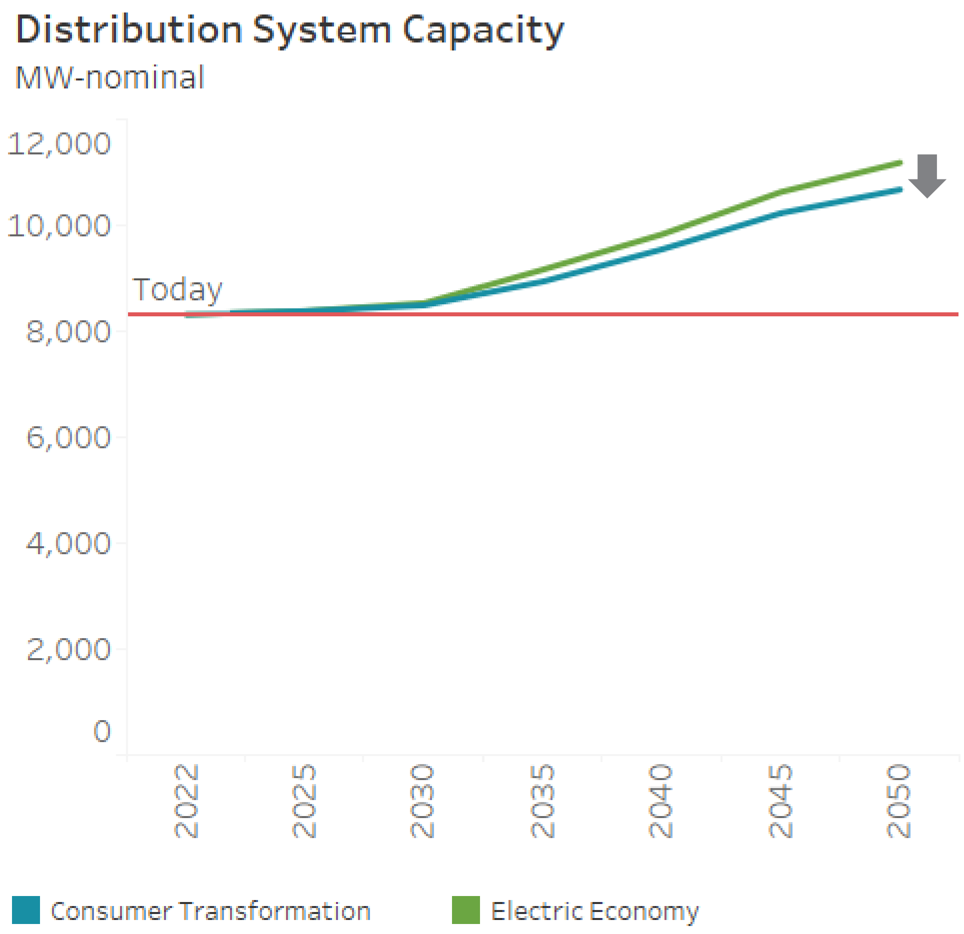


Results

Consumer Transformation

Distribution system comparison

- A combination of customer-sited solar and storage, plus load shifting contributes to avoiding growth on the distribution system
- Approximately 500 MW of nominal capacity is avoided by 2050 and most of this occurs on residential-oriented feeders



