Meeting the Challenge of Our Time: Pathways to a Clean Energy Future for the Northwest

An Economy-Wide Deep Decarbonization Pathways Study • June 2019

Meeting the Challenge of Our Time: Pathways to a Clean Energy Future for the Northwest **is the first economy-wide analysis to examine decarbonization pathways mapped to the Northwest's economic and institutional realities. The Clean Energy Transition Institute commissioned this study to understand how Idaho, Montana, Oregon, and Washington could technically and economically achieve a low-carbon economy over the next three decades.**

Executive Summary

The Clean Energy Transition Institute commissioned this economy-wide deep decarbonization pathways study to serve as a blueprint for how Idaho, Montana, Oregon, and Washington might achieve a low-carbon, clean energy economy over the next three decades. The study, *Meeting the Challenge of Our Time: Pathways to a Clean Energy Future for the Northwest*, examines alternative pathways to achieving an 86% reduction of carbon emissions below 1990 levels in the built environment, transport sector, and electricity grid by 2050. A pathways approach enables an understanding of the most economically and technically efficient means of realizing this mid-century decarbonization goal.

The study models the energy systems in each of the four Northwest states to identify the interdependencies, efficiencies, and trade-offs that must be considered when pursuing deep decarbonization. The study's purpose is to provide guidance to policymakers, advocates, leaders, and investors as decisions are made to catalyze the clean energy transition in the Northwest over the coming three decades.

Since the fall of 2017, several regional studies have been conducted for different stakeholders and with varying assumptions that offer insights into different aspects of the Northwest's decarbonization puzzle. *Meeting the Challenge of Our Time: Pathways to a Clean Energy Future for the Northwest* is the first economy-wide analysis to examine the most likely decarbonization scenarios mapped to the region's economic and institutional realities. Prior studies looked only at the electricity grid, at one state or one utility service territory, or at the role of one fuel in specific sectors or subsectors of the economy as Figure 1 shows.

"Limiting global warming to 1.5°C would require 'rapid and far-reaching' transitions in land, energy, industry, buildings, transport, and cities. Global net human-caused emissions of carbon dioxide (CO_2) would need to fall by about 45 percent from 2010 levels by 2030, reaching 'net zero' around 2050." — IPCC Special Report on Global Warming of 1.5°C, October 8, 2018.

FIGURE 1. This study is the only four-state and sector-wide decarbonization analysis of the Northwest.

Year	Study	Energy Sectors	Geographic Coverage WA	OR	ID	MT
2016	State of Washington Office of the Governor	All sectors	●	○	○	○
2017	Public Generating Pool	Electricity sector only	●	●	◔	◔
2018	Portland General Electric	All sectors	○	◑	○	○
	Climate Solutions	Electricity sector only	●	●	◔	◔
	Northwest Natural Gas Company	All sectors; optimized decisions limited to electricity sector only	●	●	○	○
2019	Public Generating Pool	Electricity sector only; reliability study	●	●	●	●
	Clean Energy Transition Institute	All sectors; optimized decisions across entire energy supply side	●	●	●	●

Source: Northwest Deep Decarbonization Pathways Study, May 2019, Evolved Energy Research, page 9.

Each of these studies had a narrower purpose and answered questions of more limited scope than those posed by *Meeting the Challenge of Our Time: Pathways to a Clean Energy Future for the Northwest*. For example, none has looked at the impact of constraining biomass, the use of natural gas in transport, limited electrification, or greater integration of the Northwest and California electric grids. This study is unique in offering a blueprint that broadly frames the opportunities and trade-offs for the Northwest to achieve economy-wide deep decarbonization between 2020 and 2050.

Olympic National Forest. Photo credit: Clean Energy Transition Institute

Key Findings

The study demonstrates how the Northwest can rapidly deploy strategies to reduce carbon emissions in the energy sector efficiently and at least cost for the electricity grid, the built environment, and transportation. The region's relatively clean electricity grid and proximity to California, where climate policies aim to achieve a massive transition to clean energy within the coming three decades, are key assets.

