# 2018 BIENNIAL ENERGY REPORT

Submitted to the

## OREGON LEGISLATURE

by the

## OREGON DEPARTMENT OF ENERGY

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OREGON DEPARTMENT OF ENERGY

# Executive Summary

In 2017, the Oregon Department of Energy, recognizing that the energy world has changed dramatically since the 1970s, introduced HB 2343. The bill charged the department with developing a new Biennial Energy Report to inform local, state, regional, and federal energy policy development and energy planning and investments. This report – based on analysis of data and information collected and compiled by the Oregon Department of Energy – provides a comprehensive review of energy resources, policies, trends, and forecasts, and what they mean for Oregon.

## What You Can Expect to See in the 2018 Biennial Energy Report

The inaugural Biennial Energy Report provides foundational energy data about Oregon. It also examines the existing policy landscape and identifies a number of options for continued progress toward meeting the state's goals in the areas of climate change, renewable energy, transportation, energy resilience, energy efficiency, and consumer protection.

As each chapter of the report discusses, Oregon is on a path toward transitioning to a cleaner, low carbon future. Looking at what this means for Oregon is a main theme throughout the report. Data and examples included in the report illustrate the effects from the state's early and sustained investments in energy efficiency, renewable energy resources, and conservation. These efforts have positioned Oregon to successfully tackle today's energy challenges, which are driven by growing demand from consumers for cleaner energy, forecasted population growth, and emerging technologies.

The report begins by looking at **energy by the numbers**—detailed information on Oregon's overall and sector-based energy use, energy production and generation, energy expenditures, and the strategies Oregon has employed to meet growing energy demand. This chapter also provides background information on Oregon's foundational energy policies and regulatory framework.

The **climate change** chapter presents an overview of current literature on strategies to reach deep decarbonization, with consideration of policy design issues such as timing, costs and benefits, equity and environmental justice concerns, and environmental tradeoffs. This section delivers an overview of greenhouse gas emissions mitigation options and opportunities across Oregon's energy sectors.

Oregon's renewable energy capacity has grown over the years. The **renewable energy** chapter looks at how and why this has happened: the policies supporting renewable energy, the growing demand for cleaner electricity, plus the substantial reductions in the costs of renewable energy technologies. The chapter also identifies a number of challenges and opportunities as Oregon integrates more variable renewable electricity onto the grid. It ends with a case study on solar energy.

The fourth chapter, on **transportation**, focuses on fuel use and emissions of fuels used in light-duty vehicles—passenger cars, pickup trucks, and SUVs. This segment of road users represents the bulk of Oregon's transportation-related fuel costs and is the highest emitter of greenhouse gases in the transportation sector. The chapter begins with an overview of national and state trends, looks at policies and strategies at work in the state to meet Oregon's GHG reduction goals, and discusses the adoption of electric vehicles in Oregon.

With the prospect of a major earthquake and tsunami in Oregon, the state is working to prepare and build resilient energy systems. The fifth chapter explores what activities are currently underway to improve the **resilience** of Oregon's energy sector when facing extreme or disruptive events. It also considers what more can be done to prepare, with a particular focus on improving community energy resilience. The chapter also touches on how energy resilience factors into climate change policy discussions.

Energy efficiency has been the cornerstone of Oregon energy policy for decades. The sixth chapter discusses policies that promote **energy efficiency** in Oregon, how efficiency is acquired through programs and incentives, and specifically how Oregon is performing in our energy efficiency activities. While accounting for the success Oregon has had in this field, the chapter also looks forward and discusses actions Oregon can take to achieve further energy efficiency.

The seventh chapter takes on some of the most important energy issues facing Oregonians: **energy burden**, **consumer protection**, and **equity**. This chapter explores the effects on residential consumers, especially those who are most vulnerable, when faced with a rapidly changing energy sector, and uncertainties about what these changes may bring. In the energy world, consumer protection has been around for almost a century, but challenges persist for energy-burdened customers. As energy-related policies and programs evolve, there is increasing interest in securing more equitable outcomes for all Oregonians.

## Energy Report Highlights

- Key Takeaways — each chapter contains key takeaways that capture the essence of the information being provided
- Energy Sector and Use Information — chapter one provides energy sector profiles, including a section for 2016 energy consumption and energy expenditures
- County-Specific Information — chapter one delivers a county-by-county look at how Oregonians heat their homes
- Oregon GHG Emissions Data — includes 2040 GHG targets for Oregon metropolitan areas, passenger vehicle emissions, and other relevant information

The Biennial Energy Report contains several recommendations in the closing pages. The recommendations are a reflection of the work conducted by the Oregon Department of Energy and informed by our many stakeholders, as well as our state and regional partners. The report organizes recommendations around four key themes: gaps in data, addressing equity and energy burden, planning for the future, and assessing the need for state engagement and investment.

The Biennial Energy Report may be found in its entirety at

https://energyinfo.oregon.gov/ber
or
www.oregon.gov/energy/Data-and-Reports/Pages/Reports-to-the-Legislature.aspx

The Department of Energy welcomes your comments and questions. Please contact our agency at askenergy@oregon.gov.

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# LETTER FROM THE DIRECTOR

About a year ago, the Oregon Department of Energy asked what we thought was a fairly simple question: what would you like to see in a new Biennial Energy Report for the state? We figured we'd get some interesting feedback, but we underestimated just how varied and rich those suggestions would be.

Between an online survey, in-person meetings, and informal conversations, we heard from more than 250 people across the state. Oregonians wanted information and research and, above all, answers to all sorts of questions, from relatively straight-forward inquiries about how much renewable energy we have in the state to more complicated questions such as what resource is being used to produce electricity at a given time of day.

We weren't able to follow up on every suggestion we received, but we certainly tried, which is why this first report is not exactly a quick read. The fact is, energy is complex and often complicated, and it's interconnected to so much that matters across our state — from land use and air quality to how we get to work or whether we can afford to pay our bills. It's inextricable from some of the biggest issues facing our state: climate change, emergency preparedness, a strong economy. Once we started pulling one thread, we just kept going.

We also found while putting this report together that it's hard to write about energy in Oregon without feeling proud about our state. When it comes to energy and climate leadership, Oregon punches above our weight. We've developed home-grown renewable energy resources and are moving the state beyond coal-fired electricity. We've invested in energy efficiency that delivers countless returns — from avoiding the need for new power plants to more comfortable and efficient homes. We're leaders on reducing greenhouse gas emissions, supporting adoption of electric vehicles, and encouraging energy innovations and emerging technologies.

And that's just part of the story we're telling in 2018.

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One thing that really stood out as we explored the suggestions we received from stakeholders is that Oregon's energy story today is very much a product of decisions made in years past. And that reminds us that the decisions we make over the next few years will not only inform future energy reports, they will also influence Oregonians' lives for decades — for a generation or more.

So when this report comes around again in two years, we want to be able to tell a new story about energy in Oregon and about the progress we've made on the state's most pressing energy and climate issues. As proud as we are of Oregon's energy accomplishments today, it's incumbent upon us to help shape what our state looks like tomorrow - where we work together to find the appropriate policies, plans, and actions that address the serious challenges ahead, and where we continue to make meaningful steps toward a clean energy future.

We also acknowledge that while this report answers a lot of questions, it probably raises even more. We hope Oregonians will reach out and provide feedback on this report and ideas for the next edition.

For now, Oregon decision-makers need comprehensive data and information to draw on as they weigh options for addressing various energy and climate issues and developing leading-edge policy. Hopefully, the statistics and deep dives into diverse energy topics included in this inaugural Biennial Energy Report support thoughtful and deliberate planning and, ultimately, continued climate and energy leadership across the state.

Janine Benner
Director, Oregon Department of Energy

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# About the Report

In 2017, the Oregon Legislature charged the Oregon Department of Energy with developing a comprehensive energy report to inform local, state, regional, and federal energy policy development and energy planning and investments, and to identify opportunities to further energy policies in our state. Our goal is to summarize and analyze Oregon's current energy resources while exploring energy topics important to people across the state. As we see in the news every day, energy is a fast-moving topic. This inaugural Biennial Energy Report is intended to help Oregonians keep up with trends, impacts, and changes in the energy sector and—more importantly—understand what those changes mean for our state.

# About the Oregon Department of Energy

## *Our mission: leading Oregon to a safe, clean, and sustainable energy future*

At the Oregon Department of Energy, we're dedicated to keeping our state on the leading edge of energy efficiency, renewable energy, and energy resilience. Our focus is on reliable, accessible energy for every Oregonian, and on safe, secure energy systems with diverse resources that can withstand change, including emergencies. As we support efforts to meet our most pressing challenges, including climate change, we're committed to meaningful, effective energy systems and policy that reflect Oregonians' needs and values.

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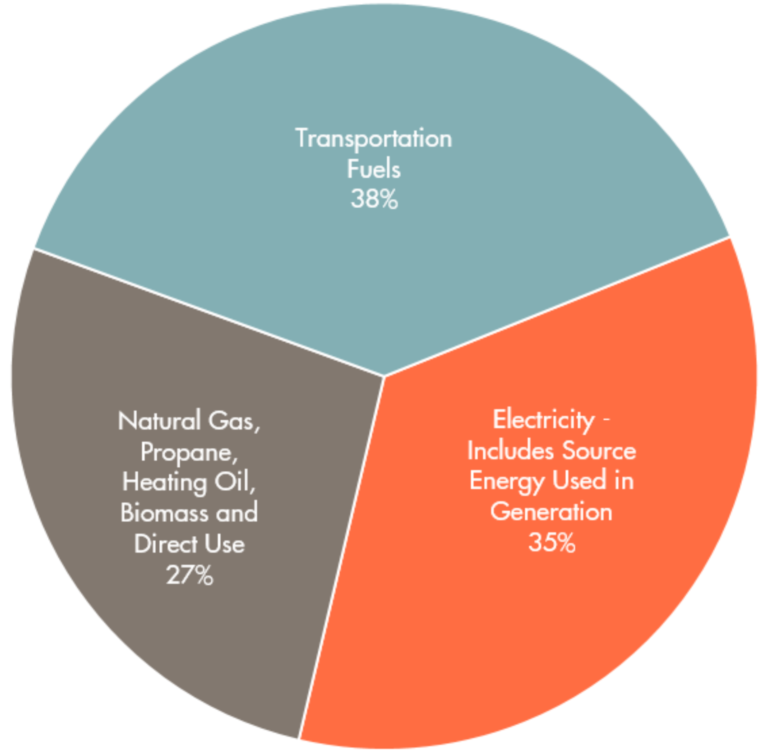
CHAPTER 1: ENERGY BY THE NUMBERS

# Energy Use in Oregon




Oregon relies on energy from a variety of resources. We import energy such as transportation fuels, natural gas, propane, and other fuels. We use electricity from both in– and out-of-state sources—including hydropower, coal, natural gas, nuclear, wind, and other renewable resources.

Energy consumption is often tracked by how it is used among four main end-use sectors: Residential, Commercial, Transportation, and Industrial. In Oregon in 2016, those four sectors combined consumed 977 trillion Btu of energy. Profiles of each sector are included later in the report.

For this introduction to Oregon's energy use, and in the next section on our energy production, the report sorts energy into three main categories:

35%

**of Oregon's 2016 energy consumption**

**Electricity**: this is where most people begin when thinking about energy—the critical resource that powers our day-to-day lives. The electricity Oregonians use comes from facilities across the western United States and in Oregon. This percentage also accounts for source fuels that come from out of state, such as natural gas, but generate electricity in-state.

27%

**of Oregon's 2016 energy consumption**

**Direct Use Fuels**: this category includes fuel oil and natural gas used to heat homes and commercial spaces, fuels used for other residential purposes, such as gas stoves, solar thermal heating, and fuels used directly in industrial processes.

38%

**of Oregon's 2016 energy consumption**

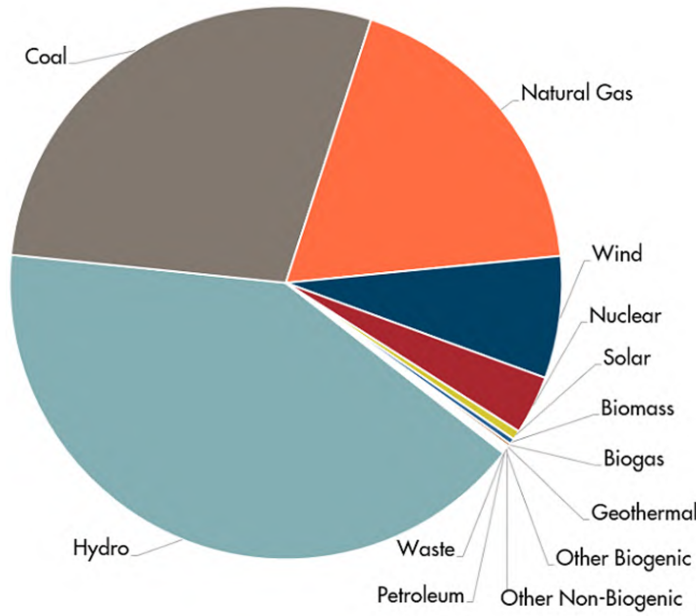
**Transportation Fuels**: this includes personal, passenger, and commercial vehicles, both on and off the roads, plus airplanes, boats, barges, ships, and trains. Nearly all transportation-related sources of energy are imported from out of state for in-state use.

