Energy Decarbonization Pathways

SSG

Washington Utilities
and Transportation
Commission

Energy Decarbonization Pathways

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Washington Utilities
and Transportation Commission

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October 2023

Acknowledgments

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Acronyms and Abbreviations

BECCS	bioenergy with carbon capture and storage
CAISO	California Independent System Operation
CCA	Climate Commitment Act
CCUS	carbon capture, utilization, and storage
CDD	cooling degree day
CETA	Clean Energy Transformation Act
CO2e	carbon dioxide equivalent
DOE	United States Department of Energy
EDAM	Extended Day-Ahead Market
EV	electric vehicle
GHG	greenhouse gas
HDD	heating degree day
IIJA	Infrastructure, Investment, and Jobs Act
IRA	Inflation Reduction Act
IRP	integrated resource plan
MAC	marginal abatement cost
NREL	National Renewable Energy Laboratory
RCW	Revised Code of Washington
RNG	renewable natural gas
UTC	Washington Utilities and Transportation Commission
WEIM	Western Energy Imbalance Market

Glossary

Actions: Any policy or investment designed or intended to reduce GHG emissions.

Balancing Authority: An entity in the US electric system that is responsible for grid balancing within a given jurisdiction or area, as well as compliance with certain requirements of the North American Electric Reliability Corporation.

Building Retrofit: Changes to the structure or systems of an existing building to reduce overall energy, electricity, and water consumption.

Carbon Sequestration: The process of capturing and storing atmospheric carbon dioxide.

Climate Change: Climate change refers to a change in the state of the climate that can be identified (e.g., through statistical tests) by changes in the mean temperature and/or the variability of its properties; the change in state persists for an extended period, typically decades or longer. Climate change may be caused by natural internal processes or external forcings such as modulations of the solar cycles or volcanic eruptions. Climate change can also be caused by persistent anthropogenic changes in land use or the composition of the atmosphere. Note that the Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as: "A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." The UNFCCC thus makes a distinction between climate change attributable to human activities that alter the atmospheric composition and climate variability attributable to natural causes.

Climate target: A climate target refers to a greenhouse gas emissions reduction goal used to avoid dangerous anthropogenic interference with the climate system.

Cooling degree days (CDD): The number of degrees that a day's average temperature is above 18o Celsius (64.4°Fahrenheit), thus requiring indoor space cooling.

CO2e: Carbon dioxide equivalents, a common unit of measurement for greenhouse gas emissions. Converting gasses, such as methane, nitrous oxide, hydrofluorocarbons, and perfluorocarbons, to carbon dioxide equivalents allows scientists to measure and compare how much a particular gas would contribute to global warming if it were carbon dioxide. This unit is typically expressed in millions of metric tons.

Energy Independence Act (EIA): Washington's Energy Independence Act set a renewable portfolio standard for Washington's electric utilities, requiring increasing amounts of power to be generated by renewable energy sources.

Emissions: In this report, the term "emissions" refers exclusively to greenhouse gas emissions, measured in grams, kilograms, or metric tons (CO2e), unless otherwise indicated.

Extreme weather event: An extreme weather event is an event that by historical standards is rare at a particular place and time of year. By definition, the characteristics of what is called extreme weather may vary from place to place in an absolute sense. For example, the extreme heat dome experienced in June 2021 in Washington was an extreme weather event. Temperatures in Seattle reached more than 100◦ Fahrenheit for more than three days in a row. In the previous 126 years, Seattle had only hit 100◦F a total of three times.[1] When a pattern of extreme weather persists for some time, such as a season, it may be classed as an extreme climate event (e.g., drought or heavy rainfall over a season).

Demand response: Reducing or shifting electricity usage during peak periods in response to time-based rates or other forms of financial incentives.

Fossil fuels: Carbon-based fuels from fossil hydrocarbon deposits, including coal, oil, and natural gas.

Greenhouse gasses (GHG): Gasses that trap heat in the atmosphere by absorbing and emitting solar radiation, causing a greenhouse effect that warms the atmosphere. The main GHGs are water vapor, carbon dioxide, methane, nitrous oxide, and ozone.

Heating degree days (HDD): Number of degrees that a day's average temperature is below 18o Celsius (64.4° Fahrenheit), thus requiring indoor space heating.

Interested and impacted communities: Any group or organization that has a concern about a development, project, policy, or action.

Marginal abatement cost (MAC): The cost or savings of reducing one more ton of GHG emissions, usually represented in net present value.

Heat pump: A device that transfers heat energy from a source to a target area using mechanical energy. Heat pumps can be used to heat or cool an indoor space.

Highly impacted communities: This study follows the following definition from the Washington State Department of Health: "Highly impacted communities meet at least one of the following two criteria:

- The census tract is covered or partially covered by 'Indian Country' as defined in and designated by statute.
- The census tract ranks a 9 or 10 on the Environmental Health Disparities Map, as designated by the Department of Health."

HVAC: Heating, ventilation, and air conditioning systems, referred to in the context of a building.

kW: A common unit for measuring electrical power, a kilowatt is the amount of energy equivalent to 1,000 Watts,

Integrated resource plans (IRP): Integrated resource plans are developed by Washington's electricity and natural gas utilities to forecast supply and demand to determine resource needs for the coming decade. The UTC reviews but does not approve IRPs.

MW: A common unit for measuring electrical power, a Megawatt is the amount of energy equivalent to 1,000 kilowatts, or 1,000,000 Watts.

[1] "Astounding Heat Obliterates All-Time Records across the Pacific Northwest and Western Canada in June 2021 | NOAA Climate.Gov," accessed April 1, 2022, **https://www.climate.gov/news-features/event-tracker/astounding-heat-obliterates-all-time-records-acros** s-pacific-northwest.

MWh: A common unit of electrical energy, a Megawatt hour is the amount of energy equivalent to 1,000 kWh, or 1,000 kilowatts of electricity used continuously for one hour.

kWh: A common unit of electrical energy, a kilowatt hour is the amount of energy that would be used to keep a 1,000 watt appliance running for one hour.

Planning reserve margin: The difference between available electricity generation capacity and peak demand, normalized by peak demand and shown as a percentage to indicate the amount of generation capacity needed to maintain reliable electricity system operation while meeting unforeseen increases in demand (e.g., extreme cold or heat) and unexpected generation outages.

Person-year: A person-year is a unit of measurement for the amount of work done by an individual throughout the entire year, expressed in the number of hours. The person-year takes the number of hours worked by an individual during the week and multiplies it by 52.

RCW: The Revised Code of Washington is the compilation of all permanent laws currently in effect in Washington state. It includes session laws (which may be enacted by the Legislature and signed by the Governor, or passed via the initiative process). It does not include temporary laws such as appropriations.

Renewable energy: Energy that comes from resources defined as renewable in RCW 19.405.020: (a) Water; (b) wind; (c) solar energy; (d) geothermal energy; (e) renewable natural gas; (f) renewable hydrogen; (g) wave, ocean, or tidal power; (h) biodiesel fuel that is not derived from crops raised on land cleared from old growth or first growth forests; or (i) biomass energy.

Renewable natural gas (RNG): a gas consisting largely of methane and other hydrocarbons derived from the decomposition of organic material in landfills, wastewater treatment facilities, and anaerobic digesters (RCW 19.405.020)

Renewable portfolio standard (RPS): Policies designed to increase the use of renewable energy sources for electricity generation. In Washington, voters approved Initiative 937 in 2007, requiring all utilities serving more than 25,000 customers to serve at least 15% of their load with qualified renewable energy. CITE

Western Energy Imbalance Market: A real-time wholesale energy trading market for the western United States that allows participants to buy and sell power close to the time the electricity is consumed.

Western Resource Adequacy Program: the Western Interconnection's first reliability planning and compliance program, created to assess and address resource adequacy.

Wild deer in Olympic National Park, Washington. @Cavan. Stock.adobe.com

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Executive Summary

Executive Summary

The purpose of the Energy Decarbonization Pathways Study is to identify and describe the various potential pathways for Washington's investor-owned electric and natural gas utilities to contribute to achieving the state's overall GHG emission reduction goals. *RCW 70A.45.020* states that Washington shall limit anthropogenic emissions of greenhouse gasses (GHGs) to 95% below 1990 levels by 2050.

In April 2021, the Washington State Legislature passed Senate Bill 5092, section 143 (Chapter 334, Laws of 2021), making 2021-2023 fiscal biennium operating appropriations for the state and providing funding to the Washington Utilities and Transportation Commission ("UTC" or "commission") for the Energy Decarbonization Pathways Examination ("the study"). According to that law, the study "must examine feasible and practical pathways for investor-owned electric and natural gas utilities to contribute their share to greenhouse gas emissions reductions as described in *RCW 70A.45.020*, and the impacts of energy decarbonization on residential and commercial customers and the electrical and natural gas utilities that serve them." Specifically, the Legislature directed the Commission to identify and consider:

"(i) How natural gas utilities can decarbonize;

(ii) The impacts of increased electrification on the ability of electric utilities to deliver services to current natural gas customers reliably and affordably;

(iii) The ability of electric utilities to procure and deliver electric power to reliably meet that load;

(iv) The impact on regional electric system resource adequacy, and the transmission and distribution infrastructure requirements for such a transition;

(v) The costs and benefits to residential and commercial customers, including environmental, health, and economic benefits;

(vi) Equity considerations and impacts to low-income customers and highly impacted communities; and

(vii) Potential regulatory policy changes to facilitate decarbonization of the services that gas companies provide while ensuring customer rates are fair, just, reasonable, and sufficient."

This project identifies and describes pathways that achieve GHG emissions reductions from actions and measures related to the use of natural gas. A pathway is defined as a suite of interrelated actions implemented over time that result in emissions reductions and related goals.[2] This project does not recommend a particular pathway, but describes pros and cons of the pathways identified.

The Commission will share with the Washington State Legislature this report on feasible and practical pathways for investor-owned electric and natural gas utilities to decarbonize, and the impacts of energy decarbonization on customers and utilities.

This study addresses the following questions:

1

How can Washington's gas utilities decarbonize?

Washington's investor-owned gas utilities face a set of options for decarbonization. An assessment of practices from across the country and the world reveals that changes in products sold (shifting from selling fossil gas as a commodity to selling renewable natural gas, hydrogen, or electricity), cost recovery and rate structure (reconsidering which customer bases pay for the distribution system and how utilities recover costs), and utility regulations (from supporting new business models to requiring new planning and coordination practices) can all support gas utility decarbonization.

The analysis in this report shows that each of these decarbonization pathways could lead to changes in existing infrastructure, and the development of new infrastructure, in Washington state and elsewhere in the Pacific Northwest region. Each pathway therefore sets a different course that has the potential to establish energy use patterns and determine emissions for the future.

2

What is the impact of increased electrification on the state's electric utilities?

In each of the decarbonization pathways explored in this study, increased electrification increases electricity demand compared to current usage, but reduces total electricity demand relative to a Business As Planned trajectory where no new policies or programs are implemented.[3] Compared with the Electrification Scenario, in which nearly all end uses are electrified, increases in electricity demand are less intensive in the Hybrid and Alternative Fuels scenarios; however these scenarios result in a relatively higher amounts of total energy use, including a higher reliance on less commercially developed technologies, as well as fuels imported from out of state, which presents risks. In all pathways, additional electricity generating capacity is required in order to serve Washington's future electricity needs while meeting the requirements of the Clean Energy Transformation Act and the Climate Commitment Act. To reduce the impact of increased electrification on total electricity consumption,

[2] Scenario modeling was conducted to identify and describe various potential pathways. Scenario planning, design, and scenarios are described in more depth in Chapter 7: Scenarios.

[3] An additional reference scenario, the Business-As-Usual scenario, was also modeled. Because it assumes the absence of policy measures that would differ substantially from those currently in place, the BAU can be considered a projection of what would happen if nothing changes beyond population increases and economic growth. This scenario provides a reference against which to assess the impacts of currently planned rules, bills, and legislation.

heavy investments in building retrofits and energy efficiency are necessary, keep electricity rates as low as possible, and achieve the associated co-benefits of electrification.

3

What is the ability of electric utilities to meet increased demand?

Based on the potential impact of increased electrification, the state's electric utilities will need to develop or contract for new electricity generating resources. New transmission capacity between Balancing Authorities will also be needed, which could be achieved through physical development and/or contractual arrangements. New transmission capacity tying Washington to other states and provinces may also be needed, depending on the scale and pace of development of generating resources within the state. Existing hydroelectric contracting agreements may need to be revisited to ensure adequate power supply in the future that matches current assumptions. As there is limited time to develop new resources in line with the requirements of CETA and the CCA, action must be taken immediately to clear barriers to develop new resources, secure transmission rights, and develop infrastructure.

4

What are the impacts on resource adequacy and transmission and distribution requirements?

Definitions of resource adequacy are evolving as renewable resources are becoming a larger part of the electricity supply. Previously reliable metrics such as planning reserve margins are less applicable when an energy system is composed of mostly or entirely renewables, given their intermittency. Therefore new definitions and metrics for resource adequacy should be defined and agreed upon by both regulatory bodies and utilities. To avoid cost-ineffective overbuilding of resources, and therefore reduce the need for new transmission infrastructure, peak electricity demand can be mitigated or managed through demand reduction strategies such as time-of-use rates, demand response technologies, and interruptible service contracts with industrial customers, in addition to widespread building retrofits, and the deployment of distributed energy resources (particularly those with bi-directional meters). Upgrades to the distribution system that are likely to occur over the study period (through 2050) can be timed with distribution upgrades to support electrification and integration of distributed energy resources, depending on the pathway. Distribution upgrade needs can be mitigated with gains in energy efficiency, for example replacing resistance heating with heat pump space heating.

5

What are the costs and benefits to customers?

Under the modelling in this study, all pathways explored deliver net societal benefits between $28 billion and $44 billion compared with a Business-As-Planned scenario. The costs and benefits of the low-carbon energy transition to customers will depend on the pathway pursued. While the energy transition has an absolute cost, these costs can also be seen as investments that will contribute to ongoing economic growth, including job creation and sectoral innovation.

Overall benefits to Washington electricity customers depend on who owns, develops, and operates the generating resources to be added to the system, as well as the timeline in which they are developed. The development of additional renewable electricity generation has a cost, between $16 billion and $30 billion in 2023 dollars compared to the costs of the BAP scenario. However these investments have the potential to bring benefits to rural communities, particularly in the case of utility-scale resource development, as well as urban and suburban communities, particularly in the case of rooftop solar development. Rooftop solar has the potential to create hundreds of thousands of low-barrier, localized jobs across the state, while a more centralized development of resources could bring thousands of jobs to rural communities, with likely lower coordination and distribution system upgrade costs. Both types of renewable energy infrastructure, utility-scale and building-scale, bring highly valuable benefits in terms of improvements in air quality and reduced health care expenditures, which has the potential to most benefit low income communities and communities of color who are currently disproportionately burdened by pollution from energy infrastructure, transportation infrastructure, and industry.

In any decarbonization pathway, Washingtonians spend less on annual fuel and energy costs compared to the BAP scenario, due to actions such as vehicle electrification, home retrofits, and heat pump installations.[4] While these actions require upfront capital investment, they result in long-term operating and maintenance cost savings and reduced energy expenditures.

The Alternative Fuels scenario relies on nascent technologies and fuel supply chains (i.e. renewable natural gas and hydrogen) which are currently projected to cost more than current resources. While there are predictions that these costs will decrease over time, it is unknown when this might occur, adding additional cost in the form of risk to this pathway. The intangible costs and benefits of energy interdependence versus independence should also be weighed. The Alternative Fuels and Hybrid pathways would continue Washington's reliance on resources imported from outside the state and region, while the Electrification Scenario could increase energy independence for the state.

6 What are the equity considerations and impacts?

Actions that reduce GHG emissions can also advance objectives for health, social and racial equity, economic prosperity, and climate resilience. In many cases, actions that reduce GHG emissions correspond or directly overlap with actions that create vibrant communities, improve public health outcomes, reduce government operating and capital costs, and support innovation; in these cases, decarbonization is a no-regrets policy.

The way in which decarbonization policies are implemented can increase existing inequities or reduce them by considering how to address the needs of Washington's diverse populations. State laws such as CETA and the Healthy Environment for All (HEAL) Act require consideration of equity impacts and addressing environmental harms in all major aspects of energy planning and regulation, including siting,

[4] Fuel costs were calculated using projections of electricity, natural gas, RNG, and hydrogen prices based on projections of utility revenue requirements and customers by fuel type. For more information, see the Data, Methods, and Assumptions Manual in Appendix A.

transmission, air quality, who gets to benefit financially, and ratemaking. Energy burdens in Washington tend to be higher among Black, Hispanic, and Native American households, as well as elderly households.[5] Lower-income households stand to gain the most from cost-saving measures, such as energy efficiency retrofits that reduce energy bills, but have the least resources to implement them. They are also less able than wealthier households to access the financial and employment opportunities linked to the energy transition, so realizing the full extent of positive impacts on equity will require focused attention on the communities most likely to be left behind.

Depending on the pathway, reduced air pollution from the cessation of burning fossil fuels translates into reduced incidences of illness and death, which when quantified as reductions in health care expenditures could equal nearly $2.1 billion in avoided costs annually by 2050.[6] This would positively impact low income communities and communities of color. Energy burdens could be reduced across all pathways, resulting from more than two million existing homes retro-fitted to improve energy efficiency and airtightness, nearly one million homes equipped with backup energy storage, and four million homes equipped with heat pumps.

Jobs with low barriers to entry could be created across the state, in both decentralized and utility-scale renewable energy development. To improve equitable access to these jobs, training and workforce development could be tailored to increase participation among those whose jobs are at risk of being lost due to the low-carbon energy transition, formerly incarcerated people and others returning to the workforce, women, and others traditionally excluded from roles in building, construction, and trades.

There are also societal benefits. Reductions in GHG emissions reduce the damage caused by climate change. The Social Cost of Carbon (SCC) is a representation of the economic value of this avoided damage, which results in additional savings of approximately $22 billion dollars in each decarbonization pathway compared to the BAP, as a result of reductions in emissions.

7 What are potential regulatory policy changes to facilitate decarbonization?

Policy makers can support decarbonization by enabling the alignment of natural gas utility interests with GHG emission reduction efforts. Redefining the role of gas utilities, as well as their permitted and/or regulated activities, could empower them to pivot from selling carbon commodities to selling decarbonized fuel products, such as RNG, and/or selling decarbonization services such as building retrofits, rooftop solar installations, and heat pump installations. Re-orienting utility regulation and ratemaking processes in service of decarbonization, such as via performance-based ratemaking with targets aligned with emission reductions and successful implementation of low-carbon actions,

[5] Drehobl, Ross, and Ayala, "How High Are Household Energy Burdens? An Assessment of National and Metropolitan Energy Burden across the United States."

[6] This figure does not include the health impact of reducing indoor air pollution related to the use of gas stoves. However, a recent study by Stanford university researchers concluded that using a gas stove can expose people to levels of benzene and other toxic chemicals at rates equivalent to or exceeding that of second-hand smoking. Yannai S. Kashtan et al., "Gas and Propane Combustion from Stoves Emits Benzene and Increases Indoor Air Pollution," Environmental Science & Technology 57, no. 26 (July 4, 2023): 9653–63, https://doi.org/10.1021/acs.est.2c09289. The American Gas Association disputes these and related claims. "AGA Response to The Weather Channel Video about Natural Gas Cooking," American Gas Association, accessed November 8, 2023, https://www.aga.org/research-policy/resource-library/aga-response-to-the-weather-channel-video-about-natural-gas-cooking/.

could tightly align utility business models with state decarbonization requirements. Policies to increase coordination between utilities, including between natural gas and electric utilities with overlapping service territories, could also contribute to reducing system development costs and the investment required of utilities individually and collectively, reducing capital burdens.

Other policy changes to support the transition of energy infrastructure include changes to processes that impact the pace of development of renewables. These include streamlining and expediting siting and permitting, reforming transmission capacity contracting and planning processes, developing consistent definitions of resource adequacy and reliability standards or requirements, and promoting regional collaboration. Other regulatory changes that may support decarbonization include those that reduce peak electricity demand and improve system reliability, such as requiring more detailed information from utilities about outages, enabling or requiring changes to customer rate design, supporting wide deployment of demand response technologies in new and existing buildings, and participating in efforts to create system resilience and balance in day ahead electricity markets. Day-ahead markets are intended to improve market efficiency by using day-ahead unit commitment and scheduling across a larger area, which the National Resources Defense Council predicts will result in faster renewable development, a cleaner grid, reduced emissions, and lower energy costs.

A focus on utilities as partners in the energy transition would assist in identifying and allowing for emerging opportunities for utilities to support decarbonization efforts while also mitigating potential rate increases and increased costs for customers. Depending on the pathway selected, policies to support this could include enabling, supporting, or requiring managed decommission of the existing gas distribution network, allowing or requiring the use of accelerated depreciation in ratemaking, allowing utilities to charge fees to address rate shortfalls, incentivizing resources to improve resource adequacy (such as long-duration energy storage, geothermal, load flexibility), and changing customer rate allocation.

A just energy transition can be fostered by taking proactive steps to mitigate potential rate increases for low- and moderate-income gas customers, such as through state funding for retrofits or rate subsidies for low income customers, incentivizing or supporting community-owned energy resources, particularly in highly impacted communities and rural areas, tying expedited permitting and siting for renewables to specific equity and community development criteria, developing equity-led statewide and local workforce development and training strategies, providing resources and incentives for decentralized energy resources in marginalized and highly impacted communities, and supporting the development of high-paying jobs in solar panel and wind turbine manufacturing within the state.

These policy considerations are limited to what Washington can achieve on its own. Leveraging the unique opportunities presented by the recently passed federal Bipartisan Infrastructure Law (BIL) and the Inflation Reduction Act (IRA), and continued collaboration with other states and provinces in the region, as well as the federal government and its agencies, will be necessary regardless of the pathway chosen.

Olympic coast, Washington. @Galyna Andrushko. Stock.adobe.com

1

Introduction

1 | Introduction

1.1 Project Context

The purpose of the Energy Decarbonization Pathways Study is to identify and describe the various potential pathways for investor-owned electric and natural gas utilities to contribute to achieving Washington's overall GHG emission reduction goals.

RCW 70A.45.020 states that Washington shall limit anthropogenic emissions of greenhouse gasses (GHGs) as follows:

i. By 2020, reduce GHGs to 1990 levels, or 90.5 million metric tons;

ii. By 2030, reduce GHGs to 50 million metric tons, or 45% below 1990 levels;

iii. By 2040, reduce GHGs to 27 million metric tons, or 70% below 1990 levels; and

iv. By 2050, reduce GHGs to 5 million metric tons, or 95% below 1990 levels.

In April 2021, the Washington State Legislature passed Senate Bill 5092, section 143 (Chapter 334, Laws of 2021), making 2021-2023 fiscal biennium operating appropriations for the state and providing funding to the Washington Utilities and Transportation Commission for the Energy Decarbonization Pathways Examination ("the study"). According to that law, the study must identify and consider:

> "(i) How natural gas utilities can decarbonize;
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> (ii) The impacts of increased electrification on the ability of electric utilities to deliver services to current natural gas customers reliably and affordably;
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> (vii) Potential regulatory policy changes to facilitate decarbonization of the services that gas companies provide while ensuring customer rates are fair, just, reasonable, and sufficient."

This project identifies and describes pathways that achieve GHG emissions reductions from actions and measures related to the use of natural gas. A pathway is defined as a suite of interrelated actions implemented over time that result in emissions reductions and related goals.[7] This project does not recommend a particular pathway, but describes pros and cons of the pathways identified.

As requested in the budget proviso directing this study, the Washington Utilities and Transportation Commission will share with the Washington Legislature this report on feasible and practical pathways for investor-owned electric and natural gas utilities to decarbonize, and the impacts of energy decarbonization on customers and utilities.

1.2 Methodology

The development of the Energy Decarbonization Pathways Examination involved a combination of energy and emissions scenario modeling, financial modeling, literature review, and engagement with interested and affected parties. Interested and affected parties included electric and natural gas utilities, industry associations, government agencies, business and economic organizations, representatives of the construction and real-estate sector, and civil society groups, including environmental groups, equity-seeking groups, and groups concerned with energy poverty. See the following figure for an overview of the approach. Chapter 4 describes the Public Engagement Process in more detail. Chapter 8 and the Data, Methods, and Assumptions (DMA) Manual in Appendix A provides a detailed description of the modeling process and assumptions used in the model.

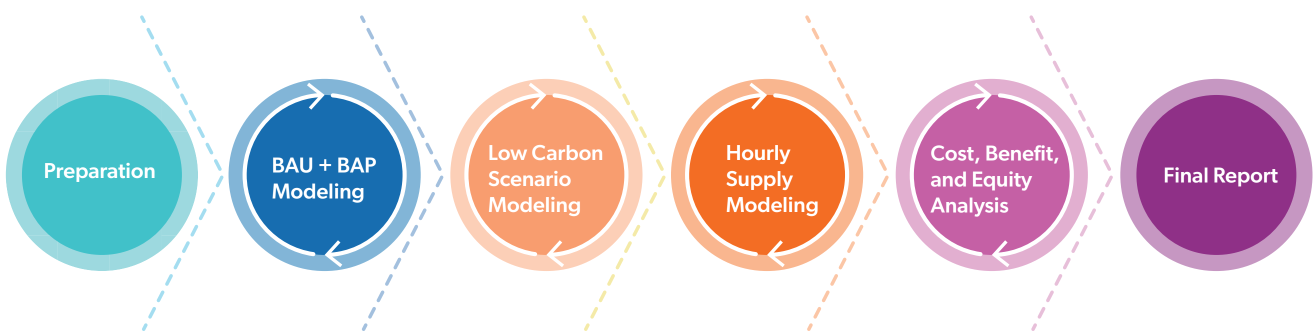

Figure 1. Project approach (conceptual diagram).

1.2.1 Technical Analysis

The consulting team developed the modeling approach and assumptions in consultation with the UTC as well as staff from the Department of Commerce, the Bonneville Power Administration, and the Northwest Power and Conservation Council. Then, the team iterated and amended the assumptions based on feedback from interested and affected communities. Public comments and SSG's responses are detailed in Appendix B What We Heard Report.

[7] Scenario modeling was conducted to identify and describe various potential pathways. Scenario planning, design, and scenarios are described in more depth in Chapter 7: Scenarios.

The modeling for this project is based on bottom-up accounting of energy supply and demand, including renewable resources, conventional fuels, and energy consuming technology stocks (e.g., vehicles, appliances, dwellings, buildings, industry, etc.). For each of Washington's 39 counties, SSG simulated energy demand and electricity demand, mapped to the relevant balancing authorities, from 2019 to 2050. The model simulated electricity generation by county and balancing authority. Electricity generated outside of Washington but consumed within the state is represented by the state and balancing authority (BA) where it is generated. The modeled emissions include emissions from the out-of-state generation of electricity consumed in Washington. Transmission of electricity is modeled as trade among BAs.

The flows and transformations of energy from sources (e.g., power plants, photovoltaic solar) are traced in the model through energy currencies (e.g., electricity, hydrogen), to end uses (e.g., space heating). An energy balance is achieved by accounting for efficiencies, conservation rates, and trades and losses at each stage in the journey from source to end use. When evaluating decarbonization pathways, policies and programs are evaluated by adjusting the flows and sources, which calculate impacts on energy consumption, GHG emissions, and costs.

The modeling time frame begins in 2019 and ends in 2050. The model uses the year 2019 as the base year because it is the most recent year for which the most current and complete data was available for calibration and modeling when the study began. The model was calibrated for the base year using as much locally observed data as possible, supplemented by data collected at the federal level (the 2019 American Community Survey (5-year) and the 2020 U.S. Census). The final year of 2050 was selected because Washington's statewide GHG emission reduction goal is to reduce emissions 95% (and achieve net-zero emissions) by 2050. The model simulated energy supply and demand in annual and hourly time steps.

The team used two models to evaluate the relationship between supply and demand of energy:

- Energy Systems Simulator, used to model energy demand, and
- Calliope, used to model energy supply.

1.2.2 Energy Systems Simulator

The Energy Systems Simulator (ESS), is an energy, emissions, and finance accounting tool developed by Sustainability Solutions Group. The model integrates fuels, sectors, and land use to enable bottom-up accounting for energy supply and demand for a specified geography and timescale. The model is calibrated using observed datasets, while future projections are driven by population change and employment growth.

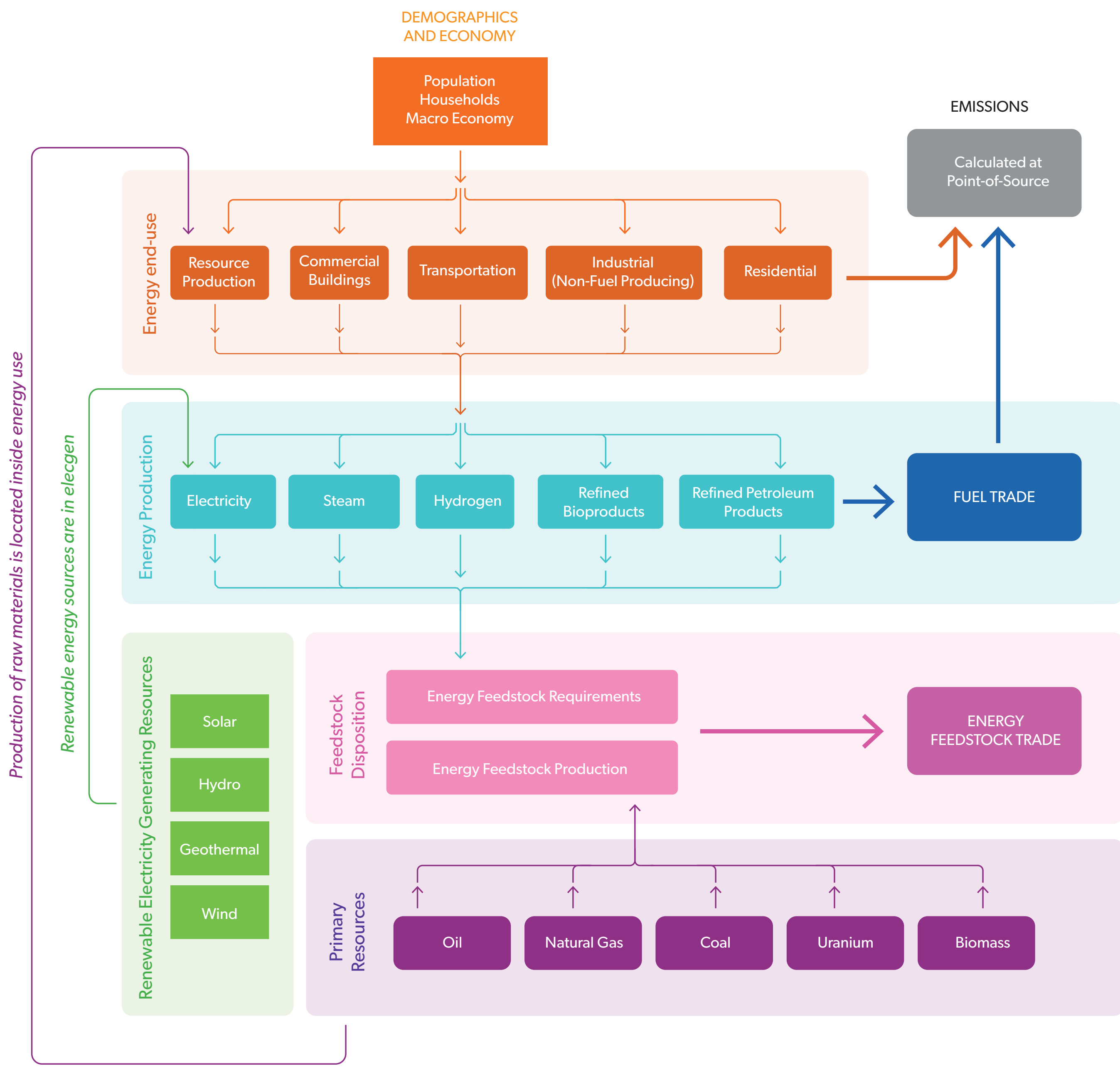

Figure 2. High-level computational structure of ESS.

The strengths of this modeling approach are as follows:

- **The model is bottom-up:** ESS tracks the physical stocks of equipment and buildings that use energy (e.g., dwellings, offices, etc.), how these stocks are used, and how GHG emissions are produced by these uses and activities. These stocks evolve as the population grows or the economy expands. This level of detail allows us to evaluate the impacts of policies and programs at a high sectoral and geographical resolution, assuming that the stocks can be located in a physical space.
- **The model is spatial**: ESS can report on impacts at the state level and at the sub-geographical level (i.e., county).
- **The model integrates hourly electricity demand**: ESS includes an integrated 8760-hour electricity demand model by sector and end use.
- **The model is designed to evaluate transformative change:** As a systems dynamics model, ESS is constrained by the character and latency of physical systems (i.e., the turnover of stocks). The systems dynamics approach exposes a wide range of possible policy levers, beyond costs or cost constraints. This flexibility is critical for evaluating transformative change in the energy system as it requires departures from historical patterns, or historically-derived coefficients.
- **The model is transparent**: The modeling logic and assumptions are defined and documented in the modeling tool, which can be freely accessed.
- **The model assesses economic impacts**: ESS calculates marginal abatement costs for each program or action and evaluates economic indicators, such as operating and capital cost impacts.
- **The model evaluates public health outcomes**: ESS tracks changes in air pollutants, which can be translated into health costs or avoided health costs.

1.2.3 Calliope: An Energy Systems Modeling Framework

Calliope is an open-source multi-scale energy systems modeling framework that allows users to build complex energy system models at various spatial and temporal scales. It is designed to be modular and extensible, with a flexible data input format and a wide range of modeling features and options. Calliope was specifically developed to analyze energy systems with high shares of renewable energy or other variable generation.

One of the key features of Calliope is its ability to model energy systems at different scales, from the individual building or household level to the national or global level. This makes it a powerful tool for energy system planning and policy-making, as it enables users to analyze and optimize energy systems under different scenarios and assumptions. The model allows analysis of internally coherent scenarios of how energy is extracted, converted, transported, and used, and how these processes might change in the future.

Calliope is highly customizable, with a wide range of options for modeling different components of an energy system. This includes the ability to model different types of energy sources, such as renewables, fossil fuels, and nuclear power, as well as various types of energy conversion and storage technologies, such as batteries, hydrogen, and thermal storage. In addition to its modeling features, Calliope includes a number of advanced optimization algorithms, including linear and mixed-integer programming solvers. This allows users to optimize their energy system models to meet specific objectives, such as minimizing costs, minimizing emissions, or maximizing renewable energy penetration.

Calliope is built on top of the Python programming language, which makes it easy to integrate with other data analysis and modeling tools. It also includes a range of built-in data visualization tools, making it easy to explore and interpret the results of energy system models.

Each model and its submodels are described in detail in Appendix A Data, Methods, and Assumptions (DMA) Manual.

1.3 Decarbonization Framework

The study uses a reduce-improve-switch framework to identify and consider policies — referred to as "actions" throughout the study — in the decarbonization pathways. This approach is adapted from similar frameworks such as the well-known reduce-reuse-recycle approach (from the waste sector) and the avoid-shift-improve approach (from the transportation sector). The focus with this approach is first on reducing or avoiding consumption of energy, followed by improving the efficiency of the energy system (supply and demand), and, lastly, fuel switching to low-carbon or zero-carbon renewable sources. This approach minimizes the cost of the energy transition by minimizing the additional capacity or energy infrastructure that might need to be installed to meet energy demands of the future.

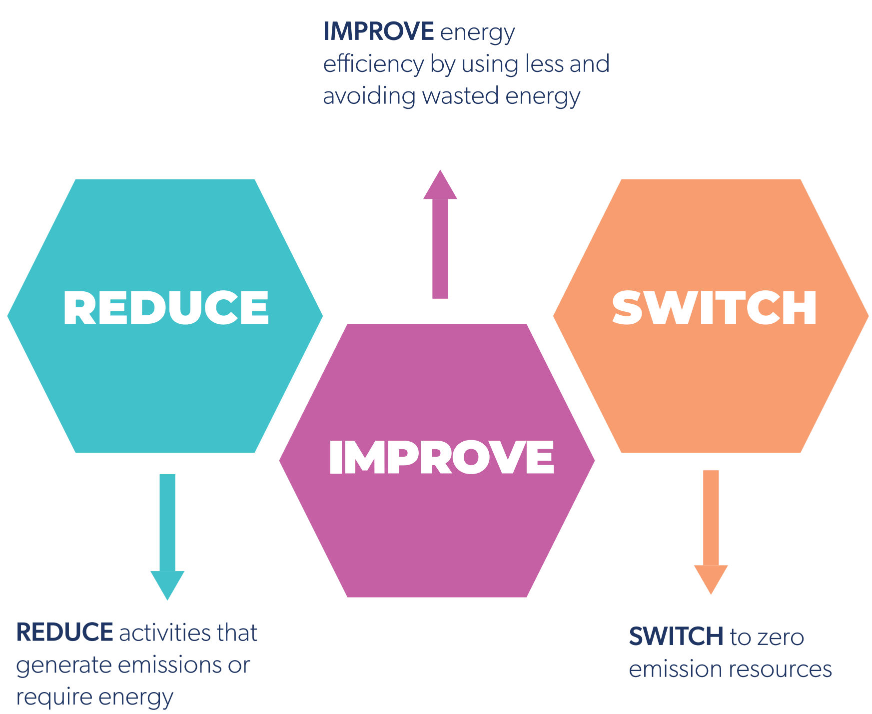

Figure 3. SSG's planning philosophy for developing decarbonization scenarios and plans.

Wind turbine farm in central Washington State. @knelson20. Stock.adobe.com

2

Public Engagement Process

2 | Public Engagement Process

The engagement goal for the Energy Decarbonization Pathways Examination was to involve interested and affected parties to assist in the development of relevant pathways for the project. These interested and affected parties include, but are not limited to:

- Members of the utility sector (natural gas utilities, electric utilities, and related industry groups and associations);
- Government organizations;
- Businesses and economic organizations;
- Representatives of the construction and real estate sector; and
- Civil society organizations, including environmental groups, equity-seeking groups, and groups concerned with energy poverty.

2.1 Engagement Planning

At the outset of the project, SSG developed an Engagement Plan to ensure interested and affected communities had opportunities to inform the process and provide feedback to ensure a relevant and comprehensive analysis of energy decarbonization pathways.

2.1.1 Engagement Objectives

The engagement plan laid out engagement techniques to achieve six objectives, designed according to the International Association for Public Participation (IAP2) methodology, a global standard in public engagement. The objectives focused on:

- Informing impacted communities and parties about the Energy Decarbonization Pathways Examination and how they could participate in the process and progress of the project;
- Informing impacted communities and parties about the energy sector, decarbonization and its potential impacts on the energy system, economy, and society;
- Involving impacted communities in documenting their suggested approaches to and concerns about decarbonization and in gathering their input on approaches and assumptions for decarbonization pathway modeling; and
- Informing impacted communities about how their feedback and participation shaped the Energy Decarbonization Pathways Examination.

The engagement plan was informed by pre-engagement interviews with key interested parties, thought leaders, and community influencers from several groups to hear about how they would like to be engaged and who should be engaged. These interviews helped SSG identify baseline knowledge about the project among interested parties, preferences for engagement, interested groups that might otherwise be missed, and other potential issues and opportunities for the engagement process.

For the full engagement plan and a pre-engagement report, refer to Appendix B What We Heard Report.

2.2 Engagement Activities

Interested and impacted communities engaged with the project in a number of ways, including via the Decarbonization Advisory Group, public meetings, surveys, and an equity focus group.

2.2.1 Kick-off Meeting

The active public engagement period began with a kick-off meeting on May 27, 2022, and the publication of the engagement plan on the project website. This meeting shared information about the project and provided information about how interested and affected parties could get involved.

2.2.2 The Decarbonization Advisory Group

The Decarbonization Advisory Group (DAG) was created to provide a venue for individuals from diverse interested and impacted parties to provide input into the development of the Energy Decarbonization Pathways study.

The consulting team worked with the UTC to create a group with representation from diverse interested and affected parties, including groups that might have been left out of other UTC engagement processes and/or found it challenging to participate in past processes.

The DAG was comprised of individuals from:

- State government agencies and local governments;
- The natural gas sector;
- The renewable energy sector;
- Environmental organizations, including environmental justice advocacy groups;
- Relevant unions;
- The construction sector; and
- A volunteer from the public.

One representative from each participating organization was requested to participate. DAG members were asked to commit to attend all four meetings so that they could build their depth of knowledge of the project and provide informed input throughout the development of the decarbonization pathways.

The DAG met four times over the course of the project to provide input on scenario assumptions, decarbonization actions and pathways, policy considerations, and equity considerations related to the decarbonization pathways.

2.2.3 Technical Meetings

Four Technical Meetings, which were public, were organized in parallel to the DAG engagement process. Like the DAG, participants had an opportunity to provide input on scenario assumptions, decarbonization actions and pathways, policy considerations, and equity considerations related to the decarbonization pathways.

2.2.4 Surveys

Two public surveys were used to gather broader input. The first survey informed respondents about the project and gathered input on the decarbonization actions under consideration for the electrification and alternative fuels pathways. The second survey gathered information about public concerns and priorities related to the impacts of decarbonization on the economy, energy costs, public health, and the environment.

2.2.5 Equity Focus Group

SSG convened a focus group in March 2023 with a diverse cross-section of Washington residents who are from or work with highly impacted communities, vulnerable communities, and other populations subject to inequities related to the energy system. The focus group gathered information about which groups are disproportionately burdened by Washington's energy system, as well as what actions should be taken to minimize unintentional negative impacts of decarbonization on these groups.

2.3 Summary of Input

For a more detailed summary of the engagement process, as well as a summary of the input provided and how it was used, please see Appendix B What We Heard Report.

2.3.1 Themes and Considerations

2.3.1.1 Key Themes and Considerations

- Support for climate action is high.
- An expressive minority does not support climate action and/or is concerned about the government focusing too much on addressing climate action.
- Some participants do not support a reduction in natural gas use.
- Some participants are concerned about harmful qualities of natural gas.
- Participants say that, in general, energy efficiency and conservation are critical.

2.3.1.2 Electrification Scenario Themes and Considerations

- Most participants support electrification actions, but have serious concerns about how they will be implemented.
- Participants are concerned about the reliability of Washington's grid and how it might worsen with electrification. For many, it is a priority to improve transmission and distribution infrastructure.
- Tribal, low-income, and rural communities are particularly vulnerable to electricity outages. Investing in weatherization and backup energy is critical for rural, low-income, and Tribal areas.

2.3.1.3 Alternative Fuels Scenario Themes and Considerations

- Participants agree that alternative fuels are necessary for successful decarbonization and to ensure energy reliability.
- Participants have mixed opinions about the alternative fuels scenario.
- Participants are concerned about the viability of alternative fuels, limited alternative fuel supplies, and safety.
- Many participants recommend dedicating alternative fuels to hard-to-electrify processes and sectors.

2.3.1.4 Renewable Energy Themes and Considerations

- Participants are concerned about the current and future supply and availability of renewable energy.
- Participants agree that distributed renewable energy and storage can contribute to a just transition.
- Participants agree that renewable energy siting must involve and benefit local communities.

2.3.1.5 Other Energy Themes and Considerations

- Some respondents recommended including nuclear energy.
- Some respondents recommended including geothermal energy.

2.3.1.6 Equity and Affordability Themes and Considerations

Participants identified the following equity and affordability themes and considerations:

- Energy cost, affordability, and cost of living are prominent concerns.
- Diverse, intersectional equity considerations are relevant to all of the pathways.
- Tribal communities face unique challenges.
- Households and organizations need incentives and funding to participate in decarbonization.
- Public health and air pollution are important considerations for evaluating decarbonization pathways and actions.
- Economic impacts are important considerations for evaluating decarbonization pathways and actions.
- Communication with and educating communities is critical. Engagement with communities burdened by the energy system during the development of decarbonization policies and programs is essential to the success of pathways.
- Financial support is necessary to ensure that all Washingtonians participate in and benefit from the energy transition.

Woman sitting on a bench looking at the Seattle, Washington skyline. @ Andy Dean. Stock.adobe.com

3

Washington's Energy System

3 | Washington's Energy System

Washington's energy system is unique. Nearly two thirds of the state's electricity is provided by hydropower, reflecting its position as the country's leading producer of hydroelectricity. It has relatively low energy demand per capita compared to other states, and is a net annual exporter of electricity.[8] Washington is reliant on imports for other sources of energy, such as natural gas, oil, and other fossil fuels.

3.1 Electricity in Washington State

3.1.1 Electric Utilities

Utilities in Washington are privately owned (investor-owned), community owned (by municipalities, public utility districts, Tribes, or the federal government), or cooperatively owned (by customers). Three investor-owned electric utilities operate in Washington: Avista Utilities, Pacific Power, d/b/a PacifiCorp, and Puget Sound Energy. In 2019, these utilities provided 36% (32.9 million MWh) of electricity consumed in Washington. Investor-owned utilities sometimes share service areas with other types of utilities such as natural gas utilities.

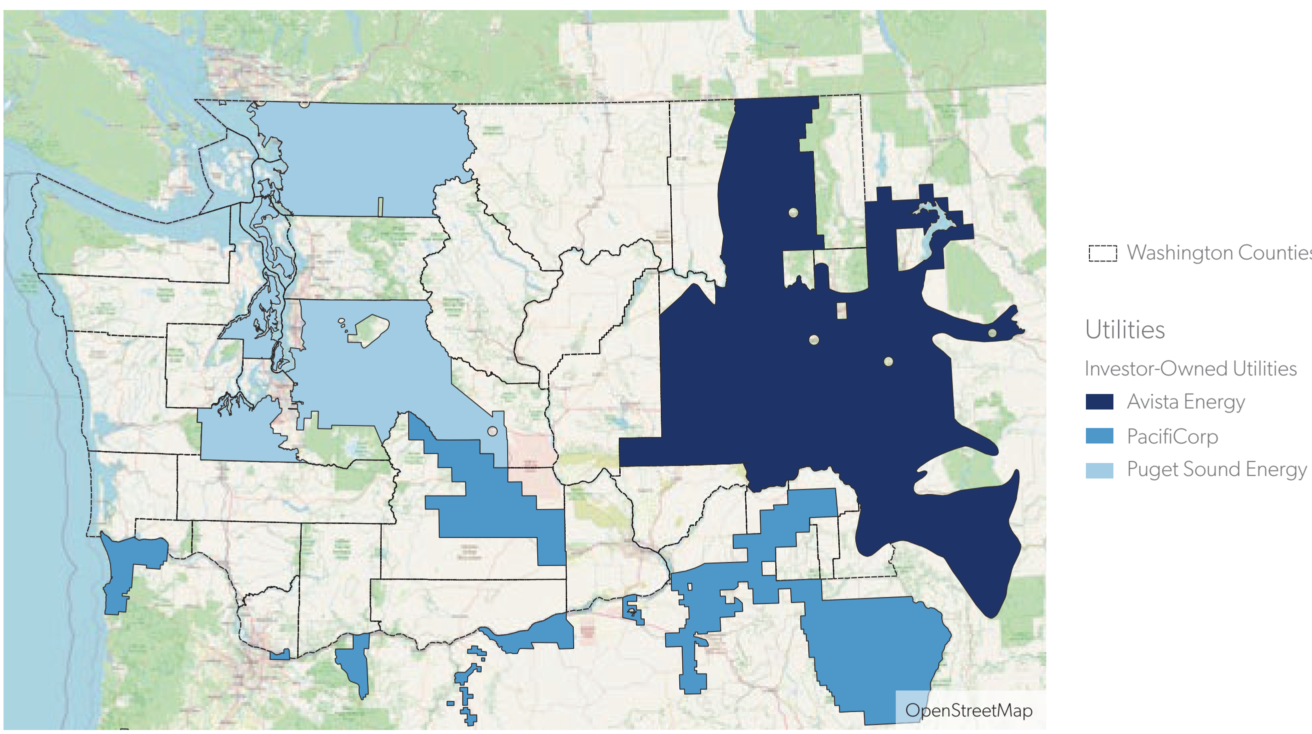

Figure 4. Investor-owned electricity utility service areas in Washington State. Source: Washington Utilities and Transportation Commission.

[8] According to the EIA, 106,463,608 MWh of electricity were produced in Washington in 2019, while electricity sales totaled 91,052,796 MWh, meaning some electricity generated in the state was exported to other states and provinces in the Western Interconnection.

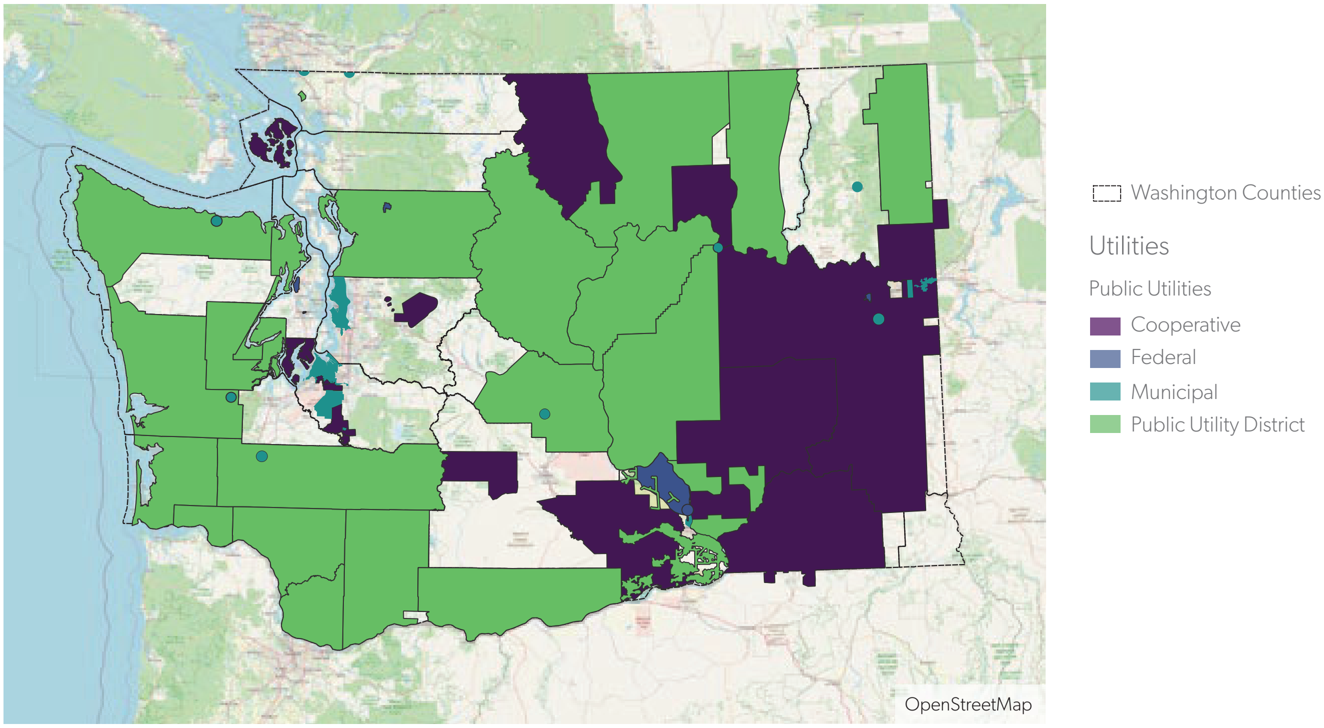

Figure 5. Cooperatively and community-owned utility service areas in Washington State. Source: Washington Utilities and Transportation Commission.

Table 1. Sales to ultimate customers by Washington electric utilities in 2019. Source: Energy Information Administration Form EIA-861, Annual Electric Power Industry Report.[9]

Ownership	Number	Total MWh	Percentage of Total MWh
Cooperative	16	4,246,983	4.90%
Federal	1	4,838,044	5.58%
Investor Owned	3	27,299,841	31.51%
Municipal	15	15,787,970	18.22%
Political Subdivision	21	32,375,124	37.37%
Retail Power Marketer	4	2,090,640	2.41%
Grand Total	43	86,638,602	100.00%

Investor-owned utilities are regulated by the Washington Utilities and Transportation Commission. The UTC is responsible for ensuring investor-owned utilities provide safe, reliable and equitable service to customers at reasonable rates while earning a fair profit. The UTC considers changes to utility rate requests through formal processes known as general rate cases, which are administrative legal proceedings with formal evidentiary hearings. The three Commissioners, who preside with an administrative law judge, decide general rate cases.

[9] The EIA makes adjustments to the data reported by utilities. The data reported by utilities may not exactly correspond to overall electricity consumption for the state as calculated by the EIA.

3.1.2 Electricity Consumption and Prices

Measured in millions of kilowatt hours, electricity consumption in Washington in 2019 was highest in the residential sector (40.1%), followed by the commercial sector (32.15%), and industrial (27.6%) sector. Industrial electricity demand in Washington has decreased 24% over the past decade, while residential demand has increased 8% and commercial demand has remained relatively constant. The transportation sector10 is a small but growing consumer of electricity in Washington, experiencing a 92% increase since 2010. The use of electricity for powering personal and commercial vehicles and ferries is expected to increase in the coming decades due to market forces, incentives, and regulations.

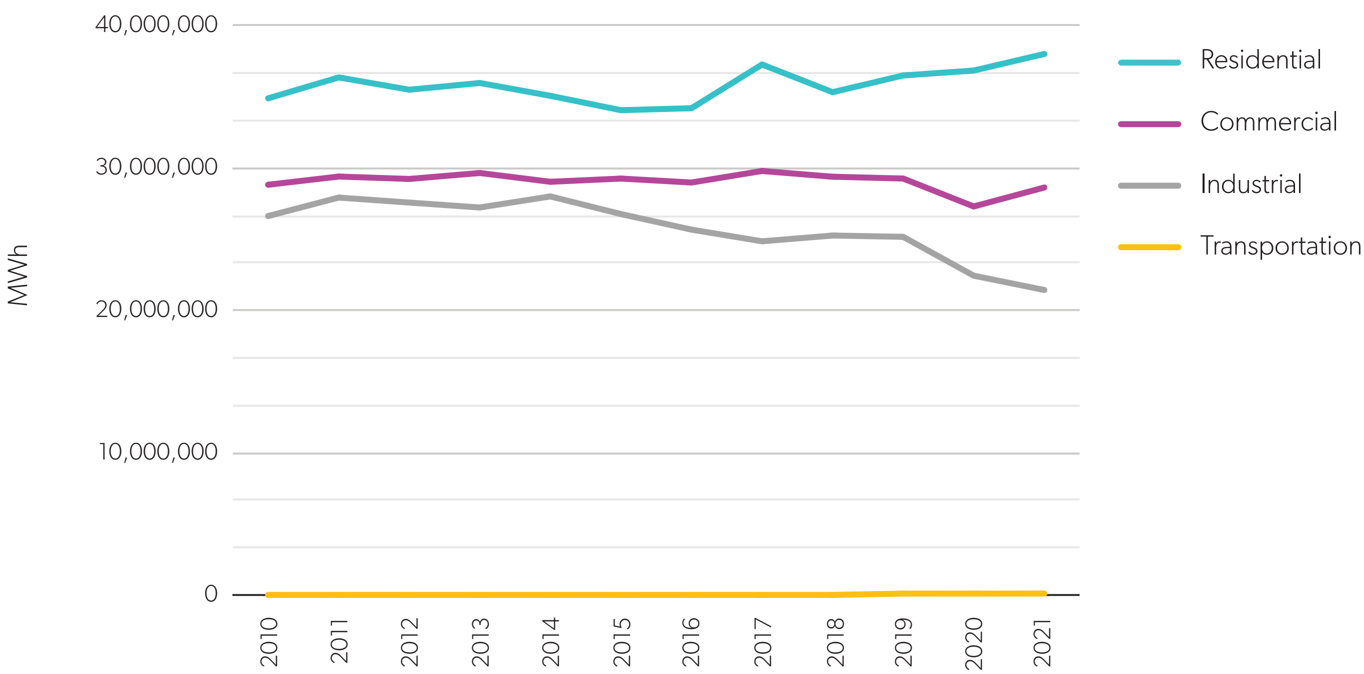

Figure 6. Annual electricity demand in Washington in megawatt hours (MWh) for the residential, commercial, industrial, and transportation sectors, 2010-2021. Source: Energy Information Administration Historic State Data.

[10] According to the EIA, "The transportation sector is defined as electrified rail, primarily urban transit, light rail, automated guideway, and other rail systems whose primary propulsive energy source is electricity. Electricity sales to transportation sector consumers whose primary propulsive energy source is not electricity (i.e., gasoline, diesel fuel, etc.) are not included. Source: EIA Electric Power Annual Technical Notes. Release date November 7, 2022.

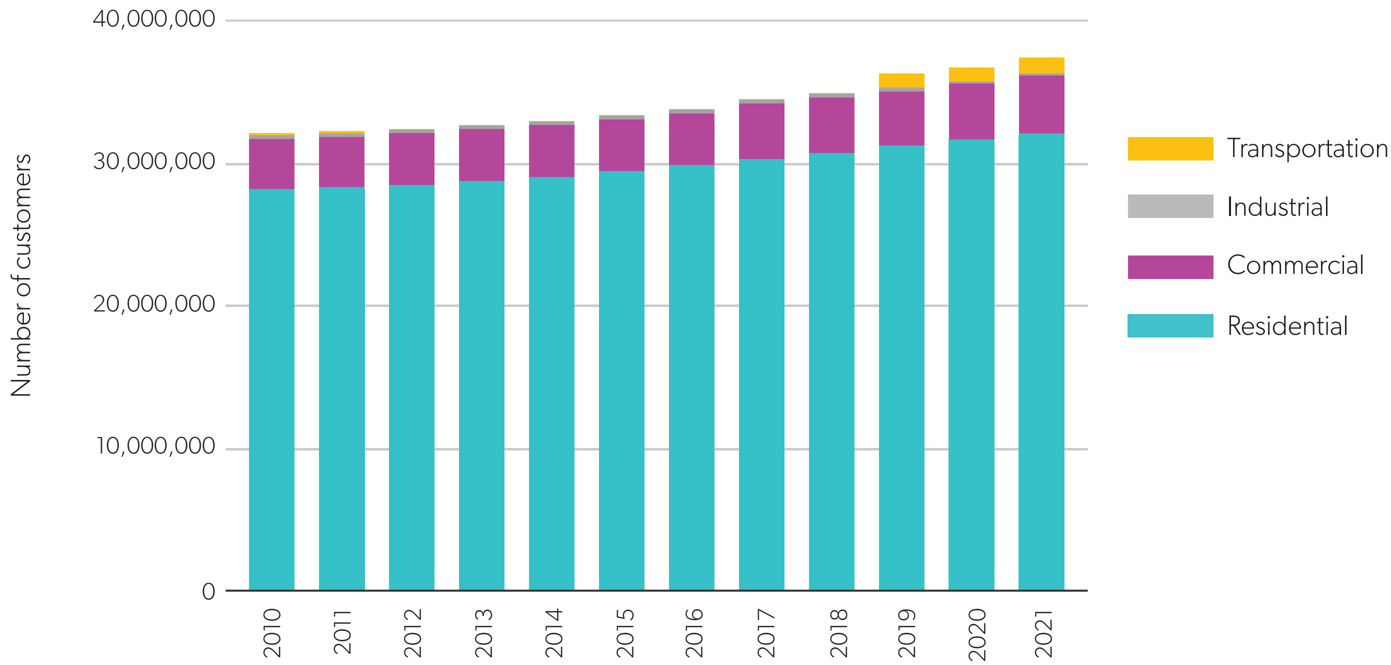

Figure 7. The number of residential, commercial, industrial, and transportation electricity customers in Washington, 2010-2021. The vast majority of electric customers are households. Source: EIA.

The number of residential customers has grown by nearly half a million households since 2010, while the number of commercial customers has remained at similar levels over the same period; industrial customers have declined.

Electricity prices in Washington are among the lowest in the nation, although they have been rising over the past decade. The average retail price of electricity has increased by 23% between 2010 and 2021, slightly less than inflation (28%) for the same period.[11] The average retail price of electricity was 8.78 cents per kWh in 2021, an increase from 8.33 cents/kWh in 2020. This change was largely driven by an increase in industrial and transportation rates.[12]

[11] "CPI Inflation Calculator," accessed April 4, 2023, https://www.bls.gov/data/inflation_calculator.htm.

[12] "Electric Power Annual 2021 - U.S. Energy Information Administration," accessed April 4, 2023, https://www.eia.gov/electricity/annual/.

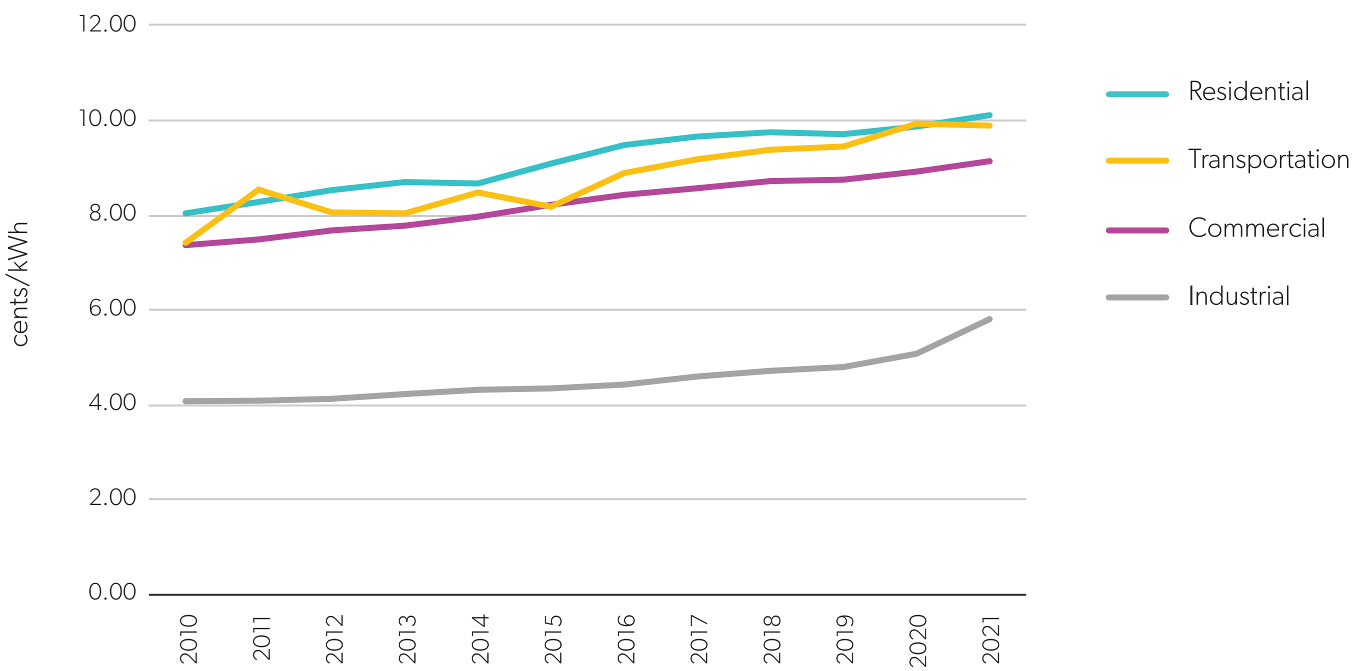

Figure 8. Average residential, commercial, industrial, and transportation electricity rates, 2010-2021. [13]

[13] The average retail price of electricity represents a weighted average of consumer revenue and sales within sectors and across sectors for all consumers and does not reflect the per kWh rate charged by the electric utility to the individual consumers. Source: EIA Electric Power Annual Technical Notes. Release date November 7, 2022.

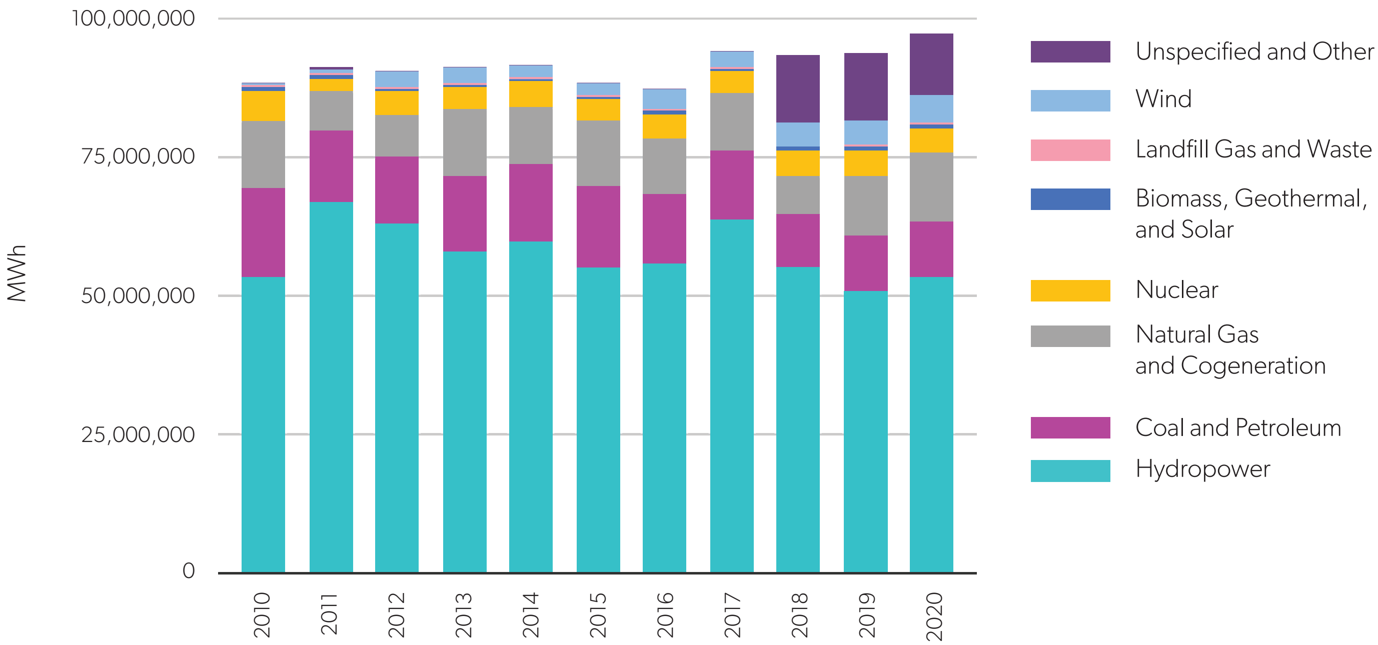

Figure 9. Aggregate fuel mix for electricity consumption in Washington, 2010-2020. Unspecified power is electricity obtained in a transaction where the seller does not identify a specific generating resource, which typically occurs using short-term transactions in bulk power markets. Prior to 2018, unspecified power was classified by the Department of Commerce using best estimates; the Department now leaves it as a separate category. Data Source: Department of Commerce Fuel Mix Disclosure Report.

Washington's fuel mix disclosure law, RCW 19.29A, requires Washington utilities to report to electricity customers on the sources of power used to generate their electricity. The Department of Commerce uses information reported by each utility, combined with fuel source data for electricity generation plants from the U.S. Energy Information Administration, to calculate the fuel mix for each utility and in aggregate for the state.

In 2019, the primary fuel used to produce electricity in Washington was hydropower (54.1%), followed by natural gas and cogeneration (11.6%), coal and petroleum (10.75%), nuclear (4.94%), and wind (4.42%). Approximately 13% of electricity consumed in Washington in 2019 came from unspecified sources. Together, biomass, geothermal, solar, landfill gas, and waste accounted for less than 2% of electricity generation. Though Washington is an annual net exporter of electricity, utilities import electricity from generating plants out of state. For example, the Colstrip power plant in Montana, which is co-owned by seven companies, including Washington utilities Avista, PacifiCorp, and Puget Sound Energy, supplies energy to Washington customers.[14]

Because hydroelectric power is a major part of the state's energy supply, reductions in hydropower capacity can significantly impact emissions associated with the power sector. For example, the drought in 2019 reduced the output from hydroelectric generation in Washington State by 16% below the average output between 1990 and 2020. The output of the Grand

[14] Utilities subject to the provisions of the Clean Energy Transformation Act may no longer allocate electricity from, or use coal fired electricity to serve customers after January 1, 2026.

Coulee Dam alone dropped from a high of 26 million MWh in 2012 to 17 million MWh in 2019.[15] In 2019, electricity consumption from fossil fuel power plants increased by 44%, which, in turn, increased Washington's carbon intensity (emission factor) by 50%, from 200 pounds of CO_2e/MWh in 2018 to 300 pounds of CO_2e/MWh in 2019.

3.1.3 Electricity Generation

Hydroelectricity is the primary source of electricity generation in Washington state (Figure 10, next page). Other resources used for electricity generation include onshore wind, biomass, natural gas, utility-scale solar facilities, nuclear (one power plant), and coal (one power plant) (Table 2).

Table 2. Electricity generating resources within Washington state as of December 2022. Some of these power plants consume more than one type of fuel (for example, both natural gas and coal, or co-location of solar panels and wind turbines). Source: EIA.

Electricity Generation Resource Type	Count
Hydroelectric power plants	71
Wind power plants	24
Natural gas-fired power plants	15
Petroleum (distillate fuel oil) power plants	9
Utility-scale solar power plants	9
Biomass power plants	5
Nuclear power plant	1
Coal-fired power plant	1
Total	135

15 "Washington - State Energy Profile Analysis - U.S. Energy Information Administration (EIA)," February 17, 2022, https://www.eia.gov/state/analysis.php?sid=WA.

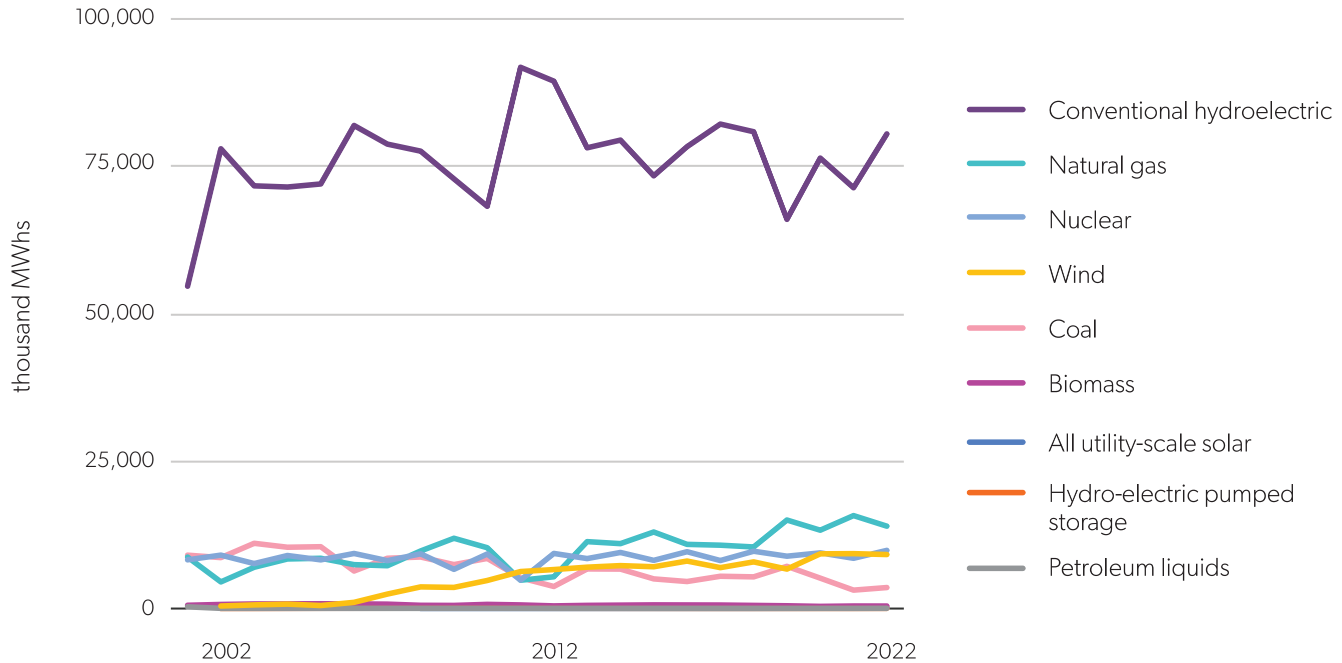

Figure 10. Net generation of electricity in Washington by fuel source, 2001-2022. The proportion of natural gas and wind power in the fuel mix has grown; however, hydroelectricity remains the largest source of electricity within the state. Source: EIA.

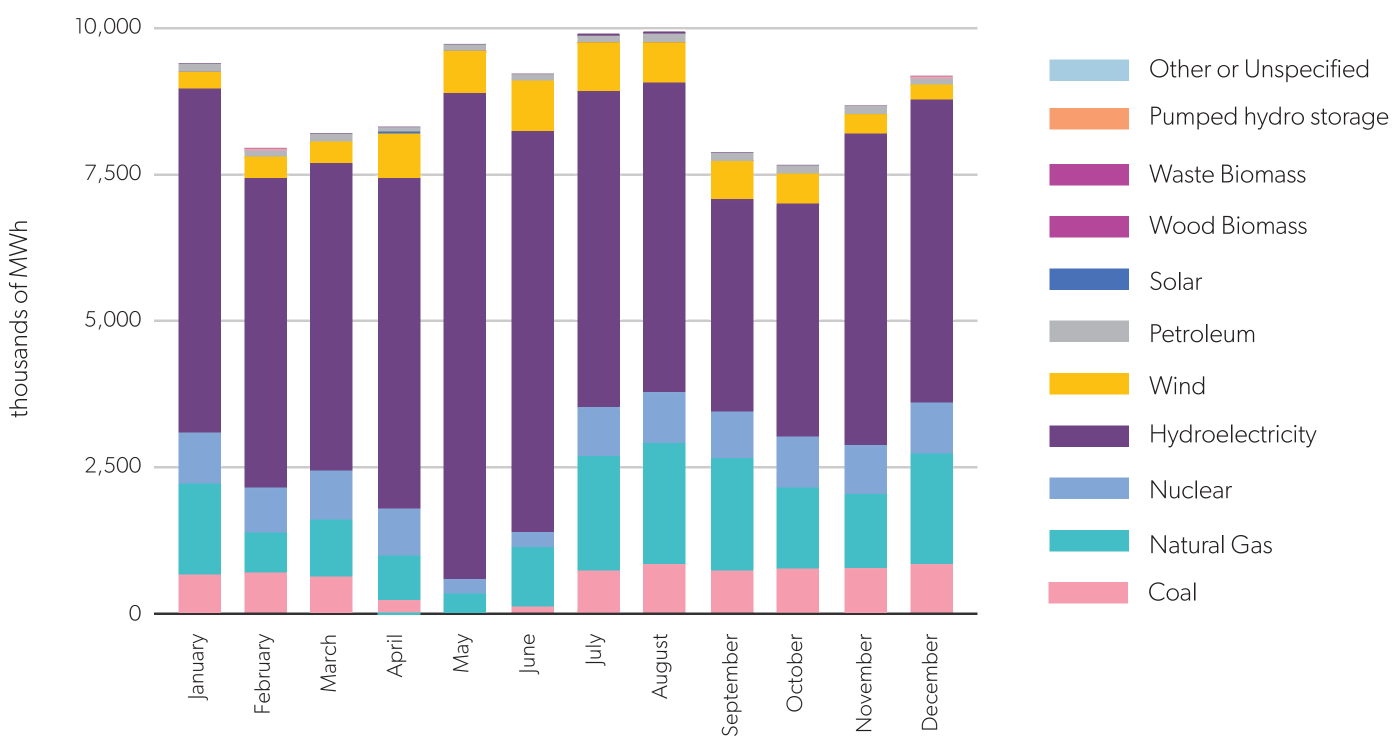

Figure 11. Net generation of electricity in Washington by energy source on a monthly basis, 2019. Source: EIA.

Washington's electricity grid is connected to customers and power plants in other states and provinces throughout the Western Interconnection, a wide-area synchronous electric grid in the Western United States that covers 14 western states, 2 Canadian provinces, and portions of Northern Baja Mexico. The Western Electricity Coordinating Council (WECC) oversees the reliability of the Western Interconnection's electricity supply. The transmission grid in this interconnection allows power producers in Washington to sell excess electricity when it is in demand in other areas of the Western Interconnection and import electricity when needed to meet Washington's demand.

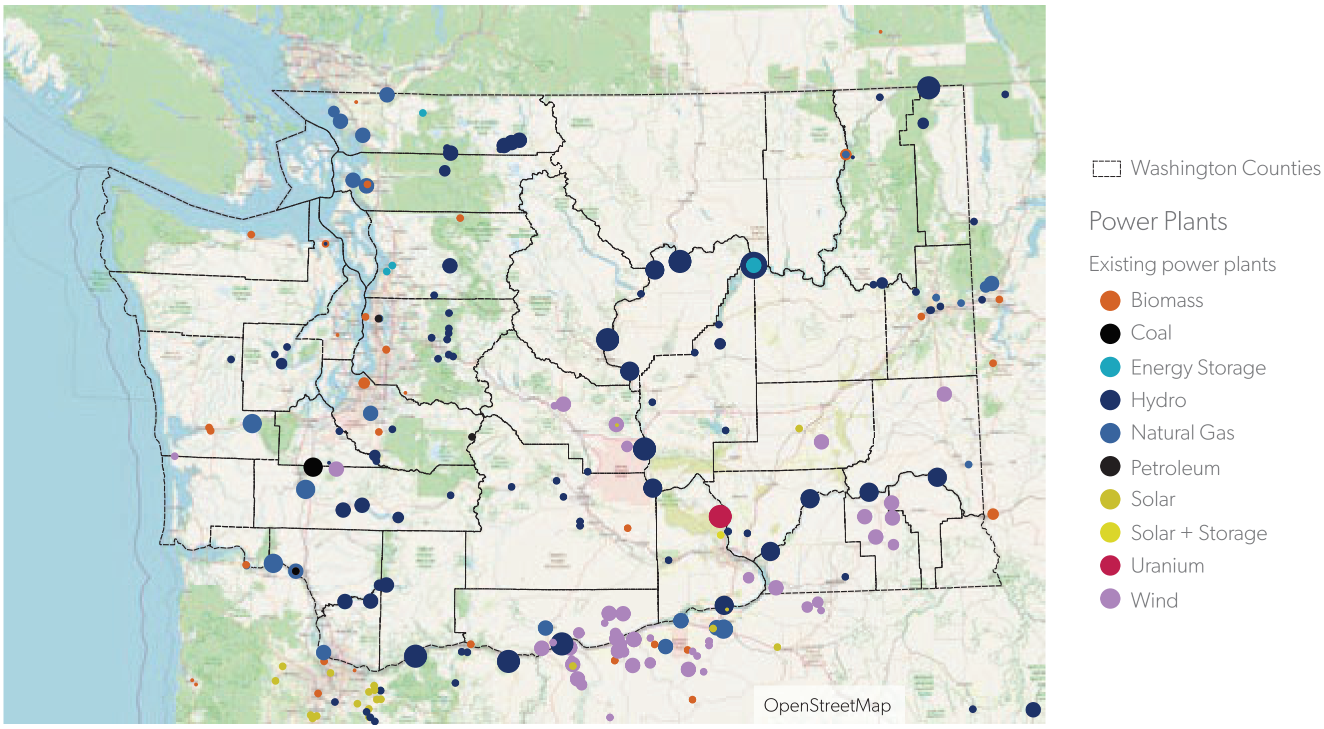

Figure 12. Map of existing electricity generating resources (power plants) in Washington and neighboring states. The larger the symbol, the higher the nameplate generating capacity. Source: NWPCC.

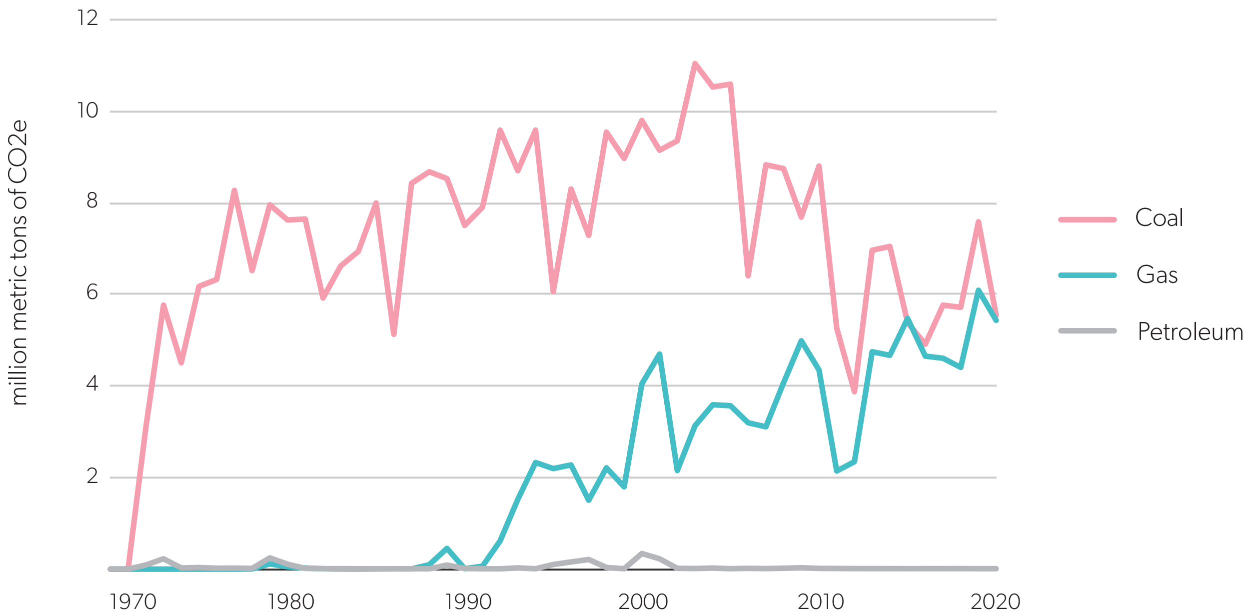

Figure 13. GHG emissions from electricity generation, by fuel source, in Washington state, 1970-2020. Source: EIA.

GHG emissions from electricity generation in Washington have decreased over time, especially since 2010, due to reduced reliance on coal generation and increasing renewable generation. In 2019, approximately 13% of electricity produced in Washington was generated by burning natural gas, according to the EIA. Utility-scale renewable energy and solar PV installations have increased in the past decade.

3.1.4 Electricity Transmission and Distribution

More than 4,500 miles of high-voltage (>230 kV) and 3,300 miles of low-voltage (<230 kV) transmission lines crisscross the state, transporting power to rural and urban areas from power plants and hydroelectric facilities in the state's interior, as well as to markets outside Washington. Most of these lines are owned and operated by the Bonneville Power Administration, a nonprofit federal power marketing administration within the Department of Energy that sells electricity from 31 federally-owned hydropower plants, one nuclear power plant operated by a joint operating agency created pursuant to RCW 43.52.360, and several small privately owned power plants located in Washington, Oregon, Idaho, and Canada.

The electricity grid in the Pacific Northwest, including Washington, operates on a bilateral model. Transmission lines are managed by balancing authorities (often, but not always, utilities) that are responsible for ensuring demand and supply are "balanced" even as power demand and supply fluctuate. Electricity generators and transmission line owners enter into bilateral contracts for transmission rights. These contracts are typically secured to match transmission needs during peak demand, which can mean lines are fully contracted but not fully utilized during times of normal demand. To secure transmission access in Washington, parties must specify a point of receipt where energy is generated and a point of delivery over a nominal contract path (actual power flow may differ) where energy is picked up. In contrast, transmission rights in a market-based grid are secured on a shorter-term, as-needed basis, and without a need to specify a specific origin or destination for the power.

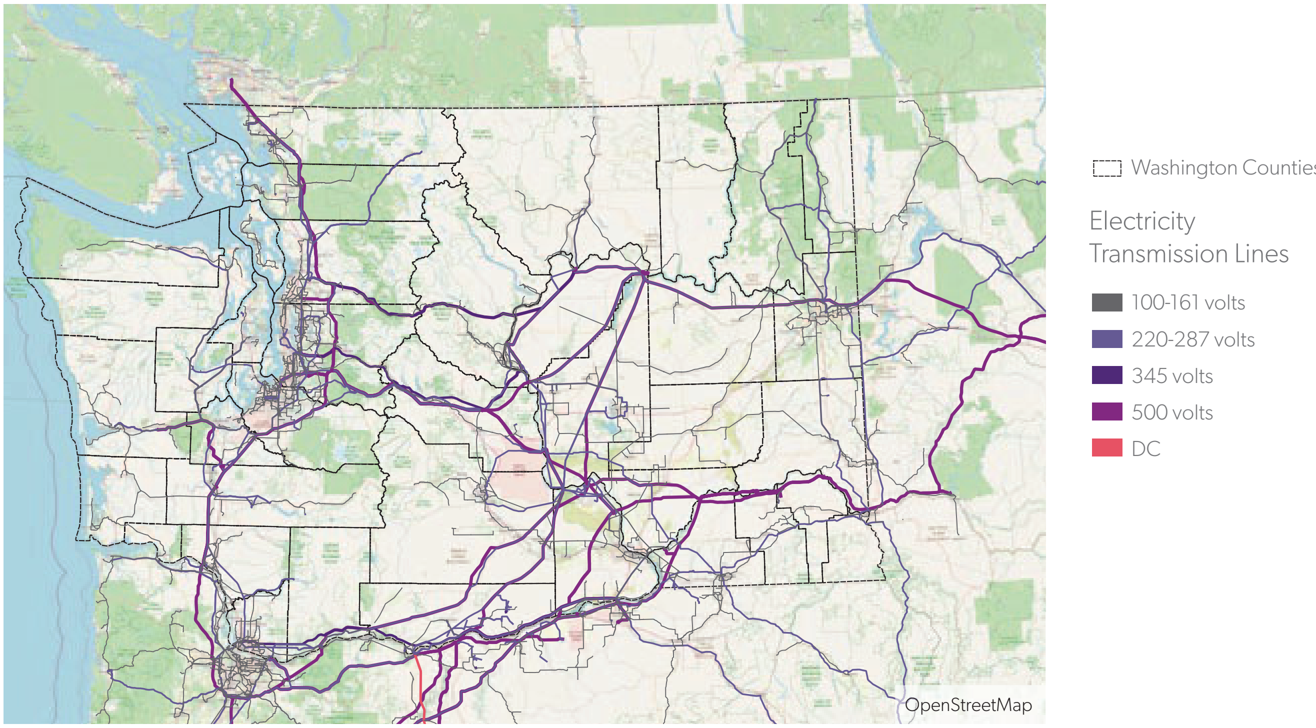

Figure 14. High-voltage transmission lines connecting generating resources to electricity customers in Washington state. Source: NWPCC.