Consistent with prior decarbonization pathways efforts, this study demonstrates that the low-carbon system of the future must have four primary features: (1) energy must be used more efficiently than it is today; (2) electricity generation must be as clean as possible; (3) liquid fuels must be as low-carbon as technically and economically feasible; and (4) clean electricity must be used for as many purposes as possible.

Student at Pyramid Lake High School in Nixon, Nevada. Photo credit: Candice Nyando

The study's key findings include:

- **Deep decarbonization is achievable in the Northwest.** Multiple strategies exist to achieve a deeply decarbonized energy system in the Northwest using today's technologies. Policymakers must decide how to achieve a low-carbon energy system at an acceptable cost.
- **Energy efficiency is a key strategy to reduce costs and meet goals.** Decreasing the demand for energy through efficiency reduces the need for new energy supply and associated infrastructure, and therefore also reduces the cost of decarbonization.
- **A nearly 100% clean electricity grid is needed.** A Northwest electric grid nearly free of fossil fuels efficiently achieves mid-century climate targets. Carbon emissions from electricity generation were reduced by 96% in the study's Central Case, the core decarbonization pathway. While coal is eliminated in a deep decarbonized future, a small amount of natural gas–generated electricity (just 3.7% of annual energy in the study's Central Case by 2050) ensures that the grid can reliably deliver power during periods of low generation from hydroelectricity and other renewable sources.

"Clean electricity is the backbone for deep decarbonization and the cross-sectoral role that electricity will play in the coming decades is key to the low-carbon future."

- **Demand for clean electricity will continue to grow.** A low-carbon future hinges on an integrated energy economy where power sources—and electricity in particular—play a cross-sectoral role in transportation and the built environment. Widespread transportation electrification (100% of light-duty, 60% of medium-duty, and 40% of heavy-duty vehicles in the study's Central Case) will be crucial to reduce emissions at least cost and avoid using either scarce biofuel supplies or relatively expensive electric fuels for transport. Clean electricity also needs to replace oil and gas to heat and cool buildings in a low-carbon future. Finally, clean electricity will be used to produce synthetic gas and liquids as additional energy sources.

- **Increased grid integration and transmission between the Northwest and California is cost-effective.** Significant cost savings can be realized if the Northwest and California electric grids are expanded and operations are better integrated. Building additional transmission lines between the Northwest and California electricity grids could reduce the costs of decarbonization by an estimated $11.1 billion in net present value over the 30-year study period accrued to the combined California and Northwest region.

- **Sustainable biomass is best used for jet and diesel fuel.** The best use for sustainable biomass is creating liquid fuels to power the hardest-to-electrify subsectors within transportation, namely aviation and long-distance freight shipping.

- **Emerging technologies will play a critical decarbonizing role.** With the correct mix of regulatory guidance, investment, and research it is likely that a range of technological developments will emerge to solve some of the most challenging deep decarbonization problems in the years beyond 2030. These technologies, which include electrolysis, direct air capture, hybrid boilers, hydrogen, synthetic fuels, and carbon capture, will provide economic value for excess renewables, displace conventional gas and liquid fuels, and help balance the grid.

This study is designed to show the trade-offs between different deep decarbonization pathways, but it does not take into account equity considerations for different communities. The study demonstrates that we can decarbonize our economy, but the critical work ahead must focus on how to do so equitably.

Pathway Scenarios

The study examined eight cases, starting with:

- **Business as Usual Case** based on existing policies and the scenario against which the seven deep decarbonization cases are compared; and

- **Central Case** that represents the study's core optimal deep decarbonization pathway.

The Central Case is the most flexible pathway to achieve emissions reductions because it is technology neutral. Six additional scenarios representing demand and supply variables relevant to current discussions in the Northwest energy community were modeled off the Central Case to understand the energy system trade-offs that occur as a result of different constraints or policies.

- **100% Clean Electricity Grid Case**, where all electricity generation must be zero-carbon in 2045.