*References: 1, 2*

# Electricity

35%
**of Oregon's 2016 energy consumption**

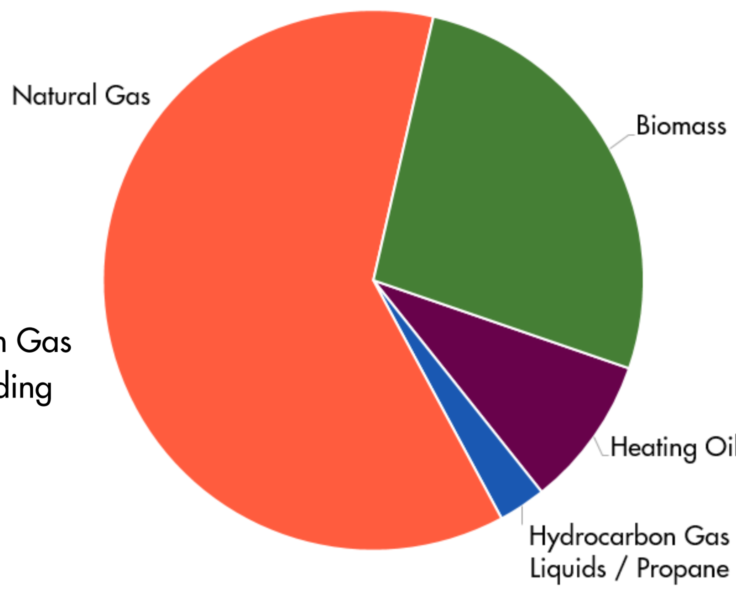
| | |
|---|---|
| 41.1% | Hydropower |
| 28.4% | Coal |
| 18.5% | Natural Gas |
| 7.1% | Wind |
| 3.4% | Nuclear |
| .54% | Solar |
| .33% | Biomass |
| .16% | Biogas |
| .12% | Geothermal |




# Direct Use Fuels

27%
**of Oregon's 2016 energy consumption**

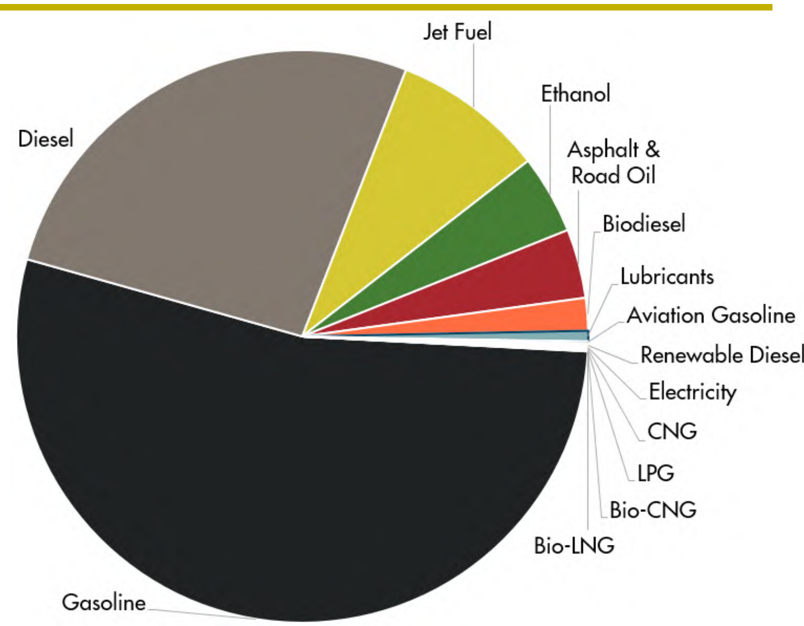
| | |
|---|---|
| 61.4% | Natural Gas |
| 26.7% | Biomass |
| 9% | Heating Oil |
| 2.8% | Hydrocarbon Gas Liquids Including Propane |




# Transportation Fuels

38%
**of Oregon's 2016 energy consumption**

| | |
|---|---|
| 53.5% | Gasoline |
| 26.6% | Diesel |
| 8.6% | Jet Fuel |
| 4.4% | Ethanol |
| 3.9% | Asphalt, Road Oil |
| 1.8% | Biodiesel |
| .60% | Lubricants |
| .15% | Aviation Gas |
| .12% | Renewable Diesel |




References: 1,2

# Energy Use in Oregon

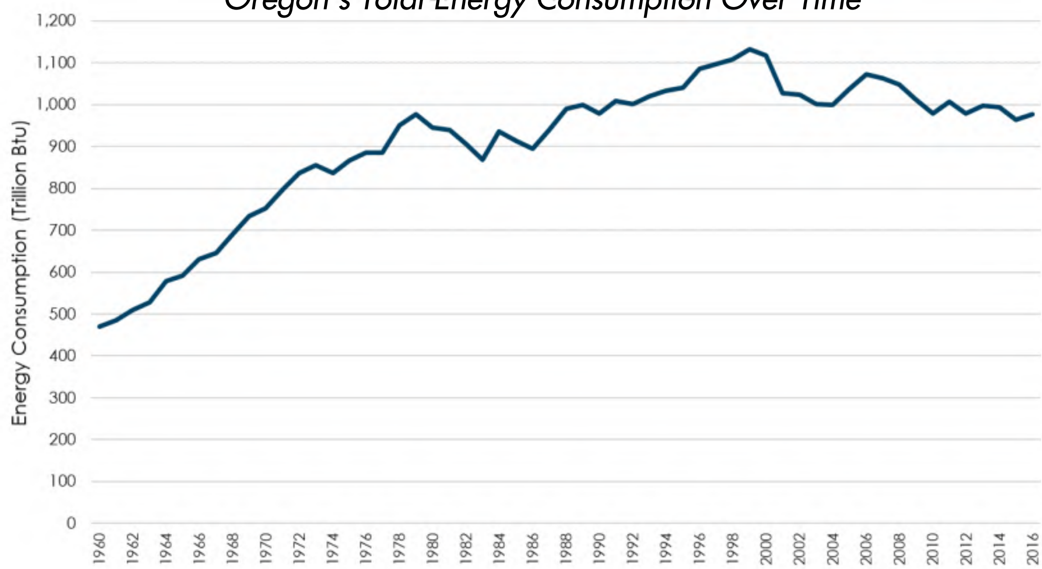
## Oregon's Energy Consumption Over Time

In 2016, Oregon ranked 13th for lowest per capita (per person) energy use

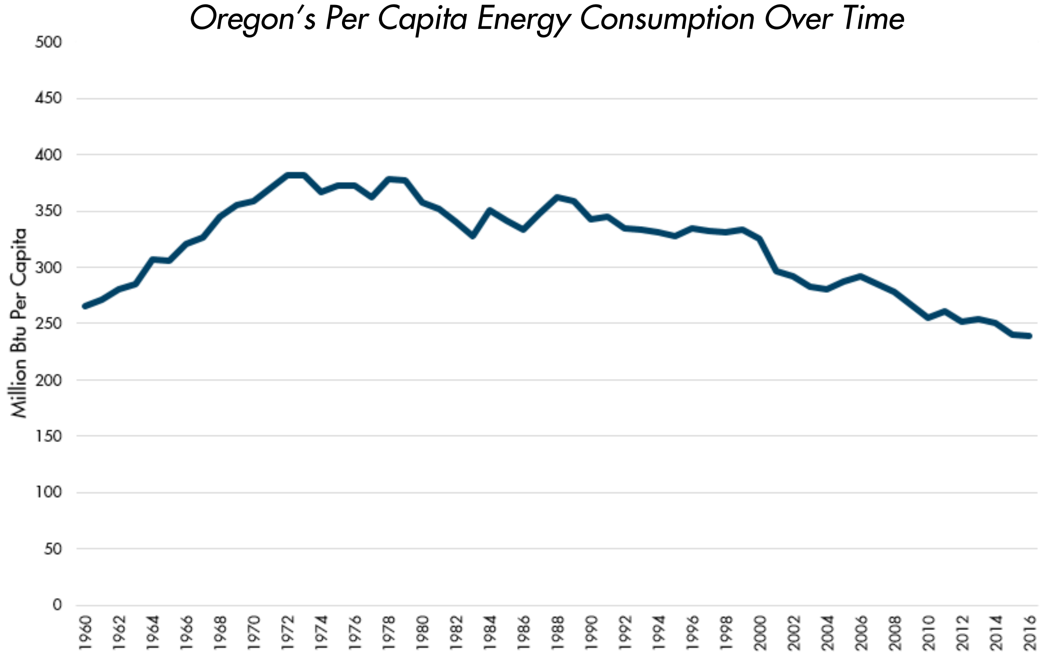
Oregon saw an overall trend of increased energy use for almost four decades—an average of 3.6 percent growth per year from 1960 to 1999. During that time, we shifted from a reliance on fuel oil and wood to increased usage of natural gas and electricity in our homes and businesses. Oregon reached our highest consumption in 1999; since then, energy use has been decreasing. The amount of energy we used in Oregon declined by 12.5 percent between 2000 and 2016.

Factors affecting Oregon's energy consumption over time include energy efficiency; economic recessions, recovery, and growth; and changes to Oregon's industrial sector, such as the closure of energy-intensive aluminum plants.

*Oregon's Total Energy Consumption Over Time*




*Oregon's Per Capita Energy Consumption Over Time*




## Btu

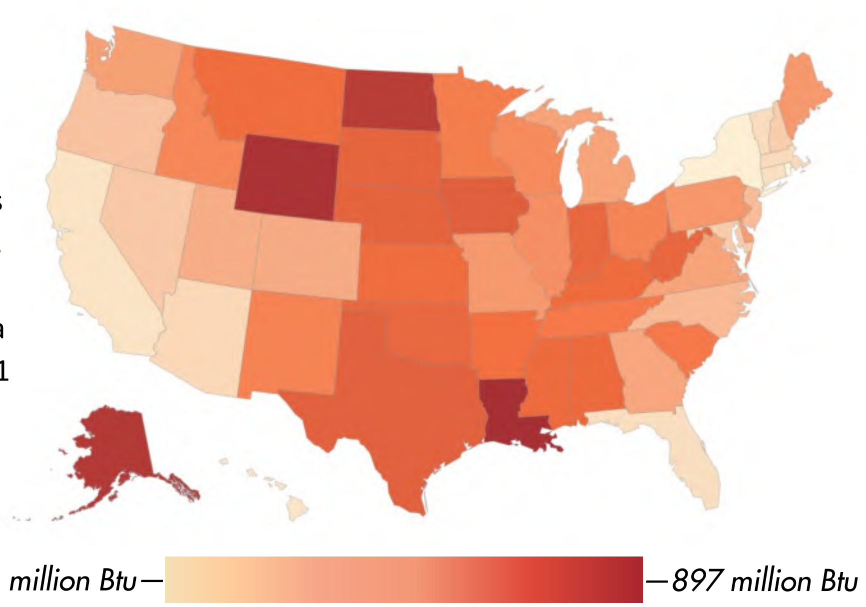
A **British Thermal Unit** is a measurement of the heat content of fuels or energy sources. Btu offers a common unit of measurement that can be used to count and compare different energy sources or fuels. Fuels are converted from physical units of measurement, such as weight or volume, into Btu to more easily evaluate data and show changes over time.

*References: 1,2*

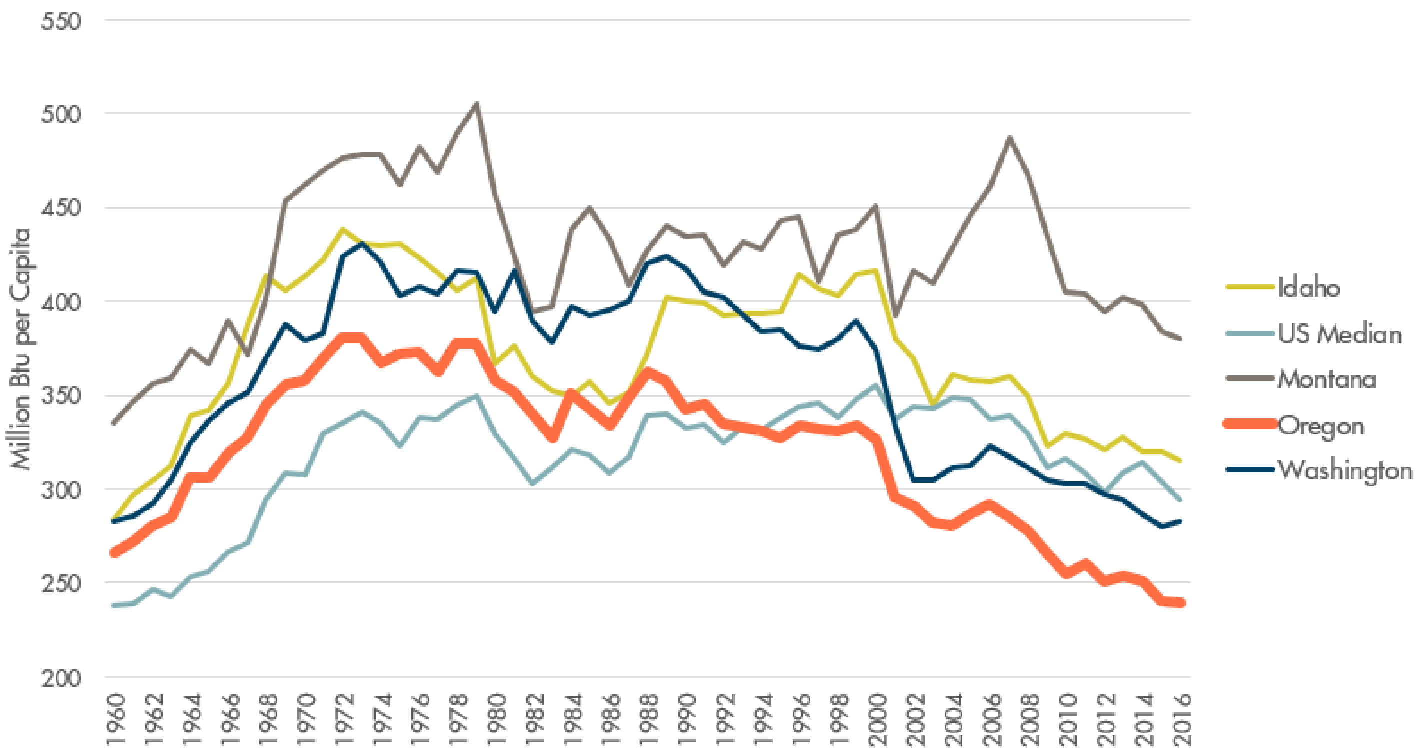
# Energy Use in Oregon

## Per Capita Energy Consumption

Per capita energy consumption in Oregon is the lowest since 1960. After a peak in 1972, per capita consumption declined by 37 percent, reaching 239 million Btu per capita in 2016 compared to the U.S. median of 301 million Btu per person. That same year, Oregon consumed 19 percent less than the U.S. median. Our per capita use is also the lowest in the Pacific Northwest.




*Total Energy Consumption Per Capita: Northwest States and U.S. Median Over Time*




## Consumption & Use

In the energy sector, *consumption* typically describes the amount of energy used. *Use* sometimes has the same meaning, but is often specifically applied when talking about the purpose of energy. For example, a home's annual electricity *consumption* goes toward a variety of *uses* like lighting, heating, and appliances. Or a furnace is *used* for heating but *consumes* electricity and natural gas. For this report, consumption and use are included in a wide variety of ways and sometimes interchangeably.

