Deep Decarb Study Overview

September 2, 2022

Background and Policy Context

In 2017, PGE retained EER to undertake an independent analysis exploring pathways to deep decarbonization for its service territory ("Deep Decarb Study"). At the time, Oregon had recently committed to expand its Renewable Portfolio Standard and remove coal-fired resources from its electricity mix, while proposed legislation considered a cap-and-trade program to limit economy-wide greenhouse gas (GHG) emissions. Against this backdrop, the original study evaluated pathways to meet 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 GHG emissions: (1) **HB 2021** establishes emission reduction targets for PGE's electricity mix; and (2) the **Climate Protection Program (CPP**) places caps on GHG emission associated with fossil fuel consumption in buildings, industry and transportation. Table 1 summarizes the covered sectors and key targets for both the study's policy targets.

Table 1 Study Policy Targets

Policy	Covered Sectors	Key Targets

HB 2021	• Electric Power	• Baseline emission levels equal the average of annual emissions for 2010 through 2012
		  ○ 80% below baseline by 2030
		  ○ 90% below baseline by 2035
		  ○ 100% below baseline by 2040 and thereafter

Climate Protection Program (CPP)	• Buildings
	• Industry
	• Transportation
		• Total emission cap (relative to 2022):
		  ○ 30% reduction by 2030
		  ○ 60% reduction by 2040
		  ○ 90% reduction by 2050
		• Separate caps for natural gas (NG) and non-NG fuel suppliers

HB 2021's impact on PGE is more apparent: realizing 100 percent clean electricity introduces high levels of inflexible, variable renewable generation that necessitates new forms of balancing resources to address imbalances across several timescales. In contrast, the CPP does not directly regulate the electric sector, but end-use electrification is likely to be a key CPP compliance strategy. Electrification will increase PGE's total load (and corresponding resource requirements to meet HB 2021), but it will also create the opportunity to leverage flexibility from newly electrified loads like smart electric vehicle charging and water heating.

This *Deep Decarb Study Update* explores how both HB 2021 and CPP emission targets could be achieved for PGE's service territory and their implications. This long-term decarbonization analysis is intended to inform planning efforts within PGE, such as the Integrated Resource Plan, Distribution System Plan and Clean Energy Plan.

In this study, we use a scenario framework to answer the key questions relevant to PGE:

(1) What energy infrastructure investments are needed to achieve compliance with both policies?

(2) What is the electric system impact of meeting CPP targets through end-use electrification versus reliance on zero-carbon fuels?

(3) How can supply-side resource innovation facilitate achieving 100% clean electricity?

(4) Can very high demand-side (customer) participation mitigate some impacts of widespread electrification?

Study Approach and Scenarios

This study expands upon the scope and variables traditionally considered in PGE planning efforts to develop a "whole system view." We project non-electric fuel consumption, such as natural gas and gasoline, in PGE's service territory to quantify the level of decarbonization needed to meet the CPP targets and the scale of potential load impacts of switching from fuel to electricity across different sectors. Furthermore, we include load from customers that are currently under direct access to account for all energy use in PGE's service territory.

Our high-level modeling approach to understand how both policy targets could be achieved is outlined in Table 2 below. First, we developed a detailed representation of the PGE service territory energy system, including a characterization of its building and vehicle stock. Next, we project electricity and fuel demand through 2050 using scenario-based (exogenous) assumptions relating to adoption of electric and efficient appliances and vehicles. Finally, we estimated the cost-optimal supply-side resource investments through 2050 to meet both study policy targets.

Table 2 High-level Modeling Approach

	Modeling Step	Components
1	**Model PGE's service territory**	Residential, commercial, industrial, transportation
2	**Project energy demand**	Electricity, pipeline gas, liquid fuels
3	**Supply energy at least-cost**	Generation, delivery, storage, fuel supply

EER worked with PGE to develop four scenarios that achieve the study policy targets. All scenarios realize the same emission goals, but each scenario incorporates alternative decarbonization strategies and technologies, as summarized in Table 3 below. The **Electric Economy** scenario represents the study's core pathway where the CPP is met by electrifying transportation, buildings, and industry to the extent possible, while electricity needs are primarily provided by supply-side onshore wind, solar and energy storage resources. The additional scenarios were developed as variations on the Electric Economy scenario to draw out insights.