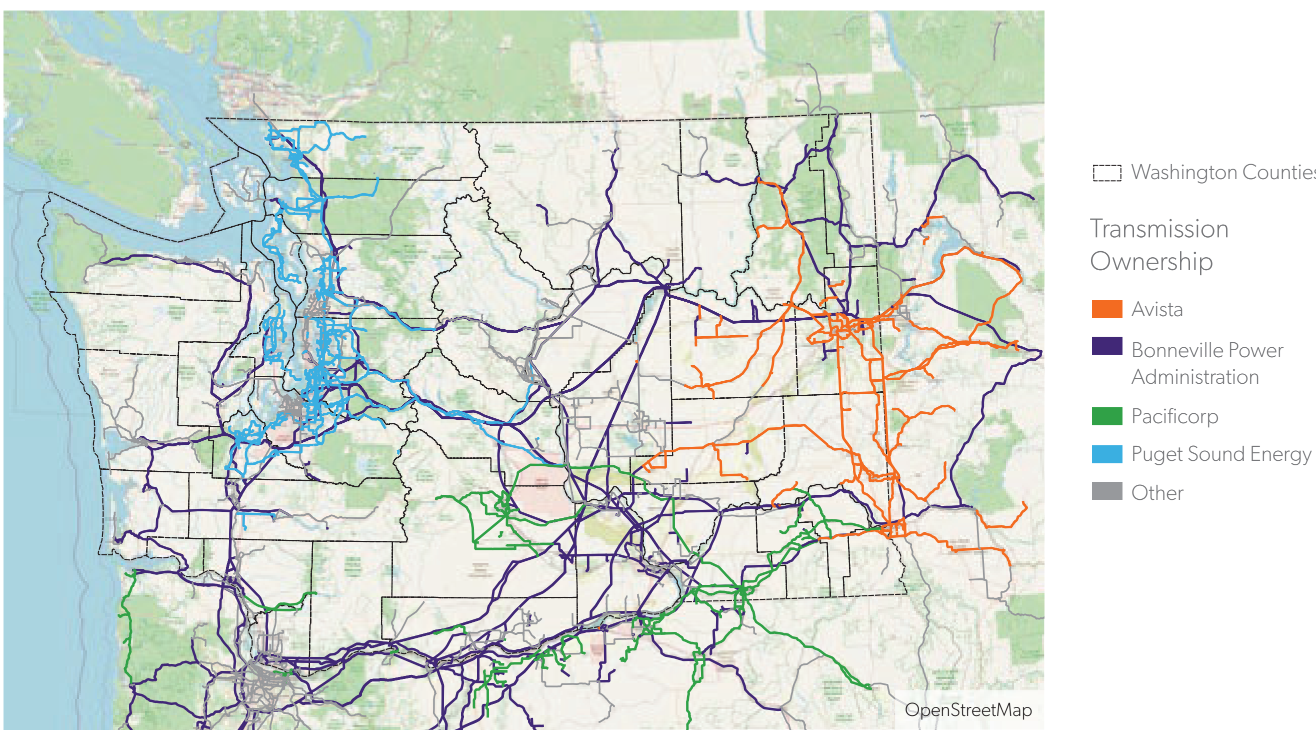

Figure 15. Ownership of high-voltage transmission lines in Washington and neighboring states. Source: NWPCC.

Washington's existing and future transmission capacity has become an important consideration since the passage of the Clean Energy Transformation Act. Existing transmission infrastructure may not be sufficient to move new renewable energy from remote locations in Eastern Washington and other states to population centers in Western Washington. Analysts at the Northwest Power and Conservation Council note that there are physical and contractual dimensions to this challenge.

The Transmission Corridors Work Group of the Washington Energy Facility Site Evaluation Council identified three transmission corridors where increased transmission capacity may be needed: East-West across the Cascades, North-South along the I-5 corridor, and southern coastal areas extending to the I-5 Corridor. Changing transmission contracting rules and/or building new physical capacity along these corridors would allow Washington's population centers to receive more power from Eastern Washington, Montana, Wyoming, California, and Canada, and offshore wind turbines in the Pacific Ocean, if developed.

Developers of new generating resources are faced with a complex system of contracting for transmission rights and securing financing. Renewable energy projects must secure transmission access based on peak demand and output, even if the average capacity needed is much lower. This can lead to applications for siting permits being rejected by siting authorities due to contracted transmission capacity, even if physical capacity is available. Due to a high volume of new projects seeking transmission access, it can take years to find out if transmission access is available, and projects are abandoned if the rights cannot be secured.

Developed in a time when only a few natural gas or coal power plants came online each year, the current permitting paradigm is a barrier to the deployment of new renewable energy resources. Developing more high voltage transmission capacity takes time (10-20 years) and skilled journey-level workers, a workforce that is aging and retiring.[16]

NorthernGrid, which launched in 2020, is a regional transmission planning organization required by the Federal Energy Regulatory Commission's Order 1000. As the regional transmission planning entity, Northern Grid facilitates regional transmission planning across the Pacific Northwest. Washington's three investor-owned electric utilities, BPA, and several large public utilities are members. They prepare a regional transmission plan every two years.

Proposed changes to the existing bilateral markets and transmission system include developing regional electricity markets in the Pacific Northwest and Western US, such as day-ahead markets or a Regional Transmission Organization (RTO). An RTO could conduct ongoing, proactive transmission planning for the state and region, as well as efficiently manage the capacity of the region's transmission system. However, the challenges associated with transmission planning and management are likely to persist. While there are active efforts underway in the Western interconnection to establish day-ahead markets through the California Independent System Operator as well as the Southwest Power Pool, as well as the possibility of a Western RTO in the eastern portion of the Western Interconnection, these efforts are still in the developing stages. This is discussed further below in Section 4.1.7.1.

[16] "Final Report - Transmission Corridors Work Group," Report to the Washington Office of the Governor (Prepared and submitted by the Washington Energy Facility Site Evaluation Council, August 1, 2022), https://www.efsec.wa.gov/sites/default/files/181034/Final_TCWG_Report%20_2022_0801.pdf.

3.1.5 Climate Change Impacts

Most of Washington's electricity infrastructure was designed and is managed for the region's historical climate. Consequently, changes in the frequency and intensity of flooding, drought, wildfire and heat waves can lead to costly damage or outages.[17] Climate change-related risks are projected to increase as the number of extreme weather events rises, decreasing the reliability of water, transportation, and energy services. According to the U.S. Department of Energy, high winds, thunderstorms and lightning, as well as winter storms and extreme cold, are the most frequent and among the most damaging (in terms of property loss) hazards currently threatening the energy system.[18] Rural and remote areas are and will be the most affected by extreme weather due to climate change.[19]

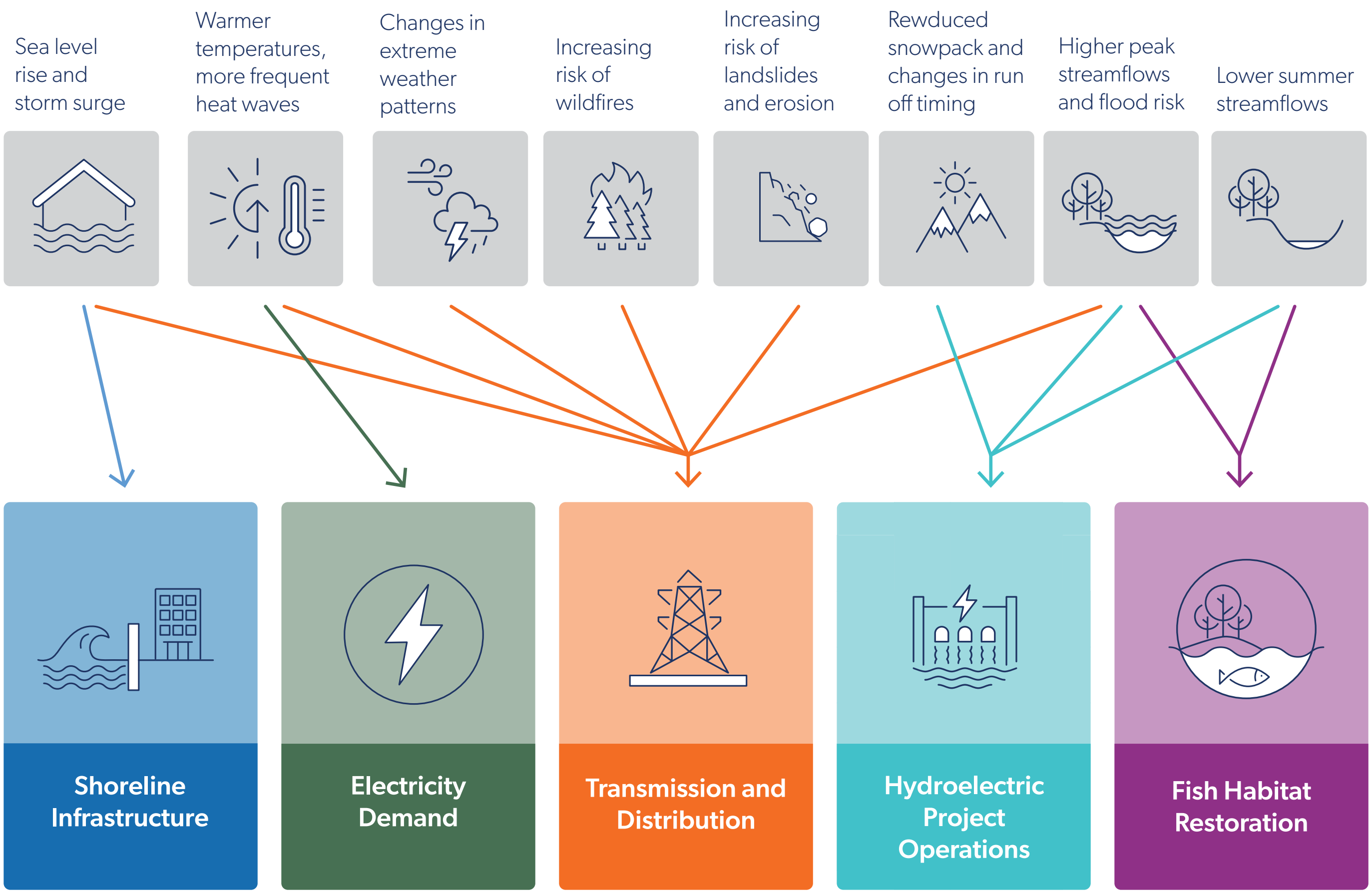

Figure 16. A figure from Seattle City Light's Vulnerability Plan that illustrates the range of extreme events that affect the vulnerability of the utility's assets, operations, and goals.[20]

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[17] USGCRP, "Fourth National Climate Assessment" (U.S. Global Change Research Program, Washington, DC, 2018), https://nca2018.globalchange.govhttps://nca2018.globalchange.gov/chapter/24.

[18] Department of Energy (DOE), Office of Electricity Delivery and Energy Reliability (OE), "State of Washington Energy Sector Risk Profile" (U.S. Department of Energy, 2020), https://www.energy.gov/sites/prod/files/2016/09/f33/WA_Energy%20Sector%20Risk%20Profile.pdf.

[19] USGCRP, "Fourth National Climate Assessment."

[20] USGCRP, "Fourth National Climate Assessment," Figure 24.11

A range of climate-related events can disrupt energy supply, lead to interruptions in the energy system, and damage to critical infrastructure.[21] Floods and storms can damage power lines and electric distribution equipment,[22] while wildfires may damage distribution and transmission lines or force utilities to de-energize transmission lines.[23] For example, during the Goodell wildfire in 2015, Seattle City Light de-energized transmission lines around the Skagit River Hydroelectric Project for days, leading to $3 million in damages and lost power production.[24] Droughts can decrease water supplies for electricity generation;[25] the western region experienced a more-than-20 percent decline in hydropower production during the 2000-2001 energy crisis.[26]

As noted above, warming temperatures can reduce the efficiency of energy infrastructure. In order to prepare the state to navigate climate-induced challenges and ensure a consistent power supply, the Washington 2021 State Energy Strategy calls for the incorporation of resilience planning into energy policy and planning.[27]

3.2 Natural Gas in Washington State

3.2.1 Gas Utilities

Four investor-owned utilities supply most of the natural gas to retail customers in Washington: Avista Utilities, Cascade Natural Gas Corporation, Northwest Natural Gas Company, and Puget Sound Energy. Public utility districts and municipalities are also authorized to produce and distribute natural gas, but only two municipalities, Enumclaw and Ellensburg, currently operate natural gas distribution systems. The primary use of natural gas, by volume, is the electric power sector, consuming 30% of natural gas delivered to the state.

21 U.S. Environmental Protection Agency. "Climate Impacts on Energy," January 19, 2017. Retrieved from: https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-energy_.html

22 Ibid.

23 USGCRP, "Fourth National Climate Assessment."

24 Ibid.

25 Ibid.

26 Sean W.D. Turner, N. Voisin, K. Nelson, and V. Tidwell, Drought Impacts on Hydroelectric Power Generation in the Western United States, Pacific Northwest National Laboratory, NNL, September 2022, at pp 2-3 (https://www.osti.gov/servlets/purl/1887470)

27 Washington State Department of Commerce. Washington 2021 State Energy Strategy: Transitioning to an Equitable Clean Energy Future. December 2020. Retrieved from: **https://www.commerce.wa.gov/wp-content/uploads/2020/12/Washington-2021-State-Energy-Strategy-December-20** 20.pdf

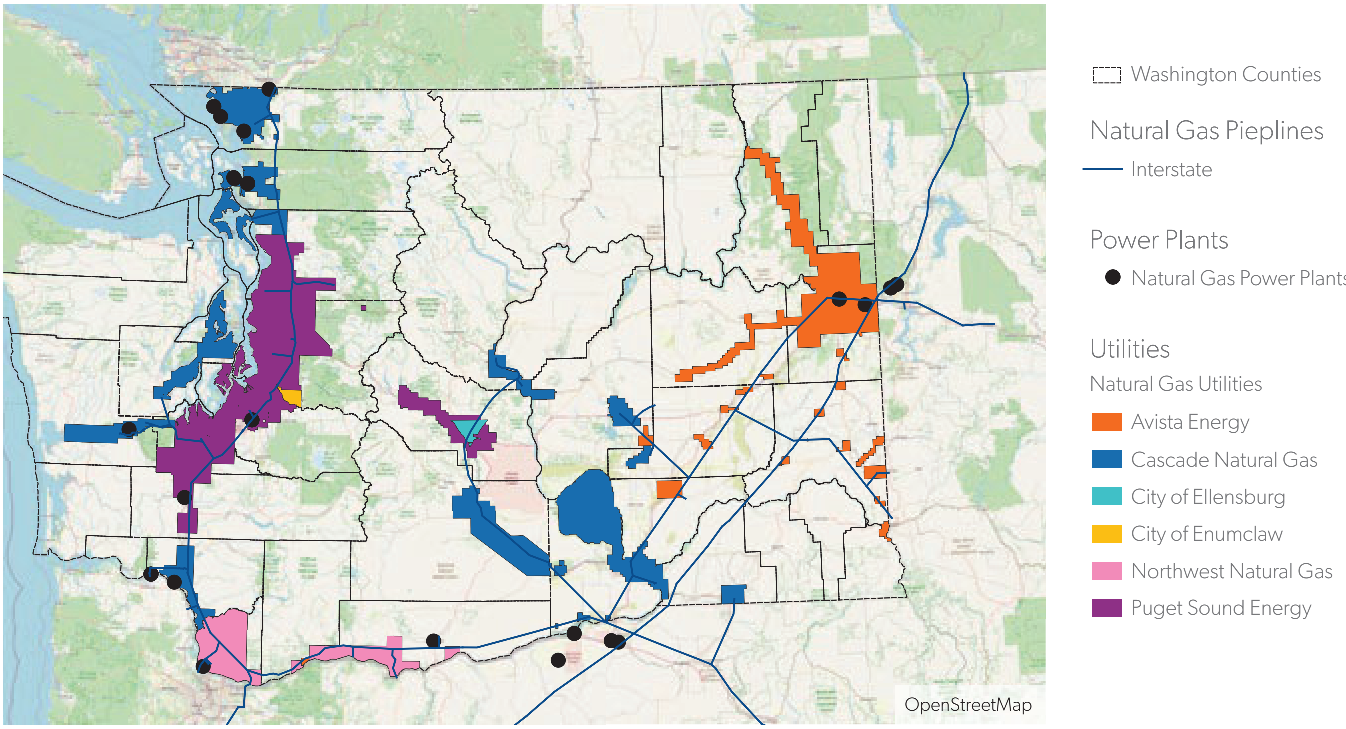

Figure 17. Natural gas utility service areas, interstate pipelines, and natural gas power plants in Washington state. Source: Washington UTC.

In 2020, natural gas consumption in Washington totaled 255 billion cubic feet (1% of the U.S. total). Washington has less natural gas use per capita than all but four other states and the District of Columbia.[28] Just over one-third of households (34.2%) rely on natural gas to heat their homes in the winter, lower than the nationwide average of 47.6%. The industrial sector accounted for 25% of total natural gas demand in 2019, while the commercial sector accounted for 18%. Compressed natural gas as a transportation fuel accounts for less than 0.1% of natural gas consumption as of 2019.

[28] "Washington - State Energy Profile Analysis - U.S. Energy Information Administration (EIA)," accessed March 28, 2022, https://www.eia.gov/state/analysis.php?sid=WA#114.

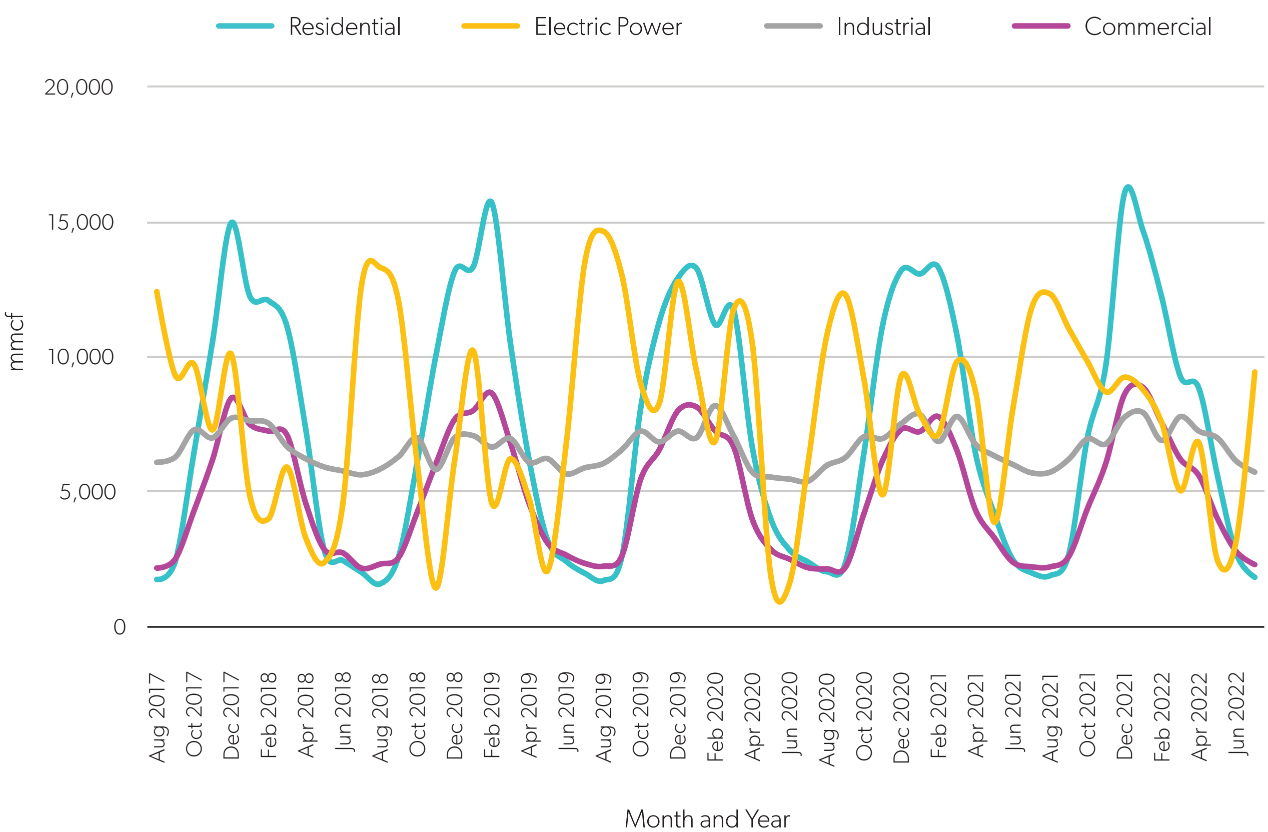

Figure 18. Natural gas delivered to consumers on a monthly basis from mid-2017 through mid-2022. Gas consumption in the residential and commercial sectors peak in the winter months, reflecting its use for space heating. Consumption of natural gas for electric power generation peaks in summer and fall months when hydroelectric power is less frequently available and demand for electricity for space conditioning is higher.

Washington has no natural gas reserves or production facilities. Natural gas largely enters the state from Canada and the Rocky Mountain region, either directly from Canada or through the state of Idaho. More than 9,500 miles of interstate gas pipelines cross the state, mainly along the I-5 Corridor between Canada and the border with Oregon, and in Washington's east and southeast regions. Only one-third of natural gas that enters into Washington stays in the state; almost two-thirds continue south to Oregon and California. Thirty-six pipeline operators maintain over 45,000 miles of pipelines and distribution lines carrying natural gas, gasoline, and jet fuel, including interstate pipelines operating at very high pressure. Natural gas is also stored underground at the Jackson Prairie Gas Storage Facility in western Washington, which has a total storage capacity of 47 billion cubic feet.

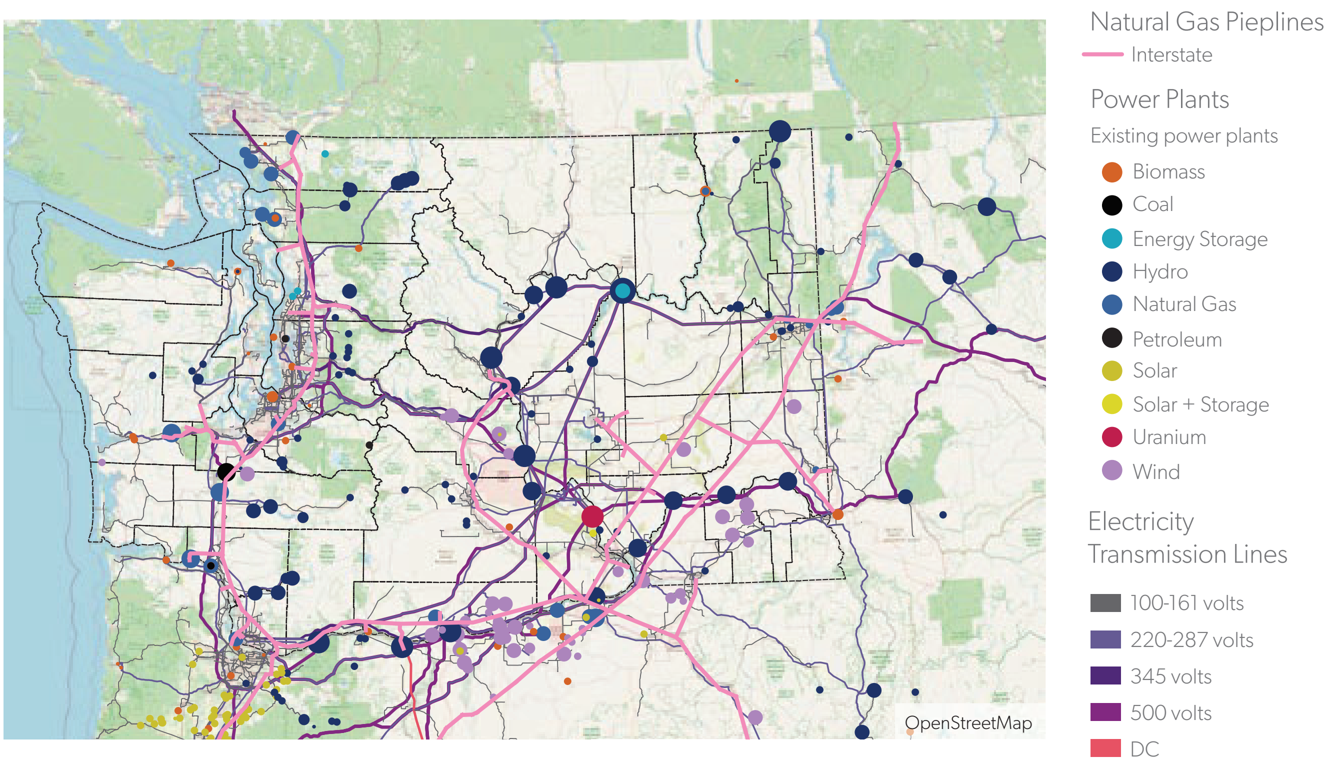

Figure 19. Key components of Washington's interconnected electricity and natural gas systems, including existing power plants, transmission lines, and interstate natural gas pipelines. Source: NWPCC.

4

Policy Context and Trends

4 | Policy Context and Trends

Washington's overall energy demand is projected to increase in the long-term because of population and economic growth, which will influence where people live, what they do for work, and how they move around.

4.1 Social and Economic Shifts

4.1.1 Population Growth and Demographics

Washington's population is one of the fastest-growing in the United States. According to the U.S. Census, Washington had the sixth highest population growth rate in the United States between 2015 and 2020. According to the Washington Office of Financial Management, Washington's population is projected to increase to 9.8 million by 2050, up from 7.8 million in 2020. Over the past decade, growth has been concentrated in the five largest metropolitan counties (Clark, King, Pierce, Snohomish, and Spokane).

Washington's economy is also projected to grow in the coming decades. Migration from other states and countries is likely to continue to drive growth, and urban, western counties will grow at higher rates than others.[29] Climate-related migration from other states with more extreme climate hazards could also increase.[30]

Population growth is driving housing growth, which has been on the rise since 2012. In 2021, housing growth increased by 2.3% relative to 2020. Just over half of this growth is in multi-family buildings. Washington is projected to need to add more than 50,000 additional units of housing annually to keep up with expected population growth.[31]

The majority of the population is White (67.5%), followed by Hispanic or Latino (13.0%), Asian (9.6%), individuals with two or more races (4.9%), and Black or African American (4.4%). Those with American Indian and Alaskan Native descent and Native Hawaiian or other Pacific Islander descent make up less than 3% of the population (1.9% and 0.8%, respectively).[32]

[29] Office of Financial Management, Forecasting and Research Division, "2021 Population Trends" (State of Washington, March 2022), https://www.ofm.wa.gov/sites/default/files/public/dataresearch/pop/april1/ofm_april1_poptrends.pdf.

[30] "Climate-Related Migration to the Pacific Northwest," Climate Impacts Group, accessed November 11, 2023, https://cig.uw.edu/projects/climate-related-migration-to-the-pacific-northwest/.

[31] Washington State Department of Commerce, March 2, 2023, Washington State will need more than 1 million homes in the next 20 years [press release], https://www.commerce.wa.gov/news/washington-state-will-need-more-than-1-million-homes-in-next-20-years/

[32] U.S. Census Bureau (2022). U.S. Census Bureau QuickFacts: Washington. https://www.census.gov/quickfacts/WA

4.1.2 Economic and Employment Trends

Washington had a gross domestic product of $677 billion in 2021, up 6.7% from 2020.[33] GDP is projected to continue growing over the next five years.[34] Additionally, the number of non-agricultural jobs is projected to increase to 4.2 million by 2050 — an increase of 35% relative to 2020.[35]

Key economic sectors in Washington include aerospace, agriculture and food manufacturing, clean technology, forest products, information and communications technology, life science/global health, maritime, and military and defense.[36] Many of these key sectors rely on natural resources that will be negatively affected by climate change. Additionally, all sectors, particularly energy intensive ones, such as forest products and aerospace, will be affected by decarbonization actions.

The pandemic significantly increased the number of people working from home, causing weekday residential electricity use to increase 20-30% in some parts of the country. In Washington, 6.5% of residents worked at home in 2019, but that percentage rose to nearly 21% in 2020.[37] The economic and social effects of the pandemic, such as increased prevalence of working from home and suburban growth, may become permanent; as of February 2022, nearly 60% of workers in the US with jobs that can be done from home reported working from home all or most of the time due to preference.[38] These trends could drive increased energy use at residences (as compared to commercial office buildings) and in urbanized areas, while some rural areas may see some increased energy demand due to growth in sectors like data centers and warehousing. However, people who are able to work remotely represent less than half (40%) of all employed adults, limiting the extent of this effect.[39]

Many of Washington's biggest employers have adopted ambitious sustainability and climate goals, supported recent climate legislation, and are actively investing in renewable electricity, alternative fuels, and carbon capture technologies. These actions may help to accelerate research and development to support the state's decarbonization goals. Decarbonization of existing heavy industry will reshape local economies, as broad changes to production systems, infrastructure, and the introduction of new technologies are all expected.

[33] U.S. Bureau of Economic Analysis, "GDP in current dollars (SAGDP1,)" https://apps.bea.gov/iTable/iTable.cfm?reqid=70&step=1&isuri=1&acrdn=1#reqid=70&step=1&isuri=1&acrdn=1n (accessed March 2022).

[34] Washington State Economic and Revenue Forecast Council, March 2023 Preliminary Forecast, https://erfc.wa.gov/sites/default/files/public/documents/forecasts/p0223.pdf

[35] Office of Financial Management, "Long-term economic forecast" [data set], accessed March 3, 2023, https://ofm.wa.gov/washington-data-research/economy-and-labor-force/long-term-economic-forecast

[36] "Key Industries in Washington State," Washington State Department of Commerce, accessed March 27, 2022, https://www.commerce.wa.gov/growing-the-economy/key-sectors/.

[37] United States. Department of Transportation. Bureau of Transportation Statistics, "State Transportation Statistics (STS)," 2019, https://doi.org/10.21949/1503664.

[38] Kim Parker Minkin Juliana Menasce Horowitz and Rachel, "COVID-19 Pandemic Continues To Reshape Work in America," Pew Research Center's Social & Demographic Trends Project (blog), February 16, 2022, https://www.pewresearch.org/social-trends/2022/02/16/covid-19-pandemic-continues-to-reshape-work-in-america/.

[39] Kim Parker Minkin Juliana Menasce Horowitz and Rachel, "COVID-19 Pandemic Continues To Reshape Work in America," Pew Research Center's Social & Demographic Trends Project (blog), February 16, 2022, https://www.pewresearch.org/social-trends/2022/02/16/covid-19-pandemic-continues-to-reshape-work-in-america/.

4.1.3 Climate Change Impacts and Policies

Climate change is and will continue to affect all aspects of the state's energy system, influencing everything from how much Washingtonians heat and cool their buildings to the availability of water for generating electricity, to stresses on transmission lines and distribution infrastructure.

4.1.3.1 Extreme Weather

The Pacific Northwest has warmed nearly 2°F since 1900, with serious implications for the state's economy, infrastructure, and public health. Warmer winters have reduced mountain snowpack and increased wildfire risk. Warmer coastal waters, rivers, and streams, as well as ocean acidification, pose challenges for the marine ecosystem, which can further impact the availability of hydroelectricity.

By 2065, annual precipitation is projected to increase by 2 to 9% depending on the region, with the most significant changes expected in central Washington and along the Juan de Fuca strait, according to a business-as-usual analysis by the Washington Department of Health.[40] Precipitation levels are primarily driven by year-to-year variations, rather than long-term trends; however, heavy rainfall is projected to become more frequent and severe.[41] The number of days in the Pacific Northwest with over one inch of rainfall annually could increase by 13 or more.[42] Such extreme weather events can cause trees to damage transmission and distribution infrastructure, and reduce solar panel output for days at a time, impacting electricity supply.

Additionally, as a result of variations in El Niño, Washington is expected to experience prolonged droughts alternating with periods of heavy rainfall. Extreme weather events, including heat waves, wildfires, severe storms, floods, and droughts, are projected to increase in frequency and intensity.

Since 2019, the Washington State legislature has passed a suite of bills pertaining to climate change, energy efficiency, and utilities regulation. As a result, Washington State currently has some of the most ambitious energy and emissions goals in the United States.

4.1.4 Greenhouse Gas Emission Limits

In 2020, the Washington State Legislature passed Greenhouse Gas Emission Limits – HB 2311 (Chapter 79, Laws of 2020), which updated targets to reduce the state's greenhouse gas emissions.

Under the new law, Washington's overall emissions must be reduced to:

- 45% below 1990 levels by 2030,
- 70% below 1990 levels by 2040, and
- 95% below 1990 levels (and achieve net zero emissions) by 2050.

[40] Washington Tracking Network, Washington Department of Health. Web. "Change In Average Annual Precipitation". Data obtained from Phase 5 of the Coupled Model Inter-comparison Project (CMIP5). Published: December 15, 2020.

[41] University of Washington Climate Impacts Group. "Climate Change." n.d. Retrieved March 2023 from https://cig.uw.edu/learn/climate-change/

[42] Ibid.

Emissions in 2019 were 102.1 million metric tons of carbon dioxide equivalent (CO_2e), higher than the 93.5 million metric tons of GHGs emitted in 1990.[43] To achieve its interim goal, Washington must nearly cut its emissions in half by 2030. Achieving the 2050 target "will require all sectors of the economy to reduce emissions at a rapid pace," according to the Washington State Energy Strategy.

The Legislature passed bills in the 2019-2020 and 2020-2021 legislative sessions that define a policy context for reducing emissions in the state's electricity and natural gas sectors. These laws incentivize and require carbon-free electricity; increase distributed energy and net metering opportunities; encourage the exploration of alternative energy sources such as renewable natural gas; address gas system and pipeline leaks; and provide consumers with information about the emissions associated with their electricity.

4.1.4.1 Climate Commitment Act

The Climate Commitment Act, Chapter 316, Laws of 2021 (SB 5126) establishes a statewide emissions cap-and-invest program, administered by the Washington Department of Ecology, that aims to reduce the state's GHG emissions to net zero by 2050. The Act applies to organizations that produce 25,000 metric tons of carbon dioxide emissions per year, as well as electric and natural gas utilities. Utilities and "emissions intensive, trade-exposed" entities will receive free allowances at the beginning of the program. The emissions cap will decrease over time, meaning fewer allowances will be available for purchase or trading. Proceeds from auctioning the allowances will be used to advance the transition to clean energy, clean transportation, and climate resiliency, with a focus on equity.

4.1.4.2 Clean Energy Transformation Act

Washington's Clean Energy Transformation Act (CETA) requires at least 80% of electricity consumed in Washington to come from renewable or non-emitting sources by 2030, while allowing the remaining supply to be carbon-neutral via offsets or other compliance mechanisms. By 2045, CETA mandates that all electricity consumed in Washington must come from clean energy sources.

CETA requires Washington's investor-owned electric utilities to develop short- and long-term strategies for meeting these targets. Clean Energy Action Plans are 10-year plans to meet customer needs filed at the same time as Integrated Resource Plans, while Clean Energy Implementation Plans are 4-year roadmaps for how each electric utility plans to acquire energy for its customers. Each investor-owned electric utility has committed to reaching the CETA targets of 100% clean electricity by 2045, with interim targets varying (Table 3, next page).

[43] "GHG Inventories - Washington State Department of Ecology," accessed November 11, 2023, https://ecology.wa.gov/Air-Climate/Reducing-Greenhouse-Gas-Emissions/Tracking-greenhouse-gases/GHG-inventories.

Table 3. Clean energy targets for each of Washington's three investor-owned utilities, according to their Clean Energy Implementation Plans. IOUs are permitted to use renewable energy credits (RECs) and other alternative compliance methods to meet up to 20% of their clean energy targets between 2030 and 2045.

Utility	2020 Actual	2025 Target	2030 Target	2040 Target
Avista Utilities	45.3%	85%	100%	100%
Pacificorp	21.9%	50%	81%	94%
Puget Sound Energy	34%	63%	80%	97%

4.1.4.3 Federal Clean Electricity Policy

Policies at the federal level are also driving decarbonization. The Infrastructure Investment and Jobs Act (IIJA), also referred to as the Bipartisan Infrastructure Law (BIL) and the Inflation Reduction Act (IRA) passed in 2021 and 2022, respectively, aim to reduce greenhouse gas emissions in electricity generation, transportation, buildings, and infrastructure. Many programs enabled by these laws will distribute funding on a state allocation basis and through state agencies. While the rules and funding allocations are still in development for many of the programs, they are likely to significantly contribute to efforts aimed at achieving Washington's decarbonization targets.

The IIJA includes investments and policies aimed at rebuilding and modernizing infrastructure across the U.S. as well as addressing climate change. More than half a billion dollars are included in new federal infrastructure funding over five years to repair and rebuild infrastructure, as well as support zero-emissions transportation (school buses, EV charging, railways, etc.) and improvements to the power grid and broadband internet. The new Transmission Facilitation Program includes $2.5 billion in competitive loans and public/private partnerships for high-capacity and interregional transmission lines, which are expected to connect new and existing clean energy generation to electricity customers. Three billion is included in the bill for the Smart Grid Investment Grant Matching Program, which supports the development of advanced technologies to improve the efficiency and resilience of high capacity transmission networks. Three hundred million dollars are allocated to the DOE's new Office of Clean Energy Demonstration for grant funding to support pilot projects in energy storage, advanced reactors, carbon capture technologies, and direct air capture technologies.

The IRA is the largest investment in climate action made by the U.S. government to date. The legislation provides nearly $400 billion in funding and tax credits for projects that reduce emissions and build community resilience to climate change. More than half the funding is dedicated to clean energy supply, with the majority of funding available in the form of tax credits to businesses. Utilities, private developers of utility-scale generating facilities, state and local governments, Tribal governments, electric cooperatives, non-profits, and individuals seeking to develop and use renewable energy projects are all eligible for various incentives outlined in the IRA. Bonus incentives are included to spur development of renewable energy in low-income communities, communities at economic frontlines of the energy transition, and rural communities. Many of the programs are technology-neutral, enabling flexible applicability and uptake across varying jurisdictions.

Table 4. Overview of clean energy tax credits and grant and loan assistance programs supporting clean energy generation in the Inflation Reduction Act.

Category	Program names	Description	Eligible entities
Clean Energy Tax Credits	Investment Tax Credit	Dollar-for-dollar credits to offset expenses for investments in renewable energy projects	Project developers, state, local, Tribes, utilities, co-ops, tax-exempt entities
	Domestic Content Bonus Credit	Bonus investment tax credit and/or production tax credit for projects using steel and iron made in US	
	Energy Communities Bonus Tax Credit	Bonus investment tax credit and/or production tax credit for facilities developed on brownfield sites or in communities with previously high levels of employment related to coal, oil, or gas	
	Low-Income Communities Bonus Credit	Bonus investment tax credit for the development of wind and solar projects with a maximum net output of less than 5 MW in low-income communities or on Indian land and are part of a qualified low-income residential building project	
	Clean Hydrogen Credit	Credit for producing hydrogen where lifecycle GHG emissions are less than 4 kg per kg of hydrogen	Owner of qualified clean hydrogen production facility
	Production Tax Credit	Rebate per kilowatt-hour of power produced from clean energy (solar, offshore and onshore wind, and geothermal)	Utilities, co-ops, state, local, tribes, tax-exempt entities
Rural Energy Investments	USDA Assistance for Rural Electric Cooperatives	Grants and loans for electric co-ops to purchase renewable energy systems, deploy such systems, or make energy efficiency improvements, and for debt relief associated with terminating the use of non-renewable energy facilities	Rural co-op with certain threshold of customer base
	USDA Electric Loans for Rural Renewable Energy	Loans to support generation of renewable energy (wind, solar, geothermal) for resale to rural and nonrural residences	Developers, local, state, Tribes, co-ops, non-profits
	USDA Rural Energy for America Program	Grants to support deployment of renewable energy for rural businesses and agricultural producers	Rural businesses and agricultural producers

In combination, these laws will stimulate unprecedented investments by Washington's publicly and privately owned utilities, businesses, local governments, and individual residents in renewable energy and related actions to reduce GHGs.

4.1.5 Buildings and Energy Efficiency

Buildings are the second largest source of greenhouse gas emissions in Washington, representing one-fifth of the state's total annual emissions in 2018.[44] Improving energy efficiency and energy conservation in buildings has been an important cost-saving measure required of Washington's utilities for decades, and will be a key factor in achieving the state's net-zero emission targets by 2050.

4.1.5.1 Energy Efficiency

Energy conservation has long been, and will continue to be, a key component of regional energy planning and utility resource planning.[45] According to the International Energy Agency, energy efficiency is the enabling factor that will allow communities to reach targets of net-zero emissions by 2050 even if global populations and economies continue to grow. Better insulated buildings, which retain heat in the winter and stay cooler in the summer, reduce heating and air conditioning use, which, in turn, reduces energy demand. Each kWh of electricity saved through efficiency is a kWh that need not be generated, transmitted, or distributed. Utilities often find it is cost-effective to conserve energy and lower system demand, compared to building additional power generation and distribution infrastructure or purchasing energy resources. The Clean Energy Transformation Act (CETA) requires that utilities, as a first priority, pursue all cost-effective, reliable, and feasible conservation and efficiency resources to reduce or manage retail electric load.

Energy efficiency initiatives have contributed to significant reductions in energy use in buildings in the US. For example, appliance energy efficiency standards and labeling programs in the U.S. led to annual fuel savings of around $40 billion in 2020, equivalent to a reduction of $320 in the average household's annual fuel bill.[46] However, energy efficiency policies can sometimes unintentionally incentivize more total energy consumption, known as the rebound effect. For example, research suggests that as U.S. homes have gotten more energy efficient, they have also gotten bigger and contain more large appliances, a phenomenon which can cancel out the decrease in energy demand created by energy efficiency.[47] Consequently, reducing overall energy consumption prior to upgrading appliances or fuel switching is critical. Modeling conducted for the 2021 Washington State Energy Strategy suggests that building electrification and efficiency measures could drive a 13-26% reduction in final energy demand, depending on the amount of natural gas that continues to be used in buildings.[48]

The Northwest Power and Conservation Council prioritizes energy efficiency, recognizing

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[44] "WA 2021 State Energy Strategy," Washington State Department of Commerce, accessed February 11, 2022, https://www.commerce.wa.gov/growing-the-economy/energy/2021-state-energy-strategy/.

[45] While energy efficiency suffered a major setback during the COVID-19 pandemic, improving only marginally compared to prior years, since 2021 governments at all levels have renewed their focus on efficiency opportunities.

[46] Keisuke Sadamori and Brian Motherway, "Energy Efficiency 2021" (International Energy Agency, 2021).

[47] Lazarus Adua, Brett Clark, and Richard York, "The Ineffectiveness of Efficiency: The Paradoxical Effects of State Policy on Energy Consumption in the United States," Energy Research & Social Science 71 (January 1, 2021): 101806, https://doi.org/10.1016/j.erss.2020.101806.

[48] Evolved Energy Research, "Washington State Energy Strategy Decarbonization Modeling Final Report Presentation," https://www.commerce.wa.gov/wp-content/uploads/2020/12/Appendix-A.-WA-SES-EER-DDP-Modeling-Final-Report- 12-11-2020.pdf.

it as the region's second-largest "power resource" after hydropower. Since 1978, utilities, governments, and other groups have invested hundreds of millions of dollars in incentive programs, market transformation initiatives, building stock assessment, and improved technologies, achieving more than 7,200 average MW of energy savings in the Pacific Northwest — equivalent to the annual energy consumption of approximately 5.1 million homes. In the latest Power Plan, the Council identifies the need for the region (which includes Washington, Oregon, Idaho, and Montana) to acquire between 750 and 1,000 average MW of energy efficiency by 2027 and at least 2,400 average MW of energy efficiency by the end of 2041.[49]

4.1.5.2 Impacts of Climate Change

Climate change will influence building energy demand. Heating degree days — or days on which there is a demand for space heating — will decrease significantly across the state.[50] This level of change varies regionally.[51] Total heating energy demand is expected to increase due to population growth, while per capita heating demand is expected to decrease.[52]

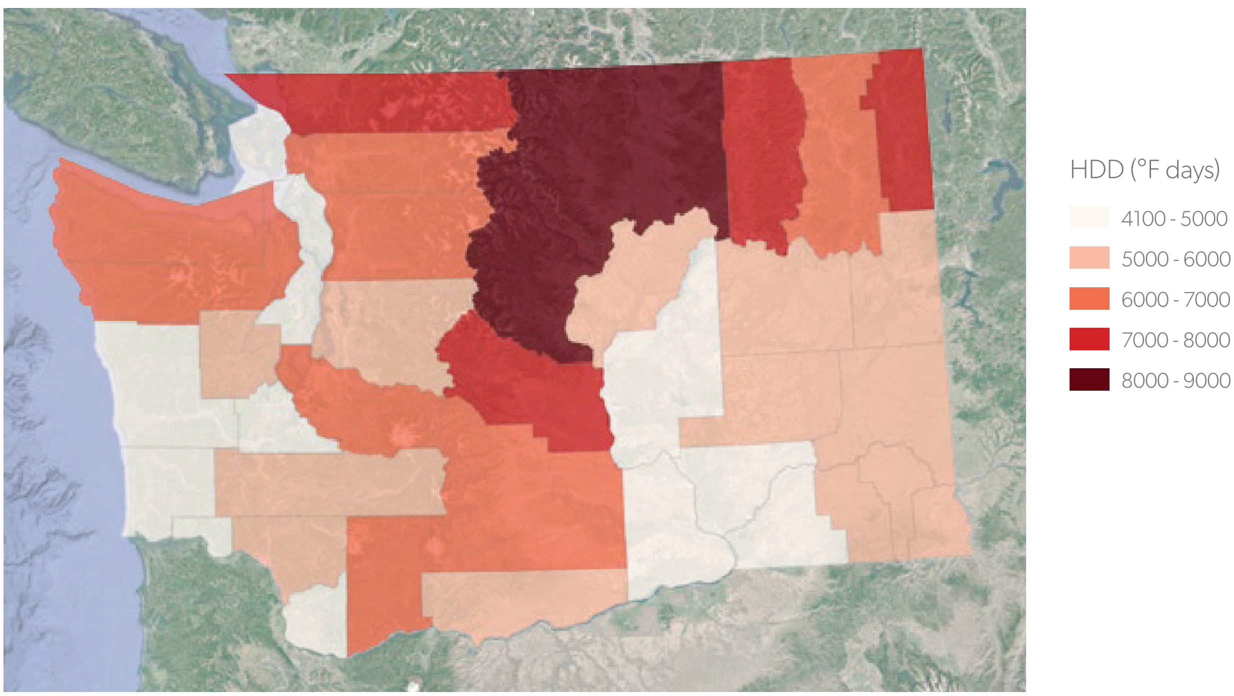

Figure 20. Heating degree day projections by county for 2050. Source: The Climate Explorer.

[49] Northwest Power and Conservation Council, "The 2021 Northwest Power Council Plan," March 10, 2022, https://www.nwcouncil.org/media/filer_public/4b/68/4b681860-f663-4728-987e-7f02cd09ef9c/2021powerplan_202 2-3.pdf.

[50] Degree days are defined as the difference in degrees between the daily temperature mean (the high temperature plus the low temperature divided in half) and 65∘F. For example, if the high temperature for a particular day was 33∘F and the low temperature was 25∘F, the mean temperature was 29∘F. The difference between the mean (29∘F) and 65∘F is 36 heating degree days. Another example: if the high temperature for a day was 90∘F and the low temperature was 66∘F, the mean temperature was 78∘F. The difference between 78∘F and 65∘F is 13 cooling degree days.

[51] Ibid.

[52] Hamlet, A.F., Lee, SY., Mickelson, K.E.B. et al. Effects of projected climate change on energy supply and demand in the Pacific Northwest and Washington State. Climatic Change 102, 103–128 (2010). https://doi.org/10.1007/s10584-010-9857-y

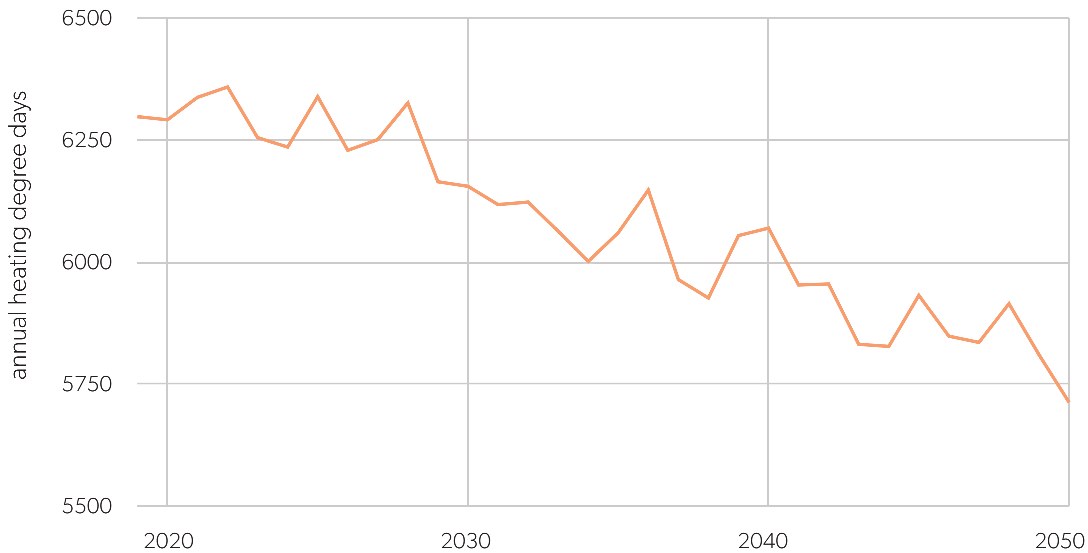

Figure 21. Annual heating degree days trends for the state from 2020 to 2050.

Warming temperatures are projected to significantly increase energy demand for space cooling (i.e., air conditioning). As temperatures warm, Washington will see an increase in cooling degree days — days on which there is a demand for space cooling. The increase in cooling demand will vary across the state, with the greatest increase in eastern Washington.[53]

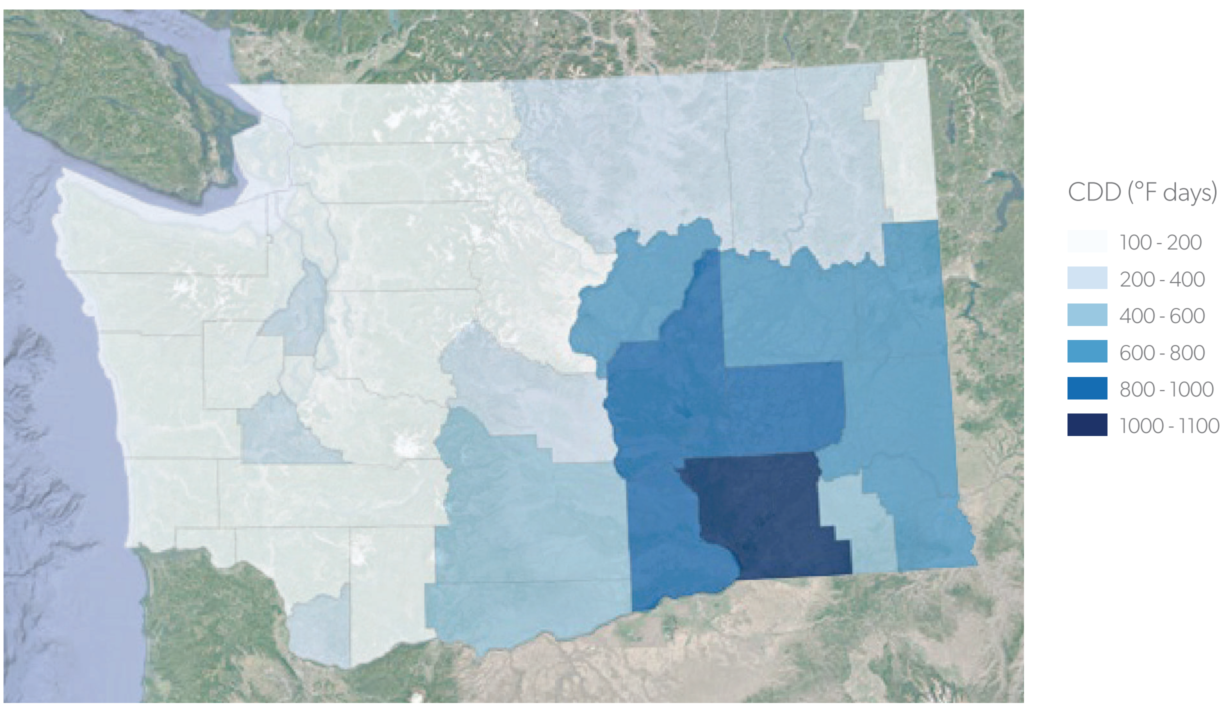

Figure 22. Cooling degree day projections by county for 2050. Source: The Climate Explorer.

[53] Washington Tracking Network, Washington Department of Health. Web. "Change In Average Daily Temperature Deviation From 65 Degree Fahrenheit (Heating Degree Day)." Data obtained from Phase 5 of the Coupled Model Inter-comparison Project (CMIP5). Published: December 15, 2020.

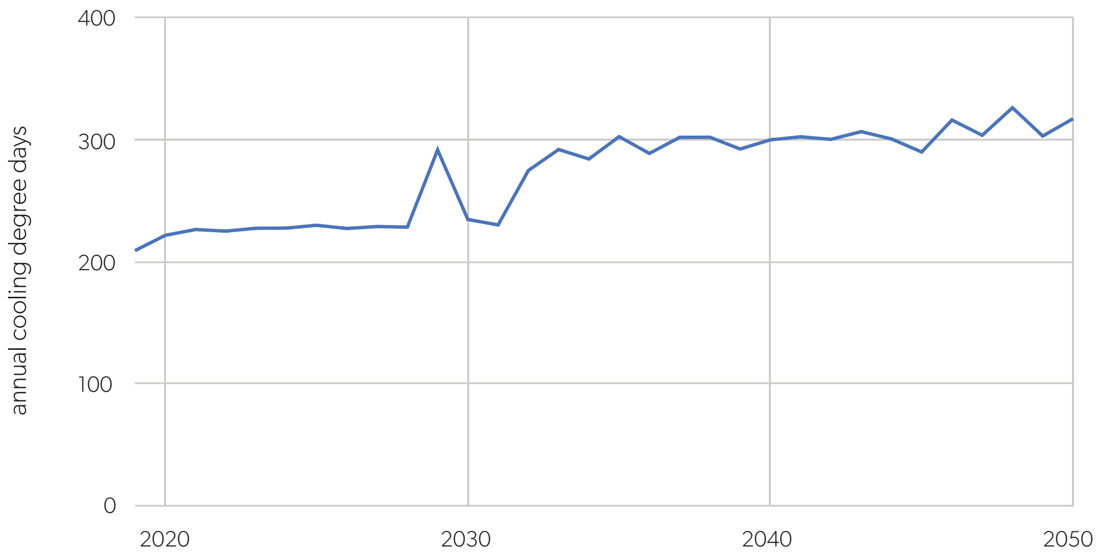

Figure 23. Annual cooling degree day trends for the state from 2020 to 2050. Source: The Climate Explorer.

4.1.5.3 Codes and Standards

In the coming decades, buildings in Washington are on track to become more energy efficient and electrified.[54] Codes and standards at all levels of government are driving increased energy efficiency and conservation in building operations for new construction and existing buildings. However, the implementation of these codes and standards is not guaranteed, as evidenced by the invalidation of similar legislation due to lawsuits in other states within the same federal district court circuit as Washington.

In 2019, the City of Berkeley, California passed an ordinance prohibiting natural gas infrastructure in newly-constructed buildings, effectively requiring all-electric construction in new buildings. Following the passage of the ordinance, the California Restaurant Association brought suit against the city, claiming that the ordinance was preempted by the federal Energy Policy & Conservation Act which limits the ability of state and local governments from setting standards "concerning the energy efficiency, energy use, or water use" of products regulated by the EPCA. In 2021, the District Court ruled against the suit, rejecting the premise that the EPCA preempts local ordinances that do "not facially address any of those standards." The claimants appealed, and on April 17 2023, the U.S. Court of Appeals for the Ninth Circuit overturned the 2021 District Court ruling, citing an interpretation of a broader scope of the EPCA. This ruling affects all states within the Ninth Circuit, which includes Washington as well as ten other western states and territories.[55]

The City of Berkeley petitioned for a rehearing, and on June 12, 2023, the US Department of Energy and the US Department of Justice submitted an amicus brief in support of the City's petition. The federal administration argued that the three-judge panel made "significant errors" in its interpretation of federal law, and that the 9th Circuit should grant a rehearing to "correct a panel opinion that destabilizes the long-settled understanding shared by the Department,

[54] "Chapter 19.27A RCW: ENERGY-RELATED BUILDING STANDARDS," accessed March 1, 2023, https://app.leg.wa.gov/rcw/default.aspx?cite=19.27A.

[55] Alaska, Arizona, California, Hawaii, Idaho, Montana, Nevada, Oregon, Guam, and the Northern Mariana Islands.

the States, municipalities, and the courts over the allocation of regulatory authority in this area; threatens to preempt broad swaths of State and local health and safety law; and throws a wrench into the federal government's administration of the [Energy Policy and Conservation] Act."[56] The case is currently pending.

Enabled by the Ninth Circuit court ruling, on May 23 2023, a coalition of Washington-based natural gas utilities, construction companies, and trade organizations filed a lawsuit against the Washington State Building Codes Council over its most recent code changes, aiming to block the updated construction codes from coming into effect.[57] On May 24, the SBCC took action to adjust the codes to become a performance standard approach, using an efficiency benchmark, and postponed the start date from July 1 to October 29 2023. On July 18 2023, Chief Judge Stanley Bastian of the Eastern Washington U.S. District Court turned down the request from the coalition of plaintiffs, saying that further delays to updating statewide building codes could have a "chilling effect" on other states and local communities attempting to pass similar new laws or regulations.[58] On August 3, the legal challenge was voluntarily dropped by the plaintiffs, enabling the continuation of the SBCC's recent code changes to improve building energy efficiency and reduce natural gas emissions.[59]

Table 5. Building and energy efficiency codes and standards relevant to natural gas utility decarbonization in Washington.

Code, Standard, or Law	Impacts on Building Decarbonization
Initiative I-937 (2006)	Requires electric utilities serving more than 25,000 customers to undertake conservation and efficiency planning, including setting conservation targets, and take action to meet these targets.
RCW 19.27A.160, implementation of Section 5 of Climate Pollution Reduction - Energy Efficiency (Chapter 423, Laws of 2009, SB5854)	Requires the State Energy Code to achieve a 70% reduction in annual net energy consumption by 2031 compared to a 2006 code baseline.
2021 Washington State Energy Code – Commercial	Requires new construction of commercial and large multi-family buildings beginning in mid-2023 to use all-electric air-source heat pumps for space heating and at least 50% of water heating. Requires all new commercial buildings over 10,000 square feet to deploy on-site renewable energy

[56] In the United States Court of Appeals for the Ninth Circuit, "Brief for the United States as Amicus Curiae in Support of Petition for Rehearing," June 2023, https://subscriber.politicopro.com/f/?id=00000188-b0c0-dc96-a39f-b9ea1d480000.

[57] Jamon Rivera et al., Complaint for Declaratory and Injunctive Relief, No. 1:23-cv-03070, accessed November 12, 2023.

[58] "Judge Denies Request to Halt WA Building Code Change That Favors Heat Pumps over Gas | Local | Yakimaherald.Com," accessed November 12, 2023, https://www.yakimaherald.com/news/local/judge-denies-request-to-halt-wa-building-code-change-that-favors-heat-pumps-over-gas/article_1563b36e-25c3-11ee-bbc4-e3c340cd5cad.html.

[59] Megan H Berge, Thomas Jackson, and Scott Novak, PLAINTIFFS' NOTICE OF VOLUNTARY DISMISSAL WITHOUT PREJUDICE, No. No. 1:23-cv-03070-SAB (UNITED STATES DISTRICT COURT FOR THE EASTERN DISTRICT OF WASHINGTON August 3, 2023).

Code, Standard, or Law	Impacts on Building Decarbonization
2021 Washington State Energy Code - Residential	Reduces space and water heating energy use in new residential construction beginning in mid-2023 by requiring the use of heat pumps as the primary space and water heating source as well as improved thermal performance compared to previous codes.
Clean Buildings for Washington Act (Chapter 285, Laws 2019, HB 1257)	Requires commercial buildings larger than 50,000 square feet to reduce energy use and meet energy use intensity (EUI) benchmarks; this is a phased program with compliance beginning in 2026. Buildings 20,000 square feet to 50,000 square feet will have to meet standards beginning in 2031. Requires gas utilities to establish two-year conservation targets that represent the total reductions in energy demand they intend to pursue via efficiency programs and incentives.
Updates to existing appliance standards[60]	Reduces energy use from plug use in commercial and residential buildings.
Commercial Property Clean Energy and Resiliency Financing - Chapter 27, Laws of 2020 (HB 2405)	Allows the Department of Commerce and Washington counties to establish voluntary C-PACE programs that allow property owners to finance up-front the cost of energy and efficiency improvements.
Urban Heat Island Effects - Utility Mitigation - Chapter 11, Laws of 2021 (HB 1114)	Requires the UTC to consider and adopt a policy allowing an incentive rate of return on investment in investor-owned utilities' tree planting and cool-roof programs to improve the efficiency of buildings.
Inflation Reduction Act	Provides tax credits to encourage homeowners to improve energy efficiency and decarbonize their residences, including: • Residential Clean Energy Tax Credit: 30% tax credit on clean energy systems such as solar panels, batteries, and associated installation costs • Energy Efficient Home Improvement Tax Credit: 30% tax credit for adding insulation, more efficient windows, and electric appliances, including heat pumps, as well as home energy audits • Home Owner Managing Energy Savings (HOMES) Rebate Program: provides cash rebates for weatherization renovations (adding insulation, etc.) and installing more efficient appliances. • High-Efficiency Electric Home Rebate: Provides low- to medium-income families as much as $14,000 per year in point-of-sale discounts for electrification projects, such as heat pumps, electric stoves, and insulation.

60 "Appliance Standards," Washington State Department of Commerce, accessed August 26, 2022, https://www.commerce.wa.gov/growing-the-economy/energy/appliances/.

4.1.5.4 Utility Incentive Programs

Utilities and their partners offer incentives for customers to purchase equipment and retrofit buildings to use less energy. According to the Northwest Power and Conservation Council, utility conservation and incentive programs have enabled over half of energy savings in the Pacific Northwest region since 1978 (Washington, Oregon, Montana, and Idaho), which totaled 7,200 average MW. The remaining energy savings have been due to codes, standards, and reduced industrial demand. These savings are equal to half the region's growth in consumption of electricity over the same time period, or enough electricity for Seattle for five years.

Each investor-owned utility in Washington manages and/or supports programs to increase energy efficiency among residential, commercial, and industrial consumers, as well as for existing buildings and new construction. Utilities offer incentives for customers to purchase new equipment or upgrade existing equipment to newer, higher-efficiency models of electric and gas appliances. Utilities also fund programs and initiatives that support energy efficiency market transformation and weatherizing and/or retrofitting existing buildings, such as those led by the Energy Trust of Oregon, the Northwest Energy Efficiency Alliance, and Washington State University's Community Energy Efficiency Program.

4.1.5.5 Emerging Technologies

Emerging technologies, such as high-efficiency electric heat pumps and smart digital devices, have the potential to improve energy efficiency in buildings. Nationally, heat-pump deployment is up, with heat pumps representing around 40% of heating systems installed in new single-family homes between 2014 and 2020.[61] Heat-pump research, development, and availability are expected to increase dramatically in response to President Biden's June 2022 Memorandum authorizing the use of the Defense Production Act of 1950 to produce electric heat pumps. New electric heat pumps are being developed and manufactured to meet the challenges of colder climates. The Northeast Energy Efficiency Partnership (NEEP) maintains a database of nearly 40,000 Cold Climate Air Source Heat Pump products indicating a wide variety of types to meet various building space conditioning needs.

Upgraded versions of common appliances — such as those for heating and cooling buildings, heating water, dishwashing, cooking, and laundry — as well as devices that allow buildings to optimize power consumption, particularly during times of peak demand, are becoming more widely available and used.[62] Rapid improvements in internet-connected "smart" devices (digitally connected thermostats, rooftop solar PV, batteries, electric vehicle chargers, meters, appliances, plugs, lighting, etc.) can assist in optimizing power consumption in residential and commercial buildings. These devices enable energy efficiency through improved measurement and enhanced control, as well as offering building occupants greater insight and command over their energy use. This information can encourage them to save even more energy.

The use of connected appliances, devices, and sensors has grown by an average of 33% per year worldwide, and is not showing signs of slowing down.[63] In existing, retrofitted buildings, installing devices to enable demand response and flexibility can be a significant infrastructural challenge. Another challenge is ensuring that devices of various types and purposes can operate

[61] Keisuke Sadamori and Brian Motherway, "Energy Efficiency 2021" (International Energy Agency, 2021).

[62] Sadamori and Motherway.

[63] Sadamori and Motherway.

smoothly together to manage flows of power while maintaining cybersecurity and privacy. According to their Clean Energy Implementation Plans, Washington's investor-owned utilities intend to increase their demand-response programs to control energy demand at hourly and annual timescales.

The rate of uptake of building efficiency improvements will depend on the availability of trained workers and adequate materials. Utility energy efficiency programs tend to be easier to implement in urban areas and higher-income households. Cities have more contractors and suppliers, as well as customers, than rural areas. Rural areas also tend to have fewer skilled suppliers, lower-income populations, and more significant energy inefficiency challenges, such as a prevalence of older, less efficient homes. Regardless of geography, lower-income households have fewer resources to invest in energy efficiency than wealthier ones, even though they stand to benefit more from reduced energy bills. Efforts to decrease this divide are limited — only 16% of U.S. electric energy efficiency spending in 2019 included programs specifically aimed at or restricted to low-income households.[64] To address these issues, Washington investor-owned utilities have developed incentive programs specifically aimed at assisting low- and moderate-income households and residents of manufactured housing with improving energy efficiency.

4.1.6 Transportation and Mobility Trends

Historically, an analysis of energy use in transportation would be independent of analysis of electricity and natural gas consumption. However, the electrification of transportation and its implications for the electricity system requires an integrated analysis.

The transportation sector uses about four-fifths of all petroleum consumed in Washington, and gasoline for motor vehicles accounts for more than two-fifths of this consumption. According to the State Energy Strategy, to achieve the state's emission reduction limits, going forward vehicles will need to be powered by renewable fuels, such as electricity, biofuels, and hydrogen. Communities across the state will also need to take action to reduce vehicle miles traveled and increase transit, cycling, and walking.

Trends indicate that mobility is expected to dramatically transform in the coming decades, with rapid and ongoing changes in fuel, mode, and mechanism. The dominant trend is electrification of public transit and private vehicles. This is expected to result in an increase in electricity demand. Fewer people are using public transit compared to before the pandemic, but more people are using alternative modes such as cycling, electric scooters, and ridesharing. Many of these trends are unfolding inequitably, as high-income, urban, white households are the primary beneficiaries.[65]

[64] "2020 State of the Efficiency Program Industry," CEE Annual Industry Report (Ferncroft Corporate Center 35 Village Road Middleton, MA 01949: Consortium for Energy Efficiency, September 2021), https://cee1.org/sites/default/files/2021-09/2020_AIR_Final.pdf.,

[65] Jingjing Jiang, "More Americans Are Using Ride-Hailing Apps," Pew Research Center (blog), accessed June 7, 2022, https://www.pewresearch.org/fact-tank/2019/01/04/more-americans-are-using-ride-hailing-apps/.

4.1.6.1 Public Transit, Active Transportation, and Shared Mobility

Supported by federal and state-level policies and funding programs, public transit fleets are rapidly electrifying across the United States, particularly in western states such as Washington and California.[66] In addition to being driven by GHG reduction mandates, many transit agencies find that electric buses are usually more cost-effective than diesel buses over their lifetime, especially in states like Washington with low electricity rates.[67]

Fewer people are riding public transit now than before the COVID19 pandemic, a trend that may continue for many years.[68] Transit shutdowns during the early period of the pandemic caused many to use alternative modes of getting around, including active transportation and private vehicles, particularly in urban areas.[69] Many avoided the crowded, enclosed environment of public transit due to fears of COVID-19, a trend which may continue as the possibility of future pandemics continues to represent a real threat.[70]

The pandemic also sparked a shift away from car dominance in the core of many cities, as governments sought to increase opportunities for social distancing while promoting economic activity such as shopping and dining.[71] Cities such as Seattle took measures like creating

pop-up bike lanes, expanding the bike network, closing streets and intersections to cars, reducing speed limits, and encouraging bike-sharing.[72]

Bikes have exploded in popularity in the U.S. since 2020. Bicycle sales increased nearly 60% between April 2020 and April 2021.[73] In the 2021 regular session, the Washington House of Representatives passed HB 1330, a bill exempting electric bikes and accessories from state sales taxes.[74]

Shared mobility services, which includes ridesharing with strangers (i.e., Uber, Lyft), peer-to-peer car sharing (e.g., driving a stranger's private car or a car from a commonly shared fleet), and shared electric scooters and e-bikes, have similarly become increasingly popular over the past decade.[75] Ride sharing is most popular among higher-income, urban, and suburban Americans. The popularity of these services may be driving down public transit use and significantly increasing per household vehicle miles traveled.[76]

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66 Charles Satterfield et al., "Electrification Assessment of Public Vehicles in Washington" (Atlas Public Policy, National Renewable Energy Laboratory, Washington State University, November 2020), https://leg.wa.gov/JTC/Documents/Studies/Electrification/FinalReport_ElectrificationStudy_Nov2020.pdf.

67 Matt Casale et al., "Electric Buses in America," PIRG, September 30, 2019, https://pirg.org/resources/electric-buses-in-america-2/.

68 "Transit Ridership: Not Expected to Return to Pre-Pandemic Levels This Decade," accessed August 26, 2022, https://www.enotrans.org/article/transit-ridership-not-expected-to-return-to-pre-pandemic-levels-this-d ecade/.

69 Jingqin Gao et al., "The Effects of the COVID-19 Pandemic on Transportation Systems in New York City and Seattle, USA," 2020, 6.

70 Ayyoob Sharifi and Amir Reza Khavarian-Garmsir, "The COVID-19 Pandemic: Impacts on Cities and Major Lessons for Urban Planning, Design, and Management," The Science of the Total Environment 749 (December 20, 2020): 142391, https://doi.org/10.1016/j.scitotenv.2020.142391.

71 Angela Francke, "Cycling during and after the COVID-19 Pandemic," Advances in Transport Policy and Planning 10 (2022): 265–90, https://doi.org/10.1016/bs.atpp.2022.04.011.

72 "Stay Healthy Streets - Transportation | Seattle.Gov," accessed September 2, 2022, https://www.seattle.gov/transportation/projects-and-programs/programs/stay-healthy-streets#Keep%20Moving%20 Streets.

73 Francke, "Cycling during and after the COVID-19 Pandemic."

74 The bill was not passed by the State Senate but was considered by the body again in the 2022 regular session.

75 "Shared Mobility: Where It Stands, Where It's Headed | McKinsey," accessed June 6, 2022, https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/shared-mobility-where-it-stands-wher e-its-headed.

76 Alejandro Henao and Wesley E. Marshall, "The Impact of Ride-Hailing on Vehicle Miles Traveled," Transportation 46, no. 6 (December 1, 2019): 2173–94, https://doi.org/10.1007/s11116-018-9923-2.

4.1.6.2 Electric and Alternative Fuel Vehicles

Demand for personal electric vehicles is projected to continue to increase in the coming years and decades. However, higher demand, coupled with supply chain bottlenecks related to the ongoing effects of the pandemic, caused supply shortages and raised prices, slowing EV adoption in the short term among higher- and lower-income households.[77, 78]

According to the Washington Department of Licensing, EV sales in Washington increased by 40% in 2021 compared to the previous year. As of July 2022, more than 100,000 EVs were registered with Washington's Department of Licensing, representing approximately 1.3% of passenger vehicle registrations. Most of these are battery electric vehicles. These registrations are concentrated in Washington's western and urban counties. King County, where Seattle is located, accounted for more EV registrations than the state's remaining 38 counties combined.

Other alternative fuel vehicles, such as hydrogen fuel cell vehicles, and those powered by biodiesel, ethanol, natural gas, and propane, are nascent consumer technologies in Washington. Infrastructure is not widely available to support them.[79] Currently, all public hydrogen fueling stations for private vehicles in the United States are located in California, with the exception of one station in Hawaii; no hydrogen fuel cell vehicles are registered in Washington. A high-profile example of hydrogen research and development in Washington includes recent trials of a hydrogen ferry vessel in Bellingham, developed with funding from the California Air Resources Board. However, the International Energy Agency predicts that use of hydrogen fuel cells will increase across the transportation sector; many countries, including the US, have recently adopted policies that support hydrogen vehicles for public transit, commercial use, railways, trucking, and aviation.

Washington is part of the West Coast Electric Highway network, a regional effort to extend public electric-vehicle charging stations along Interstate 5 and other important roads in the region. It is also part of the West Coast Green Highway, which is a similar effort stretching along the entire West coast from Canada to Mexico. Washington currently has about 1,600 public electric vehicle charging stations and 3,900 charging points, accounting for 3.4% of the U.S. total.

In recent years, the Washington State Legislature has adopted laws aimed at reducing emissions related to transportation. Laws, policies, and programs supporting transportation decarbonization, including federal laws such as the IRA and IIJA, are summarized in the following table (next page).

77 "Global EV Outlook 2021: Accelerating Ambitions despite the Pandemic" (International Energy Agency, 2021), https://www.iea.org/reports/global-ev-outlook-2022.

78 Phil LeBeau, "EV Battery Costs Could Spike 22% by 2026 as Raw Material Shortages Drag On," CNBC, May 18, 2022, https://www.cnbc.com/2022/05/18/ev-battery-costs-set-to-spike-as-raw-material-shortages-drags-on.html.

79 Washington has two public biodiesel fueling stations, four public compressed natural gas fueling stations, three public ethanol fueling stations, one public liquefied natural gas fueling station, and seventy-four public propane fueling stations. As of 2021, 59,000 biodiesel vehicles, 369,700 ethanol/flex (E85), 600 compressed natural gas (CNG), and 100 propane vehicles were registered in Washington state, compared with nearly 6 million gasoline and diesel vehicles.

Table 6. Laws, policies, and programs affecting decarbonization of the transportation sector in Washington.

Law, Policy, or Program	Impacts on Transportation Decarbonization
Move Ahead Washington	• Provides nearly $3 billion in funding for public transportation in Washington through 2038. Includes funding for transit agencies to electrify public vehicle fleets and install charging infrastructure, as well as funding for bus rapid transit networks and ultra-high speed rail development. • Provides funding for complete streets programs and specific bike and pedestrian infrastructure improvements to improve safety for active transportation. • Provides funding for safe routes to school programs. • Provides $5 billion in funding for electric vehicle charging stations, electric vehicle car sharing programs, and hybrid electric ferries.
Washington Department of Ecology - Clean Fuels Program (HB 1091, Laws of 2021)	• Reduces the overall carbon intensity of transportation fuels used in the state by 20% below 2017 levels by 2035.
Washington State Department of Transportation - Commute Trip Reduction Program	• Requires workplaces in the state's nine most populous counties with 100 or more full-time employees to incentivize commuting through modes other than driving alone.
Motor Vehicle Emission Standards - Zero Emissions Vehicles (Chapter 143, Laws of 2020, SB 5811)	• Directs the Department of Ecology to use California's zero emissions vehicle standards. The Department of Ecology has consequently adopted rules that require 35% of new sales of passenger vehicles, light-duty vehicles, and medium-duty vehicles to be ZEVs beginning in 2026. This percentage increases 6-9% each year until ZEVs make up 100% of new sales starting in model year 2035.
Washington State Department of Transportation - Zero Emissions Access Program	• Provides grant funding to non-profit organizations and local governments for zero-emissions carshare programs in low- and moderate-income communities.
Inflation Reduction Act - Clean Vehicle Tax Credit	• Provides a tax credit of $7,500 for new electric vehicles and $4,000 for used electric vehicles that were assembled in North America (United States, Canada, and Mexico), with income and vehicle cost restrictions.

Law, Policy, or Program	Impacts on Transportation Decarbonization
Infrastructure, Investment, and Jobs Act - Federal Low or No Emission Vehicle Program	• Awards transit agencies funding for electric buses and charging infrastructure. Awarded $33 million to cities, transportation authorities, and Tribes across Washington for projects to replace diesel buses with electric ones and improve maintenance facilities. Funding has increased to $1 billion per year through 2026.
Volkswagen Settlement (Department of Ecology)	• Allocated $13.3 million of funding from federal settlement with automaker Volkswagen to support purchasing 50 zero-emission buses for transit agencies.

4.1.7 Renewable Electricity and Energy Storage Trends

4.1.7.1 Electricity Market Trends

Shifts are underway in how Washington utilities are procuring and selling the power they generate. These shifts are expected to further incentivize renewable development in the Western US, create a cleaner grid, and reduce energy costs due to more efficient and cost-competitive coordination among market actors.

Washington's electricity grid is connected to other states via transmission throughout the Western Interconnection. The California Independent System Operation (CAISO), which oversees California's bulk electric system and transmission lines, operates the Western Energy Imbalance Market (WEIM), a real-time energy market for balancing purposes. The WEIM currently represents nearly 80% of the load in the Western Interconnection. Among other Washington Balancing Authorities, Bonneville Power Administration joined the WEIM in March 2022.

The CAISO currently is leading the development of the Extended Day-Ahead Market (EDAM) within the WEIM footprint to allow full electric market trading. CAISO is planning on enabling WEIM members to participate in the EDAM beginning in 2024. PacifiCorp has committed to participation in developing EDAM. The Southwest Power Pool, or SPP, is also developing a day-ahead market offering, referred to as Markets+, with the intent of filing a tariff offering with FERC in the first quarter of 2024. Utilities across the West are engaging in efforts to develop these markets. BPA, Puget Sound Energy, Snohomish Public Utilities, Chelan Public Utilities and Tacoma Power are all engaged in development of the Markets+ offering.

Day-ahead markets are intended to improve market efficiency by integrating renewable resources using day-ahead unit commitment and scheduling across a larger area. The National Resources Defense Council predicts day ahead markets will result in faster renewable development, a cleaner grid, reduced emissions, and lower energy costs due to more efficient system-wide coordination across the Western Interconnection.[80]

[80] Carl Zichella (Alum), "Western EIM Expands, Electricity Markets Outlook Brightens," NRDC Expert Blog (blog), September 24, 2019, https://www.nrdc.org/experts/carl-zichella/western-eim-expands-electricity-markets-outlook-brightens.

What are renewable resources?

Renewable energy is electricity made by using fuel sources that restore themselves over relatively short periods of time. CETA defines renewable resources as water, wind, solar energy, geothermal energy, renewable natural gas, renewable hydrogen, wave, ocean, or tidal power, biodiesel from crops not raised on land cleared from old growth or first growth forests, and biomass energy. Although the manufacturing and operation of renewable electricity technologies have an environmental impact, using them produces few greenhouse gas emissions.

4.1.7.2 Renewable Energy Development Trends

According to the International Energy Agency (IEA), global renewable electricity capacity is predicted to increase by over 60% between 2020 and 2026, reaching more than 4,800 GW of power capacity, equivalent to the current global power capacity of fossil fuels and nuclear power combined. Eighty percent of this growth is expected to occur in four countries/regions: China, Europe, the U.S., and India. In the U.S., renewable energy capacity is expected to dramatically expand over the next decade. According to IEA analysis, expansion of renewable capacity in the U.S. from 2021 to 2026 will be 65% greater than it was from 2015 to 2020, driven by international climate goals, the economic competitiveness of wind and solar over fossil fuels, increased federal government goals, federal tax credits, and a growing market for corporate power purchase agreements (including corporate climate targets).81

Renewable energy development in Washington and for Washington electricity customers is being driven by state and regional policy, as well as dramatically falling costs. The IEA anticipates that the expansion of renewable capacity globally will accelerate during the next five years, accounting for about 95% of the increase in worldwide power capacity through 2026.82 The development of solar photovoltaic (PV) is likely to continue to grow, and wind power will expand more rapidly than in the preceding five years.83 Even though rising material prices are affecting production costs, the amount of solar PV capacity globally increased by 17% in 2021. Solar PV accounted for 39% of all new electricity generating capacity added to the U.S. grid in the first half of 2022.84 The following table summarizes the major trends in renewable energy development in Washington and the Pacific Northwest.

[81] Globally, corporate clean energy purchases have increased sixfold between 2016 and 2020, with a record 23.7GW reported in 2020. Source: World Economic Forum. "Corporate Power Purchase Agreements Can Drive the Switch to Renewables," August 31, 2021. https://www.weforum.org/agenda/2021/08/corporate-power-purchase-agreements-renewable-energy/.

[82] "Executive Summary – Renewables 2021 – Analysis," IEA, accessed December 14, 2022, https://www.iea.org/reports/renewables-2021/executive-summary.

[83] Heymi Bahar et al., "Renewables 2021 - Analysis and Forecast to 2026" (International Energy Agency, Renewable Energy Division, December 2021).

[84] "Solar Market Insight Report 2022 Q3 | SEIA," accessed April 12, 2023, https://seia.org/research-resources/solar-market-insight-report-2022-q3.

Table 7. Renewable energy development trends in Washington and the Pacific Northwest.

Renewable energy type	Major trends
Hydropower	• Provides the majority of renewable electricity generation in Washington state. • Droughts and extreme heat due to climate change are expected to reduce snowpack and decrease water available for hydropower production.
Solar power	• Dramatically falling costs, dropping 52% over the past decade. • Significant increases in solar cell efficiencies, with newest cells capable of achieving up to 39.5% efficiency in normal sunlight. • State funding initiatives for rooftop solar fully subscribed; high uptake of utility scale solar serving low-income households.
Wind energy	• Steadily falling costs of wind (though costs may still exceed costs of other generating resources). • Increasing capacity factors (average 3-4 MW onshore and 9-12 MW offshore, per turbine). • Nearly 1 GW of wind power added to the region in 2020.
Biomass	• Considered to be currently underused as a fuel source, but global demand is projected to increase. • Mainly used in industrial and transportation sectors: 9% of use in 2021 in U.S. was for electric power generation; accounted for 1.2% of Washington's net electricity generation in the same year. • Use may be limited due to hazardous air pollutants and particulates produced by combustion, as well as concerns about deforestation and biodiversity reduction.
Marine energy	• Ocean energy projects face technical, economic, and environmental limitations and challenges. • Tidal and wave energy pilot projects are in development or under consideration off the West coast, including in Washington.[85]
Geothermal	• The U.S. has high geothermal energy production compared to other countries. Most production is in California. • Washington has high-temperature geothermal areas that are in areas difficult to develop due to terrain and environmental limitations. • Low-temperature geothermal already has limited applications (heating buildings) in central and eastern Washington. • Funding from federal and state governments expected to prompt development of future geothermal demonstration projects in Washington.

85 "DOE Announces $25 Million for Cutting-Edge Wave Energy Research," Energy.gov, accessed January 23, 2023, https://www.energy.gov/articles/doe-announces-25-million-cutting-edge-wave-energy-research.

4.1.7.3 Climate Change and Renewable Energy

Variations in temperature and precipitation will affect Washington's capacity to generate hydroelectricity

— the state's largest source of power. As mountain snowpack decreases, climatic changes will lead to shifts in the timing of snowmelt, affecting hydro facilities. Additionally, as Washington faces higher risk of drought, hydropower operations will face challenges related to water availability and reservoir levels.[86]

Overall hydropower generation in the Pacific Northwest is projected to decrease,[87] with variable impacts by year and season. For example, the Grand Coulee Dam, the largest dam in Washington, typically produces more than 21 million MWh of electricity annually, supplying power to eight other states and Canadian provinces. In 2019, the Grand Coulee Dam produced less than 17 million MWh of electricity, down from a peak of 26 million MWh in 2012.[88] Using predictive models, researchers at the University of Washington expect that during the 2020s, regional hydropower production could increase by 0.5-4% in the winter, decrease by 9-11% in the summer, and experience annual reductions of 1-4%.[89]

Wind power is the second largest source of renewable energy in Washington (6% of the state's total energy generation),[90] and it is poised to grow as technologies improve and prices decrease. As of January 2022, Washington had more than 3.4 GW of installed onshore wind capacity, mainly in the eastern part of the state and along the Columbia River Gorge. This represents a fraction of Washington's potential wind generation of 351,000 GWh.[91] Wind resources are quickly being added to the region.

The impact of climate change on wind energy generation is unclear. Some scientists have hypothesized that climate change will lead to a global "terrestrial stilling," or slowing of winds, which could decrease wind energy potential. For example, the Intergovernmental Panel on Climate Change predicts that, by 2100, average annual wind speeds could decrease by 10% globally. A study on the Pacific Northwest projects a decrease in wind power resources of up to 40% in spring and summer due to climate change. However, other studies suggest wind speeds are increasing and could be a boon for green energy.[92]

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[86] Kepa Solaun, Emilio Cerdá, Climate change impacts on renewable energy generation. A review of quantitative projections, Renewable and Sustainable Energy Reviews, Volume 116, 2019, 109415, ISSN 1364-0321, https://doi.org/10.1016/j.rser.2019.109415; https://www.eia.gov/todayinenergy/detail.php?id=51839

[87] Kepa Solaun and Emilio Cerdá, "Climate Change Impacts on Renewable Energy Generation. A Review of Quantitative Projections," Renewable and Sustainable Energy Reviews 116 (December 1, 2019): 109415, https://doi.org/10.1016/j.rser.2019.109415.

[88] "Washington - State Energy Profile Analysis - U.S. Energy Information Administration (EIA)," February 17, 2022, https://www.eia.gov/state/analysis.php?sid=WA.

[89] Alan F. Hamlet et al., "Effects of Projected Climate Change on Energy Supply and Demand in the Pacific Northwest and Washington State," Climatic Change 102, no. 1–2 (September 2010): 103–28, https://doi.org/10.1007/s10584-010-9857-y.

[90] "Washington - State Energy Profile Analysis - U.S. Energy Information Administration (EIA)," February 17, 2022, https://www.eia.gov/state/analysis.php?sid=WA.

[91] "WINDExchange: U.S. Installed and Potential Wind Power Capacity and Generation," accessed November 11, 2023, https://windexchange.energy.gov/maps-data/321.

[92] Robins, J., "Global 'Stilling': Is Climate Change Slowing Down the Wind?", Sept. 13, 2022. YaleEnvironment360. https://e360.yale.edu/features/global-stilling-is-climate-change-slowing-the-worlds-wind; Pryor, S.C., Barthelmie, R.J., Bukovsky, M.S. et al. Climate change impacts on wind power generation. Nat Rev Earth Environ 1, 627–643 (2020). https://doi.org/10.1038/s43017-020-0101-7; Harvey, C. "The World's Winds are Speeding Up", Nov. 19, 2019, Scientific American. https://www.scientificamerican.com/article/the-worlds-winds-are-speeding-up/; Zhenzhong Zeng, Alan D Ziegler, Timothy Searchinger, Long Yang, Anping Chen, et al.. A reversal in global terrestrial stilling and its implications for wind energy production. Nature Climate Change, 2019, 9 (12), pp.979-985. https://hal.science/hal-02440789/document; Kepa Solaun, Emilio Cerdá, Climate change impacts on renewable energy generation. A review of quantitative projections, Renewable and Sustainable Energy Reviews, Volume 116, 2019, 109415, ISSN 1364-0321, https://doi.org/10.1016/j.rser.2019.109415

Over the past decade, solar-powered electricity generation has increased quickly. Meanwhile, the cost of solar has declined dramatically, falling 52% over the last 10 years, and the efficiency of solar technologies has increased.[93]

Solar power accounts for a small share of Washington's energy generation. Until recently, almost all solar power in Washington was from rooftop solar panels and other small-scale solar installations.[94] Washington's first utility-scale solar farm opened in Klickitat County in 2023.[95] More projects are on the horizon; the Washington State Department of Commerce has granted a total of $3.7 million to support the deployment of nine solar energy projects across the state, including initiatives to reduce the energy burden of low-income households.[96] The National Renewable Energy Laboratory (NREL) estimates that Washington has the potential to install over 996 gigawatts of rural utility-scale photovoltaics and over 59 gigawatts of concentrated solar power.[97]

Climate change can impact solar PV potential and the efficacy of solar technologies. For example, an increase in mean global temperature can decrease the efficiency of solar cells, while extreme weather may damage solar PV panels. Wind speed, precipitation, and changes in solar irradiation and cloudiness, among other factors, can also affect solar potential. On the other hand, weather patterns that decrease cloud cover can increase solar potential.[98] Impacts may vary by season.

4.1.7.4 Energy Storage

Various types of energy storage are increasingly used in conjunction with renewable electricity generation to help manage its intermittency and enable the grid to be more responsive to major changes in demand. The flexibility of storage makes it a key asset when it comes to managing the energy system; adding storage in conjunction with demand response reduces the overall need for firm generating capacity. For these reasons, energy storage is likely to be a key component in achieving Washington's clean electricity mandates. NREL research suggests that energy storage deployment in the United States could increase dramatically, reaching at least five times its current capacity by 2050.[99]

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93 "Washington Solar," SEIA, accessed December 20, 2022, **https://www.seia.org/state-solar-policy/washington-solar.washing;** "News Release: NREL Six-Junction Solar Cell Sets Two World Records for Efficiency," accessed December 20, 2022, https://www.nrel.gov/news/press/2020/nrel-six-junction-solar-cell-sets-two-world-records-for-efficiency.html

94 "Washington - State Energy Profile Analysis - U.S. Energy Information Administration (EIA)," February 17, 2022, https://www.eia.gov/state/analysis.php?sid=WA.