References: 1,2

# Energy Use in Oregon

## Energy Consumption and Economic and Population Growth

Between 1960 and 1999, economic and population growth in the U.S. generally corresponded with growth in energy consumption. Starting in the early 2000s, in Oregon and the country as a whole, energy consumption is no longer directly correlated with growth factors like population and gross domestic product.

Energy efficiency and changes in industry have led to decreases in Oregon's total and per capita energy use. As discussed later in this chapter and in chapter 6, Oregon's emphasis on energy efficiency has helped reduce both total and per capita energy use despite an increasing population, thereby avoiding the need to build new electricity generation plants.

**Between 2000 and 2016:**

**Oregon Population**

↑ 19%

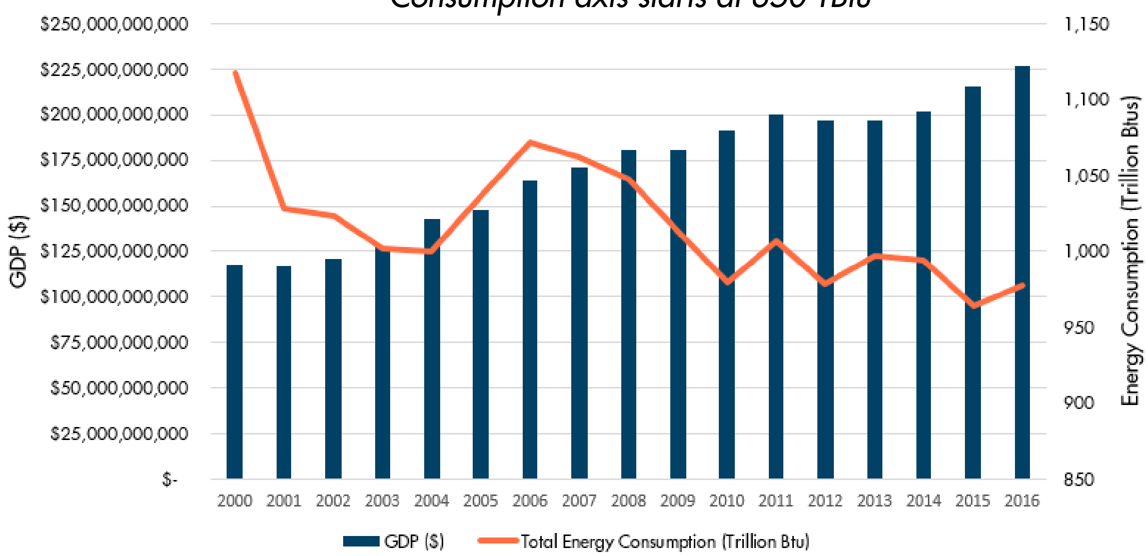
**Oregon GDP**

↑ 93%

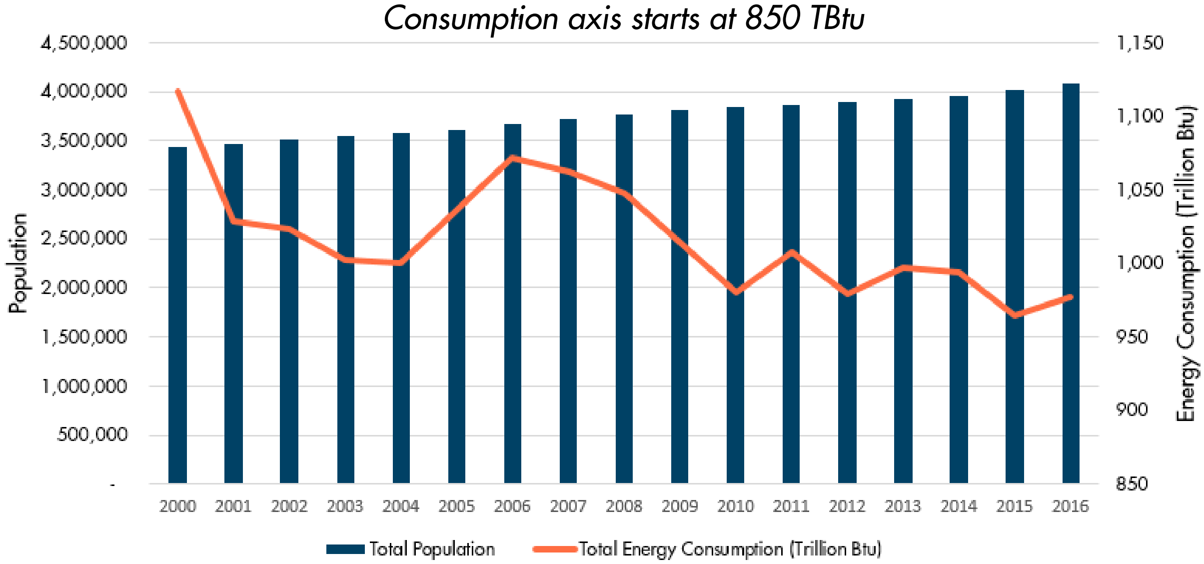
**Oregon Energy Use**

↓ 12.5%

*Oregon's GDP and Energy Consumption: 2000-2016*
*Consumption axis starts at 850 TBtu*




*Oregon's Population and Energy Consumption: 2000-2016*
*Consumption axis starts at 850 TBtu*




*References: 1,2*

# Electricity Use

## Resources Used for Oregon's Electricity Mix

In 2017, Oregon used 49,615,797 megawatt hours, or MWh, of electricity from both in-state and out-of-state sources. Hydropower, coal, and natural gas make up the bulk of Oregon's electricity resources, commonly called resource mix, although the share of each resource is evolving. Oregon's only coal plant will cease coal operations in 2020, and renewable energy makes up an increasingly larger share of the mix each year.

The breakout below of electricity resources used in Oregon is based on statewide averages using three years of data. A three-year average helps to round out variability of the output from hydropower electricity due to annual weather patterns in the Pacific Northwest. The five largest sources of electricity fuels are labeled; the other resources are each under 1 percent.

32%

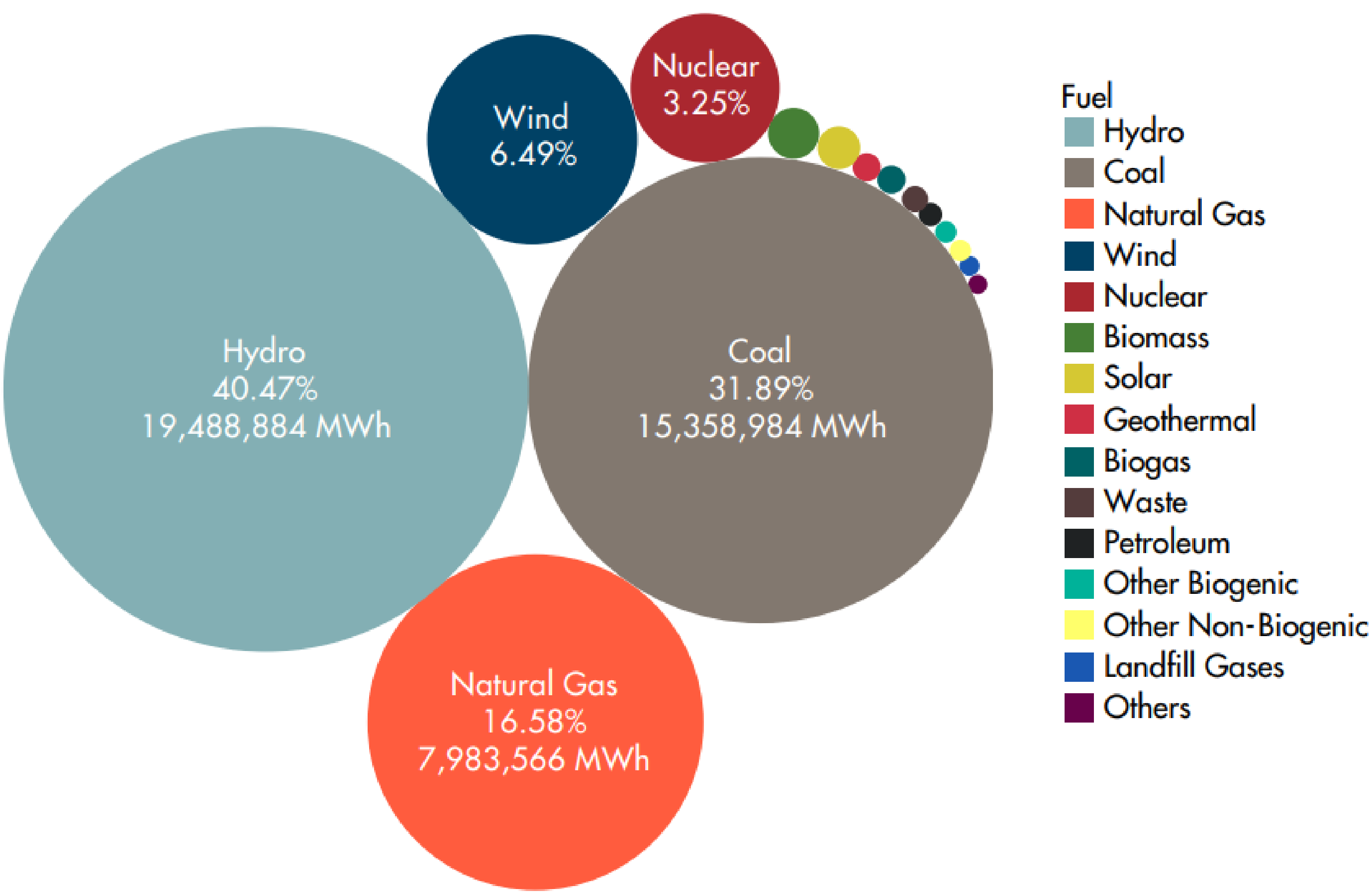
**Percentage of Oregon's current electricity mix that comes from coal**

2035

**Year by which Oregon's two largest utilities will no longer be able to generate or contract for electricity from coal for use by Oregon consumers**

### *Resources Used to Generate Oregon's Electricity*

*Based on a three-year average (2014-2016), this chart shows the energy resources used to generate the electricity that is sold to Oregon's utility customers.*

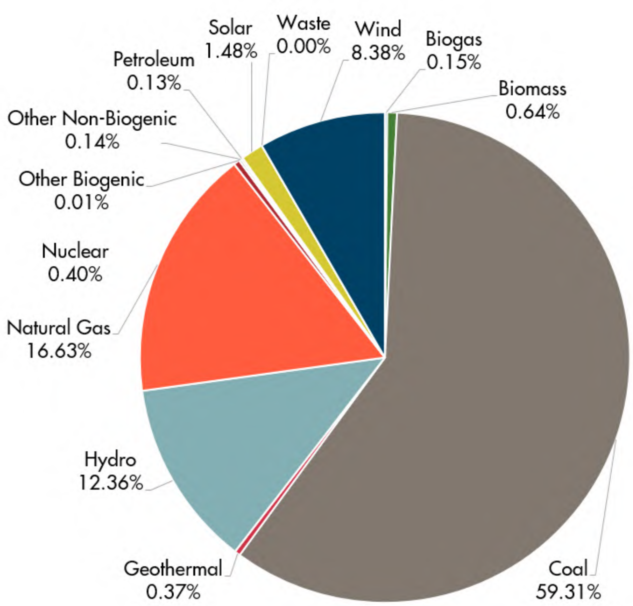



References: 3, 4, 5, 6

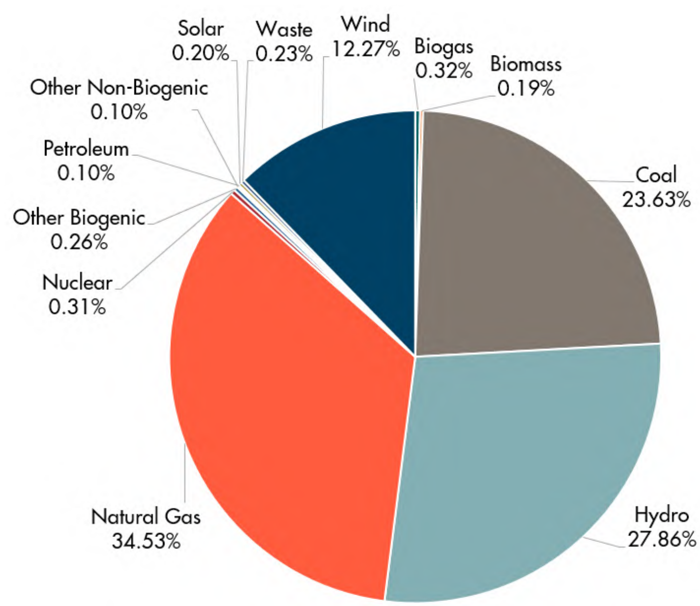
# Electricity Use

## Investor-Owned Utility Resource Mix

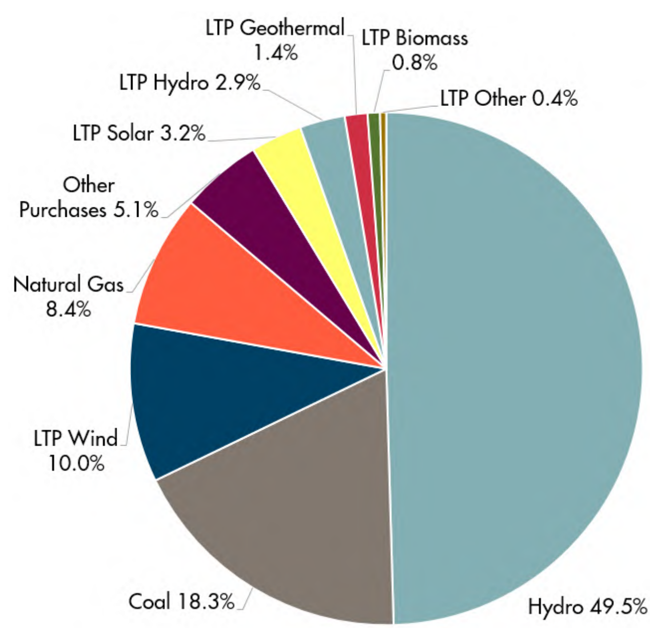
The resources utilities use to generate electricity consumed in Oregon vary depending on the utility provider. The electricity resource mixes for Oregon's three investor-owned utilities are shown below. One year of data is shown for each utility; mixes will fluctuate year to year depending on the availability of certain resources. Oregon Department of Energy's online Electricity Resource Mix tool uses a three-year average of data to account for variability in hydroelectricity. The information below includes real-time supplemental market purchases of electricity that utilities make to meet demand.