- **Limited Electrification and Efficiency Achieved Case**, in which the aggressive electrification and energy efficiency assumptions in the Central Case do not materialize.

- **No New Gas Plants for Electricity Case**, which prohibits any new gas-fired power plants from being built across the region after 2020 and retires existing gas plants at the end of their economic lifespan.

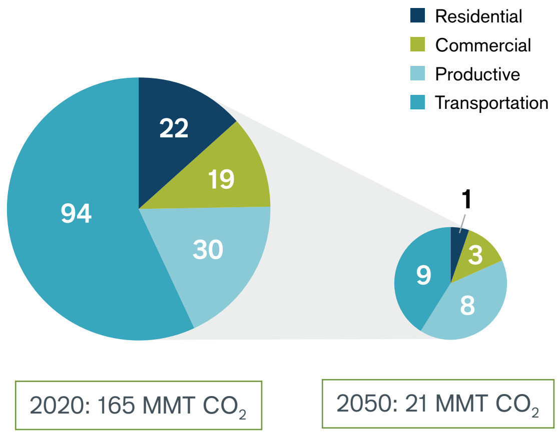
- **Increased Northwest-California Transmission Case**, where unconstrained construction of additional transmission is allowed between the Northwest and California for better grid integration.

- **Limited Biomass Available for Liquid Fuels Case**, where each state's bioenergy potential is limited to only waste and wood feedstocks, and no energy crops or biomass resources outside of the region are permitted.

- **Pipeline Gas Used for Freight Vehicles Case**, where compressed and liquefied pipeline gas replace renewable diesel fuel for freight vehicles in the Central Case.

Northwest CO_2 emissions decrease in the Central Case from 165 million metric tons (MMT) in 2020 to 20.8 MMT in 2050.

FIGURE 2. Comparison by sector of Northwest CO_2 emissions decrease from 2020 to 2050 in the Central Case.



Source: Northwest Deep Decarbonization Pathways Study, May 2019, Evolved Energy Research, page 63.

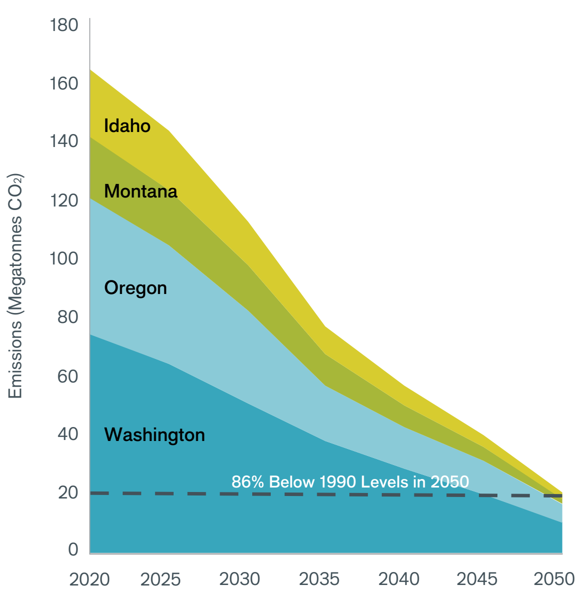
Figure 2 shows that Northwest CO_2 emissions decrease in the Central Case from 165 million metric tons (MMT) in 2020 to 21 MMT in 2050. Emissions in the residential sector decline by 95%; in the commercial sector by 86%; in the productive (industrial) sector by 72%; and in the transportation sector by 91%.

Figure 3 shows the emissions decline from 2020 to 2050 by each state, as well as by fossil fuel type. These emission reductions are achieved through five key decarbonization strategies: energy efficiency; decarbonizing electricity; decarbonizing gas and liquid fuels; fuel-switching in industry, transportation, and buildings; and carbon capture. The cost of achieving these reductions is offset by avoided fossil fuel purchases.