The **Consumer Transformation** scenario incorporates widespread electrification alongside very high levels of demand-side participation, including customer-sited solar and storage, as well as load flexibility from end-uses such as water heating and electric vehicle charging. This provides an understanding of how distributed resources could potentially moderate infrastructure upgrades associated with electrification and provide flexibility to support renewable integration. The **Advanced Technology** scenario considers an expanded supply-side toolkit to meet 100% clean electricity, including floating offshore wind and dispatchable hydrogen (H_2) turbine resources, which are both nascent clean energy technologies. Finally, the **Clean Fuels** scenario maintains high levels of end-use gas consumption in the future and primarily meets CPP requirements through a greater use of zero-carbon fuels.

Table 3 High-level Assumptions (2050)

	Demand-side (End-Use)		Electricity Resources		Fuel Supply
	Electrification	Load Flexibility	Customer-sited	Supply-side	Zero-carbon Fuels

<table>
<tr><td>Electric Economy (S1)</td><td rowspan="3">High electrification</td><td>Base</td><td>Solar: 620 MW
Storage: 120 MW</td><td rowspan="2">New onshore wind, solar PV and energy storage resources</td><td rowspan="3">Limited consumption due to fuel demand reductions</td></tr>
<tr><td>Consumer Transformation (S2)</td><td>Aspirational</td><td>Solar: 1,510 MW
Storage: 560 MW</td></tr>
<tr><td>Advanced Technology (S3)</td><td rowspan="2">Same as S1</td><td rowspan="2">Same as S1</td><td>Allow offshore wind and H_2 turbines</td></tr>
<tr><td>Clean Fuels (S4)</td><td>Low electrification</td><td>Same as S1</td><td>High renewable natural gas and H_2 use</td></tr>
</table>

Key Findings

Sustained deployment of zero-carbon resources is needed over the next three decades

Meeting the state's policy targets necessitates investment in wind, solar and storage resources at a pace that far exceeds historical levels. Approximately 1,500 MW per year of renewables and storage capacity (nameplate) are added during the decade from 2026 – 2035 in the Electric Economy scenario to meet emission goals and maintain reliability. The high levels of resource additions in the near- and medium-term are compounded by the expiration of hydro contracts and exit from Colstrip, which increases energy and capacity needs. Ongoing load growth sustains high levels of resource investment through 2050.

The portfolio of renewables in the least-cost, carbon-free electricity system expands beyond wind located in the Columbia River Gorge to resources in Montana and offshore in southern Oregon to take advantage of profile diversity. Generation from solar PV, which makes up a small share of PGE's current carbon-free portfolio, accounts for about one-third of all generation by 2040.

The overwhelming share of renewable resource additions identified in this study are located off-system and would require BPA transmission. The inability to access transmission to deliver renewable generation to PGE's load represents a significant risk to meeting HB 2021 given the sheer magnitude of new renewable resources. Without access to appropriate transmission services, the cost of meeting decarbonization goals would increase due to transmission-related curtailment of off-system resources or increased reliance on lower-quality renewables within PGE's balancing area.

Climate Protection Program accelerates electric load growth

The CPP requires aggressive reductions in the use of liquid fossil fuels in transportation and natural gas in buildings and industry, and end-use electrification is expected to be a core compliance strategy. Under a high electrification pathway, PGE's retail sales are projected to be approximately 10% higher than current internal projections by 2030 and more than 50% higher by 2050. This is primarily explained by transportation electrification for both passenger vehicles and freight trucks.

In addition to total load increases, load characteristics could be affected in other ways by CPP-driven electrification. PGE's current dual summer-winter system peak would shift towards a distinctly winter peak if heating services were electrified. Newly electrified loads such as water heating and vehicle charging have inherent flexibility, and these could be leveraged to manage short-term supply-demand imbalances, as well as distribution system peaks.