Additional considerations

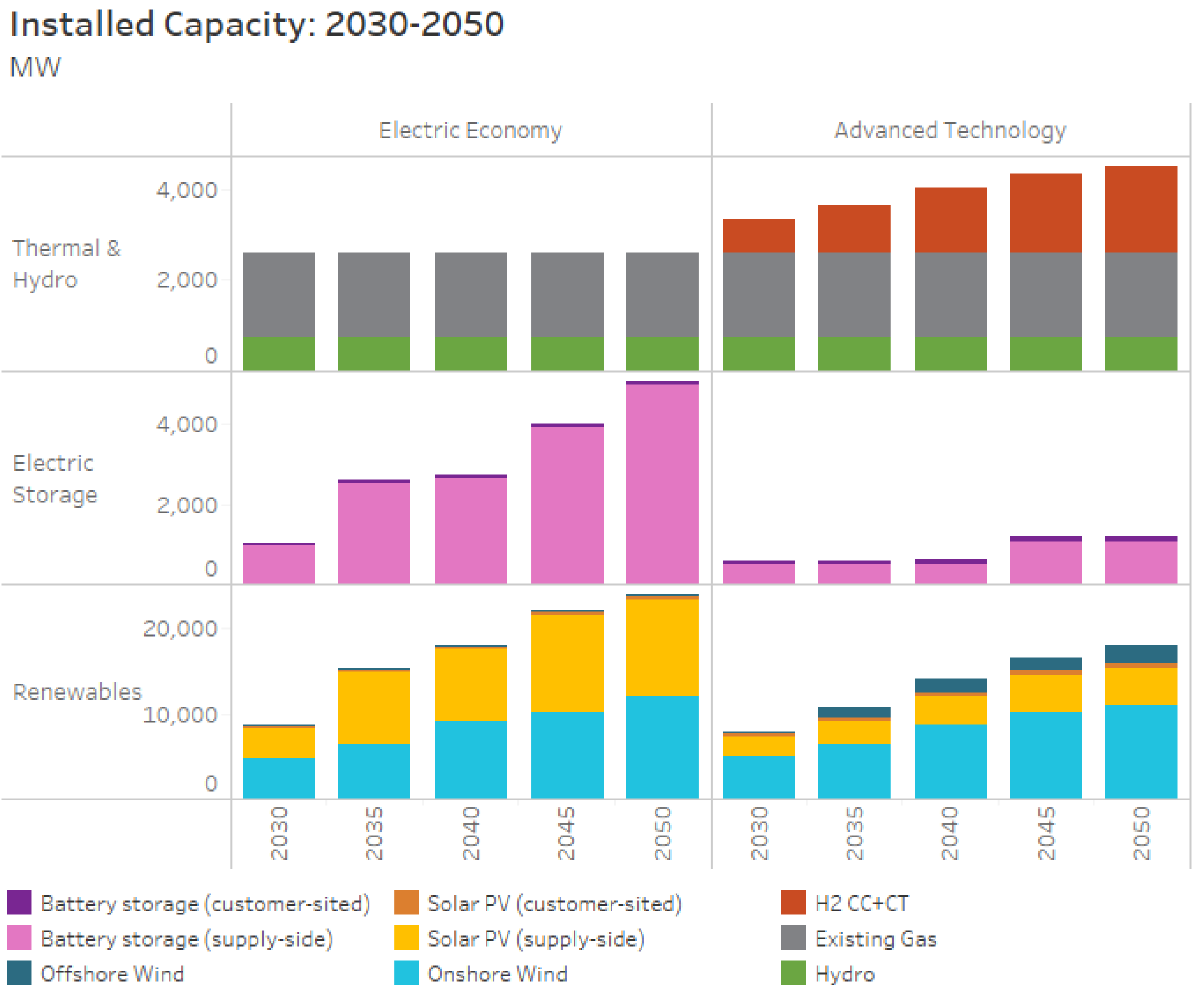
- On operationally challenging days, one of the ways to engage customers and realize further distribution deferral benefits is to implement critical peak pricing over sustained time (e.g., all day) to *reduce* rather than shift load
  - Specifically, voluntary *vehicle* load shedding on peak days would produce significant reductions
- In addition to programs that reduce consumption, customer-sited resources could be targeted on feeders near the planning threshold
- Furthermore, thermal ratings in the winter are typically higher than summer ratings, which provides additional distribution system capacity