*Pacific Power 2016*




*Portland General Electric 2016*



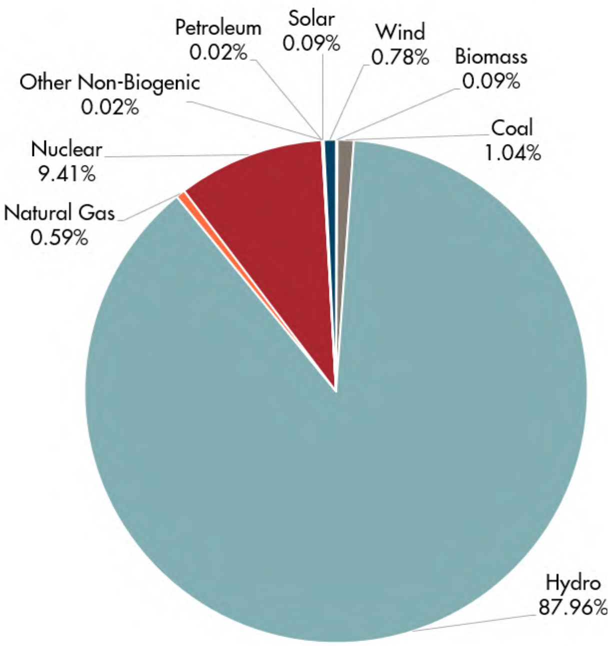

*Idaho Power 2017*

References: 4

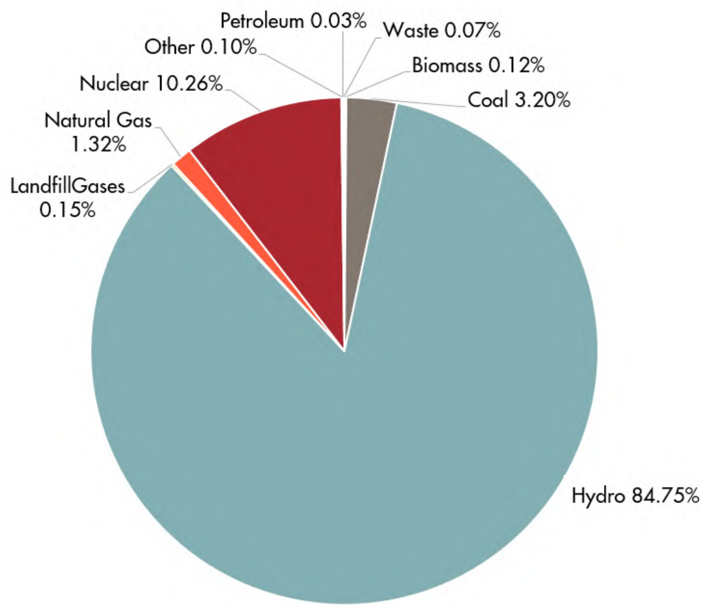
# Electricity Use

## Consumer-Owned Utility Resource Mix

The electricity resource mixes for the Eugene Water & Electric Board and a composite of other consumer-owned utilities operating in Oregon are below. One year of data is shown for each utility; mixes will fluctuate year to year depending on the availability of certain resources. Oregon Department of Energy's online Electricity Resource Mix tool uses a three-year average of data to account for variability in hydroelectricity. The information below includes real-time supplemental market purchases of electricity that utilities make to meet demand; these purchases are called "unspecified" because the exact mix delivered to consumer-owned utilities is not certain. For example, the charts below include a percentage of coal from BPA's unspecified market purchases on behalf of COUs.




*Eugene Water & Electric Board 2016*




*Average of Oregon Consumer-Owned Utilities, Not Including Eugene Water & Electric Board 2016*

## Bonneville Power Administration

Consumer-owned utilities in Oregon purchase most of their electricity from the Bonneville Power Administration, a not-for-profit federal agency that markets wholesale electrical power from 31 federal hydroelectric facilities in the Northwest, a nonfederal nuclear power plant, and several other small, nonfederal power plants. The dams generating the hydroelectric power are operated by the U.S. Army Corps of Engineers and the Bureau of Reclamation. BPA provides about 28 percent of the electric power used in the Northwest.

The Dalles Dam in the Columbia River Gorge produces up to 2,000 MW of power.

References: 4, 7, 8

# Electricity Use

## Rise In Renewables

Renewable electricity in Oregon has grown due to customer demand, dramatic decreases in costs, and policies like the Renewable Portfolio Standard.

In 2008, Oregon's electricity resource mix included 28 MWh of solar generation out of a total of more than 49 million megawatt hours for the year. In 2013 – five years later – solar was up to 30,000 MWh, with small increases over the next two years until 2016, when the resource mix jumped to 266,000 MWh of solar for the year.

Oregon's percentage of wind — topping 7 percent of our energy resource mix in 2016 — continues to grow as new wind facilities open up across the western U.S.

With this increase in renewable energy, other resources in our electricity mix have changed as well. The amount of coal included in Oregon's resource mix has been dropping since 2005. Natural gas—a resource that can help to integrate variable renewable resources like wind and solar into the grid—has increased. The percentage of natural gas-powered electricity in Oregon's resource mix increased from 12.1 percent in 2012 to 18.4 percent in 2016.

### Renewable Hydropower

Hydropower makes up a large and important part of Oregon's electricity resource mix—providing more than 40 percent of the state's electricity. In some Oregon utility territories, hydropower provides more than 90 percent of consumers' electricity.

Most of this hydropower—from dams built decades ago—is not eligible for credit toward the state's Renewable Portfolio Standard, which was created to encourage the development of ***new*** renewable electricity resources. However, the RPS can include two types of electricity from these older but still critical hydro facilities: generation attributable to efficiency upgrades made at existing hydropower facilities after 1995 is eligible, as is generation from an existing facility if it became certified as a low-impact hydroelectric facility after 1995.

50%

**Percentage of Oregon's electricity that must come from renewable resources by 2040 through the Renewable Portfolio Standard (RPS)**

741%

**Percent increase in wind energy consumed in Oregon between 2004 and 2016**

212,744

**Megawatt hours of solar photovoltaic added to Oregon's electricity mix between 2015 and 2016**

60%

**Increase in natural gas used for electricity between 2012 and 2016**

Megawatt (MW): A unit of measurement for power. One million watts of electricity capacity—the equivalent of 1,340 horsepower, or enough power to simultaneously illuminate 25,000 standard 40 Watt lightbulbs. Megawatt Hour (MWh): A unit of measurement for energy output that represents the amount of energy supplied continuously by 1 MW of capacity for one hour. Average Megawatt (aMW): Represents 1 MW of energy delivered continuously 24 hours/day for one year. A power plant with 50 MW capacity that operates at full output for 50 percent of the hours in a year delivers 25 aMW of energy.

*References: 4, 9*

# Electricity Use

## Energy Efficiency

Energy efficiency plays a critical role in our state. It is the second largest resource in Oregon after hydropower, and Oregon has consistently met increased demand for electricity by implementing energy efficiency strategies. The Northwest Power & Conservation Council reports that since 1978, the Pacific Northwest has produced nearly 6,600 average megawatts of savings through efficiency programs and improvements. That's more electricity than the whole state of Oregon uses in a year.

Over the past decade, Oregon reduced per capita energy use despite our state population growing, and energy efficiency is one reason why. In 2018, Oregon scored in the top ten states for energy efficiency in national rankings—the twelfth year in a row making this list.

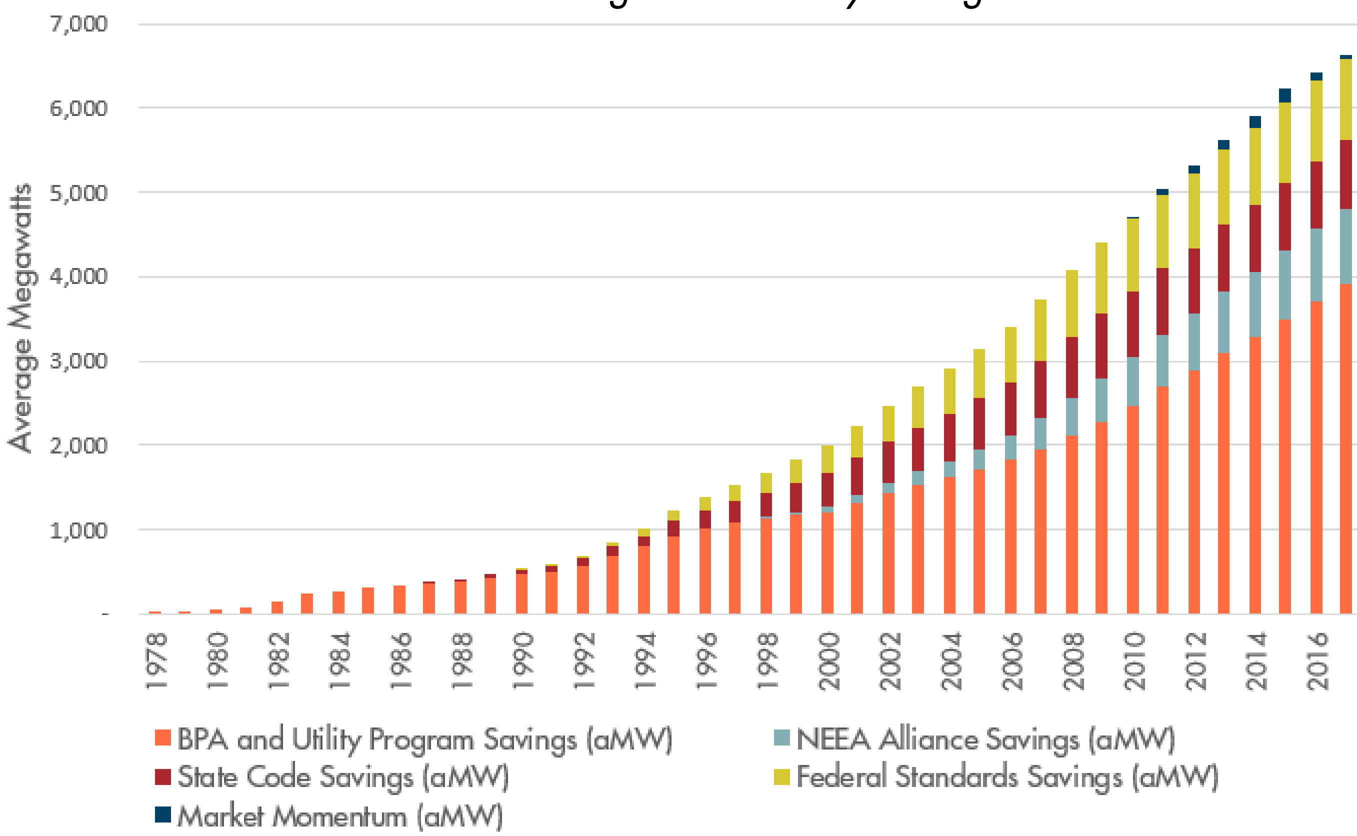
6,600

**Average megawatts of regional electricity savings due to energy efficiency from 1978 to 2017**

1,900

**Average megawatts of electricity savings in Oregon from energy efficiency over that same time period**

*How We Got Here:*
*Cumulative Regional Efficiency Savings*



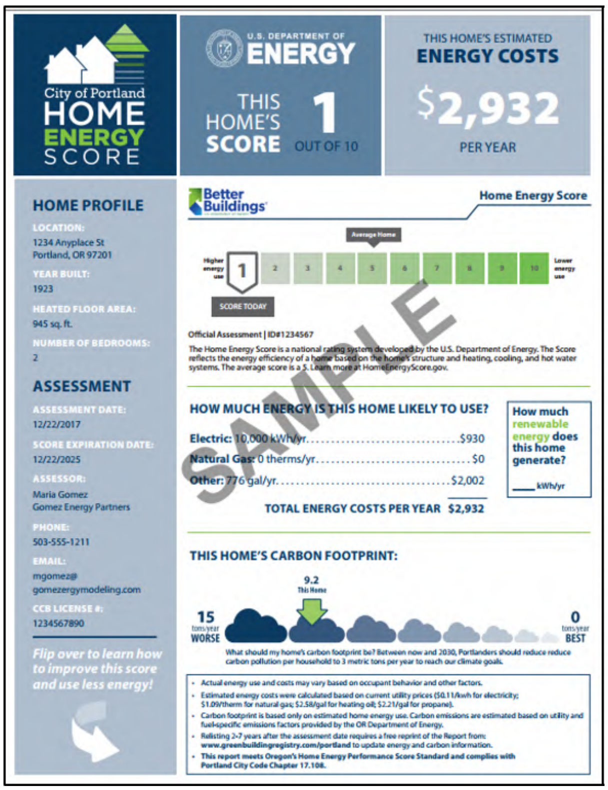

*Oregon's gains in energy efficiency have been helped by federal standards, state policies and programs, utility programs such as Energy Trust, and other nongovernmental organizations. For the region's cumulative savings, 60 percent comes from utility and BPA programs. Energy efficiency gains are cumulative and continue paying dividends for the region over time.*

References: 10, 11, 12

More energy efficiency will be realized in the future. The NWPCC's 7th Power Plan, published in 2016, concludes that cost-effective efficiency can meet a large amount of new load growth in the region – allowing Oregon to grow without needing significant new electricity resources. The plan calls on the region to develop new energy efficiency programs equivalent to acquiring 4,300 average megawatts of power by 2035. Integrated Resource Plans from Oregon's large electric utilities also identify energy efficiency as a key strategy they will use to meet demand over their planning horizon.

At an estimated $30 per MWh, energy efficiency continues to be a more cost effective approach to acquiring new energy resources compared to traditional sources of electricity.

Oregon's efficiency efforts have also reduced direct use fuels used to heat homes and provide energy in commercial and industrial settings. See the sector profiles section, beginning on page 38, for more details.




## Home Energy Scoring

Home Energy Score systems help Oregonians better understand a home's energy use and how even small improvements can save energy. A certified professional evaluates a home's energy features and issues a score, similar to the bright yellow Energy Guide label found on home appliances. The City of Portland now requires homes for sale to have a home energy score when placed on the market. More than 6,600 homes in Portland have already received a score that evaluates energy use and energy efficiency opportunities.