Maintaining significant gas use in buildings and industry, as modeled in the Clean Fuels pathway, is a viable alternative but carries higher costs and risks relative to electrification. While lower electrification does avoid electricity infrastructure investments, the trade-off is higher fuel demand that must be supplied by high-cost, zero-carbon fuels to comply with the CPP. A significant risk of this strategy is that it relies on biomass-derived fuel where the potential and cost of sustainable supply is highly uncertain, whereas electric appliances and carbon-free electricity generation resources are mature and well understood.

Thermal resources are a key component of a cost-effective, carbon-free electricity system

HB 2021 greatly expands the role of renewable resources in PGE's portfolio with wind and solar making up approximately 90 percent of generation by 2040. In a highly renewable electricity system, periods of low wind and solar output present challenging conditions for energy storage alone to address, particularly when low renewable output persists. This analysis finds that PGE's existing gas resources are an economic option to support resource adequacy even as emission limits become more stringent over time. During the 2030s, these resources continue to burn natural gas, but their operations are constrained by emission budgets. By 2040, fuel consumption in the gas fleet converts to 100 percent zero-carbon fuel sources, including hydrogen and renewable natural gas, and the generators operate infrequently as a critical capacity resource.

Although HB 2021 prevents the construction of new thermal resources that burn natural gas, turbines that utilize 100 percent renewable electricity-derived hydrogen (“H_2 turbines”) represent a promising technology option that turbines manufacturers and electric utilities are pursuing. The Advanced Technology pathway finds that new, dispatchable H_2 turbines are economic resources that can reduce the cost of meeting 100% clean electricity targets. The ability to expand the size of dispatchable capacity makes more efficient use of renewable electricity, reducing curtailment by approximately two-thirds and avoiding reliance on supply-side solar and storage resources.

Distributed resources support renewable integration and manage electrification impacts

Resources located on the distribution system – including solar and storage, heat pumps and electric vehicles – support PGE’s compliance with HB 2021 and the CPP. PGE’s portfolio of distributed resources allows load to be adjusted on a short-term basis, which provides system- and distribution-level benefits. Shifting load to align with renewable production is an alternative to supply-side balancing and reduces curtailment. A significant increase in transportation and building electrification will broadly increase peak demand at the local level, but distribution system peak demand growth can be managed if consumers play a more active role.

The Consumer Transformation scenario, which reflects large-scale distributed resource integration, demonstrates this value. In the near-term, economic benefits stem primarily from avoiding supply-side resource costs, since distributed flexibility is well-suited to address short-term imbalances. Long-term economic benefits shift towards deferring electric distribution costs associated with economy-wide electrification, and about 20% of projected distribution system growth can be avoided by distributed flexibility. The ability to manage charging from electric vehicles is the primary driver behind long-term distribution deferral benefits.

Greater distribution deferral benefits than those modeled in this study could be realized with specialized demand-side programs. Implementing critical peak pricing over a sustained time (e.g., 24 hours) on operationally challenging days could be a valuable tool to reduce rather than shift load. Specifically, voluntary vehicle load shedding on peak days would provide sizeable demand reductions that would directly avoid the need for distribution upgrades. Furthermore, solar and storage incentives could be targeted at customers on feeders that are near their capacity upgrade threshold.

Conclusions

Multiple feasible pathways exist to achieve compliance with HB 2021 and the CPP in PGE's service territory. By incorporating both policies into its various planning processes, PGE can prioritize strategies that minimize cost and maximize feasibility of compliance. Some of the most impactful opportunities identified in this study include: pursuing a renewable electricity generation portfolio with geographic and resource diversity; encouraging regional transmission expansion to increase access to renewables; supporting efforts to commercialize hydrogen combustion turbines; and targeting demand-side participation from DERs, especially electric vehicles, and especially in areas of PGE's system likely to require distribution capacity expansion.