Results

Advanced Technology

Resource mix comparison

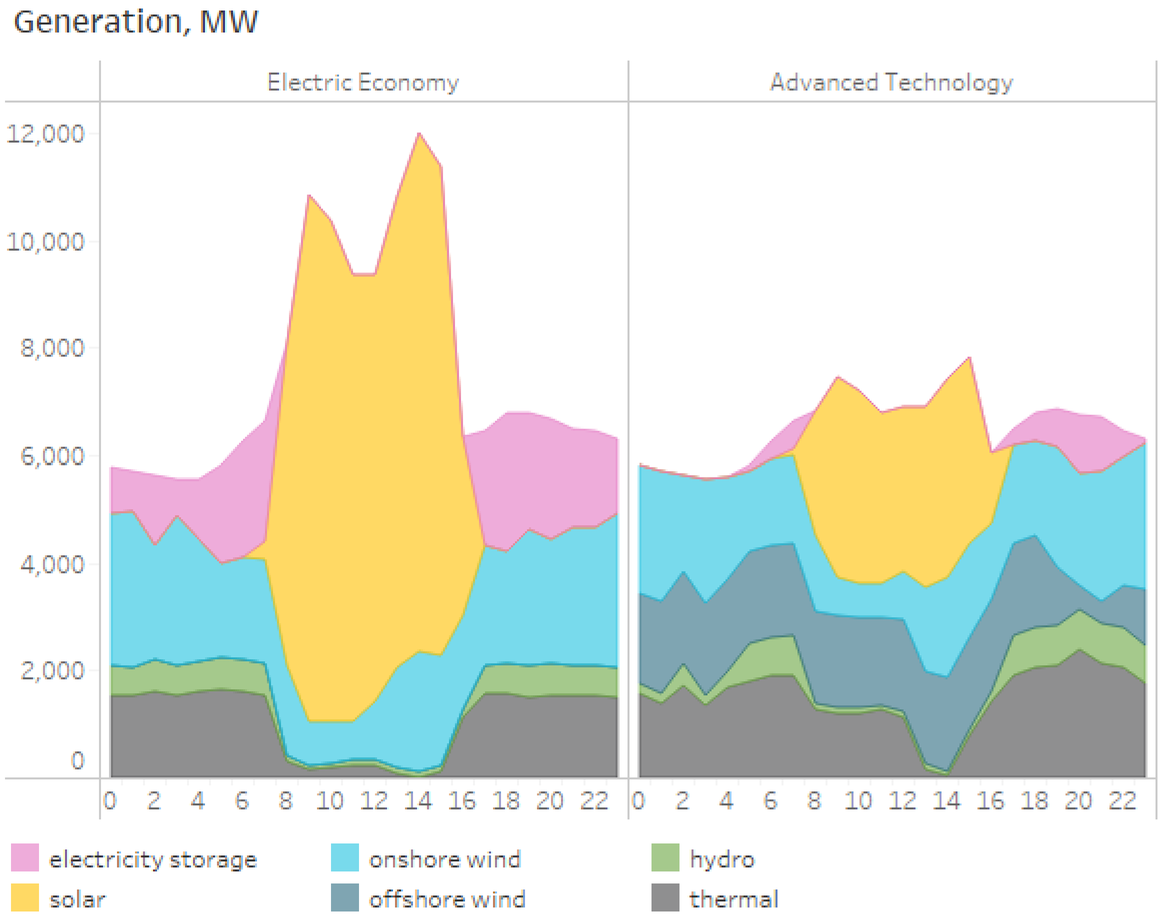
- H_2 turbines and offshore wind are both economic (~2 GW deployment for each) with near- and long-term impacts on PGE's resource mix
- These technologies primarily displace supply-side solar and storage resources, and make more efficient use of renewable electricity
  - Total installed capacity requirements decrease by nearly 10 GW by 2050
  - Curtailment is ~2/3 lower



Hourly dispatch comparison

Sample day in winter 2050

- Higher levels of dispatchable resources (H_2 turbines) and renewables with strong output in the winter (offshore wind) reduce the need for high-duration storage to meet challenging system conditions