95 Avangrid. AVANGRID's Lun Hill, Washington State's Largest Utility-scale Solar Farm, Achieves Commercial Operation [press release]. Feb. 28, 2023. Retrieved from https://www.businesswire.com/news/home/20230228005900/en/AVANGRID%E2%80%99s-Lund-Hill-Washington-State%E2%80%99s-Largest-Utility-scale-Solar-Farm-Achieves-Commercial-Operation

96 "Clean Energy Fund Solar Program," Washington State Department of Commerce, accessed December 20, 2022, https://www.commerce.wa.gov/growing-the-economy/energy/clean-energy-fund/clean-energy-fund-solar-program/.

97 Anthony Lopez et al., "U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis" (NREL, 2012), http://dspace.bhos.edu.az/jspui/handle/123456789/1093.

98 Kepa Solaun, Emilio Cerdá, Climate change impacts on renewable energy generation. A review of quantitative projections, Renewable and Sustainable Energy Reviews, Volume 116, 2019, 109415, ISSN 1364-0321, https://doi.org/10.1016/j.rser.2019.109415.

99 Nate Blair et al., "Storage Futures Study: Key Learnings for the Coming Decades" (NREL, April 12, 2022), https://doi.org/10.2172/1863547.

Energy Storage Technologies

An energy storage facility's performance depends on how rapidly it can respond to demand fluctuations, how much energy it loses during storage, its total capacity, and how quickly it can be recharged.[107] Deployed energy storage technologies include pumped storage hydropower, compressed air energy storage, battery, flywheel energy storage, and thermal energy storage. Pumped storage hydropower and compressed air energy storage are large-scale technologies with discharge periods of tens of hours and power levels of up to 1 GW; however, they are highly dependent on location. Batteries and flywheel energy storage are less powerful and have shorter discharge durations (seconds to six hours), but they are not generally restricted by location.

Pumped hydroelectric storage is a large-scale form of energy storage where reservoirs are used to store the potential energy of water for later electricity production. It is by far the most common type of energy storage, accounting for 93% of U.S. utility-scale energy storage.[108] Forty-three pumped hydro storage plants have been providing 22 gigawatts (GW) in the U.S. for decades, and according to the U.S. DOE, there is the potential for 50 GWs of new pumped storage in the United States by 2050.[109] The number of pumped hydro storage projects in the development pipeline has been increasing since 2015.

Battery energy storage systems store electrical energy as chemical energy. In the United States, the adoption of large-scale battery storage systems across the electrical grid is rapidly rising, from 59 MW in 2010 to 4,588 MW in 2021. As of October 2022, the U.S. had 7.8 GW of utility-scale battery storage.[110] Developers and power plant operators expect to add another 20.8 GW of battery storage capacity from 2023 to 2025.

Lithium-ion batteries are expected to lead the market share for energy storage. Lithium-ion battery pack prices have fallen 89%, from more than $1,200/kWh in 2010 to $132/kWh in 2021.[111] However, lithium and cobalt, which are fundamental components of lithium-ion batteries, could become scarce in the future. Approximately 10% of the world's lithium and almost all of its cobalt deposits will be gone by 2050.[112] Scientists are developing strategies for recycling lithium and cobalt batteries and designing batteries made from sodium to replace lithium.[113] However, these technologies are not currently commercially available.

107 "Fact Sheet | Energy Storage (2019) | White Papers | EESI," accessed December 28, 2022, https://www.eesi.org/papers/view/energy-storage-2019.

108 Rocío Uría-Martínez et al., "U.S. Hydropower Market Report," January 2021, 158; Turgut M. Gür, "Review of Electrical Energy Storage Technologies, Materials and Systems: Challenges and Prospects for Large-Scale Grid Storage," Energy & Environmental Science 11, no. 10 (October 10, 2018): 2696–2767, https://doi.org/10.1039/C8EE01419A.

109 US Department of Energy, "Hydropower Vision: A New Chapter for America's 1st Renewable Electricity Source" (Wind and Water Power Technologies Office), accessed December 23, 2022, https://www.energy.gov/sites/prod/files/2018/02/f49/Hydropower-Vision-021518.pdf.

110 "U.S. Battery Storage Capacity Will Increase Significantly by 2025," accessed December 28, 2022, https://www.eia.gov/todayinenergy/detail.php?id=54939.

111 ACP, "Clean Energy Storage Facts," ACP, accessed December 29, 2022, https://cleanpower.org/facts/clean-energy-storage/.

112 "Scenario 2050: Lithium and Cobalt Might Not Suffice: With the Increased Significance of Lithium-Ion Batteries, the Pressure on the Availability of Relevant Resources Rises," ScienceDaily, accessed December 30, 2022, https://www.sciencedaily.com/releases/2018/03/180314110856.htm.

113 "It's Time to Get Serious about Recycling Lithium-Ion Batteries," Chemical & Engineering News, accessed December 30, 2022, https://cen.acs.org/materials/energy-storage/time-serious-recycling-lithium/97/i28; "Sodium-Ion Batteries Poised to Pick Off Large-Scale Lithium-Ion Applications - IEEE Spectrum," accessed December 30, 2022, https://spectrum.ieee.org/sodium-ion-battery.

Renewable energy generation in Washington, especially eastern Washington, will fluctuate on a daily and seasonal basis. In contrast, other western regions, such as California and Arizona, will produce more consistent solar and wind power.

Washington currently has 320 MW of energy storage installed.[114] The majority of this energy storage capacity (314 MW) is pumped storage hydropower provided by the John W. Keys III Pumped Generation Plan at the Grand Coulee Dam. In 2014, four utility-scale energy storage projects were put in place with the help of $14.3 million in matching funds from the Washington Clean Energy Fund as part of the Grid Modernization Program.[115] Washington leads the country in hydropower capacity and hydropower percentage of in-state generation.

While Washington has not adopted specific targets or requirements for storage, the Washington UTC issued a policy statement in 2017 directing utilities to place greater importance on energy storage in resource planning and procurement[116]. In California, pumped hydroelectric storage under 50 MW is eligible to help achieve the state's target of 1,3225 MW of total energy storage (of all types) by 2020.[117, 118] In 2019, Oregon passed legislation (SCR1) to encourage regulators and utilities to develop closed-loop pumped storage hydropower projects.[119] By the end of 2019, 67 pumped storage hydropower projects were in the development pipeline across 21 states, with three of those being in Washington.[120]

4.1.8 Alternative Fuels

Utilities and industries are actively researching and developing alternative fuels that may enable them to continue using existing infrastructure and assets while meeting federal, state, and local decarbonization requirements. Fuels being explored include hydrogen, biomethane (renewable natural gas), synthetic methane (synthetic gas), and biofuels (ethanol, biobutanol, dimethyl ether, renewable hydrocarbons, alternative jet fuel, biobutanol, methanol, and renewable hydrocarbon biofuels. Many of these fuel sources are not yet widely commercially available.

What are alternative fuels?

The U.S. Environmental Protection Agency defines alternative fuel as "gaseous fuels such as hydrogen, natural gas, and propane; alcohols such as ethanol, methanol, and butanol; vegetable and waste-derived oils." These are fuels that could be used individually or in combination with other fuels, including fossil fuels and electricity, in mixed systems such as hybrid-electric or flexible fuel vehicles. Electricity is also considered an alternative fuel in cases where it can replace fossil fuel use.

114 Center for the New Energy Economy, Tom Plant, and Trina Hoffer, "State Brief: Washington" (Colorado State University, 2021), https://cnee.colostate.edu/wp-content/uploads/2021/10/State-Brief_WA_October-2021.pdf.

115 "Energy Grid Modernization," Washington State Department of Commerce, accessed December 29, 2022, https://www.commerce.wa.gov/growing-the-economy/energy/clean-energy-fund/energy-grid-modernization/.

116 "PNNL: Energy Storage: Energy Storage Policy Database," accessed June 2, 2022, https://energystorage.pnnl.gov/regulatoryactivities.asp.

117 Decision Adopting Energy Storage Procurement Framework and Design Program, No. Decision 13-10-040 (Before the Public Utilities Commission of the State of California October 17, 2013).

118 "Bill Text - AB-2514 Energy Storage Systems.," accessed December 29, 2022, https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=200920100AB2514.

119 "SCR1 2019 Regular Session - Oregon Legislative Information System," accessed December 29, 2022, https://olis.oregonlegislature.gov/liz/2019R1/Measures/Overview/SCR1.

120 National Hydropower Association's Pumped Storage Development Council et al., "2021 Pumped Storage Report" (Washington, D.C: National Hydropower Association), accessed December 29, 2022, https://www.hydro.org/wp-content/uploads/2021/09/2021-Pumped-Storage-Report-NHA.pdf.

4.1.8.1 Hydrogen

Hydrogen is the lightest element and an atom of hydrogen contains significant energy. However, hydrogen typically does not exist naturally and must be produced from compounds that contain it. Hydrogen can be made from fossil fuels like coal and gas ("grey" and "blue" hydrogen, respectively), electrolysis powered by renewable energy sources ("green" hydrogen), a mix of both, or nuclear energy resources. The way it is made affects how cost-effective it is as a fuel and how much its use contributes to decarbonization targets.[121] In the coming decades, either "blue" or "green" hydrogen will become more accessible and less expensive, depending on factors such as technological development, the price of carbon, and the availability of renewable electricity. Globally, most hydrogen produced is created using fossil gas through steam methane reforming.[122] A growing number of facilities in the United States deploy electrolysis technology to extract hydrogen from water using electricity.[123]

While the colors used to describe hydrogen take into account the GHG emissions associated with its production, hydrogen molecules themselves pose a climate risk. Though hydrogen molecules do not directly trap heat, they indirectly prolong the impact of other GHGs such as methane, ozone, and water vapor by interfering with the chemical reactions that normally neutralize those GHGs over time.[124] One calculation found that a ton of hydrogen in the atmosphere will indirectly warm the Earth 11 times more than a ton of CO2 over a 100-year time period.[125] Hydrogen leakage risks occur along its entire supply chain, with studies estimating a leakage rate of anywhere between 2.9% to 10%. This represents a "non-negligible contribution to global warming," particularly as hydrogen use becomes more widespread.[126]

Hydrogen can be deployed in industry (to make ammonia and steel and to refine oil), transportation (to power hydrogen fuel cell vehicles), buildings (hydrogen can be added to natural gas networks in small amounts), and power generation (especially to store renewable energy when prices are low or negative). Currently, the vast majority of the hydrogen generated in the U.S. is used to refine petroleum, treat metals, make fertilizer, and process food. In Washington, hydrogen is primarily used to desulphur oil at refineries.[127]

Hydrogen could be blended into existing natural gas infrastructure that supplies heat to buildings, replacing up to 5–15% of natural gas. At the same time, integrating hydrogen into natural gas infrastructure could increase leakage. Data on the risks and benefits is scarce.[128] There is a maximum amount of hydrogen that could be injected into the existing gas network, subject to country-specific regulations. Additionally, gas-fired appliances (gas turbines, burners, engines, and natural gas vehicles) can safely support only small amounts of hydrogen.

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[121] "What Is Green Hydrogen and Why Do We Need It? An Expert Explains," World Economic Forum, accessed April 27, 2022, https://www.weforum.org/agenda/2021/12/what-is-green-hydrogen-expert-explains-benefits/.

[122] Klaus Altfeld and Dave Pinchbeck, "Admissible Hydrogen Concentrations in Natural Gas Systems," Gas for Energy 03 (2013): 12.

[123] "DOE Establishes Bipartisan Infrastructure Law's $9.5 Billion Clean Hydrogen Initiatives," Energy.gov, accessed January 23, 2023, https://www.energy.gov/articles/doe-establishes-bipartisan-infrastructure-laws-95-billion-clean-hydrogen-initiatives.

[124] CGEP, Columbia |. "Hydrogen Leakage: A Potential Risk for the Hydrogen Economy." Center on Global Energy Policy at Columbia University SIPA | CGEP, July 5, 2022. https://www.energypolicy.columbia.edu/publications/hydrogen-leakage-potential-risk-hydrogen-economy/.

[125] With an uncertainty of ± 5.

[126] Columbia | CGEP, "Hydrogen Leakage: A Potential Risk for the Hydrogen Economy," Center on Global Energy Policy at Columbia University | SIPA, July 5, 2022, https://www.energypolicy.columbia.edu/publications/hydrogen-leakage-potential-risk-hydrogen-economy/.

[127] David Sjoding and Erin Hamernyik, "Overview of Hydrogen and Fuel Cells in Washington State," n.d.

[128] M W Melaina, O Antonia, and M Penev, "Blending Hydrogen into Natural Gas Pipeline Networks: A Review of Key Issues," Renewable Energy, 2013, 131.

State and federal legislation are driving the development of clean hydrogen projects. The IIJA allocated $8 billion to Regional Clean Hydrogen Hubs — with Washington expected to become one of the hubs — as well as programs to incentivize hydrogen production with clean electricity and hydrogen-related equipment manufacturing. The IRA created a production tax credit for hydrogen that is expected to bring down the cost of clean hydrogen.

Washington's first hydrogen production facility broke ground in Douglas County in March 2022. It has a 5 MW capacity and can produce 2 tons of hydrogen per day.[129] An Australian energy company is exploring transforming the Centralia Power Plant site, home to Washington's last coal-fired electric generation facility, into a green hydrogen production facility by 2026.[130]

4.1.8.2 Biomethane/Renewable Natural Gas

Biomethane, also called renewable natural gas (RNG), is made by extracting carbon dioxide, hydrogen sulfide, and other gasses from the biogas produced by landfills, anaerobic digesters at wastewater treatment plants, food processing plants, and farms.[131] Biogas can be used in two ways: 1) in its untreated state for power and heat generation, and 2) processed into RNG and conditioned to satisfy quality criteria similar to those applied to fossil natural gas (at least 97% methane). Washington law (Chapter 164, Laws of 2018) defines RNG as "a gas consisting largely of methane and other hydrocarbons derived from the decomposition of organic material in landfills, wastewater treatment facilities, and anaerobic digesters." RCW 54.04.190(6)(b); RCW 19.405.020(33). Methane accounts for 45%–65% of raw biogas, with a trace of carbon dioxide and a few other chemicals also present; RNG gas contains 90% or more methane.

Agricultural and landfill RNG projects are increasing nationwide, particularly since 2019, due to federal and state-level renewable fuel standards. As of 2022, more than 173 RNG projects are active in 31 states; another 40 or so projects are in planning stages. Over 46% of active RNG projects use gas from landfills while 55% of active projects come from anaerobic digester systems, which include systems for managing manure and food waste.[132] Other states on the West Coast are actively promoting biomethane research and development. California has renewable portfolio standards that include renewable energy certificates that give RNG made from biogas a financial boost.

RNG can be used as a one-for-one replacement for fossil natural gas; when purified and upgraded, it can be blended with the fossil natural gas supply and moved or stored for long periods using existing natural gas system infrastructure. In 2019, 1.3% of Washington's consumption of natural gas was met by RNG.

Several RNG projects, including two landfill gas facilities, one wastewater treatment plant, one dairy digester, and one food waste facility, are being planned or are already in development in Washington, and there are dozens of potential additional projects across the state. In 2021, the

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129 "Douglas County PUD Renewable Hydrogen Production Facility Groundbreaking," Douglas County PUD (blog), May 1, 2021, https://douglaspud.org/renewable-hydrogen-production-facility-groundbreaking-d30/

130 "Hydrogen Valley Vision for Southwest Washington Gets Boost from Aussies' Proposed Plant," Spokane Public Radio, May 15, 2022, https://www.spokanepublicradio.org/regional-news/2022-05-15/hydrogen-valley-vision-for-southwest-washington-gets-boost-from-aussies-proposed-plant.

131 The Coalition for Renewable Natural Gas, "Economic Analysis of the US Renewable Natural Gas Industry," https://static1.squarespace.com/static/53a09c47e4b050b5ad5bf4f5/t/639b3e7fd137bc1175286d7d/1671118464387/RNG+Coalition+Final+Report+2022.pdf.

132 "An Introduction to Renewable Natural Gas"," n.d.

Cedar Hills Regional Landfill, about 20 miles south of Seattle, produced around 6,500 standard cubic feet of landfill gas, which was turned into pipeline-quality RNG and injected into natural gas distribution infrastructure, meeting the demand of 17,500 homes in King County. The Roosevelt Regional Landfill, the fourth largest permitted landfill in the United States, converts enough methane gas to electricity to power more than 20,000 homes annually.

Washington law promotes the use of biomethane; it requires natural gas utilities to make RNG accessible to all consumers and authorizes gas utilities to propose RNG programs that their customers can opt into. RNG is expected to be a key fuel in meeting Washington's Clean Fuel Standards for vehicles. According to a Washington State University analysis, 3-5% of current natural gas consumption in Washington could be met by RNG production from existing or relatively easy-to-build facilities.[133] In addition, researchers from Washington State University identified hundreds of other places near the natural gas pipeline grid within Washington where biomethane could be made. These locations could produce more than 50 million BTU per year.[134] Given that in 2019 natural gas use in Washington was approximately 392 million BTUs, maximizing RNG production from these sources could replace 8-13% of current natural gas use.[135]

Additional feedstocks not near current natural gas pipelines or infrastructure have the potential to increase renewable natural gas as well.[136] However, estimates developed by ICF for the American Gas Association indicate that the RNG resource potential for the United States ranges from a low of 1,913 trillion BTU to 4,513 trillion BTU. As the natural gas demand averaged nearly 16,000 trillion BTU from 2009-2018, these potentials represent less than one third of total current demand, meaning RNG feedstocks are insufficient to fully replace current natural gas use.[137]

The cost of producing RNG, particularly in small volumes at distributed locations, is currently more than conventional fossil fuel natural gas extraction because it requires costly equipment and new pipeline connections. Costs can vary widely depending on the size and type of the project. It took $80-$100 million of investment to reach Washington's current level of RNG production; however, existing projects are considered the low-hanging fruit and future projects will likely be more expensive. But the price difference is likely to shrink over time as methods for making biomethane improve and carbon pricing makes fossil natural gas more expensive in some places.[138] The International Renewable Energy Agency predicts that cost cuts of 30–40% are possible.[139]

Plants that generate power with natural gas and RNG could see reduced efficiency as the climate warms because they use water for cooling. If air and water temperatures are higher, more energy

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133 "Promoting Renewable Natural Gas in Washington State," accessed March 28, 2022, https://www.commerce.wa.gov/wp-content/uploads/2019/01/Energy-Promoting-RNG-in-Washington-State.pdf.

134 Washington State University Energy Program, "Harnessing Renewable Natural Gas for Low-Carbon Fuel: A Roadmap for Washington State" (Olympia, Washington: Washington State University, December 2017), https://www.commerce.wa.gov/wp-content/uploads/2018/02/Energy-RNG-Roadmap-for-Washington-Jan-2018.pdf.

135 Ibid.

136 Ibid.

137 American Gas Foundation, "Renewable Sources of Natural Gas - Supply & Emission Reduction Assessment Study" (Washington, D.C, 2019), https://gasfoundation.org/wp-content/uploads/2019/12/AGA_3894-RNG-2-Pager_V-11.pdf.

138 International Energy Agency, "Outlook for Biogas and Biomethane: Prospects for Organic Growth," World Energy Outlook Special Report (France, March 2020), https://iea.blob.core.windows.net/assets/03aeb10c-c38c-4d10-bcec-de92e9ab815f/Outlook_for_biogas_and_biomethane.pdf.

139 "Biogas Cost Reductions to Boost Sustainable Transport," accessed January 17, 2023, https://www.irena.org/news/articles/2017/Mar/Biogas-Cost-Reductions-to-Boost-Sustainable-Transport.

may be required to cool water. At the same time, water supply for cooling power plants may decrease.[140] Additionally, droughts in other states may threaten fracking for natural gas and other fossil fuel production.[141]

Public opinion and economic considerations may limit the development of RNG projects in Washington.[142] RNG projects may have more support than oil, coal, and fossil natural gas projects. However, neighboring communities tend to be opposed to projects that treat organic waste.[143] Facilities that are already flaring (burning off) methane may not find current economic incentives and policy to be adequate to justify the cost of installing technology that could direct the biomethane to gas pipelines or to produce electricity.[144] Finally, there is skepticism about the climate impact and emissions intensity of RNG, since it would be distributed using the same infrastructure as fossil natural gas and with the same leakage rate.[145]

4.1.9 Other Electricity Resources

4.1.9.1 Nuclear Power

Since 1958, the United States has been producing electricity at commercial nuclear power plants. About 20% of all the energy used in the United States comes from nuclear power plants, which use nuclear fission to make heat and electricity.[146] It continues to be an important source of low-carbon power production in the United States and other countries.[147]

Across the U.S., 93 commercial nuclear reactors were in operation by the end of 2021, spread among 55 nuclear power stations in 28 states with a total generating capacity of about 95,492 MW.[148] Two of the four reactors that were under construction have been recently canceled.

Reasons include improved maintenance methods for existing plants, as well as a turn from nuclear technologies to other energy sources, which has diminished supply networks and related workforces.

Washington is home to the only nuclear power plant in the Northwest, the Columbia Generating Station at Hanford, operated by Energy Northwest. With a capacity of 1,207 MW, it has been operational since 1984 and is authorized to operate until at least 2043, or potentially 2063 with a license extension. In addition to the Columbia Generating Station, there are also several nuclear research facilities in Washington state, including Pacific Northwest National Laboratory (PNNL), Washington State University Nuclear Radiation Center (WSU-NRC), and the University of Washington Nuclear Reactor, which is used for research and educational purposes.

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140 U.S. Environmental Protection Agency. “Climate Impacts on Energy,” January 19, 2017. Retrieved from: https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-energy_.html

141 USGCRP, “Fourth National Climate Assessment” (U.S. Global Change Research Program, Washington, DC, 2018), https://nca2018.globalchange.gov.

142 Hazboun, Shawn, and Hilary Boudet. “Chapter 8 - A ‘Thin Green Line’ of Resistance? Assessing Public Views on Oil, Natural Gas, and Coal Export in the Pacific Northwest Region of the United States and Canada.” In Public Responses to Fossil Fuel Export, edited by Hilary Boudet and Shawn Hazboun, 121–39. Elsevier, 2022. https://doi.org/10.1016/B978-0-12-824046-5.00003-5.

143 Ibid.

144 Emily Grubert, “At Scale, Renewable Natural Gas Systems Could Be Climate Intensive: The Influence of Methane Feedstock and Leakage Rates,” Environmental Research Letters 15, no. 8 (August 2020): 084041, https://doi.org/10.1088/1748-9326/ab9335.

145 Natalie Karas et al., “Aligning Gas Regulation and Climate Goals: A Road Map for State Regulator” (Environmental Defense Fund, January 2021), http://blogs.edf.org/energyexchange/files/2021/01/Aligning-Gas-Regulation-and-Climate-Goals.pdf.

146 “Nuclear,” Energy.gov, accessed March 1, 2023, https://www.energy.gov/nuclear.

147 “Nuclear Reactor Technologies,” Energy.gov, accessed March 1, 2023, https://www.energy.gov/ne/nuclear-reactor-technologies.

148 “U.S. Nuclear Industry - U.S. Energy Information Administration (EIA),” accessed March 1, 2023, https://www.eia.gov/energyexplained/nuclear/us-nuclear-industry.php.

Nuclear power plants provide continuous, reliable, and carbon-free electricity. For these reasons, existing nuclear power plants can be an important option for ensuring grid stability as the electricity sector decarbonizes.[149] However, they also produce nuclear waste, which is extremely radioactive and can remain hazardous for thousands of years, and which must be managed and stored with absolute care to prevent harm to humans and the environment.

According to the Nuclear Energy Institute, many states are exploring or have recently enacted policies to promote current and new nuclear generation.[150] The Office of Nuclear Energy (NE) promotes nuclear energy by providing funding opportunities and launching programs, including the U.S. Industry Opportunities for Advanced Nuclear Technology Development (Industry FOA), Advanced SMR R&D Program, and the Light Water Reactor Sustainability (LWRS) program. In 2021, Washington State legislators proposed developing legislation to promote the manufacturing of advanced nuclear reactors, small modular reactors, and components, but the proposed Bill did not male it out of committee.[151] Public utility districts in Washington, such as Grant County PUD, are investigating the feasibility of developing small-scale modular nuclear reactors to serve their customers,[152] and PacifiCorp has included advanced modular nuclear generation in its 2023 Integrated Resource Plan.[153]

4.1.9.2 Carbon Capture and Utilization

Carbon capture, utilization, and storage (CCUS), also referred to as carbon capture, utilization, and sequestration, refers to technologies that capture carbon dioxide emissions from the air or from sources, such as power generation or industrial facilities, that use fossil fuels or biomass fuel. The carbon dioxide is either used on site, compressed, and transported, or injected into deep geological formations for permanent storage. Captured carbon dioxide can be converted into a variety of fuels (methane, methanol, gasoline, diesel, aviation fuel), chemicals, and building materials (cement, concrete), in addition to being used directly as fertilizer, solvents, and heat transfer fluids. It can also be used in food and beverages, and in welding, among other uses.

Thirty-five commercial CCUS facilities operate worldwide, capturing 44 Mt CO2 in 2021.[154] The vast majority of them play a role in natural gas processing. The U.S. is home to 10 commercial CCUS facilities, some of which date back to the 1970s and 1980s. These facilities capture 25 Mt/year of CO2. Over 20 proposed projects across the U.S. would, if realized, add another 46 Mt/year of CO2 capture capacity.[155] Most of the stationary emission sources in the U.S. are situated in close proximity to possible geological storage sites; approximately 85% of CO2 emissions from power plants and industries are generated within 100 kilometers of potential storage locations.[156]

149 "Keeping the Balance: How Flexible Nuclear Operation Can Help Add More Wind and Solar to the Grid," Main, accessed November 11, 2023, https://energy.mit.edu/news/keeping-the-balance-how-flexible-nuclear-operation-can-help-add-more-wind-and-solar-to-the-grid/.

150 "From Alaska to Maine: State Nuclear Energy Policy Action Is Booming," Nuclear Energy Institute, February 9, 2023, https://www.nei.org/news/2023/alaska-to-maine-state-nuclear-energy-policy-action.

151 "Washington State Legislature," accessed March 2, 2023, https://app.leg.wa.gov/billsummary?BillNumber=5244&Initiative=false&Year=2021.

152 "Grant PUD: Nuclear Power," Grant PUD, accessed April 13, 2023, https://www.grantpud.org/nuclear.

153 PacifiCorp, "2023 Integrated Resource Plan," accessed November 10, 2023, https://www.pacificorp.com/energy/integrated-resource-plan.html.

154 "Carbon Capture, Utilisation and Storage - Fuels & Technologies."

155 Akorn, "Interactive Map of CCUS Projects in Development in the U.S.," Clean Air Task Force, July 27, 2020, https://www.catf.us/2020/07/ccus-interactive-map/.

156 "CCUS in Clean Energy Transitions."

CCUS technologies, particularly direct air capture (DAC), are in the early stages of development. To meet decarbonization goals, many more sites would need to come online. An advantage of CCUS is that it can be adapted to existing facilities.[157] Due to investment incentives, enabling policies, as well as climate targets, momentum is building around CCUS. The number of facilities has more than doubled since 2010.

The IIJA allocated $12 billion to support CCUS technology, including new programs and previously-approved demonstration programs under the Energy Act of 2020, and the development of four DAC hubs.[158] In 2022, DOE announced $14 million to fund five DAC projects. AirCapture LLC was one of the funded projects that will implement its DAC system at Nutrien's Kennewick Fertilizer Operations plant in Kennewick, Washington, in order to separate CO2 from the air and transform it into valuable chemicals.[159]

Currently, around 300 CCUS projects are in different phases of development worldwide along the CCUS value chain. The world's first million-ton DAC facility is expected to operate starting in 2024 in the Permian Basin in Texas.[160]

CCUS has the potential to capture greenhouse gasses already in the air and decrease emissions from large stationary sources, such as power plants and big industrial facilities, when combined with bioenergy (BECCS) or DAC. The International Energy Agency has positioned DAC as a critical technology in the transition to a net-zero energy system because it has the potential to remove all CO2 released into the atmosphere.[161] IEA estimates in its net zero emissions by 2050 scenario modeling that DAC must capture more than 85 Mt of CO2 in 2030 and around 980 Mt of CO2 in 2050 (we're at 0.01 Mt of CO2 Mt today).[162]

DAC is currently expensive because the air has lower concentrations of CO2 than fuel gas from a power station or cement plant (which needs more air to get the same amount of CO2), and compressing the CO2 for storage requires higher capital and operating costs compared to using the CO2 for other purposes. The future cost of DAC is uncertain, with estimates ranging from $100 to $1000 per ton. Under certain conditions costs of $94–$232 per ton, including energy costs and facility setup, may be achievable. [163] [164]

157 "CCUS in Clean Energy Transitions," Energy Technology Perspectives, 2020.

158 Peter A. DeFazio, "Text - H.R.3684 - 117th Congress (2021-2022): Infrastructure Investment and Jobs Act," legislation, November 15, 2021, 2021/2022, http://www.congress.gov/.

159 "DOE Invests $14 Million to Scale Up Direct Air Capture and Storage Technology, Coupled to Low-Carbon Energy Resources," Energy.gov, accessed January 26, 2023,
https://www.energy.gov/fecm/articles/doe-invests-14-million-scale-direct-air-capture-and-storage-technology-coupled-low.

160 "DAC 1 – CCUS around the World – Analysis," IEA, accessed January 26, 2023, https://www.iea.org/reports/ccus-around-the-world/dac-1.

161 "CCUS in Clean Energy Transitions."

162 "CCUS in Power – Analysis," IEA, accessed June 8, 2022, https://www.iea.org/reports/ccus-in-power.

163 "Can Direct Air Capture Really Help in the Fight Against Climate Change," IDTechEx, May 28, 2021, https://www.idtechex.com/en/research-article/can-direct-air-capture-really-help-in-the-fight-against-climate-change/ 23898.

164 "What It Will Take to Achieve Affordable Carbon Removal," MIT Technology Review, accessed January 26, 2023, https://www.technologyreview.com/2021/06/24/1027083/what-it-will-take-to-achieve-affordable-carbon-removal/.

4.2 Conclusion

Washington's energy system is unique, complex, and undergoing rapid changes. It consists of two interrelated systems, the electricity system and the natural gas distribution system, each of which is required to decarbonize over the next few decades. Demographic and economic shifts, as well as trends toward electrification of the buildings and transportation sectors, are expected to increase electricity demand relative to today. Gas utilities are exploring alternative fuels such as biomethane (renewable natural gas) and hydrogen, the production of which is being promoted by state and federal law. Other resources, such as nuclear power and carbon capture, may play a role in achieving energy system decarbonization as well. With the infrastructure for both components of the energy system co-located along major transportation corridors, near population centers, and in resource-rich areas, system transformations will have to be carefully planned and implemented.

5

Global Approaches to Gas Utility Decarbonization

5 | Global Approaches to Gas Utility Decarbonization

Many countries and U.S. states, including Washington, have adopted decarbonization targets aiming to reduce emissions rapidly by 2050. Governments are enforcing their targets and mandates through a variety of policies and actions, many of which are transforming gas utilities' operations and business models. Four interconnected concerns are crucial for investor-owned gas utilities to address during the transition to a low-carbon energy system:

- Product mix (procuring and distributing low- and zero-emission fuels);
- Cost recovery and rates (maintaining fair and just customer rates as well as economic competitiveness);
- Utility regulations (policies supporting the energy transition for gas utilities); and
- Safety and reliability (ensuring reliable and safe service for customers).

Many public utility commissions and state governments in the U.S. are considering policies to decarbonize space and water heating and other systems that rely on natural gas. In tandem, some gas utilities have begun to develop plans to meet current and anticipated decarbonization requirements. In a variety of places, utilities and governments are collaborating on policy changes, shifts in business models, and infrastructure development to support new and different roles for the utilities.

The following chapter presents an overview of theoretical and actual practices for gas utility decarbonization, as explored and implemented in other places, including the prominent example of the country of Denmark, which may offer insights for Washington's context.

5.1 Product Mix

One way gas utilities can operate in a low-carbon economy is by procuring and distributing alternative fuels such as biomethane (renewable natural gas), hydrogen, and synthetic methane.[165] Biomethane can be used as a one-for-one replacement of fossil gas in the existing distribution system and appliances, while the use of hydrogen would require distribution system and appliance upgrades. If similar volumes of gas are delivered to similar customer types, gas utilities could continue operating in similar ways as they do today. However, utilities and regulators face several challenges related to the procurement and distribution of alternative fuels, including high costs, limited availability, air pollution, and greenhouse gas emissions other than carbon dioxide.

RNG is currently more expensive than natural gas. The lowest-cost sources of RNG have, for the most part, already been developed. As noted in the previous chapter, the American Gas Association estimates that RNG could fulfill less than 20% of the U.S.'s current fossil gas use.[166]

[165] These fuels are discussed in detail in Chapter 4.

[166] American Gas Foundation, "Renewable Sources of Natural Gas - Supply & Emission Reduction Assessment Study" (Washington, D.C, 2019), https://gasfoundation.org/wp-content/uploads/2019/12/AGA_3894-RNG-2-Pager_V-11.pdf.

Moreover, several states have low-carbon fuel standards and GHG emission reduction targets, which could lead to competition for supply and upward pressure on RNG prices. For example, California natural gas utilities are required to replace 12.2% of fossil gas they deliver to core customers with RNG by 2030.[167]

Gas utilities are also exploring synthetic methane (or power-to-gas), which is produced with green hydrogen and captured carbon dioxide. Producing it, however, requires considerable renewable electricity. Studies by the California Energy Commission have also found that when burned, both biomethane and synthetic methane exhibit similarly high levels of toxicity.[168]

Gas utilities are also interested in green hydrogen, but producing it from renewable electricity is cost intensive and production is in nascent stages of development in Washington.

Hydrogen's use beyond low-level blends with fossil or renewable gas would require installing a new distribution network. Moreover, as the smallest molecule on Earth, hydrogen is more prone to leaking than fossil gas. Hydrogen has significant near-term global warming potential as a result of its chemical interactions in the atmosphere; these effects are not as well understood as other greenhouse gasses.[169] A further challenge for gas utilities is that, because producing green hydrogen is inefficient relative to directly using renewable electricity, a highest and best-use paradigm would prioritize green hydrogen for harder-to-decarbonize sectors.[170]

Prioritizing the use of RNG, hydrogen, and synthetic methane to hard-to-electrify sectors such as industry, agriculture, and freight transportation is a key strategy, given these issues.[171]

However, utilities in Massachusetts, Washington, D.C., and California have created decarbonization strategies that contain plans to procure and distribute alternative fuels such as biomethane and hydrogen using their existing distribution networks.[172,173] These jurisdictions have decarbonization targets similar to those in Washington. In Washington, Northwest Natural Gas has included modeling of both RNG and synthetic gas in its Integrated Resource Plan, noting that these potential resources are "emerging technologies," which it defines as "technology that is not yet commercially available but is in some stage of development with a reasonable chance of becoming commercially available within a 20-year timeframe."[174]

167 "California Natural Gas Utilities Required by 2030 to Supply 12% RNG," Natural Gas Intelligence (blog), February 28, 2022, https://www.naturalgasintel.com/california-natural-gas-utilities-required-by-2030-to-supply-12-rng/.

168 California Energy Commission, "Air Quality Implications of Using Biogas to Replace Natural Gas in California," California Energy Commission (California Energy Commission, current-date), https://www.energy.ca.gov/publications/2020/air-quality-implications-using-biogas-replace-natural-gas-california.

169 BEIS (2022) Atmospheric implications of increased hydrogen use; Frazer-Nash Consultancy (2022) Fugitive hydrogen emissions in a future hydrogen economy.

170 Whitehead, J., Newman, P., Whitehead, J., & Lim, K. L. (2023). Striking the right balance: understanding the strategic applications of hydrogen in transitioning to a net zero emissions economy. Sustainable Earth, 6(1), 1.

171 Steve Griffiths et al., "Industrial Decarbonization via Hydrogen: A Critical and Systematic Review of Developments, Socio-Technical Systems and Policy Options," Energy Research & Social Science 80 (October 1, 2021): 102208, https://doi.org/10.1016/j.erss.2021.102208.

172 Attorney General, "Docket #20-80: Investigation by the Department of Public Utilities on Its Own Motion into the Role of Gas Local Distribution Companies as the Commonwealth Achieves Its 2050 Climate Goals," Mass.gov, June 4, 2020, https://eeaonline.eea.state.ma.us/DPU/Fileroom/dockets/bynumber/20-80.

173 Washington Gas and AltaGas, "Natural Gas and Its Contribution to a Low Carbon Future: Climate Business Plan for Washington, D.C.," March 16, 2020, https://sustainability.wglholdings.com/wp-content/uploads/Climate-Business-Plan-March-16-2020.pdf.

174 NW Natural Gas 2022 Integrated Resource Plan, submitted in TC Docket UG-210094 (Sept. 23, 2022), at 142, fn. 90.

The Danish government is closely collaborating with gas utilities to develop and distribute alternative fuels specifically for these sectors. A leader in renewable energy, Denmark began decarbonizing in the 1970s by developing vast networks of district energy, building wind turbines, increasing transit and cycling infrastructure, and retrofitting buildings.

According to recent analysis by sustainability consultancy i-Sustain, Denmark's leaders and climate experts have determined that up to 40-60% of the country's energy needs in 2050 cannot be electrified easily (in sectors such as industry, heavy trucking, aviation, and maritime). They concluded that Denmark will be unable to achieve its climate targets without significantly increasing the production and use of alternative fuels such as biogas, RNG, and hydrogen.[175] Based on this conclusion, the Danish government created policies to support deployment of biogas, including subsidies to incentivize the development of biogas production plants.[176] These policies have resulted in a sharp rise in RNG in Denmark's pipelines. By the end of 2022, RNG provided 34% of gas consumed in the country, up from 8% in 2018. The Danish government is aiming to use RNG for 100% of the country's natural gas needs by 2030.

Key to Denmark's success has been a close collaboration between the government, farmers, alternative energy developers, and utilities. Denmark's biogas program is informed by a circular economy lens, where waste products are used as much as possible to create new products. Danish laws prohibit the disposal of organic waste in landfills and set maximums for the amount of raw manure farmers can spread on their pastures, requiring excess to be transferred to another farm or to a biogas plant. Wastewater treatment plants have been fully engaged in biogas production as well. Biogas plants co-digest a diversified stream of materials rather than relying on a single waste stream, which enables a higher production output and customized fuel mixes. These practices generate valuable feedstock for the biogas industry, and have allowed utilities to take advantage of these new opportunities to reinvent themselves as clean energy providers, while creating opportunities for new companies to commercialize the products and infrastructure needed to serve the industry.

Farmers and rural landowners have been supported by the government to develop cooperatively owned biogas plants. As co-owners of the energy infrastructure, rural businesses are partners in the energy transition. This builds social cohesion and support for the projects, accelerating their development. The biogas plants are also configured to produce other valuable products such as chemical byproducts and fertilizers, making the biogas and biomethane production more economically viable. These developments have resulted in Denmark's gas system becoming much more decentralized and less reliant on a single, finite source (i.e., the North Sea gas fields) and created jobs at biogas projects across the country. Beyond biogas, Denmark is now ramping up production of renewable fuels through "Power-to-X" technologies, utilizing green electricity from wind turbines to power electrolysis plants that will split water into hydrogen and oxygen.

175 "Decarbonizing the Gas Grid: The Role of Renewable Fuels in Denmark's Path to Carbon Neutrality" (i-Sustain, April 2022), https://www.i-sustain.com/_files/ugd/384157_803bd33deebc46dda2e90ce6777a6100.pdf.

176 An annotated list of policies can be found in "Biogas Policy in Denmark: An Overview of Technology and Policy Supportive Reports from 2013 to 2021." Denmark: Biogas Go Global, 2021.

5.2 Cost Recovery and Rates

The combination of Washington's climate policy, clean energy goals, and building codes and efficiency standards have the potential to significantly drive down demand for natural gas in Washington. Demand per customer for fossil gas and alternative fuels is already declining nationally, and is likely to be lower than present day demand for natural gas, which will reduce the need for a fuel distribution system of today's shape and scale.[177] Buildings are becoming more efficient, as are appliances that use gas; electric end-use equipment is declining in price while increasing in efficiency and popularity. Over the past 50 years, residential consumption of gas has remained relatively flat, and in Washington, new gas-heated homes use 32% to 59% less gas than those built to earlier codes.[178] With restrictions on using fossil gas, driven by concerns about greenhouse gas emissions, health, and safety, the number of gas appliances, vehicles, and gas-fired power plants are expected to decline in the long term.

At the same time, gas utility revenue requirements are expected to continue to rise at approximately 1% per year based on projections of past estimates.[179] Gas utilities are required to maintain the gas distribution system for safety and reliability. In Washington, gas utilities are permitted to recover infrastructure replacement costs annually (in accordance with a 20-year pipeline replacement plan) through their customer base, outside of general ratemakings.[180,181] In addition to the costs of maintenance and upgrades, gas utilities have been making up for lower demand per customer by slowly extending the system each year to connect new customers. Nearly 20,000 residential and commercial customers were added to the gas system in 2021, a 1.5% increase over 2020.[182] However, Washington regulations will limit the number of new customers who can be brought onto the system going forward.[183]

As the number of customers using gas and overall gas demand falls but fixed costs remain flat or increase in the coming decades, utilities are likely to request dramatic rate increases to recover the revenue gap. Without policy intervention, such increases would most significantly impact low-to-moderate income customers who might remain gas customers for longer if they lack resources to retrofit and electrify their homes (Figure 24, next page).[184] An accelerated transition could lead utilities to become increasingly financially unstable, resulting in an inability to raise capital from debt and equity markets, which could threaten their ongoing ability to provide safe and reliable service.

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[177] Megan Anderson, Mark LeBel, and Max Dupuy, "Under Pressure: Gas Utility Regulation for a Time of Transition" (Montpelier, VT: Regulatory Assistance Project, May 2021).

[178] Henry Odum et al., "Modeling the Washington State Energy Code - 2006 & 2018 Baseline Energy Consumption" (Department of Enterprise Services, State of Washington, September 18, 2020), https://sbcc.wa.gov/sites/default/files/2020-11/SBCC%20BaselineStudy%20Revised_inclusive%20Final_2020_Nov6.pdf.

[179] Dan Aas et al., "The Challenge of Retail Gas in California's Low-Carbon Future: Technology Options, Customer Costs, and Public Health Benefits of Reducing Natural Gas Use" (California: California Energy Commission, April 2020).

[180] Washington Utilities and Transportation Commission, Commission investigation into the need to enhance the safety of natural gas distribution systems., No. UG-120715 (May 17, 2012).

[181] Washington Utilities and Transportation Commission, "Commission Policy on Accelerated Replacement of Pipeline Facilities with Elevated Risk" (2012), https://apiproxy.utc.wa.gov/cases/GetDocument?docID=101&year=2012&docketNumber=120715.

[182] "Natural Gas Annual 2021 (NGA) - Energy Information Administration - With Data for 2021," accessed March 28, 2023, https://www.eia.gov/naturalgas/annual/.

[183] Washington Utilities and Transportation Commission, Consideration of whether to continue to use the Perpetual Net Present Value Methodology to calculate natural gas line extension allowances, No. UG-210729 (September 20, 2021).

[184] Adapted from Aas, Dan, Amber Mahone, Zack Subin, Michael MacKinnon, Blake Lake, and Snuller Price. "The Challenge of Retail Gas in California's Low-Carbon Future: Technology Options, Customer Costs and Public Health Benefits of Reducing Natural Gas Use." California Energy Commission, 2020.

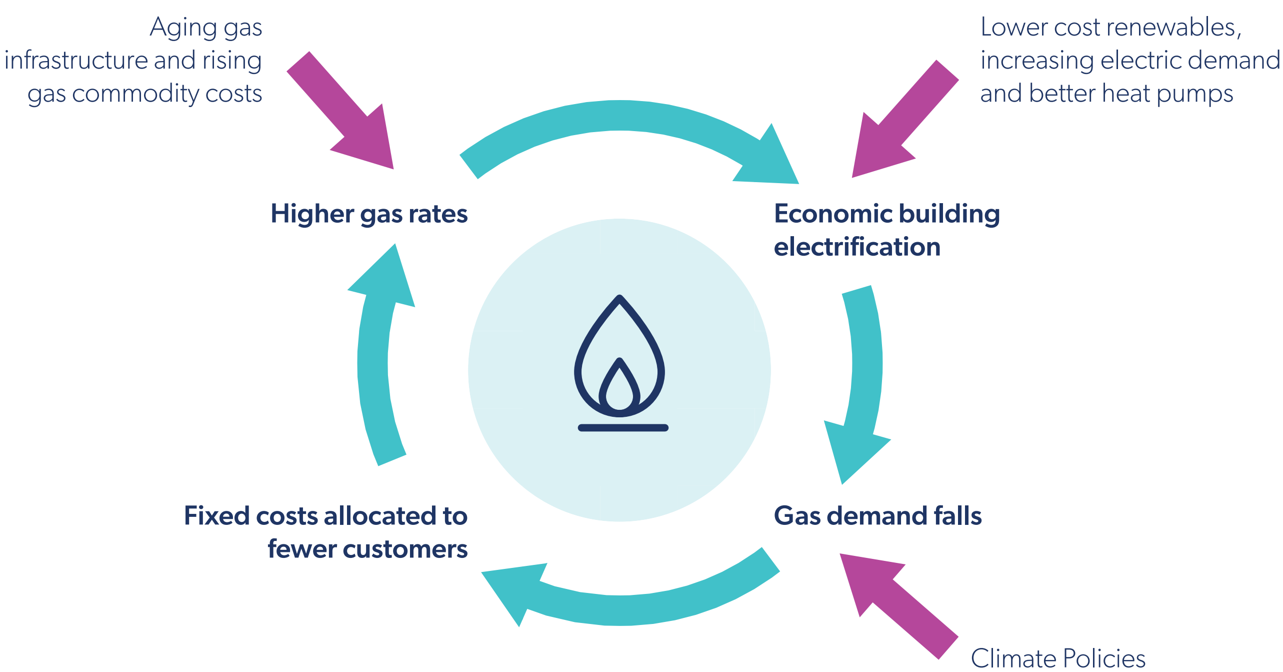

Figure 24. Outside forces driving change in the natural gas delivery sector could lead to lower gas demand and higher gas rates in future scenarios.[185]

Policy interventions to mitigate these scenarios include:

- Avoiding gas system expansion;
- Managing a strategic decommissioning of the existing distribution system; and
- Filling the financial gap between future costs and revenues.

5.2.1 Avoiding Gas System Expansion

The adoption of the new state energy codes for commercial and residential buildings will significantly curtail natural gas use for space and water heating in new buildings. However, thousands of new gas customers are still being connected to the gas distribution system each year because new developments are permitted to install natural gas for cooking stoves under current codes. Natural gas connections can cost thousands of dollars, but up until very recently, developers and homeowners in Washington seeking new gas line extensions benefitted from line extension allowances and subsidies covered by the utilities' rate base. Thus, the cost of growing the distribution system was borne by all of the users, rather than solely by newly connected homes or businesses.

In October 2021, the Washington Utilities and Transportation Commission eliminated the Perpetual Net Present Value (PNPV) calculations, adopting instead a net present value (NPV) calculation for natural gas line extension allowances within a seven-year timeframe. Customers who already submitted applications that are either approved or pending prior to April 1 2022

[185] Aas et al., "The Challenge of Retail Gas in California's Low-Carbon Future: Technology Options, Customer Costs, and Public Health Benefits of Reducing Natural Gas Use."

were able to pay rates reflecting previous tariff calculation methods.[186] The new calculations are considerably smaller than before, and are set at a level intended by the Commission to align with the state legislature's direction and policy goals and therefore the public interest.[187]

Neighboring states are acting in similar ways. In 2023, California became the first U.S. state to fully eliminate line extension allowances, citing the harmful climate, economic, and health impacts of growing the natural gas distribution system.[188] The decision by the California Public Utilities Commission is expected to save ratepayers $164 million every year. The California Public Utilities Commission has created an application process for exceptions that may be deserving of subsidies. To be subsidized, projects must demonstrate a reduction in GHG emissions and lack of feasible alternatives.

Recent building and energy code changes by the Washington State Building Code Council limit the number of new customers that may be added to the natural gas distribution system. In addition, the cities of Seattle, Bellingham and Shoreline have passed ordinances precluding new commercial and multifamily building construction from including any natural gas service. The basis for these ordinances and building code changes is that natural gas infrastructure is long-lived, with a typical distribution main lasting between 50 and 65 years. The premise for the ordinances and building code changes is that avoiding gas system expansion will reduce current development and future maintenance costs, and the number of potentially stranded assets (new infrastructure built that must be decommissioned before it is fully depreciated) as throughput declines and customers leave the system over time.

A recent Ninth Circuit Court of Appeals decision, however, may impact the ability to limit natural gas expansion in some cases. In California Restaurant Association v. City of Berkeley, a three-judge panel of the Court held that the federal Energy Policy and Conservation Act (EPCA) expressly preempts a 2019 Berkeley city ordinance banning the installation of natural gas infrastructure in newly constructed buildings, with some exceptions.[189] Statutory preemption prohibits any state regulation of the "energy use," "energy efficiency," or "water use" of certain covered products, including home appliances such as kitchen ovens. Reversing a district court's determination that EPCA preemption applies only to facial regulation of those products, the panel found that "EPCA preemption extends to regulations that address the products themselves and the on-site infrastructure for their use of natural gas."[190] The City has petitioned for en banc review by the full Court. This will be an ongoing issue for cities and states going forward. For more discussion, see Section 4.1.5 Buildings and Energy Efficiency.

[186] Washington Utilities and Transportation Commission, Consideration of whether to continue to use the Perpetual Net Present Value Methodology to calculate natural gas line extension allowances, No. UG-210729 (September 20, 2021).

[187] Washington Utilities and Transportation Commission, Consideration of whether to continue to use the Perpetual Net Present Value Methodology to calculate natural gas line extension allowances, No. UG-210729 (September 20, 2021).

[188] "CPUC Decision Makes California First State in Country to Eliminate Natural Gas Subsidies," accessed March 29, 2023, https://www.cpuc.ca.gov/news-and-updates/all-news/cpuc-decision-makes-ca-first-state-in-country-to-eliminate-natural-gas-subsidies.

[189] Cal. Rest. Ass'n v. City of Berkeley, No. 21-16278, 2023 WL 2962921 (Apr. 17, 2023) (CRA Decision).

[190] CRA Decision, p. 15.

5.2.2 Managed Decommissioning

To ensure safety and reliability, gas utilities must continually reinvest in the existing gas system. Depending on the use and utility of investments,[191] natural gas companies may spread these investments over the entire customer base, which is projected to decline over time. Managed decommissioning of the existing gas distribution system is a potentially cost-effective decarbonization strategy because it could reduce the system's overall footprint in a strategic and predictable way while reducing the need to reinvest in aging infrastructure. While limited large-scale, managed decommissioning has occurred in the U.S., the California Energy Commission recently initiated a project to develop a replicable framework for local communities to use for location-targeted building electrification and gas decommissioning. Results are forthcoming.[192]

In areas where maintenance or infrastructure investment are needed to ensure reliable or safe service, one alternative is to retire the infrastructure at that point in time, instead of repairing or replacing it, with support for remaining gas customers on that segment of the system to electrify their buildings. Utilities could be required to forecast when and where these replacements or repairs are likely to be needed, and create plans for decommissioning. Such a strategy would need different considerations for residential, commercial, and industrial customers, as the latter are more likely to continue to rely on natural gas and alternative fuels.

The gas system could also be strategically decommissioned to protect specific populations, such as low- and moderate-income customers and rural customers, from increased gas rates. This would involve geographically targeting particular areas with high concentrations of identified customers, with lower proportions of gas customers per mile of distribution, and/or areas that are most suitable for district energy systems and conversion to networked geothermal systems.

Networked geothermal systems are a novel approach to repurposing the gas utility right of way for an interconnected system of ground-source heat pumps. Home Energy Efficiency Team (HEET), a Massachusetts-based nonprofit, developed the concept as a way to continue using existing infrastructure in the transition to a low-carbon energy system. In networked geothermal systems, heat pumps in individual buildings transfer thermal energy between a shared, underground water district loop and their own heating and cooling distribution systems (see Figure 25, next page). As an interconnected system, this type of infrastructure could take advantage of "thermal waste" from entities that create significant heat, such as data centers, to reduce the amount of energy needed to heat homes and businesses.

Two networked geothermal pilot projects are being led by utilities Eversource and National Grid in Massachusetts, and another is in the works at Colorado Mesa University. The initial capital costs of such systems are estimated to be about 60% more than replacing existing natural gas infrastructure, but the systems use existing right of way and require no fuel other than electricity to power the pumps, suggesting that overall costs for customers could be lower over time.[193]

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191 See WUTC Docket U-190531 for a policy statement on Property That Becomes Used and Useful after Rate Effective Date.]https://www.utc.wa.gov/casedocket/2019/190531/docsets

192 Matthew Kahn, "E3 Undertakes Analysis of Targeted Decommissioning of Natural Gas Infrastructure in California," E3 (blog), August 26, 2022, https://www.ethree.com/e3-undertakes-analysis-of-targeted-decommissioning-of-natural-gas-infrastructure-in-califo rnia/.

193 "Volts Podcast: Audrey Schulman and Zeyneb Magavi on How to Replace Natural Gas with Renewable Heat," Podcast, Volts, April 1, 2022, https://www.volts.wtf/p/volts-podcast-audrey-schulman-and#details.

Enabling gas utilities to create zero-carbon district energy systems, such as networked geothermal grids, could potentially require changes to the statutory permissions and regulations that govern utilities, but could allow gas utilities a viable option for continuing and even expanding their operations, enabling improved financial integrity and ability to attract capital investments. Utility regulators would need to consider how rate design would work across both service offerings (especially if there were cross-subsidies proposed) during the period when the gas utilities are providing both gas and zero-carbon district energy.

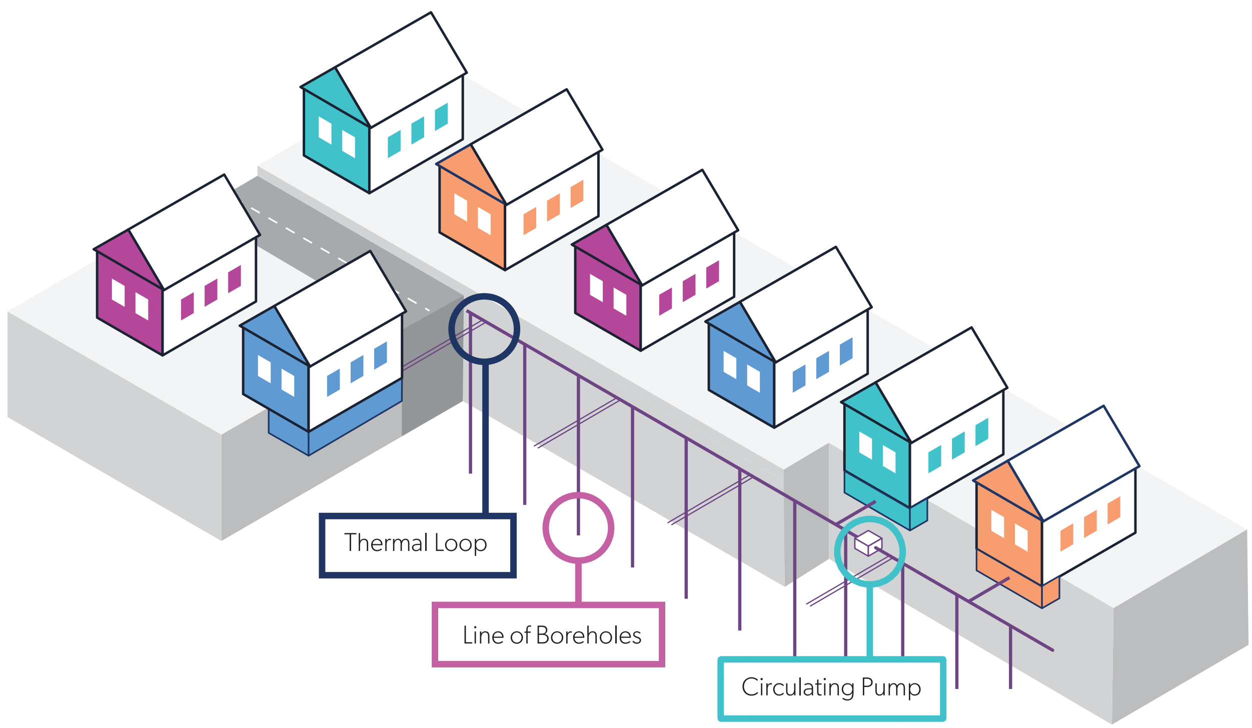

Figure 25. The GeoMicroDistrict concept for transferring heat between buildings and neighborhoods. (Image: HEET)

5.2.3 Fill the Financial Gap

To fill the gap between each utility's projected revenue requirement and expected revenues from a smaller customer base without dramatically raising rates, alternative funding sources and mechanisms need to be identified. Many of the strategies described below are being actively considered by utilities and regulators across the country.

5.2.3.1 Accelerated Depreciation of Existing Assets

Depreciation is an accounting method used to allocate the cost of a tangible or physical asset over its useful life. It is used by companies to earn revenue from the assets they own by paying for them, and recovering the cost of the asset, over a certain period of time. Depreciation helps to tie the cost of an asset, such as gas distribution service lines, with the benefit of its use over time. Accelerated depreciation recovers investments over a shorter time period than the typical useful lifetime. For example, an asset with a baseline depreciation schedule of 30 years could instead be depreciated over 15 years. Since depreciation schedules are meant to reflect the useful life of an asset, utilities could be granted the ability to use accelerated depreciation to reflect the shortened usefulness of some of their assets, given decarbonization mandates. Additionally, accelerated depreciation would allow utilities to recoup more of the fixed costs of the gas system in the short term, prior to large-scale electrification and reductions in the number of customers still using the gas system. This could have the effect of creating moderate rate increases today in exchange for less steep rate increases in the future. However, accelerated depreciation would have to be carefully paired with long-term plans to reduce gas system expenditures such as avoiding system expansion and strategic decommissioning; otherwise, it could be counterproductive to decarbonization goals.

5.2.3.2 Exit or Termination Fees

To create an additional source of revenue for natural gas utilities that addresses the problem of having fewer customers with increased costs, utilities could be allowed to impose exit fees on customers seeking to disconnect from the gas distribution system. These fees would likely be politically unpopular and discourage full building electrification or the adoption of low-emission technologies such as electric heat pumps. Such fees would be additionally burdensome for low- and moderate-income households. In Oklahoma, such a fee was considered and ultimately rejected in 2022 by the Oklahoma Corporation Commission, which governs gas utilities for the state, following a request from the utility Oklahoma Natural Gas.[194] Alternatively, a systems benefit charge could be exacted from electricity customers of electric utilities assuming service from gas customers, allowing the costs of the transition to be spread out more evenly over time. However, this could have the effect of increasing electricity rates and negatively impacting electrification efforts.

5.2.3.3 Changes to Cost Allocation and Customer Rate Design

Predictions of steep customer rate increases in the coming decades are based on cost allocations and a customer rate design using today's methods. Currently, gas customers pay for gas delivery based on how much they use the system. Use of the system typically includes total annual consumption as well as peak demand. Residential and small-scale commercial customers tend to have higher peak demands due to winter space heating loads, thus these customer classes tend to pay higher rates. As the number of these customers decreases over time, steep rate increases for remaining customers could be mitigated by allocating distribution costs, (which could include transmission, distribution, and storage costs), to industrial customers.

Another way utilities could change cost allocation is by charging rates based on time-of-use. Because gas prices fluctuate seasonally, and gas is often procured in large quantities and stored in preparation for times of peak demand. Alternatively, utilities could allocate administrative and general costs based on revenue, and allocate program costs (such as energy efficiency and beneficial electrification programs) based on system benefits to each customer class. One special consideration is that electric power customers and some industrial customers may be able to choose between gas service from a gas utility and electric power from the federally regulated transmission system. Cost allocation increases to these customers could drive them to leave the gas utility's service altogether.

194 "Commission: 'No' to ONG Termination Fee; 'Yes' To Fuel Cost Recovery," Oklahoma Corporation Commission, accessed March 29, 2023, https://oklahoma.gov/occ/news/news-feed/2022/commission-says-no-to-ong-termination-fee-yes-to-fuel-cost-recovery.html.

Adjustments to customer rate design can create more efficient customer behavior, lower overall system costs, and prevent unfair and inequitable customer charges during the energy transition. These changes should be introduced gradually to provide time for customers to become acquainted with them and understand their benefits and limitations. Gas utilities could adopt changes being undertaken in electric utility rate design, such as improved seasonal and monthly pricing variation for all customer types. During times of highest demand, utilities could offer demand response programs and critical peak pricing, as well as direct load control and interruptible rates for industrial customers.195 These mechanisms would allow gas utilities to directly turn down gas usage for industrial customers, preventing the need for maintaining transmission and storage infrastructure beyond certain thresholds and, thus, reducing overall system costs.

Critical peak pricing would accomplish this as well, but because periods of peak demand come during times of coldest weather, this mechanism could cause higher bills for residential customers without adjustments to cost allocations. Higher bills could be limited by measures such as inclining block structures, where the initial use ("block") of gas up until a certain threshold has one cost and use beyond that threshold has another cost. The initial block could be sized to cover typical space heating needs for residences. Palo Alto's municipal gas utility in California has adopted this type of variable pricing across seasons, charging the same amount per therm in winter and summer ($0.5038 per therm), but changing the threshold at which a higher rate is charged for additional usage ($1.288 per therm charged after first 20 therms in summer and after first 60 therms in winter). This rate design allows utilities to directly recover costs related to peak demand from the customer classes using the most gas during those times while also incentivizing lower use.

5.2.3.4 Alternative Sources of Funding

Beyond additional fees, changes to rate structures, and utility accounting mechanisms, policymakers may seek additional funding to close the projected revenue gap. Sources of funding could include state general funds or proceeds from Climate Commitment Act allowance auctions.

5.3 Utility Regulations

Gas utilities have various options for participating in and contributing to economy-wide decarbonization efforts. As detailed above, one option is to procure and distribute alternative, lower-emissions fuels using existing infrastructure and/or right-of-way. Utilities can also strategically decommission their infrastructure to reduce future costs, shift the way they charge customers for fuels to stabilize their finances, and bring in additional sources of funding to meet shortfalls. Beyond these adjustments, gas utilities could also change the scope of their services, ultimately performing a different function in a decarbonized society.

[195] Of these options, interruptible rates for industrial customers are currently in use by some gas utilities in Washington.

5.3.1 Energy-as-a-Service

Natural gas utilities are concerned about the impact of decarbonization targets on their revenues and profits. One option is to transition gas utilities from selling commodity fuels and toward selling energy as a service. Because gas utilities are allowed to earn a specific return on their investments in infrastructure, this option would require regulators to expand the definition of "infrastructure" to include energy retrofits and heat pumps.

Currently, in the energy-as-a-commodity paradigm, the costs to consumers of meeting their thermal comfort needs include the cost of energy (fossil gas, heating oil, and electricity) and the cost of owning and maintaining equipment that converts fuel to energy in buildings (e.g., the cost of replacing a fossil gas furnace or boiler, expressed as an annual cost).

In a new energy-as-a-service paradigm, gas utilities would invest in energy retrofits and electric heat pumps on behalf of their customers. Consumers would repay these investments over time and gas utilities would earn revenues through mark-ups on the cost of equipment and retrofits, through the difference in the interest rates, which the utility pays for capital, and the rate it charges consumers, and through a mark-up in the cost of electricity sold to their customers. The markup in electricity cost used in this simple analysis is based on the assumption that gas utilities would effectively buy electricity at transmission or industrial rates, and sell electricity to consumers at retail rates.

This type of service change would require gas utilities and electric utilities to cooperate in their planning and operations. For that reason, this may be a particularly interesting option for Washington's combined electric and gas utilities where they have overlapping service areas.

In this new paradigm, consumers would pay lower costs for energy, but higher costs for energy retrofits and heat pump installations when compared to the energy-as-a-commodity paradigm (see the table below). The initial goal would be no net increase in the total cost to consumers of meeting their thermal comfort needs and no net loss of revenues to utilities.

The table below (next page) shows an illustrative comparison of the costs to consumers, and revenues for utilities for the two cases.

Table 8. Annual costs of energy as a commodity versus energy as a service.

Consumer view (per home)	**Energy as a commodity**	**Energy as a service**	**Capital cost**
Cost of energy[196]	$2,200	$700	
Cost of furnace[197]	$368	-	$5,000
Cost of water heater[198]	$123	-	$1,000
Cost of maintenance[199]	$50	$50	
Payments (equipment, retrofit)[200]		$1,988	$31,050
Total	$2,741	$2,738	
Cost change for consumer		-$4	

Utility view (per home)	**Energy as a commodity**	**Energy as service**	**Capital cost**
Revenue from energy sold[201]	$2,200	$700	
Cost of energy to utility[202]	-$1,320	-$420	
Net revenue from energy[203]	$880	$280	
Revenue from services[204]		$1,988	
Cost of equipment and retrofit[205]		-$1,383	$27,000
Total	$880	$885	
Net revenue change for utility		$5	

196 The energy-as-a-commodity (baseline) cost of energy to the consumer is based on fossil gas furnaces and electric water heaters (note that a carbon tax would increase this cost). The energy-as-a-service cost is based on the cost of electricity for heat pumps for space heating and water heating serving a more efficient (retrofitted) building.

197 The annual cost is based on a replacement value of $5,000 for a gas furnace that is conventionally owned by a building owner and an amortization period of 20 years.

198 The annual cost is based on a replacement value of $1,000 for an electric water heater that is conventionally owned by a building owner and an amortization period of 10 years.

199 Assumed to be equal in both cases.

200 This is the capital cost (which is financed) to the consumer for a heat pump for heating, cooling, and water heating, and for an energy retrofit. The capital cost is based on a mark-up on the utility's cost of 15%, and the payments are based on an interest rate charged to the consumer by the utility of 4.0% and an amortization period of 25 years. It is possible that these loans would need to be attached to the property title so that, when a building is sold, the new owner continues to make payments.

201 These are the payments for fossil fuels or electricity made by the consumer.

202 This is the wholesale cost of energy to the utility, based on the assumption that the wholesale cost is 60% of the retail cost.

203 This is the difference between the wholesale cost of energy to the utility and the price for which it is sold to consumers.

204 These revenues are equal to the payments made by consumers for heat pumps and energy retrofits.

205 Based on an interest rate to the utility of 2% (e.g., long-term bonds) and an amortization period of 25 years. The utility would use bulk purchase agreements to secure lower wholesale costs for materials and installation services than building owners could.

This analysis does not take into account the additional value of comprehensive retrofits to building owners. When a retrofit improves the envelope of a building, the work often includes replacing components that would need to be replaced at some later time, independent of the energy equipment retrofit. For example, the existing windows in a building could have a few years of life remaining, but are replaced today as part of a comprehensive energy retrofit. The avoided cost of replacing these windows in the future is a real economic value to the building owner. The same argument applies to heat pumps: a retrofitted building with an economical heating and cooling system is worth more than an un-improved building.

Another benefit of this strategy is that it can overcome the barriers to action on the part of consumers and building owners regarding energy improvements. It's simple for consumers to continue to pay a bill for fossil gas, but it can be burdensome for most consumers and building owners to afford or know how to go about retrofitting an older building and replacing fossil fuel burners with electric heat pumps. If a utility manages the entire process on behalf of consumers and building owners, then this barrier of expertise and capital can be overcome.

The steps would include:

1. **Design:** determining the best strategy for retrofitting the building, the best heat pump technology, etc.;
2. **Contracting:** choosing qualified tradespeople to carry out the work; and
3. **Cost management:** guaranteeing a fixed monthly cost to the building owner to repay the investment in retrofits and heat pumps.

This simple analysis suggests that it could be possible to achieve this transition without increasing costs for consumers or decreasing revenues for utilities. Apart from significant greenhouse gas reductions, this arrangement would also tend to insulate consumers and utilities from fuel price volatility, particularly if the introduction of biomethane and other synthetic fuels increases the costs of gas) and the energy portion of the total costs will be lower for consumers and utilities.

With this concept, gas utilities would be entering an already established building retrofits market. This raises key questions about the fairness of regulated gas utilities competing with businesses that have access to unregulated capital. The Regulatory Assistance Project suggests that this option may be more successful if gas utilities are converted from being regulated to unregulated entities.206 This would remove a guaranteed return on investment but allow gas utilities' resources and expertise to be used in new ways that directly support decarbonization.

5.3.2 Performance-Based Regulations

Typical approaches to utility regulation, known as traditional cost-of-service ratemaking, incentivize investing in infrastructure and capital because doing so can allow utilities to earn a return on their investments. To address this issue, utility regulators in Washington and beyond are exploring performance-based rate-making. The purpose of this regulatory approach is to more closely align utilities' financial interests with those of their customers and the jurisdictions within

[206] Megan Anderson, Mark LeBel, and Max Dupuy, "Under Pressure: Gas Utility Regulation for a Time of Transition" (Montpelier, VT: Regulatory Assistance Project, May 2021).

which they operate.[207] There is not necessarily a distinct line between cost-of-service ratemaking and performance-based ratemaking, and regulators in many states, including Washington, currently combine elements of both approaches to reduce risks and promote specific objectives.

Performance-based rate-making includes a number of mechanisms, including multiyear rate plans, revenue decoupling, and performance incentives.

The UTC has approved decoupling mechanisms for the majority of the state's electric and gas investor-owned utilities for over 10 years. Under Senate Bill 5295, passed by the Legislature in 2021, Washington utilities must file multiyear rate plans when they file general rate cases. SB 5295 also requires utilities to include performance metrics in the multi-year rate plan proposal, and requires the UTC to initiate a performance based regulation proceeding. That proceeding is currently underway.

Multiyear rate plans stabilize utility revenues over a period of time by calculating a limited allowed revenue growth, and can also include mechanisms to reduce regulatory lag, the timing difference between when utilities make investments and when they recover revenues from customers to pay for the investments. As of 2017, multiyear rate plans are a feature of utility regulation in 18 states.[208]

Revenue decoupling is also already a component of ratemaking for Washington's gas and electric utilities. Decoupling removes the link between utility revenue and commodity (gas or electricity) sales by allowing price adjustments to account for variations in sales and to ensure that actual revenues collected match the allowed revenues. Regulators then have the authority to determine how mismatches between actual revenues and allowed revenues are handled; for example, whether customers may be refunded if revenues are higher than expected, or how to distribute surcharges if revenues are lower than expected.

Performance metrics can be developed to track how each utility is achieving specific objectives, such as constraining costs, enhancing customer satisfaction, improving system efficiency, and meeting decarbonization targets. Metrics can range from simple reporting of operations (service reliability, rates and revenues, etc.) to scorecard evaluations (progress against energy efficiency program spending and clean energy capacity targets). These metrics can then be used to build mechanisms that reward utilities financially for achieving and reporting particular goals, such as developing and implementing a plan to support strategic decommissioning of the gas system. One such proposal suggests that bonuses be paid to executives if the goals are met, and could be a low-cost way for utilities to attract and retain skilled employees during the critical transition period.[209]

Utility regulators across the world are beginning to use performance metrics to financially reward utilities for achieving certain goals. Ofgem, the utility regulator in the United Kingdom, requires utilities to demonstrate how they intend to align the structure of pay and reward within the organization with components of their business plan.[210] In 2019, the Minnesota Public Utilities Commission adopted desired outcomes and 36 associated performance metrics for Xcel Energy. In New York, as part of its Reforming the Energy Vision package, investor-owned utilities report

207 Elaine Prause and Jessica Shipley, "Performance-Based Regulation: Considerations for the Washington Utilities and Transportation Commission," n.d., 34.

208 Prause and Shipley.

209 Jackie Nock, "Rate Setting for an Electrified World," 2022.

210 Nock.

on scorecard metrics in order to potentially earn more revenue. ConEdison's scorecard metrics included distributed energy resource utilization, residential energy intensity, commercial energy intensity, and multifamily and public energy intensity. In 2018, it scored high enough in distributed energy resource utilization to earn $8.3 million in a cash payout.[211]

The Washington Utilities and Transportation Commission is currently in the process of reviewing how it regulates utilities as part of a five-year plan to examine and implement performance-based alternatives to traditional ratemaking. According to its current plans, the Commission intends to establish specific performance targets for each utility beginning in 2024.[212] Performance standards being considered by the Commission include reliability of utility service for different communities using an equity lens, utilities' preparation and response to severe weather, the effectiveness of utility infrastructure investments and maintenance spending, and investments in clean energy. As performance-based ratemaking evolves in Washington, decoupling, performance metrics, and multiyear rate plan designs may come to guide utility investment motivations through decarbonization of the energy system.

5.3.3 Integrated Resource Planning and Combining Utilities

Gas and electric utilities in Washington are required to file multiyear integrated resource plans (IRPs), a practice recommended by the Regulatory Assistance Project. However, regulators may want to consider requiring further coordination between gas and electric utilities in developing IRPs. The trend toward electrification impacts the gas industry alongside electric utilities, which must plan for increased loads. Without coordination, gas and electric utilities may make different assumptions about the pace and scale of electrification, with subsequent implications for the demand for gas and alternative fuels.

At present, gas and electric utilities are aware of other utilities' plans but these processes merely run parallel to each other rather than being coordinated. An enhanced IRP process to support gas utility decarbonization could involve requiring combined gas and electric utilities (such as Avista and Puget Sound Energy) to merge data from their gas and electric systems to develop one integrated energy plan. However, this may only be applicable in areas where service territories overlap. Another option could be to coordinate separate gas and electric utility planning via a neutral, overarching council or even by a coordinated group of representatives from various state agencies. This could ensure all relevant climate- and decarbonization-related policy mandates are considered while developing each utility's resource plan.

This policy could be enhanced by additional coordination with municipalities regarding their climate action plans to align community visions with energy planning processes. Municipalities can shape energy demand through land-use planning and other policies, as they develop climate action plans, ordinances, and programs that directly impact energy services.

[211] Prause and Shipley, "Performance-Based Regulation: Considerations for the Washington Utilities and Transportation Commission."

[212] "Performance-Based Regulation (PBR)," Washington Utilities and Transportation Commission, accessed March 30, 2023, https://www.utc.wa.gov/performancebased. Docket U-210590.

5.3.4 Regulations on Marketing and Terminology

Gas utilities may seek to prolong the transition away from selling fossil gas as a commodity through targeted messaging and marketing campaigns that promote the continued use of gas and gas utility services. Numerous consultant reports recommend that gas utilities promote the use of gas as a preferable option for cooking, for example, to promote a "balanced discussion of decarbonization policies."[213]

Gas utilities and fossil fuel companies are aware that the terms used to communicate about this fossil fuel can have different effects. The phrase "natural" gas is promoted over terms like "methane." A study by the Climate Communications Lab at Yale University found that "natural gas" evokes positive associations to themes like energy, clean, fuel, and cooking compared to "methane," which survey respondents associated with cows, greenhouse gas, global warming, and climate change, even though the terms refer to the same substance.[214]

The fossil fuel industry has positioned fossil gas as a "clean" option and a "bridge" fuel in the transition to a low-carbon economy. Organizations such as the Energy Solutions Center create educational and marketing materials to promote "energy efficient natural gas solutions and systems,"[215] including a recent ad that makes the false claim that "electricity is only 30% efficient" while "natural gas is 90% efficient."[216] Fossil fuel companies have also been successful in providing their viewpoints to children and their families in the form of educational materials for schools. These types of campaigns aimed at schoolchildren have been led by utilities such as FortisBC in British Columbia,[217] Eversource in Cambridge, Massachusetts,[218] and by trade organizations such as the New Mexico Oil and Gas Association.[219]

Countries and cities worldwide have taken steps to limit such efforts. In August 2022, France became the first European country to ban advertisements for all energy products related to fossil fuels; natural gas ads are still allowed but expected to be limited by further rulemaking in 2023. Companies that break the rules are subject to fines between 20,000 and 100,000 euros.[220] The City of Amsterdam adopted similar regulations in 2021, prohibiting advertisements of fossil fuel powered cars and flights in areas such as the subway and city center.[221] Sydney, Australia, is also considering adopting similar rules.

213 "Decarbonization Policies Mean Utilities Must Change | McKinsey," accessed March 1, 2022, https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/are-us-gas-utilities-nearing-the-en d-of-their-golden-age.

214 Karine Lacroix et al., "Should It Be Called 'Natural Gas' or 'Methane'?," Yale Program on Climate Change Communication (blog), accessed March 30, 2023, https://climatecommunication.yale.edu/publications/should-it-be-called-natural-gas-or-methane/.

215 "About Us," accessed March 30, 2023, https://www.energysolutionscenter.org/about/default.aspx.

216 "Where_Does_Gas_Come_From_60_unbranded_WEB_SMALL.Mp4," accessed March 30, 2023, https://videos.myescenter.com/Where_Does_Gas_Come_From_60_unbranded_WEB_SMALL.mp4.

217 "Why Are Oil-and-Gas Companies Developing Lesson Plans for Teachers? | The Walrus," August 26, 2022, https://thewalrus.ca/why-are-oil-and-gas-companies-developing-lesson-plans-for-teachers/.

218 Ysabelle Kempe, "How Natural Gas Propaganda Made It into Elementary Classrooms," Grist, May 19, 2021, https://grist.org/culture/how-natural-gas-propaganda-made-it-into-elementary-classrooms-in-deep-blue-america/.

219 Leanna First-Arai, "How the Oil and Gas Industry Is Trying to Hold US Public Schools Hostage," The Guardian, May 4, 2022, sec. Environment, https://www.theguardian.com/environment/2022/may/04/oil-and-gas-industry-us-public-schools.

220 Rosie Frost, "France Becomes the First European Country to Ban Fossil Fuel Adverts," euronews, August 24, 2022, https://www.euronews.com/green/2022/08/24/france-becomes-first-european-country-to-ban-fossil-fuel-ads-but-does-the-new-law-go-far-e.

221 "Amsterdam to Become First City in the World to Ban This Type of Advert," euronews, May 20, 2021, https://www.euronews.com/green/2021/05/20/amsterdam-becomes-first-city-in-the-world-to-ban-this-type-of-advert.

6

Equity and the Just Transition

6 | Equity and the Just Transition

This chapter describes the current state of energy access and energy burden in Washington state, as well as legislation and key considerations related to equity, energy, and climate action. The energy transition has the potential to decrease or worsen inequities depending on which decarbonization actions are selected and how they are implemented.

6.1 The Role of Equity in This Project

Senate Bill 5092 lays out three key considerations for this study related to equity. According to that proviso, the study must identify and consider:

- "The costs and benefits to residential and commercial customers, including environmental, health, and economic benefits;
- "Equity considerations and impacts to low-income customers and highly impacted communities; and
- "Potential regulatory policy changes to facilitate decarbonization of the services that gas companies provide while ensuring customer rates are fair, just, reasonable, and sufficient."

6.2 Key Definitions

In identifying the impacts of decarbonizing gas utilities with an equity lens, the consulting team used definitions informed by Washington state laws and policies.

Table 9. Equity-related terms, definitions, and sources.

Term	Definition	Source
Environmental justice	"The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, rules, and policies. Environmental justice includes addressing disproportionate environmental and health impacts in all laws, rules, and policies with environmental impacts by prioritizing vulnerable populations and overburdened communities, the equitable distribution of resources and benefits, and elimination of harm."	Healthy Environment for All (HEAL) Act, 2021 RCW 70A.02.010
Low-income household	A household whose "income does not exceed the higher of 80% of the area median income or 200% of federal poverty level, adjusted for household size."	Washington Administrative Code 180-109-060

Term	Definition	Source
Highly impacted communities	"Highly impacted communities meet at least one of the following two criteria: • "The census tract is covered or partially covered by 'Indian Country' as defined in and designated by statute. • "The census tract ranks a 9 or 10 on the Environmental Health Disparities Map, as designated by the Department of Health."	Washington State Department of Health[222]
Vulnerable populations	"Communities that experience a disproportionate cumulative risk from environmental burdens due to: (a) Adverse socioeconomic factors, including unemployment, high housing and transportation costs relative to income, access to food and health care, and linguistic isolation; and (b) Sensitivity factors, such as low birth weight and higher rates of hospitalization." "'Vulnerable populations' includes, but is not limited to: • Racial or ethnic minorities; • Low-income populations; • Populations disproportionately impacted by environmental harms; and • Populations of workers experiencing environmental harms."	RCW 19.405.020 RCW 70A.02.010

In addition to considering the definitions above, the Energy Decarbonization Pathways Examination considered the principle of a "just transition" to a decarbonized energy system. This study borrows a definition from the Just Transition Alliance (JTA), a California-based organization that serves Black, Indigenous, and people of color, as well as low-income communities and workers, threatened by polluting industries. The JTA lays out the principle as follows:

"The principle of just transition is that a healthy economy and clean environment can and should co-exist. The process for achieving this vision should be a fair one that should not cost workers or community residents their health, environment, jobs, or economic assets."

Critically, the definition of equity must be flexible to adapt to diverse contexts. "Many definitions of equity exist, and no single definition can perfectly capture the expectations and goals of all communities and populations," the Washington State Energy Strategy says. The strategy

[222] Washington Tracking Network--EPH-WTN--4300, "Instructions for Utilities to Identify Highly Impacted Communities," Washington State Department of Health, accessed November 10, 2023, https://doh.wa.gov/data-statistical-reports/washington-tracking-network-wtn/climate-projections/clean-energy-transformation-act/ceta-utility-instructions.

elaborates that groups falling into particular categories, such as "highly impacted communities," should not be considered as a monolith. "Each community, family, and individual will have different histories and needs. There is no one-size-fits-all approach to equitable design," the strategy explains.[223]

6.3 Energy and Inequity

Low-income households across the United States face high energy costs that can make it difficult for them to meet their household needs. In 2020, one in 10 of Washingtonians lived in poverty[224] and, in 2018, one in four Washington residents struggled financially to meet their basic needs.[225] Additionally, between 2017 and 2019, 9.9% of households, on average, were food insecure.[226] During the pandemic, the rate of food insecurity increased to 27%.[227] Poverty is more prevalent east of the Cascades.

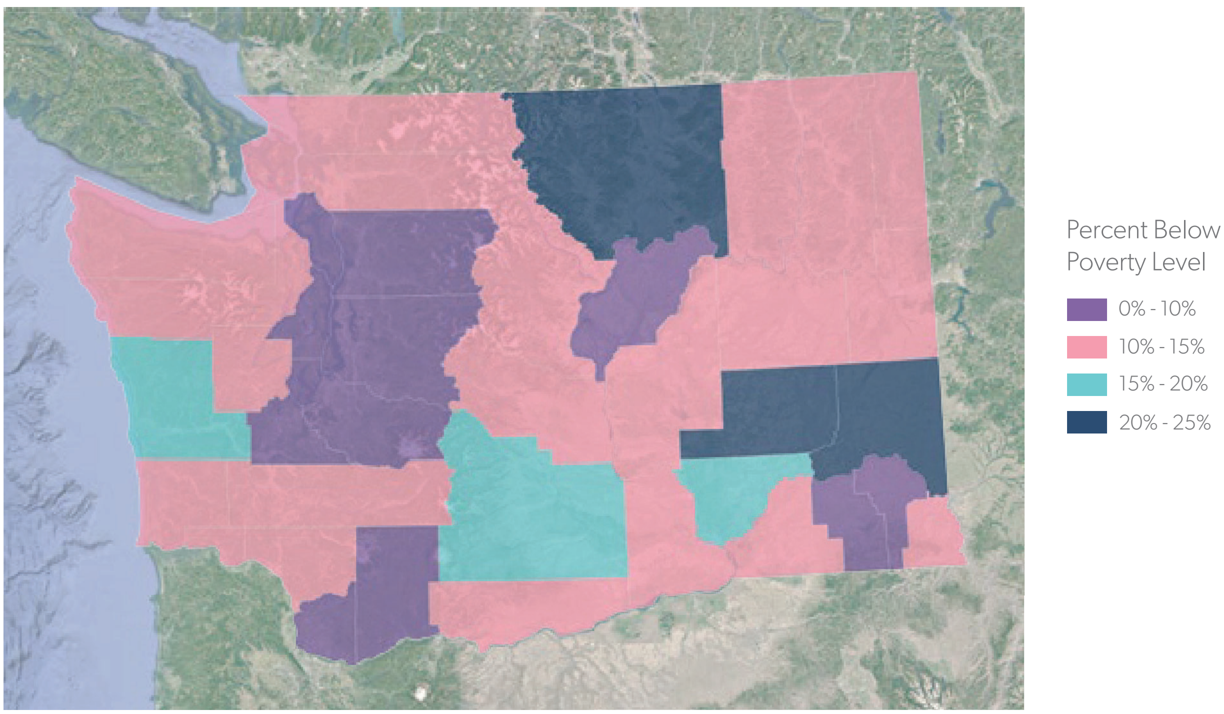

Figure 26. Map showing percentage of families in poverty by census tract or county in Washington, 2021.

[223] Washington State Department of Commerce. (Dec. 2020). Washington 2021 State Energy Strategy: Transitioning to an Equitable Clean Energy Future. https://www.commerce.wa.gov/wp-content/uploads/2020/12/Washington-2021-State-Energy-Strategy-December-2020.pdf

[224] U.S. Census Bureau (2022).

[225] Governor Inslee's Poverty Reduction Workgroup, "Interim Progress Report," October 2018, https://www.governor.wa.gov/sites/default/files/PRWG_2018InterimProgressReport_FINAL.pdf.

[226] "Washington Report - 2020," Talk Poverty, accessed March 25, 2022, https://talkpoverty.org/state-year-report/washington-2020-report/.

[227] "Food Insecurity Remains High and Need for Assistance Dramatically up in Washington," UW News (blog), accessed March 29, 2022, https://www.washington.edu/news/2021/07/30/food-insecurity-remains-high-and-need-for-assistance-dramatically-up-in-washington/.

Low-income households tend to have high energy cost burdens in part because their homes tend to be draftier, older, and have poorer insulation than those of wealthier households, making them energy inefficient. According to the U.S. Department of Energy, cost-effective energy efficiency measures, such as improving insulation and installing more efficient appliances, have the potential to reduce energy use by 13-31% in households below the 80% Area Median Income in the 48 contiguous states.[228]

A household faces a high energy burden when it spends more than 6% of its income on energy and a severe energy burden when it spends more than 10% of its income on energy. In 2018, 11% of low-income households (defined as households below 200% the federal poverty level) across Washington faced a high or severe energy burden.[229]

Energy burdens tend to be higher among Black, Hispanic, and Native American households, as well as elderly households.[230] For example, an analysis of household energy burdens in Seattle found that 14% of Black households and 15% of Hispanic households in the area experience a high energy burden (above 6%), compared to a citywide median energy burden of 1.8%. The study also found that the median energy burden of Black households in Seattle is 28% higher than that of non-Hispanic White households.[231]

Additionally, BIPOC populations are disproportionately represented among those living in poverty. For example, 21% of Native Americans are below the poverty line, even as they account for under 2% of the population. Similarly, 16.4% of African Americans are below the poverty line, even as they account for 4.4% of the population. In contrast, 8.2% of White people are below the poverty line even as they account for 67.5% of the population.[232]

The rate of high energy burden in low-income households varies across Washington. Thirty-seven percent of low-income households in Ferry County experience a high energy burden, compared to 6% in Snohomish County. Largely rural counties in the eastern two-thirds of the state tend to face higher household energy burden levels; in many of them, the low-income household energy burden exceeds 20%.[233] These numbers are in line with national trends: rural American households have a median energy burden three times higher than urban ones.[234]

These inequities have implications for decarbonization. Lower-income households stand to gain the most from cost-saving measures, such as energy efficiency retrofits that reduce energy bills, but have the fewest resources to implement them. They are also less able than wealthier households to engage in the financial and employment opportunities linked to the energy transition. The way in which decarbonization policies are implemented can increase existing inequities or reduce them by considering how to address the needs of Washington's diverse populations.