23.5 million

**Tons of carbon emissions reduced per year in the region due to energy efficiency**

$4 billion

**Amount saved by Pacific Northwest residents due to lower electricity bills in 2015**

$182 million

**Amount utilities, governments, and nonprofit programs invested in Oregon energy efficiency in 2017**

$12.7 million

**Amount Oregon spent in 2017 on energy efficiency programs targeting low-income households**

*References: 10, 12, 13*

# Electricity Use

## Where It Comes From

Electricity used by Oregonians can come from facilities across the western United States. We rely on hydroelectric power produced on the Columbia River, access small amounts of nuclear power from the Columbia Generating Station in Washington, and use electricity generated at coal-powered facilities.

The map below shows the various electricity generation sources in the Western Electric Coordinating Council. The map uses data from the Energy Information Administration and includes facilities with a nameplate capacity of 1 megawatt or greater. Not all of the resources or facilities shown contribute to Oregon's overall fuel mix but are available when a utility purchases power on the open market. In the same way, electricity generated in Oregon may be sold through the market to support electricity needs in other states.

### "WECC"

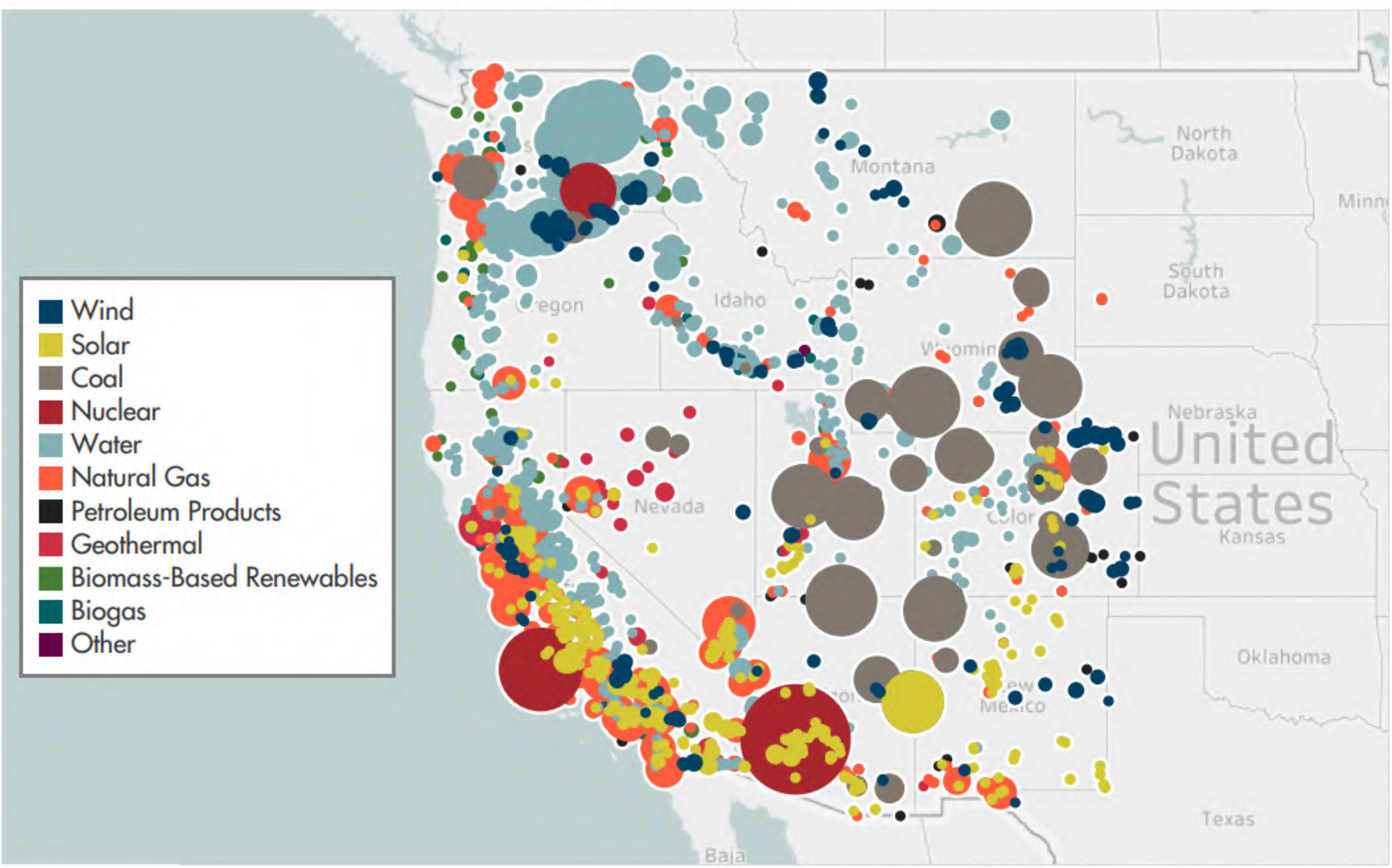
*The Western Electricity Coordinating Council is a nonprofit corporation that focuses on system-wide electricity reliability across a geographic region known as the Western Interconnection. This diverse region includes Oregon as well as most of the inter-mountain west and parts of Canada.*

3.25%

**Share of Oregon's electricity that comes from Washington's Columbia Generating Station Nuclear Facility**

### *Electric Generation Sources in the Western Electric Coordinating Council Region*

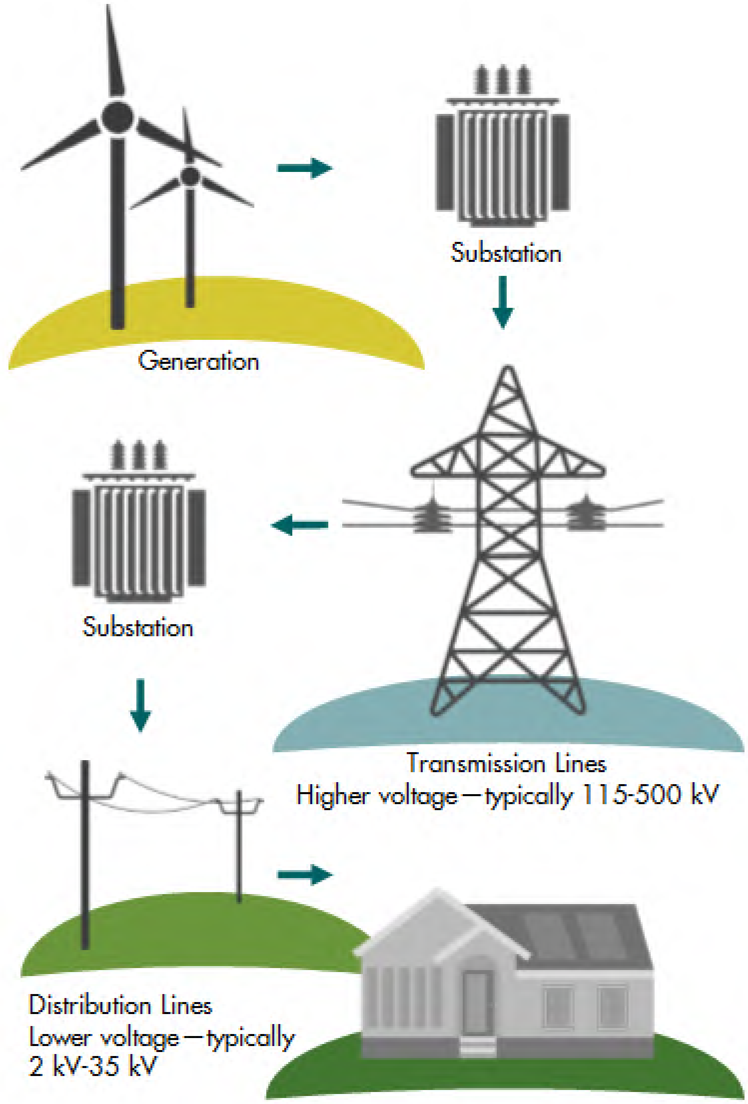
*Average 2014-2016 Net Generation in MWh by Plant*




References: 1, 4, 65

# Electricity Use

## How It Gets To Us

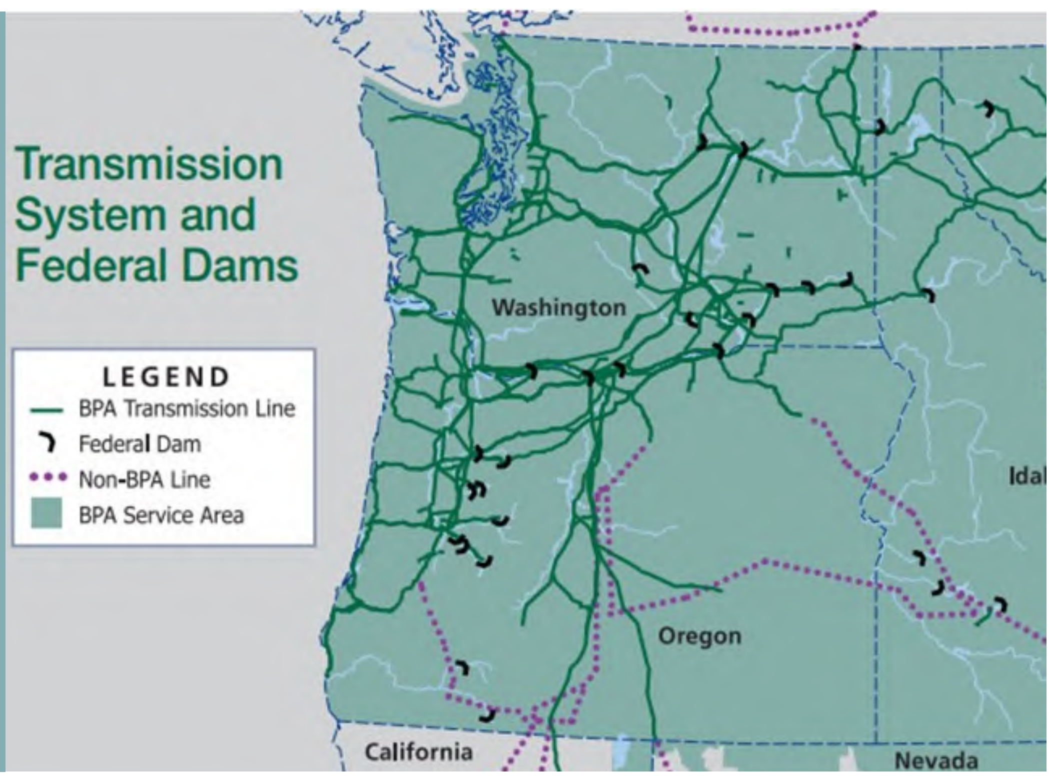



Electricity travels from generating facilities to customers over an interconnected network of transmission and distribution wires and substations, which connect the higher-voltage transmission system with the lower-voltage distribution network.

Collectively, this interconnected network of transmission and distribution wires and substations is referred to as "the electric grid," or simply "the grid." Unlike the networks designed to deliver other types of energy—like liquid fuels or natural gas—the electric grid has been designed to simultaneously deliver enough electricity from generators to meet the highest consumer demands on the system.

By comparison, production of liquid fuels or natural gas can occur at a more constant rate and still meet hourly or daily fluctuations in demand, due to the ability to easily and cheaply store large quantities of both. Because it is much more difficult and costly to store electricity, the grid needs to carry electricity from power plants to customers nearly instantaneously to meet fluctuations in demand from moment to moment.

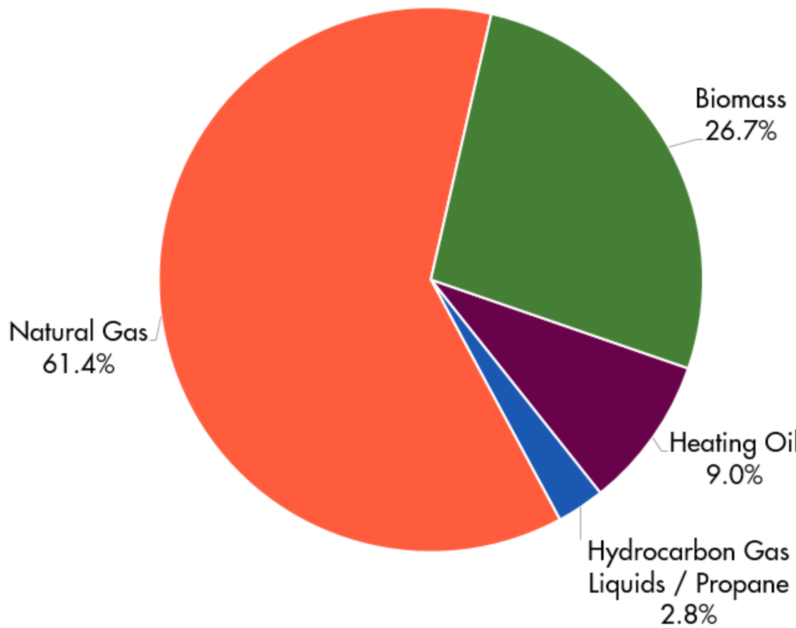
*In the Pacific Northwest, the Bonneville Power Administration owns and operates nearly 75 percent of the high-voltage electric transmission network—including more than 15,000 miles of lines. The majority of the rest of the transmission system is operated by one of the region's larger privately owned utilities, such as PacifiCorp or Idaho Power. The lower voltage distribution system in Oregon is owned and operated by dozens of different distribution utilities.*




References: 1, 7, 14

# Direct Use Fuels

## What We Use and Where It Comes From




In 2016, Oregon used 139 trillion Btu of natural gas, 6 trillion Btu of propane, and 21.1 trillion Btu of heating oil. Biomass is also a significant source; the Energy Information Administration estimates Oregon used 60.4 trillion Btu. Direct uses include cooking, heating, and industrial and commercial process heat. Additionally, the state used thermal energy generated from solar thermal and geothermal sources.

**Natural Gas**: The previous section focused on natural gas used for electricity, but the resource is equally important for direct uses such as space and water heating, cooking, and many agricultural, commercial, and industrial processes. In 2016, the state used 139 trillion Btu of natural gas for direct uses. Oregon imports most of the natural gas, or methane, we use from Canada and the Rocky Mountain states. The Pacific Northwest's only natural gas production is at a location outside of the town of Mist, northwest of Portland. The field is owned and operated by NW Natural Gas, one of three investor-owned gas companies in the state. The Mist field produced about 801,491,000 cubic feet of natural gas in 2016, which represents less than one-half percent of Oregon's annual use. For more information about the Mist facility, see page 23.