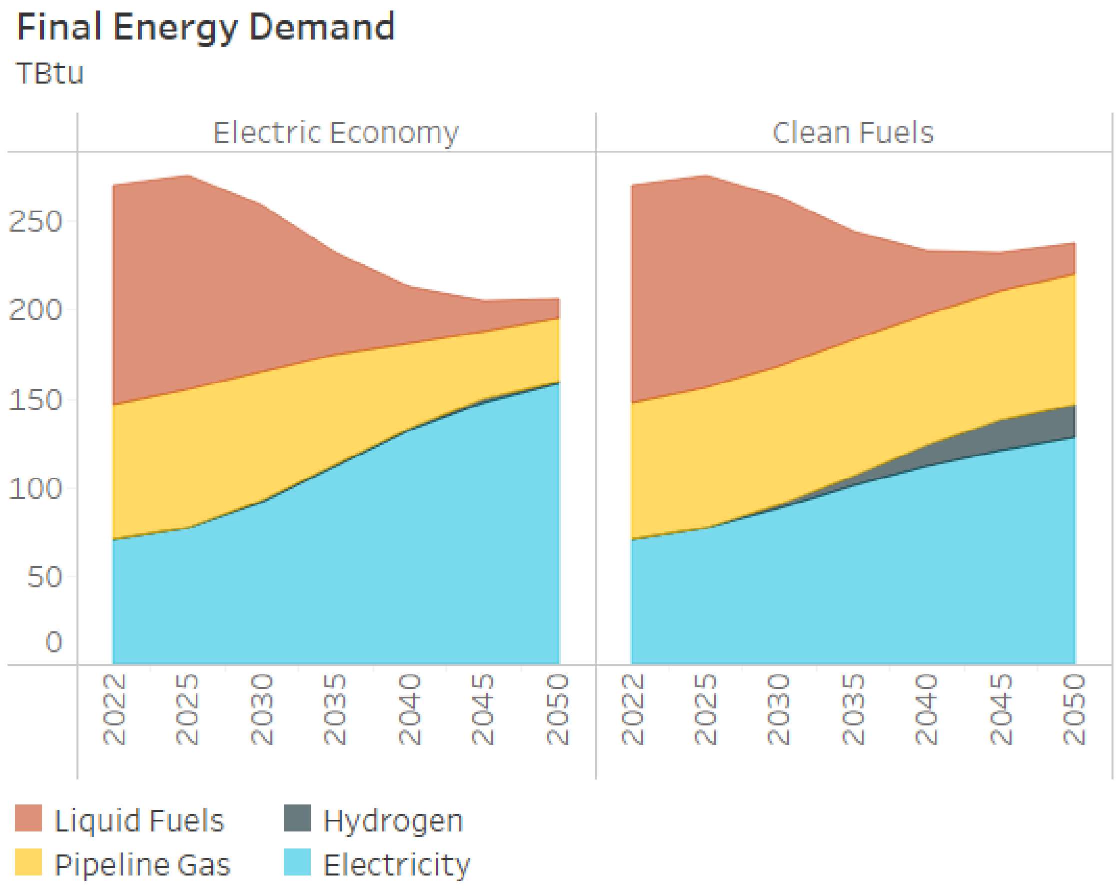
Results

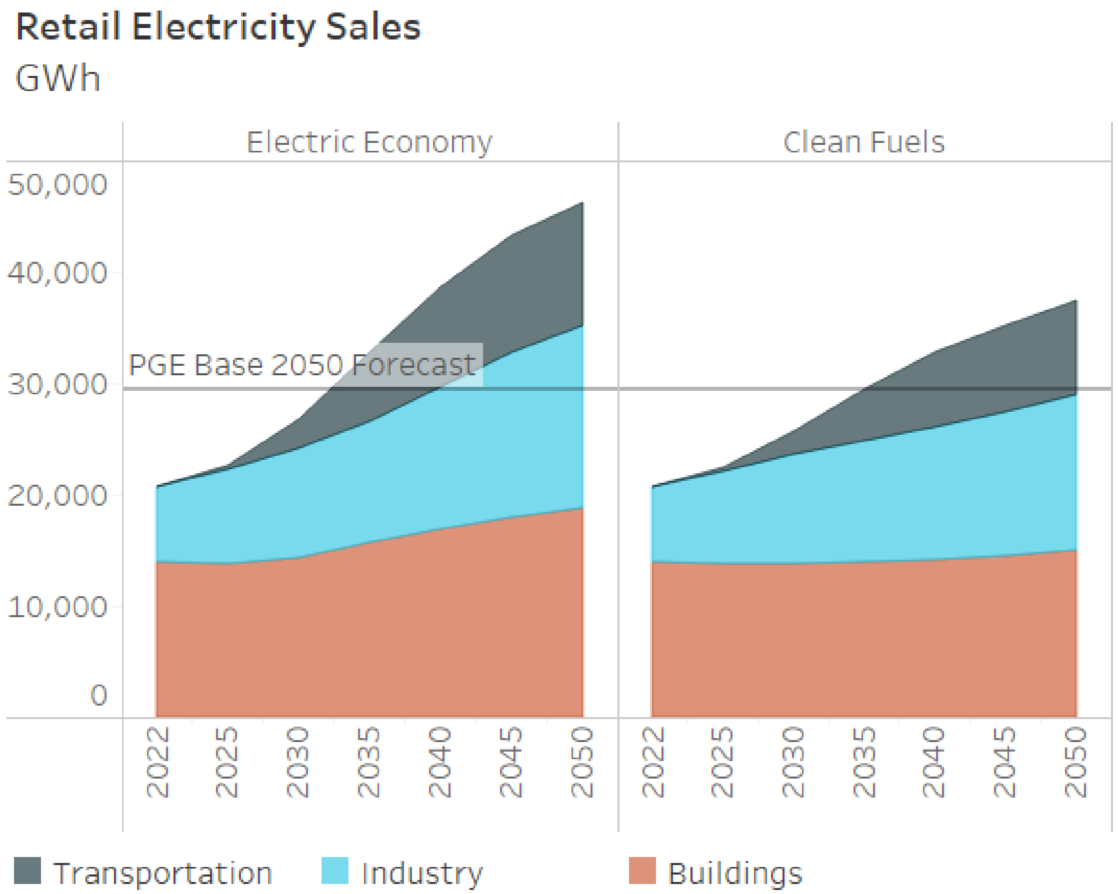
Clean Fuels

Energy demand comparison

Clean Fuels pathway retains significant use of gas in buildings, while expanding