228 U.S. Department of Energy Office of Energy Efficiency & Renewable Energy, "Low-Income Household Energy Burden Varies Among States - Efficiency Can Help In All of Them" (U.S. Department of Energy, December 2018); Ariel Drehobl, Lauren Ross, and Roxana Ayala, "How High Are Household Energy Burdens? An Assessment of National and Metropolitan Energy Burden across the United States" (American Council for an Energy-Efficient Economy, 2020), https://www.aceee.org/research-report/u2006.

229 Washington State Department of Commerce. Revised: Statewide energy burden data [RCW 19.405.120(3).], (April 29, 2021), distributed by Washington State Department of Commerce, https://deptofcommerce.app.box.com/s/czuj8tqaj9i5i7c8gyhld8htscbn9xsk.

230 Drehobl, Ross, and Ayala, "How High Are Household Energy Burdens? An Assessment of National and Metropolitan Energy Burden across the United States."

231 American Council for an Energy-Efficient Economy, "Energy Burdens in Seattle," September 2020, https://www.aceee.org/sites/default/files/pdfs/aceee-01_energy_burden_-_seattle.pdf.

232 "Washington Report - 2020."

233 Washington State Department of Commerce. Revised: Statewide energy burden data.

234 Lauren Ross, Ariel Drehobl, and Brian Stickles, "The High Cost of Energy in Rural America: Household Energy Burdens and Opportunities for Energy Efficiency" (American Council for an Energy Efficient Economy, July 18, 2018).

6.4 Relevant Legislation

Legislation passed in the 2019, 2020, and 2021 legislative sessions includes provisions to consider the equity implications of the costs and benefits of decarbonizing the energy system and activities within the state.

Table 10. Legislation passed since 2019 relating to equity and energy system decarbonization.

Legislation	Equity and social justice impacts
Clean Energy Transformation Act Chapter 288, Laws of 2019 (SB 5116)	• Requires utilities to consider the social cost of emissions — the economic cost of emitting one additional ton of a greenhouse gas into the air — in resource planning. • Requires utilities to assess the impact of their operations on vulnerable and highly impacted communities. • Requires utilities to create low-income energy assistance programs to ensure the clean energy transformation will be equitable and reduce the energy burden of vulnerable and highly impacted communities. • Commission rules developed to enforce CETA require utilities to create utility equity advisory groups to discuss the equitable distribution of benefits and reduce harm to overburdened communities.
Healthy Environment for All (HEAL) Act, Chapter 314, Laws of 2021 (SB 5141)	• Requires seven state departments, including Commerce and Ecology, to operationalize environmental justice practices and procedures within their work. This includes developing environmental justice assessments to identify environmental justice impacts caused by significant agency actions, such as loan programs, legislative rules, or budget and funding assessments. • Authorizes the creation of an Environmental Justice Council that advises the seven departments on incorporating environmental justice into their plans, budgets, and policies. The Environmental Justice Council brings together environmental justice advocates, practitioners, and state agency representatives.
Climate Commitment Act, Chapter 316, Laws of 2021 (SB 5126)	• Proceeds from auctioning emissions allowances will be used to advance the transition to clean energy, transportation, and climate resiliency. Thirty-five percent of the funds must go toward projects serving overburdened communities and 10% must go to Tribal projects. • Authorizes the newly created Environmental Justice Council to make recommendations to the State Legislature regarding projects funded by the CCA and monitors the progress of CCA-funded projects on their environmental justice goals and progress on decreasing emissions and pollutants. Ecology must adopt additional measures if sufficient reductions have not occurred.

6.5 Equity in The Washington State Energy Strategy

The Washington State Energy Strategy states that "historical energy policy has been based on an incomplete understanding of equity" and provides guidance for understanding how to create equitable outcomes with decarbonization. The strategy focuses on five themes.

First, the strategy recommends considering the distribution of the costs and benefits of decarbonization: "The clean energy transition will not be equitable if it benefits only a few or if the costs are not fairly distributed across communities. The institutions largely responsible for our current inequities share a common responsibility to assist highly impacted populations and ensure their participation in the clean energy transition."

Second, the strategy highlights the importance of considering equity in a holistic manner, rather than focusing on specific metrics such as energy costs: "Equity must consider the price of energy but also energy sufficiency and the health and economic impacts from energy production. It is not an equitable result if everyone receives low electricity rates and gas prices, while highly impacted populations disproportionately bear the health and economic costs of our energy system or lack sufficient energy to live healthy, productive lives."

Additionally, the strategy says public participation and the inclusion of historically marginalized voices is essential to generate support for decarbonization, ensure implementation is shaped by local knowledge and meets local needs, and to avoid worsening inequities.

Fourth, the strategy says that energy resilience must be prioritized in energy policy and planning.

Finally, the strategy calls for "embed[ding] equity into the design of clean energy policies and programs." It recommends focusing on three dimensions: structural equity, procedural equity, and distributional equity.

6.6 Key Equity Considerations

To achieve a just transition, decision-makers must assess equity considerations when evaluating a given decarbonization pathway or selecting a set of actions for decarbonization. This section details key equity considerations for energy decarbonization pathways based on desk research and input from interested and impacted communities.

6.6.1 Demand-Side Equity Considerations and Impacts

6.6.1.1 Air Quality

One of the most beneficial and immediate health benefits of actions to reduce GHG emissions is improved air quality. Air pollution can harm human health from prenatal development through to old age. Research indicates that air pollution has an impact on "virtually all systems in the human body."[235] Air pollution from fossil fuels has been linked to the development of neurological

[235] Academy of Science of South Africa et al., "Air Pollution and Health – A Science-Policy Initiative," Annals of Global Health 85, no. 1 (December 16, 2019): 140, https://doi.org/10.5334/aogh.2656.

disorders including Parkinson's disease, Alzheimer's disease and other dementias,[236,237] acute bronchitis in children, asthma, other respiratory illnesses, heart disease, stroke, and increasing cancer risks.[238, 239]

In addition to reducing outdoor air pollution, decarbonization can also reduce indoor air pollution. People typically spend 90% of the time indoors,[240] where concentrations of pollutants are two to five times higher than typically found outdoors. The phenomenon of "sick building syndrome," prevalent in the 1980s and 1990s and continuing today, in addition to the COVID 19 pandemic, helped public health officials to identify building indoor air quality as a major health-influencing factor. Improvements in ventilation systems and less toxic building materials (e.g., insulation, wall paneling) improves air quality, often while reducing energy use. Improving energy efficiency can also affect health directly by influencing indoor temperatures, the use and cost of energy (with indirect effects on financial choices for low-income families), and the emission of toxic pollutants to the local environment.[241] Buildings with more stable and comfortable indoor environments have been found to reduce the risk of deaths from cold and hot spells, and indirectly reduce school absenteeism.[242]

Cooking with gas stoves can spike emissions of nitrogen dioxide and carbon monoxide to levels higher than outdoor standards set by the EPA and some states.[243] According to the Rocky Mountain Institute, homes with gas stoves can have nitrogen dioxide levels that are 50-400% higher than homes with electric stoves.[244] Even in low concentrations, nitrogen dioxide is a toxic gas that can trigger breathing problems for those who live with asthma or chronic obstructive pulmonary disease and increase the risk of respiratory infections particularly in children. Ongoing exposure can lead to the development of acute or chronic bronchitis.[245,246] A meta-analysis of the effects of nitrogen dioxide found that children who live in homes equipped with gas stoves have about a 20% increased risk of developing respiratory illness.[247] Children are particularly susceptible to illnesses associated with air pollution due to having higher breathing rates, greater levels of physical activity, higher surface-area-to-body-weight ratios, and immature respiratory

236 Liuhua Shi et al., "Long-Term Effects of PM2·5 on Neurological Disorders in the American Medicare Population: A Longitudinal Cohort Study," The Lancet Planetary Health 4, no. 12 (December 2020): e557–65, https://doi.org/10.1016/S2542-5196(20)30227-8.

237 Muye Ru et al., "Exploration of the Global Burden of Dementia Attributable to PM2.5: What Do We Know Based on Current Evidence?," GeoHealth 5, no. 5 (2021): e2020GH000356, https://doi.org/10.1029/2020GH000356.

238 ORD U.S. EPA, "Research on Health Effects from Air Pollution," Overviews and Factsheets, October 28, 2020, https://www.epa.gov/air-research/research-health-effects-air-pollution.

239 Emily York et al., "Climate and Health in Oregon - 2020 Report" (Portland, OR: Oregon Health Authority, December 2020), https://www.oregon.gov/oha/PH/HEALTHYENVIRONMENTS/CLIMATECHANGE/Documents/2020/Climate%20and%20 Health%20in%20Oregon%20 2020%20-%20Full%20Report.pdf.

240 U.S. Environmental Protection Agency (EPA). 1989. Report to Congress on Indoor Air Quality — Vol. II: Assessment and Control of Indoor Air Pollution. EPA/400/1-89/001C. Washington, D.C.: U.S. EPA. Available at tinyurl. com/CCN-2013-R017E

241 Milner, J., Davies, M., & Wilkinson, P. (2012). Urban energy, carbon management (low carbon cities) and co-benefits for human health. Current Opinion in Environmental Sustainability, 4(4), 398–404.

242 International Energy Agency, "Capturing the Multiple Benefits of Energy Efficiency" (Paris, France, 2014), http://www.iea.org/publications/freepublications/publication/Captur_the_MultiplBenef_ofEnergyEficiency.pdf.

243 "Gas Stoves: Health and Air Quality Impacts and Solutions," RMI, accessed September 28, 2022, https://rmi.org/insight/gas-stoves-pollution-health/.

244 Dan Slanger, "Indoor Air Pollution: The Link between Climate and Health," RMI, May 5, 2020, https://rmi.org/indoor-air-pollution-the-link-between-climate-and-health/.

245 OAR U.S. EPA, "Nitrogen Dioxide's Impact on Indoor Air Quality," Overviews and Factsheets, August 14, 2014,https://www.epa.gov/indoor-air-quality-iaq/nitrogen-dioxides-impact-indoor-air-quality.

246 Weiwei Lin, Bert Brunekreef, and Ulrike Gehring, "Meta-Analysis of the Effects of Indoor Nitrogen Dioxide and Gas Cooking on Asthma and Wheeze in Children," International Journal of Epidemiology 42, no. 6 (December 1, 2013): 1724–37, https://doi.org/10.1093/ije/dyt150.

247 Vic Hasselblad, David M. Eddy, and Dennis J. Kotchmar, "Synthesis of Environmental Evidence: Nitrogen Dioxide Epidemiology Studies," Journal of the Air & Waste Management Association 42, no. 5 (May 1, 1992): 662–71, https://doi.org/10.1080/10473289.1992.10467018.

and immune systems.[248] The American Gas Association has funded studies that dispute these claims, concluding that the existing research does not provide sufficient evidence to support them.[249]

Lower-income households and communities of color may be disproportionately impacted by indoor air pollution. These groups are more likely to live in older, smaller homes with poor ventilation and more people (higher occupant density), lack adequate stove top ventilation, and have higher rates of asthma and other respiratory diseases due to other pollutants.[250] In some cases, lower-income households may experience more exposure to pollutants from gas stoves because they are used as a source of heat when other heating systems are broken, inefficient, or not working properly.[251]

A 2021 study in California found that home cooktops, ovens, and broilers emit methane even when they are completely turned off, regardless of the age and price of the appliance.[252] In a Massachusetts study examining samples of unburned natural gas in 69 homes over 16 months, researchers found 21 “air toxics,” hazardous pollutants, including hexane, toluene, heptane, cyclohexane, and benexed, known or suspected to cause cancer, birth defects, or other health effects.[253] Exposure to benzene can cause drowsiness, dizziness, headaches, eye and skin irritations, and even increase the long-term risk of blood disorders and cancers such as leukemia.[254] Reducing the combustion of fossil fuels within homes and buildings can help alleviate a wide range of air quality health impacts and result in a more livable indoor environment for communities across Washington.

6.6.1.2 Retrofits and Energy Efficiency

In addition to reducing GHG emissions, energy efficiency retrofits reduce energy consumption and, therefore, energy costs, as well as improving the comfort of buildings. Benefits of improved energy efficiency and tighter building envelopes include reduced mold, (which has been found to directly reduce depression, arthritis and rheumatism, and injuries and death), as well as reduced allergies and symptoms of respiratory disease.[255] Improving occupant comfort and energy efficiency also reduces the likelihood of residents turning to other sources of heat, such as gas ovens and stoves, which are dangerous and harmful to health.

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248 “Gas Stoves.”

249 “New Study Finds Research on Natural Gas Cooking and Asthma Fails to Demonstrate Causal Relationship,” American Gas Association, April 20, 2023, https://www.aga.org/news/news-releases/new-study-finds-research-on-natural-gas-cooking-and-asthma-fails-to-demonstrate-causal-relationship/.

250 “Gas Stoves.”

251 “Gas Stoves.”

252 Eric D. Lebel et al., “Methane and NOx Emissions from Natural Gas Stoves, Cooktops, and Ovens in Residential Homes,” Environmental Science & Technology 56, no. 4 (February 15, 2022): 2529–39, https://doi.org/10.1021/acs.est.1c04707.

253 Drew R. Michanowicz et al., “Home Is Where the Pipeline Ends: Characterization of Volatile Organic Compounds Present in Natural Gas at the Point of the Residential End User,” Environmental Science & Technology 56, no. 14 (July 19, 2022): 10258–68, https://doi.org/10.1021/acs.est.1c08298.

254 Elena Shao, “Gas Piped Into Homes Contains Benzene and Other Risky Chemicals, Study Finds,” The New York Times, June 28, 2022, sec. Climate, https://www.nytimes.com/2022/06/28/climate/natural-gas-home-toxic-chemicals.html.

255 International Energy Agency, “Capturing the Multiple Benefits of Energy Efficiency.”

There is a risk that those who could benefit most from these changes, such as highly impacted and low-income communities, could miss out on these health benefits if they are unable to afford retrofits. Designing programs to make building improvements accessible is critical for ensuring equitable outcomes, as well as the overall success of decarbonization efforts.

6.6.1.3 Energy Costs and Energy Burden

Energy costs are an important, but insufficient, metric to evaluate affordability and equity outcomes. This is highlighted by the State Energy Strategy, as well as input from engagement with interested and impacted communities conducted for the Energy Decarbonization Pathways Examination. Energy costs are one element of a wider range of factors, from the cost of housing to health impacts, that affect affordability and equity outcomes. For example, Washington currently has some of the lowest energy prices in the country; yet, 11% of low-income households face a high or severe burden with the number increasing to above 20% in some counties.

A household faces a high energy burden when it spends more than 6% of its income on energy and a severe energy burden when it spends more than 10% of its income on energy. In 2018, one in four Washington residents struggled financially to meet their basic needs, with 10% of households experiencing food insecurity. In 2020, one in 10 Washingtonians lived in poverty, with rates of poverty being more prevalent east of the Cascades. Low-income households tend to have high energy cost burdens in part because their homes tend to be draftier, older, and have poorer insulation than those of wealthier households, making them energy inefficient, and increasing the overall energy burden they face, which is compounded by basic minimum charges and reactivation fees. In 2018, 11% of low-income households (defined as households below 200% the federal poverty level) across Washington faced a high or severe energy burden.[256]

The rate of high energy burden in low-income households varies across Washington. Largely rural counties in the eastern two-thirds of the state tend to face higher household energy burden levels; in many of them, the low-income household energy burden exceeds 20%.[257] These numbers are in line with national trends.[258] Energy burdens tend to be higher among Black, Hispanic, and Native American households, as well as elderly households.[259]

Lower-income households stand to gain the most from decarbonization-related cost-saving measures, such as energy efficiency retrofits that reduce energy bills, but have the fewest resources to implement them. They are also less able than wealthier households to engage in the financial and employment opportunities linked to the energy transition. The way in which decarbonization policies are implemented can increase existing inequities or reduce them by considering how to address the needs of Washington's diverse populations.

256 Washington State Department of Commerce. Revised: Statewide energy burden data [RCW 19.405.120(3).], (April 29, 2021), distributed by Washington State Department of Commerce, https://deptofcommerce.app.box.com/s/czuj8tqaj9i5i7c8gyhld8htscbn9xsk.

257 Washington State Department of Commerce. Revised: Statewide energy burden data.

258 Lauren Ross, Ariel Drehobl, and Brian Stickles, "The High Cost of Energy in Rural America: Household Energy Burdens and Opportunities for Energy Efficiency" (American Council for an Energy Efficient Economy, July 18, 2018).

259 Drehobl, Ross, and Ayala, "How High Are Household Energy Burdens? An Assessment of National and Metropolitan Energy Burden across the United States."

6.6.2 Supply-Side Equity Considerations and Impacts

6.6.2.1 Resource Siting Considerations

In recent years, siting of solar and wind farms in rural Washington has been a source of social and political conflict. Residents and others opposed to projects are concerned about losing farmland, blights on scenic landscapes, threats to birds and other wildlife, negative impacts on local ecosystems and lands important to tribes, and flashing lights on wind turbines.[260,261] In some cases, these tensions have led to perceptions that rural areas, especially in Eastern Washington, are being forced into these developments for the sake of urban areas.262 At the same time, rural areas can also benefit from renewable energy developments. For example, farmers stand to benefit from leasing their land for renewable development, while others could secure jobs at renewable developments.[263]

In many cases, opposition arises from a lack of community consultation or consideration of local concerns and preferences.[264] Selecting sites without consideration for community concerns and preferences can worsen rural-urban divides, violate Tribal rights to consultation, put land and ecosystems important to Tribes at risk, affect land and property values, and create health and safety concerns, among other issues, that increase inequities.[265] In addition to raising a host of equity concerns, such opposition can derail renewable energy development.[266]

Consulting and collaborating with the public and Tribes can ease concerns and enable equitable siting and project design.[267] Identifying least-conflict land — an approach to identifying land for solar or wind in collaboration with the communities — has shown promise in California and is currently being applied in parts of Washington. Recently passed legislation (HB 1216) will set up a formal, state-led process for least-conflict renewable resource siting.[268] Additionally, the Washington State Energy Strategy includes recommendations for integrating equity considerations into renewable energy developments.[269]

Tribes require special consideration due to their unique relationship with the government, and their needs should be addressed separately from public participation. Tribes wishing to create their own renewable energy developments face barriers and governance issues that may differ from other communities.[270]

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260 The Seattle Times editorial board. May 7, 2021. "Seek compromise before siting solar, wind farms in rural Washington." The Seattle Times. https://www.seattletimes.com/opinion/editorials/seek-compromise-before-siting-solar-wind-farms/; Flatt, C. May 12, 2021. "Solar power becomes 'nightmare' for some Klickitat County residents." Northwest Public Broadcasting. https://crosscut.com/environment/2021/05/solar-power-becomes-nightmare-some-klickitat-county-residents; Gilmour, D. L. Jan. 17, 2023. "New legislation takes aim at blinking lights on Washington wind turbines." Northwest Public Broadcasting. https://www.nwpb.org/2023/01/17/new-legislation-takes-aim-at-blinking-lights-on-washington-wind-turbines/

261 House Bill 1173 passed in April 2023 limits blinking red lights on wind turbines.

262 The Seattle Times editorial Board. May 7, 2021; Stang, J. Feb 4, 2022. "WA wind power farms may conflict with habitat preservation projects." Crosscut. https://crosscut.com/environment/2022/02/wa-wind-power-farms-may-conflict-habitat-preservation-projects

263 Bernton, H. May 4, 2021. "A proposed $1.7 billion wind and solar projects generates hopes and fears in South Central Washington state." The Seattle Times. https://www.seattletimes.com/seattle-news/a-proposed-1-7-billion-wind-and-solar-project-generates-hopes-and-fears-in-south-central-washington-state/

264 Sussking, L. et al.Sources of opposition to renewable energy projects in the United States. Energy Policy: 165 (June 2022), 112922. https://doi.org/10.1016/j.enpol.2022.112922

265 Sussking, L. et al.

266 Sussking, L. et al.

267 Sussking, L. et al.

268 Flatt, C. March 15, 2023. "Washington bill could help ease renewable energy development tensions." Northwest News. https://www.nwnewsnetwork.org/government-and-politics/2023-03-15/washington-bill-could-help-ease-renewable-e nergy-development-tensions

269 Washington State Department of Commerce. (Dec. 2020).

270 Sussking, L. et al.

6.6.2.2 Jobs and Economic Development

Any decarbonization pathway will have implications for the economy, generating jobs and investment in some sectors while decreasing it in others. Climate actions tend to generate more jobs than they reduce.[271] Additionally, decarbonization can lower energy costs in the long term, creating savings for households and businesses.[272]

In general, the transition to a low carbon economy is expected to have four categories of impacts on labor markets. First, additional jobs will be created in emerging sectors, such as electric vehicles and energy efficiency. Second, some employment will be shifted, for example, from fossil fuel production and distribution to renewables. Third, certain jobs will no longer be relevant or necessary, and may be transformed and redefined; for example, vehicle mechanics who specialize in internal combustion engines may be retrained in electric vehicle maintenance. In this regard, employment opportunities may emerge that are not yet possible to anticipate.[273]

The transition from a fossil fuel-based energy system to a system based on clean and renewable energy will require massive investments in infrastructure — from vehicles to district energy, from manufacturing to energy efficiency. This mobilization of public and private finance requires many new jobs in different sectors. For example, the IEA estimates that 8 to 27 jobs are created for every million euros invested in energy efficiency.[274] Reducing GHG emissions from the electricity grid through regulation can also result in job creation. Los Angeles's 100% Renewable Energy Study found that decarbonizing the city's energy system would create 7,900 to 13,200 jobs per year.[275]

Analyses of recently passed state and federal legislation demonstrate the economic opportunities enabled by decarbonization. The Political Economy Research Institute at UMass Amherst estimates that the climate and energy investments integrated into the Inflation Reduction Act will create more than 9 million job years across the U.S. over the next decade, with more than half of those jobs being created in the electricity, transportation, and building sectors.[276]

Policy and implementation design will be key to realizing the benefits of the new jobs created during the energy transition, as well as mitigating the negative impacts of job losses. Workers in industries that will likely see reductions (e.g., internal combustion engine vehicle maintenance and repair, fossil fuel extraction and refinement, gasoline stations) will need tools and resources to transition into new jobs. These could include transition assistance (financial or otherwise), investment in workforce training, and economic development assistance.

Low-income workers and communities of color have long been on the front lines of jobs that expose them to toxic pollution and hazardous conditions. Interested and impacted communities who participated in the engagement process for this project said the impact of decarbonization pathways on jobs and economic development is a critical consideration. However, to improve

271 International Energy Agency. Net Zero Roadmap: A Global Pathway to Keep the 1.5°C Goal in Reach. 2023. https://www.iea.org/reports/net-zero-roadmap-a-global-pathway-to-keep-the-15-0c-goal-in-reach

272 Ibid.

273 Martinez-Fernandez, C., Hinojosa, C., & Miranda, G. (2010). Green jobs and skills: the local labour market implications of addressing climate change. Working Document, OECD. Retrieved from http://www.oecd.org/regional/leed/44683169.pdf

274 International Energy Agency. (2014). Capturing the multiple benefits of energy efficiency. Paris, France. Retrieved from http://www.iea.org/publications/freepublications/publication/Captur_the_MultiplBenef_ofEnergyEficiency.pdf

275 Cochran, Jaquelin, and Paul Denholm, eds. 2021. The Los Angeles 100% Renewable Energy Study.

Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-79444. https://maps.nrel. gov/la100/.

276 Robert Pollin, Chirag Lala, and Shouvik Chakraborty, "Job Creation Estimates through Proposed Inflation Reduction Act" (University of Massachusetts Amherst: Political Economy Research Institute (PERI), August 2022).

equity, economic impacts must be considered at a granular level in terms of the impact on workers in specific sectors and opportunities for highly impacted and vulnerable communities.

Special attention must be given to workers and communities most likely to be impacted by job losses in the fossil fuel industry and related sectors. Creating well paying, high-quality jobs should also be a focus to avoid potential economic harms. Currently, one in five utility industry workers are unionized, compared to one in 10 of all American workers.[277] Recommendations for ensuring an economically just transition include investing in jobs that support unions and worker organizing, comply with or exceed mandatory labor standards, and maximize training and apprenticeship programs.[278] Advancing employment and training opportunities specifically for those from low-income households and historically marginalized groups, such as communities of color and Tribes, particularly in areas already experiencing job loss, is also key.

6.6.2.3 Resource Adequacy and Grid Reliability

Ensuring an adequate regional power supply while increasing renewable energy and electrification is a key decarbonization challenge for Washington — in the short- and long-term. The latest resource adequacy assessment by the Northwest Power and Conservation Council states the region needs to develop new resources aggressively to ensure an adequate power supply by 2027.[279]

Resource adequacy and grid reliability is a critical equity challenge. Electricity tends to be less reliable in rural and Tribal areas, especially at the end of transmission lines and during bouts of extreme weather, which are expected to increase with climate change.

In some cases, days pass before power is restored to these communities. Long outages can be detrimental to health, especially in freezing winter weather, affect the ability to perform or travel to jobs, and impact the storage of essential goods, such as medicine. Those with low incomes suffer the most. Currently, these challenges are mitigated by access to natural gas and backup heat sources, such as wood stoves.[280]

In an electrification strategy, these sources of backup power and heat powered by fossil fuels would likely be phased out. Interested and impacted communities engaged for the study made it clear that, to mitigate negative impacts, it is essential that any shift toward electrification or alternative fuels improve grid reliability and include backup systems, whether as an electric battery, a furnace, or some other strategy.

6.6.2.4 Equitable Opportunities to Participate in Decarbonization

From energy efficiency retrofits to installing rooftop solar to transitioning to EVs, decarbonizing is costly. Highly impacted communities and vulnerable groups will require financial support, incentives, and well-designed programs to participate in the transition. Lack of consideration for these communities can inhibit the success of decarbonization while widening inequities.

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277 "BlueGreen Alliance | Climate Change & the Clean Economy," accessed October 5, 2022, https://www.bluegreenalliance.org/work-issue/climate-change/.

278 "Solidarity for Climate Action" (San Francisco, CA, US: BlueGreen Alliance), accessed October 5, 2022, http://www.bluegreenalliance.org/wp-content/uploads/2019/07/Solidarity-for-Climate-Action-vFINAL.pdf.

279 Northwest Power and Conservation Council. January 2023. Pacific Northwest Power Supply Adequacy Assessment for 2027. https://www.nwcouncil.org/reports/2023-1/; Cary, A. Feb. 2, 2023. "'Too close, too big,' say opponents of huge Tri-Cities wind farm, despite jobs." The Spokesman-Review. https://www.spokesman.com/stories/2023/feb/02/too-close-too-big-strong-opposition-for-huge-tri-c/

280 Comments from DAG and Technical Meetings, and an equity focus group.

Successful decarbonization actions require different policies for different communities. For example, rebates for heat pumps and solar PV may incentivize adoption among middle- and upper-income households, but are unsuitable for low-income households that cannot afford to front the costs. In contrast, building upon existing programs, such as those focused on weatherization in low-income households, can make it easier for these households to access energy efficiency improvements, solar PV, and other interventions.[281]

Special efforts may also need to be made to engage those households that are struggling to meet their basic needs. These households may not have time to access information about how to participate in decarbonization.

6.6.2.5 Community Engagement

Consultation and collaboration with interested and impacted communities is a key factor in designing decarbonization initiatives with equitable outcomes, as is consulting and working with Tribes. Interested and impacted communities engaged for this project recommended that communities burdened by the energy system should be engaged during the development of decarbonization policies and programs. Tribes must be engaged through a process distinct from public participation due to their unique rights and relationship with the state.

The benefits of engaging equity-seeking groups include improved understanding of equity challenges, local needs, and local preferences for decarbonization actions. Additionally, community consultation and collaboration helps ensure community support for decarbonization actions.

The importance of community engagement is backed by the 2021 Washington State Energy Strategy, as well as research on decarbonization. A 2022 study of sources of opposition to renewable energy projects in the U.S. found a key source of opposition is "public perceptions of unfair participation processes or inadequate inclusion in light of regulatory requirements."[282]

The Washington State Energy Strategy indicates that open public meetings alone are insufficient, as they tend to lack participation from those who have been historically excluded. Moreover, other forms of engagements, such as focus groups, surveys, and advisory groups, can gather more in-depth input and set the stage for collaborative, two-way relationships with communities.[283]

[281] These recommendations are based on Comments from DAG and Technical Meetings, and an equity focus group.

[282] Susskind, Lawrence, Jungwoo Chun, Alexander Gant, Chelsea Hodgkins, Jessica Cohen, and Sarah Lohmar. "Sources of Opposition to Renewable Energy Projects in the United States." Energy Policy 165 (June 1, 2022): 112922. https://doi.org/10.1016/j.enpol.2022.112922.

[283] Sussking, L. et al.

7

Scenarios

7 | Scenarios

7.1 About Scenario Planning

Developing scenarios is a strategy to assess options in the face of uncertainty and significant and intractable problems. The inherent uncertainty of the future of decarbonization of energy systems is further clouded by discontinuities imposed by megatrends such as climate change and geopolitics. Scenario planning facilitates the imagining and evaluation of contrasting, possible futures. This process combines expertise with mathematics; insights with rigorous analysis. The end goal is to develop plans and decisions that are resilient to unforeseeable dynamics by challenging assumptions and encouraging learning.

7.2 Scenario Design

The scenarios in this study are designed to explore divergent energy system decarbonization transition pathways. They are not intended to be forecasts, but are assessments of the current system that question and describe the strengths and weaknesses of each scenario.

The development of meaningful scenarios requires the contribution of multiple different perspectives to gain a robust understanding of the challenges and options ahead. This is a process of engaging diversity to understand complexity. Sophisticated modeling of the energy system in Washington complements and informs this diversity of perspectives and the dialogue that results.

What Is a Scenario?

Scenarios are alternative descriptions of different possible futures that can help decision makers consider the implications of future planning and decision-making. Scenarios are not predictions. Rather, they are stories about how the world could change over some specified time in the future.

A scenario is distinguishable from a vision and forecast in two ways:

- a scenario is a possible future – it need not be desirable to everyone, thus it is not a vision, and,
- it need not be likely, thus it is not a forecast; a scenario emphasizes a process of change, not just a point in the future.

Many people assume that the future will closely resemble the present; however, scenarios are not grounded principally in a continuation of past trends or data. Rather, they involve plausible ways that relevant uncertainties might evolve in the future.

Characteristics of Scenarios

- Plausible: The scenario must be believable.
- Relevant to the key strategic issues and decisions at hand: If the scenario would not cause a decision-maker to act differently compared to another scenario, there is little use in considering it.
- Challenging today's conventional wisdom: It should make one think about different possibilities and options.
- Divergent from each other: Together, the scenarios should "stretch" the thinking about the future environment, so that the decisions take account of a wider range of issues.
- Balanced: It is useful to ensure that a group of scenarios strike a balance between challenges and opportunities, and between risks and potential benefits.

7.3 Reference Scenarios

Reference scenarios provide a baseline from which the impacts of decarbonization actions can be explored. Two reference scenarios are used in the analysis: Business-as-Usual (BAU) and Business-as-Planned (BAP). Appendix A includes detailed assumptions used for each scenario.

7.3.1 Business-As-Usual Scenario

The BAU scenario estimates energy use and emissions from the base year (2019) to the target year (2050). Because it assumes the absence of policy measures that would differ substantially from those currently in place, it can be considered a projection of what would happen if nothing changes beyond population increases and economic growth. This scenario provides a reference against which to assess the impacts of currently planned rules, bills, and legislation.

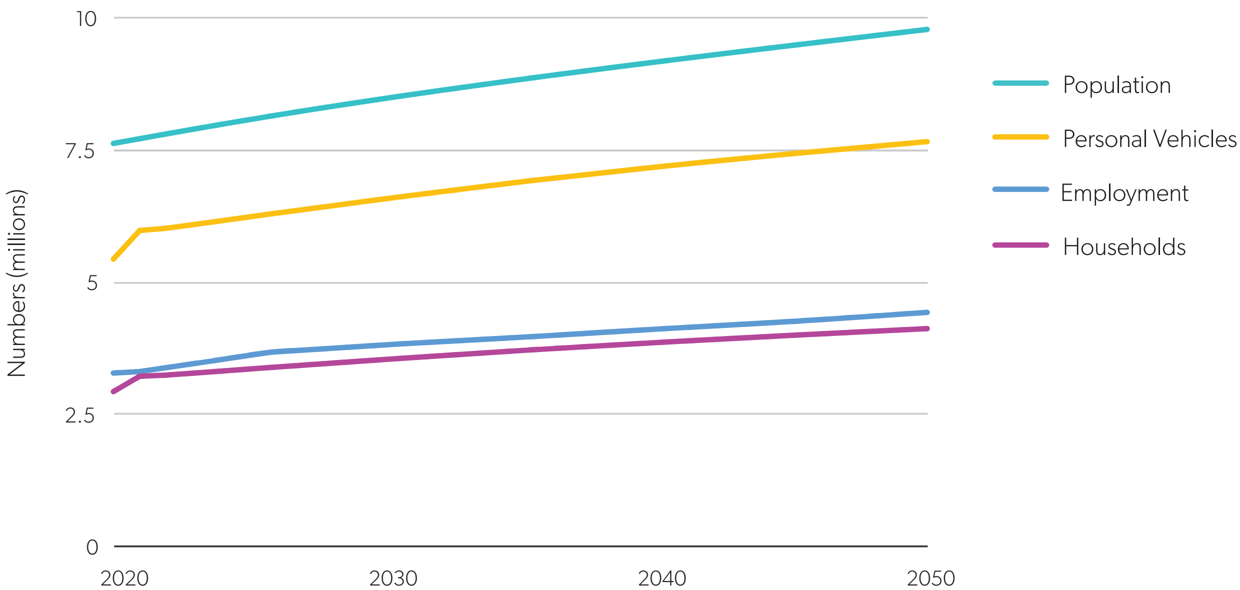

Figure 27. Population, household, employment (in full-time equivalent person-years), and personal vehicle growth projections for Washington State from 2019-2050.

Climate change projections used in modeling

To ensure all scenarios reflect temperature changes that are expected to occur as a result of climate change, the modeling incorporated climate data obtained from the U.S. Climate Resilience Toolkit Climate Explorer (version 3.1).[285] The Climate Explorer tool provides statistically downscaled global climate models for Washington's counties and county-equivalents. Observed and projected heating and cooling degree days for each county in Washington were used to assess projected changes in space heating and space cooling energy demand over time. The impact of projected extreme weather events for each county were used to test scenarios against these events for adequacy.

7.3.2 Business As Planned Scenario

The Business-As-Planned (BAP) scenario estimates energy use and emissions from the base year (2019) to the target year (2050), incorporating assumptions about the likely effects of planned policies and programs. In order to be considered part of the BAP an action must be:

- In rule;
- Funded;
- Legislatively required; or
- Following well-established market trends.

[285] Climate Explorer (nemac.org)

The BAP scenario incorporates the following laws and policies:[286]

- Clean Energy Transformation Act (CETA) (SB 5116, Chapter 288, Laws of 2019)
- Climate Commitment Act (CCA) (Chapter 316, Laws of 2021 (partial veto), SB 5126)
- 2021 Washington State Energy Code (WSEC) - Commercial[287]
- Section 5 of Climate Pollution Reduction - Energy Efficiency (Chapter 423, Laws of 2009, SB 5854)
- Clean Buildings for Washington Act (Chapter 285, Laws 2019, HB 1257) and Clean Buildings Performance Standard
- Move Ahead Washington (Supplemental Transportation Budget SB 5689, Chapter 186, Laws of 2022)
- Advancing Green Transportation Adoption (HB 2042, Chapter 287, Laws of 2019)
- Zero Emissions Vehicle Standards (SB 5811, Chapter 143 Laws of 2020)
- Zero Emission Vehicles - Preparedness (HB1287, Chapter 300, Laws of 2021)
- Washington Department of Ecology - Clean Fuels Program (HB 1091, Laws of 2021)

Collectively, these policies drive significant reductions in GHG emissions (Figure 28), but fall short of the state's overall 2050 target.

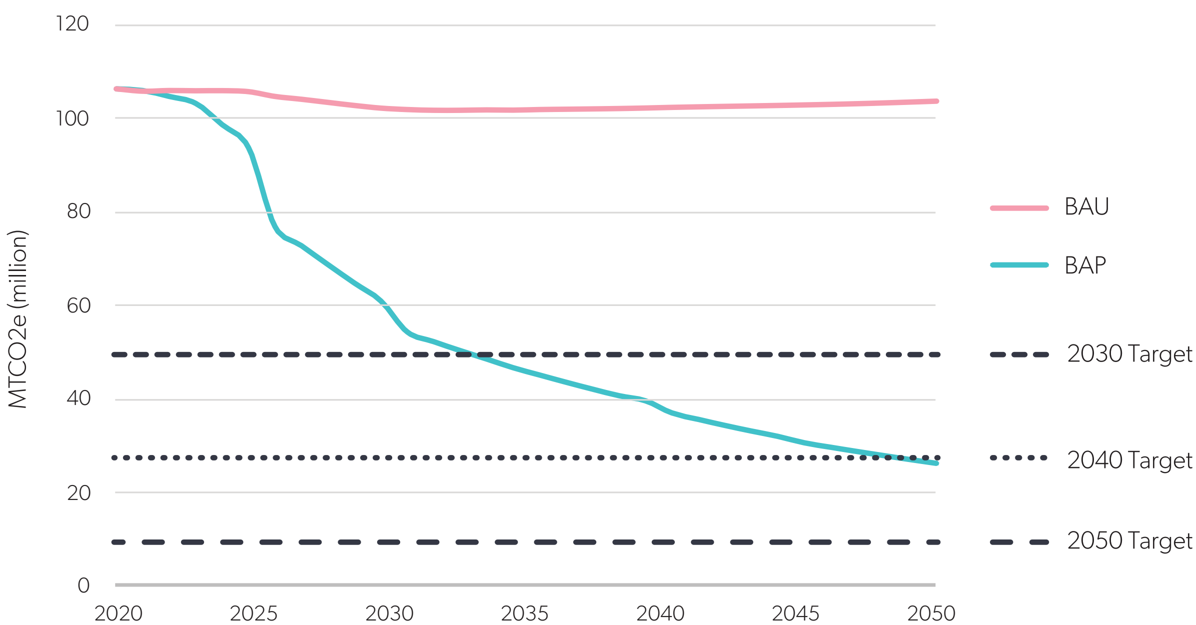

Figure 28. Total projected emissions from 2020-2050 for the Business-As-Usual and Business-As-Planned scenarios.

[286] These policies are documented in further detail in Chapter 5: Current Conditions. The detailed assumptions used in the model for each policy are described in Appendix A: Data, Methods, and Assumptions Manual.

[287] The 2021 Washington State Energy Code - Residential was adopted after the development of the BAP scenario and is therefore not reflected in the BAP. Instead, observed trends from the 2018 Washington State Energy Code - Residential were used (88% of homes heated with electric heat pumps, 12% with gas).

Among the policies, the Clean Energy Transformation Act and the Climate Commitment Act are the largest contributors to GHG reductions in the state. These two policies require decarbonization of the electricity and natural gas systems. However, because these policies are not prescriptive regarding how their specified targets are met, there may be multiple, diverging ways to meet these outcomes. Therefore, the decarbonization scenarios explore different types of actions that could be taken.

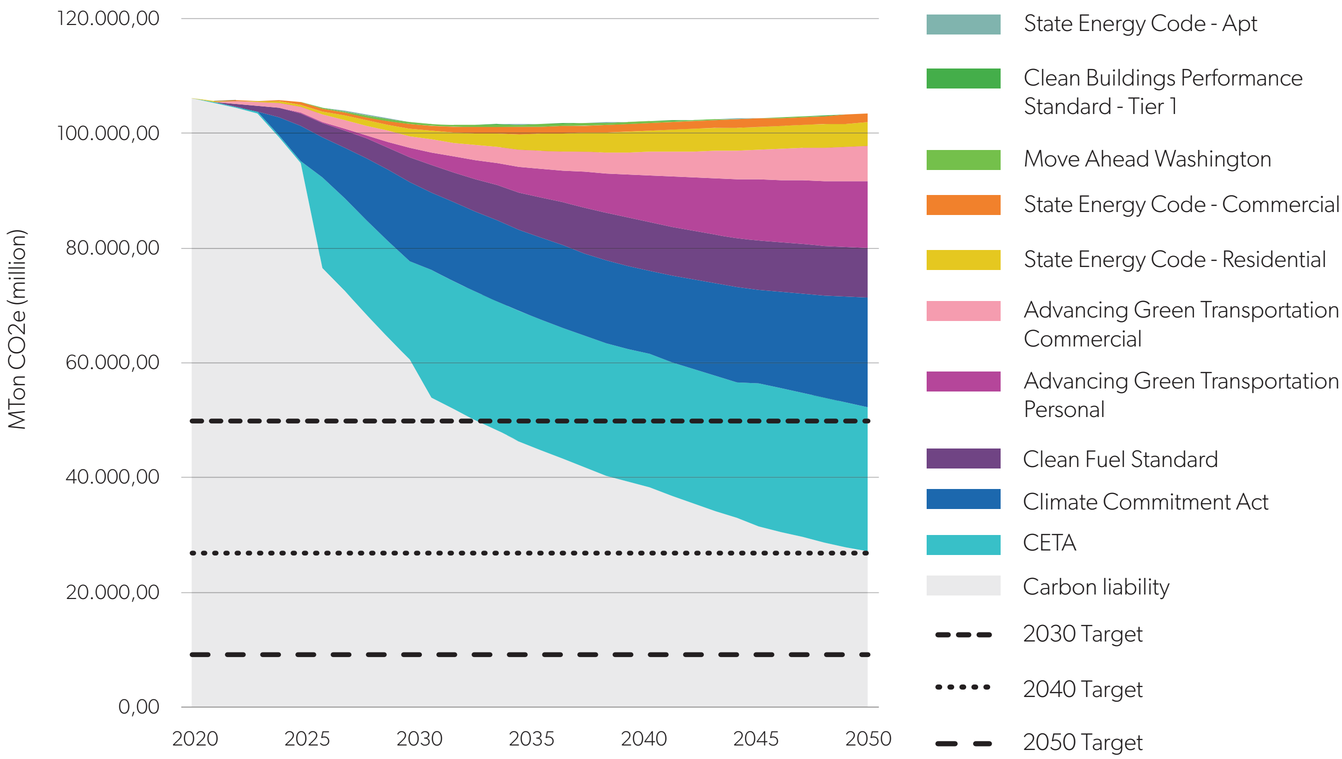

Figure 29. Emission reductions by policy from 2020-2050. CETA and the CCA provide the largest emission reductions, followed by policies in the transportation and building sectors.

7.4 Decarbonization Scenario Overview

The pathway to a GHG emissions reduction target can vary (Figure 30). Different pathways result in more (right figure) or fewer (left figure) emissions being released overall between now and 2050. It is the cumulative GHG emissions that drive warming, not targets tied to a particular year. Consequently, the decarbonization pathway matters, in addition to the interim and final targets.

Figure 30. Emissions reductions scenarios are associated with the timing of actions and setting interim targets.

As described in Chapter 1, this analysis is guided by a paradigm of Reduce-Improve-Switch. This paradigm prioritizes avoiding energy use, followed by increasing energy efficiency (Improve). The logic of this approach is that avoiding and reducing energy use not only directly reduces emissions, but also reduces the quantity of renewable energy generation needed to meet demand as electrification increases.

The recently completed Washington State Energy Strategy provided another jumping off point for designing decarbonization scenarios.

Based on these considerations, and input from interested and affected parties during the engagement phase, three future demand scenarios were developed:

1. **Electrification:** Use electricity to power the vast majority of activities and processes.
2. **Alternative Fuels:** Use fuels such as renewable natural gas and hydrogen to power the majority of activities and processes.
3. **Hybrid:** Use electricity for some activities and alternative fuels for others.

Each of the three scenarios evolves differently in the model, as each has different annual and hourly demand profiles for electricity as well as for fuels such as renewable natural gas.

The following outlines the actions explored across all of the scenarios. Specific actions for each scenario are described in the Scenarios in Depth section later in this chapter. Refer to Appendix A - Data, Methods and Assumptions Manual for more detailed information about the assumptions used in modeling.

7.4.1 Common Actions

7.4.1.1 Demand Side

In line with the Reduce-Improve-Switch decarbonization philosophy, as well as input from interested and affected parties engaged in the project, a set of energy efficiency actions was developed commonly across the scenarios. Reducing energy consumption also reduces annual energy expenditures. These actions also reduce the amount of clean electricity that will need to be developed to meet clean electricity targets required by the Clean Energy Transformation Act.

Not all emissions are related to electricity or natural gas use; actions were not specified to reduce emissions related to industrial processes and aviation, for example, although these activities were included in the model. Transportation actions were included in the modeling due to expected electrification of vehicles over time under current policies, which may drive increases in annual and hourly electricity demand.

Table 11. Common actions to reduce energy consumption. Cumulative emission and energy reductions (2019-2050).

Action	Specification	Cumulative Emissions Reductions (Thousand MTCO2e)	Cumulative Energy Reductions (Million MMBTU)
Buildings			
Deep retrofits in the building stock	Retrofit 95% of existing buildings by 2040 to achieve a 50% reduction in space heating/cooling and a 40% reduction other non-heating energy use	34,945	2,437
Increase density of development in urban zones	Reduce fraction of single new builds to 25% of new buildings in counties with high urban density by 2040, which results in a decrease in personal use vehicle miles traveled	15,651	560
Transportation			
Increase transit ridership	Triple transit ridership in urban centers by 2040	10,045	278
Decrease freight vehicle miles traveled	Decrease vehicle miles traveled by 15% by 2050	18,493	384
Mode Shift to cycling	Transfer 10% of personal use vehicle trips to electric micro-mobility (e.g., e-bike/e-scooter) in urban counties by 2035	5,548	144

Action	Specification	Cumulative Emissions Reductions (Thousand MTCO2e)	Cumulative Energy Reductions (Million MMBTU)
Marine passenger electrification	Electricity 100% of passenger ferries by 2040	41,790	440
Industry			
Efficiency improvements in industry	Improve the energy efficiency of industrial facilities to achieve a 50% reduction in energy use by 2050	78,397	1,686

7.4.1.2 Supply Side

A set of common actions and assumptions for energy supply was also applied to all scenarios, based on a literature review and input from interested and affected parties.

Table 12. Common actions for energy supply.

Assumption	Specification
Comply with legislation	
Comply with Clean Energy Transformation Act	20% of annual demand can be met with GHG-emitting generating resources (excluding coal) if needed in 2030 and 2040
Focus on self-sufficiency	
Add additional generating capacity in-state first	Focusing on adding additional generating capacity in-state before looking to other states for resources assesses the capacity of Washington's utilities to achieve renewable electricity goals in the absence of cooperation or coordination with other actors.[288]

[288] It is not a requirement that Washington achieve self-sufficiency in electricity generation, and Washington is integrated with the Western Interconnection which its utilities can use to access power across state lines. However, competition for new clean and renewable resources in other states may be high as states and provinces neighboring Washington state have similar clean energy goals. Additionally, the ability to expand interstate transmission supplies may be constrained by technical, legal, or market forces. There are currently no organized/optimized electricity trade agreements between states, although some are in development.

Assumption	Specification
Retain existing generating resources	
Retain existing natural gas power plant capacity through 2045	Current natural gas power plant capacity is available in 2030 and 2040, but is used only as needed to meet peak demands when no other resources are available.
Retain existing nuclear power plant capacity through 2050	The Columbia Generating Station is authorized to operate until at least 2043, or potentially 2063 with a license extension. It will operate through at least 2050.
Use existing wind resources and incorporate additional wind capacity	Existing wind resources continue to be operational through 2050. Additional 80 meter-tall wind turbines can be added within each Balancing Authority (BA) area in quantities up to the technical potential as determined by NREL. Hourly capacity factor profiles (how much energy can be produced compared with the maximum output) for the wind turbines vary by BA, reflecting differences in terrain, weather patterns, and other variables relating to wind power output in different parts of the state. Profiles were informed by data from NREL.[289]
Use existing solar resources and incorporate additional utility-scale solar capacity	Existing solar resources continue to be operational through 2050. Additional utility-scale solar arrays could be added within each BA area in quantities up to the technical potential as determined by NREL. Hourly capacity factor profiles (how much energy can be produced compared with the maximum output) for the solar arrays vary by BA, reflecting differences in terrain, weather patterns, and other variables relating to solar power output in different parts of the state. Profiles were informed by data from NREL.[290]
Incorporate utility-scale energy storage	An unlimited quantity of 4-hour duration lithium ion batteries can be added by utilities to support meeting electricity demand. The batteries modeled have a 0.91 overall efficiency factor (for charging and discharging) and an energy storage loss fraction of 0.0000833 per hour.[291]

[289] Department of Energy National Renewable Energy Laboratory, "Wind Power - System Advisor Model - SAM.," NREL System Advisor Model (SAM), accessed April 28, 2023, https://sam.nrel.gov/wind.html.

[290] Department of Energy National Renewable Energy Laboratory, "SAM Photovoltaic Models - System Advisor Model

- SAM.," NREL System Advisor Model (SAM), accessed April 28, 2023, https://sam.nrel.gov/photovoltaic.html.

[291] The optimization model (Calliope) was given the option to incorporate a 4-hour or 8-hour duration battery, but during initial model runs, only the 4-hour batteries were selected. For this reason, only 4-hour duration batteries were incorporated into the final modeling assessment. Longer duration batteries (8+ hours) exist but they are not common; most batteries used at the utility-scale level have durations of 2, 4, or 6 hours. More information can be found at https://www.eia.gov/todayinenergy/detail.php?id=51798.

Assumption	Specification
Use demand response and industrial peak load shedding	During hours of peak demand, demand response methods such as time-of-use rates and interruptible service agreements are used to reduce demand by shifting it to other hours of the day. Up to half of industrial producers develop on-site battery storage and/or power generation by 2050 is able to contribute to load shedding as necessary to contribute to reducing peak demand.
Transmission and imports	
Gradually increase transmission capacity between Washington's Balancing Authorities	• For the year 2030, existing transmission capacity between Washington's BAs was used. Data was obtained directly from the Northwest Power and Conservation Council. • For the year 2040, transmission capacity between BAs increases by 25% compared to capacity in 2030. • For the year 2050, transmission capacity between BAs increases 20% compared to capacity in 2040.
Meet remaining peak demand loads with imports, RNG, or stored hydrogen	During hours of peak demand, after demand response and energy storage options have been used, the remaining load - up to 6,500 MW - can be supplied by imports from the rest of the WECC, or by either RNG or stored hydrogen (made from surplus wind and solar generation) burned in combined-cycle generators.292 The exact combination of imports, RNG and hydrogen was not specified, as this would have required modeling at least all of WECC, and possibly all of the North American electricity system. Instead, an allowance of $500/MWh was included in the cost estimate.
Use surplus supply to produce alternative fuels	The use of renewably produced electricity that would otherwise be curtailed is maximized to produce alternative fuels such as hydrogen.

[292] While all wind, solar, RNG, and hydro generation was assumed for modeling purposes to be located in state, it may be more cost-effective to contract for out-of-state supply and increase transmission capacity accordingly.
Modeling indicated no significant cost difference between in state and out-of-state generation after taking transmission costs into account.

7.4.2 Electrification Scenario

The Electrification Scenario is designed to evaluate the impact of electrifying nearly all energy consuming activities in Washington. This scenario is similar to the electrification scenario described in the Washington State Energy Strategy, which investigated a rapid shift to electrified end uses as well as "aggressive electrification and aggressive efficiency."

Table 13. Electrification scenario actions 2019-2050 and associated cumulative emission reductions in metric tons of CO2 equivalents and energy reductions in MMBTU.

Action	Specification	Cumulative Emissions Reductions (Thousand MTCO2e)	Cumulative Energy Reductions (Million MMBTU)
Buildings			
Transition to heat pumps for residential space conditioning and water heating	95% of existing buildings are equipped with electric heat pumps for space and water heating by 2040. Heat pumps are installed when existing equipment needs to be replaced.	21,203	56
Transition to heat pumps for commercial space conditioning and water heating	95% of existing commercial buildings are equipped with electric heat pumps for space and water heating by 2040. Heat pumps are installed when existing equipment needs to be replaced.	19,887	289
Transportation			
Electrify commercial use vehicles	Percentage of new vehicles (sales) that are electric by 2035: • Classes 2b–3 trucks (vans, medium pickup trucks): 100% • Classes 4–8 trucks (delivery trucks, delivery/service vans, lighter truck tractors, bucket trucks): 90% • Class 8 truck tractors: 80%	131,115	1,344

Action	Specification	Cumulative Emissions Reductions (Thousand MTCO2e)	Cumulative Energy Reductions (Million MMBTU)
Industry			
Electrification of some industrial processes	Replace 55% of fossil fuel use in industry with electricity by 2050	74,597	0
Energy			
Enable distributed energy resources with Enhanced Energy Storage	Add 18.5 GW of rooftop solar capacity to residential buildings by 2035. Add 3.45 GW of energy storage to residential buildings equipped with rooftop solar by 2035. Assume each energy storage unit is 14 kWh.	10,808	290
Blend RNG into the natural gas supply	Use Washington's full RNG potential of 87.5 tBTU by 2050.	84,058	0

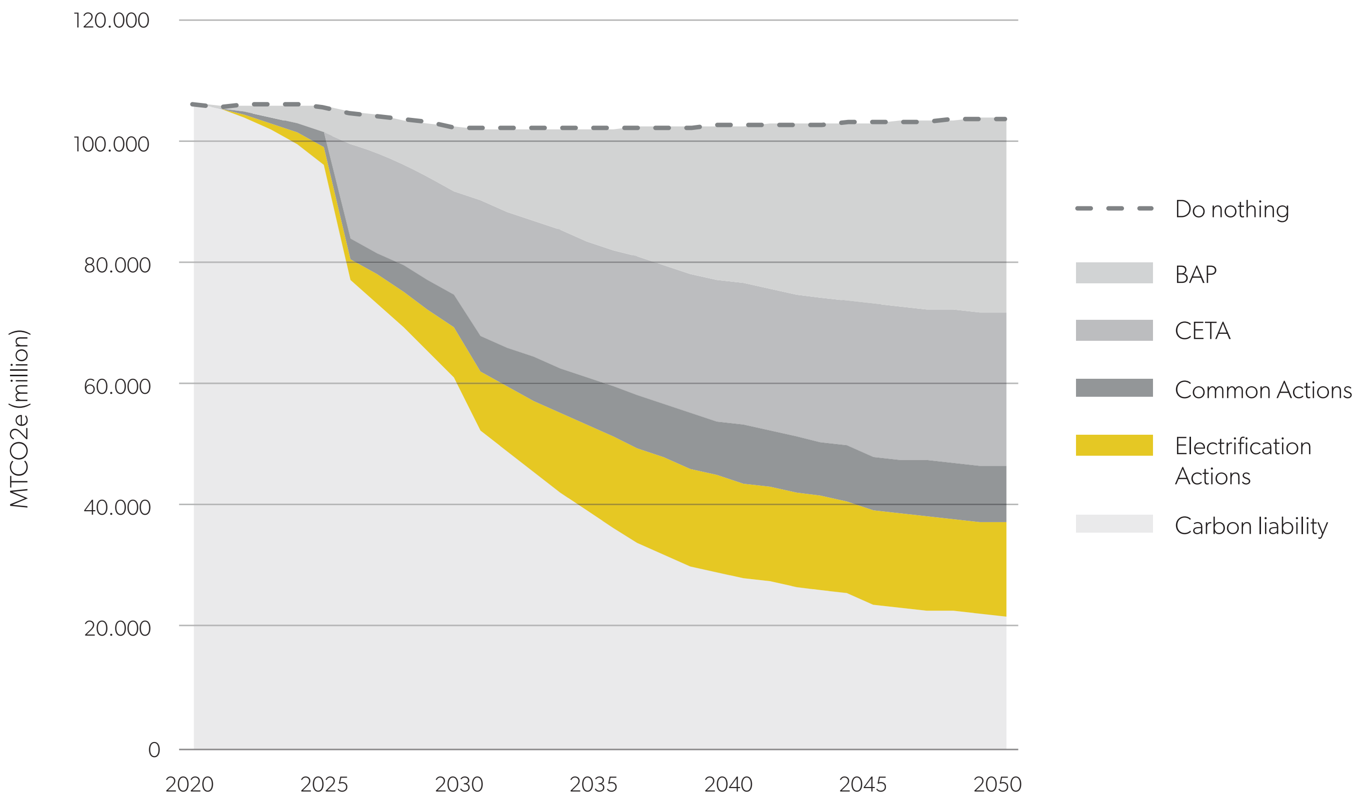

Figure 31. Emission reductions resulting from actions specific to the Electrification Scenario.

7.4.3 Alternative Fuels Scenario

The Alternative Fuels scenario is designed to replace fossil fuels with renewable or zero emission fuels such as renewable natural gas and hydrogen. Although electricity is still a major energy source, electricity consumption is similar to the BAP. This scenario is similar to the "Gas In Buildings" scenario in the State Energy Strategy. With this scenario one can understand the amount of alternative fuels that would be necessary to achieve this type of transition of the existing gas system. The alternative fuels actions evaluated are found in the table below.

Table 14. Alternative Fuels scenario actions 2019-2050 and associated cumulative emission reductions in metric tons of CO2 equivalents and energy reductions in MMBTU.

Action	Specification	Cumulative Emissions Reductions (Thousand MTCO2e)	Cumulative Energy Reductions (Million MMBTU)
Buildings			
Transition to heat pumps for residential space conditioning and water heating	95% of existing buildings are equipped with electric heat pumps for space and water heating by 2040. Heat pumps are installed when existing equipment needs to be replaced.	14,182	168
Transition to heat pumps for commercial space conditioning and water heating	95% of existing commercial buildings are equipped with electric heat pumps for space and water heating by 2040. Heat pumps are installed when existing equipment needs to be replaced.	11,228.26	203
Deploy clean hydrogen fuel cells in residences for heating	5% of homes have hydrogen fuel cells by 2030	246.37	46

Action	Specification	Cumulative Emissions Reductions (Thousand MTCO2e)	Cumulative Energy Reductions (Million MMBTU)
Transportation			
Transition nearly all commercial use vehicles to zero emission vehicles	Percentage of new vehicles (sales) by 2035: • 100% of Classes 2b–3 trucks (vans, medium pickup trucks) are zero emissions vehicles: 80% EV, 20% alternative fuels • 90% of Classes 4–8 trucks (delivery trucks, delivery/ service vans, lighter truck tractors, bucket trucks): 50% EV, 50% alternative fuels • 80% of Class 8 truck tractors: 20% EV, 80% alternative fuels	122,390	926
Industry			
Use hydrogen and RNG for industrial processes	70% of industrial processes fueled by hydrogen (68% by volume) or RNG (32% by volume) by 2050	97,310	0
Energy			
Blend green hydrogen into the natural gas supply	Blend up to 15% hydrogen into the natural gas supply by 2035 and enact a new round of standards for appliances and equipment beyond those codified in 2021 to support.	22,982	0
Blend RNG into the natural gas supply	Use Washington's full RNG potential of 87.5 tBTU by 2050.	81,455.68	0
Produce RNG within Washington	Produce sufficient RNG to provide 6% of RNG demand within the state by 2050	0.00	0
Provide hydrogen within Washington	Produce sufficient hydrogen to provide 50% of hydrogen demand within the state	-13,186	-2,158

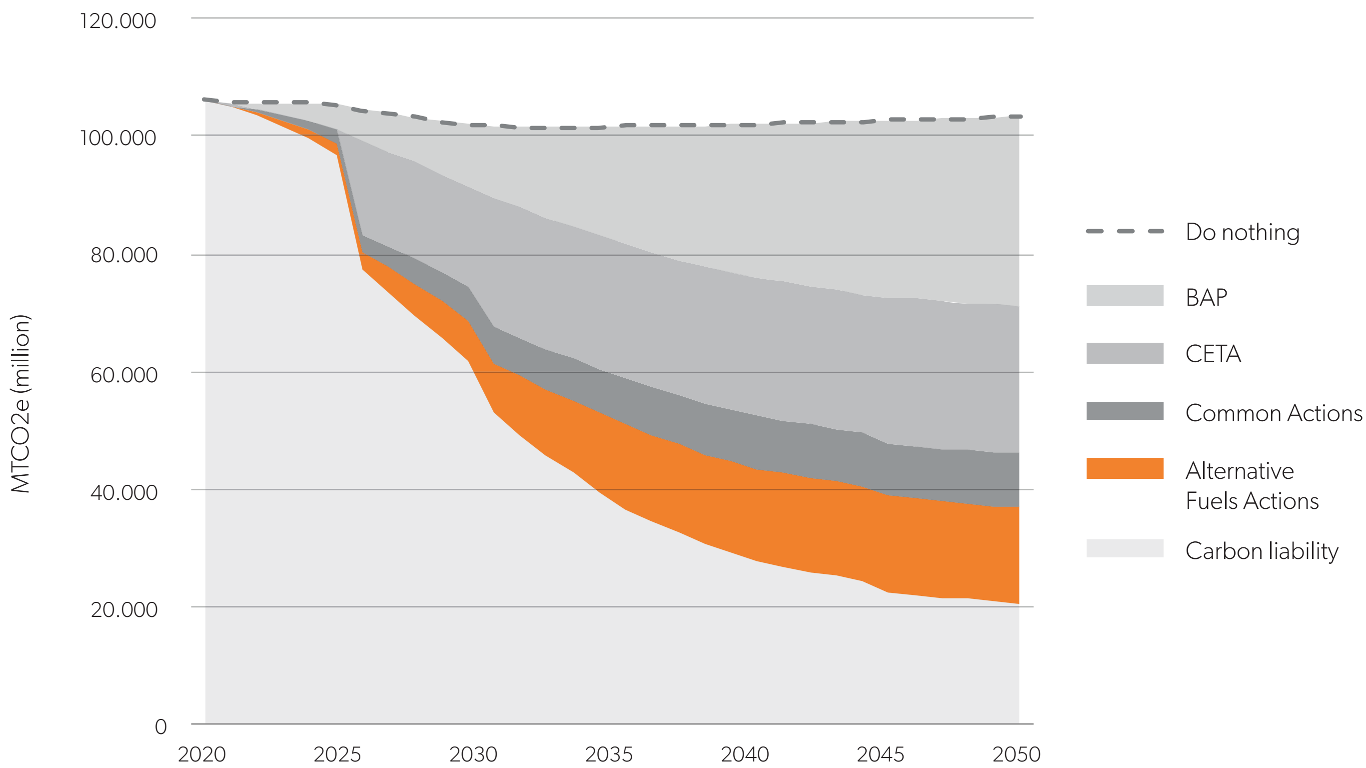

Figure 32. Emission reduction impacts of actions specific to the Alternative Fuels scenario.

7.4.4 Hybrid Scenario

The hybrid scenario combines the strengths of the Electrification and Alternative Fuels scenarios. Residential and commercial end uses are electrified, following existing trends in those sectors. In sectors that will be more difficult to electrify, such as heavy duty transportation and industry, alternative fuels such as RNG and hydrogen are used more prominently than in the Electrification scenario. Altogether, this scenario explores the most effective use of the three main clean energy sources under consideration (electricity, RNG, and hydrogen).

Table 15. Hybrid scenario actions 2019-2050 and associated cumulative emission reductions in metric tons of CO2 equivalents and energy reductions in MMBTU.

Action	Specification	Cumulative Emissions Reductions (Thousand MTCO2e)	Cumulative Energy Reductions (Million MMBTU)
Buildings			
Transition to heat pumps for residential space conditioning and water heating	95% of existing buildings are equipped with electric heat pumps for space and water heating by 2040. Heat pumps are installed when existing equipment needs to be replaced.	21,203	56

Action	Specification	Cumulative Emissions Reductions (Thousand MTCO2e)	Cumulative Energy Reductions (Million MMBTU)
Transition to heat pumps for commercial space conditioning and water heating	95% of existing commercial buildings are equipped with electric heat pumps for space and water heating by 2040. Heat pumps are installed when existing equipment needs to be replaced.	19,887	289
Transportation			
Transition nearly all commercial use vehicles to zero emission vehicles	Percentage of new vehicles (sales) by 2035: • 100% of Classes 2b–3 trucks (vans, medium pickup trucks) are zero emissions vehicles: 80% EV, 20% alternative fuels • 90% of Classes 4–8 trucks (delivery trucks, delivery/ service vans, lighter truck tractors, bucket trucks): 50% EV, 50% alternative fuels • 80% of Class 8 truck tractors: 20% EV, 80% alternative fuels	122,390	926
Industry			
Use hydrogen and RNG for industrial processes	70% of industrial processes fueled by hydrogen (68% by volume) or RNG (32% by volume) by 2050	97,310	0
Energy			
Enable distributed energy resources with Enhanced Energy Storage	Add 18.5 GW of rooftop solar capacity to residential buildings by 2035. Add 3.45 GW of energy storage to residential buildings equipped with rooftop solar by 2035. Assume each energy storage unit is 14 kWh.	10,808	290

Action	Specification	Cumulative Emissions Reductions (Thousand MTCO2e)	Cumulative Energy Reductions (Million MMBTU)
Blend green hydrogen into the natural gas supply	Blend up to 15% hydrogen into the natural gas supply by 2035 and enacted a new round of standards for appliances and equipment beyond those codified in 2021 to support.	22,982	0
Blend RNG into the natural gas supply	Use Washington's full RNG potential of 87.5 tBTU by 2050.	81,455.68	0
Produce RNG within Washington	Produce sufficient RNG to provide 6% of RNG demand within the state by 2050	0.00	0
Provide hydrogen within Washington	Produce sufficient hydrogen to provide 50% of hydrogen demand within the state	-13,186	-2,158

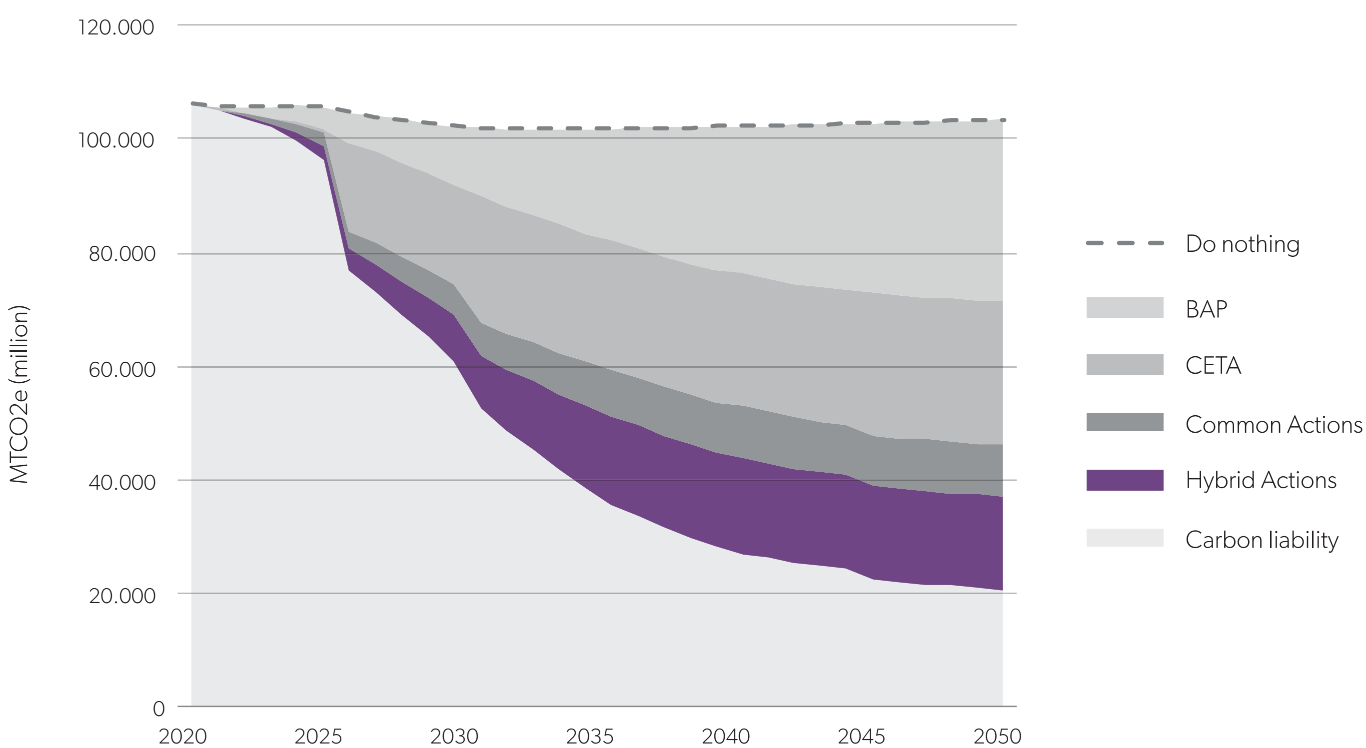

Figure 33. Emission reduction impacts of actions specific to the Hybrid scenario.

Dock at Lake Crescent, at Olympic National Park, Washington. @ jonbilous. Stock.adobe.com

8

Findings

8 | Findings

8.1 How Can Washington's Gas Utilities Decarbonize?

8.1.1 Multiple Options Exist

Actions in all three scenarios reduce emissions enough to meet Washington's emission reduction targets for the years 2030 and 2040, while none of them achieve the 2050 target. To meet the 2050 target, additional actions to decarbonize the sources of the remaining emissions - industrial processes and aviation - would need to be taken, which were beyond the scope of this analysis.

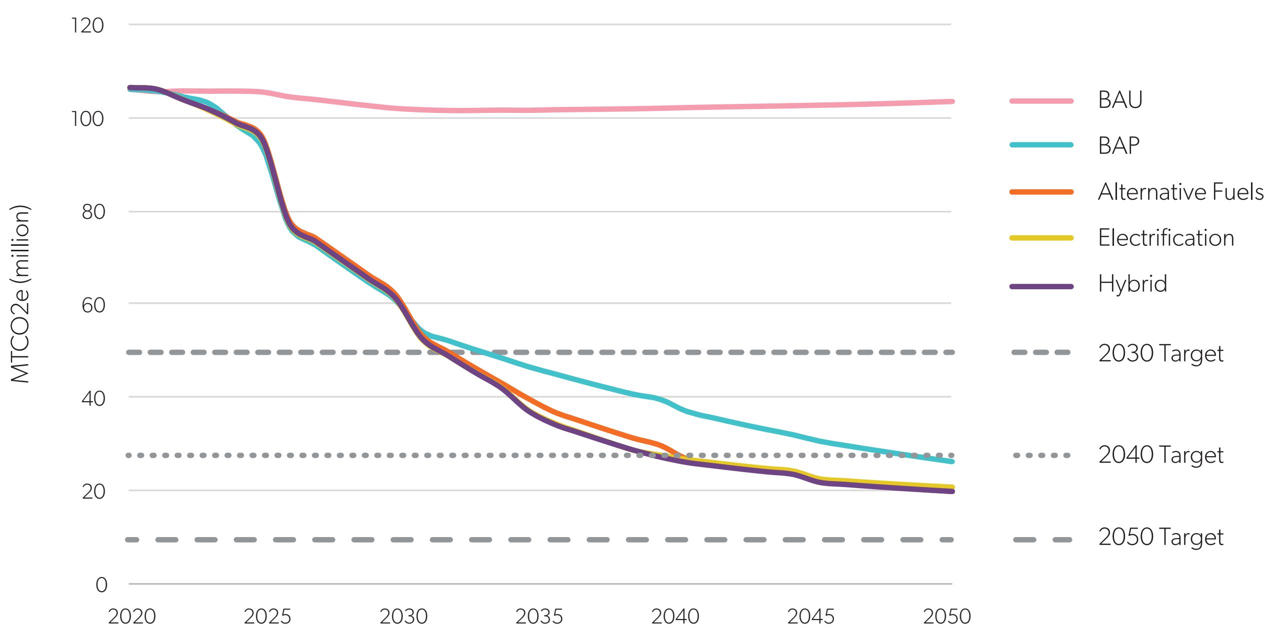

Figure 34. GHG emissions trajectories of the BAU, BAP and three policy scenarios

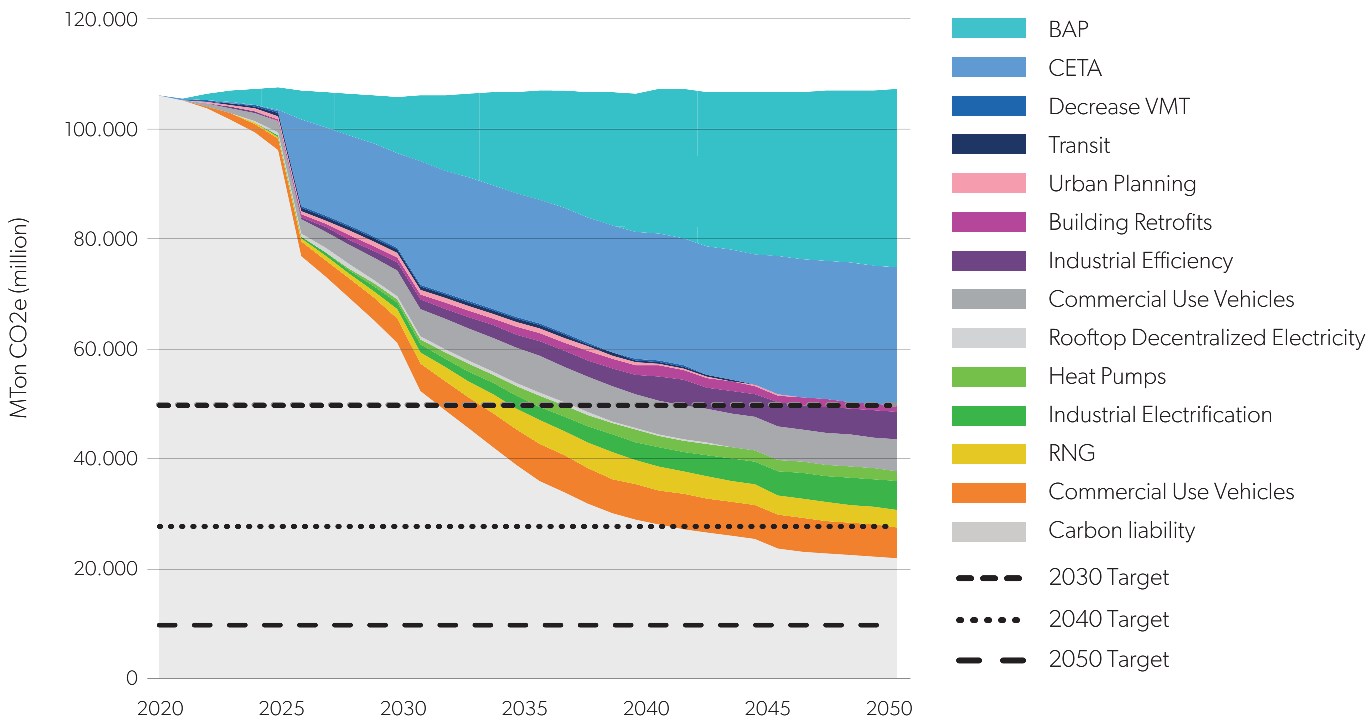

Figure 35. GHG emissions impact of the Electrification scenario by policy and action

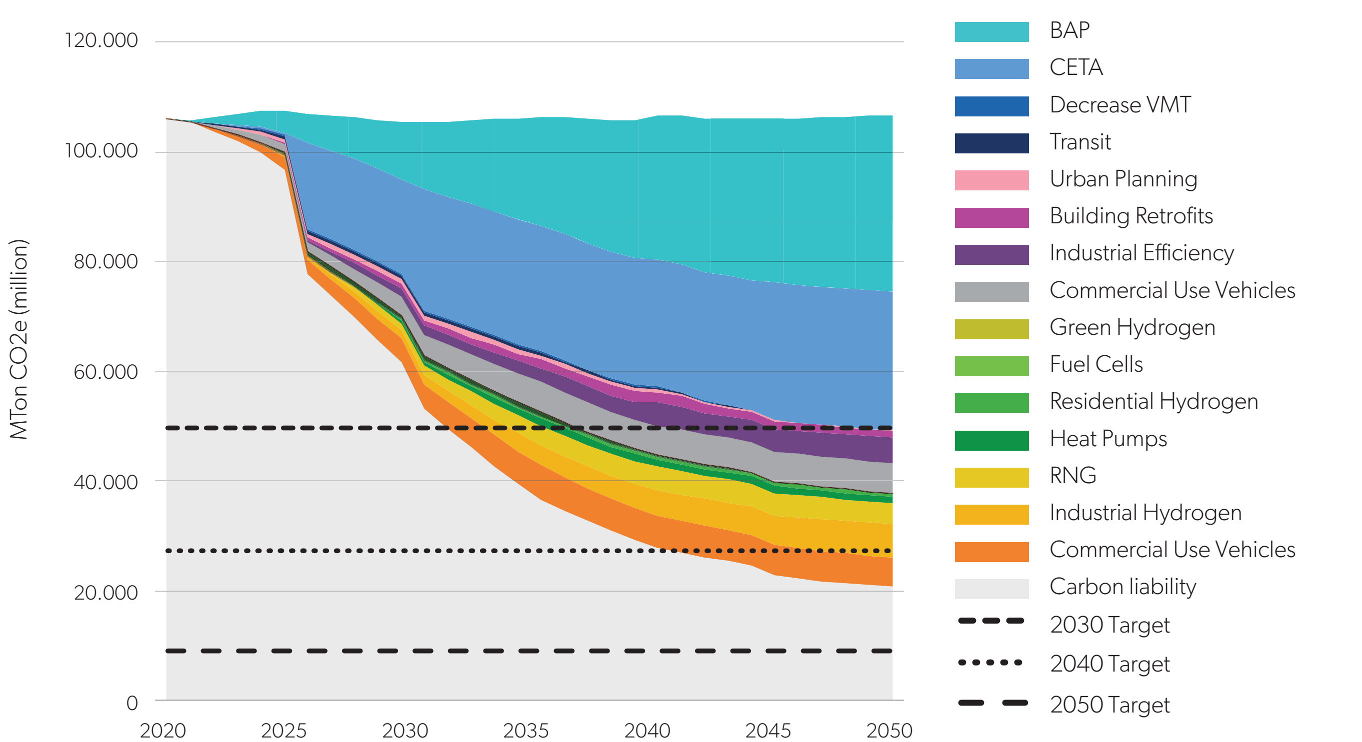

Figure 36. GHG emissions impact of the Alternative Fuels scenario by policy and action

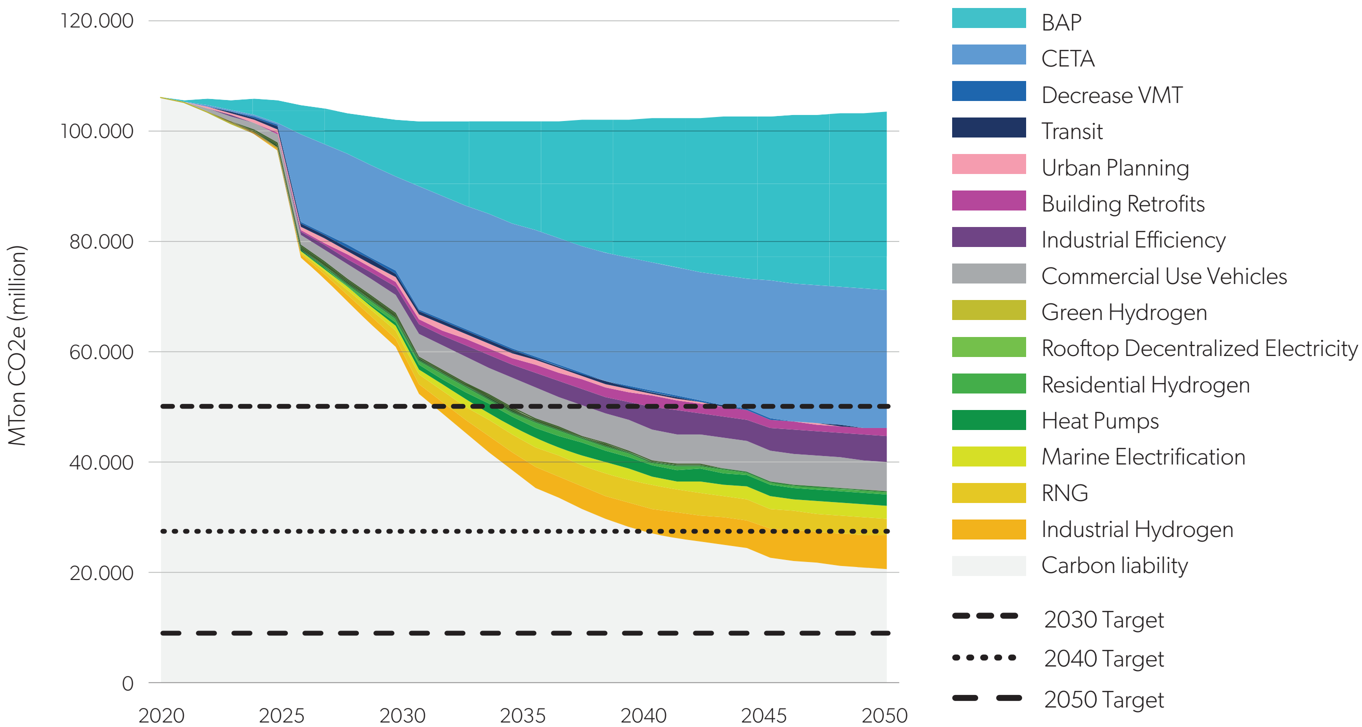

Figure 37. GHG emissions impact of the Hybrid scenario by policy and action

Insights:

Decarbonizing the natural gas system allows Washington to make significant gains toward Washington's overall emissions goal.

- Electrification is an efficient, off-the shelf approach to decarbonizing heating in most cases.
- Applying the principle of best use ensures that supply-constrained fuels (RNG) and more energy intensive fuels (hydrogen) are available for hard to electrify sectors such as industry and heavy vehicles.
- The ability of the industrial sector to electrify has limitations that have been represented in the modeling (see scenario assumptions in Chapter 8). This limitation results in more non-natural gas related fossil fuels emissions left in the industrial sector that fall out of the scope of this analysis.

8.1.2 Natural Gas is Phased Out, Carefully

Natural gas as an energy source is assumed to be phased out rapidly in all of the three decarbonization scenarios, mostly within the next decade. Due to recent state policy, particularly the Climate Commitment Act and the Clean Energy Transformation Act, the transformation is imminent, with wide-reaching implications for the business models, infrastructure, and customers of the natural gas utilities.

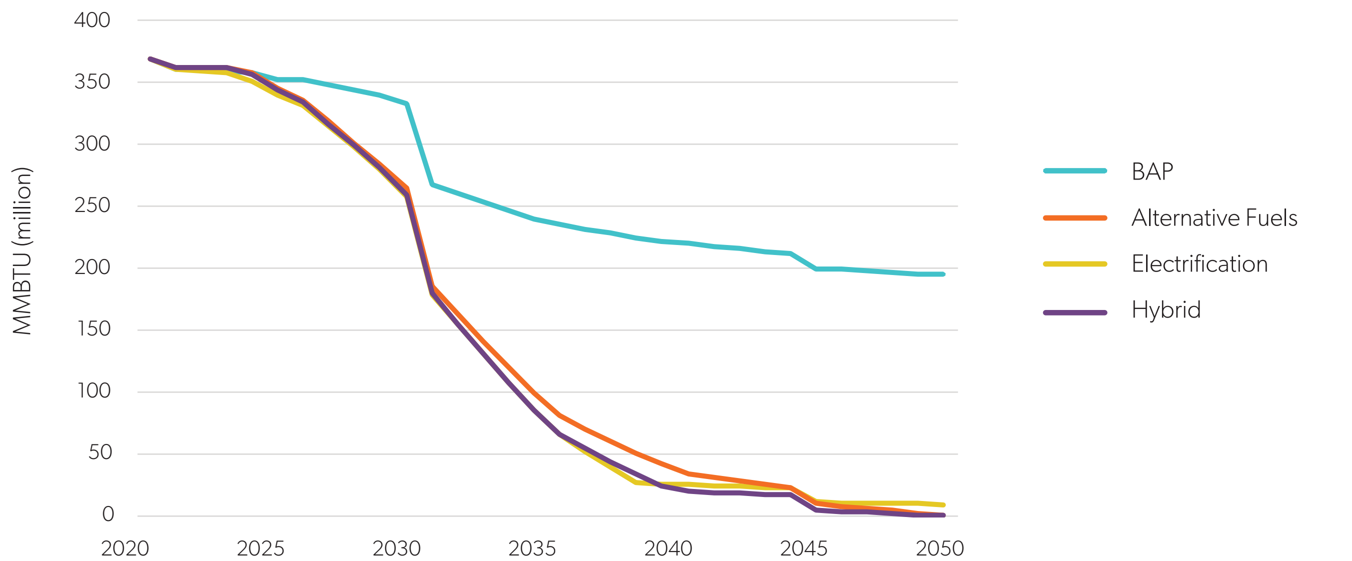

Figure 38. Natural Gas Energy Consumption by Source (million MMBTU) for each scenario annually

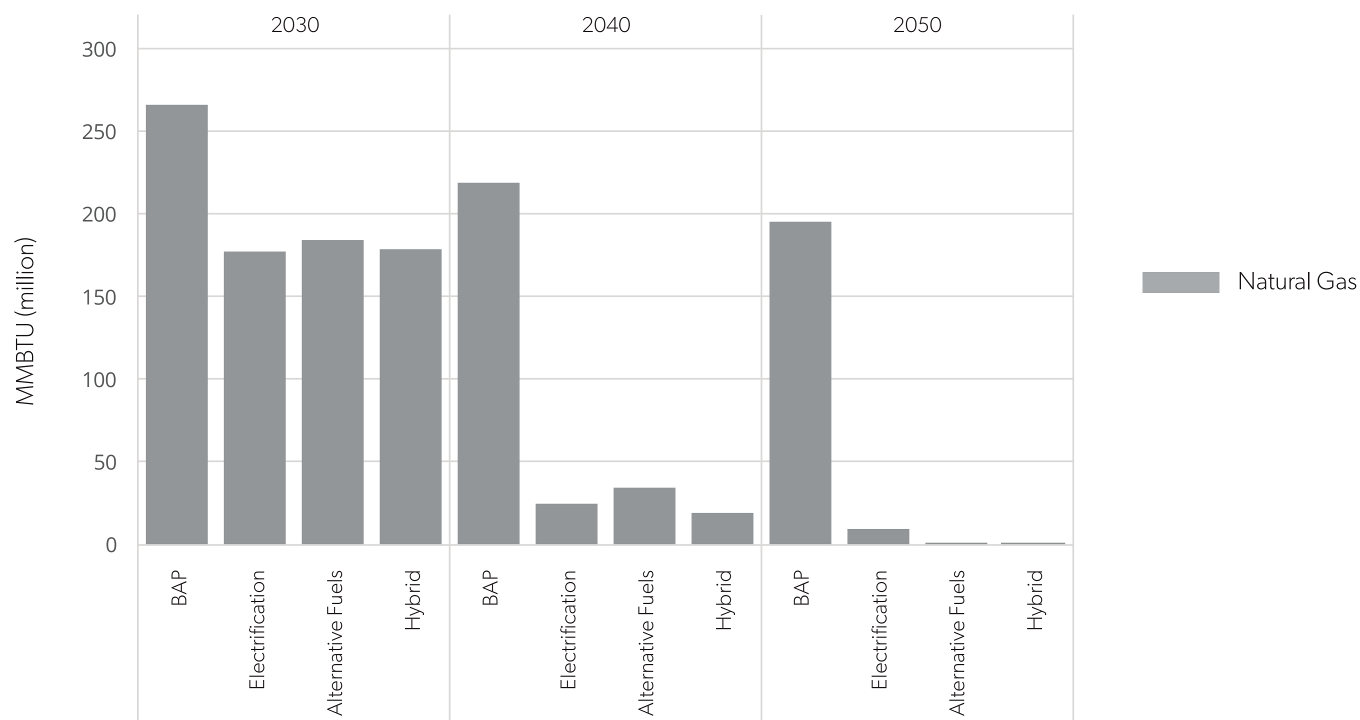

Figure 39. Natural Gas Energy Consumption by Source (million MMBTU) for each scenario by decade

Insights:

- Regulatory agencies and utilities need to plan for a decadal drawdown of natural gas consumption.
- Policy solutions are necessary to minimize and avoid stranded assets, including strategies such as preventing expansion, managed decommissioning, accelerated depreciation of assets, performance-based regulation.
- Opportunities to leverage natural gas infrastructure and develop new business models need to be explored, such as using the natural gas distribution system for thermal water storage in high density areas or offering energy as a service.
- Programming and funding will need to be targeted to energy burdened and equity-seeking groups that could be stranded on a legacy natural gas system, and left paying for all the costs of the system.