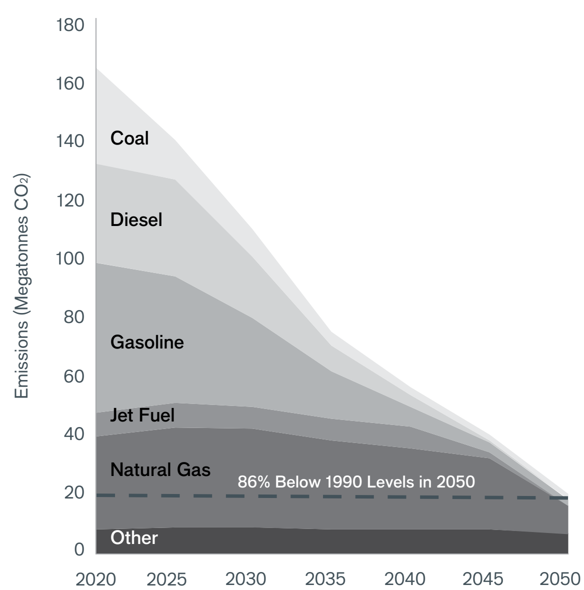
This study is unique in offering a blueprint that broadly frames the opportunities and trade-offs for the Northwest to achieve economy-wide deep decarbonization between today and 2050.

FIGURE 3. Declining emissions by state and by fossil fuel type 2020–2050.

Declining Emissions by State



Declining Emissions by Fossil Fuel Type



Five Key Decarbonization Strategies

Transitioning the Northwest to a low-carbon energy system relies on five decarbonization strategies:

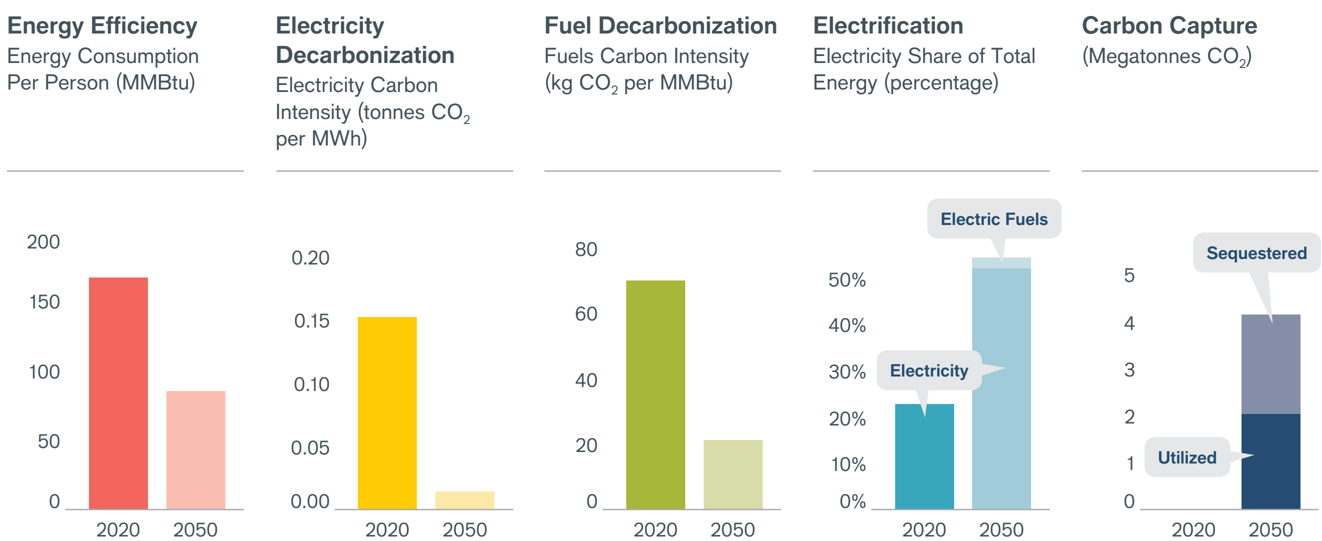
1. **Energy Efficiency:** reducing energy consumed to provide an energy service
2. **Electricity Decarbonization:** reducing the emissions intensity of electricity generation
3. **Fuel Decarbonization:** reducing the emissions intensity of liquid and gaseous fuels
4. **Electrification:** switching end uses from fuel to electricity
5. **Carbon Capture:** capturing CO_2 from a facility or removing CO_2 from the atmosphere

The purpose of the fifth strategy, carbon capture, is twofold: the captured CO_2 can either be used as a carbon feedstock for electric fuel production or sequestered.