direct hydrogen consumption in freight transportation

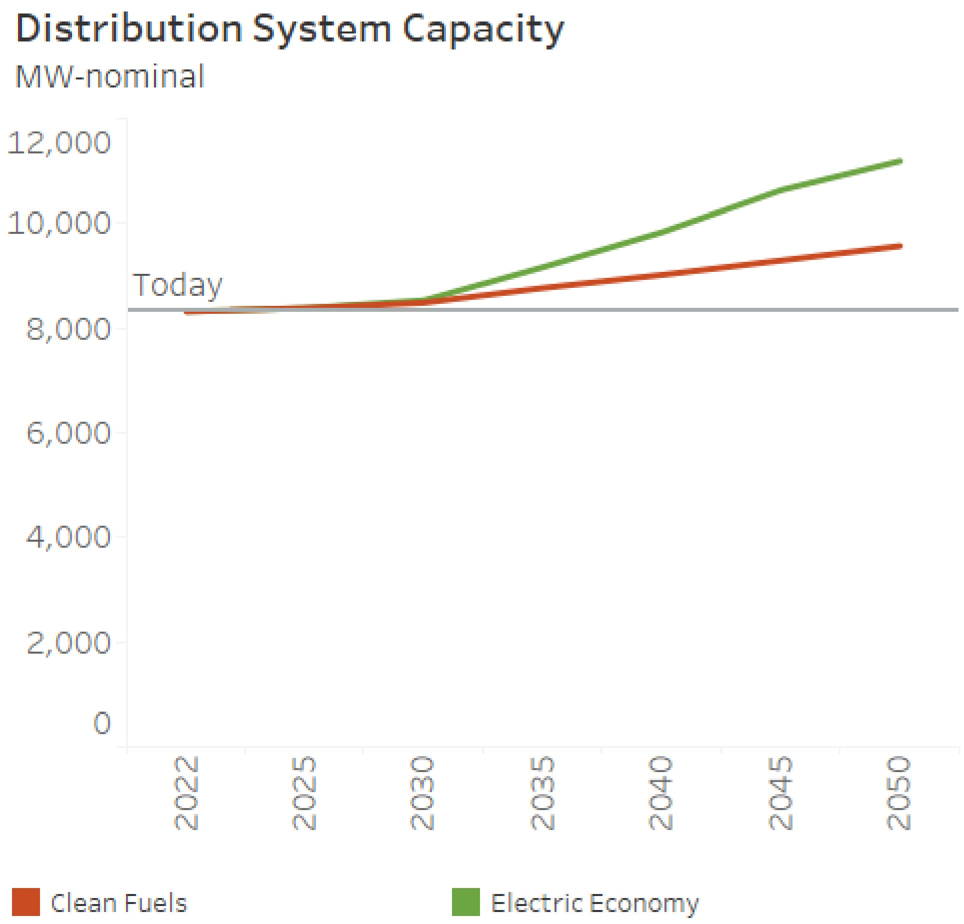
As a result, retail electricity sales are ~10,000 GWh lower by 2050 relative to the Electric Economy scenario