**Propane**: Oregon residents consumed about 66.6 million gallons of propane in 2015; more than 25,000 homes used propane for heat. Nationally, 54 percent of propane is used in residential applications like heating and cooking. Another 19 percent is used in commercial applications, 11 percent as transportation fuel, 7 percent in agriculture, 6 percent in industry, and a little over 3 percent in backyard grills. Propane can be used to power buses, locomotives, forklifts, taxis, farm tractors, and Zamboni machines at ice skating rinks. Propane remains a viable fuel over long periods of storage, making it a common backup fuel for correctional facilities and hospitals and a potential resource in emergency response.

**Heating Oil**: Many Oregon homes have on-site oil tanks for heating. Fuel oil is also used in commercial, industrial, and institutional sectors. In 2016, Oregon used approximately 21.1 trillion Btu or 150.4 million gallons of fuel oil. Much of Oregon's supply comes from refineries in Washington.

**Biomass**: Biomass is organic material from plants and animals that can be converted to liquid, gaseous, and solid fuels for direct uses or to generate electricity. Biomass energy sources in Oregon include residuals from commercial forest harvest, agricultural manure, and organic materials breaking down in landfills, wastewater treatment plants, and food waste collection facilities. While some biomass sources are the same as biogas or renewable natural gas (covered under transportation fuels), biomass also commonly refers to end-products such as wood chips, wood pellets, and charcoal that are used for thermal energy.

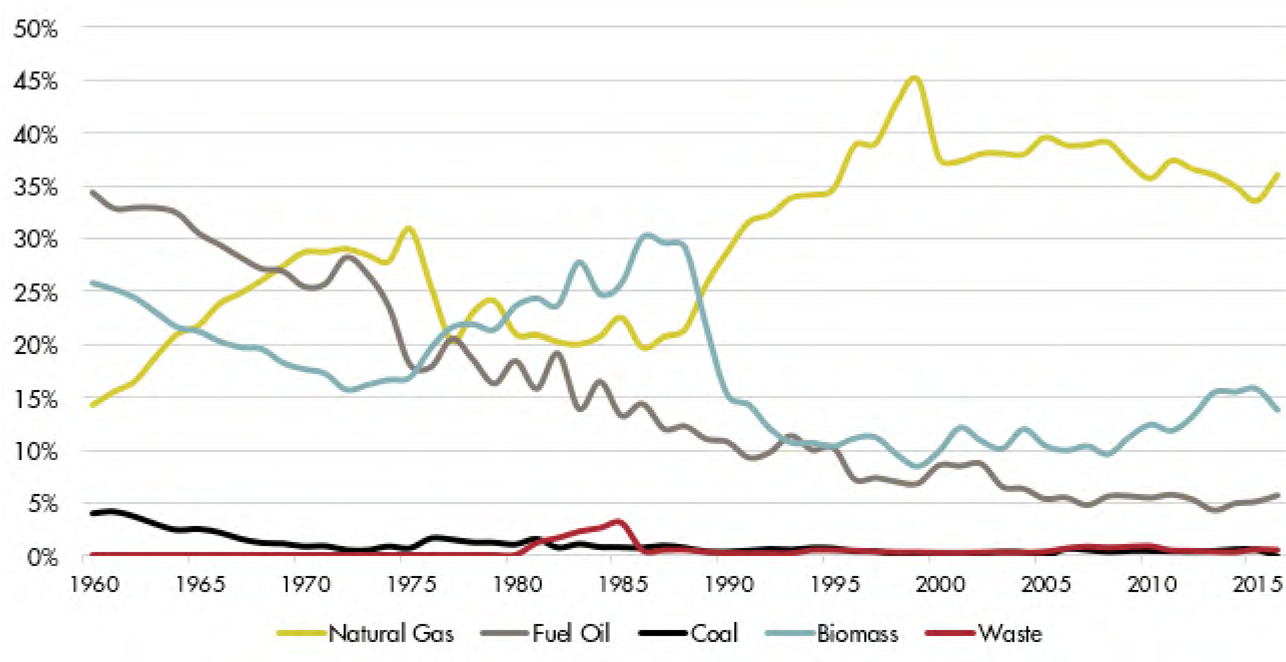
**Geothermal**: While geothermal energy is often used for electricity, it can also be used for thermal energy applications such as heating spaces and keeping bridges and sidewalks from icing over. It, too, makes up a small portion of Oregon's annual direct use energy total.

*References: 1, 2, 15, 16, 17, 18*

## How Direct Use Fuels Have Changed Over Time

Energy consumption continues to change in Oregon and across the U.S. For direct use fuels in Oregon, that means less wood and fuel oil and more natural gas. The chart below compares percentages of different fuel types used in the residential, commercial, and industrial sectors and their relationship over time. Fuel oil in particular has declined steadily since 1960, while natural gas has increased. More recently, electricity has replaced the use of some direct fuels.

*Oregon's Direct Fuels Consumption in the Residential, Commercial, and Industrial Sectors*




# Solar Thermal

While not included in Oregon's direct use fuels reporting data, solar thermal energy is a resource used directly in Oregon homes. Solar thermal systems use energy from the sun to provide water heating and space heating in buildings. The majority of the systems installed in Oregon provide supplemental energy to residential water heaters and offset up to 70 percent of the households' water heating bills. More than 10,700 solar water heating systems have been installed under the Oregon Residential Energy Tax Credit program. Of these, more than 9,200 were installed before 2008. In the last ten years, residential solar water heating systems have declined from over 300 installations per year to fewer than 100 installations per year. They make up a very small portion of Oregon's annual direct use energy total.

*References: 1, 2, 19*

# Direct Use Fuels

## How They Get to Us

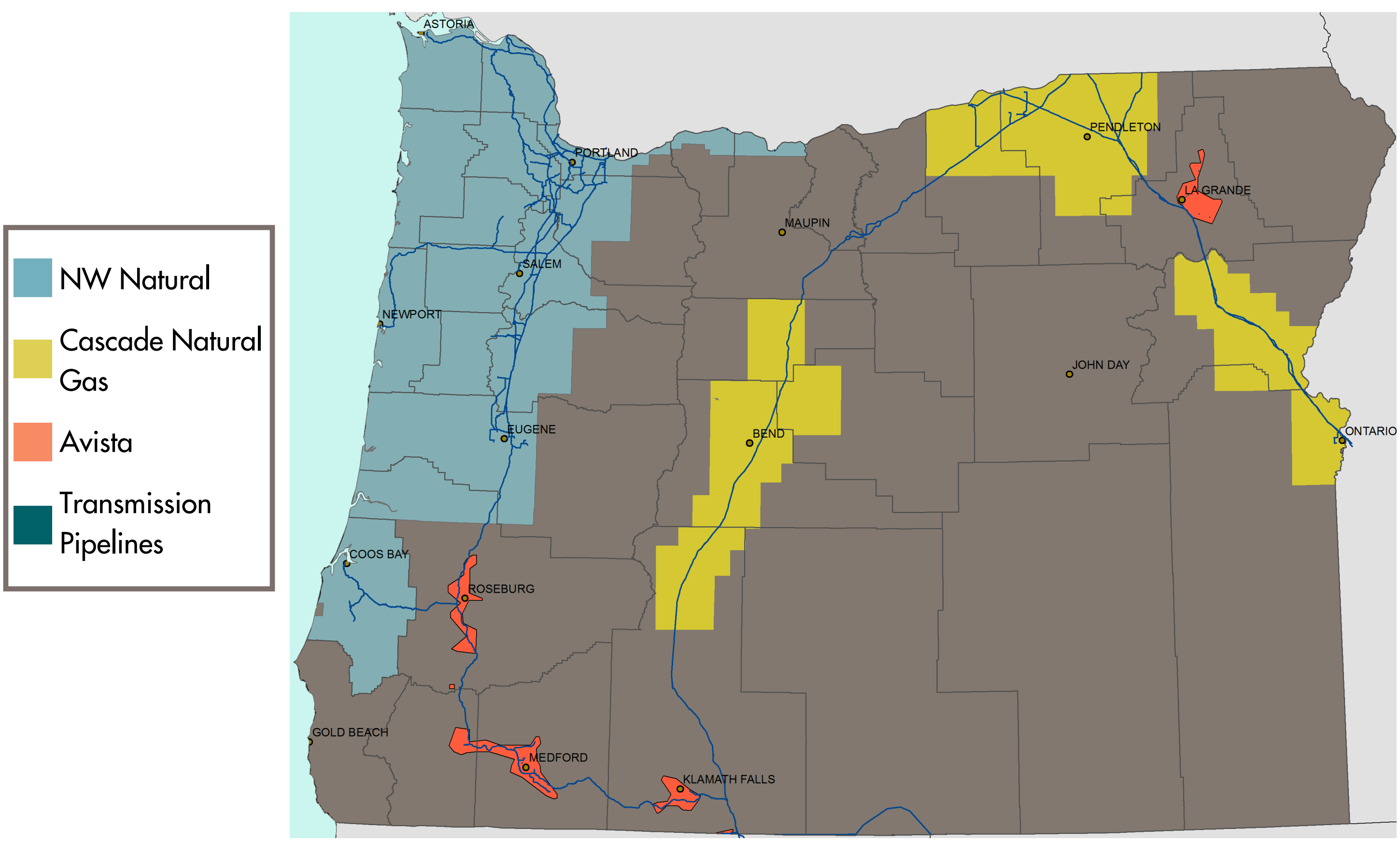
Natural gas is transported across Oregon in pipelines, which are connected to the distribution systems of the three natural gas utilities: NW Natural, Avista, and Cascade Natural Gas. Unlike electricity, natural gas is not available in less-populated areas of the state.

All propane and heating oil used in Oregon arrives by truck or rail car. More than 300 Oregonians manage and operate the propane distribution network.

Numerous facilities across the state convert biomass to energy. Seven companies make liquid biofuels, nine companies make wood pellets, and one company makes charcoal briquettes. Oregon also has seven landfill gas-to-electricity operations and 10 agricultural anaerobic digesters making electricity (six are currently operating). Twelve wastewater treatment plants can generate up to 8.7 MW from biogas; seven woody biomass combined heat and power plants across the state have the ability to generate up to 273.3 MW of electricity and an undetermined amount of thermal energy for commercial and industrial process heat or to heat buildings.

The map below shows natural gas transmission lines and the service territories of Oregon's three natural gas utilities. A large portion of Oregon is not covered by any gas utility territory, and even within existing gas utility territories, many Oregonians lack access to natural gas service.

*Oregon Natural Gas Transmission Pipelines and Utility Territories*




References: 1, 15, 17, 20

# Transportation Fuel Use

## What We Use

Transportation fuels represent the largest energy use in Oregon. Compared to direct use fuels and electricity, transportation fuels account for 38 percent of our state's total energy use. This includes fuels used for cars, passenger trucks, and SUVs—often called "light-duty vehicles"—heavy duty vehicles used for transport and delivery, plus fuels used in the aviation and marine industries.

When energy use is divided among what are commonly called "end-use" sectors, the transportation sector is the largest—31 percent compared to smaller percentages for residential, commercial, and industrial sectors.

Petroleum-based products accounted for 93.3 percent of fuel consumed in the transportation sector, while biofuels such as ethanol, biodiesel, and renewable diesel accounted for 6.4 percent. Other smaller sources are listed below. As more Oregonians switch to electric vehicles, electricity's share of transportation will grow. See chapter 4 for more details.

85%

**Percentage of energy used in the transportation sector consumed on Oregon roadways**

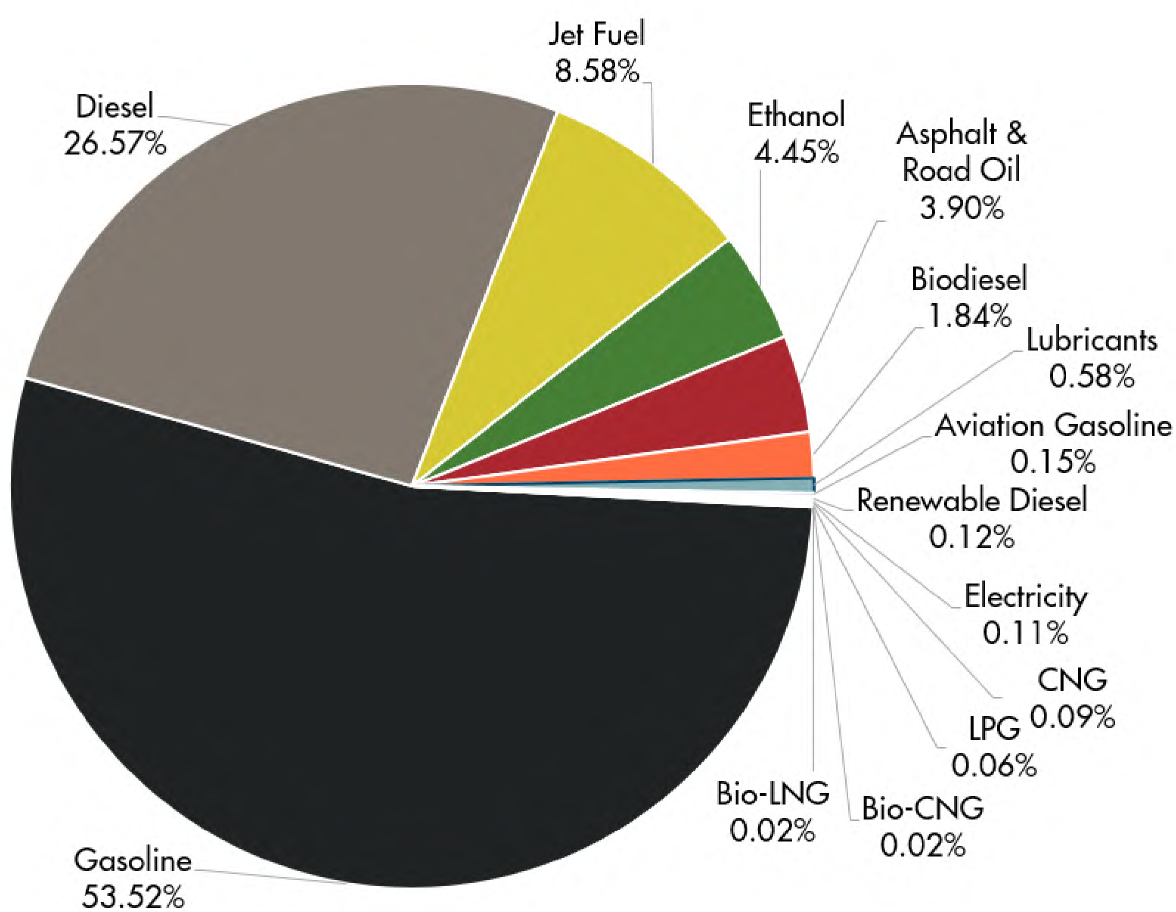
5%

**Biodiesel blend is used in nearly all heavy-duty vehicles both on and off the highway**

10%

**Ethanol blend fuel is used in a majority of light-duty vehicles in Oregon**

*Transportation Fuels Used in Oregon 2016*




References: 2, 21

# Transportation Fuel Use

## Where It Comes From

In 2016, less than 2 percent of transportation fuels consumed in Oregon were produced in-state. Oregon does not have crude oil reserves or refineries to process petroleum. Over 90 percent of the petroleum products delivered to and consumed in Oregon come from four refineries in Washington state. Crude oil used at Washington refineries comes from Alaska, western Canada, and North Dakota.