Figure 4 shows metrics for the five strategies in the Central Case. Per capita energy consumption decreases from approximately 170 MMBtu per person today to 85 MMBtu per person in 2050, a 50% decrease. The average carbon intensity of electricity generation, which is already relatively low in the Northwest due to the hydroelectric system, decreases to near-zero by 2050.

The carbon intensity of fuels (liquid and gas) decreases by 70% primarily using biofuels. The share of total final energy served by electricity or electrically produced fuels (e.g., hydrogen and synthetic natural gas) more than doubles from approximately 23% today to 55% in 2050. Four million metric tons of CO_2 are captured in 2050, with about half of the CO_2 being utilized to produce synthetic fuels and the other half being sequestered (e.g., in saline aquifers in Montana).

FIGURE 4. Five decarbonization strategies.



Source: Northwest Deep Decarbonization Pathways Study, May 2019, Evolved Energy Research, page 65.

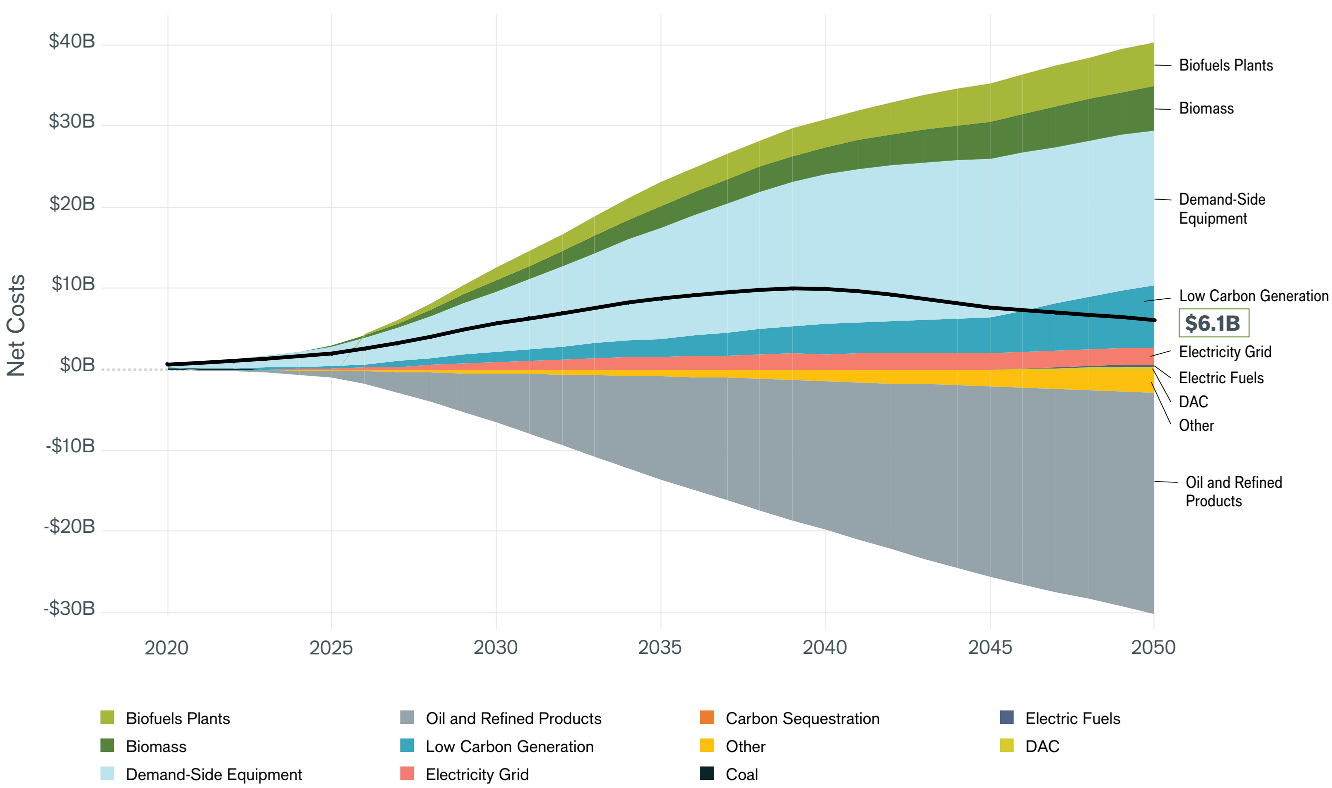
Wind turbines at the Judith Gap Wind Farm, Montana.
Photo credit: Nomadic Lass