8.1.3 The Electricity System is the Fulcrum

Heat and transportation are electrified in all the scenarios so that electricity becomes the core source of energy powering most human activities in Washington. Despite the electrification of these two major end uses, combined with population and economic growth, electricity consumption grows relatively slowly due to system-wide efficiency gains. Electricity consumption grows at the rate of 1.15%, 0.8% and 0.9% per year in the Electrification, Alternative Fuels, and Hybrid scenarios, respectively.

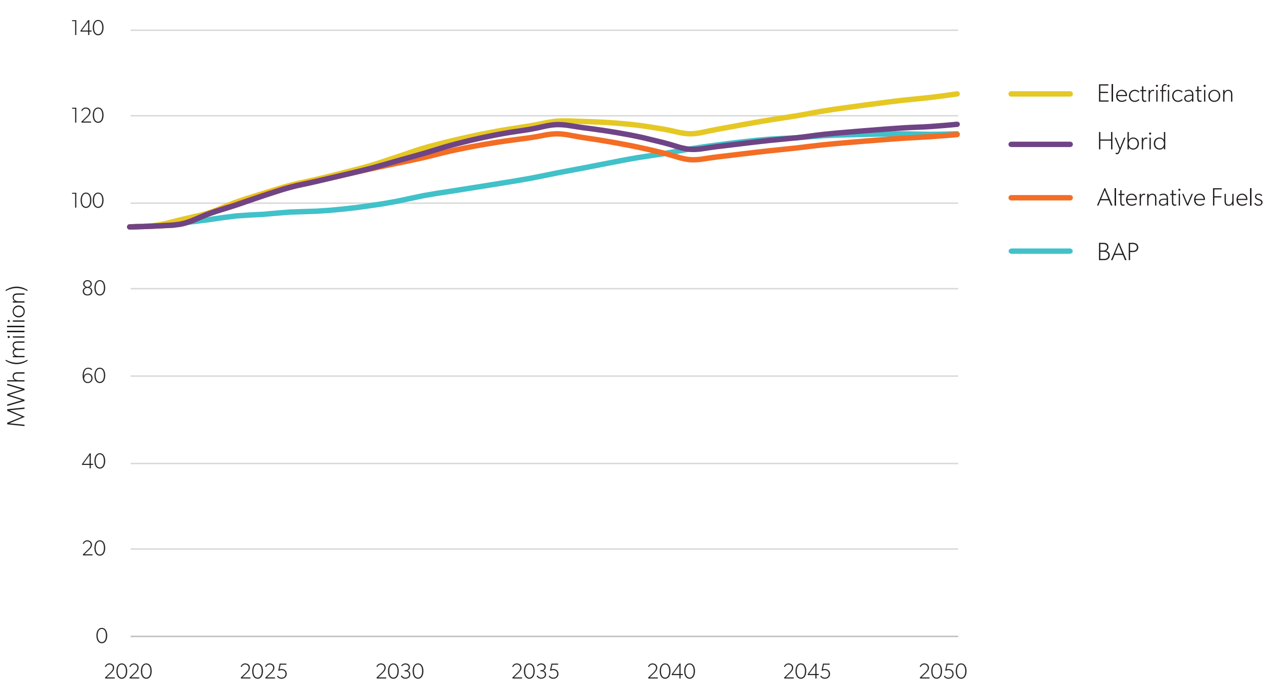

Figure 40. Electricity Consumption for Each Scenario, annually

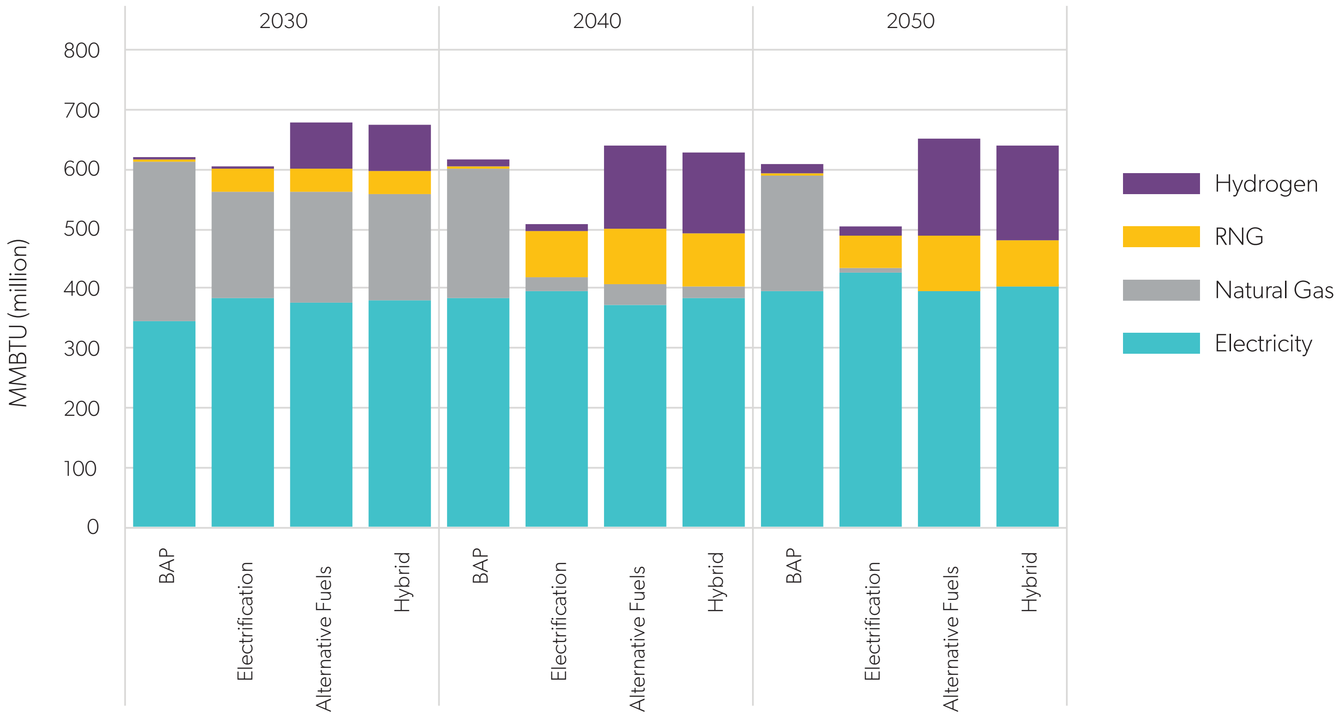

Figure 41. Stationary Energy Consumption by Source, by decade

Insights:

- Electricity consumption grows slowly, at approximately 1% per year, in all scenarios despite electrification of transportation and heating.
- In the Alternative Fuels scenarios, in-state production of 50% of the hydrogen consumed increases overall electricity consumption. Excess hydrogen could potentially be exported for trade with other states, similarly to excess electricity production.
- The Alternative Fuels and Hybrid scenarios further reduce the burden on the electricity grid to decarbonize and grow simultaneously.

8.1.4 Efficiency is the Lynchpin

Energy consumption declines in all three decarbonization scenarios relative to the BAU and BAP by 2050. The reduction is greatest in the Electrification scenario, while the Alternative Fuels and Hybrid scenarios reduce energy consumption by similar amounts.

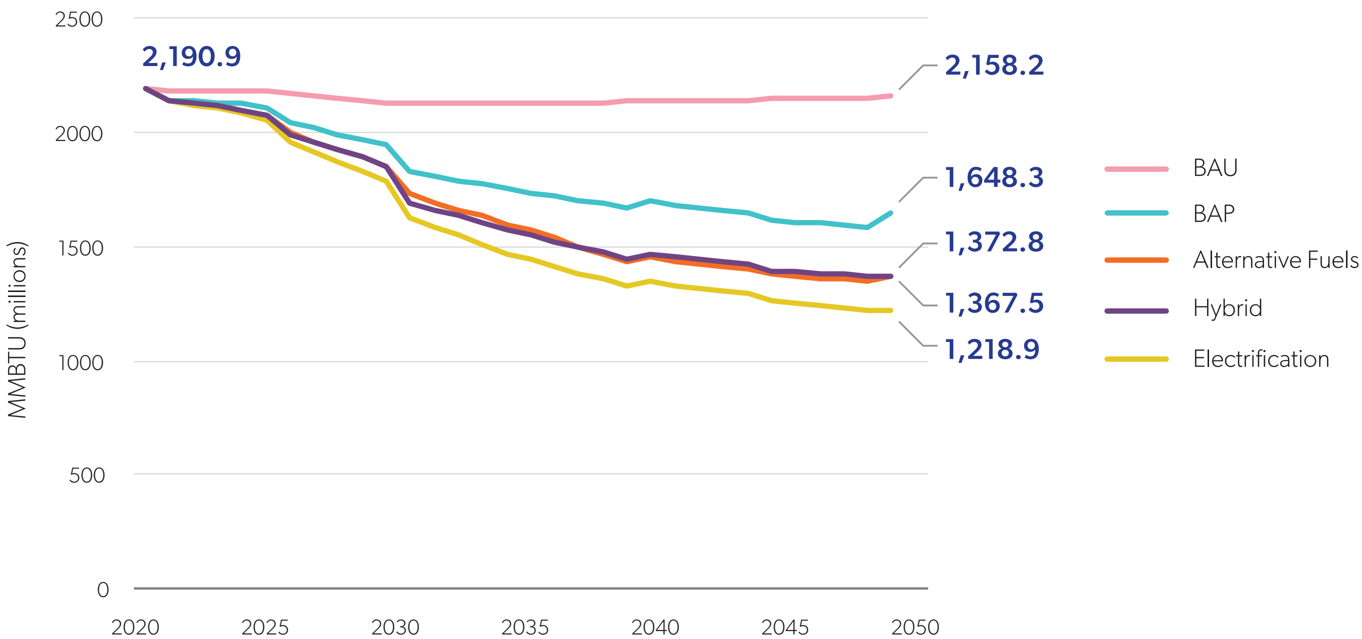

Figure 42. Total Energy Use, 2019 to 2050

Including the common actions, actions in the Electrification scenario reduce the amount of energy required to power Washington's homes, businesses, and industries by nearly half. Total energy consumption in the Electrification scenario decreases 41% from 2019 to 2050, from a peak of 2.190 million MMBTUs in 2019 to 1.283 million MMBTUs. Energy use decreases in all sectors: residential (48%), commercial (53%), transportation (69%) and industrial (22%). Energy used to produce electricity decreases by 48%.

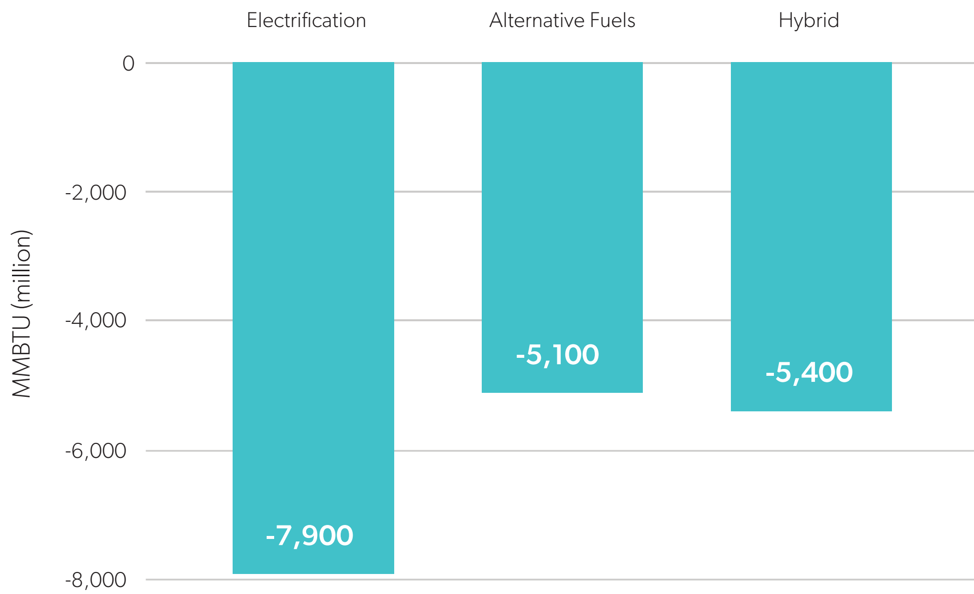

Figure 43. Cumulative energy consumption, 2019-2050, for all three decarbonization scenarios.

Insights:

- Modern electric systems are more efficient than resistance-based electric systems or combustion-based systems, often by multiple factors.
- Increased efficiency decreases transition and ongoing operating costs.
- Reductions in energy consumption ease the costs and impacts of decarbonization of the energy system by reducing the need for new renewable capacity, transmission, and distribution.

8.1.5 The Energy System is Integrated

Electrification can result in an even more integrated energy system than currently exists, enabling the impacts of energy efficiency to compound across sectors. For example, shifting vehicular trips to active modes (such as a walking trip) and increasing the energy efficiency of warehouses are both energy efficiency measures that reduce energy demand, allowing more electricity to be available when needed while requiring fewer additional electricity generating resources.

From the perspective of the energy system, energy use in the residential, commercial, and transportation sectors decreases dramatically, with electricity becoming the primary source of energy for these sectors. Total energy consumption declines in each sector across all the scenarios, except for the industrial sector in alternative fuels and hybrid scenarios. In these two scenarios, energy consumption increases in order to produce 50% of the green hydrogen required for the state's consumption.

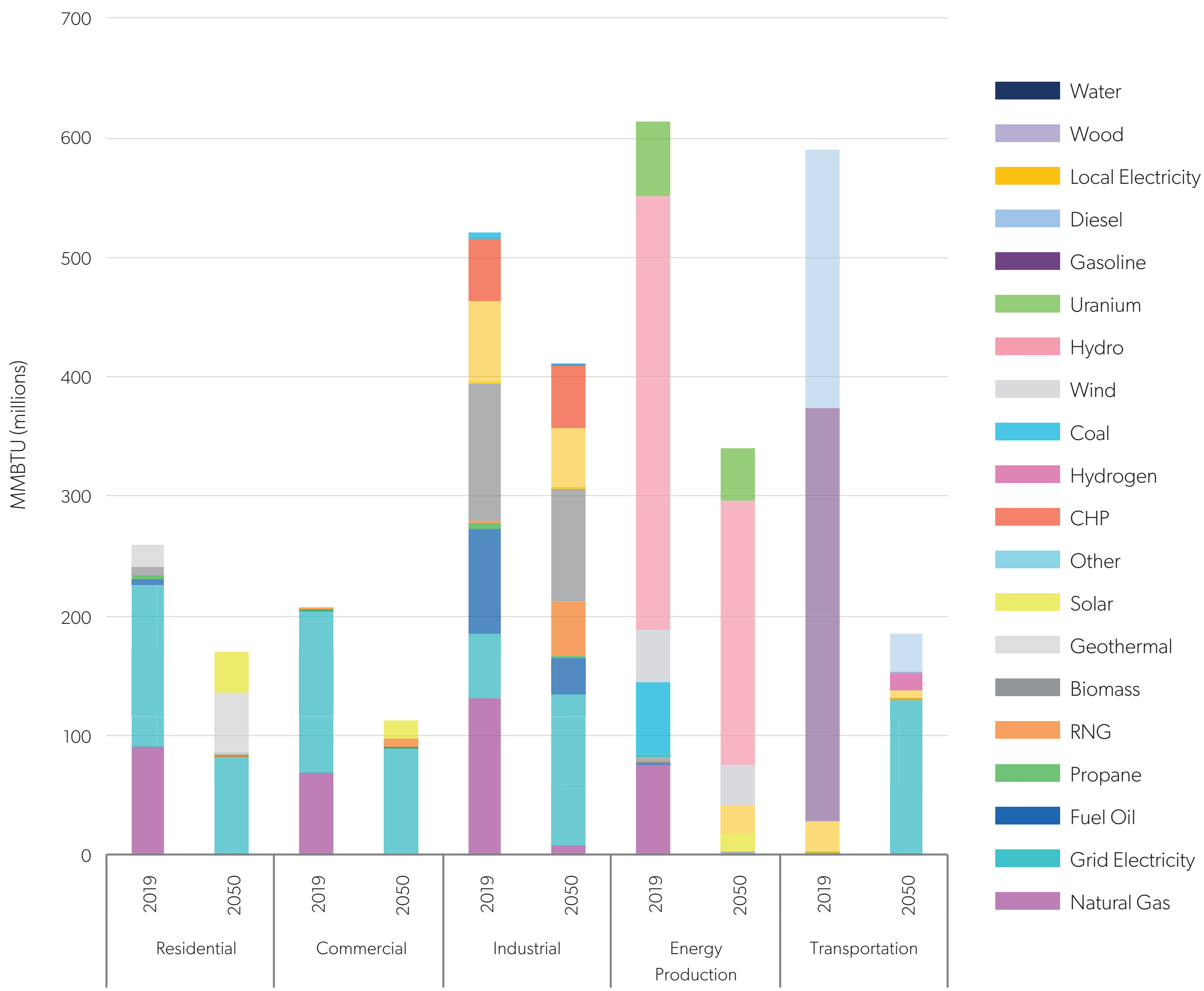

Figure 44. Fuels used to supply energy by sector from 2019-2050 the Electrification scenario.

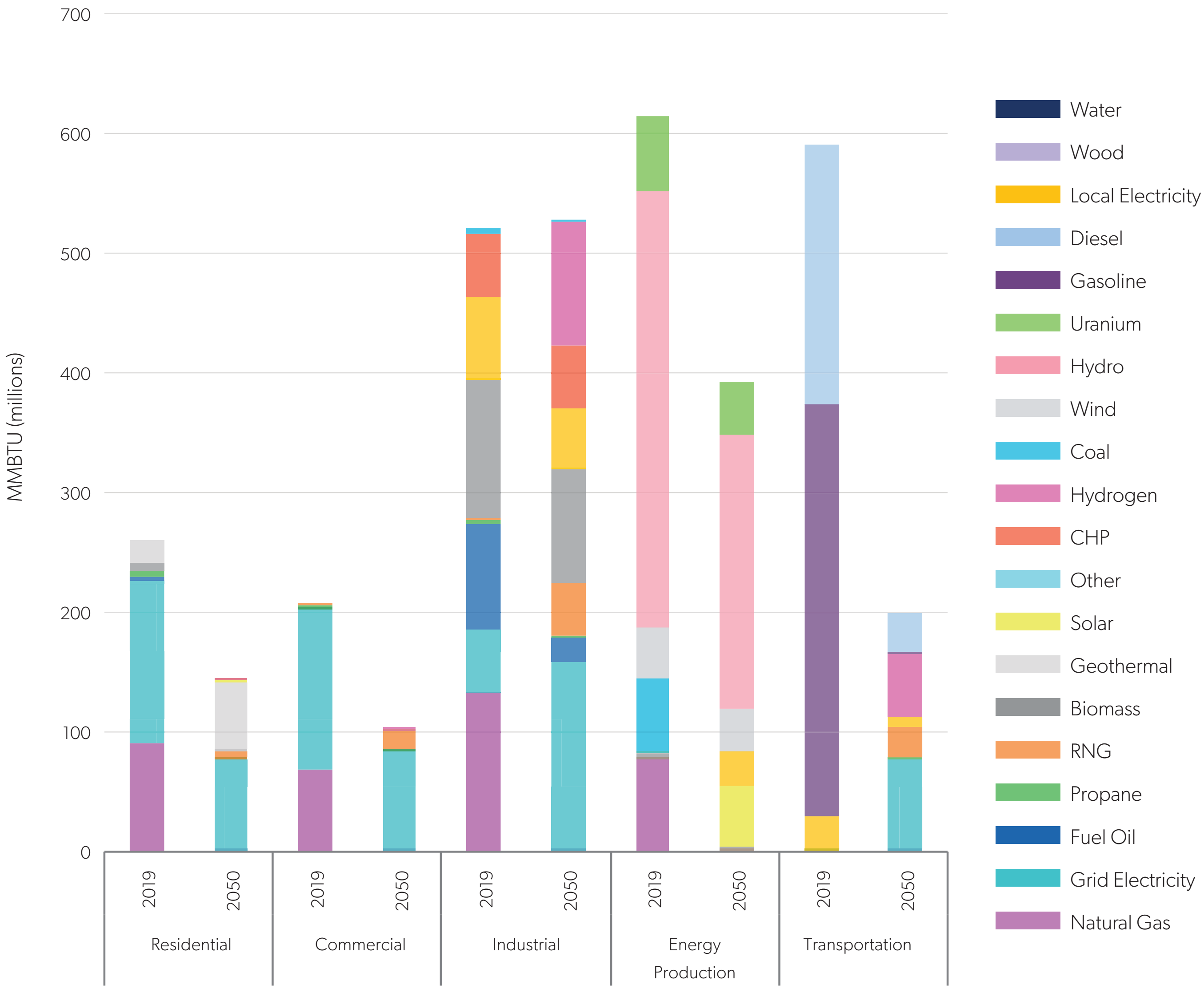

Figure 45. Fuels used to supply energy by sector from 2019-2050 for the Alternative Fuels scenario.

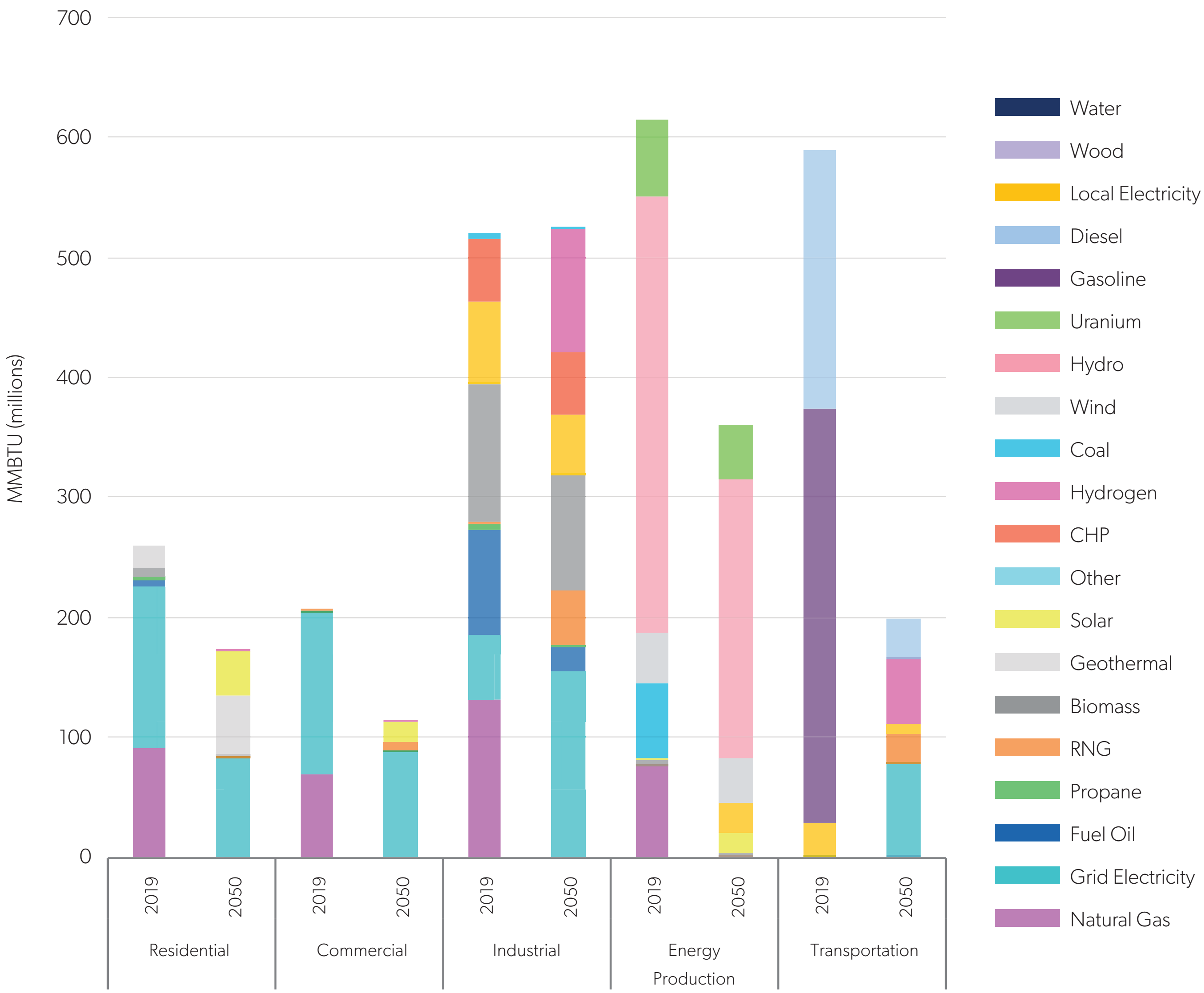

Figure 46. Fuels used to supply energy by sector from 2019-2050 for the Hybrid scenario.

Insights:

- Deep energy savings are possible across all sectors, with secondary dividends for the electricity system.
- The historic sector-based energy supply and demand and regulatory approaches are no longer applicable in an integrated energy system.
- When efficiency programs and incentives are developed across all sectors, energy savings are compounded throughout the energy system
- Hydrogen production can drive up electricity consumption, overwhelming the efficiency gains, depending on the scope of its deployment and the extent to which it is produced locally.
- Demand for electricity for green hydrogen production could compete with decarbonizing other end uses for capital, materials (metals, rare earth minerals, etc.), design and engineering resources, construction trade labor, and manufacturing capacity to produce specialized equipment.

8.1.6 RNG and Green Hydrogen Have a Small to Medium Role

8.1.6.1 RNG Use

RNG consumption rises in all three decarbonization scenarios compared to the Business-As-Planned scenario. RNG is the primary source of energy use in industry in all three scenarios. In the Alternative Fuels scenario, the adoption of natural gas heat pumps drives RNG use in the residential and commercial sectors. In the Alternative Fuels and Hybrid scenarios, the commercial vehicle fleet consumes a significant portion of RNG.

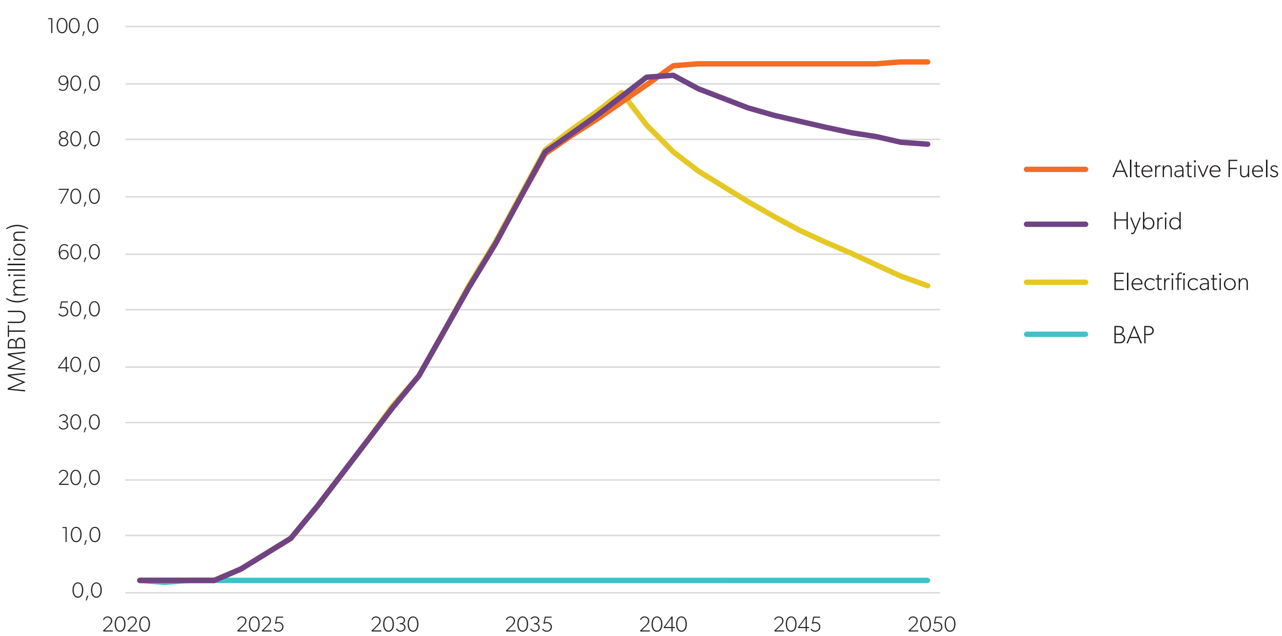

Figure 47. Renewable Natural Gas Energy Consumption (million MMBTU) for each scenario, annually

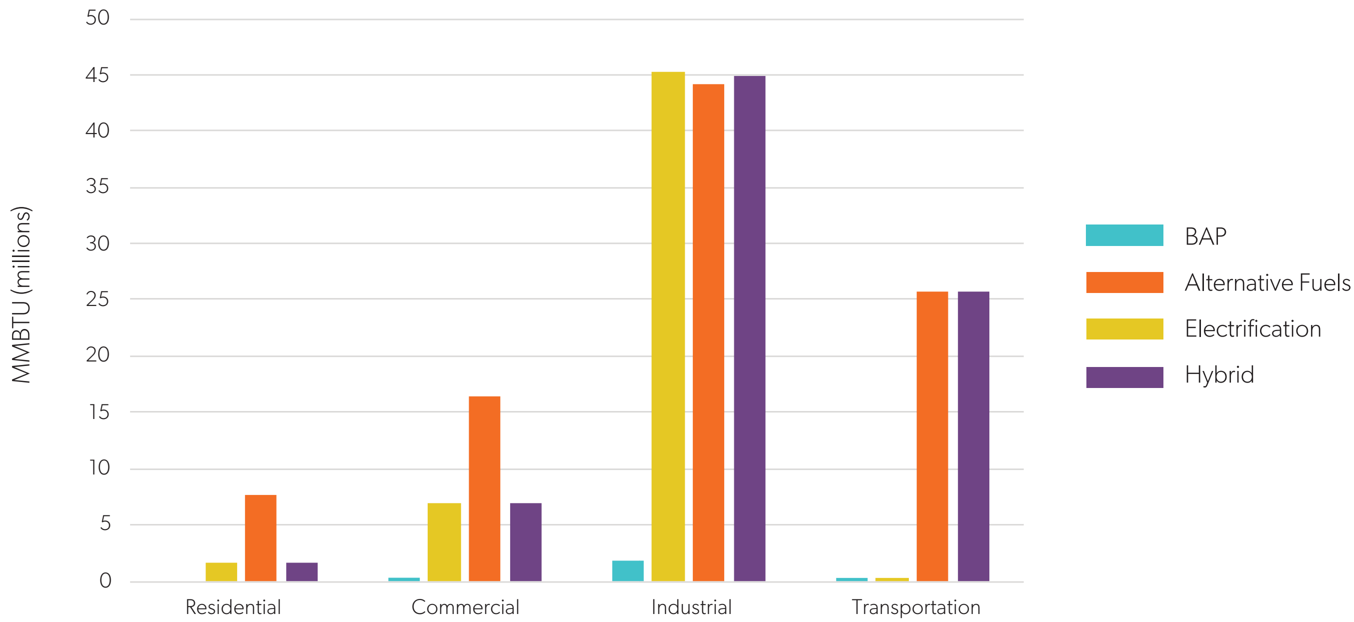

Figure 48. Renewable Natural Gas Energy Consumption by Source (million MMBTU) for each scenario by sector in 2050

The Alternative Fuels scenario requires ~8 tBTUs more RNG than is estimated to be available in Washington;[293] thus implementing this pathway may require additional production or purchasing of RNG from as-yet-unidentified sources, representing a potential risk of this pathway. In the Electrification scenario and the Hybrid Scenario, when taking into account the technical potential of RNG available to Washington, excess RNG is available (~30 tBTUs and ~5tBTUs respectively) and is reserved to power plants during periods of peak demand.

[293] The technical potential of RNG for consumption in Washington, 87.5 tBTU by 2050, was determined by downscaling the U.S.- wide projection of available RNG, produced by the American Gas Foundation, by the population of Washington. Production due to synthetic methane was excluded from the total due to the uncertain long-term viability of this technology. The technical potential represents the RNG that can be produced in state and imported from out of state.

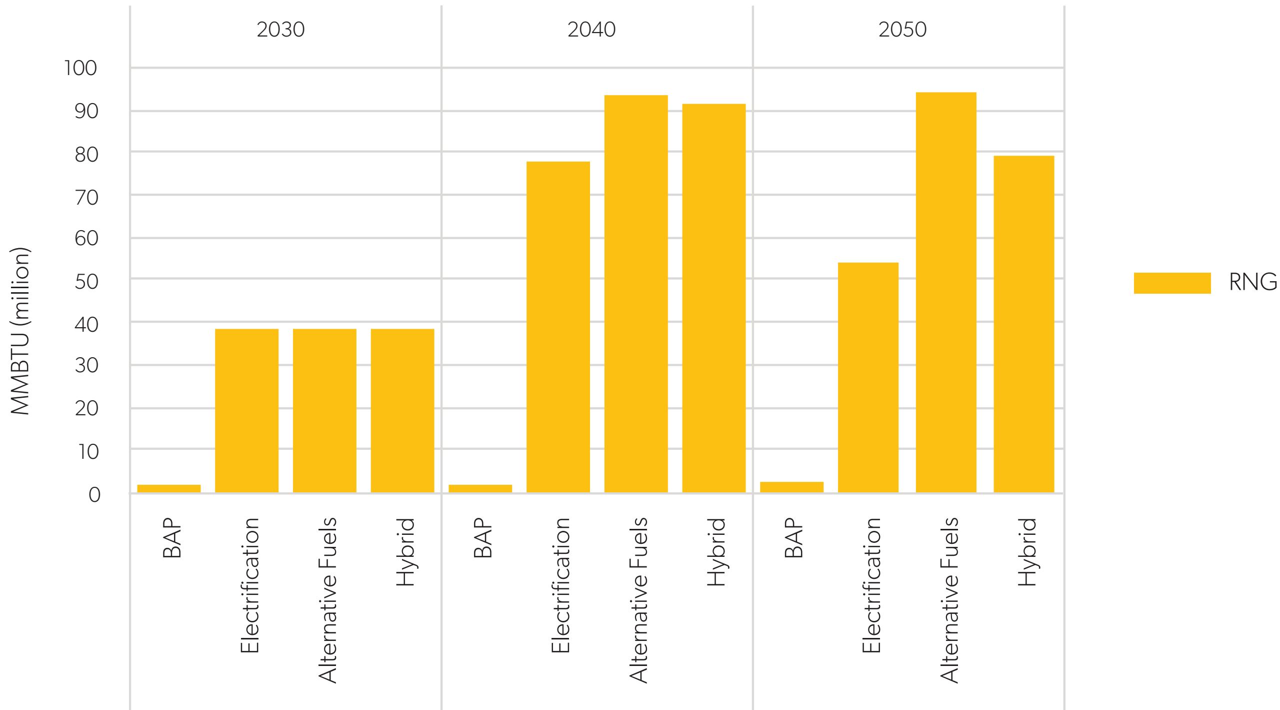

Figure 49. Renewable Natural Gas Energy Consumption by Source (million MMBTU) for Each Scenario, 2030, 2040, and 2050.

Insights:

- Electricity consumption grows slowly, at approximately 1% per year, in all scenarios, despite electrification of transportation and heating.
- In the Alternative Fuels scenarios, in-state production of 50% of the hydrogen consumed increases electricity consumption.
- The Alternative Fuels and Hybrid scenarios further reduce the burden on the electricity grid to decarbonize and grow simultaneously.

8.1.6.2 Hydrogen Use

Hydrogen consumption rises in all three decarbonization scenarios compared to the BAP scenario, but is minor in the Electrification scenario. The BAP scenario includes some projected hydrogen use in the transportation sector as a means of meeting the State's transportation decarbonization requirements.

In the Electrification scenario, hydrogen use is limited to some transportation activities, and decreases in comparison to the BAP because some vehicles are later converted to electricity from hydrogen fuel cells. In the Alternative Fuels and Hybrid scenarios, hydrogen is mainly used in the industrial and transportation sectors with a small amount used in the residential and commercial sectors via fuel cells and mixing with NG/RNG. All hydrogen is assumed to be green hydrogen, produced using renewable electricity, and 50% of the hydrogen consumed is assumed to be produced in Washington.

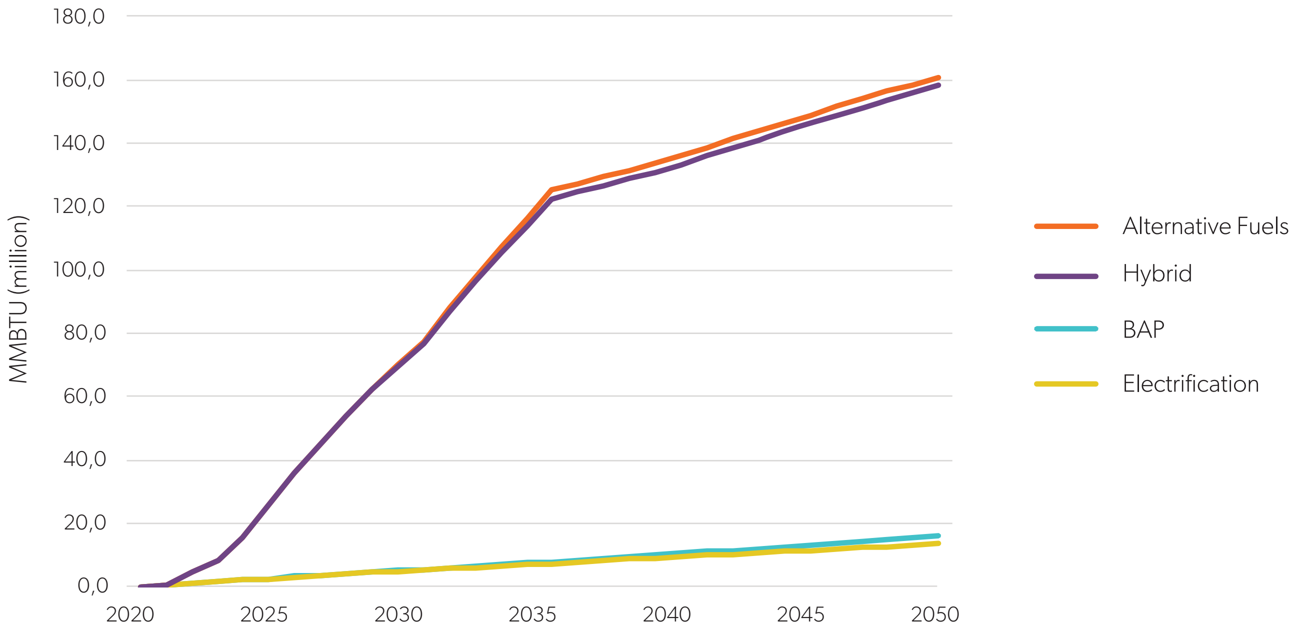

Figure 50. Hydrogen Energy Consumption by Source (million MMBTU) for each scenario, annually

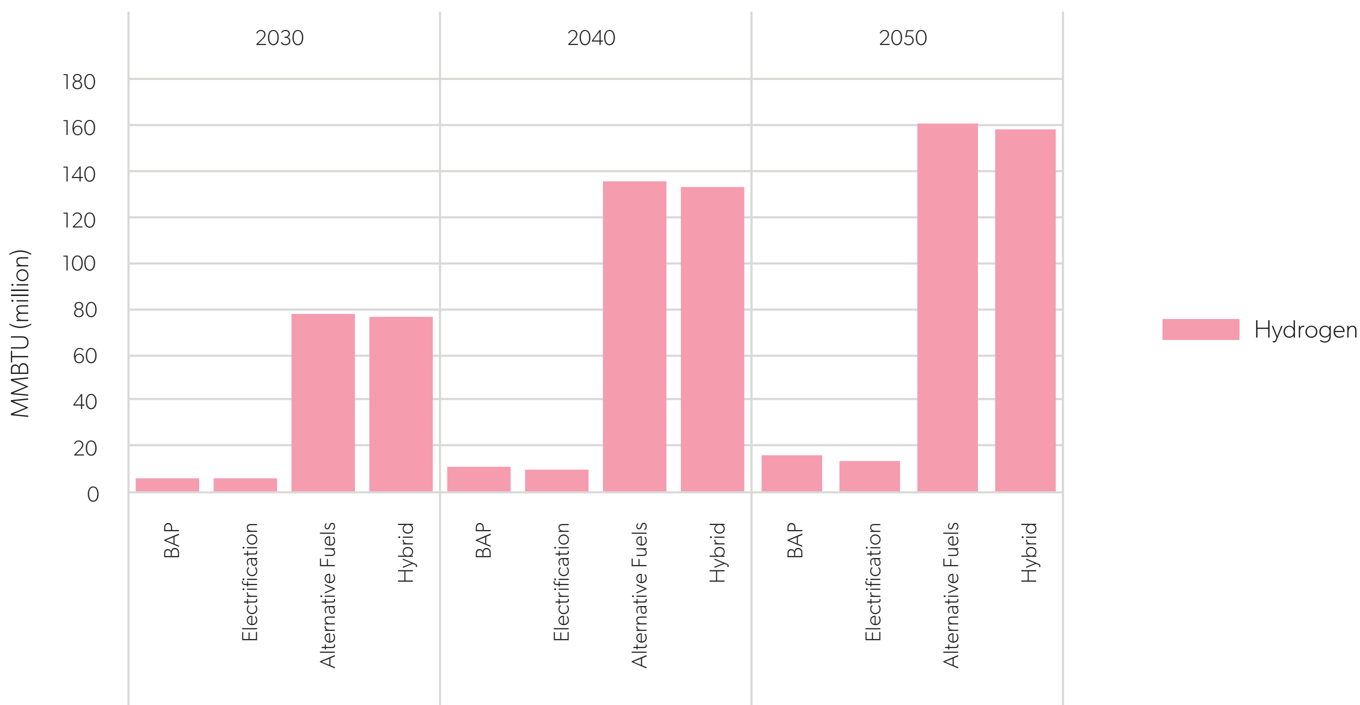

Figure 51. Hydrogen Energy Consumption by Source (million MMBTU) for each scenario, by decade.

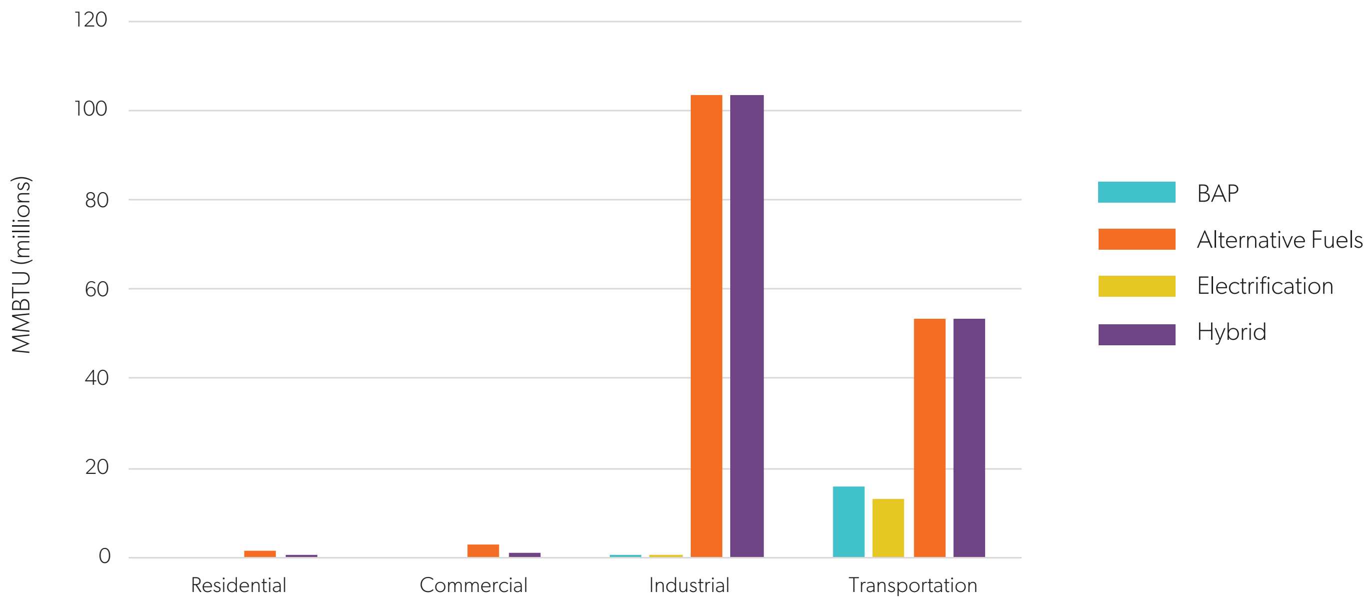

Figure 52. 2050 Hydrogen Consumption by Scenario and Sector

Insights:

- Annual electricity consumption grows slowly, at approximately 1% per year, in all scenarios, despite electrification of transportation and heating, mitigating the challenge of relying on renewable energy. In this light, steps to increase energy efficiency are key to supporting the decarbonization of the natural gas system.
- Even though the alternative fuels and hybrid scenario are not electrifying as aggressively, the generation of hydrogen requires electricity (amount depends on how much is generated in Washington), specifically 111 million MMBTU (28% of total electricity demand).
- Acquiring a steady supply of renewable natural gas is a risk to all 3 scenarios. RNG assumptions rely on significant imports of RNG (approximately 78% of RNG demand).
- Hydrogen has a role to play in supporting the decarbonization of the industrial sector.
- The scope of work was to focus on decarbonizing the natural gas system. The actions explored have the co-benefit of reducing emissions for other fossil fuels. In the transportation and industrial sectors, however, some emissions remain from sectors outside the scope of this analysis (i.e., air travel and other industrial process related emissions).
- In the Alternative Fuels scenarios, in-state production of 50% of the hydrogen consumed increases electricity consumption.
- The Alternative Fuels and Hybrid scenarios further reduce the burden on the electricity grid to decarbonize and grow simultaneously.

8.2 The impact of increased electrification on the state's electric utilities

8.2.1 Electricity Consumption Increases

While overall energy use decreases in the decarbonization scenarios due to efficiency gains and fuel switching, the electrification of nearly all end uses causes total annual electricity consumption in the Electrification Scenario to rise 24% from 2019 to 2050, from 94 million MWh to 125 million MWh; in the Alternative Fuels Scenario it rises 18.2% from 94 million MWh in 2019 to 115 million MWh in 2050; and in the Hybrid Scenario it rises 20.1% from 94 million MWh in 2019 to 118 million MWh in 2050.

Figure 53 illustrates how electricity can be spread out across the different sectors. For example, in the electrification scenario it is observed that increases in the transportation and industrial sectors are absorbed by reductions in the residential and commercial sectors.

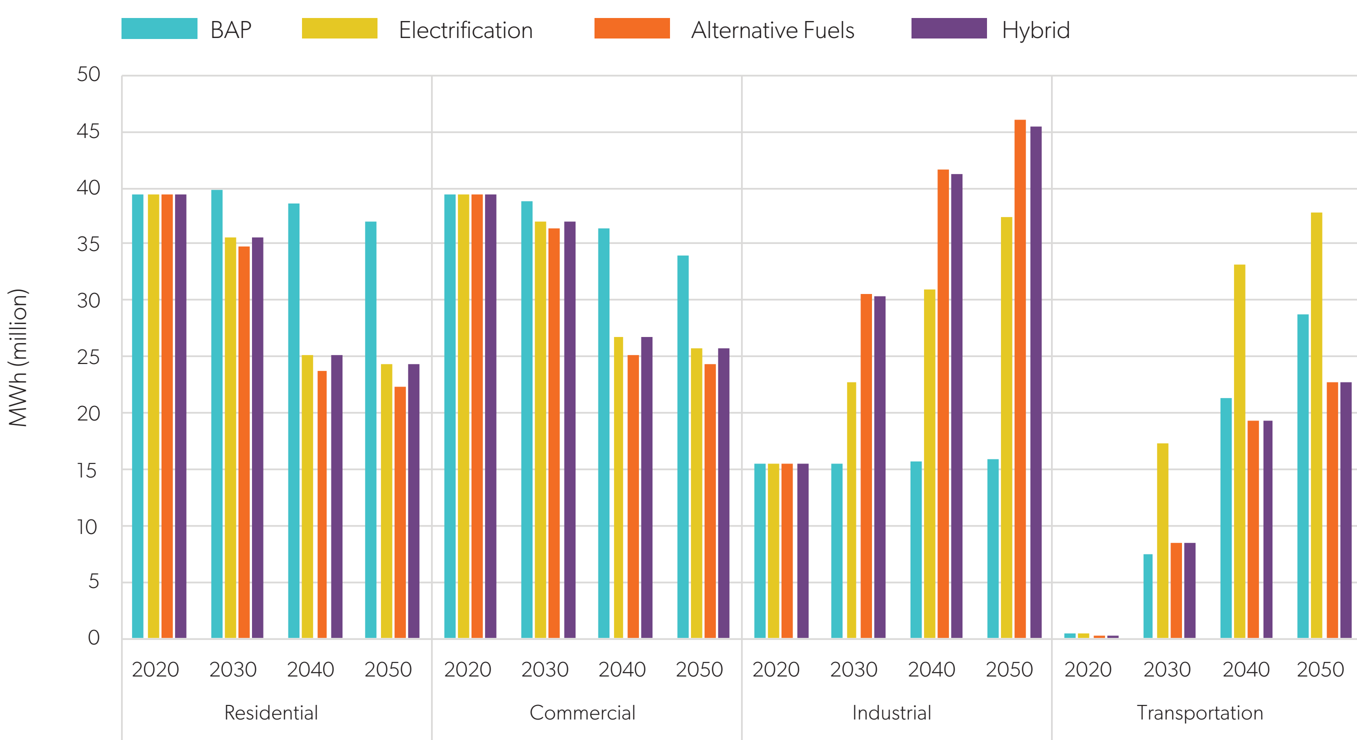

Figure 53. Annual electricity demand by sector for 2030, 2040 and 2050.

Across all scenarios, replacing electric resistance heaters in existing buildings with heat pumps, combined with retrofits, results in decreased electricity consumption in both the residential and commercial sectors, despite the electrification of heating.

8.2.2 Peak Demand Increases, but is Manageable

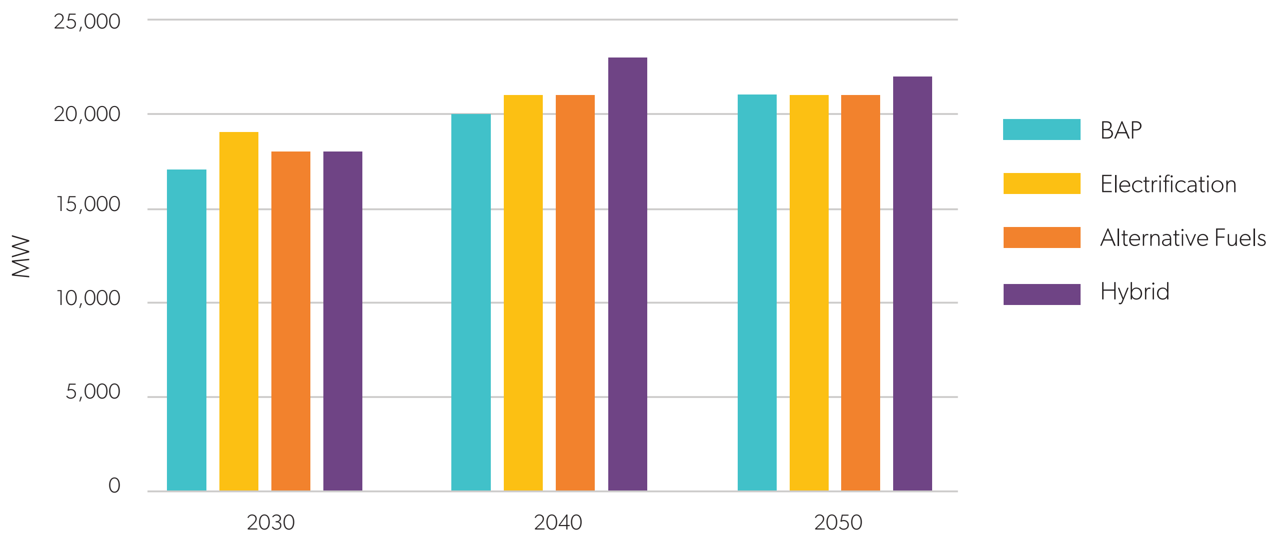

Figure 54. Max peak electricity demand (MW) for 2030, 2040, 2050 for each scenario

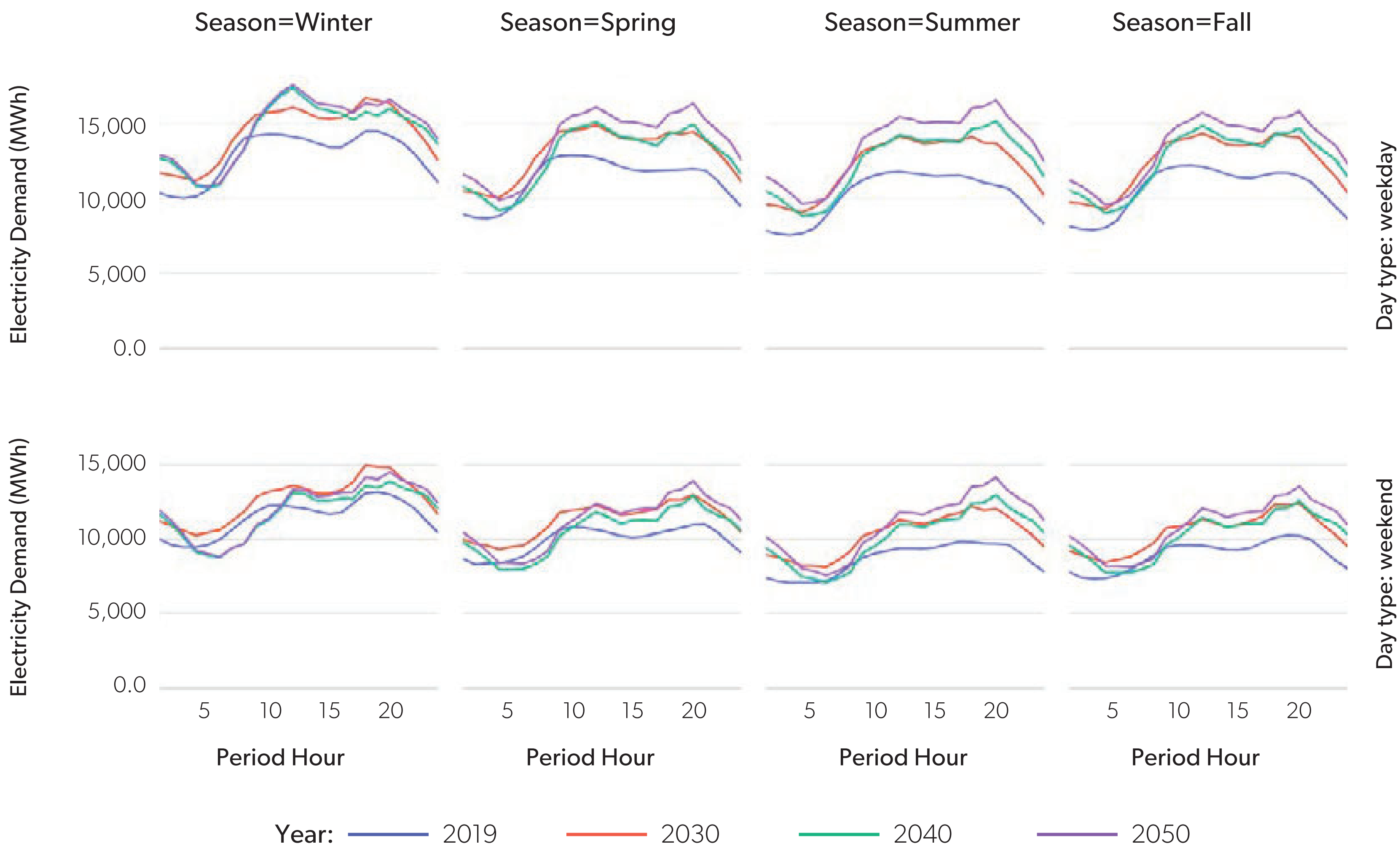

Figure 55. Seasonal Electricity demand for average weekdays (top) and weekend days (bottom) in winter, spring, summer, and fall in the Electrification scenario. Each line represents a year (2019, 2030, 2040, and 2050). By 2050, average peak hourly demand in MW reaches around 15,000 MW on weekdays.

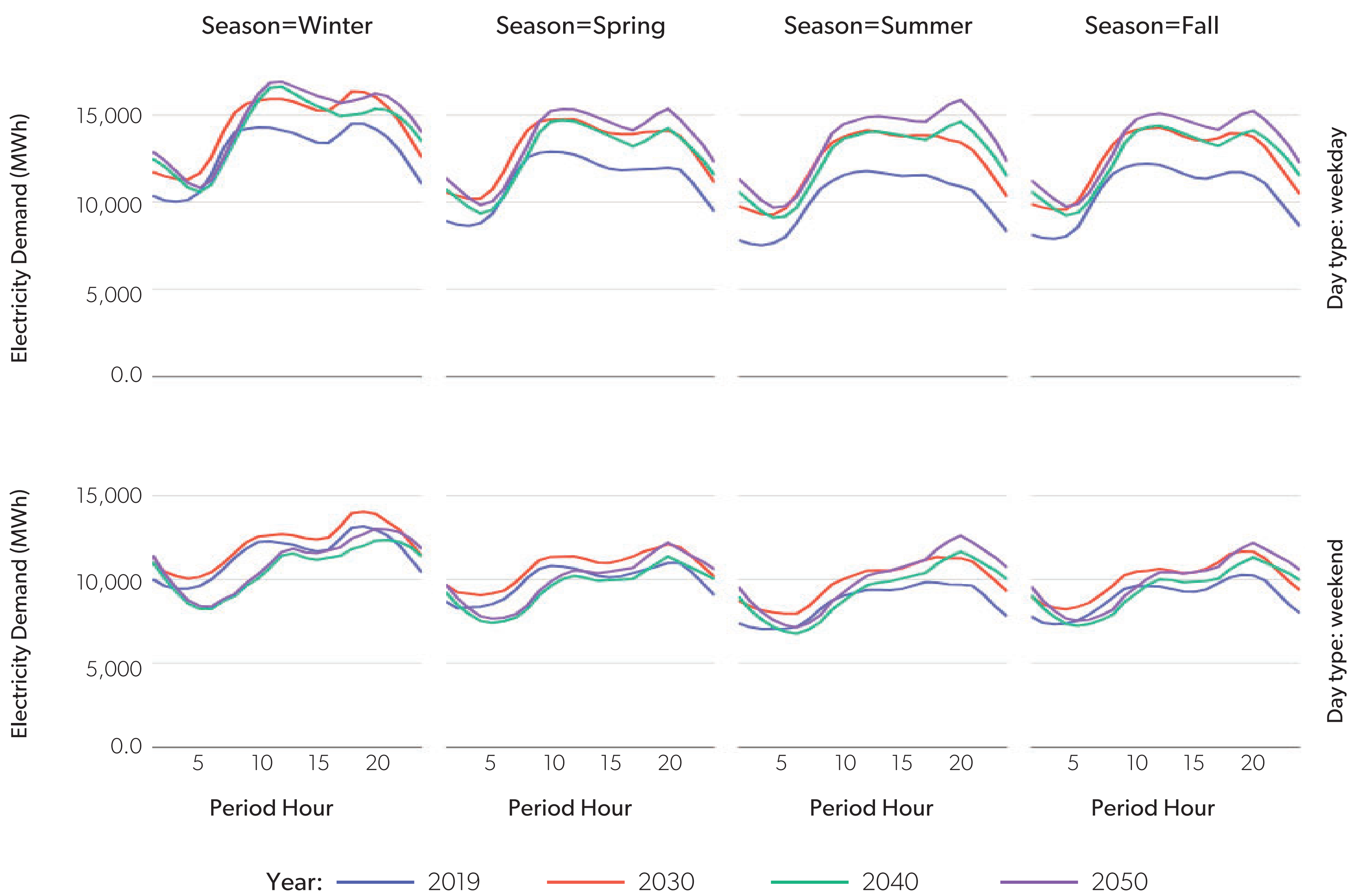

Figure 56. Seasonal Electricity demand for average weekdays (top) and weekend days (bottom) in winter, spring, summer, and fall in the Alternative Fuels scenario. Each line represents a year (2019, 2030, 2040, and 2050). By 2050, average peak hourly demand in MW reaches around 15,000 MW on weekdays.

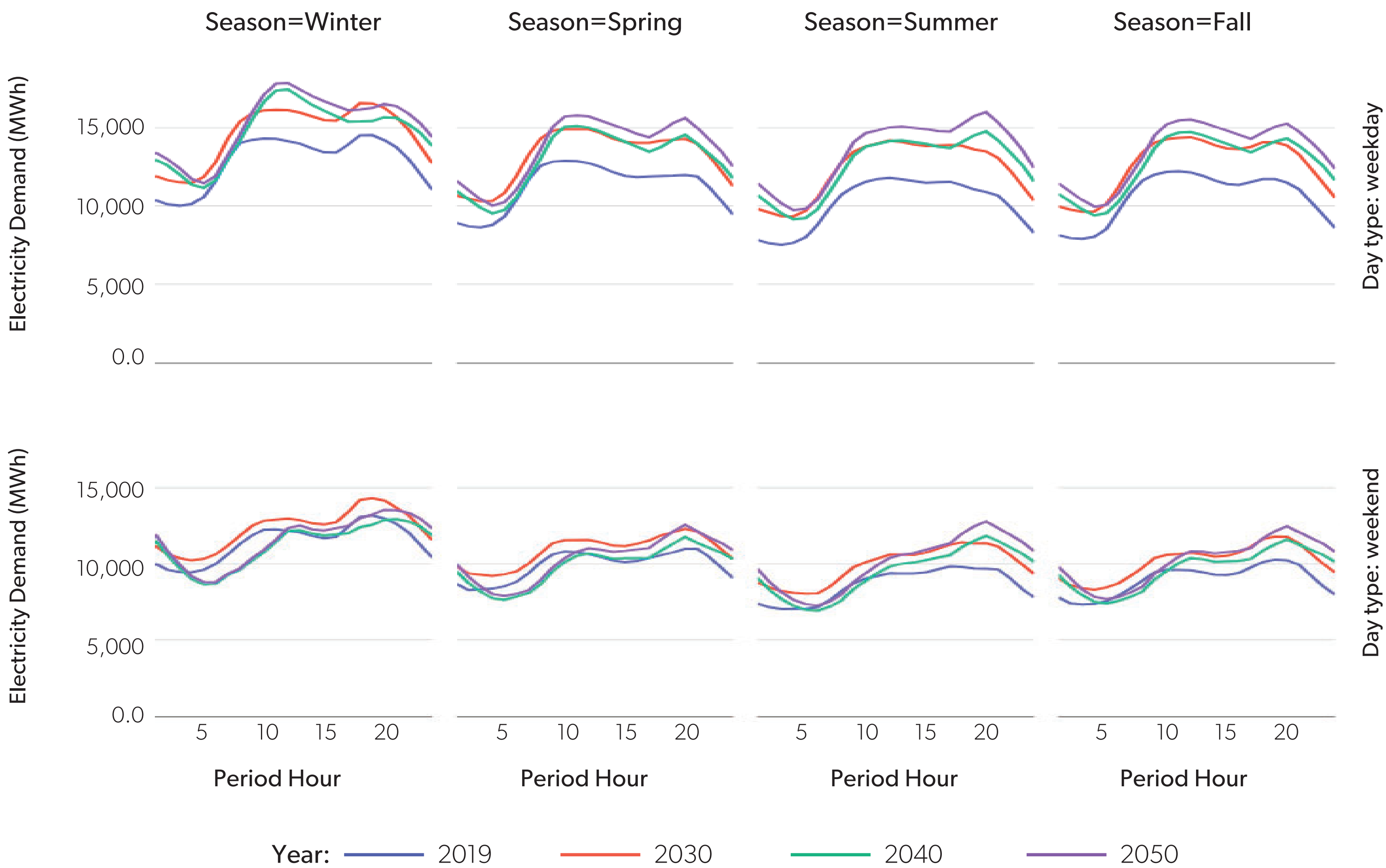

Figure 57. Seasonal Electricity demand for average weekdays (top) and weekend days (bottom) in winter, spring, summer, and fall in the Hybrid scenario. Each line represents a year (2019, 2030, 2040, and 2050). By 2050, average peak hourly demand in MW reaches around 15,000 MW on weekdays.

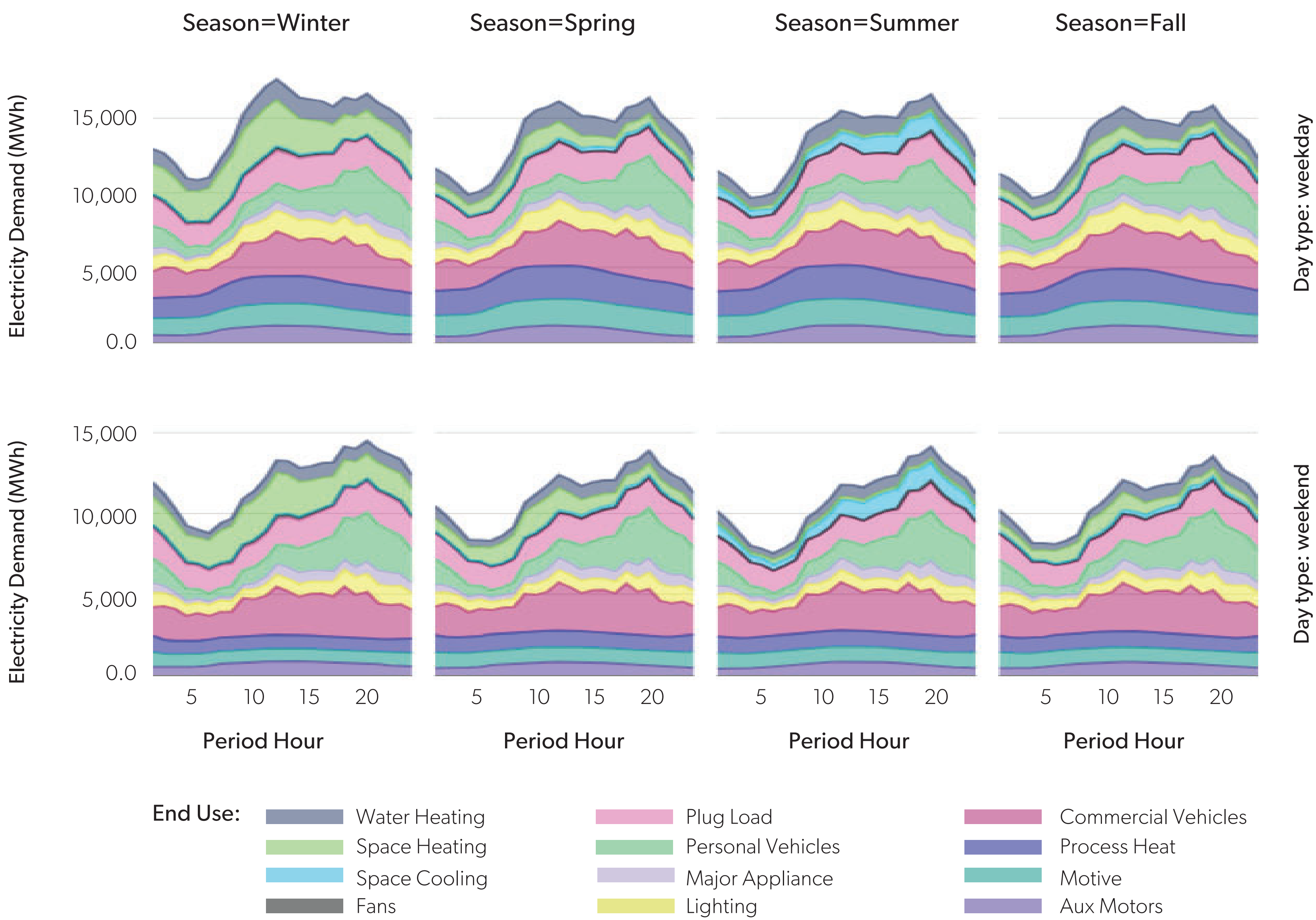

Figure 58. Seasonal Electricity demand for average weekdays (top) and weekend days (bottom) in winter, spring, summer, and fall in the Electrification scenario by End Use

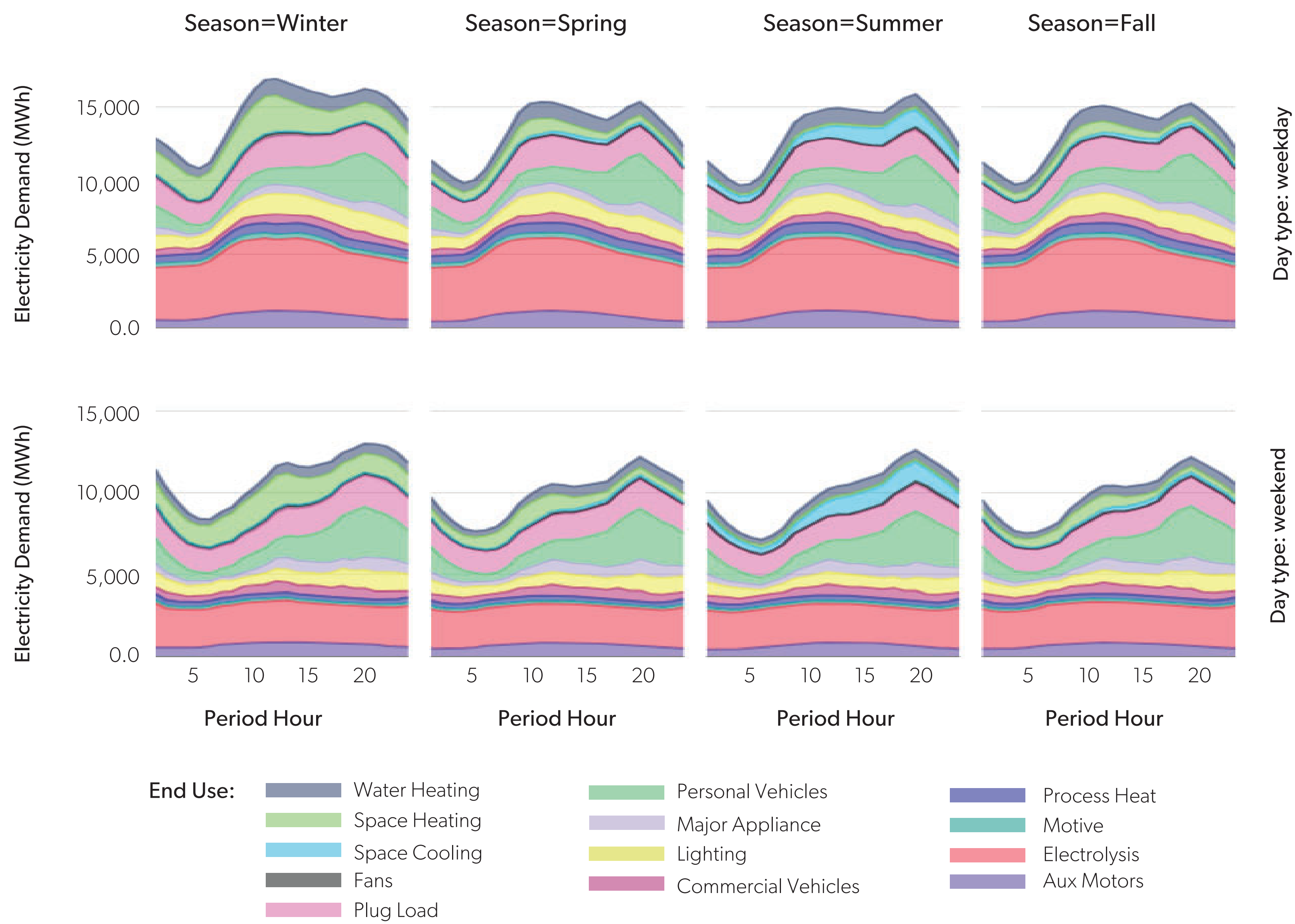

Figure 59. Seasonal Electricity demand for average weekdays (top) and weekend days (bottom) in winter, spring, summer, and fall in the Alternative Fuels scenario by End Use

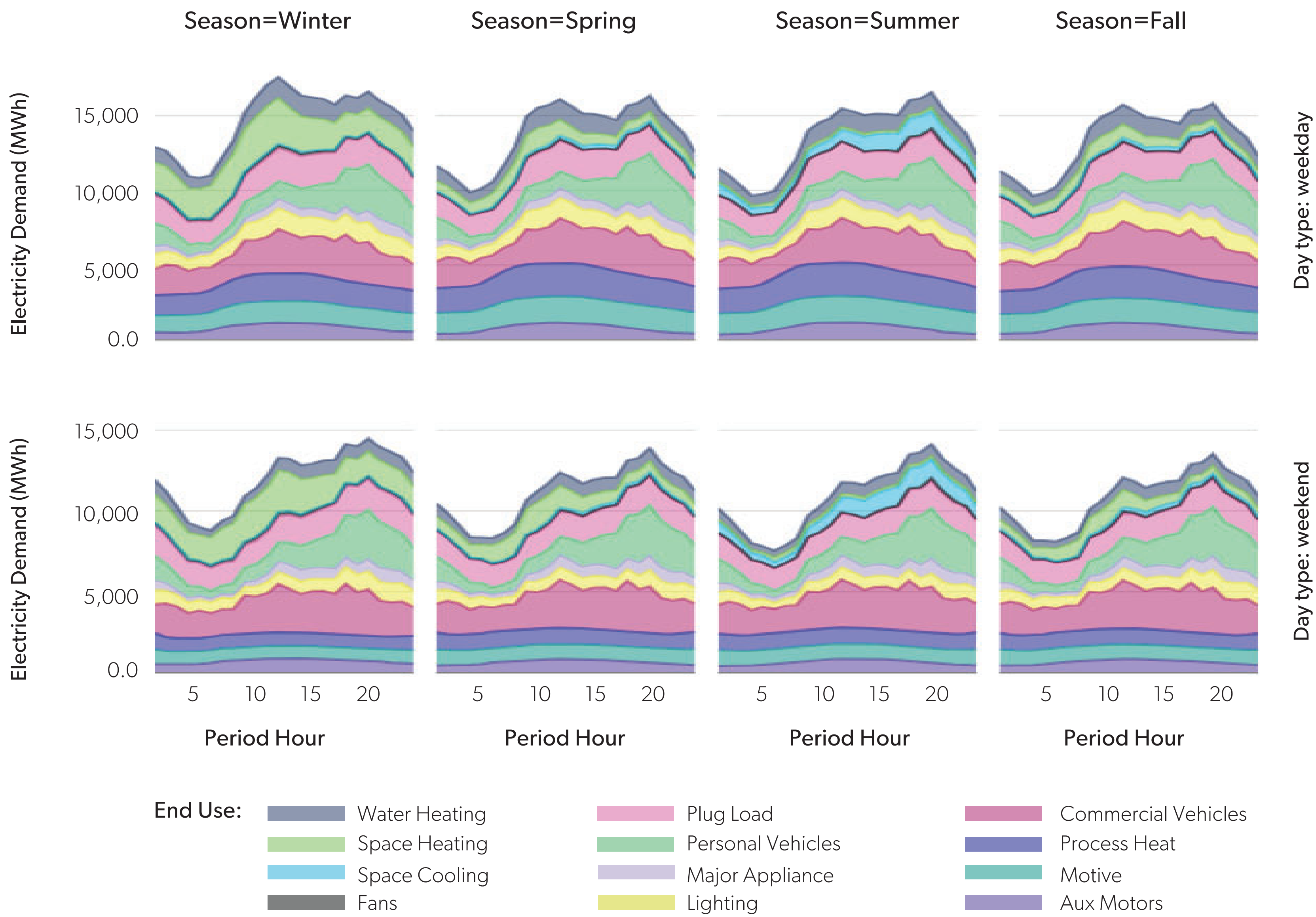

Figure 60. Seasonal Electricity demand for average weekdays (top) and weekend days (bottom) in winter, spring, summer, and fall in the Hybrid scenario by End Use

8.2.3 Demand Response is Critical

In any given year, Washington can expect to experience periods of heightened demand coincident with limited output from renewable energy sources such as solar, wind, and hydroelectric power. These periods can range from hours to days to weeks. While batteries can be used to meet hourly fluctuations in demand, they are not yet cost effective in addressing multi-day shortages where there is not enough power to both meet demand and charge batteries for later use.[294]

As an alternative to adding additional resources to ensure adequate supply during times of peak system load, electric utilities may choose to plan to use demand response as a resource to temporarily reduce or shift demand for electricity. Demand response can take many forms, and can involve eliminating load entirely, or shifting it to another time of the same day or week. For example, electric vehicle charging stations can be interconnected with utility operations, and be programmed to shift charging rates and times in anticipation of reduced electricity supply. This can shift the charging of electric vehicles from the nighttime to the daytime, when renewable electricity from solar power is more available. Peak industrial demand can be reduced through interruptible service agreements, where customers are financially compensated for reducing energy use, or through incentivization of onsite battery storage or renewable energy production for supplementary energy supply.

The following table (next page) describes the demand response used in each scenario to bring peak demand down to a level where adding resources or using imports becomes more cost effective. It represents a limited deployment of demand response and a conservative estimate of the potential impacts. If demand response is developed further, such as with increased use of domestic hot water heaters with enhanced thermal storage, reliance on unspecified supply would go down.

[294] When given the option of incorporating a 4 or 8-hour duration battery, the optimization model (Calliope) only chose 4-hour duration battery life; for this reason, only 4-hour duration was incorporated in the final runs. 4-hour duration batteries are better for short bursts of peak power that occur within a 4-hour window. Also, it provides higher power output during the 4-hour duration, which can be advantageous for handling sudden spikes in demand and assisting with demand response. In this way, increasing the battery duration would not help to provide a quick response to peaks of power, however, it could help in sustained power increases over time, for more than 4 hours.

Table 16. Demand response actions applied by sector and end use in each scenario.

Sector	End Use	DR Action	Scenarios	Assumption
Commercial	Space heating	Shift 50-100% from afternoon to morning	Electrification	Retrofitted building envelope holds heat allowing building to preheat earlier in the day then "coast" in the afternoon
Industrial	Process Heat	Shed 50% of load	Electrification	Industrial facilities develop on-site battery storage and/or power generation to support load shedding
	Motive	Shed 50% of load	Electrification	Industrial facilities develop on-site battery storage and/or power generation to support load shedding
	Electrolysis	Shift 100% to hours with renewable curtailment	Alternative Fuels Hybrid	Storage is available for hydrogen generated during periods when renewable electricity would otherwise by curtailed
Residential	Space heating	Shift 50-100% to previous adjacent hours	Electrification	Retrofitted building envelope holds heat allowing building to preheat earlier in the day then "coast" in the afternoon
Transportation	Commercial use vehicles	Shift 50-100% to other hours within same day	Electrification	Removable batteries allow for offline charging at hours with lower demand
	Personal use vehicles	Apply load leveling profile for entire day to home and workplace charging to even spread over charging hours	Electrification Alternative Fuels Hybrid	20% of personal use vehicles may be charged at workplace

In general, demand response represents a very small fraction of overall annual electricity demand, less than 1% on average, although it is critical in the moment when it is used.

Demand response reaches more than 2% of total electricity demand only in 2050 for the Electrification scenario, where peak electricity demand is highest, fossil fuel generation is completely phased out, and hydrogen fuel is not in widespread use.

Table 17 below describes the impact in MWh of modeled demand response mechanisms. These include shifting when heating occurs in residential buildings using smart home control systems (pre-heating), shifting when heating occurs in commercial buildings using smart control systems (pre-heating) and implementing building energy system plans, shedding industrial load through contracts with industries that are able to shift production, and charging EVs at times when renewable energy is plentiful and demand is low.

Figure 17. Total demand response by sector, in MWh, for each of the decarbonization scenarios in 2030, 2040, and 2050.

Scenario	Sector	2030	2040	2050
Alternative Fuels	Commercial	0	0	0
	Residential	0	0	0
	Industrial - Shed	0	0	0
	Industrial - Shifted	164,937	137,138	201,735
	Transportation	0	0	0
Electrification	Commercial	1,049	0	1,066
	Residential	0	7,734	11,768
	Industrial - Shed	99,025	337,400	1,498,287
	Industrial - Shifted	99,025	337,400	1,498,287
	Transportation	50,677	94,559	285,778
Hybrid	Commercial	0	0	0
	Residential	0	0	0
	Industrial - Shed	0	0	0
	Industrial - Shifted	136,488	229,514	280,409
	Transportation	0	76,057	191,507

Figure 18. Percentage of annual electricity demand represented by demand response for each scenario in the years 2030, 2040, and 2050.

Scenario	2030	2040	2050
Alternative Fuels	0.15%	0.13%	0.18%
Electrification	0.23%	0.72%	2.87%
Hybrid	0.06%	0.14%	0.21%

Insights:

- Demand for electricity fluctuates depending on the season and the time of day. In winter, peak demand is driven by space heating. In the summer, peak demand is driven by space cooling. Peak hourly demand increases by 2050.
- The system peaks in the winter at 18,000 MW for the electrification scenario and at 17,000 MW in the alternative fuels and hybrid scenarios on an average weekday.
- By 2050 the winter peaks and valleys can be shifted by a couple of hours or more to smooth out demand and address strains on the electricity supply through demand response mechanisms.
- Electricity demand in the space heating and space cooling end uses is fairly constant between the three scenarios. The difference is found in the commercial vehicle and industrial sectors. The increase in electricity demand for electrified commercial vehicles and process heat requirements in the industrial sector is matched by the increase in electricity demand by electrolysis for hydrogen production in the Alternative Fuels and Hybrid scenarios.

8.3 The ability of electric utilities to meet increased demand

8.3.1 Renewable Supply Needs to be Built Out

To meet future electricity demand with resources that align with the requirements of CETA, new non-emitting electric generating capacity must be added. To analyze how much generating capacity to add, an hourly analysis of demand and supply was conducted for each decarbonization scenario using the common supply assumptions described earlier in this chapter. The results of the modeling show that additional generating capacity will be needed in all three scenarios, in addition to existing hydro, solar, nuclear, natural gas power plants, and wind capacity within Washington state.

Table 19. New electricity generating capacity (in MW) of renewable resources added in 2030, 2040, and 2050 for all three decarbonization scenarios.

Scenario	2030	2040	2050	Total
Electrification	21,398	7,105	0	28,503
Alternative Fuels	18,638	0	3,312	21,951
Hybrid	21,454	7,105	110	28,669

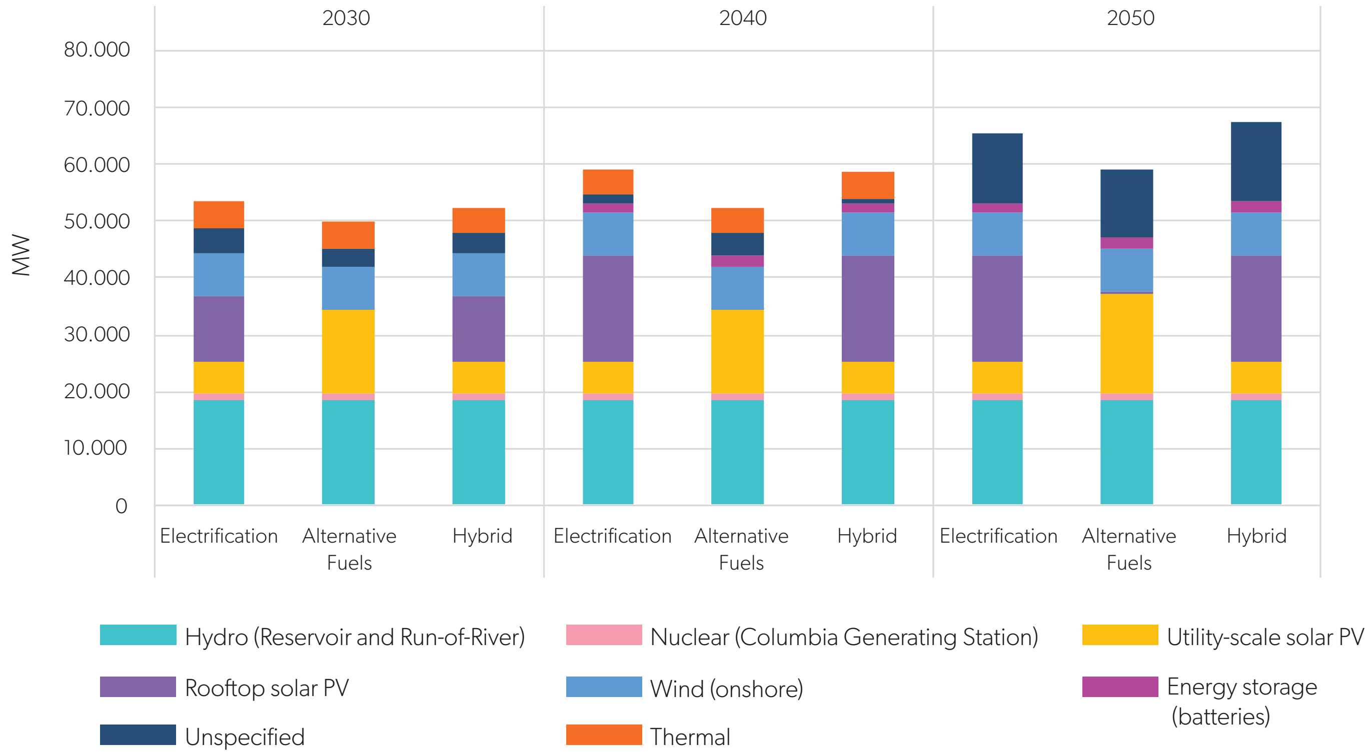

Figure 61. Total installed nameplate capacity (in MW) by resource type in 2030, 2040, and 2050 for all three decarbonization scenarios.

In the Electrification Scenario, additional resources are needed sooner compared to other scenarios, as end uses rapidly electrify, but new additions taper off by 2050. In the Alternative Fuels and Hybrid scenarios, additional resources are added more gradually, aligning with a more gradual increase in electricity demand. In both the Electrification and Hybrid scenarios, new rooftop solar capacity and energy storage are added to residential buildings in 2030 and 2040 during the course of deep energy retrofits and equipment upgrades. In the Alternative Fuels scenario, this action is not taken, resulting in a higher buildout of utility-scale solar PV and wind, as well as a higher reliance on imports in 2050.