Distribution system comparison

- Lower residential and commercial building electrification translates into lower distribution system growth
- However, upgrades are still needed due to extensive passenger transportation electrification and base industrial load growth



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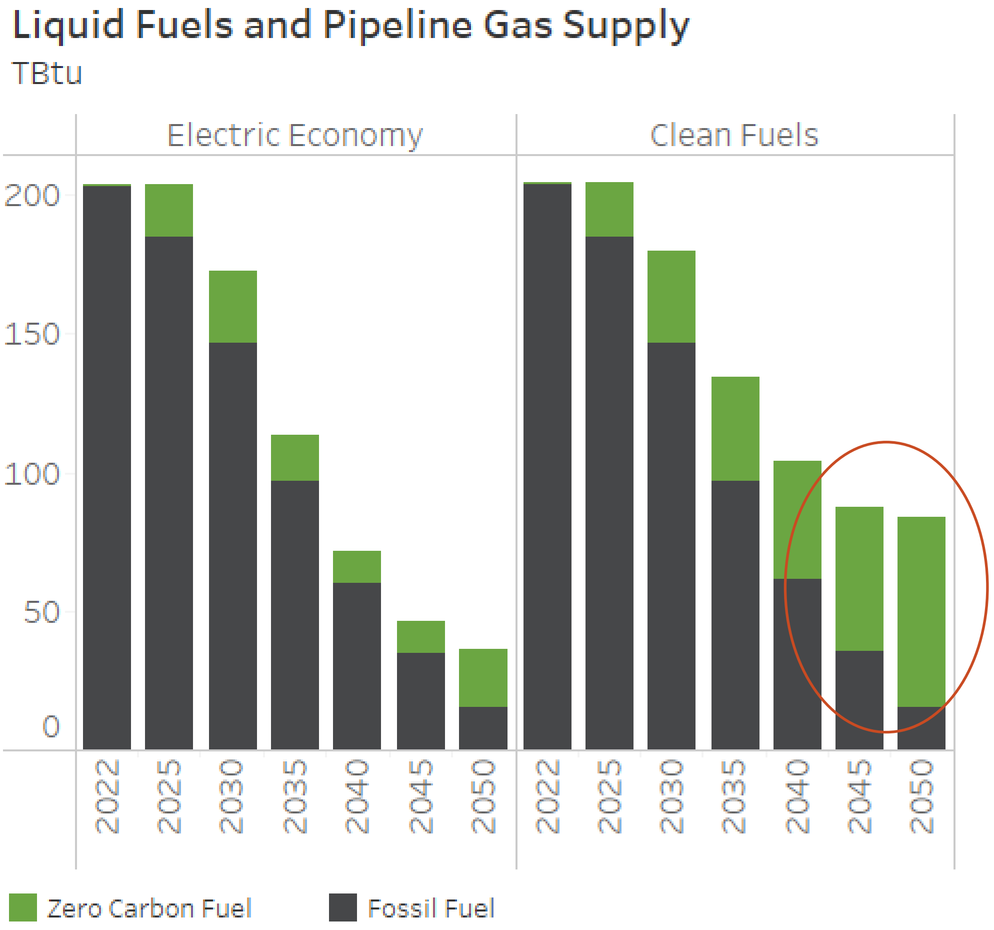
Fuels supply comparison

- The trade-off with lower electricity sector delivery (T&D) and generation infrastructure is the extensive use of expensive ($20/MMBtu+) zero carbon fuels
- Zero carbon fuel consumption in 2050 to meet CPP is more than triple
  - Gasoline demand reductions from passenger transportation drive lead to most demand reductions