Costs

The study models the annual energy system costs of producing, distributing, and consuming energy, comparing the annual costs of the Business as Usual Case and the Central Case from 2020 to 2050. Net annual costs of the Central Case vary over the modeled period based on the timing of infrastructure investments, peaking at 16.1% ($9.8 billion) above the Business as Usual Case in 2038 and decreasing to 8.3% ($6.1 billion) higher than the Business as Usual Case in 2050. The cumulative costs of decarbonizing the energy system in the Central Case are 9.5% higher than the capital and operating expenses of the Business as Usual Case's energy system, roughly 1% of the region's total GDP in 2017 of more than $870 billion.[1] (See Figure 5.)

ZHome, Issaquah, Washington. Photo credit: City of Issaquah

FIGURE 5. Annual net energy system costs for the Central Case relative to the Business as Usual Case 2020–2050.



Source: Northwest Deep Decarbonization Pathways Study, May 2019, Evolved Energy Research, page 106.

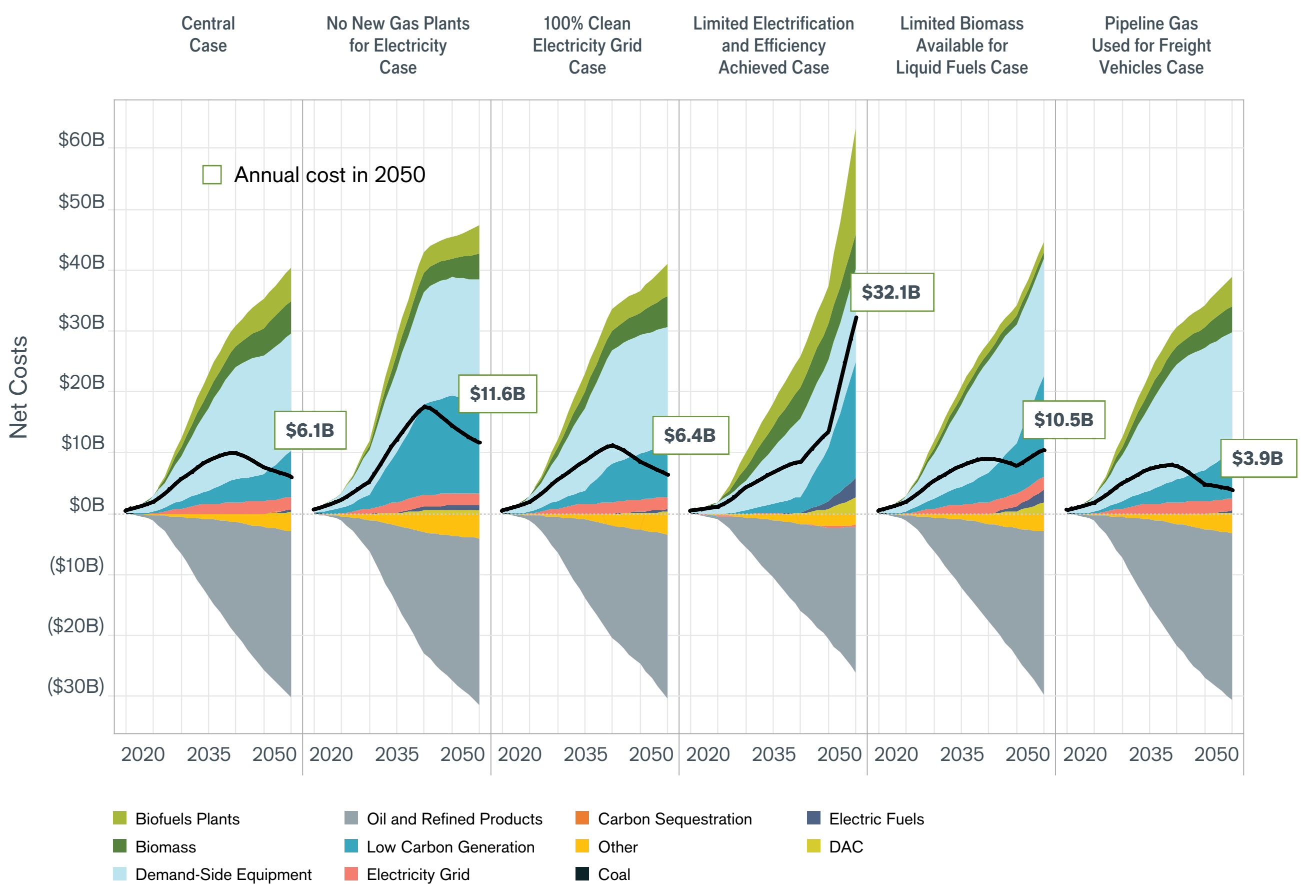
Increased costs in a decarbonized system consist primarily of biofuel feedstocks and infrastructure, demand-side electrification and efficiency investments, and renewable power plants and supporting electricity infrastructure. These costs are mitigated by the savings from reduced spending on fossil fuels, primarily liquid petroleum products such as gasoline, diesel, and jet fuel.

Costs for each scenario were modeled and compared to the Business as Usual Case. All cases performed worse than the Central Case, with the exception of the 100% Clean Electricity Grid scenario, which was only a marginal change from the Central Case and therefore has only a