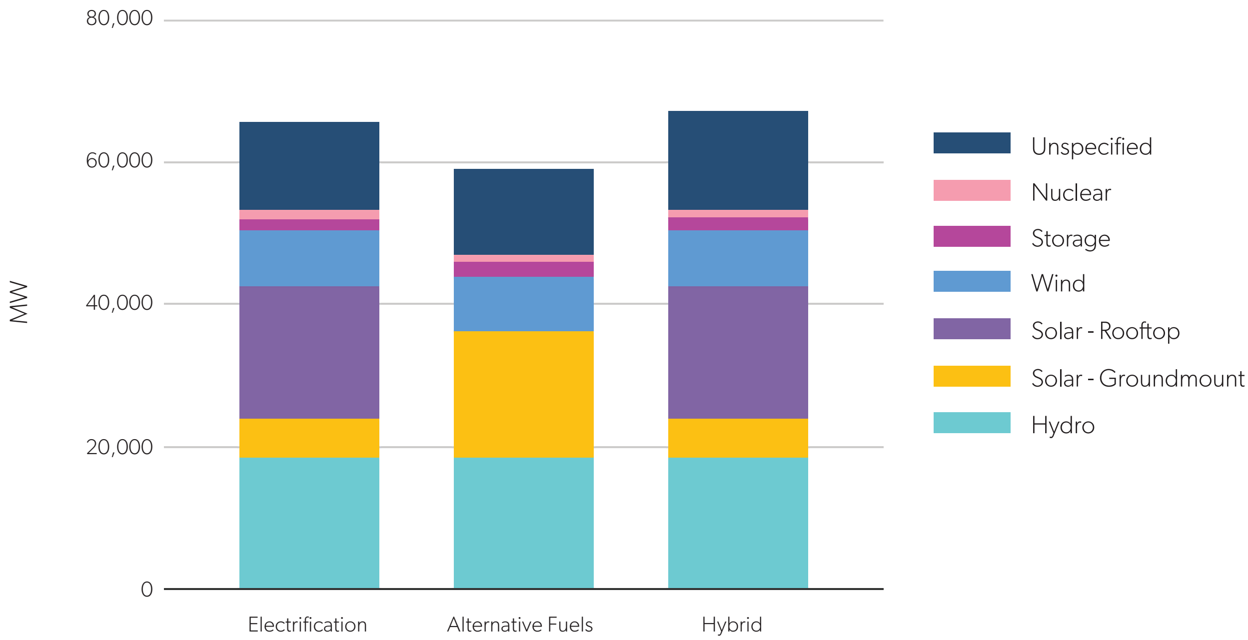

Figure 62. Total installed nameplate capacity (in MW) by resource type in 2050 for all three decarbonization scenarios.

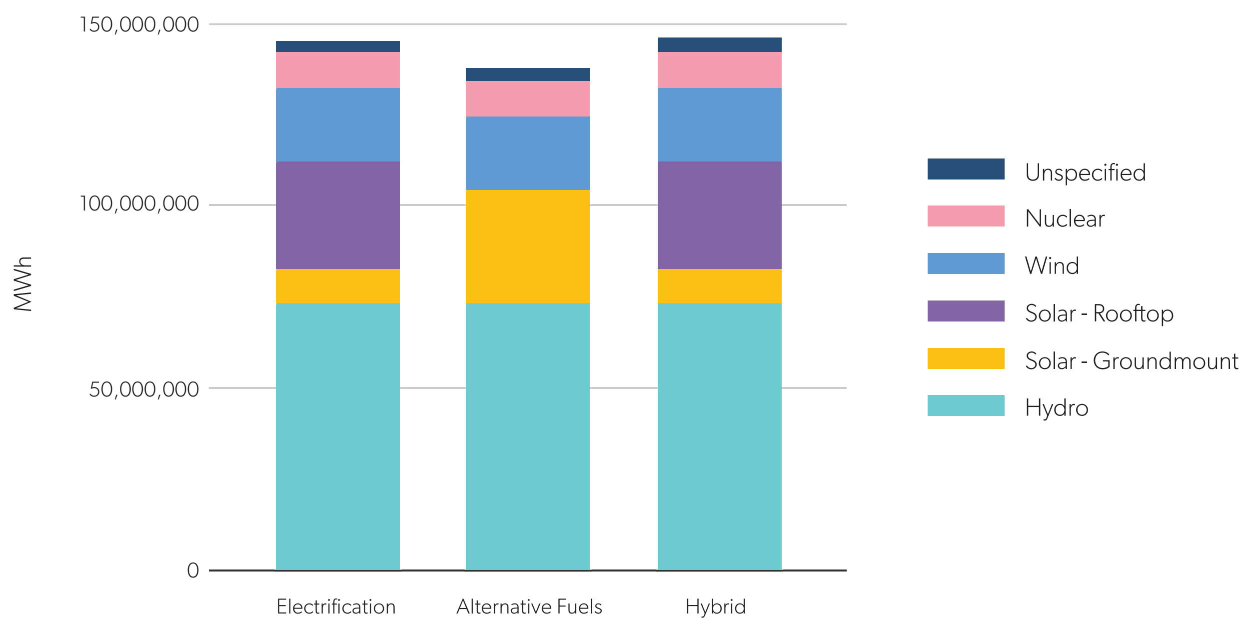

Figure 63. Total generation (in MWh) by resource type in 2050 for all three decarbonization scenarios.

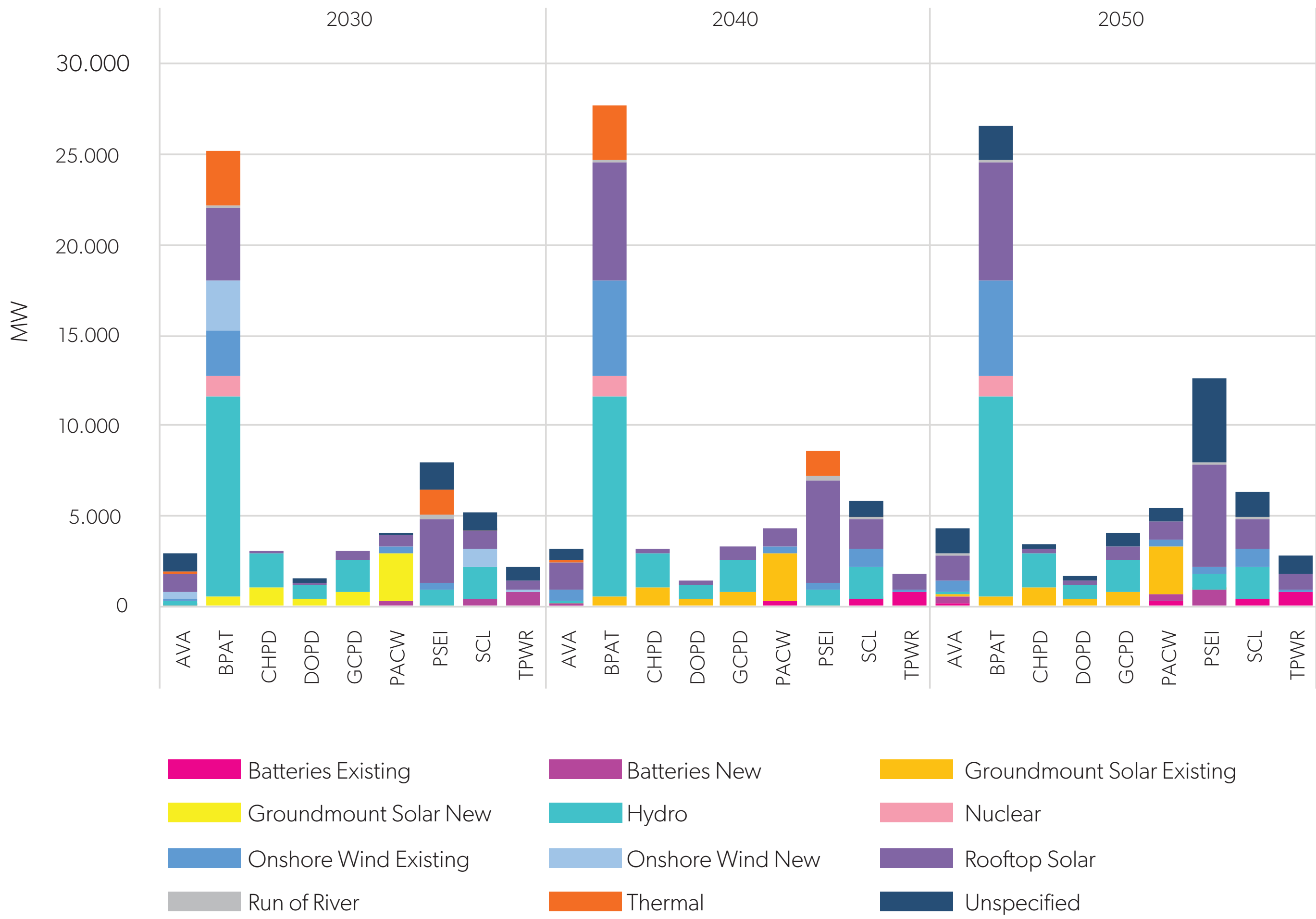

Figure 64. Total installed energy capacity by Balancing Authority for 2030, 2040, and 2050 in the Electrification scenario

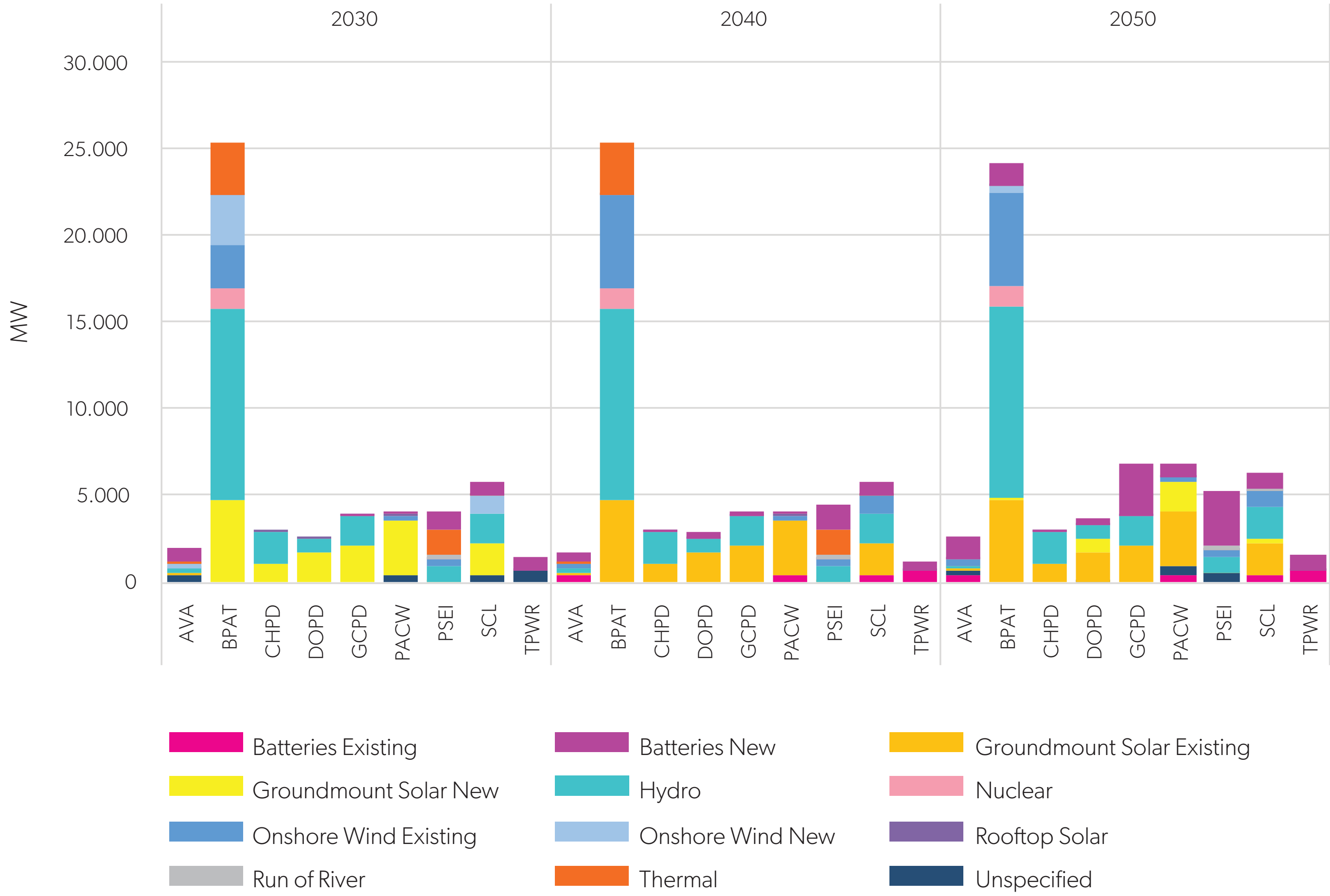

Figure 65. Total installed energy capacity by Balancing Authority for 2030, 2040, and 2050 in the Alternative Fuels scenario.

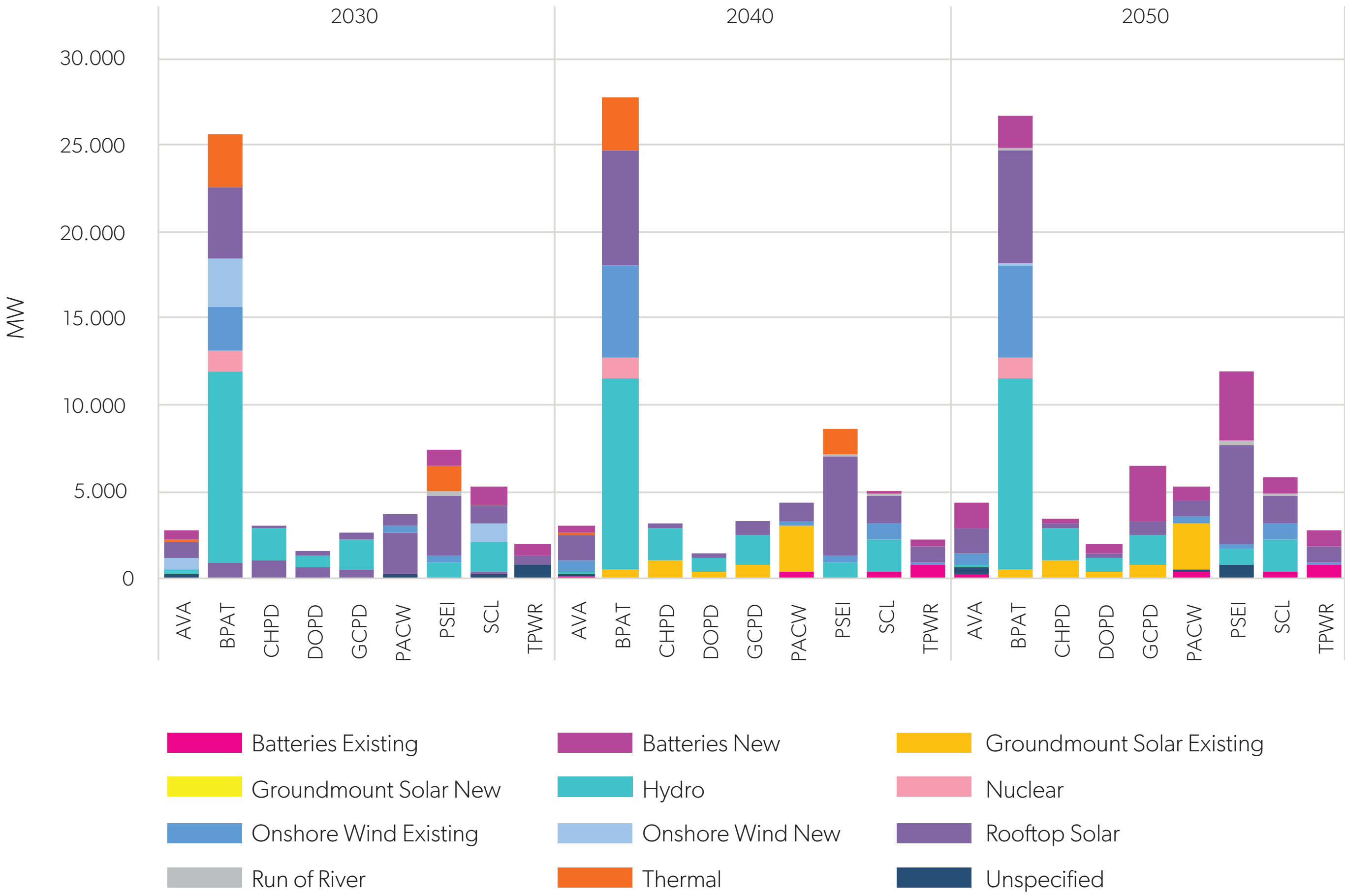

Figure 66. Total installed energy capacity by Balancing Authority for 2030, 2040, and 2050 in the Hybrid scenario.

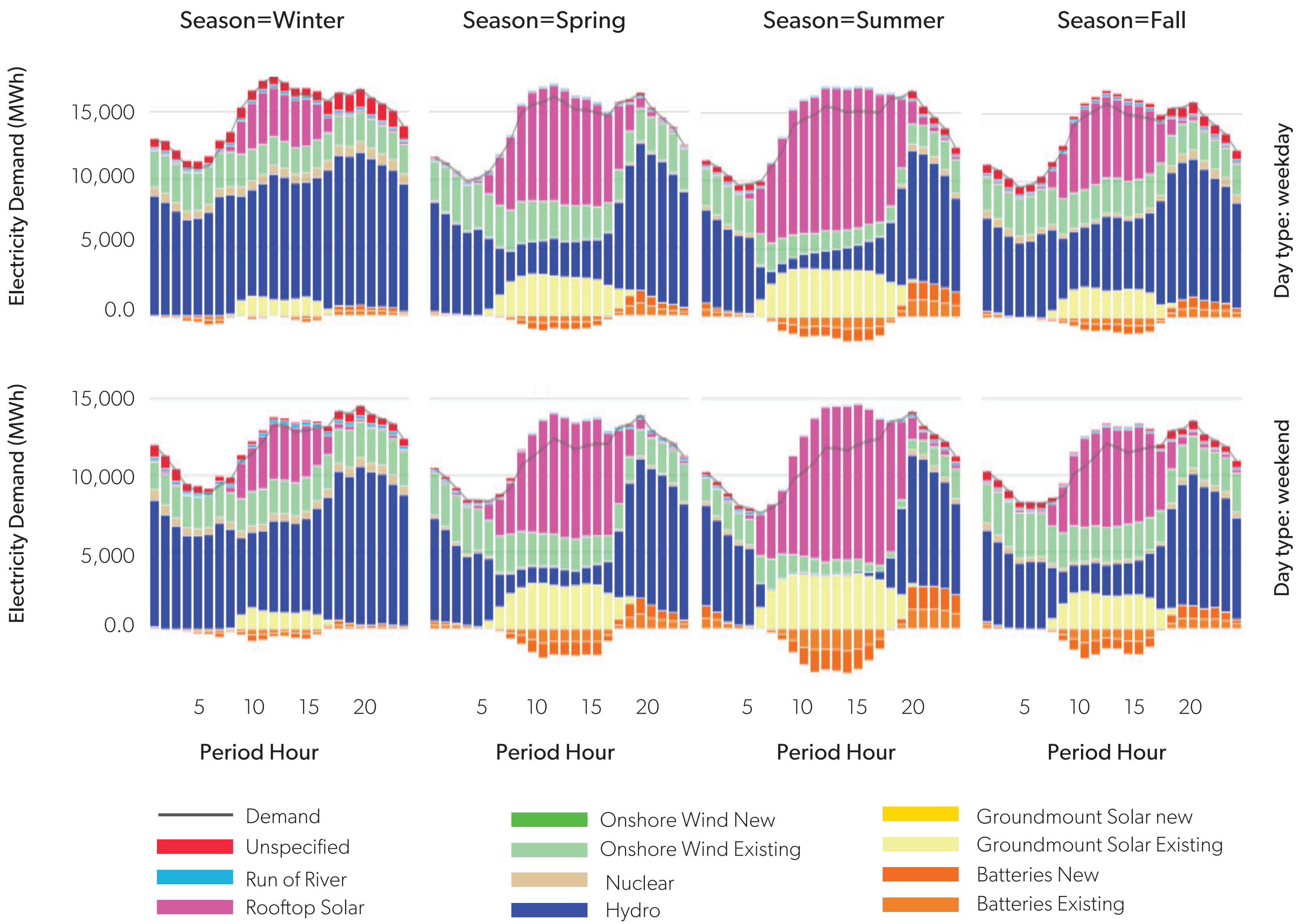

Figure 67. Average week of electricity supply for weekdays (top) and weekends (bottom) in 2050 in the Electrification Scenario.

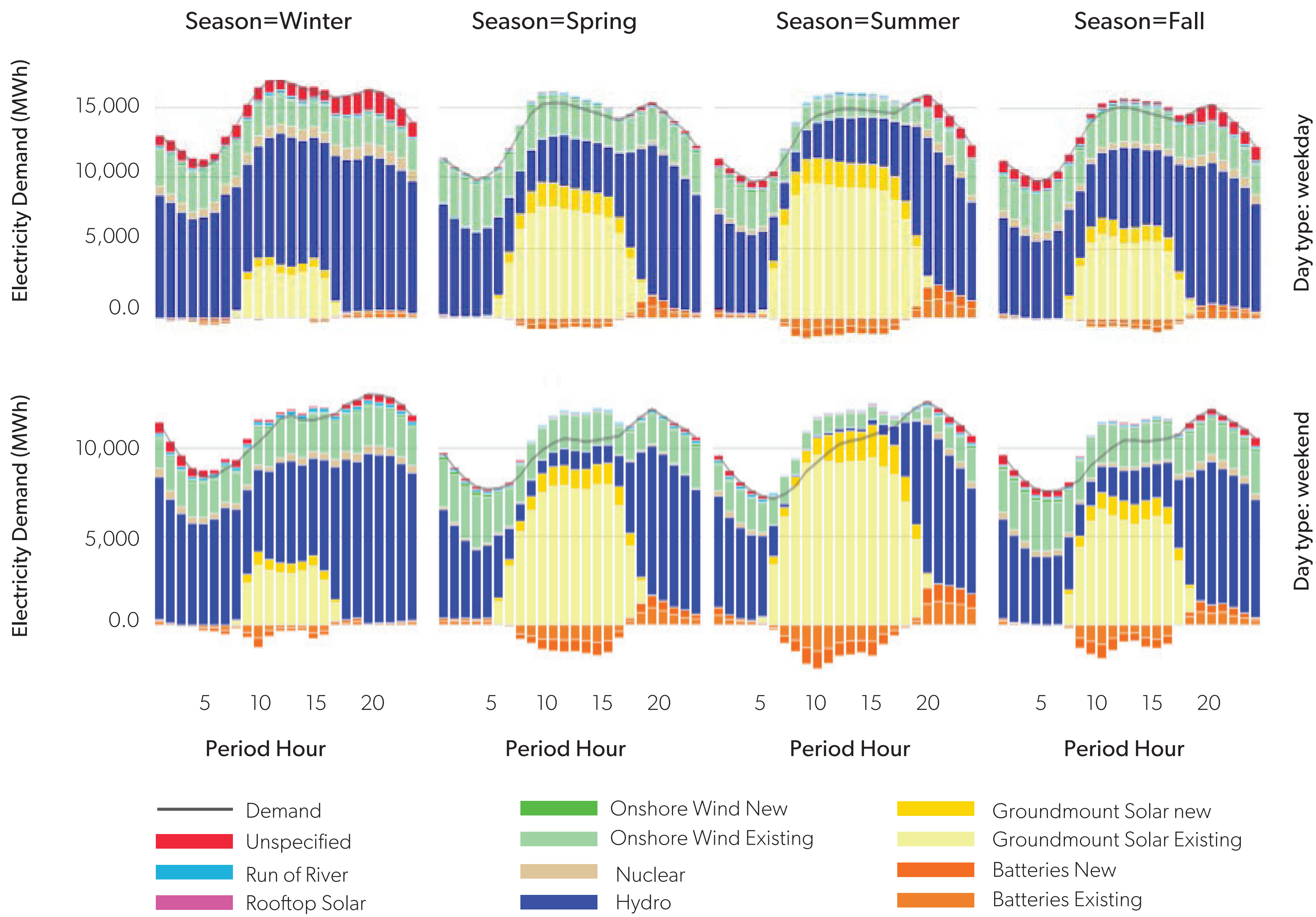

Figure 68. Average week of electricity supply for weekdays (top) and weekends (bottom) in 2050 in the Alternative Fuels Scenario.

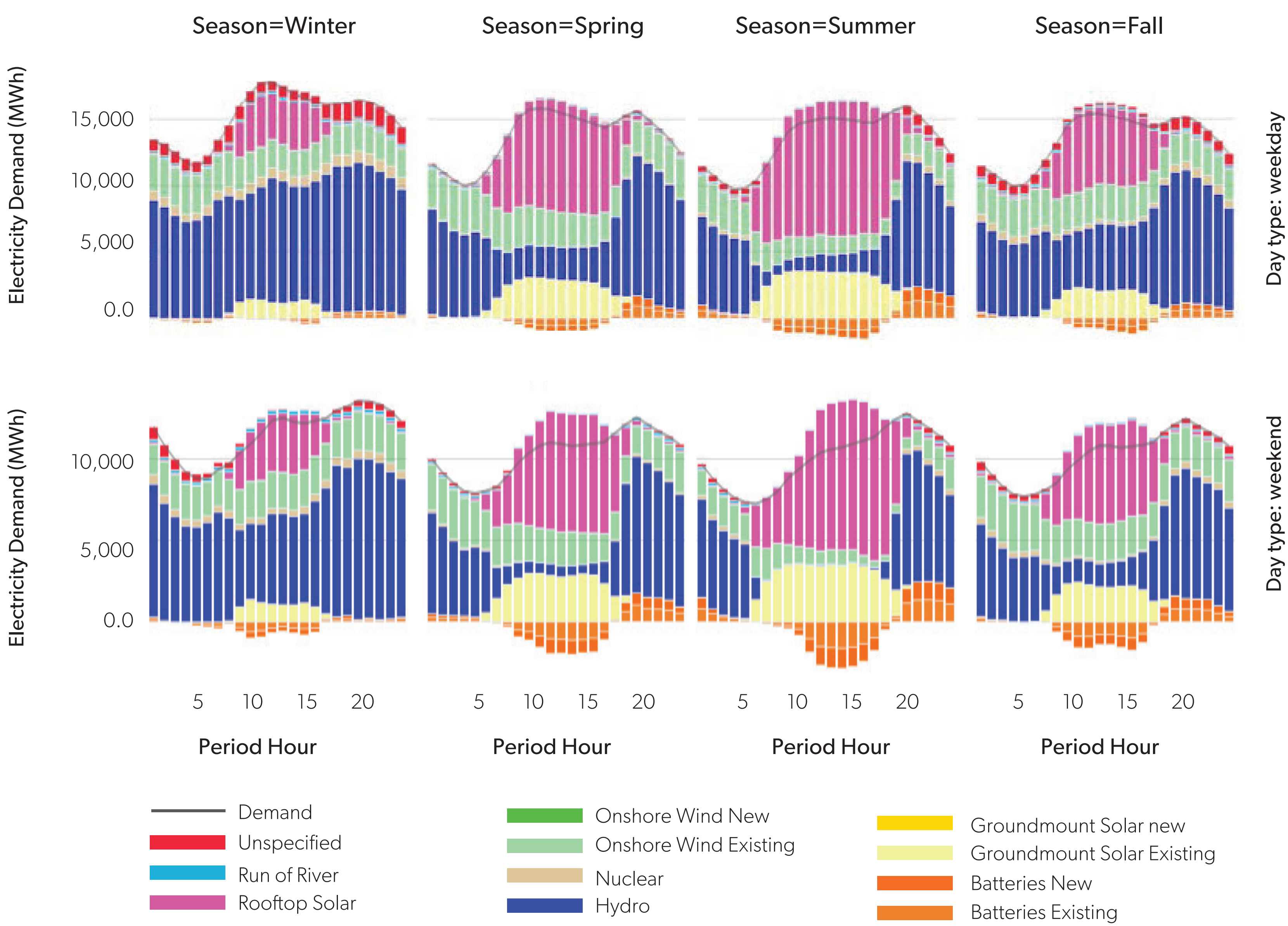

Figure 69. Average week of electricity supply for weekdays (top) and weekends (bottom) in 2050 in the Hybrid Scenario.

Insights

- A key takeaway is that it is possible to transition to a renewable energy supply that is mainly generated within the state.
- Electricity supply is matched to electricity demand, which varies depending on the season and the time of day. With an increasing portion of electricity supply required to be renewable or non-emitting by 2050, the hourly supply profile of electricity changes by the day, the season, and the year.
  - During the day, electricity supply is provided by a mix of rooftop and utility-scale solar, wind power, and some hydroelectric power, while at night, supply is provided by a larger proportional quantity of hydroelectric power, in addition to batteries and thermal and/or imported electricity providing supply.
  - In the summer, rooftop and utility-scale solar power production increases with the lengthening days and sunnier weather, while batteries, and hydroelectric power, which has reduced output in the summer, are reserved to meet nighttime electricity demand. In the winter, hydroelectric power and wind power are critical sources of supply across all scenarios.
  - Two main pathways for supply resource procurement emerge: one pathway that relies on a more distributed supply, where rooftop solar is a key component of the electricity supply, contrasted with another pathway where centralized, utility-scale renewables are developed.
  - A more distributed model could alleviate siting, permitting, and transmission challenges associated with a more centralized pathway in which there are fewer actors, however it would require capital investments in substations, transformers, switchgear, and control systems. There are financial drivers to support both pathways, which will be discussed in sections below. Regardless of the pathway, a new energy system requires a number of different technologies working together, which will require more integrated planning.

8.3.2 Unspecified Demand can be Addressed with Imports

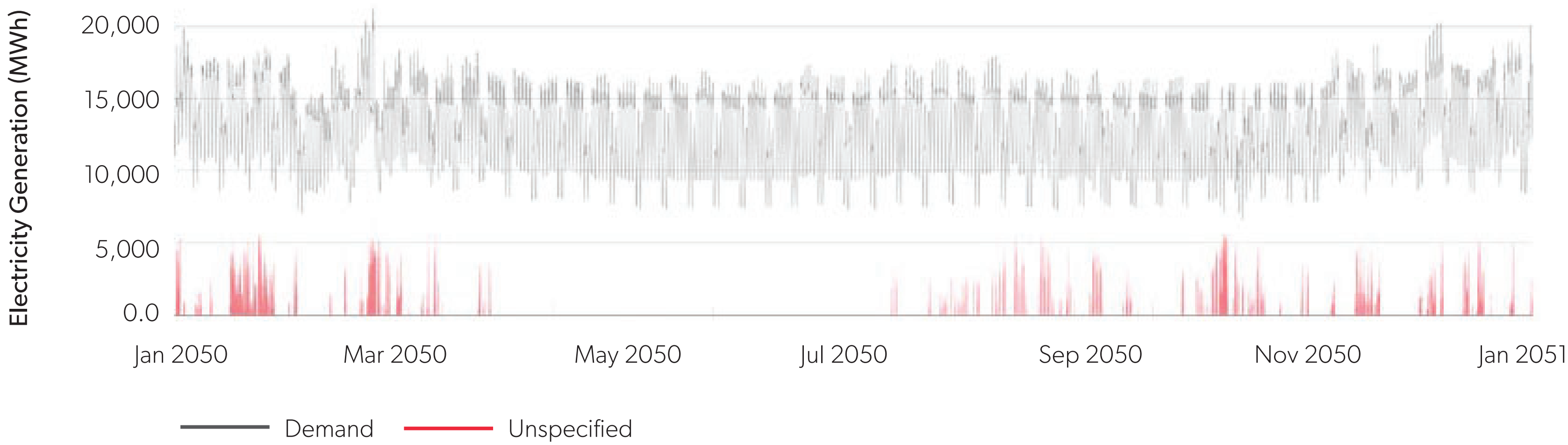

Figure 70. Periods when imports or additional capacity are needed (in red) compared to overall demand in the Electrification scenario in 2050. These periods are primarily in the Spring, Fall, and Winter.

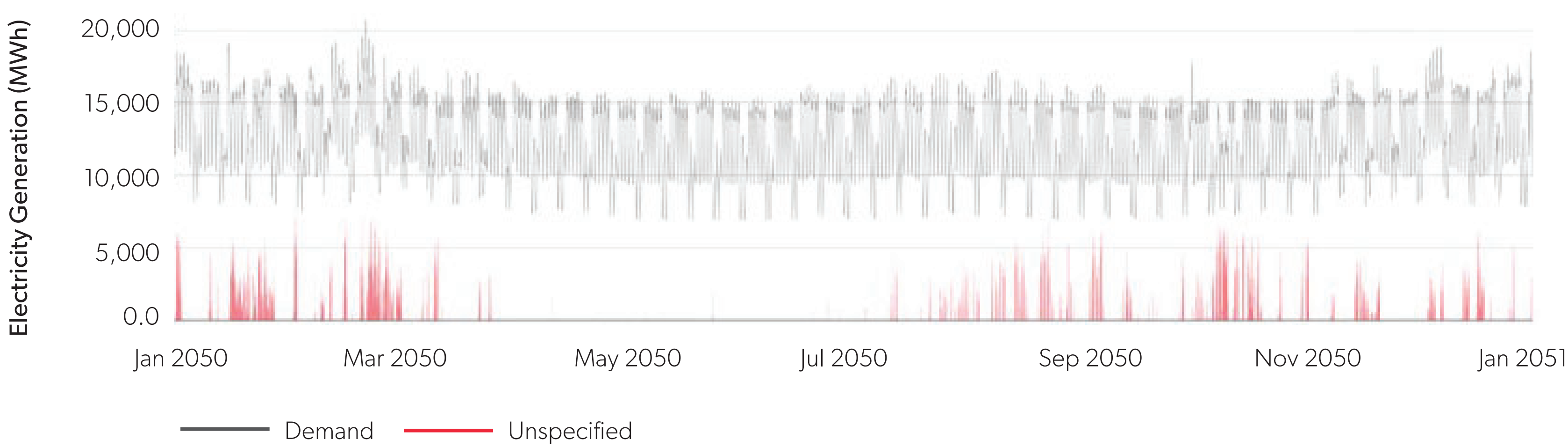

Figure 71. Periods when imports or additional capacity are needed (in red) compared to overall demand in the Alternative Fuels scenario in 2050. These periods are primarily in the winter and fall.

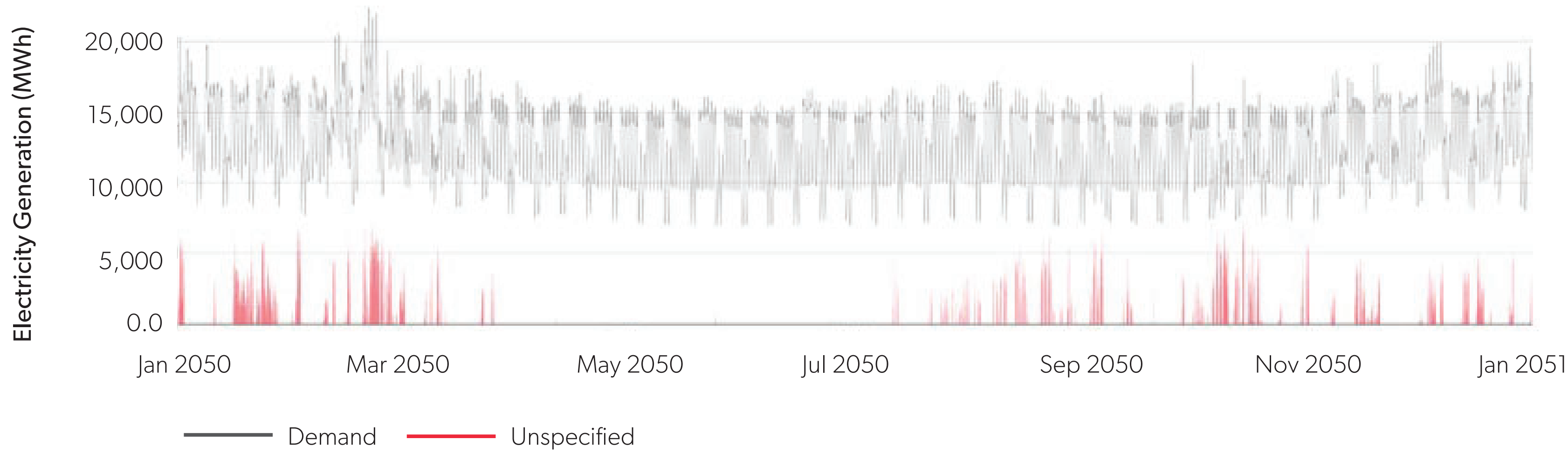

Figure 72. Periods when imports or additional capacity are needed (in red) compared to overall demand (blue line) in the Hybrid scenario in 2050. These periods are primarily in the winter and fall.

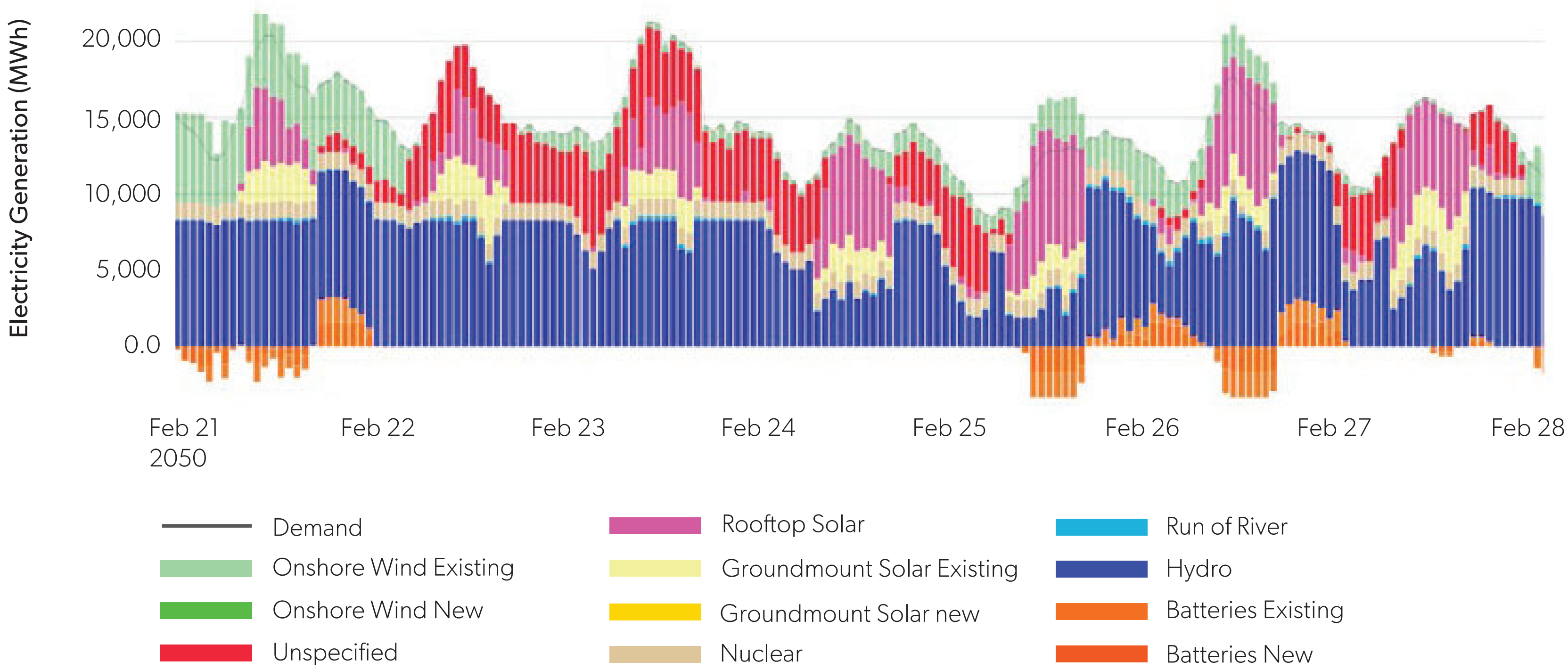

Figure 73. Hourly electricity supply during a typical February week in Washington in 2050 for the Electrification scenario. While wind, solar, and hydroelectric generation, as well as batteries, are usually enough to meet demand, there may be periods where their output is lower and batteries cannot be recharged. During these periods, unmet demand (shown in red) could be supplied with power from renewable resources in places where they are producing at a higher output, or from firm, dispatchable, non-emitting power plants.

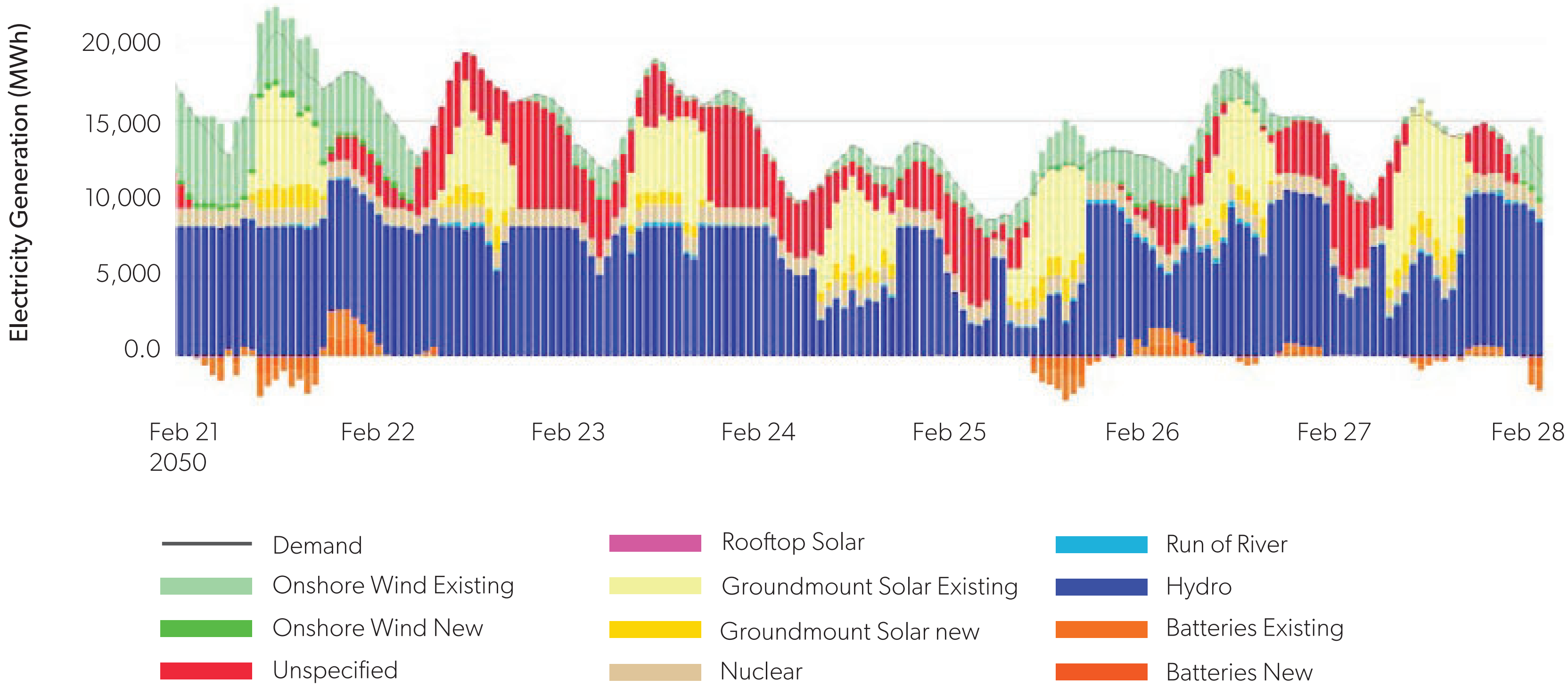

Figure 74. Hourly electricity supply during a typical February week in Washington in 2050 for the Alternative Fuels scenario. While wind, solar, and hydroelectric generation, as well as batteries, are usually enough to meet demand, there may be periods where their output is lower and batteries cannot be recharged. During these periods, unmet demand (shown in red) could be supplied with power from renewable resources in places where they are producing at a higher output, or from firm, dispatchable, non-emitting power plants.

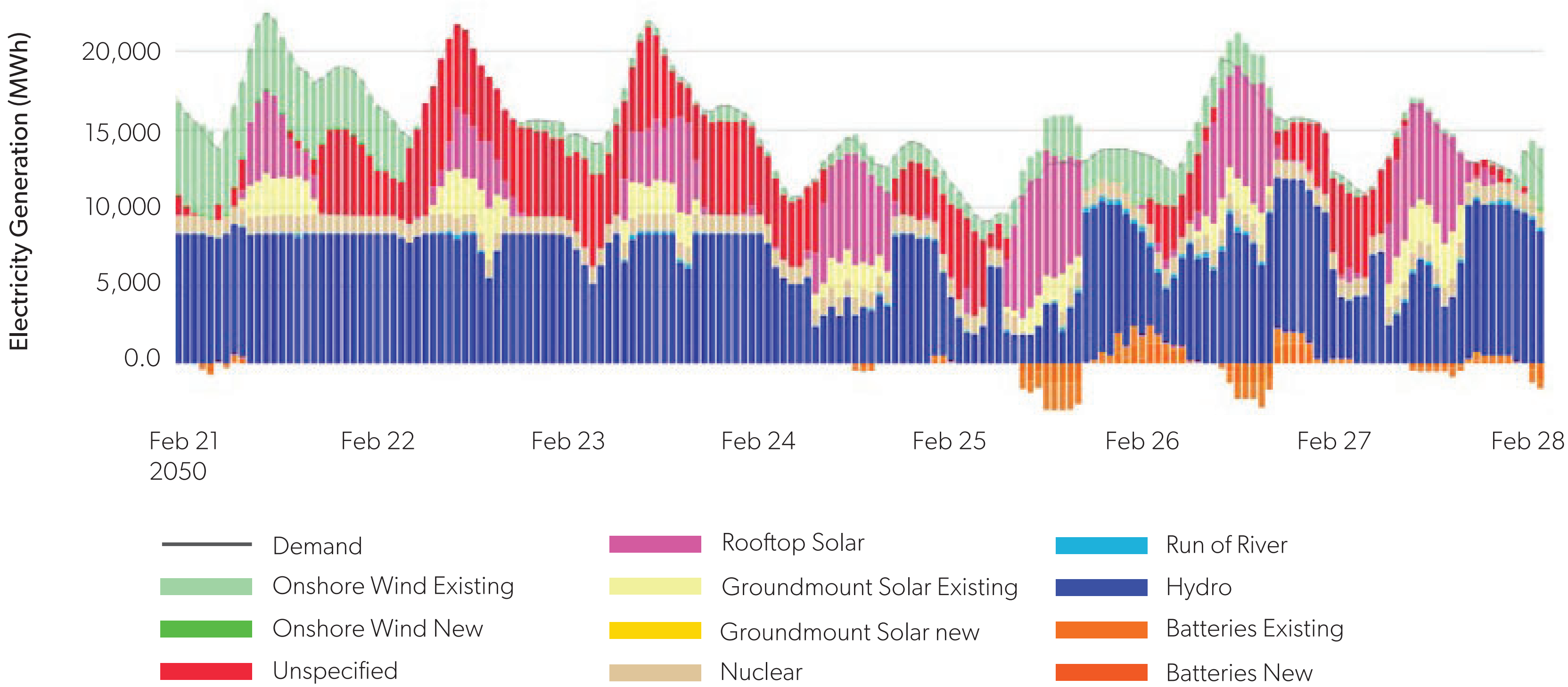

Figure 75. Hourly electricity supply during a typical February week in Washington in 2050 for the Hybrid scenario.

Just as in the Electrification scenario, the model selects imported renewable energy generation from other states and regions and/or firm and 100% dispatchable resources to address the capacity gap during these periods.

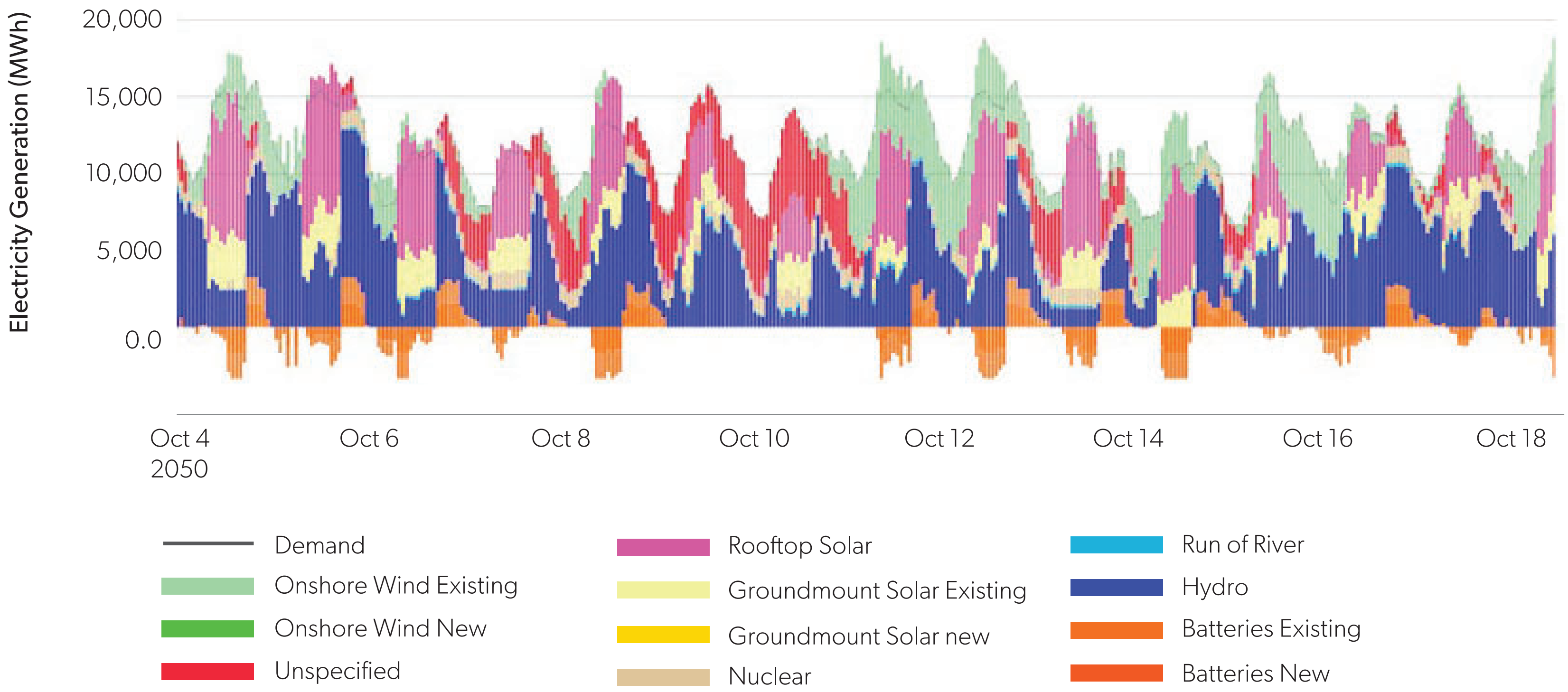

Figure 76. Hourly electricity supply during a typical week in October in Washington in 2050 for the Electrification scenario. Periods of low solar, wind, and hydroelectric generation result in periods of unmet demand that can last many hours.

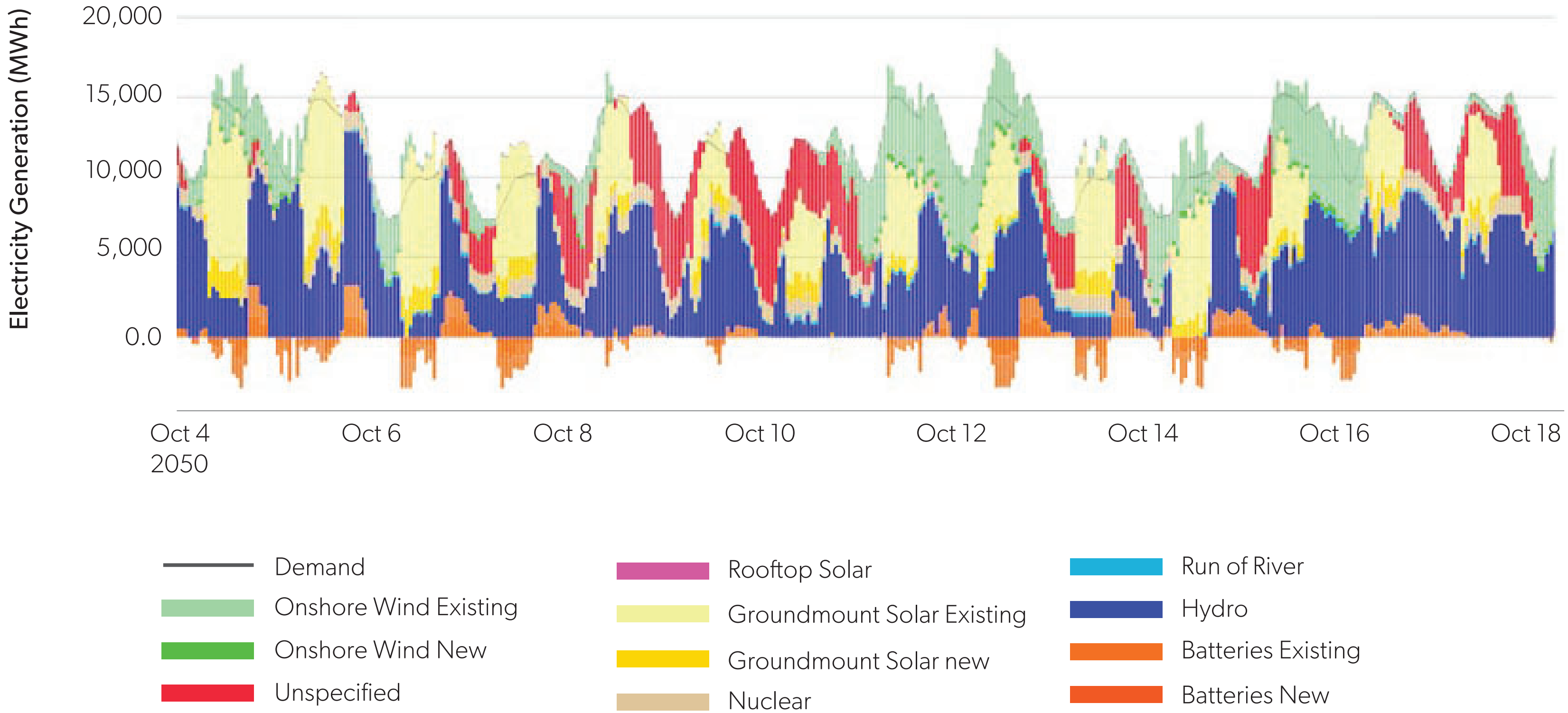

Figure 77. Hourly electricity supply during a typical October in Washington in 2050 for the Alternative Fuels scenario. Periods of low solar, wind, and hydroelectric generation result in periods of unmet demand that can last many hours or even days.

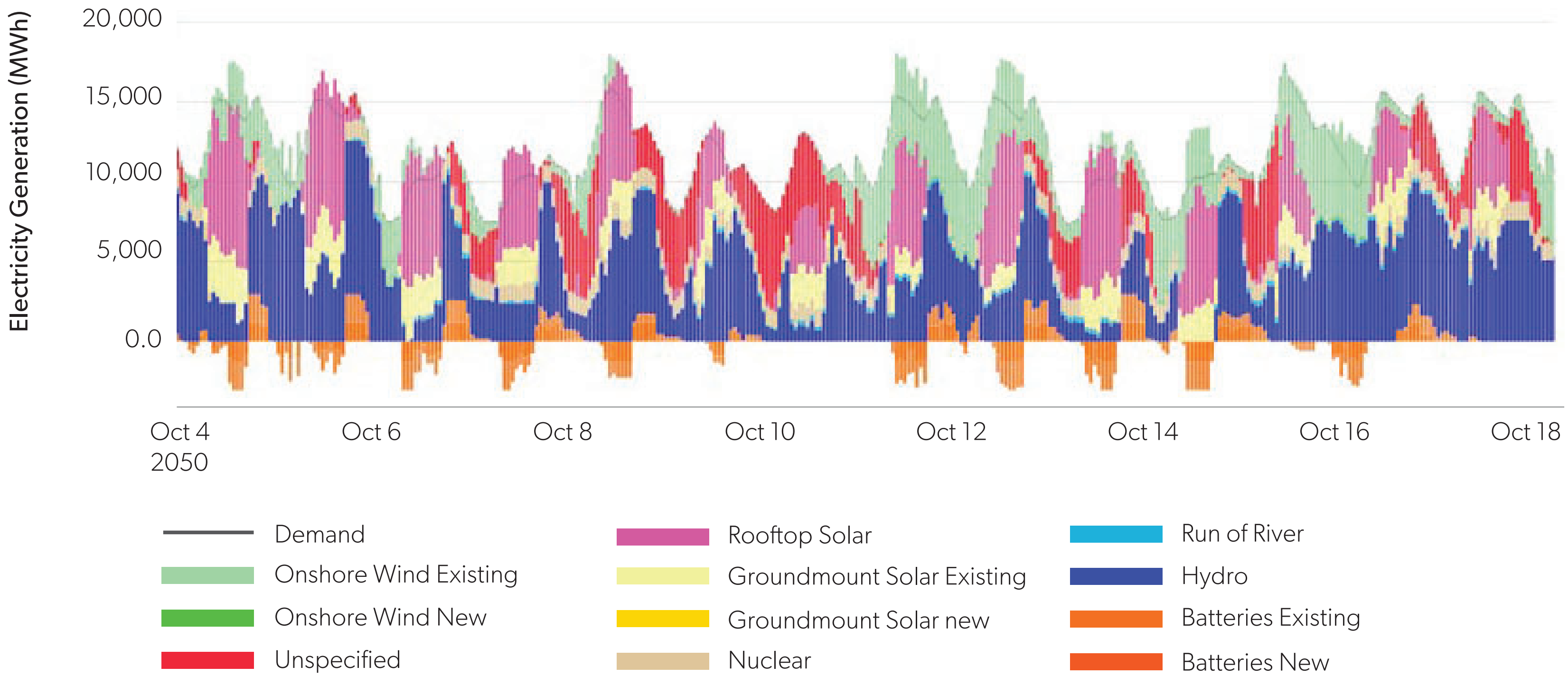

Figure 78. Hourly electricity supply during a typical October in Washington in 2050 for the Hybrid scenario.

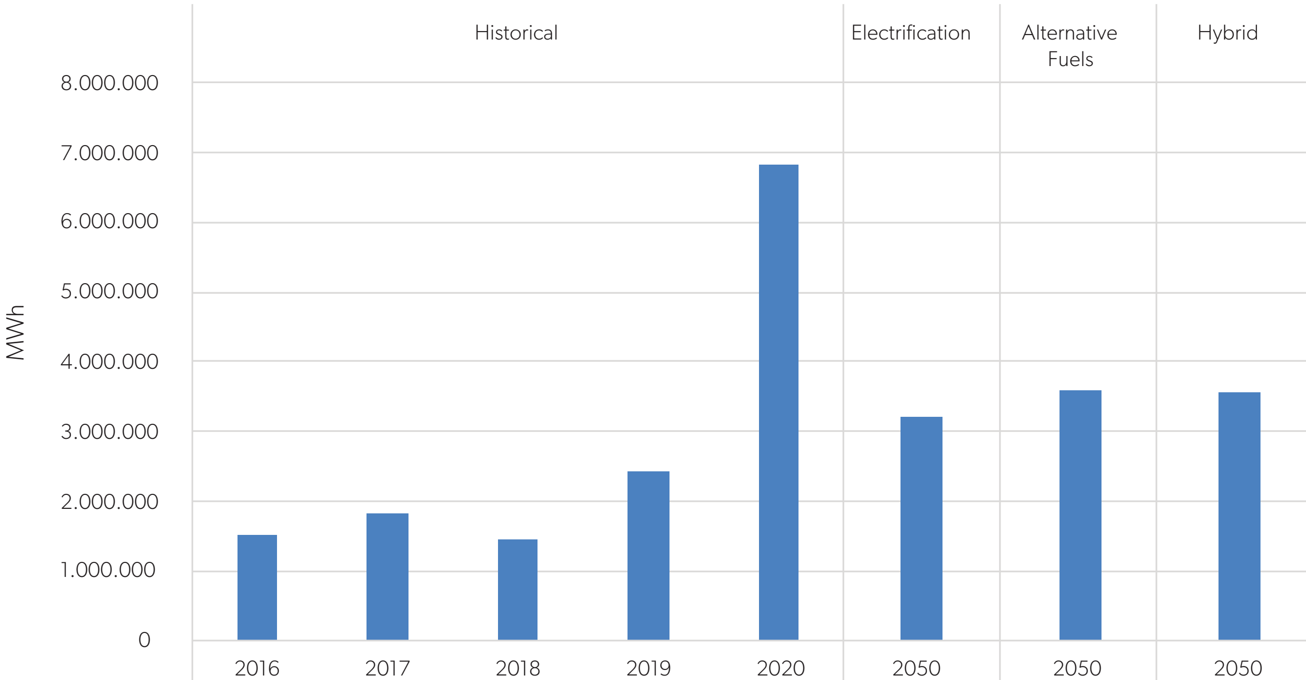

Figure 79. Historic imports of electricity in Washington compared to unspecified supply in the decarbonization scenarios (MWh).

What is unspecified supply?

Unspecified supply represents the supply that cannot not be met by adding more renewables within Washington. Priced at $500/MWh, this portion of supply is added to the system when renewable sources of generation within Washington exceed this price. This supply is "unspecified" because it has been used to represent various options that utilities can take to provide this supply, such as importing clean electricity from neighboring states and regions, firm and 100% dispatchable resources (such as renewable natural gas power plants or hydrogen fired power plants),[295] and engaging industry to further shed electrical load or invest in energy conservation.

The costs of this unknown supply can be used to understand which options for meeting the required demand could be feasible. It should also be noted that if imports come from a state or province with a complementary demand profile, i.e. a location where local demand is low when supply is high in Washington and vis versa, the cost of imported electricity to Washington could be offset on an annual basis by sales from Washington the location.

[295] It should be noted that hydrogen fired power plants have a relatively low end-to-end efficiency when accounting for the efficiency of electrolysis and the efficiency of combustion and electricity production. Source: Yue, Meiling, Hugo Lambert, Elodie Pahon, Robin Roche, Samir Jemei, and Daniel Hissel. "Hydrogen Energy Systems: A Critical Review of Technologies, Applications, Trends and Challenges." Renewable and Sustainable Energy Reviews 146 (August 1, 2021): 111180. https://doi.org/10.1016/j.rser.2021.111180

Insights:

In the periods when there is insufficient in-state generation, the model selects which additional capacity is required to meet demand. Because renewable energy resources have limited output during specific periods, the model determines that it is more cost effective to rely on a variety of other solutions, which are labeled as "unspecified."

- Adding additional renewable resources within the state just to meet these periods of demand would be costly because those plants would be underutilized compared to their capacity during other periods of the year. This highlights the potential opportunity of improving interstate transmission, particularly high voltage direct current (HVDC), to bring renewable power from locations outside of Washington.
- The periods of unspecified demand occur when hydropower generation is limited in combination with low wind and/or solar generation.
- The highest concentration of unspecified demand occurs in the winter and fall. This generally coincides with periods of limited hydro power generation.

8.4 The impacts on resource adequacy and transmission and distribution requirements

8.4.1 Impacts on Resource Adequacy, Transmission, and Distribution

As discussed in Chapter 5 and demonstrated by the scenarios in Chapter 9, significant changes in the electricity generation resource mix can be expected in Washington, the Pacific Northwest, and the WECC over the next 30 years.[297, 298] The Clean Energy Transformation Act, the Climate Commitment Act, and similar legislation in neighboring states and provinces, combined with significant declines in the costs of wind, solar, and batteries, will drive a major shift in the resources used to generate the electricity that is consumed in Washington. This will also change how transmission capacity and resource adequacy in the region are understood, analyzed, and planned for. Furthermore, developing and upgrading electricity distribution infrastructure to meet increasing electrification of buildings and vehicles, as well as other end uses depending on the pathway pursued, will necessitate transparent and coordinated planning.

To ensure generating resources are adequate to meet demand and provide reliable service, particularly during times of peak demand, electricity system planners and utilities have traditionally relied upon modeled indicators of system adequacy such as loss of load probability (LOLP) and planning reserve margin (PRM) requirements (see box "What is resource adequacy?" on page 186). These metrics have been fairly reliable indicators of maintaining a reliable electricity system when there has been a generally high availability of fossil fuel resources such as natural gas and coal-fired power plants that are predictable and quickly dispatchable. Achieving a decarbonized electricity system requires a more complex and sophisticated resource mix that "balances fluctuating loads, variable renewable generation, anomalous weather events, and evolving climate trends and other uncertainties."[299] This may include renewable power plants such as solar and wind, short- and long-duration storage, load flexibility (i.e., demand response), biomass, geothermal, and hydrogen generation.

In each of the decarbonization scenarios explored in this report, electric utilities in Washington are expected to increasingly rely on energy-limited resources (hydroelectric power and battery storage) and renewable energy resources (wind and solar) to meet demand, with nearly full reliance on these types of resources by 2050. Generation from these sources fluctuates depending on the time of day and the time of year. Generating capacity may be low for long periods, such as during multi-day winter storms that constrain solar production over wide geographic areas, or during large-scale high pressure weather systems where wind output is low. These events could also coincide with periods of high demand, for example for space heating. When peak demand is combined with drought hydro conditions, there is even higher potential for supply to not meet demand for even longer periods.[300] For these reasons, installed generating capacity is no longer a good measure of a resource's dependability, and reliability becomes more challenging to measure and plan for in low carbon electricity systems compared to those in place today.

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297 Energy+Environmental Economics, "Resource Adequacy in the Pacific Northwest," Research study, March 2019, https://www.ethree.com/wp-content/uploads/2019/03/E3_Resource_Adequacy_in_the_Pacific-Northwest_March_2019.pdf.

298 Northwest Power and Conservation Council, "The 2021 Northwest Power Council Plan."

299 Redefining Resource Adequacy Task Force, "The Intersection of Resource Adequacy and Public Policy: Ensuring Not Only Clean Energy, but Reliability," Policy Brief (Reston, VA: Energy Systems Integration Group; Golden, CO: National Renewable Energy Laboratory, Interim Secretariat of the Global Power System Transformation Consortium., 2021), https://www.esig.energy/reports-briefs.

300 Jacob Wessel et al., "Technology Pathways Could Help Drive the U.S. West Coast Grid's Exposure to Hydrometeorological Uncertainty," Earth's Future 10, no. 1 (2022): e2021EF002187, https://doi.org/10.1029/2021EF002187.

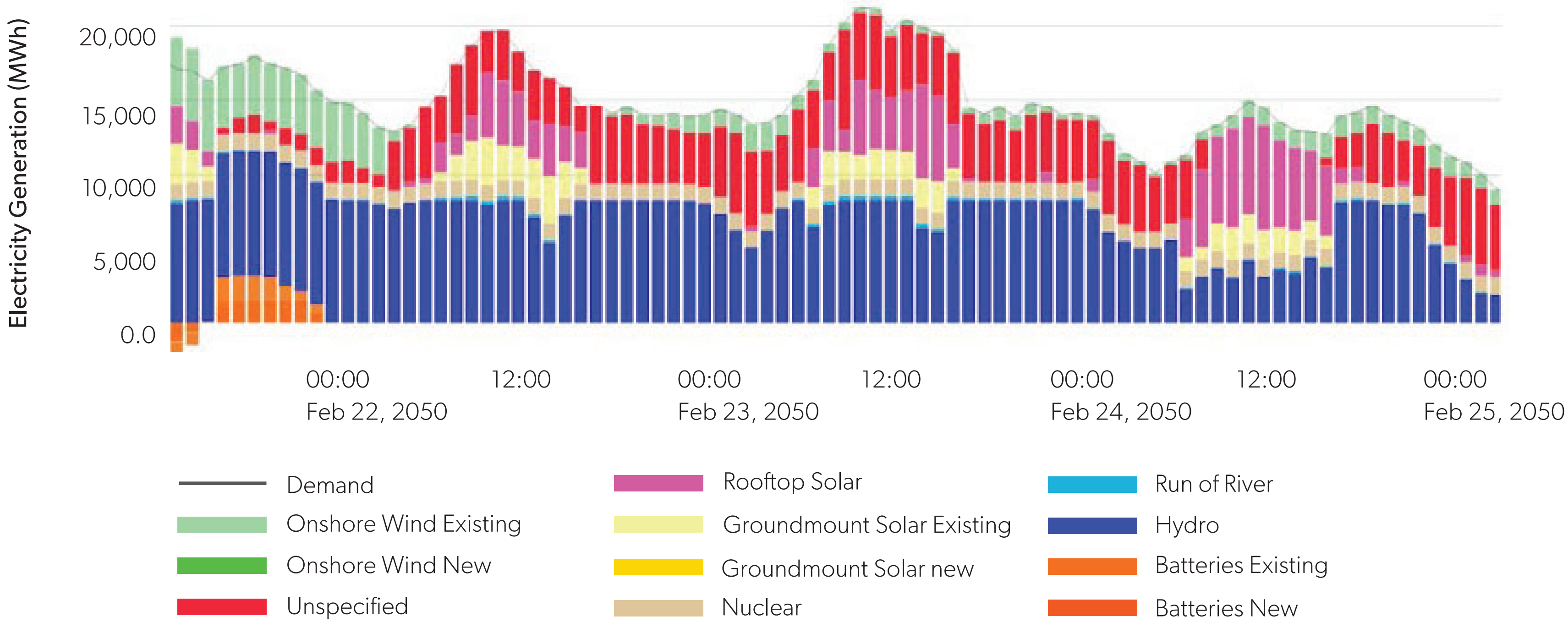


Figure 80. Hourly demand and supply during a critical period in 2050 in the Electrification scenario.

Typical resource adequacy planning metrics such as PRMs are made based on the assumption that if a power system has enough resources to cover the highest load hour of the year (peak demand), then it would also have sufficient resources for the rest of year. Adding an amount of generating capacity 12-15% above peak load (as is typical for most utilities in the PNW) would be enough to cover load forecast and unexpected generator outages, and all resources could be treated as equal contributors to reliability. In the new paradigm, periods of the highest risk of loss of load are not limited to periods of peak demand; rather, these periods may occur during periods of more typical demand but when renewable generation is lower, such as early evening hours with low wind and solar generation.

What is resource adequacy?

Resource adequacy is the ability of electric utilities, and the system within which they operate, to serve demand during a wide range of conditions, such as fluctuations in demand and changing weather conditions. If an electric power system does not have adequate resources available to meet demand, it will struggle to provide reliable service, and in the most extreme cases, could result in catastrophic system failures. The factors involved in assessing resource adequacy include the variable characteristics of both the system's electricity demand (hourly and seasonal patterns in energy consumption) and supply (generating capacity, dispatchability, outage rates, etc.).

There are no mandatory or voluntary national standards for resource adequacy.[301] The North American Electric Reliability Council (NERC) and the Western Electric Coordinating Council (WECC) provide guidelines but don't have specific requirements. Utilities design their resource portfolios to meet their own specified resource adequacy and reliability targets.

Resource adequacy for a utility or electricity system is usually determined using two steps: 1) loss of load probability (LOLP) modeling, which calculates how often during a given period there might not be enough electricity supply to meet demand, and 2) planning reserve margin (PRM) requirements, which determine the total supply capacity needed to meet peak demand while taking into account extreme conditions and potential temporary reductions in resource availability (such as unplanned downtime).

Calculations of acceptable targets for LOLP and PRM vary. A typical standard of system reliability used in LOLP modeling is an expectation that supply falls short of meeting all demand for fewer than 24 hours over a period of ten years, or 2.4 hours per year. The Northwest Power and Conservation Council (NWPCC) has a reliability target of a 5% annual loss of load probability (meaning the likelihood of 1 or more shortfalls in a year is less than 5%). Reserve margin requirements typically vary by utility and planning area; they can range from a target to have between 12-19% more resources of generating capacity than would be needed to meet the highest peak demand.

Grid planners and policymakers use resource adequacy targets and analyses to make investment decisions - or provide market signals - for new resources. Utilities may seek to add more generating resources, or additional energy efficiency measures, or use demand response. The selection of strategies depends on factors such as cost-effectiveness and reliability of each type of reserve

[301] Energy+Environmental Economics, "Resource Adequacy in the Pacific Northwest."

resource. Due to their low effective capacities, solar and wind tend to need more reserves to meet adequacy requirements. Demand response, batteries, and pumped energy storage can contribute but tend to be less cost-effective and reliable to address adequacy issues. Energy efficiency is another effective type of reserve resource, but going beyond the energy efficiency measures already outlined in the common actions described in this study may not be cost-effective.

Utilities in Washington plan for resource adequacy individually, and in coordination with neighboring utilities. Planning for resource adequacy spans a wide time horizon, from day-ahead planning of generation and imports, to seasonal decisions around maintenance and short-term contracts, to long-term planning for new generating resources or plant decommissioning.[302] To ensure they have enough resources to meet peak demand, Washington utilities develop and operate their own generating resources, purchase power using bilateral contracts from other utilities and generators, and make short-term market purchases using front-office transactions (FOTs). FOTs account for a significant portion of meeting peak capacity requirements.[303]

Washington utilities also participate in the Western Resource Adequacy Program (WRAP) which was approved in February 2023 by the Federal Energy Regulatory Commission (FERC) to support increased coordination amongst utilities in the Western Interconnection in terms of resource adequacy planning, benchmarking of resource adequacy standards, and sharing a diverse set of resources.[304] The WRAP is the first regional reliability planning and compliance program in the history of the Western interconnection system, and it seeks to deliver a regional approach for assessing and addressing resource adequacy.[305] The WRAP builds on decades of coordination among western Power Pool members to maximize reliability, address transmission challenges, and reduce risk.

Regardless of the strategy, it is important to note that the grid is assumed to never reach 100% perfect reliability. Developing the resources to achieve this would be prohibitively expensive in both construction and operating costs, and would require a substantial amount of overbuild of generating capacity that would likely never run. As a result, policymakers implicitly decide how much grid reliability it is worth paying for and what are acceptable levels of risk. Metrics such as loss of load expectation (measured in either days per year or hours per year) are crude in that they don't illuminate the differences between shorter and longer periods of power loss, how many customers are affected, or what is causing the shortfall and how frequently the conditions may occur. In a decarbonized electricity system, policymakers will require information from utilities and BAs on the causes and characteristics of reliability failures, such as size, frequency, duration, and timing, in order to develop policies and incentives for resources and technologies that address reliability challenges.

302 Redefining Resource Adequacy Task Force, "The Intersection of Resource Adequacy and Public Policy: Ensuring Not Only Clean Energy, but Reliability."

303 Energy+Environmental Economics, "Resource Adequacy in the Pacific Northwest."

304 "History," accessed July 14, 2023, https://www.westernpowerpool.org/about/history/.

305 "Western Resource Adequacy Program (WRAP)," accessed November 14, 2023, https://www.westernpowerpool.org/about/programs/western-resource-adequacy-program.

The 2021 Northwest Power Plan recommends additional strategies to address resource adequacy.[306] Utilities and power plant generators could share more information with each other about anticipated peak demand events, which could provide adequate time to operators of firm or more flexible resources (gas power plants and hydro, for example) to stay online or start up when needed. A price signal that pays extra money to plants with the flexibility to stay online could ensure more system flexibility and responsiveness using resources that already exist, reducing the need to build out or contract for more resources.

Another strategy is to develop and use a wholesale electricity market to take advantage of other resources in the Northwest Power Pool region and the greater Western power grid that may be available at times of peak demand in Washington. The Northwest Power Plan notes that the development of such a market would drive "significant cost savings from greater regional collaboration" and it could achieve "reliability and cost benefits from the central dispatch of resources across a broad [geographic] footprint."[307] However, this strategy comes with risks, because other states and regions have varying policies and requirements, and Washington utilities and governments have little say in their planning processes.

These strategies are also key to addressing the future issues posed to the electricity transmission system. In the decarbonization scenarios explored in this study, new generating capacity is added throughout the state and in all BAs in order to serve increasing electricity demand. An assumption in the modeling is that transmission infrastructure between BAs will be upgraded over time, reaching 1.5 times its current capacity by 2050 (an increase from 70,800 MW to 106,200 MW). The maximum used capacity reaches 81,877 MW in the Alternative Fuels scenario, the highest of all the scenarios. As discussed in Chapter 5, transmission capacity is driven by peak demand and supply per generating resource, rather than overall system needs, leading to a potential overbuild and underutilized transmission capacity. To bring in additional capacity from outside of the BAs within Washington state, for example to meet periods of peak demand, additional coordination regarding interstate transmission, and potentially physical upgrades, may be required.

Transmission capacity upgrades are also related to the location of new generating resources. Utility scale solar and wind will be developed in large scales in remote areas, and existing transmission infrastructure may not be sufficient to move the electricity to its point of consumption. The Transmission Corridors Work Group of the Washington Energy Facility Site Evaluation Council identified three transmission corridors where increased transmission capacity may be needed: East-West across the Cascades, North-South along the I-5 corridor, and Southern Coastal areas to the I-5 Corridor. Changing transmission contracting rules and/or building new physical capacity along these corridors would allow Washington's population centers to receive more power from Eastern Washington, Montana, Wyoming, California, Canada, and offshore wind turbines in the Pacific Ocean.

[306] Northwest Power and Conservation Council, "The 2021 Northwest Power Council Plan," March 10, 2022, https://www.nwcouncil.org/fs/17680/2021powerplan_2022-3.pdf.

[307] Northwest Power and Conservation Council, "The 2021 Northwest Power Council Plan."

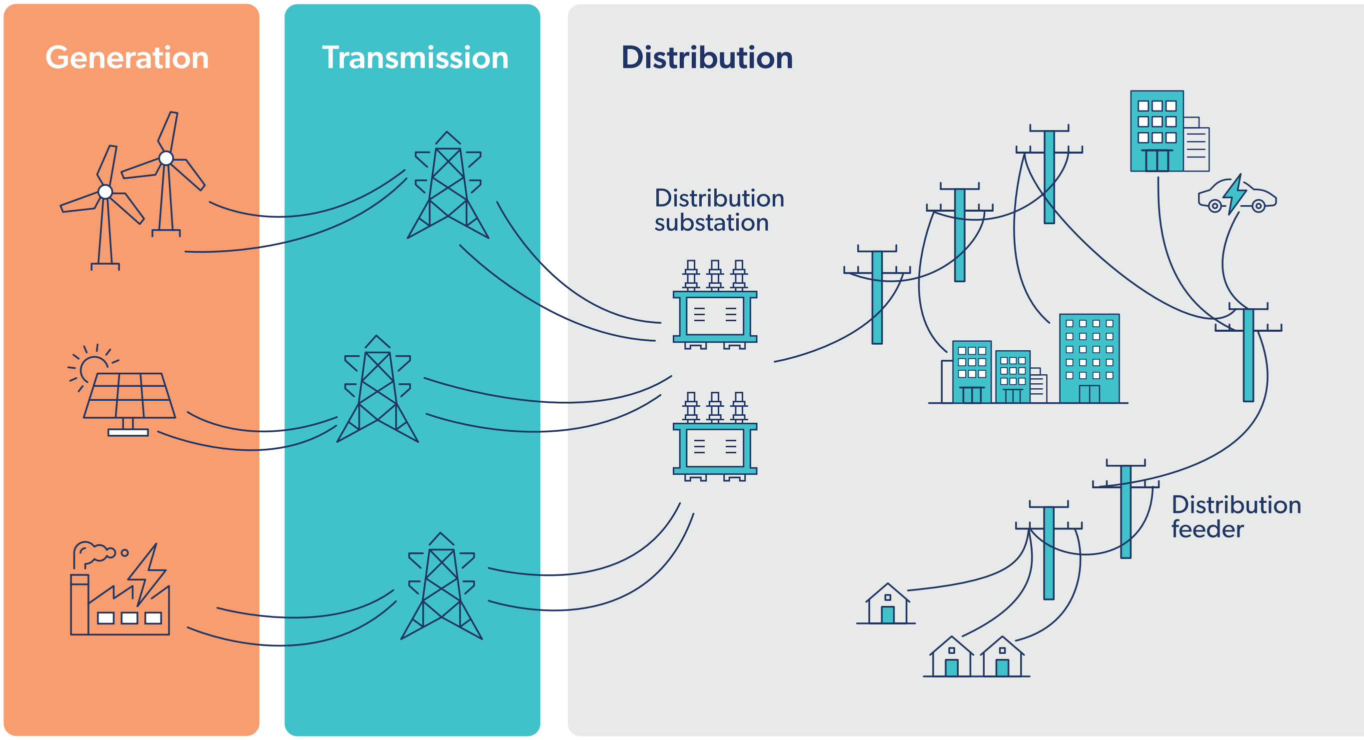


Figure 81. Simplified diagram showing the main components of the electric grid, from generating resources to transmission to distribution substations, distribution feeders, and final end users.

Existing and ongoing policies will drive increased electrification of both vehicles and buildings in Washington. Policies and programs explored in the Electrification scenario and Hybrid scenarios would further increase electricity use compared to the Business-As-Planned scenario. These actions can be assumed to have an impact on each utility's distribution infrastructure, such as substations and transformers. The specific implications on each utility's distribution infrastructure were not quantified as a part of this study but are required to be carried out by utilities as a part of their Integrated Resource Plans.[308]

The costs of upgrading distribution infrastructure could vary widely based on the adoption rate of EVs, the location and time-of-use of chargers, as well as the penetration of rooftop solar PV, energy storage, grid-integrated devices, and demand response programs. One study found that the buildout of infrastructure to support 2.6 million new EVs across the U.S. between 2019-2025 would cost $1.3 billion if done via at-home charging vs. $940 million for workplace/public charges.[309] A separate study of the PG&E service area in California, which serves 4.8 million electricity customers and has similar building and vehicle electrification targets as Washington, found that distribution upgrades will cost at least $1 billion between 2022 and 2030.[310] Additional distribution system capacity may be needed to support a high penetration of residential chargers, but there may be enough excess capacity on existing commercial

[308] "RCW 19.280.100: Distributed Energy Resources Planning.," 19, accessed April 27, 2023, https://app.leg.wa.gov/RCW/default.aspx?cite=19.280.100.

[309] Michael Nicholas, Dale Hall, and Nic Lutsey, "Estimating Electric Vehicle Charging Infrastructure Costs across Major U.S. Metropolitan Areas," The International Council on Clean Transportation, August 2019.

[310] Salma Elmallah, Anna M Brockway, and Duncan Callaway, "Can Distribution Grid Infrastructure Accommodate Residential Electrification and Electric Vehicle Adoption in Northern California?," Environmental Research: Infrastructure and Sustainability 2, no. 4 (December 1, 2022): 045005, https://doi.org/10.1088/2634-4505/ac949c.

building circuits to accommodate large amounts of electric vehicle adoption.[311] Large-scale deployment of rooftop PV coupled with on-site energy storage, as explored in the Electrification and Hybrid scenarios, could also reduce the need for distribution system upgrades, by producing power in proximity to where it is being used and aligning supply and consumption through controls. Additionally, demand response actions such as time-of-use rates, grid-integrated EVs and thermostats, and other behavioral incentives can also reduce upgrade requirements and costs. For example, vehicle charging could be incentivized to occur primarily during daytime hours so it can use low-cost solar PV electricity, leading to larger system-wide cost savings.

These are significant costs and would impact the base rate for electricity customers into the future. However, electrification is occurring in a context in which many utilities already need to invest in distribution infrastructure to maintain system reliability, regardless of the levels of electrification.[312] This deferred investment can be considered a form of "credit" to offset the magnitude of the predicted investment required for electrification. For example, if the deferred investment required to maintain reliability is $1 regardless of electrification considerations, and the total cost of upgrading the same systems to operate reliably during electrification is $3, then the real investment required for electrification would be the difference, or $2.

Furthermore, if increased electrification occurs, utilities will earn an economic return on their investment in infrastructure from additional sales of electricity, an additional return that would not be expected in the absence of further electrification. Further analysis of the impacts of distribution system upgrades could be supported in Washington by adopting the practice of the State of California to require utilities to transparently disclose distribution system cost upgrades.

8.5 Costs and benefits to customers

8.5.1 All Scenarios Results in Savings

The results of the scenario modelling in this study demonstrate that there are compelling economic reasons to implement a decarbonization pathway as quickly as possible. By 2050, compared to the Business-As-Planned scenario, the Electrification Scenario results in savings of $28.1 billion, the Alternative Fuels Scenario results in savings of $44.1 billion, and the Hybrid Scenario results in savings of $31.4 billion.

In any decarbonization pathway, Washingtonians would expect to spend less on fuel and energy costs compared to the Business-As-Planned scenario, due to actions such as vehicle electrification, home retrofits, and heat pump installations.[313] While these actions require upfront capital investment, they result in long-term operating and maintenance cost savings as well as reduced energy expenditures. The Electrification Scenario and Hybrid Scenario both involve higher upfront costs due to the inclusion of rooftop solar, which is not built out in the Alternative Fuels scenario.

[311] "What Will Electrification Cost the Distribution System?," UC Berkeley Rausser College of Natural Resources, accessed April 27, 2023, https://nature.berkeley.edu/news/2022/06/what-will-electrification-cost-the-distribution-system.

[312] For example, PG&E in California plans to invest $20 billion to bury 10,000 miles of power lines in California to reduce their vulnerability to wildfires. Utilities in Washington may need to take similar steps to improve the resilience of their infrastructure. Source: IER. "PG&E to Bury Transmission Lines at Cost of $2 Million per Mile," August 2, 2021. https://www.instituteforenergyresearch.org/the-grid/pge-to-bury-transmission-lines-at-cost-of-2-million- per-mile/.

[313] Fuel costs were calculated using projections of electricity, natural gas, RNG, and hydrogen prices based on projections of utility revenue requirements and customers by fuel type. For more information, see the Data, Methods, and Assumptions Manual in Appendix A.

Across all three scenarios, cost savings from reduced health expenditures are expected compared to the BAP. These are due to reduced incidences of health issues that result from improved air quality (as described in the next section of this chapter). When the social cost of carbon is incorporated (see box "The Social Cost of Carbon" on page 205 for more information), approximately $22 billion dollars are saved in each decarbonization scenario compared to the BAP, as a result of reductions in emissions. The Hybrid Scenario results in the highest amount of emission reductions and therefore higher savings on the social cost of carbon.[314]

The cost of implementing the scenarios differs when it comes to the cost of building and operating electricity generating resources as well as alternative fuels such as RNG and hydrogen. Compared to the BAP scenario, the cost of developing and operating the energy supply is lower in the Electrification Scenario by $1.2 billion and in the Hybrid scenario by $0.5 billion. These savings are partially due to the introduction of rooftop solar. The cost of developing hydrogen and RNG production facilities and infrastructure means that the Alternative Fuels scenario has higher supply costs compared to the BAP.

Table 20. Net present value of energy system costs in 2023 ($USD billions) (discounted at 3%) of capital and operating expenditures for all three decarbonization scenarios from 2030-2050 as compared to the BAP scenario.

	Electrification	Alternative Fuels	Hybrid
Capital Expenditures	$135.6	$103.6	$140.1
O&M Expenditures	-$40.5	-$36.9	-$34.8
Energy Expenditures	-$67.3	-$50.9	-$75.9
Net Implementation	**$27.8**	**$15.8**	**$29.4**

Table 21. Net present value of energy system costs in 2023 ($USD billions) (discounted at 3%) of capital and operating expenditure and social costs for all three decarbonization scenarios from 2030-2050 as compared to the BAP scenario.

	Electrification	Alternative Fuels	Hybrid
Capital and Operating Expenditures	$27.8	$15.8	$29.4
Health Expenditures	-$33.7	-$38.2	-$38.2
Social Cost of Carbon	-$22.2	-$21.7	-$22.6
Net Implementation + co-benefits	**-$28.1**	**-$44.1**	**-$31.4**

[314] While the social cost of carbon includes some costs related to human health, these costs are calculated at an economy-wide level and at a global scale. The health expenditures were calculated using the EPA's COBRA tool, which quantifies the specific health expenditure impacts by county in Washington state. Including cost savings from both provides a more comprehensive picture of the potential impacts of reducing pollution and emissions in Washington than either would on its own.