In 2016, more than 75 percent of the ethanol and 84 percent of biodiesel consumed in Oregon was produced out-of-state—primarily in the midwest. About 23 percent of ethanol used in Oregon is produced in Boardman, while biodiesel is produced in Salem; see the next section for production details.


*Above, a CNG-powered truck delivers commercial food waste to the North Portland transfer station. The waste will go to JC Biomethane to be digested and converted into electricity and soil amendments. Eventually, the hope is to collect the methane from the anaerobic digester and then turn that methane into renewable natural gas that can fuel trucks currently using CNG.*

Oregon is exploring how to use more renewable natural gas in the transportation sector. While fossil natural gas is typically associated with oil deposits, biogas and renewable natural gas come from landfills, waste water treatment plants, anaerobic digesters at dairies, food processing plants, or waste processing facilities. Twenty-five Oregon facilities are producing biogas and converting it to electricity for in-state use. This biogas can also be cleaned up for use in the transportation sector or to meet natural gas pipeline standards.

## How It Gets to Us

Transportation fuels are delivered to six Portland-area terminals via the Olympic Pipeline, by barge, and to a lesser extent by rail. These terminals receive, store, blend, and transfer petroleum products. The Portland region has a demand of about 200 to 210 thousand barrels a day. Some of this product flows in a pipeline south to Eugene and to Portland International Airport. The Eugene distribution hub serves southern, central, and eastern Oregon. Eastern Oregon is also served by hubs in the Tri-Cities area, Moses Lake, and Spokane. Additional small amounts of petroleum products come by tanker from California and Pacific Rim Countries. An estimated 1,500 tanker trucks deliver fuel throughout the state to about 2,400 fueling locations.

Ethanol and biodiesel primarily travel to Oregon via rail.

*References: 20, 21*

# Energy Production in Oregon

The previous section focused on different energy resources Oregon uses. This section discusses what we make. Oregon ranks 33rd in the country for energy production—and seventh in the country for total renewable energy production.

In the following pages, energy production is divided into the three categories below, with specific information on the types of energy produced in Oregon, along with more general information about the environmental effects of each resource no matter where it is produced. Later chapters go into more detail about the benefits, impacts, and tradeoffs associated with various resources.

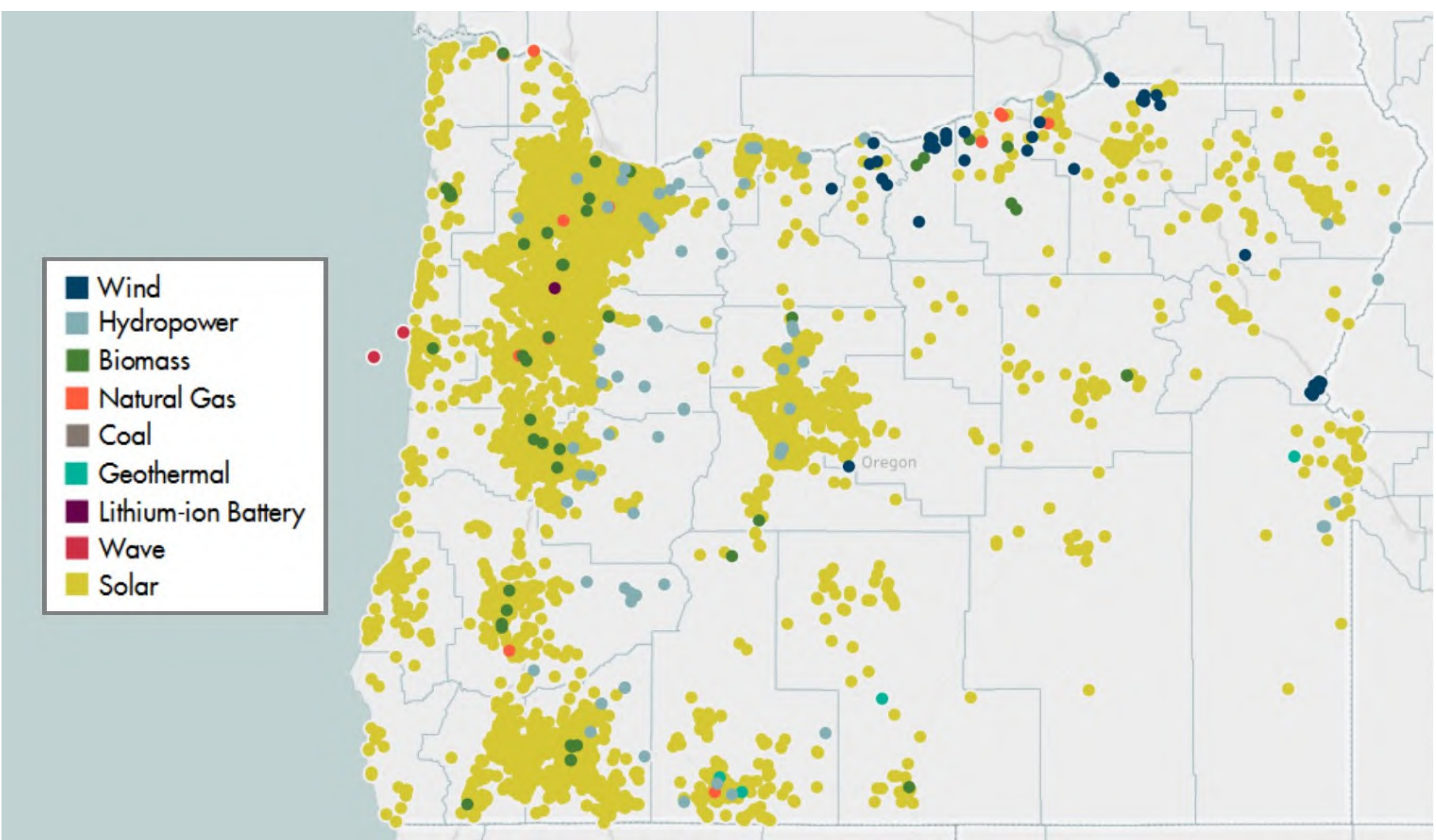
**Electricity**: Much of the electricity generated in-state uses Oregon-based natural resources—wind or hydropower, for example. Oregon energy facilities also generate electricity using raw materials from out of state; all of the coal and natural gas used at Oregon's in-state coal and natural gas power plants comes from out of state.

**Direct Use Fuels**: These include natural gas and biofuels produced in-state; hog fuel, or wood chips, used for industrial heat; commercial wood pellets for commercial and industrial heat; and more.

**Transportation Fuels**: Oregon produces about 25 percent of the biofuels our transportation system uses; overall, biofuels make up 6.4 percent of Oregon's use of transportation fuels.

*Energy Production in Oregon*

*The map below shows more than 16,000 sites, including residential rooftops, where energy is being produced across the state.*




*References: 1, 2, 21, 22*

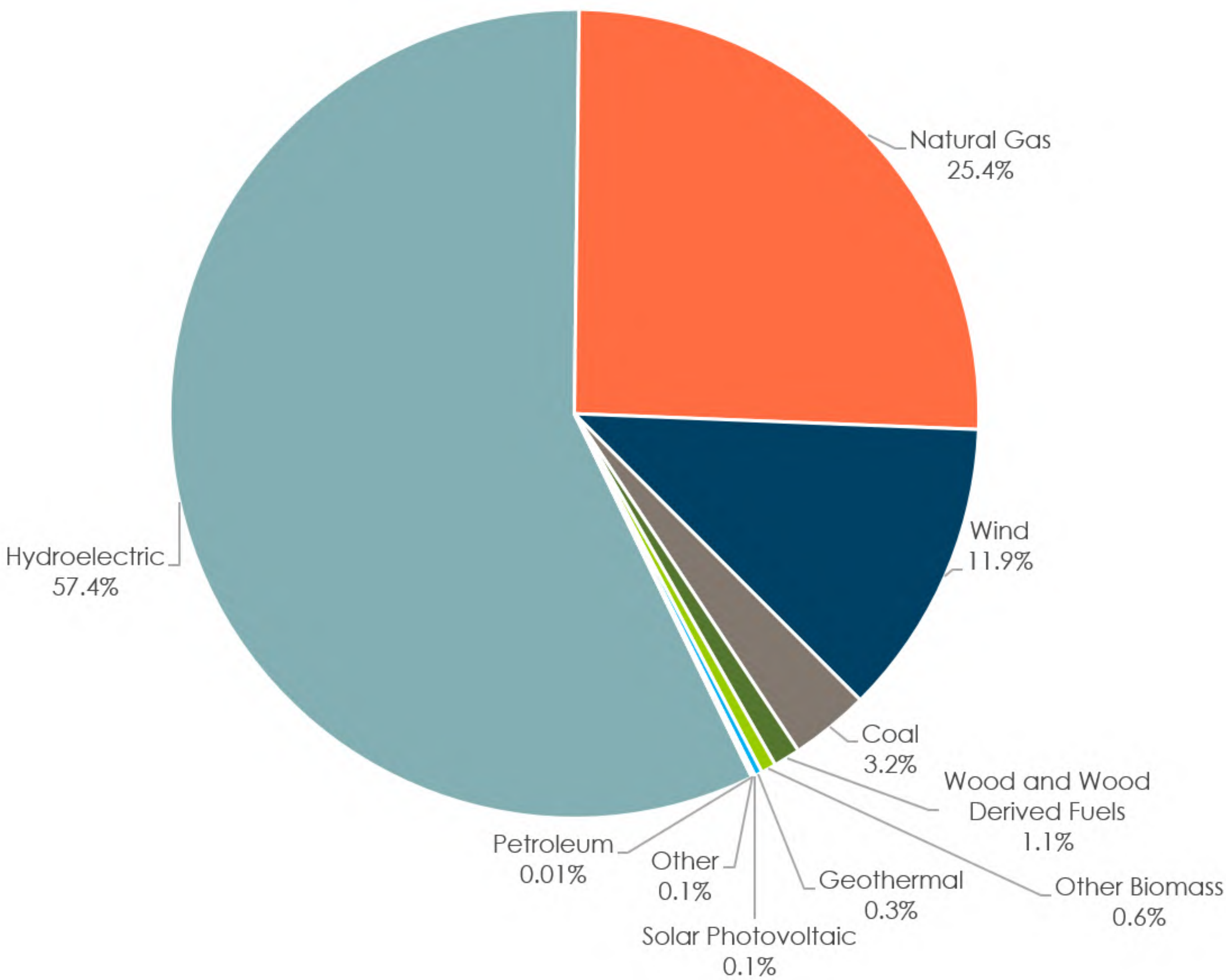
# Electricity Generation in Oregon

Oregon generates electricity from a variety of resources; hydropower, natural gas, and wind are the largest. In 2016, 71 percent of Oregon's utility-scale net electricity generation came from hydroelectric facilities and other renewable energy resources. Oregon also imports coal and natural gas from other states, using the fuels at Oregon-based power plants to generate electricity .

In 2016, Oregon generated 60,182,012 MWh of electricity. A portion of the electricity we generate from hydropower, wind, natural gas, and solar is exported to other states, while electricity from those states is imported for Oregonians' use. Comparing total megawatt hours of use to generation, we use about 17 percent less electricity than we generate.

## *Electricity Generated in Oregon — 2016*

*While the previous page's map showed all energy generation, this map uses data from EIA and does not include rooftop solar generation.*



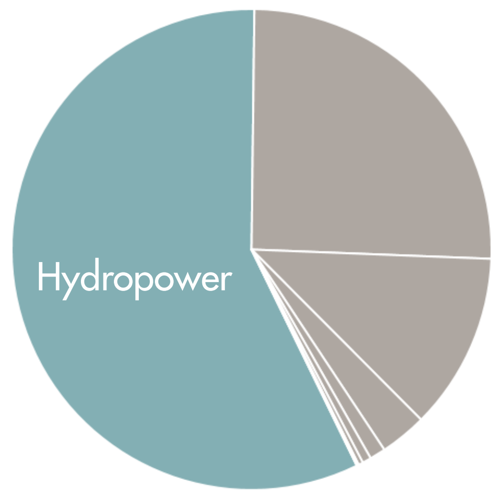

*References: 1, 2, 15*

# HYDROPOWER

8,865 MW of capacity
88 hydropower facilities—80 in Oregon, 8 crossing state borders
Smallest: .04 MW
Largest: 2,160 MW
12 facilities over 100 MW
Third highest installed capacity of hydropower in the U.S.

Hydropower was responsible for more than 57 percent of the state's electricity generation in 2016.

## Hydropower in Oregon




Much of this power comes from the Federal Columbia River Power System (FCRPS), which includes 31 hydroelectric facilities across four states with a total capacity greater than 22,000 MW of power. The dams are operated by the U.S. Army Corps of Engineers and the Bureau of Reclamation, and the Bonneville Power Administration markets the power from the system. Ten of these hydropower facilities are fully located in Oregon, and four of the largest projects—Bonneville, The Dalles, John Day, and McNary—span the Oregon and Washington state borders on the Columbia River.

*Hydropower is responsible for 57.4 percent of Oregon's in-state electricity generation. Of the electricity Oregon uses, hydropower makes up 40.5 percent of the state's resource mix.*

Oregon's 36 consumer-owned utilities rely on BPA for all or a majority of their power. These utilities span the state. Many of the smaller BPA customer utilities count on BPA for 100 percent of the power they sell to customers, and these utilities have some of the lowest retail power rates in the U.S. After serving their public power customers, BPA also sells a significant amount of power to investor-owned utilities in the region and to entities out-of-state.