minimal impact on costs. The Pipeline Gas for Transport Case was $2 billion less than the Central Case. While this is a more cost-effective result, there are two issues that must be considered: (1) the model does not take into account the upstream emissions of pipeline gas production, and (2) there are significant technical challenges with using gas in the transport sector.

The Limited Electrification and Efficiency Achieved, No New Gas Plants for Electricity, and Limited Biomass Available for Liquid Fuels scenarios differ the most from the Central Case in terms of an increase in net systems costs. (See Figure 6.)

In 2050, the average cost of avoided carbon is $48/tonne and declining. The model makes conservative assumptions about the costs and scalability trends of clean energy technologies. A future report will explore in greater depth details on costs and emissions reductions, the assumptions that returned these results, and what these results mean for how the Northwest should consider investing in transitioning the region to a low-carbon economy.

FIGURE 6. Annual net energy system costs for six cases compared to the Business as Usual Case.



Source: Northwest Deep Decarbonization Pathways Study, May 2019, Evolved Energy Research, page 107

Next Steps for the Northwest

Meeting the Challenge of Our Time: Pathways to a Clean Energy Future for the Northwest aims to represent potential energy futures in enough technical detail to be used as blueprints to develop a future of the Northwest's choosing. While this analysis offers a functional technical representation of low-cost deep decarbonization pathways, successful implementation is more uncertain. Implementation challenges include the following:

- A nearly 100% clean grid is a key feature of low-cost decarbonization in the region. Policymakers and utilities must focus on overcoming the policy, technical, business model, and economic barriers to cleaning the grid well in advance of 2050.
- The level of transportation electrification called for by 2050 requires immediate attention to accelerating the widespread adoption of electric vehicles, investing in the essential charging infrastructure, and determining how the grid will handle the additional load required to serve this new demand. Not only must we move quickly to electrify transportation, we also need to invest in solutions that promote greater equity, especially for people historically least served or most impacted by fossil fuel–based transportation systems.
- New grid infrastructure and operational integration are needed to leverage renewable development efficiently and cost-effectively in California and across the West. Achieving this integration and installing the needed grid capacity is complicated politically and technically, so planning must get underway now to ensure successful integration of these markets.

Further work is needed to develop the policies that will accelerate a deep decarbonization path in the Northwest that is affordable, equitable, and meets reliability standards.

There are several areas of additional examination that the study suggests pursuing, including changing assumptions about hydroelectricity and nuclear availability, coal plant retirement dates, and natural gas pricing and carbon intensity. Further examination is needed of the role of natural gas and the decentralization of the electricity grid, as is work on the key policy drivers that are needed to accelerate decarbonization in the Northwest.

This study is designed to show the trade-offs between different deep decarbonization pathways, but it does not take into account equity considerations for different communities. The study demonstrates that we can decarbonize our economy, but the critical work ahead must focus on how to do so equitably.

Meeting the Challenge of Our Time: Pathways to a Clean Energy Future in the Northwest is the only independent and rigorous deep decarbonization analysis framing the choices we must make in the coming decade to achieve a deeply decarbonized future in the next 30 years. Stakeholders can use the results of this and other decarbonization studies to formulate policies and make investments and operational decisions to accelerate the clean energy transition and put the Northwest on a deep decarbonization path that is sustainable, affordable, equitable, and meets reliability and security needs.

Electric bus charging station, Seattle, Washington. Photo credit: SounderBruce

About the Clean Energy Transition Institute

The Clean Energy Transition Institute is an independent, nonpartisan Northwest research and analysis nonprofit organization with a mission to accelerate the transition to a clean energy economy by identifying deep decarbonization strategies, advancing urban clean energy, and building a clean energy workforce. The Institute provides information about the pathways to a clean energy economy and convenes stakeholders to accelerate the shift to a low-carbon economy.

Idaho Falls wind farm. Photo credit: Daxis

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The Clean Energy Transition Institute gratefully acknowledges the funders that provided the financial support to commission a Northwest deep decarbonization pathways study and launch the Institute; the consultants whose energy sector modeling expertise provided the basis for this rigorous study; the Technical Advisory Group and stakeholders that advised on the scope and assumptions for the study; the Institute's fiscal sponsor from September 2018 to February 2019, Climate Solutions, without which the Institute could not have operated as a nonprofit organization; the Institute's contractors, for their help reviewing and publicizing the study; and the firms that provide in-kind support to the Institute.

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Technical Consultant

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EER brings tried and tested expertise in planning for least-cost decarbonization, using a tool kit built to answer technical and economic questions about deep decarbonization, including the EnergyPATHWAYS and RIO models. EER's integrated approach to holistic energy planning finds the lowest-cost pathways to future policy goals by co-optimizing investments in the electric and non-electric energy sectors, which is essential for finding realistic and least-cost solutions for a clean energy future.

Decarbonization Pathways Work Group

The Clean Energy Transition Institute convened a work group from February to November 2017 to determine whether to conduct a Northwest deep decarbonization pathways study. The Institute gratefully acknowledges the critical input of the following Decarbonization Pathways Work Group members:

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Seastack, Oregon Coast. Photo credit: Clean Energy Transition Institute

Technical Advisory Group

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Design Firm

One Visual Mind designed *Meeting the Challenge of Our Time: Pathways to a Clean Energy Future for the Northwest*. Founded in 2004, One Visual Mind has offices in Boston, MA, and in Portland, OR, and aims to provide functional design solutions that have an impact.