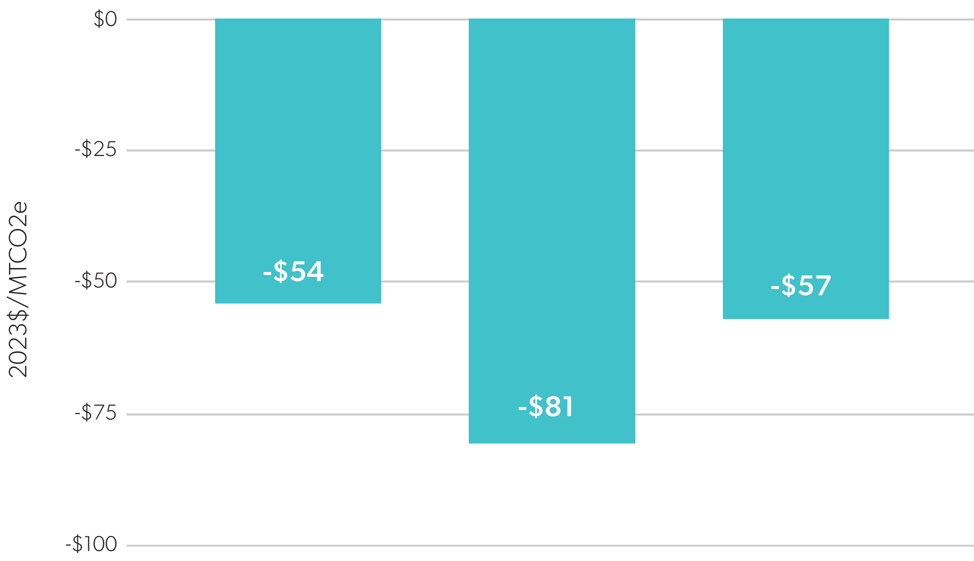


Figure 82. Net present value of a metric ton of avoided GHG emissions with a 3% discount rate.

8.5.2 Demand-Side Costs and Savings

The annual costs, savings, and revenue associated with implementing the actions in each scenario are shown in detail in the figures below, with capital expenditures shown in full for the years in which they are incurred. These charts show the costs of fully implementing demand-side actions, including rooftop solar for the Electrification scenario and the Hybrid scenario. The costs include the complete system cost for implementing the common actions and unique actions for each scenario, including the capital, operating, and fuel costs for electricity and energy supply. Cost savings, including avoided health expenditures, as well as the social cost of carbon, are also included.

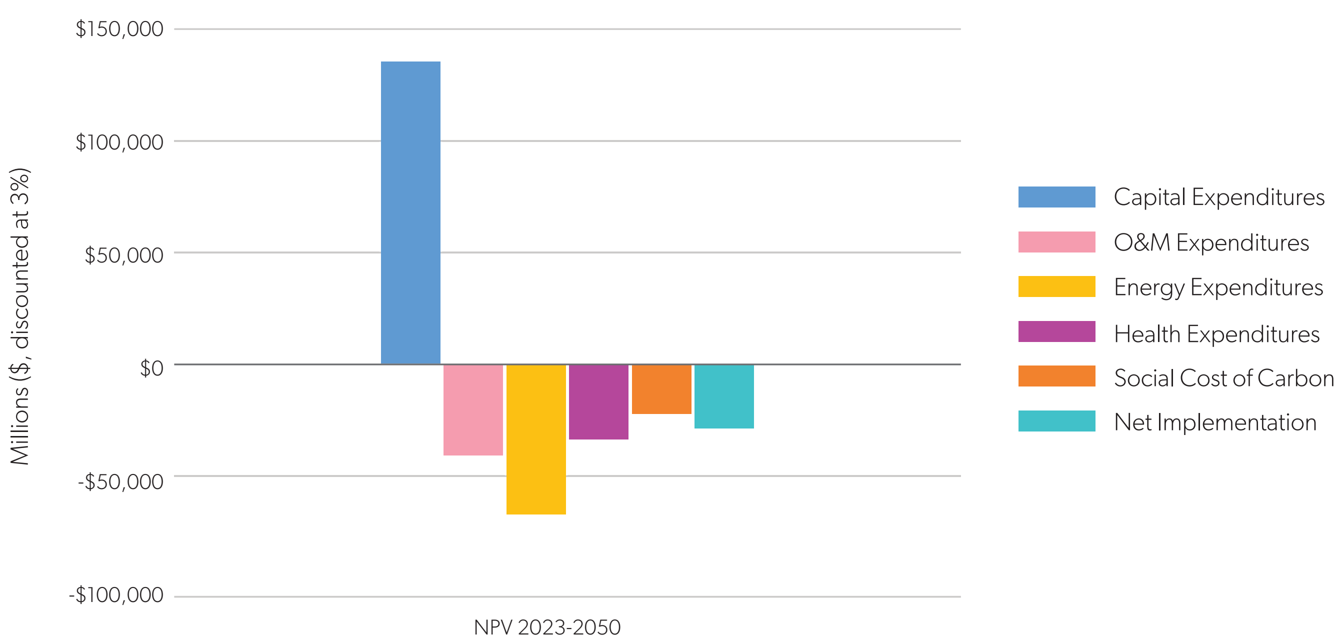


Figure 83. Net present value of cumulative investment and returns for the Electrification scenario in millions of dollars ($USD 2023) (2023-2050). Costs are discounted at a rate of 3%.

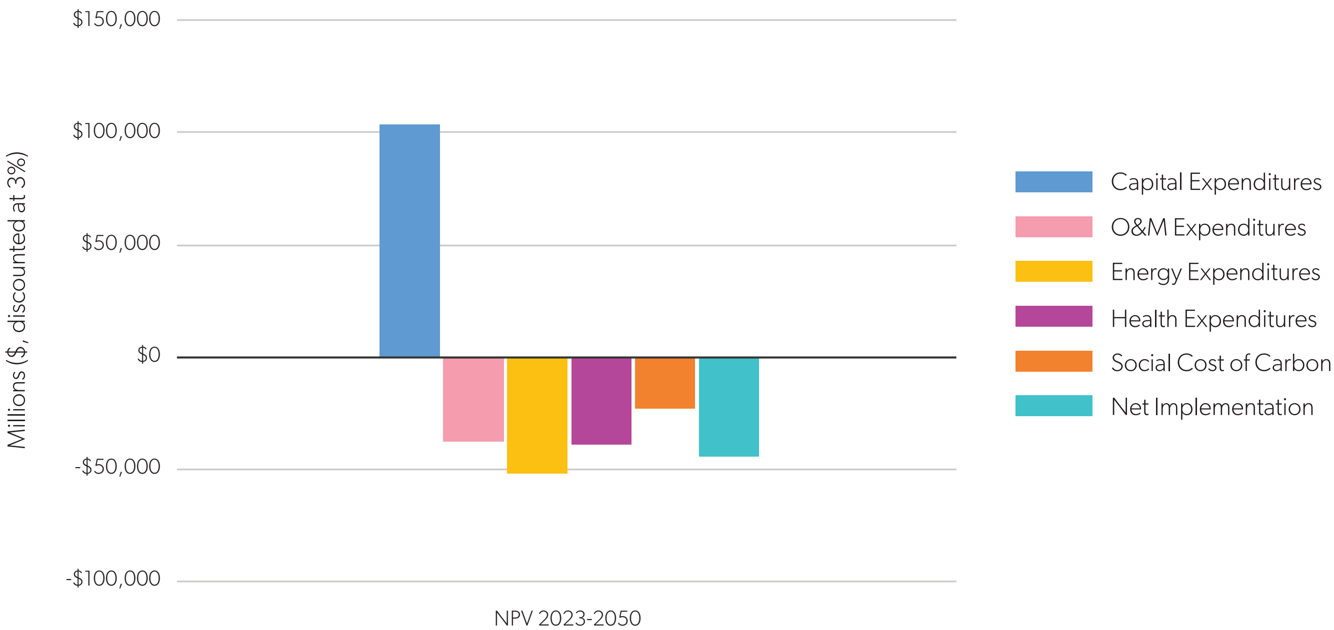


Figure 84. Net present value of cumulative investment and returns for the Alternative Fuels scenario in millions of dollars ($USD 2023) (2023-2050). Costs are discounted at a rate of 3%.

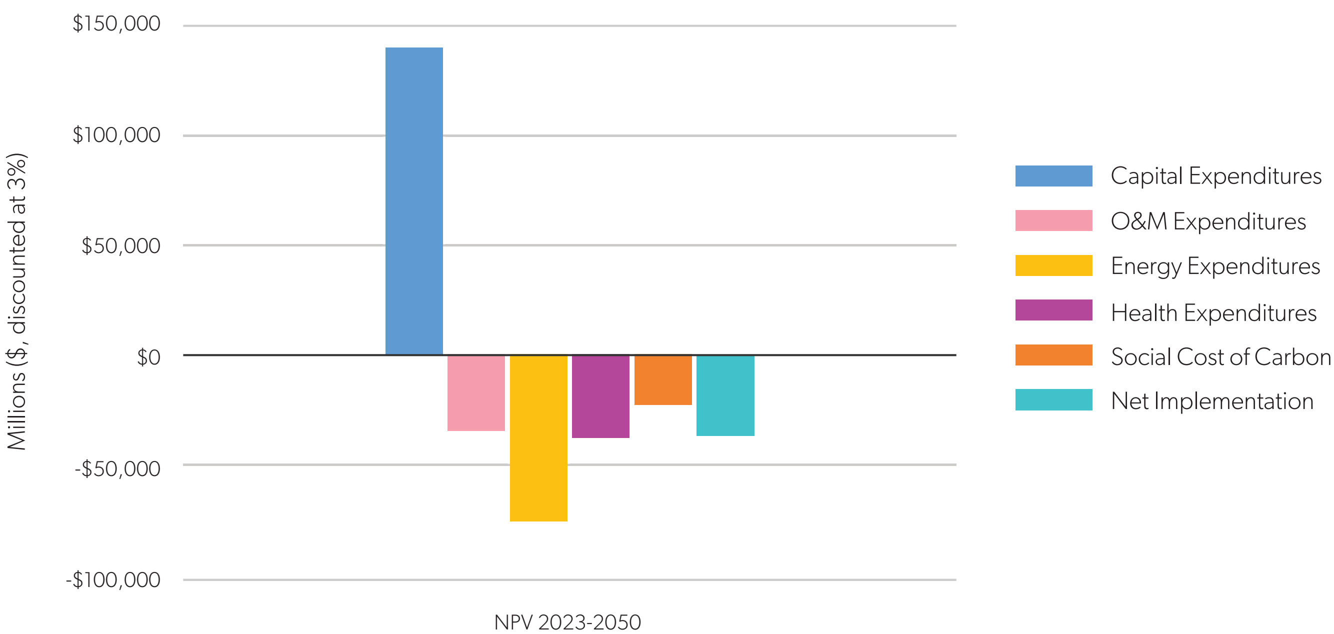


Figure 85. Net present value of cumulative investment and returns for the Hybrid scenario in millions of dollars ($USD 2023) (2023-2050). Costs are discounted at a rate of 3%.

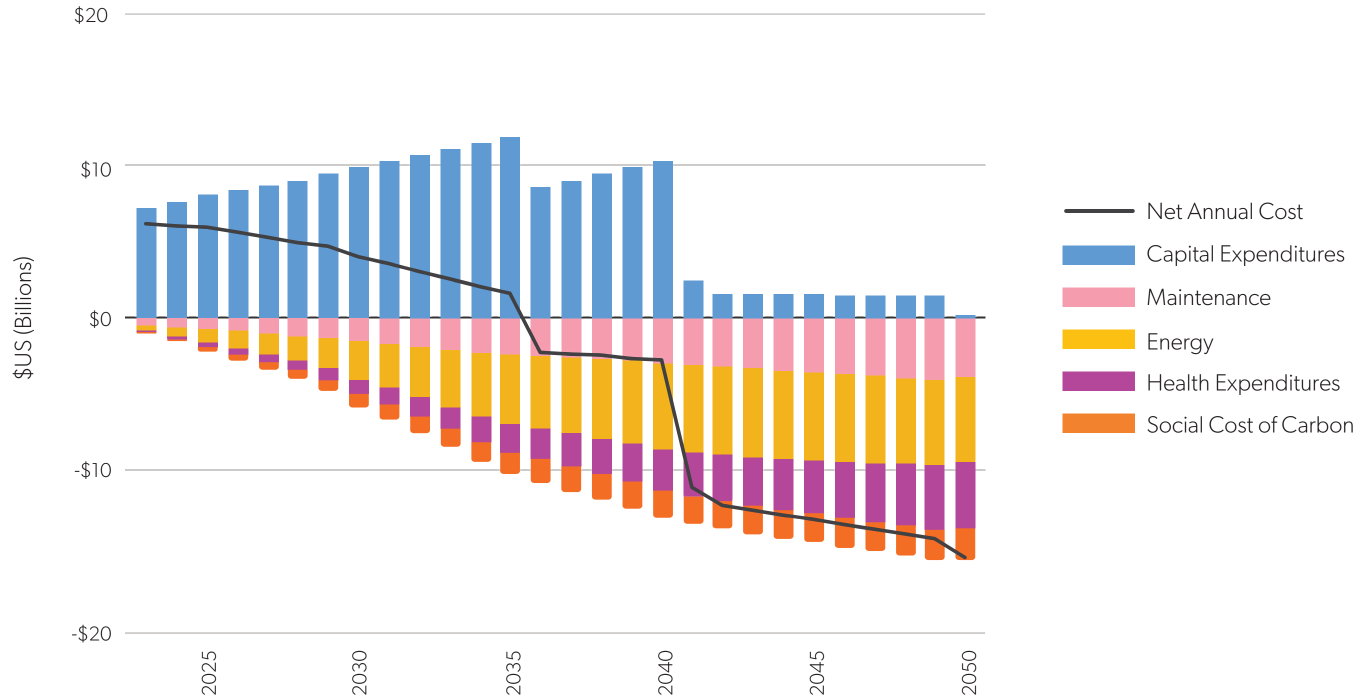


Figure 86. Year-over-year Electrification Scenario investments and returns including the social cost of carbon, undiscounted.

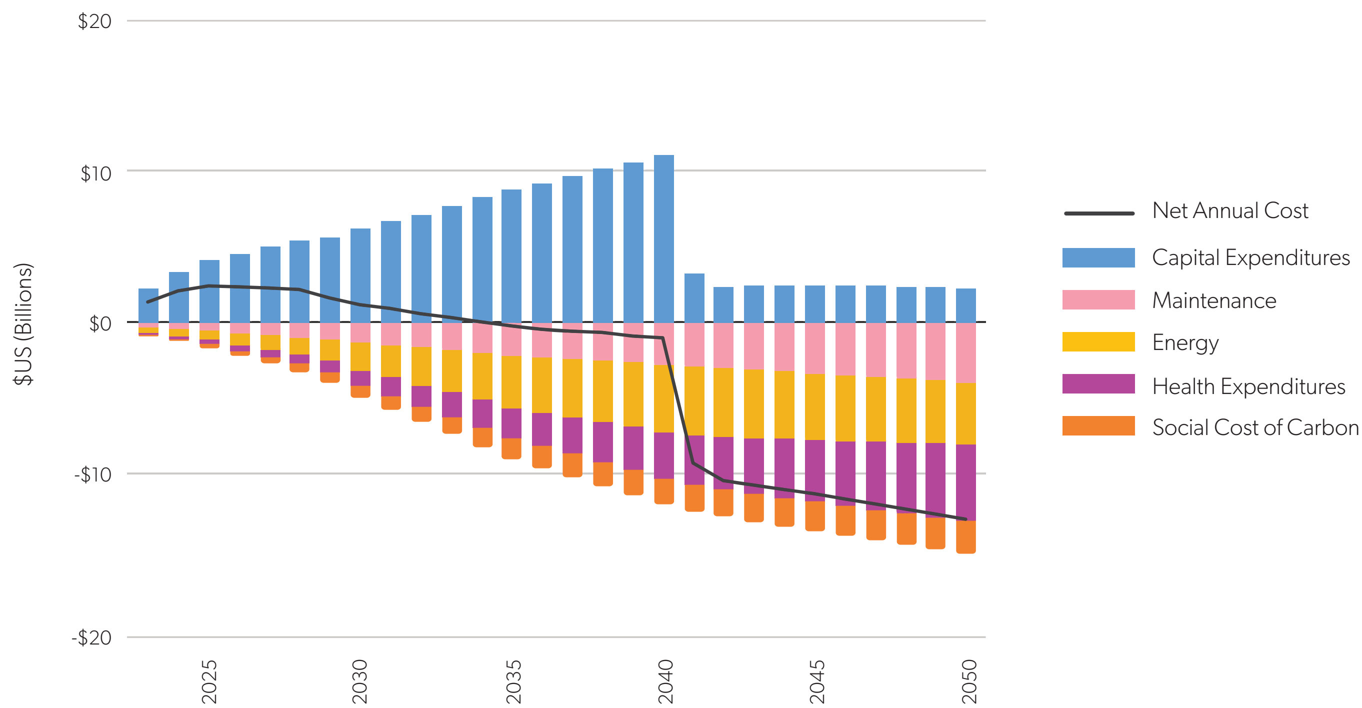


Figure 87. Year-over-year Alternative Fuels Scenario investments and returns including the social cost of carbon, undiscounted.

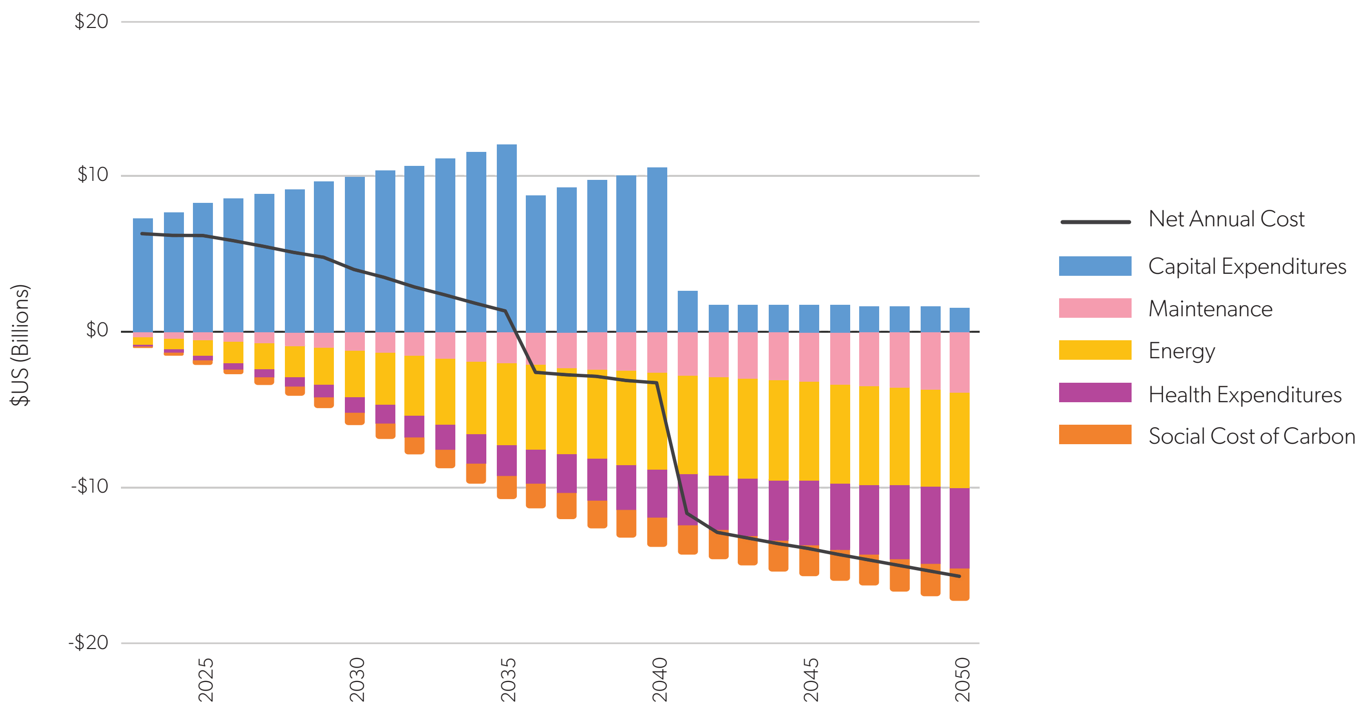


Figure 88. Year-over-year Hybrid Scenario investments and returns including the social cost of carbon, undiscounted.

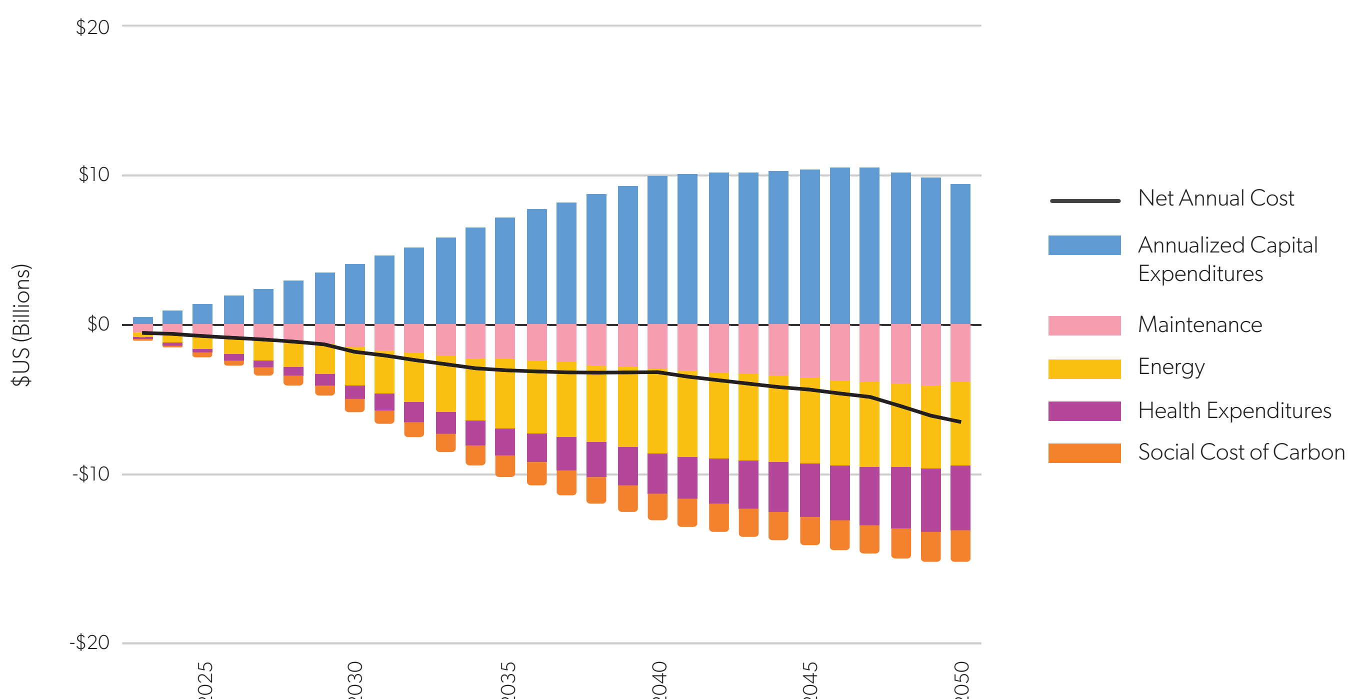


Figure 89. Year-over-year Electrification Scenario investments and returns including the social cost of carbon, undiscounted. Capital costs are annualized over 25 years at 3%

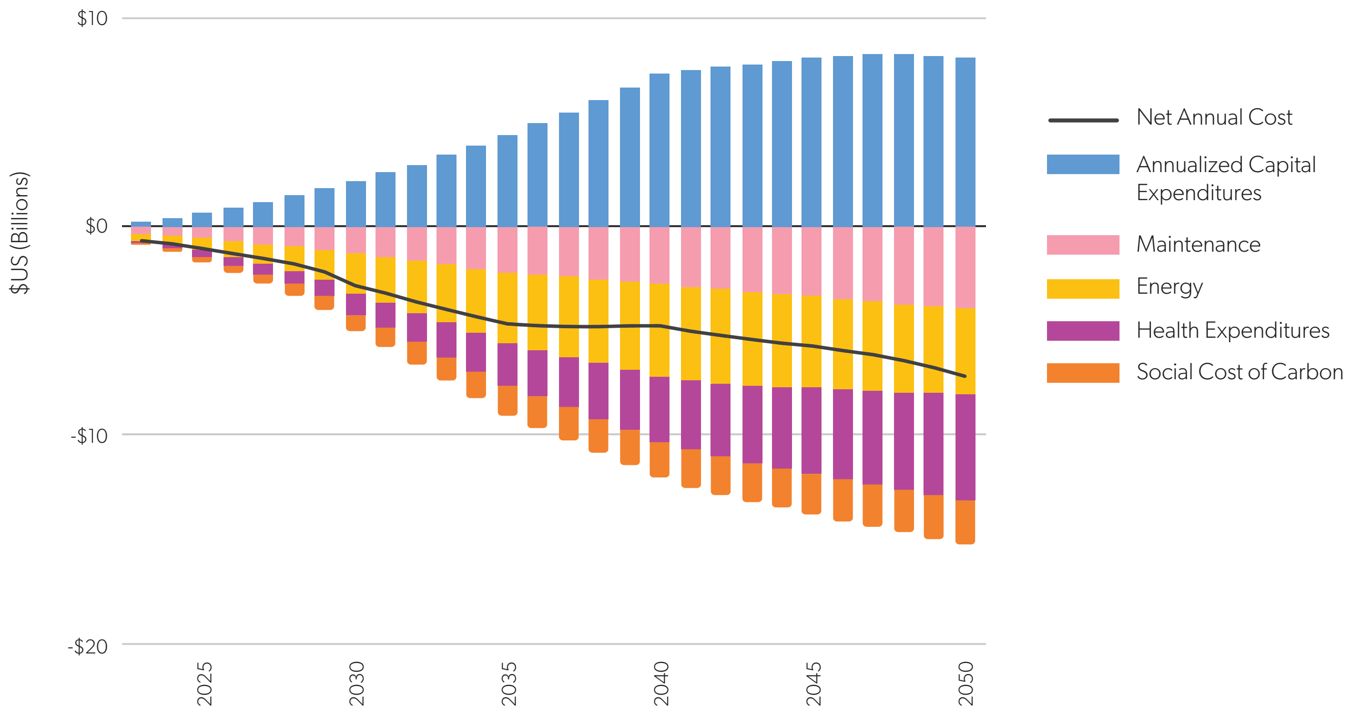


Figure 90. Year-over-year Alternative Fuels Scenario investments and returns including the social cost of carbon, undiscounted. Capital costs are annualized over 25 years at 3%

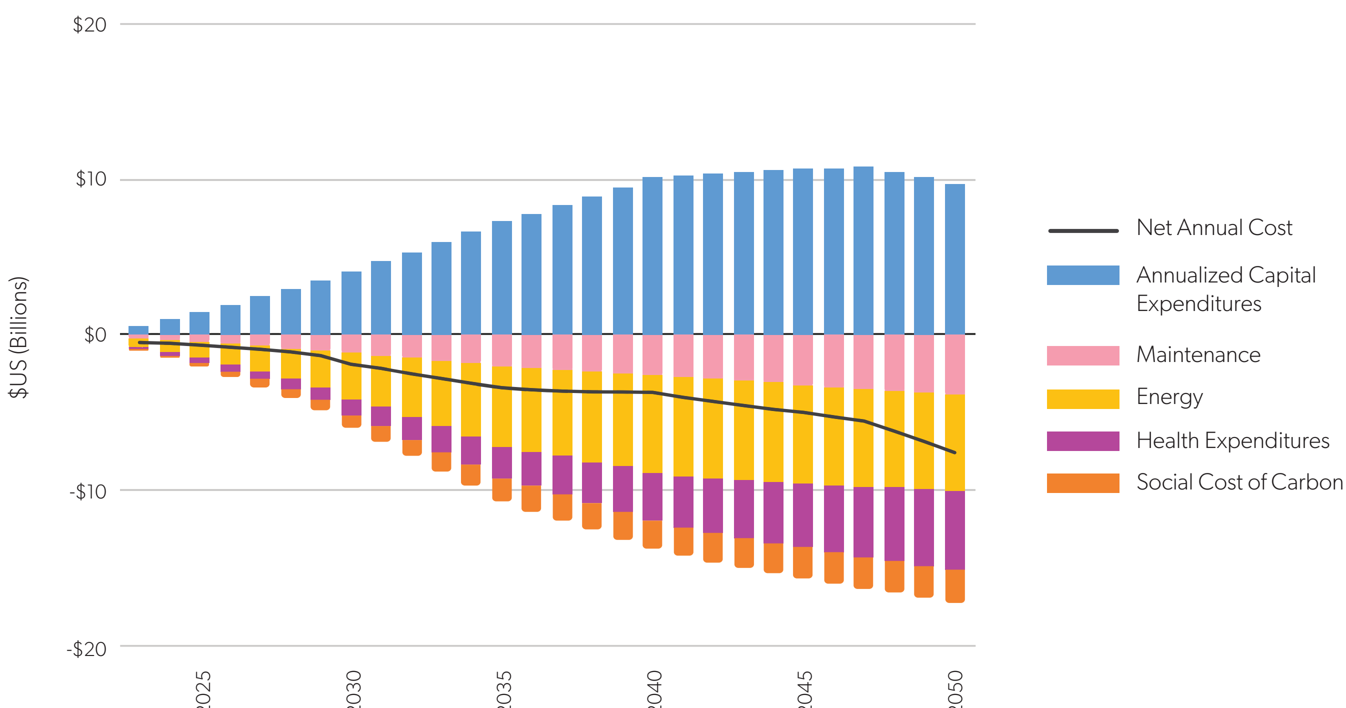


Figure 91. Year-over-year Hybrid Scenario investments and returns including the social cost of carbon, undiscounted. Capital costs are annualized over 25 years at 3%

8.5.3 Supply-side Costs and Savings

Meeting future electricity and energy demand in each scenario requires investing in new generating resources. However, each decarbonization scenario explored reduces energy and electricity consumption relative to the Business-As-Planned, meaning each scenario requires less investment in these resources. The total costs and relative savings for developing and operating energy supply in each scenario, as compared to the BAP scenario, are detailed in the charts below.

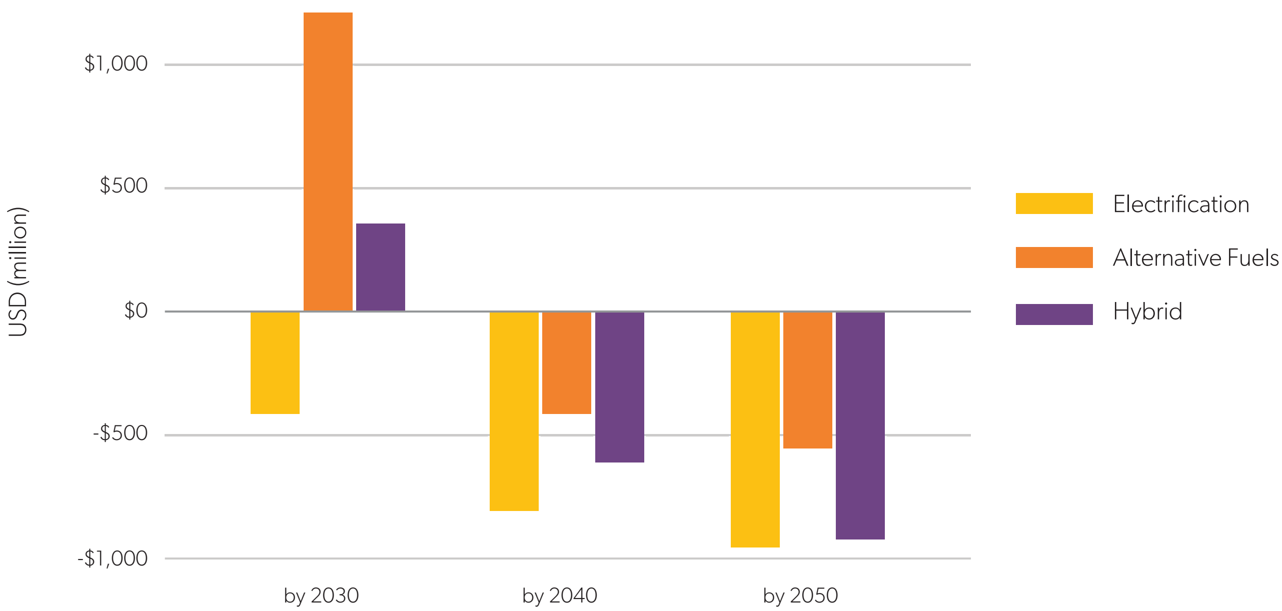


Figure 92. Incremental total costs (capital and O&M) of developing supply-side infrastructure for the Electrification, Alternative Fuels, and Hybrid scenarios relative to BAP for 2030, 2040, and 2050.

Compared to the BAP scenario, less investment in ground mount solar is required in the Electrification Scenario between now and 2030. In addition, because electricity demand is reduced, the Electrification scenario saves capital costs that would have to be spent on meeting peak demand relative to the BAP. By 2050, the Electrification scenario maximizes investment in demand response, requiring less investment in ground mount solar, batteries, wind, and other resources to meet peak demand. Overall, the Electrification scenario results in cost savings between now and 2050 compared to the BAP scenario.

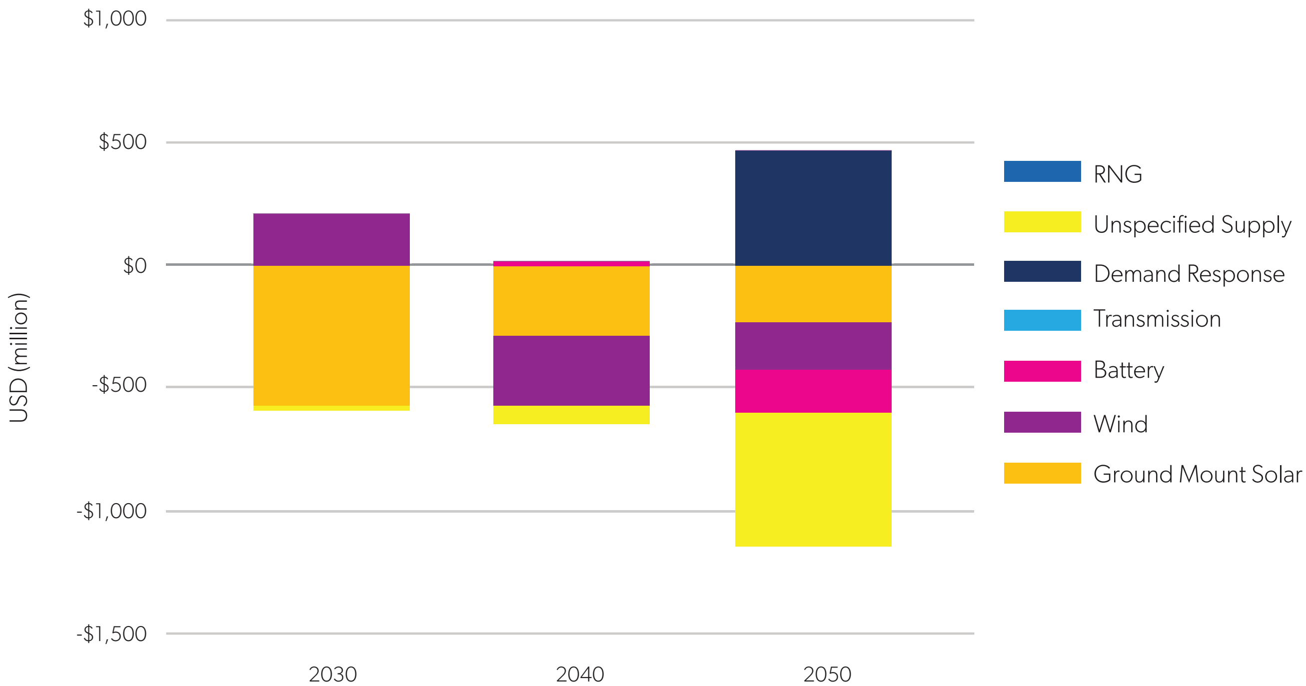


Figure 93. Incremental capital costs for developing energy supply in the Electrification scenario, relative to the BAP.

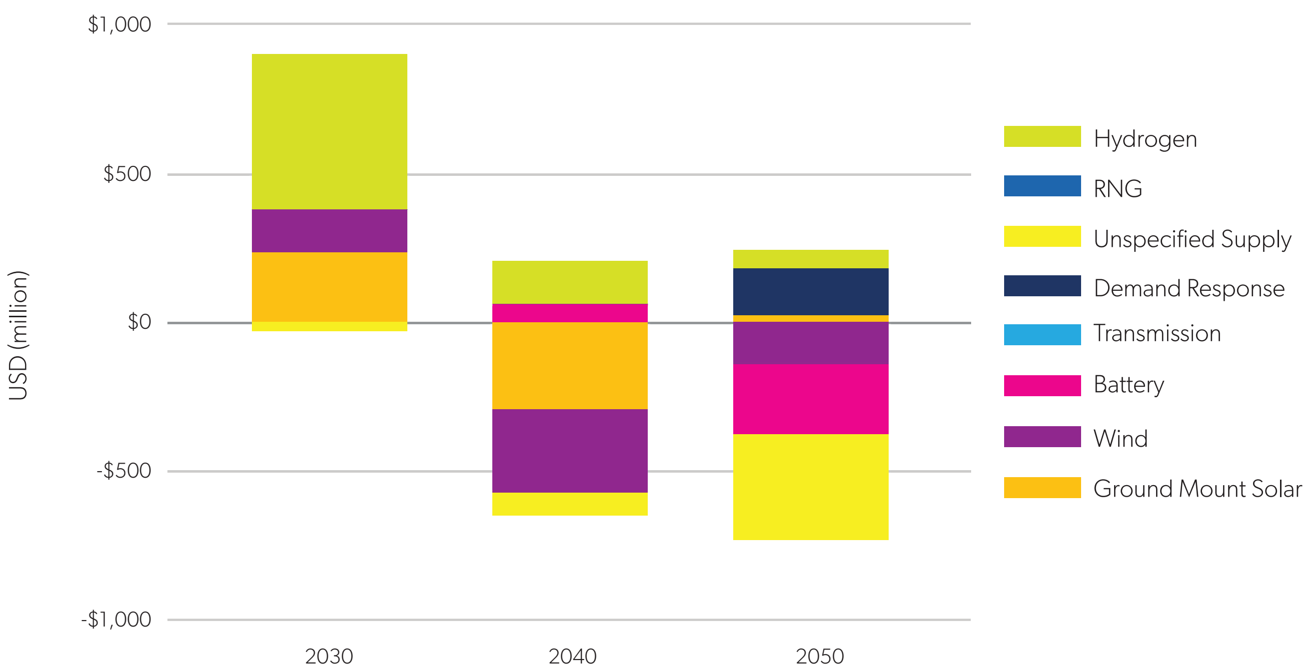


Figure 94. Incremental capital costs for developing energy supply in the Alternative Fuels scenario, relative to the BAP.

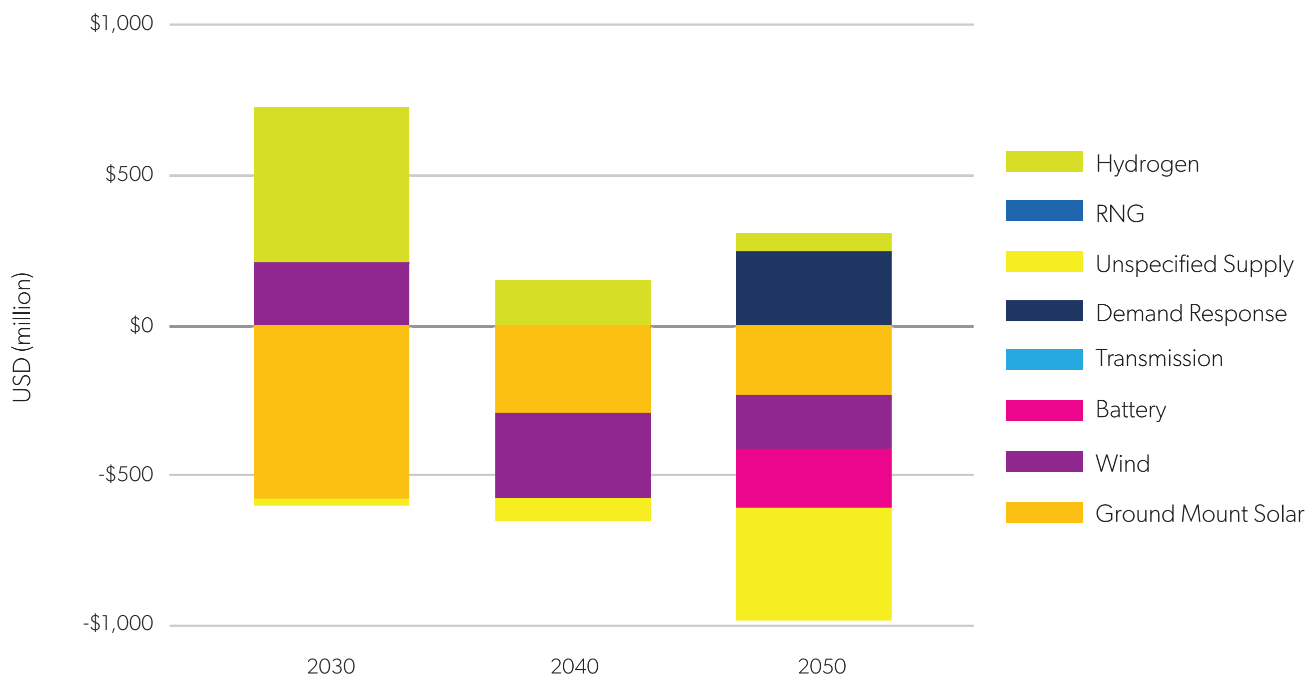


Figure 95. Incremental capital costs for developing energy supply in the Hybrid scenario, relative to the BAP.

Compared to the BAP scenario, the Alternative Fuels scenario requires investment in hydrogen production, as well as utility-scale wind and solar installations in the short term (by 2030). In addition, because electricity demand is reduced compared to the BAP scenario, the Alternative Fuels scenario saves capital costs that would have to be spent on meeting peak electricity demand as well as developing generating resources such as ground mount solar, wind, and batteries. By 2050, the Alternative Fuels scenario requires more investment in demand response and hydrogen than would be needed in the BAP. Overall, costs in the Alternative Fuels scenario are higher before 2030 relative to the BAP scenario, but become less than what would be required in the BAP by 2050.

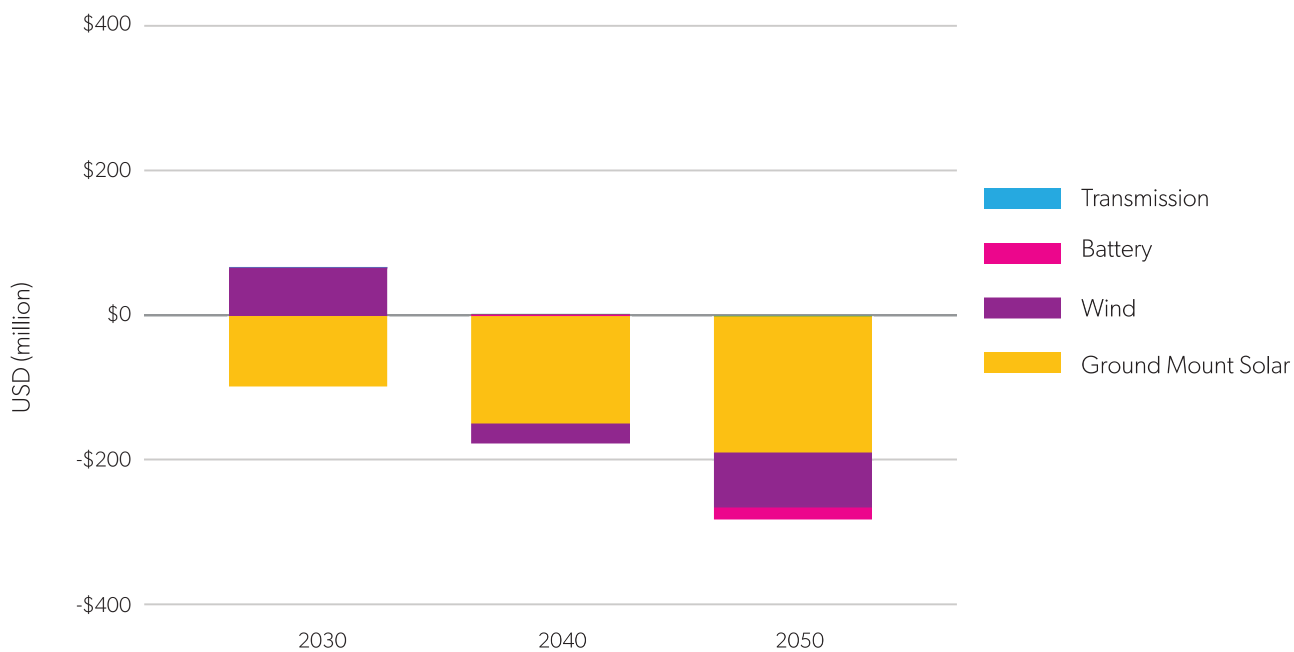


Figure 96. Incremental operating and maintenance costs in 2030, 2040, and 2050 to meet electricity demand in the Electrification scenario, relative to the BAP.

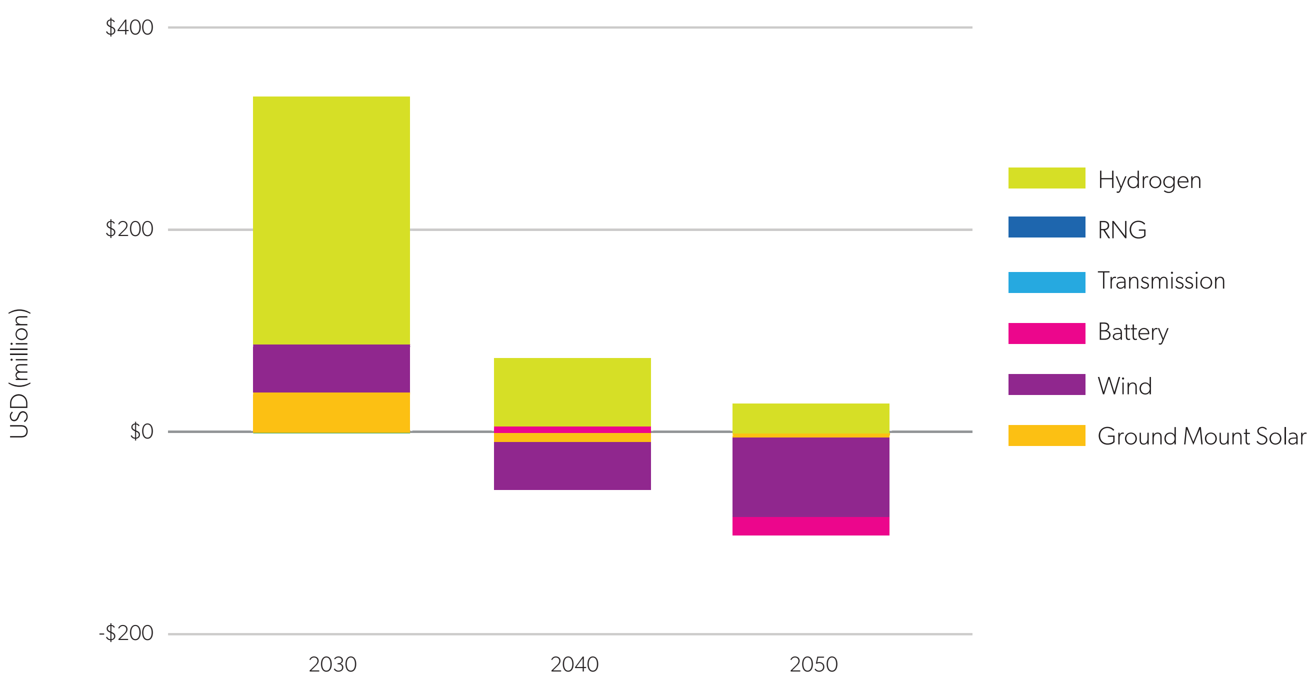


Figure 97. Incremental operating and maintenance costs in 2030, 2040, and 2050 to meet electricity demand in the Alternative Fuels scenario, relative to the BAP.

Figure 98. Incremental operating and maintenance costs in 2030, 2040, and 2050 to meet electricity demand in the Hybrid scenario, relative to the BAP.

Compared to the BAP scenario, the Hybrid scenario requires investment in hydrogen production between now and 2050, as well as utility-scale wind installations in the short term (by 2030). Fewer investments in utility-scale solar and resources to meet peak demand are needed compared to the BAP due to the inclusion of rooftop solar buildout in this scenario. In addition, because electricity demand is reduced compared to the BAP scenario, the Hybrid scenario saves capital costs that would have to be spent on meeting peak electricity demand as well as developing generating resources such as ground mount solar, wind, and batteries. By 2050, the Hybrid scenario requires more investment in demand response and hydrogen than would be needed in the BAP. Overall, costs in the Hybrid scenario are slightly higher before 2030 relative to the BAP scenario, but become less than what would be required in the BAP by 2050.

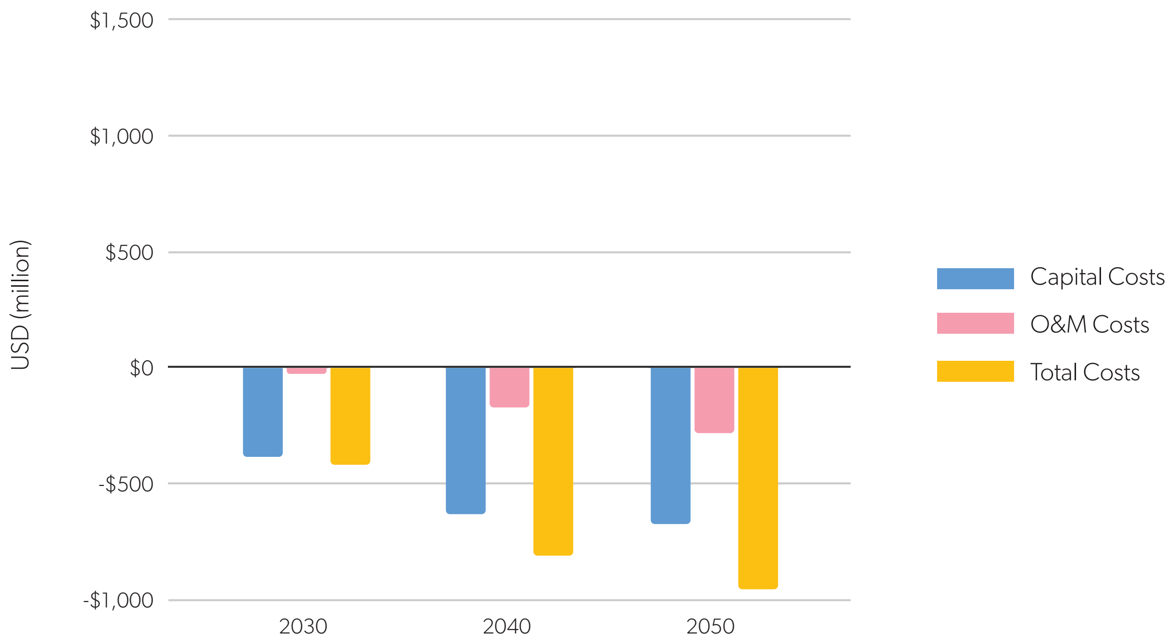


Figure 99. Incremental costs of developing energy supply in 2030, 2040, and 2050 in the Electrification scenario, by category, relative to the BAP.

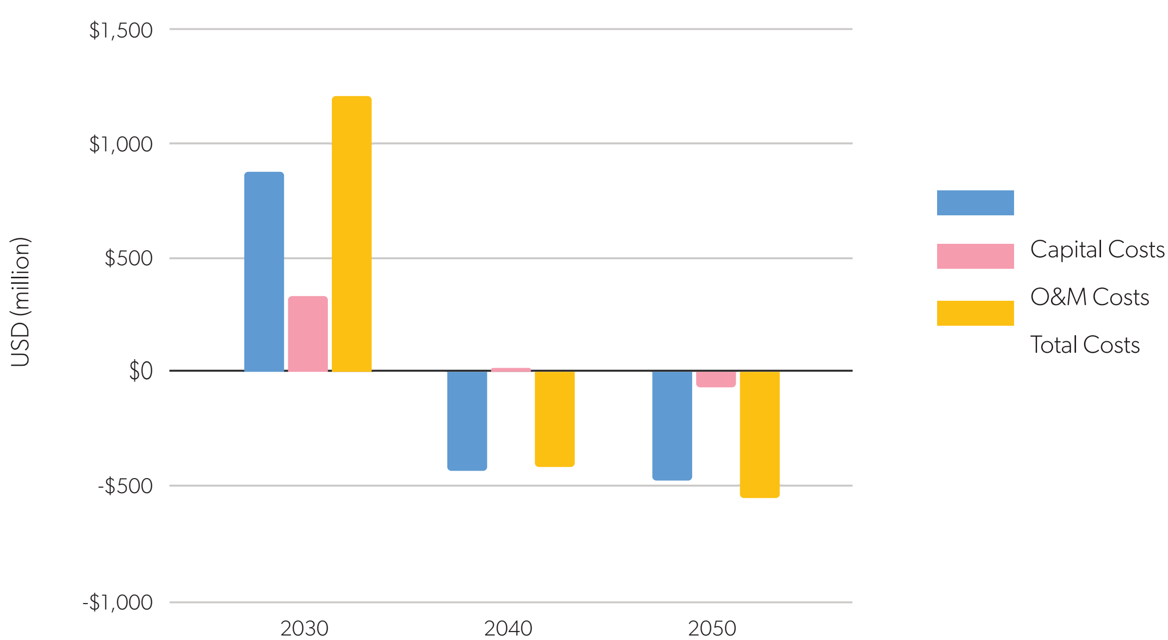


Figure 100. Incremental costs of developing energy supply in 2030, 2040, and 2050 in the Alternative Fuels scenario, by category, relative to the BAP.

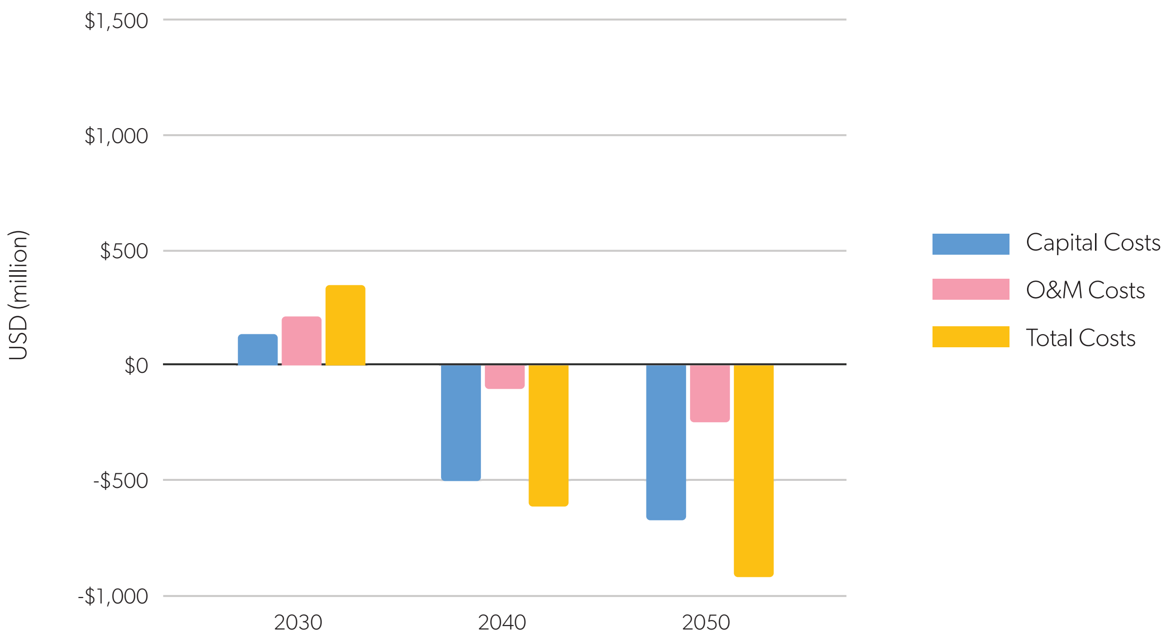


Figure 101. Incremental costs of developing energy supply in 2030, 2040, and 2050 in the Hybrid scenario, by category, relative to the BAP.

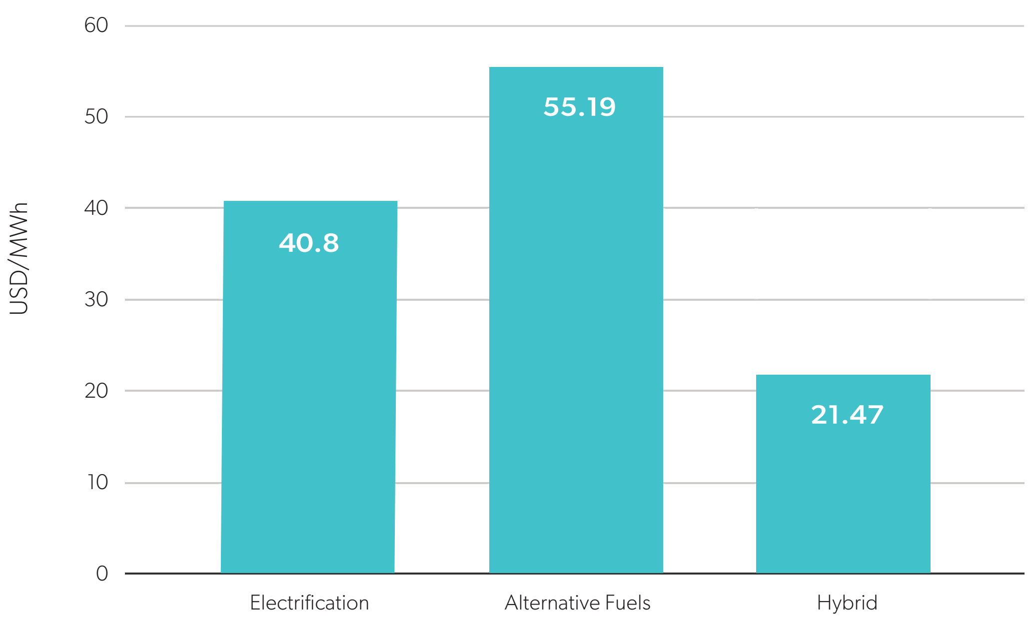


Figure 102. Consolidated unit cost of generating on MWh of electricity in 2050 for the Electrification, Alternative Fuels, and Hybrid Scenarios.

Insights:

- The investment required to develop new generating resources represents 24% of one year's worth of Washington's GDP in the Electrification scenario, 18% of GDP in the Alternative Fuels scenario, and 24% of GDP in the Hybrid scenario.315 These investments would not be made in a single year, but over several years. Rather than representing a sunk cost, the capital deployed would contribute to reducing ongoing costs for families and businesses, and contribute to the development of jobs and sectors (explored in the next section). These investments also represent a significant opportunity for economic growth, as they will contribute to municipal, county, and state tax revenues which can be reinvested in improvements to public infrastructure.
- Investment opportunities, and capital expenditures, are distributed among various actors within each scenario. All three scenarios include investment in utility scale renewable energy. Investment in the Electrification scenario has the least utility scale investment; capital expenditures are focused more on the homeowner/business owner. Investment in the Alternative Fuels scenario has a stronger utility-based focus with investments in both renewables and hydrogen production. Government funding (such as the Inflation Reduction Act and revenues from the Climate Commitment Act allowance system), utility investment, or energy-as-a-service business models could be some ways of addressing the investment needs.
- Capital investment needs vary across scenarios. The Alternative Fuels scenario shows the lowest capital investment of the three scenarios. The Alternative Fuels and Hybrid scenarios require a large utility scale investment in ground mount solar, wind, and hydrogen in the short term. The capital risk associated with higher unspecified supply in the Alternative Fuels scenario are discussed earlier in this report. Rooftop solar adds a significant capital investment in the Electrification and Hybrid scenarios, but as noted above, would fall upon homeowners and businesses installing the assets, unless subsidized or otherwise paid for (and potentially owned by) by other entities such as cooperatives and utilities.
- Energy expenditures reduce over time across all scenarios. However, the Electrification and Hybrid scenarios show the largest decrease in energy expenditures, which directly translates to household energy costs and energy burden explored in the section below. If the costs of rooftop solar installations are subsidized or otherwise reduced for homeowners and businesses, the savings from energy expenditures can reduce overall energy spending significantly.

[315] The GDP of Washington State in 2021 was $575.1 billion. Source: Bureau of Economic Analysis (2023). https://apps.bea.gov/.

- All three scenarios show net savings in implementation around 2035 as the energy savings from the transition kick-in. Annualizing the investments over a period of time results in net savings sooner across all scenarios. Net savings can be recycled in this transition reducing the overall pool of capital needed, using for example, a mechanism like a green bank. A green bank can reinvest the savings in additional projects which advance decarbonisation objectives.
    - Health benefits in the Electrification scenario are lower than the other scenarios due to the remaining fossil fuel emissions in the industrial sector outlined in the emission section above. These fossil fuels are displaced in the Alternative Fuels and Hybrid scenarios with hydrogen.
    - The demand side actions described earlier in the chapter contribute to the observed supply side cost savings relative to the BAP scenario. Implementing energy efficiency and demand response measures are key to these savings.

8.6 Equity considerations and impacts

The Social Cost of Carbon

The Social Cost of Carbon (SCC) is a comprehensive estimate of climate change damages and includes changes in net agricultural productivity, human health, property damages from increased flood risk, and changes in energy system costs, such as reduced costs for heating and increased costs for air conditioning.

The SCC is one of the best ways to reflect future damages to ensure that decision-making that has implications for future emissions accounts for those implications.

The discount rate is a significant assumption within the models that calculate SCC. Discounting reflects the idea that people would rather have $100 now than $100 in 10 years. From an ethical perspective, a higher discount rate indicates that future generations are worth less than current generations; for this reason, the Stern Review[316] recommended a discount rate of 1.4%, well below traditional discount rates. As Stern pointed out in a subsequent article, "A 2% pure-time discount rate means that the life of someone born 35 years from now (with given consumption patterns) is deemed half as valuable as that of someone born now (with the same patterns)." [317] For the purposes of consistency with other processes, a 3% discounting rate is used in this analysis.[318]

The analysis presents the results of the SCC for the avoided emissions resulting from the actions taken in each of the decarbonization scenarios.

[316] Stern, N. (2006). The Stern review on the economic effects of climate change. Cambridge University Press.

[317] Stern, N. (2015). Economic development, climate and values: making policy. Proc. R. Soc. B, 282(1812), 20150820. https://doi.org/10.1098/rspb.2015.0820

[318] U.S. Government (2021). Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide. Retrieved from: https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf

As described in Chapter 7, racial and social equity and the just transition are key elements when considering how Washington's gas utilities can decarbonize. Actions that reduce GHG emissions can also advance objectives on health, social, and racial equity, economic prosperity, and climate resilience. In many cases, actions that reduce GHG emissions correspond or directly overlap with actions that create vibrant communities, improve public health outcomes, reduce government operating and capital costs, and support innovation; these are no-regrets policies.

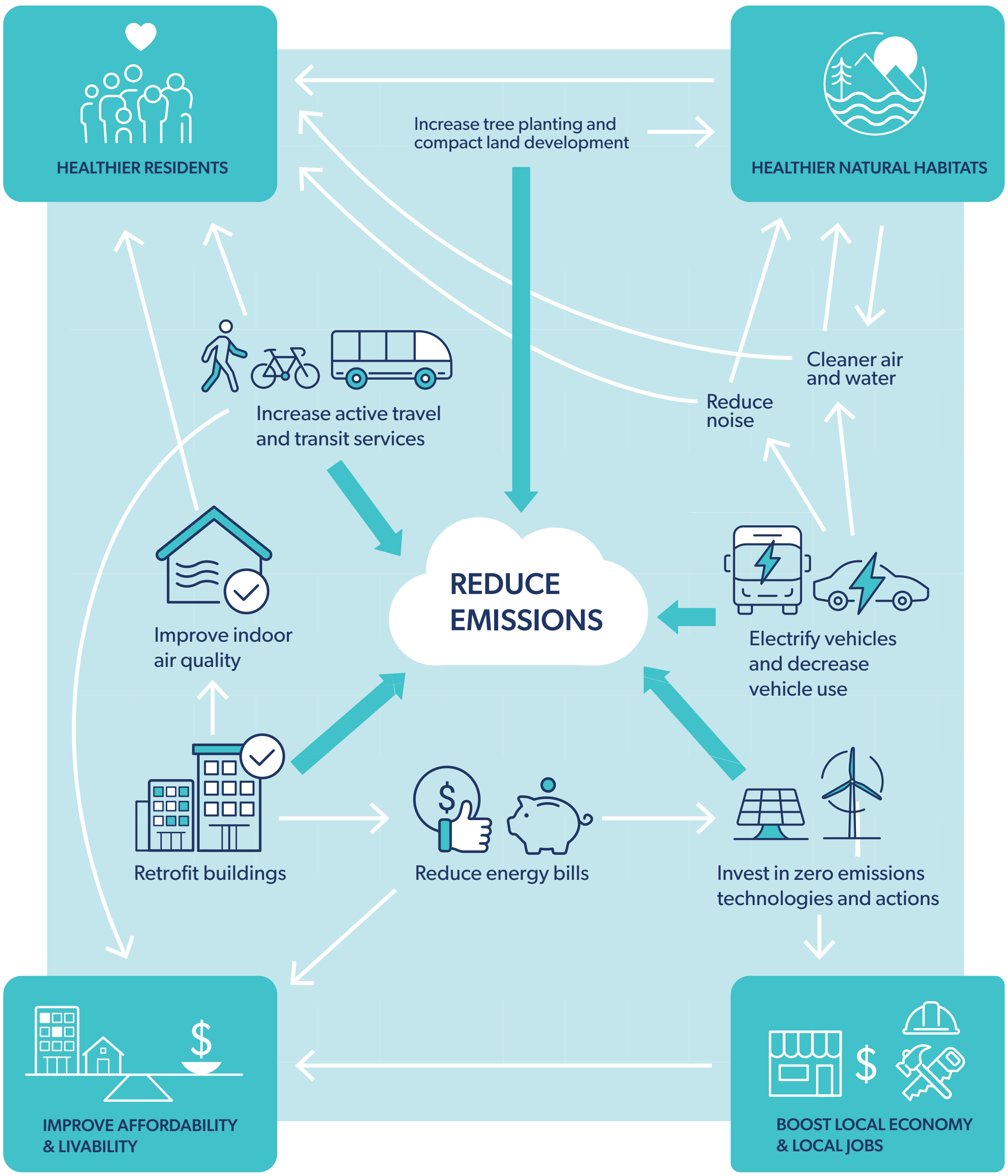


Figure 103. This figure indicates the multiple co-benefits of actions to reduce emissions, for example investing in zero emissions technologies and actions has the potential co-benefit of boosting the state's economy and jobs, while retrofitting buildings improves indoor air quality and therefore the health of residents.

While generally true, a positive synergistic outcome is not universal — there is potential for co-harms and negative feedback cycles. For example:

- Infrastructure to reduce emissions will require major investments and the distributional effects of those investments may favor households with higher incomes at the expense of those with lower incomes.
- Increased costs in urban centers may result in increased lower cost housing at the edges of communities, leading to an increase in transportation emissions and congestion.

Co-benefits and co-harms

Co-benefits and co-harms are effects that result from and are incidental to actions reducing GHG emissions. The IPCC defines co-benefits as "the positive effects that a policy or measure aimed at one objective might have on other objectives, irrespective of the net effect on overall social welfare. Co-benefits are often subject to uncertainty and depend on local circumstances and implementation practices, among other factors."[321] Policy intention is an important feature of co-benefits; a co-benefit is generally not the primary intention of the policy, but it can be intentionally pursued.

The term co-benefits, and its corollary, co-harms, has a variety of synonyms, including "ancillary effects" and "ancillary benefits and costs," and an equal variety of definitions. One distinction, made by the Organization for Economic Co-operation and Development (OECD), is that co-benefits are effects that are valued in the mitigation costs of a policy or action, whereas ancillary benefits are effects that are incidental and are not accounted for in that analysis.[322] In this analysis, co-benefits are assumed to be any potential or anticipated benefits of the action in addition to its impact on GHG emissions.

Furthermore, not all co-benefits or co-harms are equal. The following set of criteria can be used to consider the co-benefits of initiatives and actions to reduce GHG emissions:[323]

- Synergies: Many low-carbon actions have multiple socio-economic benefits. Examples of these types of actions include transit, improving energy efficiency, and fostering a more compact urban design.
- Urgency: Some actions are associated with greater urgency to avoid loss of inertia on action already taken, lock-in effects,[324] irreversible outcomes, or elevated costs. This may occur with road infrastructure decisions, major ecosystems displacement and the physical characteristics of cities and their growth, such as their size and shape,

[321] IPCC, "IPCC, 2022: Annex II: Glossary," ed. V. Möller et al., 2022

[322] IPCC.

[323] Adapted from (Fay et al., 2015).

[324] Lock-in effect refers to implementation of a strategy or action that improves performance of an object or activity in the short term but is prohibitive of future change. Lock-in effect can refer to building upgrades or land use. For example, where quick building retrofits are undertaken, no additional improvements in the equipment installed can be expected over the course of its lifetime without considerable additional expense. In this way, lower levels of energy reductions can be locked in for a long period.

and the spatial arrangement of buildings, their facades, fenestration, and materials.[325] Some low-carbon actions require time to realize their effects, making immediate implementation paramount.

- Costs: Acting early is generally less expensive than acting later. This is because delayed action often involves "fixing" high-emissions infrastructure rather than making it a low- carbon option from the beginning. Examples include buildings that are initially constructed to low energy efficiency standards and then need to be retrofitted later.
- Longevity: Related to urgency, the longevity of planning and development decisions locks cities into their effects for decades and sometimes centuries. For example, widening a roadway allows more vehicles to travel, encouraging more emissions for as many years as the widened roadway remains in use.
- Distribution effects: Low-carbon actions have different impacts on different subsets of the population. Those with lower income levels may be unable to afford new heating and cooling systems in their homes and those with limited mobility may not be able to use transit as easily as the able-bodied. Effects can also be spatially or temporally uneven. Those living in areas at higher risk of potential damage due to climate change (ex. areas with high sea level rise or wildfire risk) may experience more benefits from actions that enhance resilience; those living in future generations will inherit the impacts of climate change caused by those who came before them.

Table 22. Co-benefit categories and their respective indicators.

Category	Impact overview	Indicators	Analytical method
1. Health			
1.1 Outdoor air quality	Improvement in outdoor air quality.	• Avoided mortality and incidence of disease • Dollar value of total health benefits	Calculated using air pollutants from modeling inputted into EPA's CO-Benefits Risk Assessment (COBRA) tool
1.2 Physical and Emotional Wellbeing	Increased physical activity, increased mental wellbeing	• Walking miles traveled; cycling miles traveled • Number of vehicles per household	Relationship between vehicle miles traveled and indicators of physical and mental health
1.3 Occupant Comfort and Indoor Air Quality	Occupant comfort and indoor air quality are improved.	• Number of homes retrofitted • Square footage of non-residential space retrofitted	Correlation of retrofits and use of heat pumps with improved indoor air quality and health and social benefits

[325] Živković, Jelena. "Urban Form and Function." In Climate Action, edited by Walter Leal Filho, Ulisses Azeiteiro, Anabela Marisa Azul, Luciana Brandli, Pinar Gökcin Özuyar, and Tony Wall, 1–10. Encyclopedia of the UN Sustainable Development Goals. Cham: Springer International Publishing, 2019. https://doi.org/10.1007/978-3-319-71063-1_78-1.

Category	Impact overview	Indicators	Analytical method
2. Economic prosperity			
2.1 Employment	New employment opportunities are created. Existing employment opportunities are lost.	• Jobs created/lost by sector and by county	Employment multipliers for every dollar spent on decarbonization
2.2 Energy infrastructure development	New energy infrastructure development opportunities are created. Existing infrastructure is decommissioned or retired.	• MW of new energy generating capacity by county • Number of rooftop solar installations by county	Spatial relationship between location of new energy infrastructure and highly impacted communities.
3. Social equity			
3.1 Poverty	Energy efficiency will reduce household building and transportation costs.	• Household energy and travel expenditures	Change in expenditures on transportation and housing as calculated in the model
3.2 Intergenerational equity	Reduced GHG emissions will reduce the damage caused by climate change	• Value of avoided damage (social cost of carbon)	Calculated in the model using the UTC's social cost of carbon.[326]

326 "Social Cost of Carbon," Washington Utilities and Transportation Commission, accessed April 27, 2023, https://www.utc.wa.gov/regulated-industries/utilities/energy/conservation-and-renewable-energy-overvie w/clean-energy-transformation-act/social-cost-carbon.

8.6.1 Health Impacts: Outdoor Air Quality

Decarbonization can significantly reduce air pollution by reducing the amount of fossil fuels burned in the buildings, energy, waste, and transportation sectors. All three decarbonization scenarios explored, as well as actions in the Business-As-Planned Scenario will reduce fossil fuels combustion.

Table 23. Reduction in fossil fuel combustion and associated particulate matter air pollution in the Electrification, Alternative Fuels, and Hybrid scenarios, as compared to the BAP.

	Electrification	Alternative Fuels	Hybrid
Fossil fuels combusted in Washington			
MMBTU fossil fuels combusted in 2050 (millions)	159	146	143
Cumulative MMBTU of fossil fuels combusted (2020-2050) (millions)	17,126	16,775	16,942
Particulate matter released in Washington			
Particulate matter (PM2.5 U.S. ton) released in 2028	181.8	181.8	181.8
Particulate matter (PM2.5 U.S. ton) released in 2050	178.2	177.5	177.5

Using the EPA's COBRA tool, the cumulative effects of actions across all major energy sectors would result in total health benefits of approximately $1.8 billion (Electrification scenario) and $2.1 billion (Alternative Fuels and Hybrid scenarios) annually by 2050. This indicator incorporates avoided costs and incidences due to reduced air pollution of estimated mortalities for adults and infants, nonfatal heart attacks, hospital admissions for respiratory issues, restricted activity days, work loss days, and asthma attacks. The COBRA analysis was conducted on a per county basis for the years 2028 and 2050, as these are the years available in the tool, with the intervening years calculated as an extrapolation of the data for the preceding calculated year. Due to existing inequities as described in Chapter 7, low-income communities and communities of color will benefit to a greater extent from improvements in air quality.

The higher amount of particulate matter found in the electrification scenario is due to the remaining non-natural gas fossil fuels remaining in the industrial sector after electrification. As outlined in the electrification assumptions in Chapter 7, 55% of fossil fuel use in the industrial sector was electrified compared to 70% of fossil fuels in the Alternative Fuels and Hybrid scenarios. This speaks to the challenge of electrifying industrial processes. Because these remaining fossil fuels fall outside the scope of this analysis, no effort was made to remove them from the system.

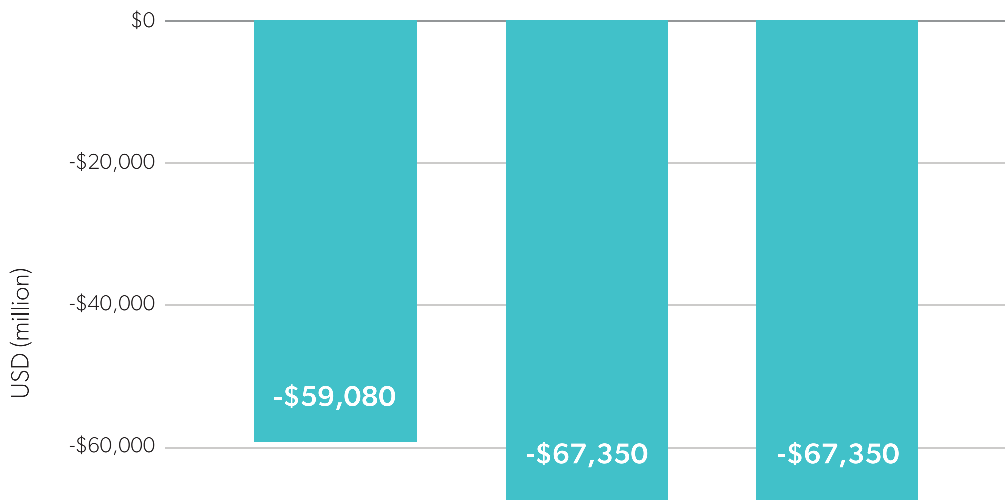


Figure 104. Cumulative avoided health care expenditures (2020-2050), million USD

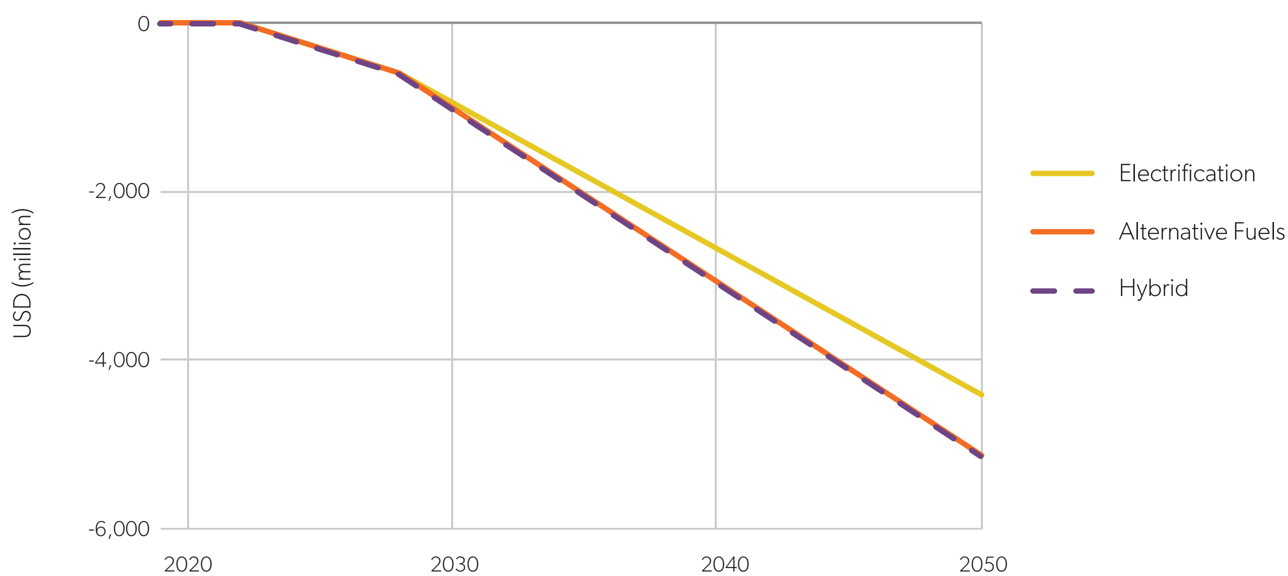


Figure 105. Reductions in annual health expenditures in billions of dollars for the Electrification, Alternative Fuels, and Hybrid scenarios.

8.6.2 Health Impacts: Occupant Comfort and Indoor Air Quality

Actions across all three decarbonization scenarios will serve to improve occupant comfort and reduce negative health impacts from building construction and operation. Retrofitting 95% of existing buildings (reducing space heating/cooling energy use 50% and other non-space condition energy by 30%) by 2040 and installing heat pumps and heat pump hot water heaters in 95% of existing buildings will reduce energy use, improve occupant comfort, and improve indoor air quality. Efforts to equip 5% of homes with clean hydrogen fuel cells by 2030 (Alternative Fuels Scenario) or 25% of non-apartment residences by 2035 (Electrification and Hybrid scenario) will further increase residents' ability to withstand the impacts of power disruptions and extreme weather events.

Table 24. Indicators of occupant comfort. All figures are compared to the BAP.

	Electrification	Alternative Fuels	Hybrid
Dwelling units retrofit			
Cumulative number of existing homes retrofit (2020-2050) (thousands)	2,122	2,122	2,122
Non-residential buildings retrofit			
Square footage of non-residential building floor space retrofit (2020-2050) (million)	830	830	830
Number of homes with heat pumps by 2050	4,040,000	4,000,000	4,040,000
Number of homes with energy storage (battery or hydrogen fuel cell)	900,000 (battery storage)	106,00 (hydrogen fuel cell)	900,000 (battery storage)

8.6.3 Economic Prosperity: Employment Opportunities

Nearly all actions explored in the decarbonization scenarios will result in new employment opportunities, while some actions will result in the phasing out or elimination of some jobs. Actions that will create jobs include the installation of electric heat pumps in residential and commercial buildings, retrofitting 95% of existing buildings, increasing the amount of rooftop solar, deploying clean hydrogen fuel cells for homes, and developing renewable generating resources such as utility-scale solar, wind, RNG, and hydrogen production facilities. Job losses compared to the BAP are primarily related to the electrification of commercial use vehicles. Job growth occurs across all decarbonization scenarios across the state, with some counties such as Pierce, King, and Snohomish in Western Washington and Spokane County in the East seeing larger increases in new employment opportunities compared to others.

While not quantified in this report, the manufacturing of materials to support the development of new energy generating resources, such as solar panels and wind turbines, also presents a significant opportunity for new employment opportunities. Capturing these opportunities within Washington state could reduce risk of reliance on materials manufactured in jurisdictions where forced labor practices have been documented.[327]

Table 25. Indicators of employment opportunities created in the low-carbon scenarios (Number of person years of employment between 2020 and 2050).

	Electrification	Alternative Fuels	Hybrid
Change in employment opportunities relative to the BAP			
Building Retrofits	503,400	503,400	503,400
Heat pump installations	43,300	85,400	43,300
Industrial efficiency	27,000	27,000	27,000
Rooftop Decentralized Electricity	196,700	0	196,700
Commercial Vehicles	-314,400	-262,800	-262,800
Renewable Energy (Solar and Wind) (in-state)	2,090	3,243	2,086
RNG production (in-state)	196	196	196
Hydrogen production (in-state)	0	726	726

[327] "In Broad Daylight Uyghur Forced Labour in the Solar Supply Chain | Sheffield Hallam University." Accessed June 11, 2023. https://www.shu.ac.uk/helena-kennedy-centre-international-justice/research-and-projects/all-projects/in-broad-daylight.

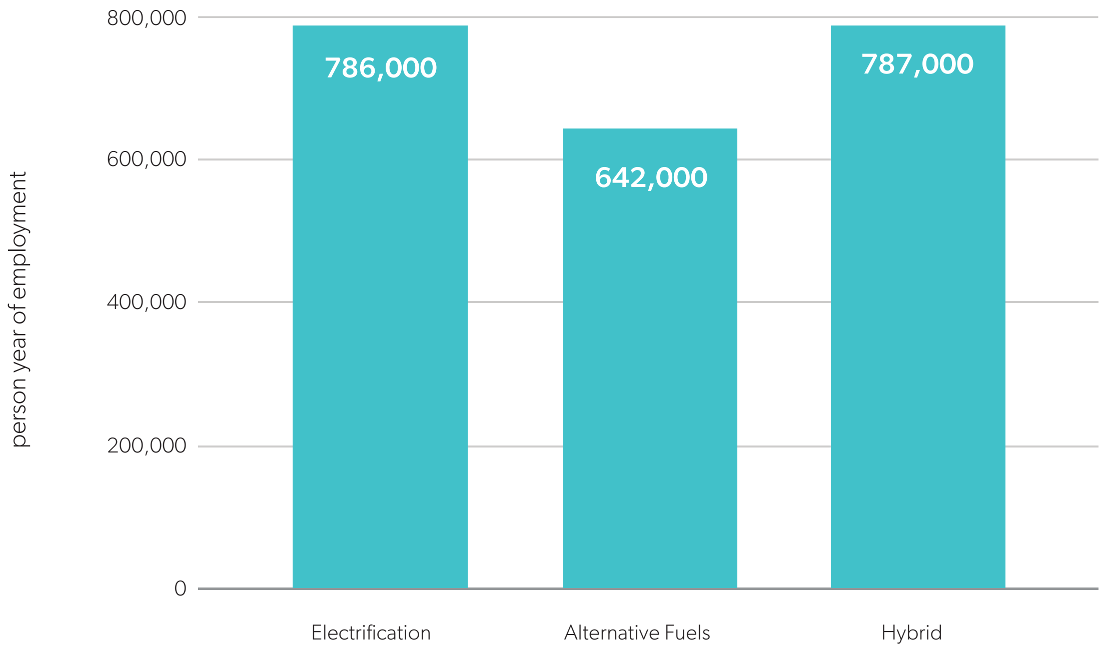


Figure 106. Cumulative annual person years of employment (2023-2050).[328]

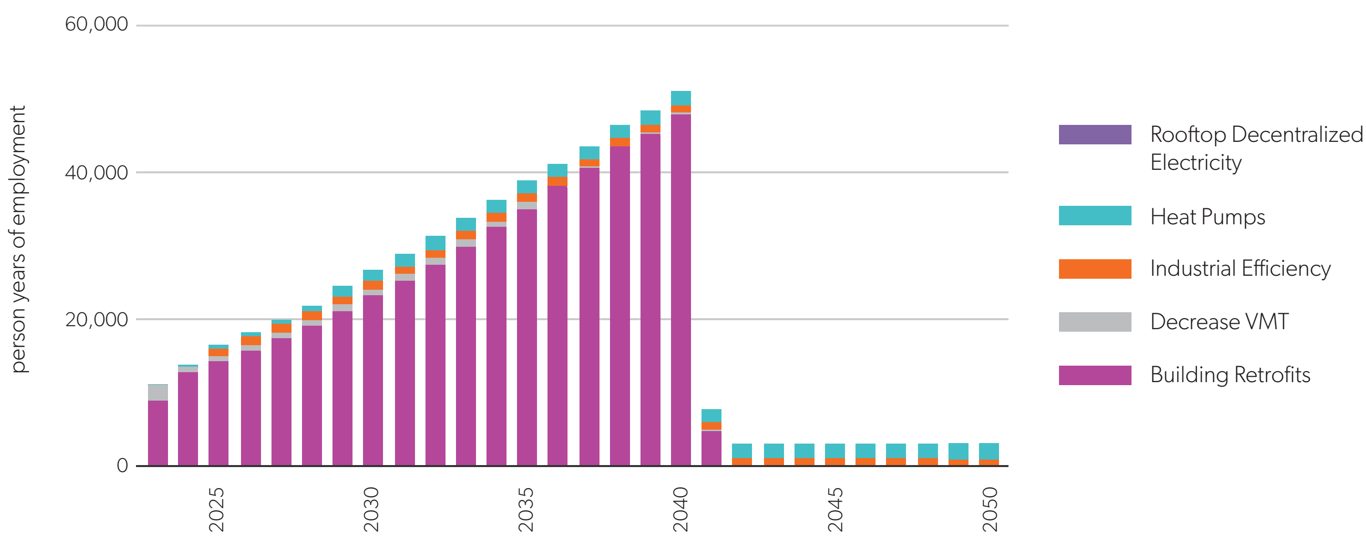


Figure 107. Person years of employment created in the Electrification scenario.

[328] A person-year is a unit of measurement for the amount of work done by an individual throughout the entire year, expressed in the number of hours. The man-year takes the number of hours worked by an individual during the week and multiplies it by 52. For example, the Alternative Fuels scenario generates employment opportunities equivalent to 21,000 people working for one year each.