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Summary

Overview

- The results of the analysis demonstrate the feasibility of PGE achieving compliance with HB 2021 and CPP
- We use scenarios to evaluate alternate strategies to meet the emissions reductions required by those policies
- Through this process, we have identified key insights and important implications for PGE

Zero-carbon resource growth

- Meeting policy targets requires new renewable and storage procurement at an unprecedented scale and pace
- In the **Electric Economy** scenario, PGE adds ~1,500 MW/year of renewables and storage from 2026-2035
- Both technology and geographic diversity is key – metrics for 2040:
  - Wind:solar generation ratio of 60:40
  - Montana wind is ~20% of total generation
  - When offshore wind is allowed as a resource, 1.5 GW is added (15% of generation)
- In the absence of new thermal, battery storage provides capacity and flexibility
  - Average duration of the battery storage fleet is 7 hours in 2030 and 10 hours by 2040

Thermal resources

- Since PGE cannot build new thermal resources that burn fossil fuels, existing resources continue operations through 2050, supporting system reliability
  - Existing gas resources switch from natural gas to zero carbon fuel in 2040, in compliance with the CPP
- If new thermal resources (H_2 turbines) can be constructed, it complements existing gas resources and reduces over-reliance on battery storage
  - Significantly less resource procurement is needed
  - Renewable curtailment is reduced by two-thirds

Distributed resources

- Benefit of flexible load and increased penetration of customer-sited solar and storage is twofold
  - – Align load with renewable production profile
  - – Mitigate distribution upgrades
- Battery electric vehicle charging represents the largest opportunity to avoid distribution peak impacts
- Economic benefits could be maximized with:
  - – Resources are targeted on feeders that are already near their planning threshold or anticipated to grow rapidly
  - – Implement critical peak pricing over a sustained time (all day) to reduce rather than shift load to another time of day –specifically voluntary vehicle load shedding

Electrification versus clean fuels

- Clean fuels may be a viable alternative to electrification in meeting CPP targets, but they carry higher costs and risks
- Total zero carbon fuel consumption required in 2050 is 3x higher in the Clean Fuels scenario relative to Electric Economy
- Cost and availability of clean fuels in 2050 is also highly uncertain & all biomass-derived fuel potential would be required

CPP implications for PGE

- Oregon's CPP does not directly regulate PGE but it has important implications for the electric sector
- PGE should expect significant building and transportation electrification as a CPP compliance strategy
- This will increase total load, but also affect load characreristics in other ways
  - Electrifying heat in buildings will eventually transform PGE's system from a dual peaking to distinctly winter peaking system
  - Electric vehicle charging introduces valuable flexibility that can help avoid distribution system upgrades if managed carefully
  - Electrolyzers serving hydrogen demand in the industrial and transportation sectors introduce large, flexible electric loads that can absorb otherwise curtailed renewable generation

Thank You

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Update: directional impact of legislation on PGE strategy

Customer Demand

Oregon could see upwards of $40 billion of investment over the next ten years, with tens of thousands of jobs and $2-3 billion in local tax revenue.

Additional funding for transportation electrification, domestic semiconductor production/R&D, and IIJA funding for manufacturing to provide upward pressure on demand.[1]

PGE long-term load forecast revised upward by 1% per year in response.

Price impact

Increased funding of renewable and carbon-free energy sources, credits expanded and extended:

60% solar ITC
$35/MWh wind PTC
60% offshore wind PTC
30% storage ITC
$31/MWh nuclear PTC

Leveled playing field through transferability and normalization fixes.

Technology availability

IIJA and IRA funding aims to make new technologies commercially feasible: EV adoption, solar and storage credits, and loan programs for customers.

Funding available for transmission projects.

ITC expanded to include offshore wind

Nuclear tax credits

Carbon capture and storage credits

Long-term earnings power

Legislative action drives potential for strategic capital investment while providing downward pressure on per-unit prices through tax credits.

Technology neutral tax incentives, grants, and funds for customer-sited technology will reduce customer rate impacts of decarbonizing.

Legislative action on normalization and transferability reduces earnings drag and makes solar ownership feasible.

Partnership in pursuit of grant funding likely to add to strategic capital opportunities.

Per Oregon Business Council and ECONorthwest