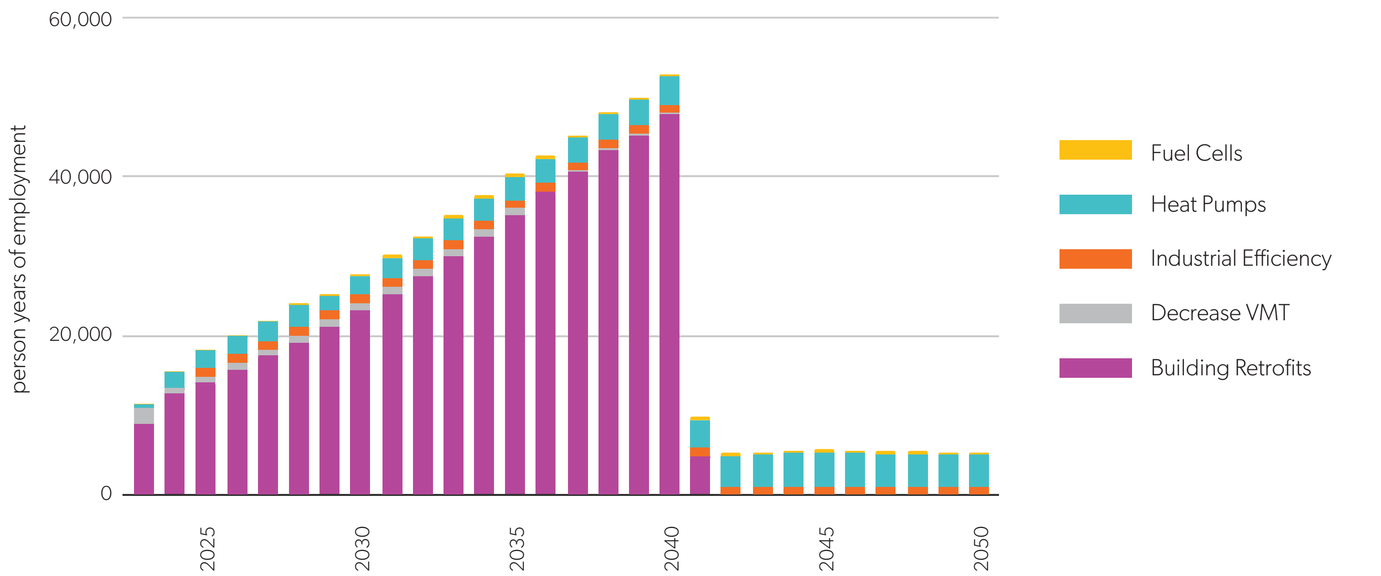


Figure 108. Person years of employment created in the Alternative Fuels scenario.

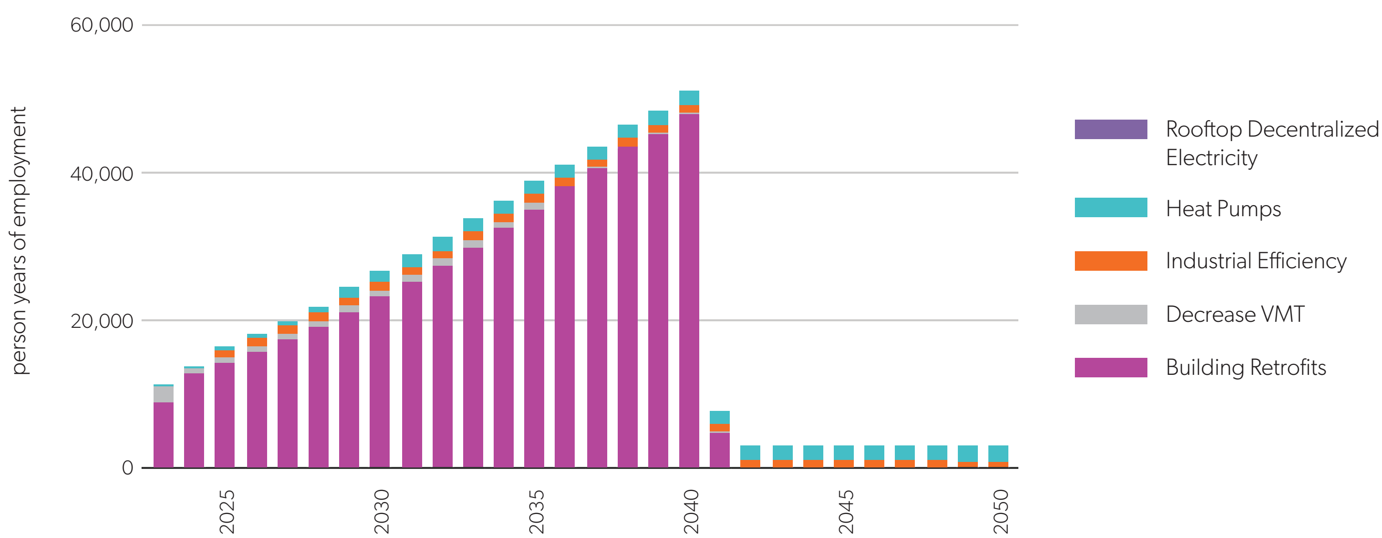


Figure 109. Person years of employment created in the Hybrid scenario.

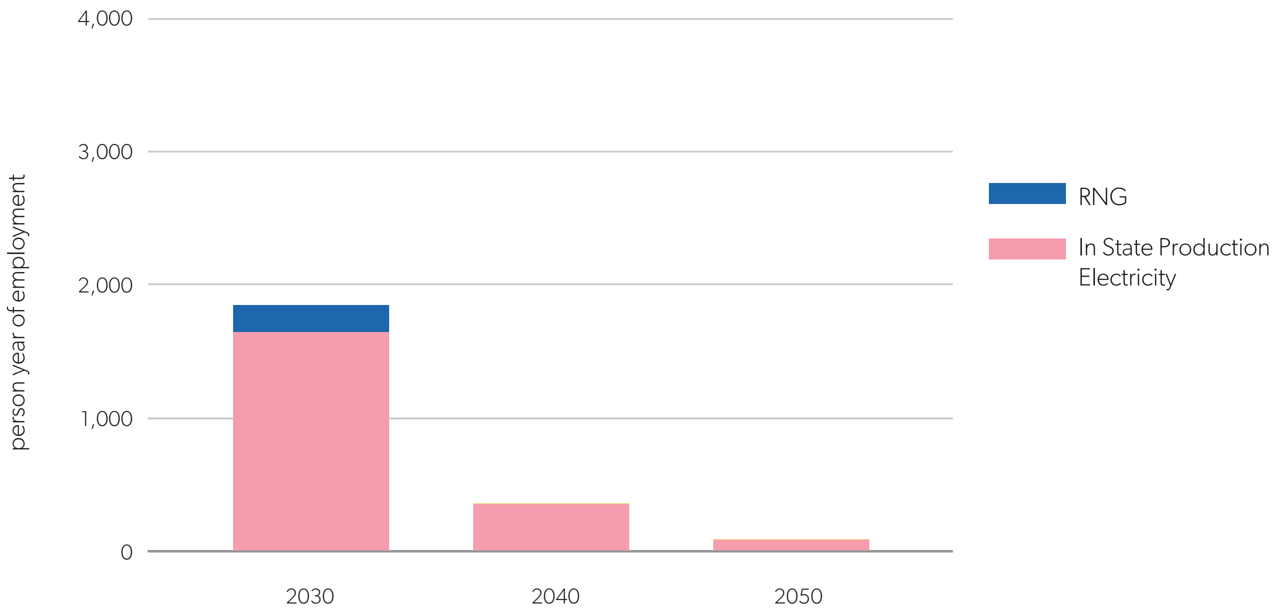


Figure 110. Supply side Person years of employment created in the Electrification scenario.

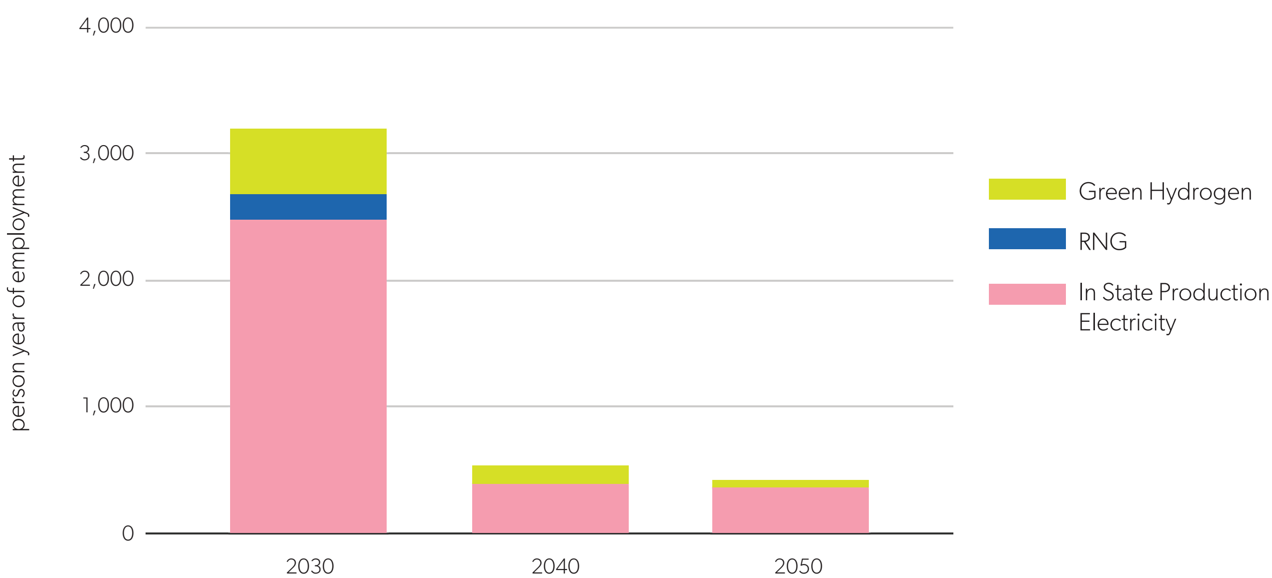


Figure 111. Supply side Person years of employment created in the Alternative Fuels scenario.

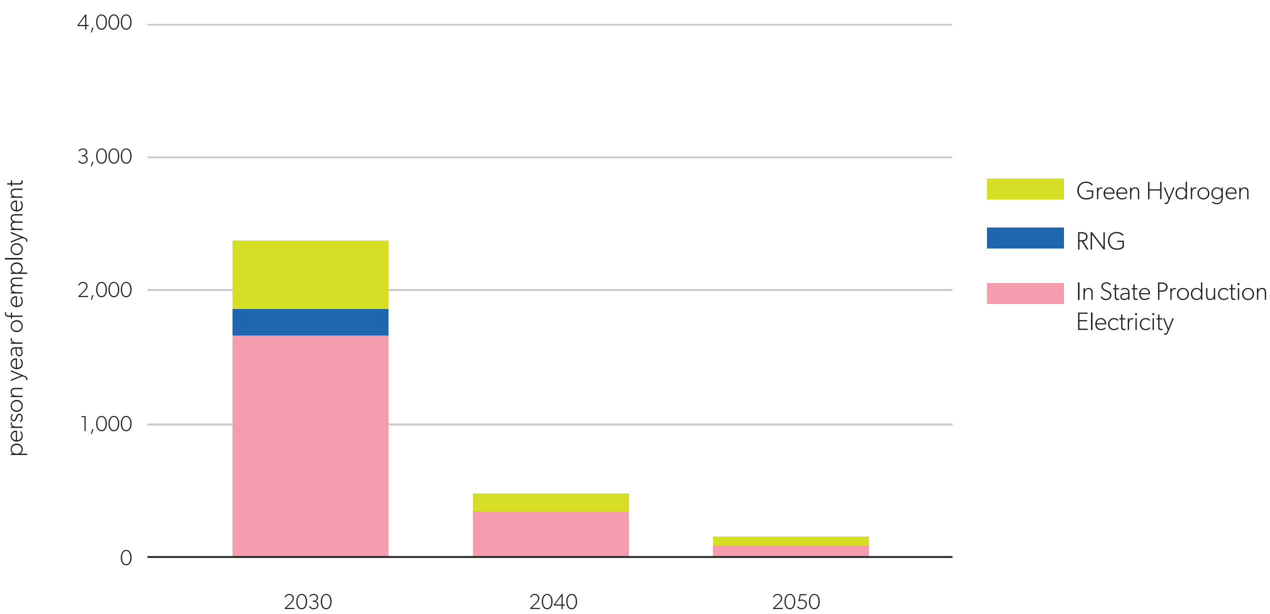


Figure 112. Supply side Person years of employment created in the Hybrid scenario.

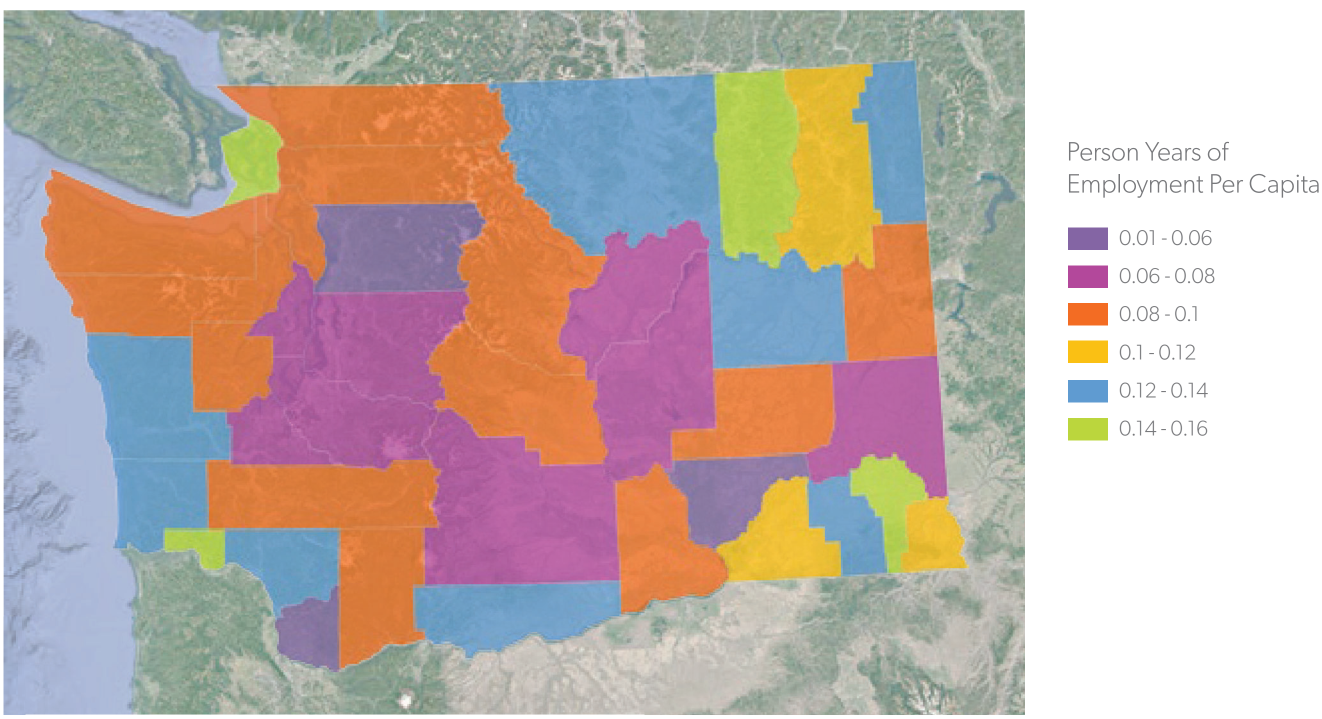


Figure 113. Cumulative person years of employment per capita created per county (2023-2050) by demand-side actions in the Electrification scenario.

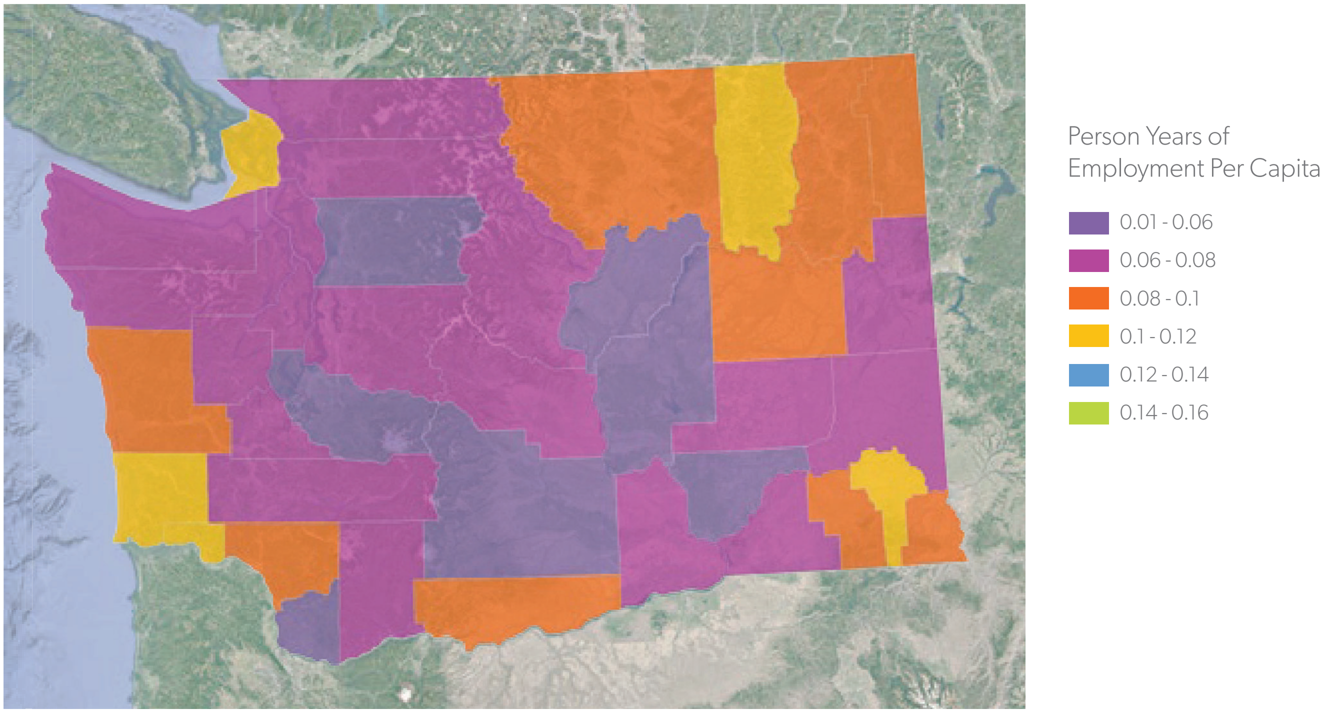


Figure 114. Cumulative person years of employment per capita created per county (2023-2050) by demand-side actions in the Alternative Fuels scenario.

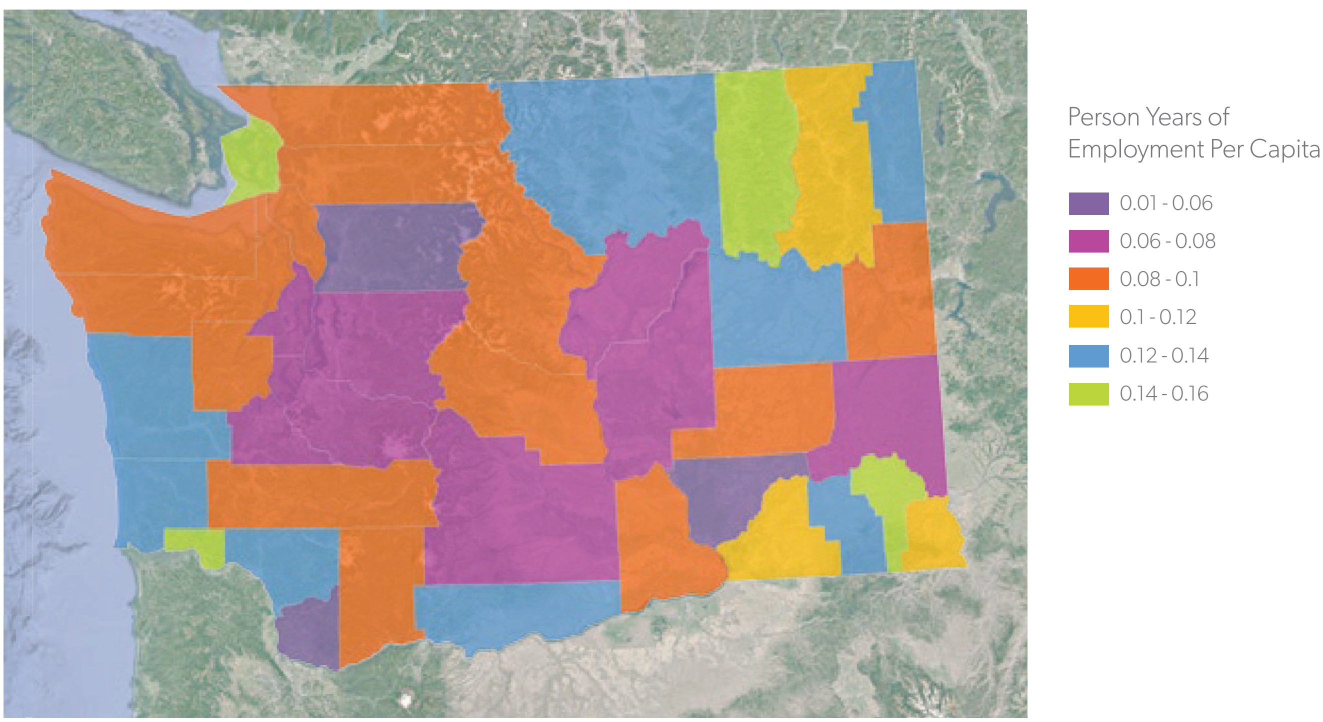


Figure 115. Cumulative person years of employment per capita created per county (2023-2050) by demand-side actions in the Hybrid scenario.

Insights:

- Both the Electrification and Hybrid scenarios generate the most employment opportunities, particularly due to jobs in distributed energy (i.e., rooftop solar installations). These jobs offer distributed (local) social benefits, and have relatively low barriers to entry. In contrast, the Alternative fuels scenario creates more opportunities for utility scale investments, which typically involve national or multinational corporate capital.
- Employment opportunities are strongest in the Western, urban counties as many of the opportunities are focused on building retrofits and heating/water heating equipment installations.
- The Electrification and Hybrid scenarios impact more counties as a result of installing rooftop solar.

8.6.4 Economic Prosperity: Energy Infrastructure

Developing new decarbonized energy infrastructure within the state of Washington could provide energy for consumption as well as jobs. It is also an economic development opportunity for cities and counties. As noted in Chapter 7, equity and the just transition are key considerations for how, where, and when decarbonized energy should be developed in Washington. Additionally, as discussed in Chapter 7, developing new resources is an opportunity for community economic development in rural areas and highly impacted communities, and the ownership structure of new energy projects is an important consideration of maximizing the benefits of economic prosperity presented by these opportunities.

New energy infrastructure is needed to meet energy demand across all the decarbonization scenarios. In the Electrification and Hybrid Scenarios, actions to increase rooftop solar installations drive further development of the rooftop solar industry. In the Alternative Fuels and Hybrid Scenario, actions to use and produce hydrogen within the state drive the development of that industry.

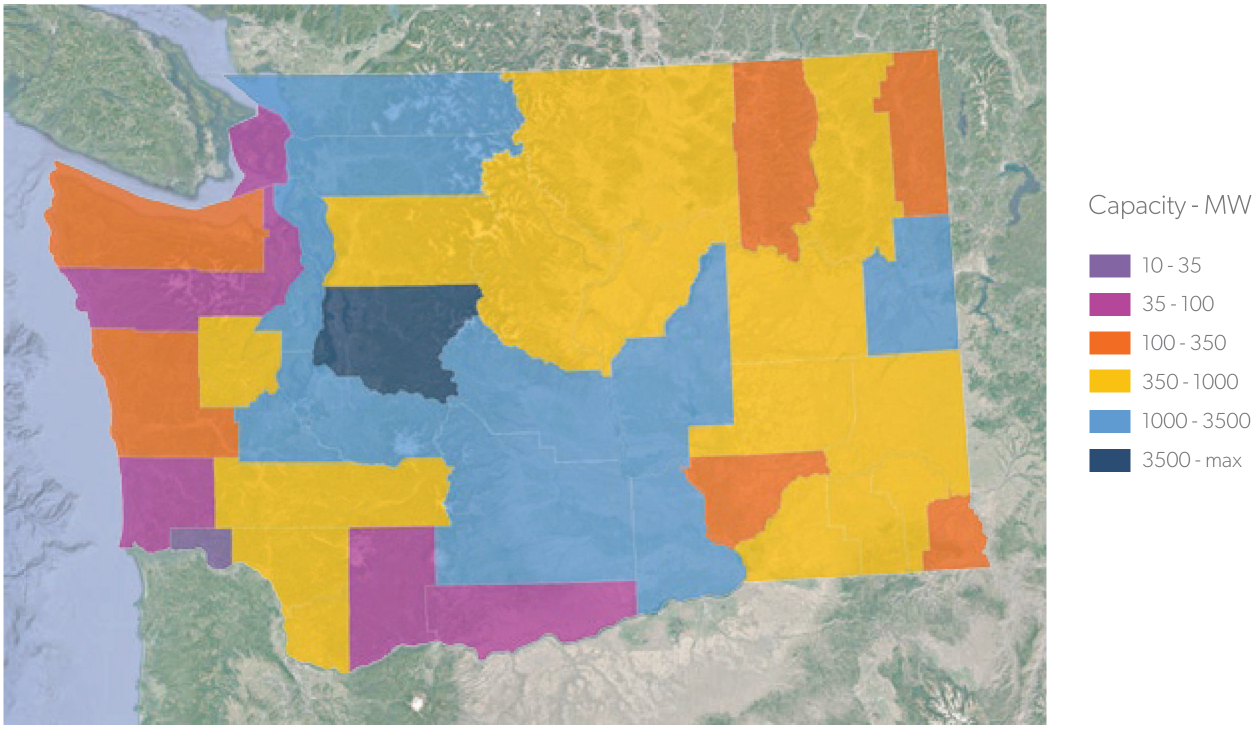


Figure 116. MW of new renewable energy (wind and solar) generating capacity by county in the Electrification scenario. Includes rooftop solar.

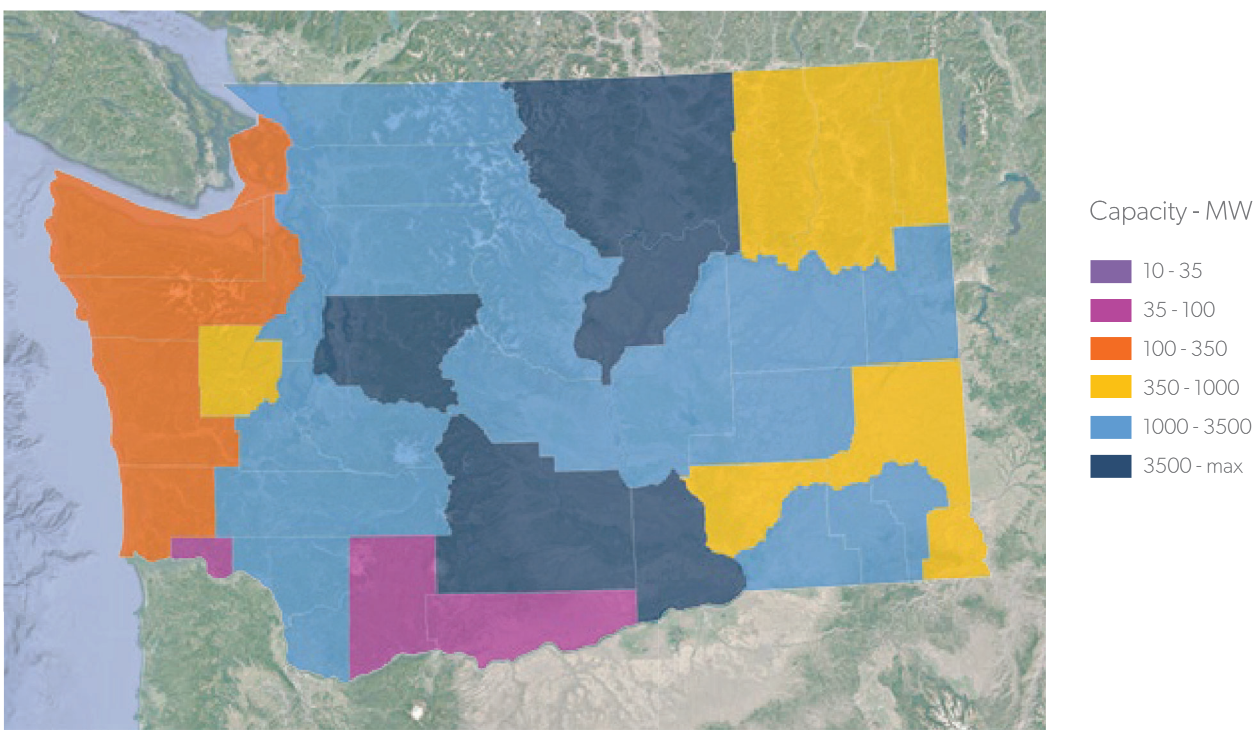


Figure 117. MW of new renewable energy (wind and solar) generating capacity by county in the Alternative Fuels scenario. Includes rooftop solar.

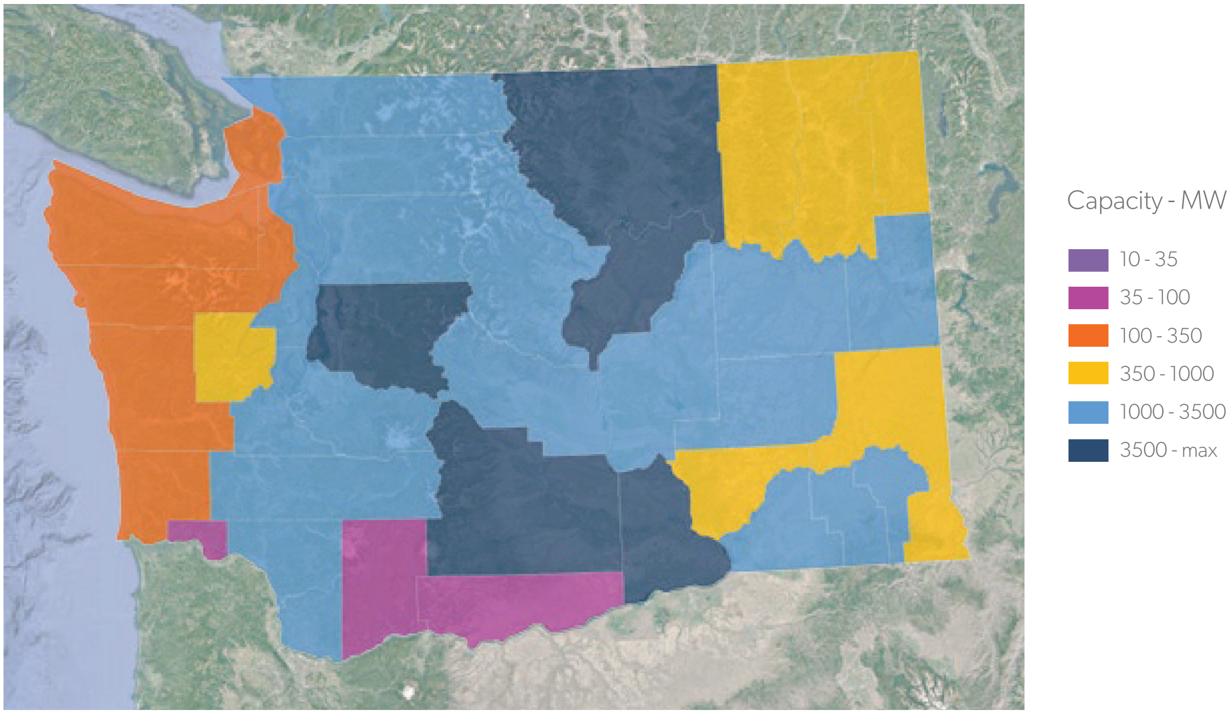


Figure 118. MW of new renewable energy (wind and solar) generating capacity by county in the Hybrid scenario. Includes rooftop solar.

Insights:

- The Calliope model selects the location by balancing authority (BA) of the new installed capacity by taking into consideration the renewable energy potential of each BA based on NREL solar and wind curves, demand in each BA and the links for exchange between BAs.[329]
- Renewable siting opportunities and challenges will vary by county.

[329] U.S. Department of Energy, National Renewable Energy Laboratory, (2023), Geospatial Data Science portal, https://www.nrel.gov/gis/

8.6.5 Resilience: Reducing Energy Poverty

Actions to reduce building energy use common to all three decarbonization scenarios include implementing thermal retrofits in existing buildings and adopting high efficiency space conditioning and hot water heating systems. These actions directly address the burden current energy bills have on households as described above by decreasing overall energy consumption and therefore energy costs. Common actions across all three scenarios to shift purchases toward electric vehicles will also contribute to lower transportation energy and maintenance costs, further reducing household energy costs.

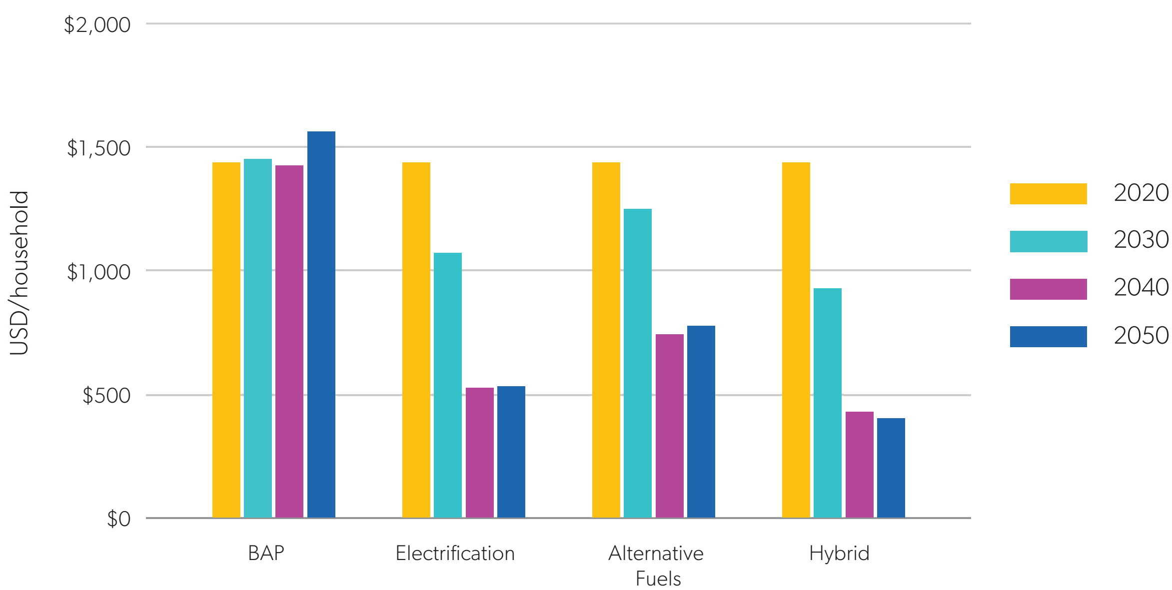


Figure 119. Household energy cost savings for all scenarios.

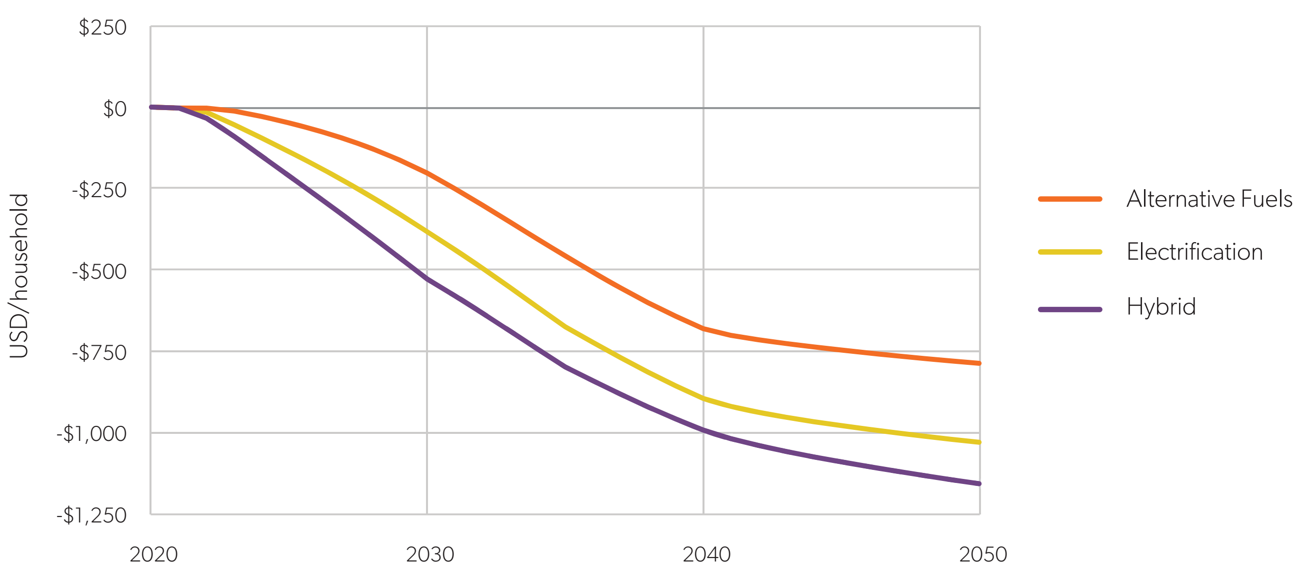


Figure 120. Total annual household energy cost savings relative to the BAP scenario for each of the decarbonization scenarios.

Relative to the BAP scenario, energy cost reductions are higher in the Electrification and Hybrid scenarios compared to the Alternative Fuels scenario, primarily due to the higher reliance in the Alternative Fuels scenario on RNG and hydrogen as fuels, which have high current and future costs (Figure 120). By 2050, energy costs per household are reduced in the Electrification and Hybrid Scenarios by more than $1,000 annually, about a third more than the reductions in energy costs per household in the Alternative Fuels scenario.

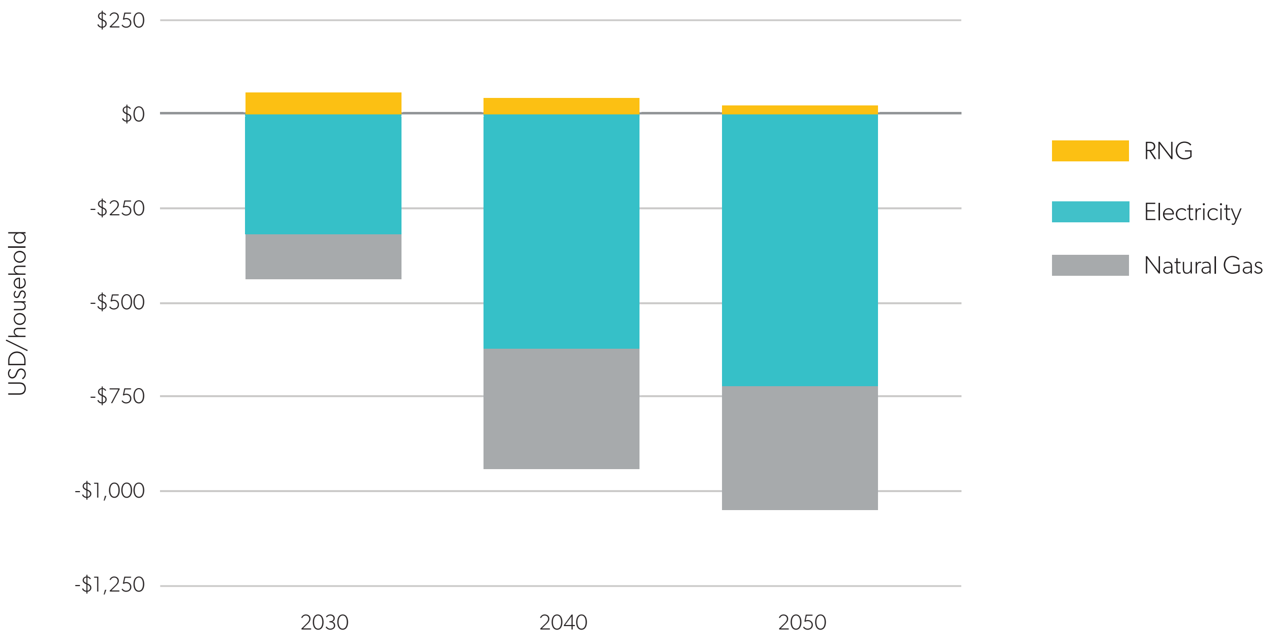


Figure 121. Energy costs per household relative to the BAP for the Electrification scenario.

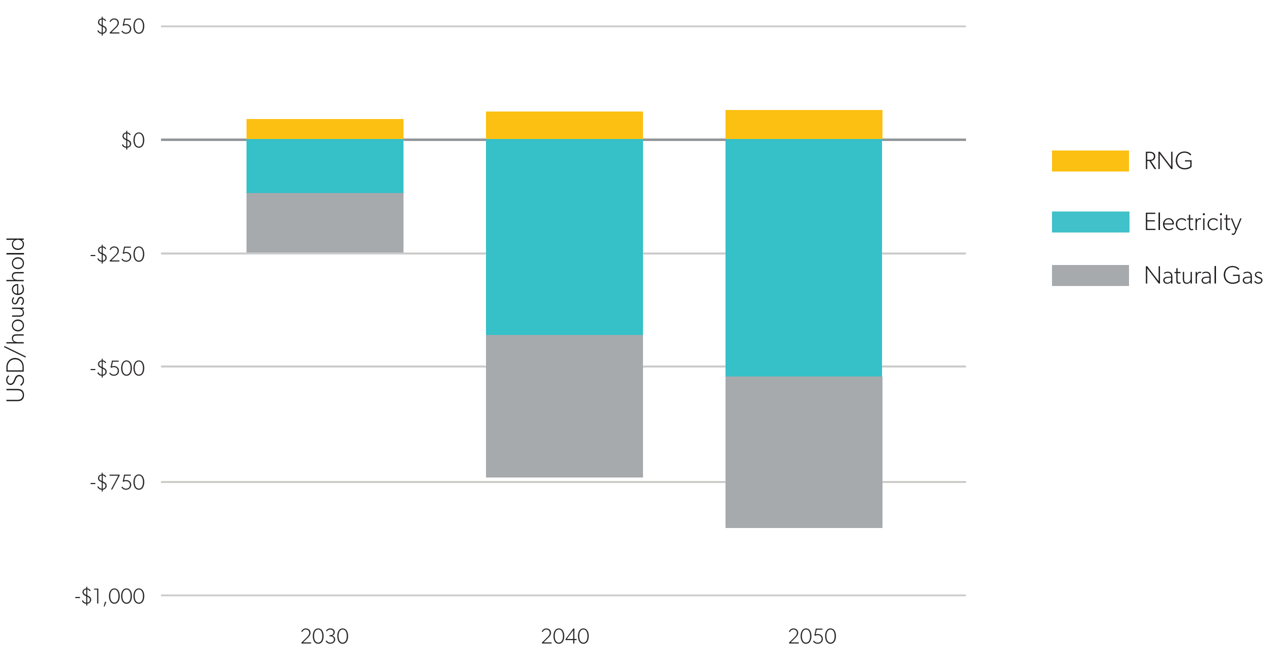


Figure 122. Energy costs per household relative to the BAP for the Alternative Fuels scenario.

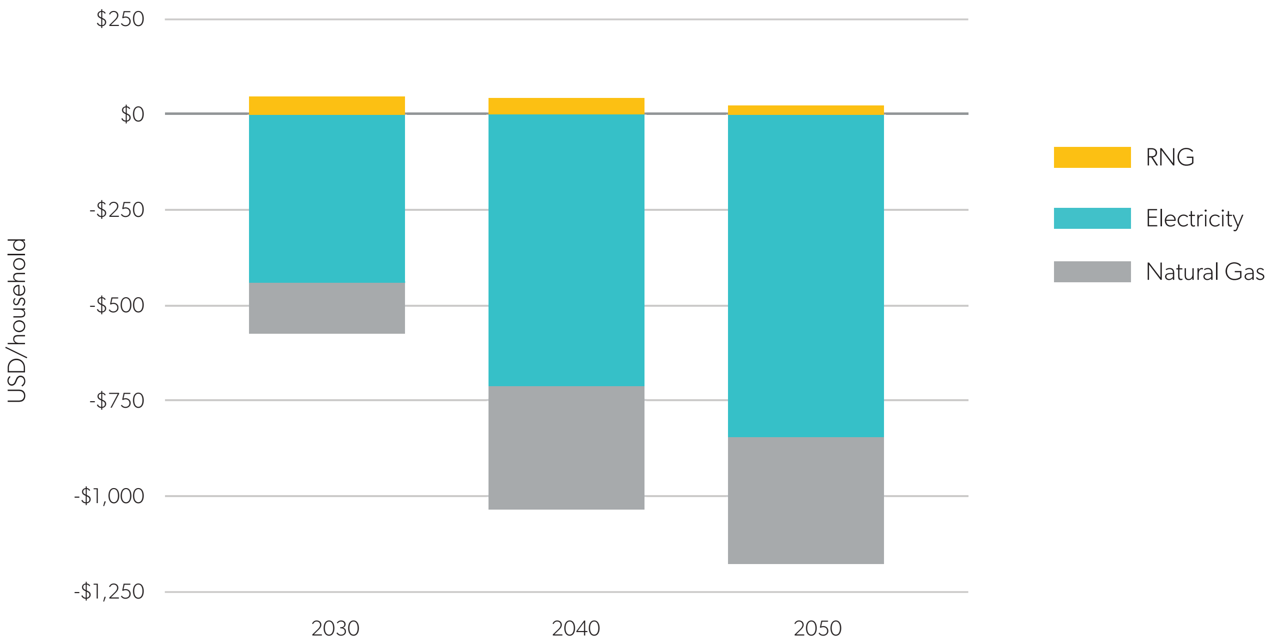


Figure 123. Energy costs per household relative to the BAP for the Hybrid scenario.

As a result of projected household energy cost reductions, rates of energy poverty are also reduced across all three decarbonization scenarios. The Electrification and Hybrid Scenarios reduce the portion of energy burdened households to just over 2.5% by the late 2030s, whereas in the Alternative Fuels scenario approximately 5% of households remain energy cost burdened by 2050. The Hybrid Scenario results in the deepest reductions in energy burden across all counties in the state by 2050.

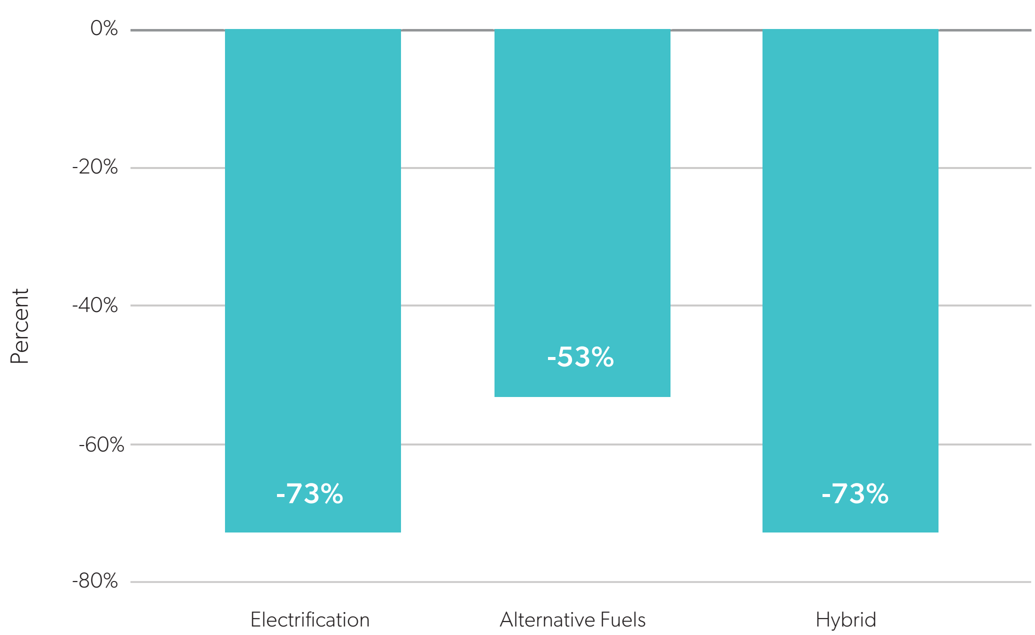


Figure 124. Change in share of households considered energy burdened from 2020 to 2050, relative to the BAP

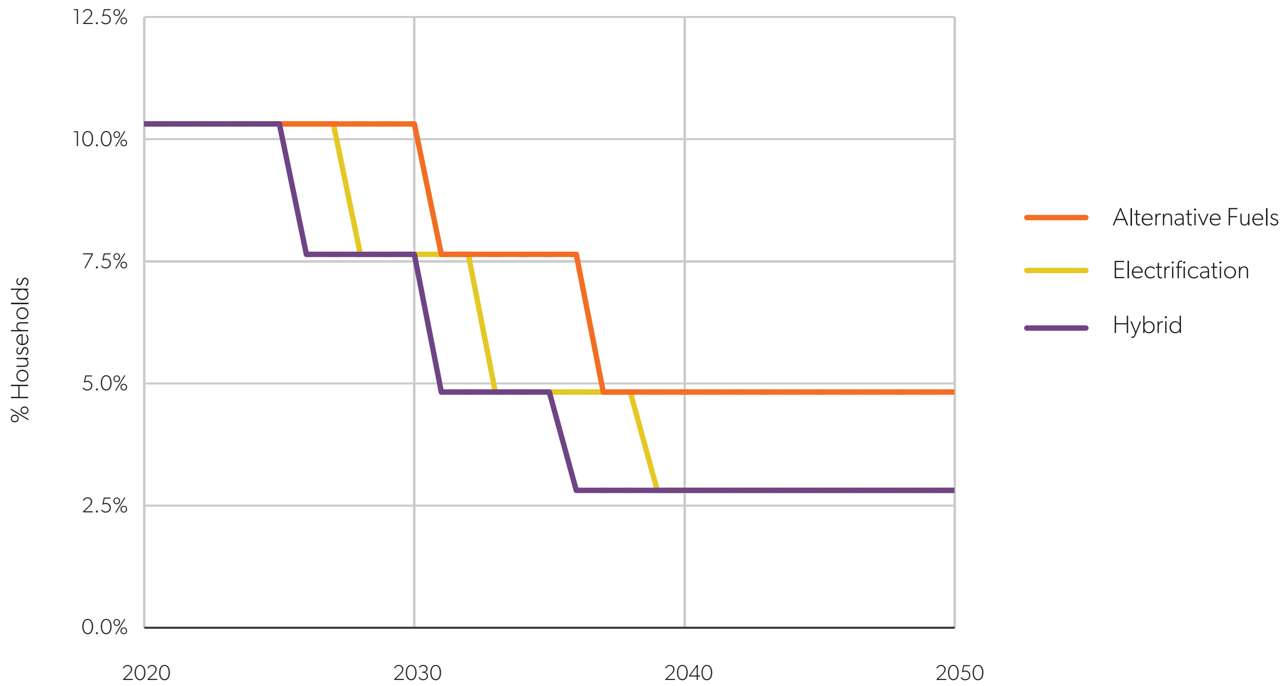


Figure 125. Energy burden by scenario for the three decarbonization scenarios.

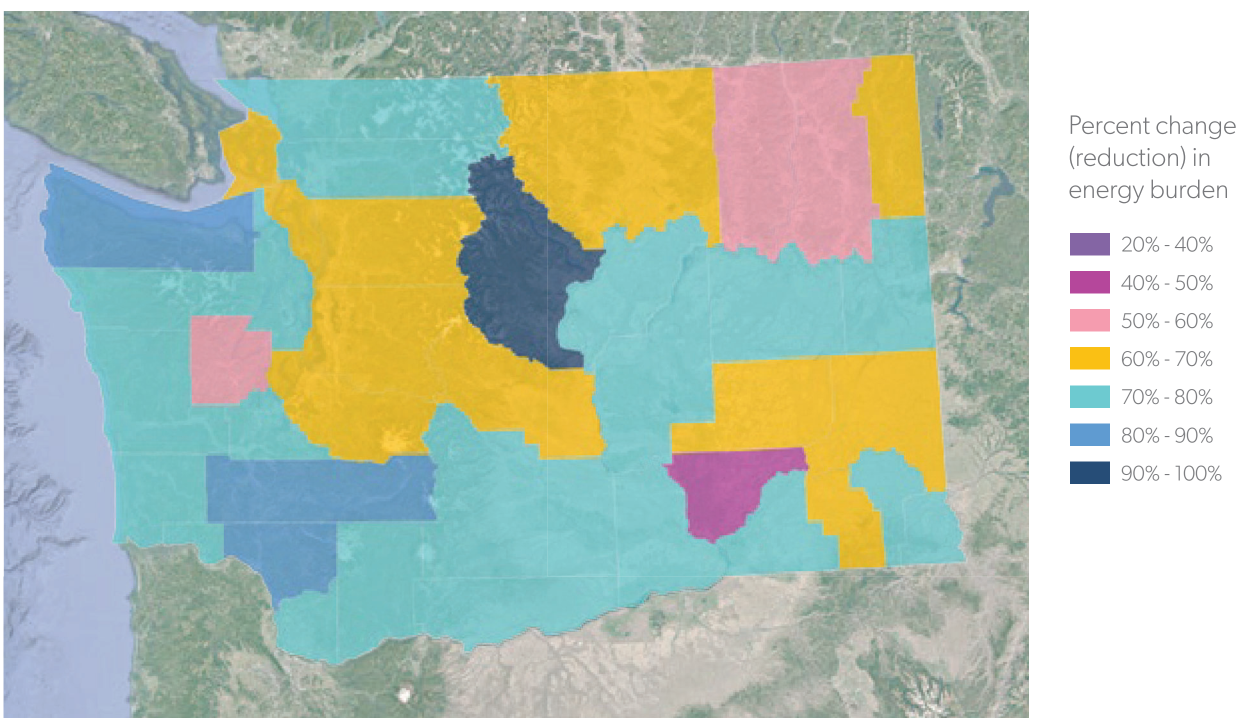


Figure 126. Percent change (reduction) in energy burden by county between 2020 and 2050, Electrification scenario.

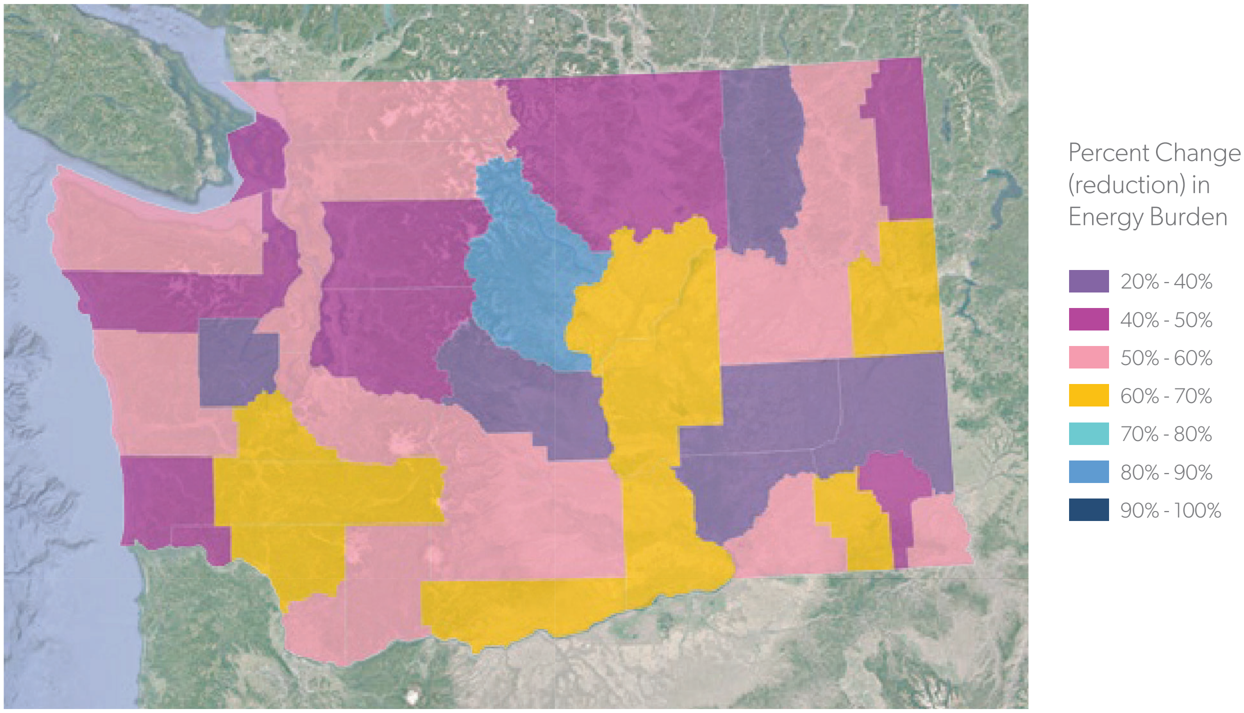


Figure 127. Percent change (reduction) in energy burden by county between 2020 and 2050, Alternative Fuels scenario.

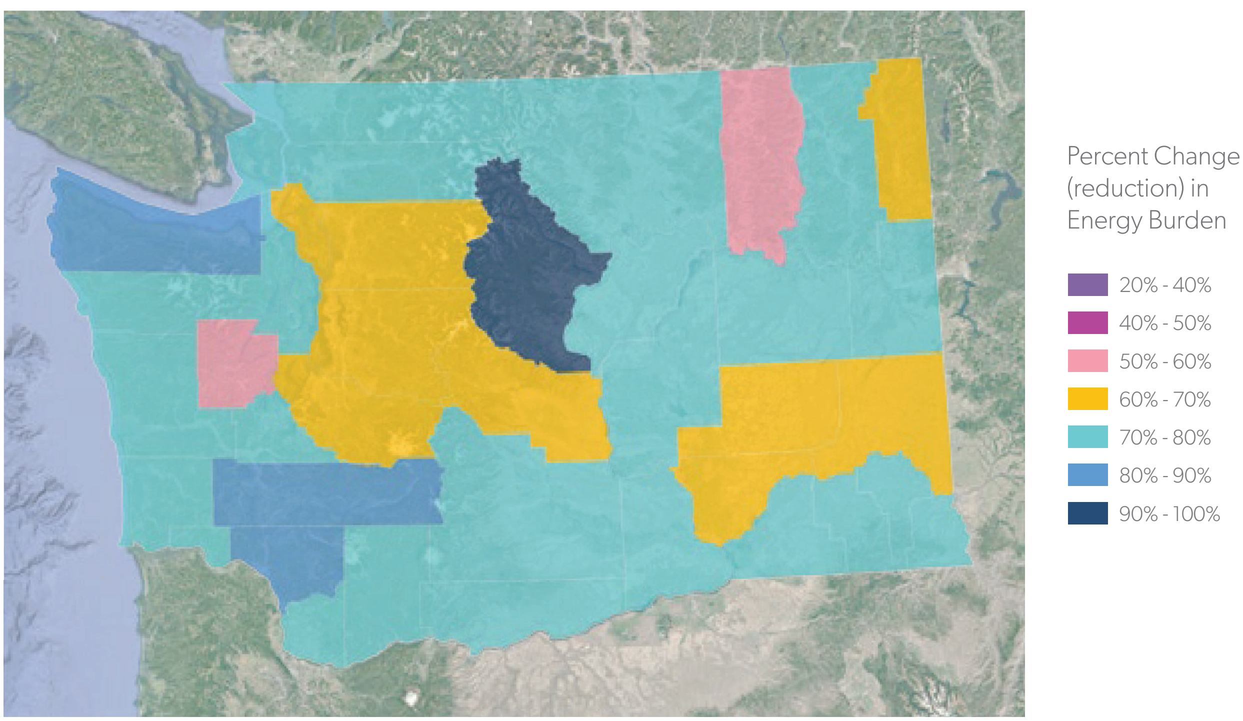


Figure 128. Percent change (reduction) in energy burden by county between 2020 and 2050, Hybrid scenario.

Insights:

- One of the main co-benefits of reducing energy consumption for businesses and residents is the decrease in energy bills.
- The inclusion of rooftop solar and the varied energy mix in the Hybrid scenario translates into a large decrease in energy burden throughout almost all counties, especially compared to the Alternative Fuels scenario.
- Electricity costs are projected to increase the most in the Alternative Fuels scenario as all of the investment goes into utility scale renewable electricity development as opposed to including rooftop solar into the mix.
- A conservative projection around natural gas and renewable natural gas prices was taken.
  - It was assumed that there was no significant decommissioning of existing natural gas infrastructure to respond to decreasing gas consumption. Decommissioning actions would help reduce these costs.
  - Natural Gas residential and commercial customers are affected most in this scenario. Action could also be taken to shift the costs to industrial consumers who would be using a majority of the natural gas and renewable natural gas supply by 2050 under any decarbonization pathway explored in this study.[330]

8.6.6 Resilience: Intergenerational equity

Climate change represents a burden on future generations and the complexity of the climatic system means that these impacts are difficult to anticipate. The burden of action increases the longer action is delayed.

The social cost of carbon (SCC) has been used in regulatory processes to reflect the impacts of climate change on society. The Legislature has required the use of the social cost of carbon in reflecting costs under CETA and for purposes of establishing conservation targets for natural gas utilities.[331,332] The SCC attempts to add up the quantifiable costs and benefits of a metric ton of carbon dioxide. While the estimates of SCC are uncertain, it is one of the best ways to reflect future damages and guide decision-making that accounts for those implications.

The SCC includes assumptions around future conditions including population size, economic growth, rate of climate change and the impact of climate change on those conditions, drawing on the results of integrated assessment models. The discount rate is a significant assumption within the models. Discounting reflects the idea that people would rather have $100 now than $100 in ten years. From an ethical perspective, a higher discount rate indicates that future generations are worth less than current generations; for this reason the Stern Review recommended a discount rate of 1.4%, well below traditional discount rates.[333] As Stern pointed

[330] For more detailed information on future energy use by sector and fuel type, see the dashboard at https://cis-community.ssg.coop/washington/disclaimer

[331] "RCW 80.28.395: Natural Gas—Cost of Greenhouse Gas Emissions—Calculation.," accessed November 13, 2023, https://app.leg.wa.gov/RCW/default.aspx?cite=80.28.395.

[332] "WAC 480-100-660: Incremental Cost of Compliance.," accessed November 13, 2023, https://app.leg.wa.gov/WAC/default.aspx?cite=480-100-660.

[333] Stern, N. (2006). The Stern review on the economic effects of climate change. Cambridge University Press.

out in a subsequent article "A 2% pure-time discount rate means that the life of someone born 35 years from now (with given consumption patterns) is deemed half as valuable as that of someone born now (with the same patterns)".[334]

The analysis presents the results of the SCC both for remaining emissions and avoided emissions associated with the scenarios analyzed. The SCC also includes estimated damages associated with lower probability and high-cost damages using a 3% discounting rate.[335] This cost reflects less likely impacts of increased temperatures that result in greater damage, as described within the 95th percentile of the SCC frequency distribution.

The results of the SCC both for avoided emissions associated with the Electrification, Alternative Fuels, and Hybrid scenarios are illustrated in Figure 129. The cumulative avoided SCC resulting from the scenarios is approximately $22 billion, with a 3% discounting rate.

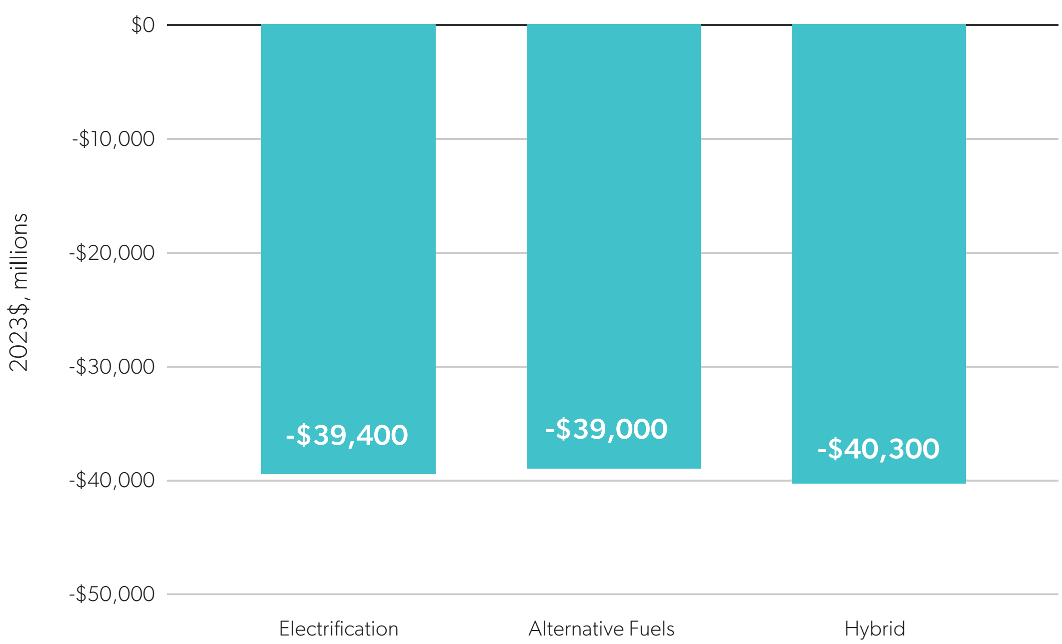


Figure 129. Cumulative avoided damage as a result of climate change globally (2023-2050)

334 Stern, N. (2015). Economic development, climate and values: making policy. Proc. R. Soc. B, 282(1812), 20150820. https://doi.org/10.1098/rspb.2015.0820

335 U.S. Government (2021). Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide. Retrieved from: https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMet **haneNitrousOxide.pdf**

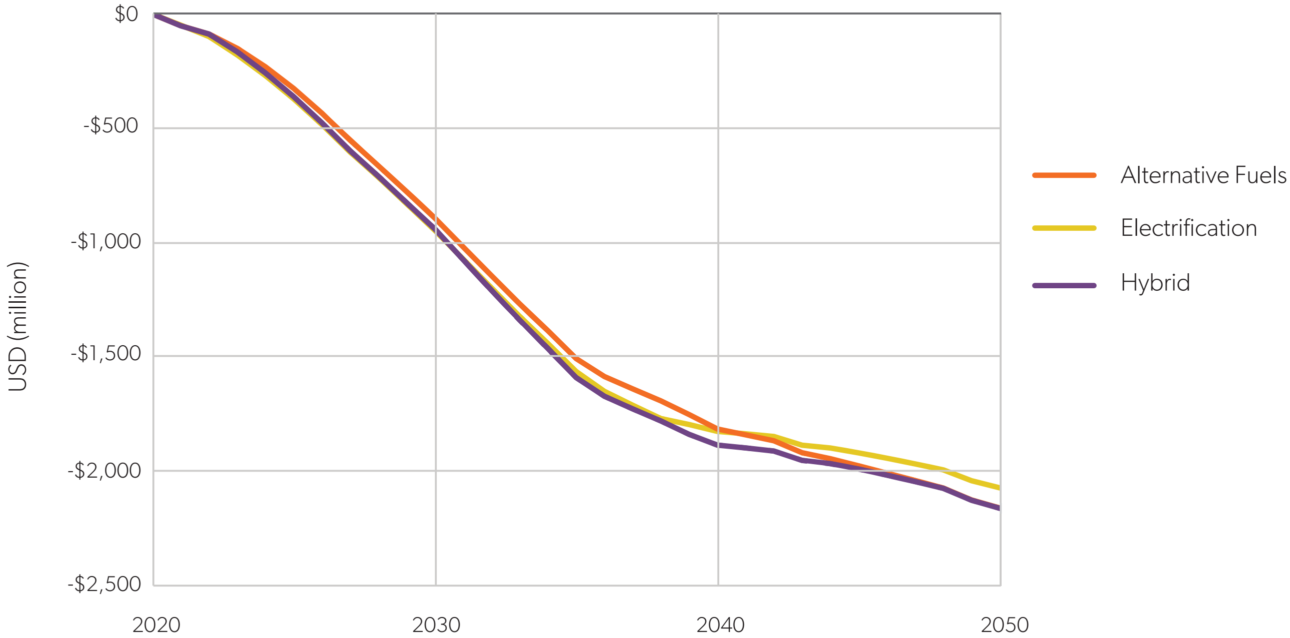


Figure 130. Value of avoided damage, social cost of carbon, in $2023 at a 3% discounting rate.

9

Conclusion

9 | Conclusion

9.1 Project Context

The Energy Decarbonization Pathways Study identifies and examines pathways for investor-owned electric and natural gas utilities to contribute to Washington's GHG emission reduction goals. A pathway is defined as a suite of interrelated actions implemented over time that result in emissions reductions and related goals. While this study does not recommend a particular pathway, it describes the impacts of the pathways on GHG emissions, energy use, energy infrastructure needs, employment opportunities, health impacts, energy poverty, resilience, and intergenerational equity, etc.

9.2 Public Engagement Process

An engagement process enabled interested and affected parties to assist in the development of the pathways, ensuring their relevance. Interested and affected parties included utilities, government agencies, business and economic organizations, construction and real estate representatives, and civil society organizations. Appendix B includes a detailed summary of the engagement activities and their results.

9.3 A Rapidly Evolving Energy System

Washington's energy system is complex, and changing rapidly. It consists of two increasingly interrelated systems, the electricity system and the natural gas distribution system, each of which is required to decarbonize over the next few decades to comply with state laws, especially CETA and CCA. Demographic and economic shifts, as well as trends toward electrification of the buildings and transportation sectors, are expected to increase electricity demand relative to today, further compounding the decarbonization challenge.

To meet decarbonization targets, electricity utilities are expected to take advantage of newly passed laws and policies at the state and federal level that support the development of renewable electricity generation. Gas utilities are similarly exploring alternative fuels such as biomethane (renewable natural gas) and hydrogen, the production of which is also being enabled by state and federal laws and incentives. Other resources such as nuclear power, biomass, and carbon capture may play a role in achieving energy system decarbonization as well. With the infrastructure for both components of the energy system co-located along major transportation corridors, near population centers, and in resource-rich areas, system transformations need to be carefully planned and implemented.

Ongoing and emerging trends in where people live, what they do for work, how they get around, and how much renewable and alternative energy is available to them, will all affect the decarbonization of Washington's energy system. Taken as a whole, these trends indicate that Washington's overall energy demand is likely to decrease over the next 30 years in most sectors, and actions are being taken in each of these sectors to decarbonize the sources of energy that are currently used and will be used to meet that demand.

9.4 Global Approaches to Gas Utility Decarbonization

Alongside Washington, many other states and countries have adopted decarbonization targets aiming to rapidly reduce emissions across the economy by 2050. Governments are enforcing their targets and mandates through a variety of policies and actions, many of which are transforming the operations and business models of gas utilities. Investor-owned gas utilities are faced with the following interconnected issues during the transition to a low-carbon energy system:

- Product mix (procuring and distributing low- and zero-emission fuels);
- Cost recovery and rates (maintaining fair and just customer rates as well as economic competitiveness);
- Utility regulations (policies supporting the energy transition for gas utilities); and
- Safety and reliability (ensuring reliable and safe service for customers).

Public utility commissions and state governments in various geographies in the U.S. are considering policies to decarbonize gas end uses, such as space heating and water heating. Some gas utilities have begun to develop plans to address current and anticipated decarbonization requirements. In other countries such as Denmark where decarbonization efforts have a longer history, gas utilities and governments are collaborating on policy changes, shifts in business models, and infrastructure development to support new and different roles for the utilities into the future. Both theoretical and actual practices for gas utility decarbonization may be applicable to Washington.

9.5 Three Decarbonisation Pathways

Three decarbonization scenarios were developed to identify strategies to examine how Washington's gas utilities might decarbonize, The scenarios were designed to explore divergent decarbonization transition pathways. They are not intended to be forecasts, but are assessments of how the current system might evolve.

Two reference scenarios are used in the analysis: a Business-as-Usual (BAU) and the Business-as-Planned (BAP) scenario. The BAU scenario estimates energy use and emissions from the base year (2019) to the target year (2050), assuming that nothing changes beyond population increases and economic growth. This scenario provides a reference against which to assess the impacts of currently planned rules, bills, and legislation.

The Business-As-Planned (BAP) scenario estimates energy use and emissions from the base year (2019) to the target year (2050), incorporating assumptions about the likely effects of planned policies and programs. Actions included in the BAP scenario must be in rule, funded, legislatively required, or follow well-established market trends. The BAP scenario incorporates legislation passed in recent legislative sessions in 2019, 2021, and 2022. Collectively, these policies drive significant reductions in GHG emissions (Figure 131), but fall short of the state's overall 2050 target.

The Clean Energy Transformation Act and the Climate Commitment Act result in the largest GHG reductions. These two policies require decarbonization of the electricity and natural gas systems. The policies are agnostic to technologies or measures, leaving the pathway required as an open question that is explored in this analysis.

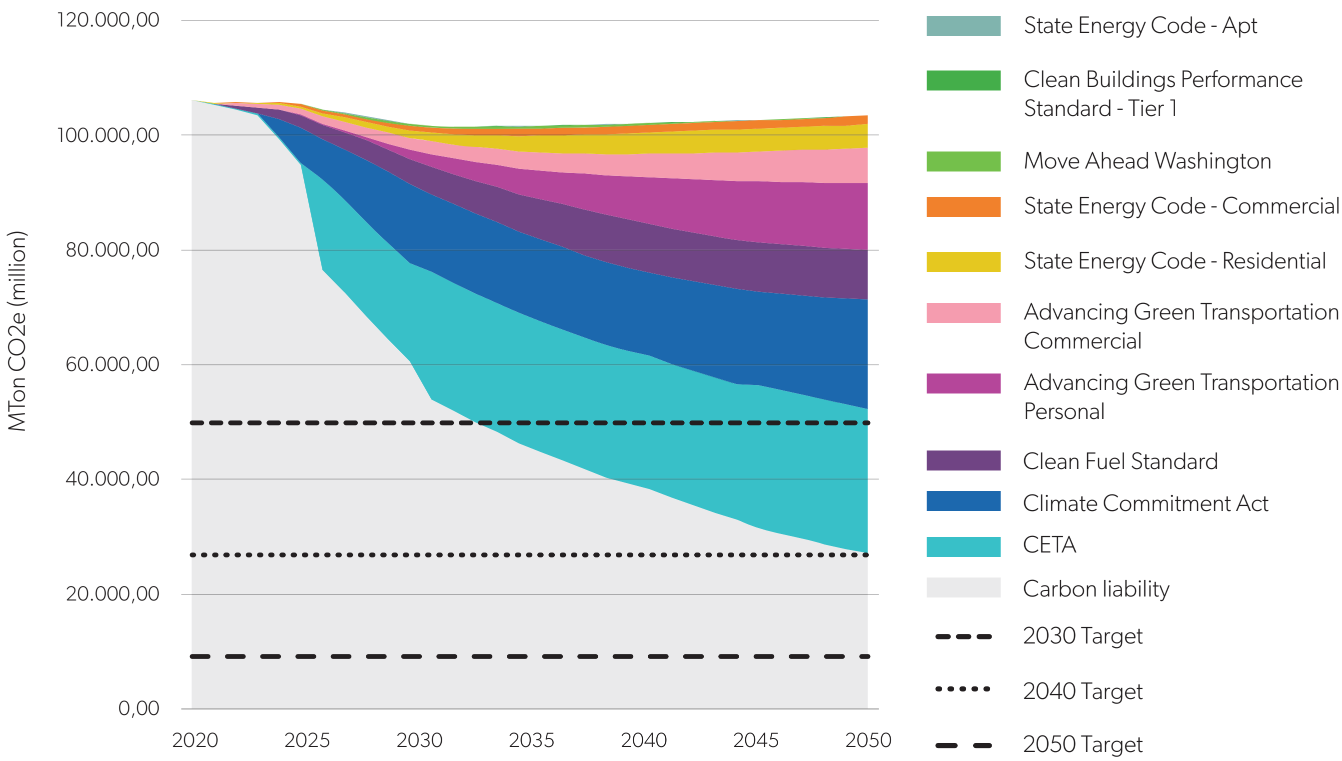


Figure 131. Emission reductions by policy from 2020-2050. CETA and the CCA provide the largest emission reductions, followed by policies in the transportation and building sectors.

The pathway to a GHG emissions reduction target can vary (Figure 132). Different pathways result in more (right figure) or fewer (left figure) emissions being released overall between now and 2050. It is cumulative GHG emissions that drive warming, not targets tied to a particular year in the future. Consequently, from the perspectieve of climate change, the decarbonization pathway matters, in addition to the interim and final targets.

Figure 132. Emissions reductions scenarios are associated with the timing of actions and setting interim targets.

The pathways evaluated in this study are guided by a hierarchy of Reduce-Improve-Switch, which prioritizes avoiding energy use, followed by increasing energy efficiency (Improve). Avoiding and reducing energy use not only directly reduces emissions, but also reduces the quantity of infrastructure and equipment needed to decarbonize.

The recently completed Washington State Energy Strategy provided direction for the design of three pathways, in concert with the engagement process described above.

1. **Electrification:** Use electricity to power the vast majority of activities and processes.
2. **Alternative Fuels:** Use fuels such as renewable natural gas and hydrogen to power the majority of activities and processes.
3. **Hybrid:** Use electricity for some activities and alternative fuels for others.

Each of the three pathways evolves differently in the model, resulting in different annual and hourly demand profiles for electricity and for fuels such as renewable natural gas.

Energy consumption declines in all three decarbonization scenarios relative to the Business-As-Usual scenario by 2050. Actions in all three pathways achieve Washington's emission reduction targets for the years 2030 and 2040, while none of them achieve the 2050 target. To meet the 2050 target, additional actions to decarbonize the sources of the remaining emissions - industrial processes and aviation - would be required.

Additional generating capacity is needed in all three scenarios, in addition to existing hydro, solar, nuclear, natural gas power plants, and wind capacity within Washington state. The development of additional capacity requires reforming how transmission capacity and resource adequacy is understood, analyzed, and planned for. Transparent and coordinated planning will be required for electricity distribution infrastructure which can address increased demand from electrification of buildings and vehicles, and possibly other end uses depending on the pathway pursued. Demand response is an additional strategy which can temporarily reduce or shift demand for electricity during times of peak demand, further reducing the amount of generating resources such as wind and solar farms that will need to be developed.

Energy efficiency measures including building retrofits, mode shifting, vehicle electrification, and the use of heat pumps reduce the requirement for additional capacity. Efficiency gains result in reduced expenditures on fuel and energy.

Health expenditures are reduced in each pathway due to improved air quality, reduced noise pollution, improved occupant comfort in buildings, and increased physical activity. The cumulative effects of actions across all major energy sectors would result in total health benefits between $1.8 billion and $2.1 billion annually by 2050. This indicator incorporates avoided costs and incidences due to reduced air pollution of estimated mortalities for adults and infants, nonfatal heart attacks, hospital admissions for respiratory issues, restricted activity days, work loss days, and asthma attacks.

In each pathway, hundreds of thousands of new employment opportunities are generated in the building and construction industry, renewable energy generation and solar panel installation, and industrial efficiency, even as existing opportunities are lost. New jobs are likely to be created across the state, with higher concentrations of potential increases compared to the BAP scenario in Western Washington along Puget Sound.

9.6 Potential Regulatory Policy Changes

Washington's energy system is at a crossroads. The state's utilities and energy providers have clear objectives and statutory obligations to reduce emissions by 2050. There are different pathways to achieve the decarbonization requirements, all of which require full implementation of existing policies and programs such as CETA and the CCA, as well as a set of common strategies to improve energy efficiency across the state.

Pathway independent policies which support gas utility decarbonization and overall efficiency of the energy system:

- Support equity and the just transition
    - Mitigate potential rate increases for low- and moderate-income gas customers who may remain on the gas system before it is fully decarbonized, using state funding or subsidies.
    - Incentivize or support community-owned energy generation resources, particularly in highly impacted communities and rural areas, to ensure equitable distribution of economic and social benefits and overcome siting opposition.
    - Provide expedited permitting and siting for renewables that meet specific equity and development criteria (e.g., jobs, location, and community partnerships). Develop renewable energy zones that reflect these priorities.
    - Develop apprenticeship and training programs to increase equitable access and participation in renewable electricity, retrofits, manufacturing, and other industries related to decarbonization, with focus on disadvantaged and under resourced people and communities
    - Provide financial support to property owners and supporting organizations for building retrofits, rooftop solar installations, and battery systems to improve equitable access to and benefit from these technologies
- Improve building and industrial energy efficiency
    - Require, incentivize, and/or support residential and commercial building retrofits that result in significant operational energy savings.
    - Continue to update and extend the applicability of the state's Building Performance Standards.
    - Implement the recommendations for industry in the State Energy Strategy, including developing energy efficiency benchmarking standards for different subsectors, and coordinating with other states to create uniform decarbonization policies and standards to minimize the risk of Energy Intensive Trade Exposed entities relocating out of state.
    - Continue development and implementation of policies within and related to the Growth Management Act to reduce sprawl and increase local access to housing, amenities, and transportation.

- Improve transportation energy efficiency
  - Implement and expand the impact of the transit and active transportation investments as adopted in Move Ahead Washington, including accelerated electrification of public transit and ferries
  - Accelerate the deployment of additional incentives for electric and alternative fuel vehicles and supportive infrastructure for personal and commercial use, including e-bikes and heavy duty vehicles
  - Encourage the development of centralized delivery hubs and similar mechanisms in urban areas to reduce freight miles traveled
- Mitigate potential rate increases and costs for residential and commercial customers
  - Enable, support, or require managed decommissioning of the existing gas distribution network, for example by allowing or requiring utilities to use accelerated depreciation or to develop networked geothermal infrastructure.
  - Allow utilities to sell "energy as a service" i.e., finance retrofits and heat pump installations paid for through on-bill financing or leasing.
  - Allow gas utilities to charge an exit fee or allow electric utilities to charge a cost-of-decarbonization fee to address rate shortfalls.
  - Incentivize resources capable of improving resource adequacy (long-duration storage, hydro, hydrogen, geothermal, biomass, load flexibility).
  - Enable or require changes to cost allocation across customer bases (shift system costs between customer classes).
- Reduce peak electricity demand and improve reliability
  - Align the timing of building retrofits with rooftop solar and battery installations to maximize energy efficiency benefits and increase electricity supply and independence during times of peak electricity demand
  - Maximize the potential of building, energy, and zoning codes to support renewable energy siting and rooftop solar development in a way consistent with equity goals and other priorities
  - Incentivize or support demand response technologies and grid-integrated devices in both new and existing buildings.
  - Support research and deployment of battery technologies that meet the needs of residential, commercial, and industrial energy users
  - Develop policies and incentives for resources and technologies that address reliability challenges, such as load shedding and interruptible service agreements in industry
  - Provide increased funding for research and coordination on resource adequacy and interregional coordination.
  - Support efforts to create system resilience and balance in regional resource adequacy programs and day ahead electricity markets.

- Improve utility planning and coordination and address transmission and distribution needs and issues
    - Support or explore ongoing improved coordination and planning by utilities, including those with overlapping service territories, and with entities outside the state, such as through day ahead markets or a Regional Transmission Organization.
    - Support training and outreach materials for state policymakers to develop deeper understanding of resource adequacy and reliability concerns
    - Provide funding and develop programs for weather and climate data, particularly for use in resource adequacy analysis.
    - Collect detailed information from utilities about the costs of distribution infrastructure upgrades and use this to inform future decarbonization policy and program design.
    - Implement the recommendations of the Transmission Corridors Working Group report, including reforming transmission contracting and planning to promote capacity expansion, and funding transmission upgrades that are broadly beneficial and spread the cost among a wide set of energy providers and users

9.7 Conclusion

The purpose of the Energy Decarbonization Pathways Study provides new insights on the changes in the energy system required to decarbonise Washington's energy systems and the costs and benefits of those changes. The study concludes that the existing policies must be fully implemented and enhanced to achieve the State's GHG targets, and that the pathways to decarbonize are feasible based on current trends and technologies. Additionally, the implementation of these policies provides co-benefits for health and economic development across the state, which further enhances the public benefit of the policies.

10 | Appendices

Appendix A | Data, Methods, and Assumptions (DMA) Manual

External document

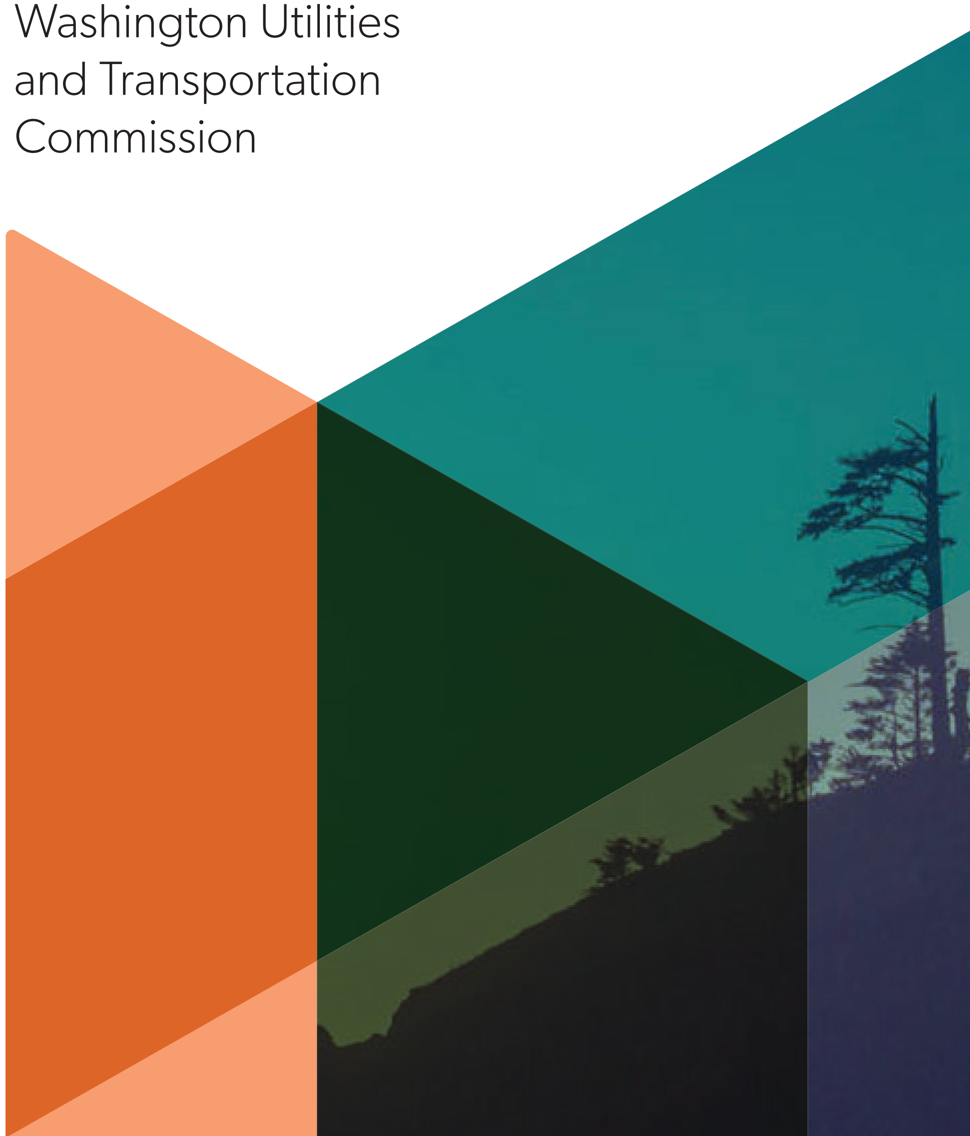
Appendix B | What We Heard Report

External document

Family at Olympic National Park, Washington. @Aleksei Potov. Stock.adobe.com

Energy Decarbonization Pathways

Washington Utilities and Transportation Commission



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