BPA is not the only entity in Oregon to sell electricity from large hydroelectric facilities. Portland General Electric and Eugene Water and Electric Board are two examples of Oregon utilities that own and operate utility -scale hydro facilities. PGE wholly owns five hydroelectric plants with 192 MW capacity, and jointly owns two hydroelectric plants with 303 MW capacity.

As of 2016, there were approximately 50 hydroelectric facilities of 1 MW or larger operating in Oregon that were not part of the FCRPS. Oregon also has other smaller hydropower projects, many of which are certified as low impact facilities. For example, the Three Sisters Irrigation District is building three hydropower stations — each sized between 200 and 700 kW — as part of an irrigation modernization project. And as part of a planned retrofit, the City of Portland replaced portions of existing municipal water supply pipes with new pipes that include four in-conduit turbines with a total generating capacity of 200 kW.

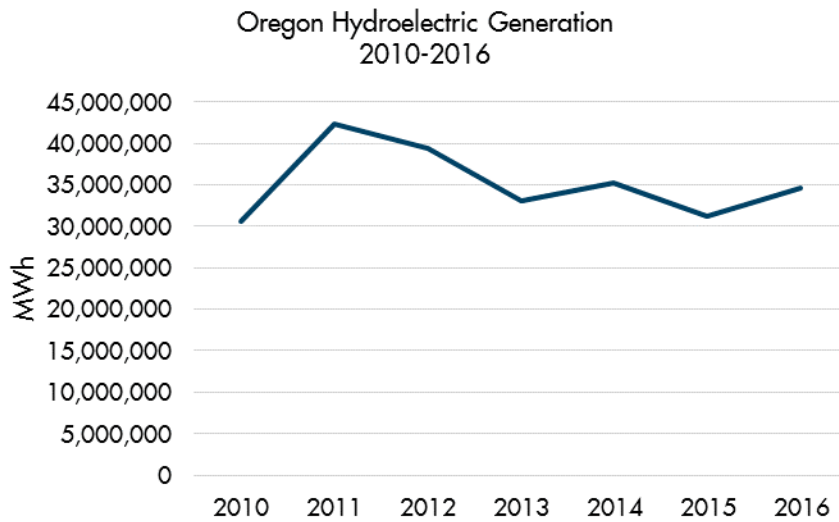
These hydropower projects deliver significant benefits to Oregon and the region, including low-cost, carbon-free power, flood control, navigation, and irrigation. Many of these hydropower projects also have significant

*References: 1, 4, 7, 17, 23, 24*

operational flexibility that allows them to ramp output up or down relatively quickly, providing a useful resource to integrate variable renewable resources like wind and solar.

## Resource Potential

The first U.S. hydroelectric power generation facility began operation in 1880, and the first of the FCRPS dams began operating in the 1930s. A number of the aging dams in the FCRPS have been retrofitted with more efficient turbines and other improvements such as enhanced fish passage. See chapter 3 for more details. New applications of hydropower technology, including “micro-hydro” projects like in-pipe conduit turbines, have also been deployed.

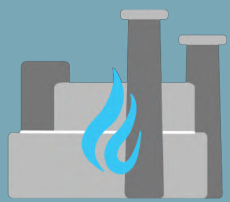



*Annual variations can have a dramatic impact on the hydroelectric system. Years with less rainfall and lower snowpack levels will yield lower amounts of hydroelectric generation.*

## Environmental Effects

Hydropower in Oregon is considered a zero-emissions resource. Hydropower has a low lifecycle carbon footprint from the embedded GHG emissions from manufacturing and construction. Dams also have significant stream flow and temperature impacts on fish habitat; alter sediment and nutrient regimens; and affect the ability of fish to migrate from the river to the ocean and back. In addition, the initial construction of dams inundates land, and their continued operation changes water levels throughout the year.


*Map used courtesy of the U.S. Army Corps of Engineers*

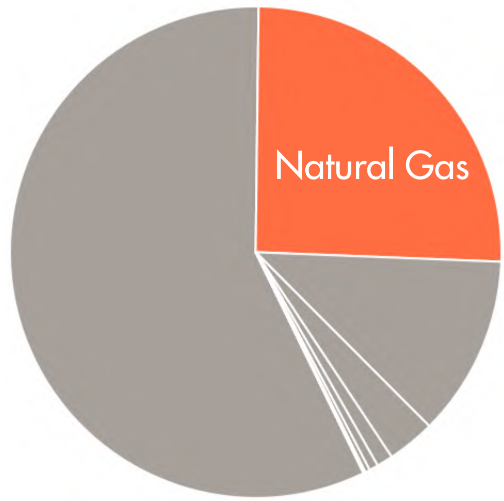


## NATURAL GAS

More than 4,066 MW of capacity
20 facilities produce electricity
45% of state's capacity comes from 3 facilities larger than 500 MW
3 state universities use on-site natural gas to generate their own power
Oldest facility came online in 1950, newest in 2016

Natural gas was responsible for 25.4 percent of the state's electricity generation in 2016.

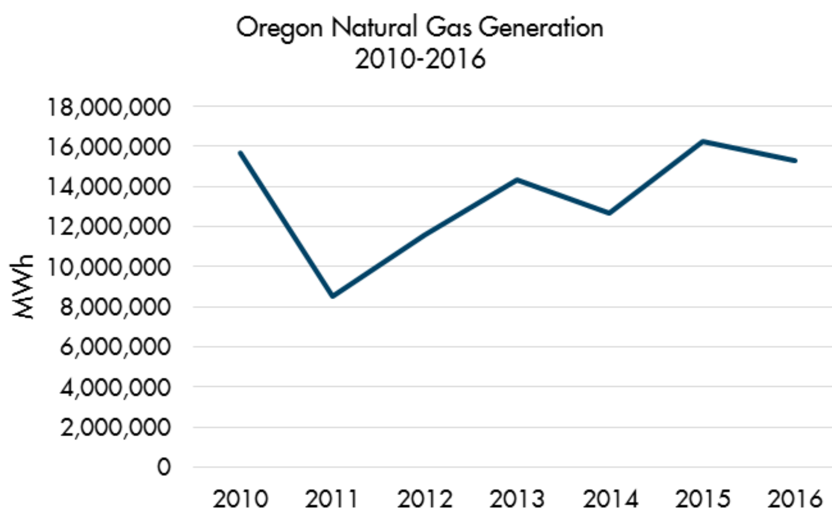
### Natural Gas in Oregon




Oregon has 20 operating natural gas-fired power plants, with 10 producing between 220 and 689 MW. The oldest plant is a 1.5 MW plant at the University of Oregon. The oldest plant generating more than 100 MW is Beaver 1 Plant, which began operating in 1974.

Oregon's natural gas plants operate in a variety of ways, with some operating at more constant output, and others operating less frequently to meet peak needs. Some of the plants are owned by Oregon utilities and provide electricity to those utilities' customers, while others generate electricity that is sold to out-of-state customers. Of the electricity generated by Oregon's natural gas plants, about 60 percent is exported to out-of-state users.

A key benefit of natural gas-fired power plants is their flexibility. Somewhat similar to hydropower plants, many natural gas plants can ramp output up or down quickly, a characteristic that is useful for integrating variable output from renewables. Electricity from natural gas plants has a lower carbon intensity than electricity from coal plants.




### Resource Potential

Electricity generated from natural gas in Oregon has increased 1,768 percent in 26 years. This parallels a broader national trend driven primarily by a reduction in cost resulting from increased natural gas production due to fracking across North America.

The Pacific Northwest's only natural gas production is at a location outside of the town of Mist, northwest of Portland. The facility is owned by NW Natural, and its production represents less than 0.5 percent of the state's natural gas use. The main purpose of the facility at Mist is underground gas storage to help align the seasonal mismatch between energy production and energy use for the region's natural gas and electric utilities. NW Natural pumps methane into the underground rock formations for direct use and electric generation during cold weather events, for electric generation during hot weather events, and to help balance additions and withdrawals to its pipeline system throughout the year. The North Mist facility, now under construction, will be used for quick dispatch of natural gas to PGE's Port Westward plant.

Oregon also has a coal bed methane site near Coos Bay. The site has been drilled and the substrate fractured to facilitate coalbed methane gas extraction, but it currently is not producing gas, nor is it connected to any intra or interstate pipelines.

## Environmental Effects

Extraction of natural gas has significant land use impacts, but very little natural gas extraction happens in Oregon. A significant impact of natural gas in Oregon is due to pipelines; land on top of buried pipelines can be used for agriculture but not for forestry. Pipeline installation and maintenance can disturb wetlands, riparian zones, and stream channels and cause habitat fragmentation. Pipelines and storage sites have the potential for methane leakage. Gas that leaks from pipelines, storage facilities, and production sites is referred to as fugitive methane. Some natural gas companies in Oregon have taken more advanced measures to reduce fugitive emissions of methane by lining their pipes with plastic and upgrading their control systems to reduce leakage. Combustion of natural gas for electricity generation or for thermal energy emits greenhouse gases, mainly carbon dioxide, with associated climate impacts.

# Proposed Energy Facilities

When a new energy facility is proposed in Oregon, it must be approved through the appropriate federal, state, or local regulatory process. The State of Oregon has permitting jurisdiction through the Energy Facility Siting Council (EFSC) for certain energy facilities defined in state law. These include:

- Thermal power plants above 25 MW.
- Wind or geothermal electric power generating plants with an average capacity of 35 MW.
- Solar photovoltaic (PV) energy facilities using more than 100 acres of high-value farmland or high quality soil or 320 acres elsewhere.
- Certain high voltage electric transmission lines.
- Certain natural gas pipelines and storage facilities.
- Nuclear installations.
- Synthetic fuel plants which convert biomass to a gas, liquid or solid product intended to be used as a fuel.
- Storage facilities for liquid natural gas.

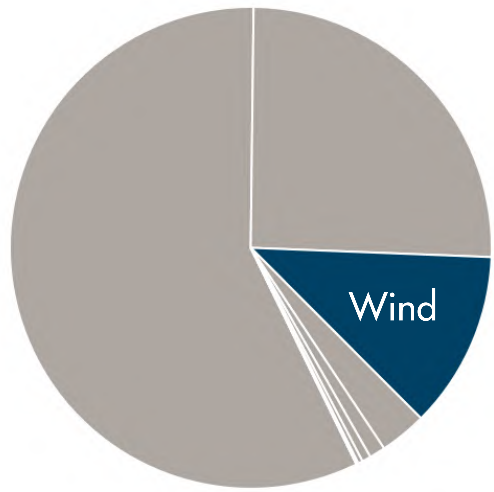
EFSC is made up of seven volunteer members who approve or deny an energy facility based on state standards applicable to each proposed facility. Oregon has 14 general standards that most proposed energy facilities must meet to receive approval for a site certificate, plus facility-specific standards. Standards cover issues such as land use, environmental impacts, noise concerns, cultural resources, and more. EFSC makes it decisions through a public process facilitated by the Oregon Department of Energy that includes multiple opportunities for public and other stakeholder engagement and input.

*References: 15, 28, 29, 30*

# WIND

3,383 MW of capacity
44 operating facilities, 1 spans Oregon and Washington state line
2,147 MW of additional capacity proposed, approved, or under review
Sites range from 1.6 to 300 MW
13 largest facilities make up 69% of total capacity
15 facilities, representing 590 MW, came online in 2009

Wind is the third largest electricity resource generated in Oregon—representing nearly 12 percent of Oregon's electricity generation in 2016.



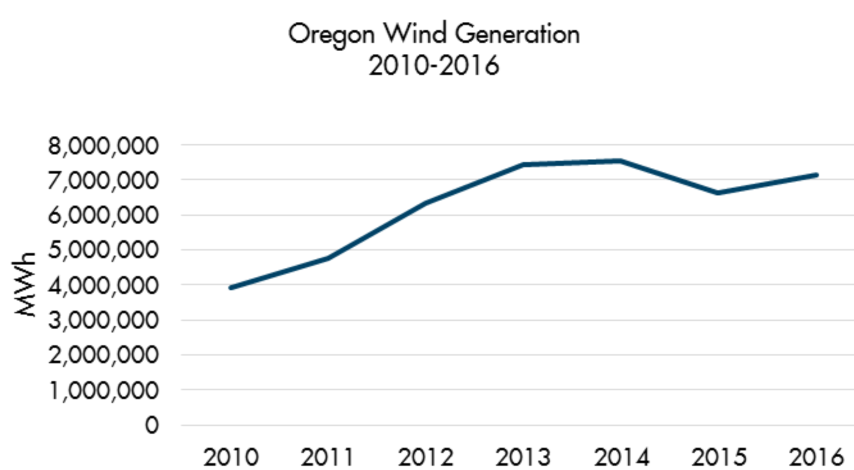

## Wind in Oregon

The development of wind energy projects in Oregon has occurred mainly on the Columbia River Plateau in north central Oregon, with additional development in eastern Oregon — both locations offer strong wind resources and proximity to segments of the electric transmission grid with available capacity.

Most wind projects consist of utility-scale wind turbines that each stand hundreds of feet in the air. Most of Oregon's wind generation capacity comes mainly from large-scale wind projects that supply power directly to the electric grid. Oregon has 34 wind projects of 10 MW or greater and another 10 facilities under 10 MW. Sherman County has 1,057 MW of capacity; Umatilla, Morrow, and Gilliam counties combined have 2,179 MW of capacity.

Large-scale wind projects have made a significant contribution to PGE's and PacifiCorp's ability to meet their Renewable Portfolio Standard (RPS) targets to date. With the increase of the Oregon RPS to 50 percent renewable energy by 2040 for these utilities, additional renewable projects, including wind, may be built in the state in the coming years.

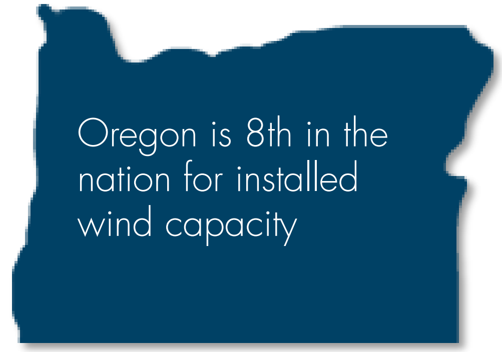
Among the key benefits of wind energy projects: the levelized cost of electricity from new projects is increasingly cost-effective compared to alternative resources. Additionally, wind projects have minimal ongoing costs, which should allow them to remain cost-effective during their operating lifetimes.



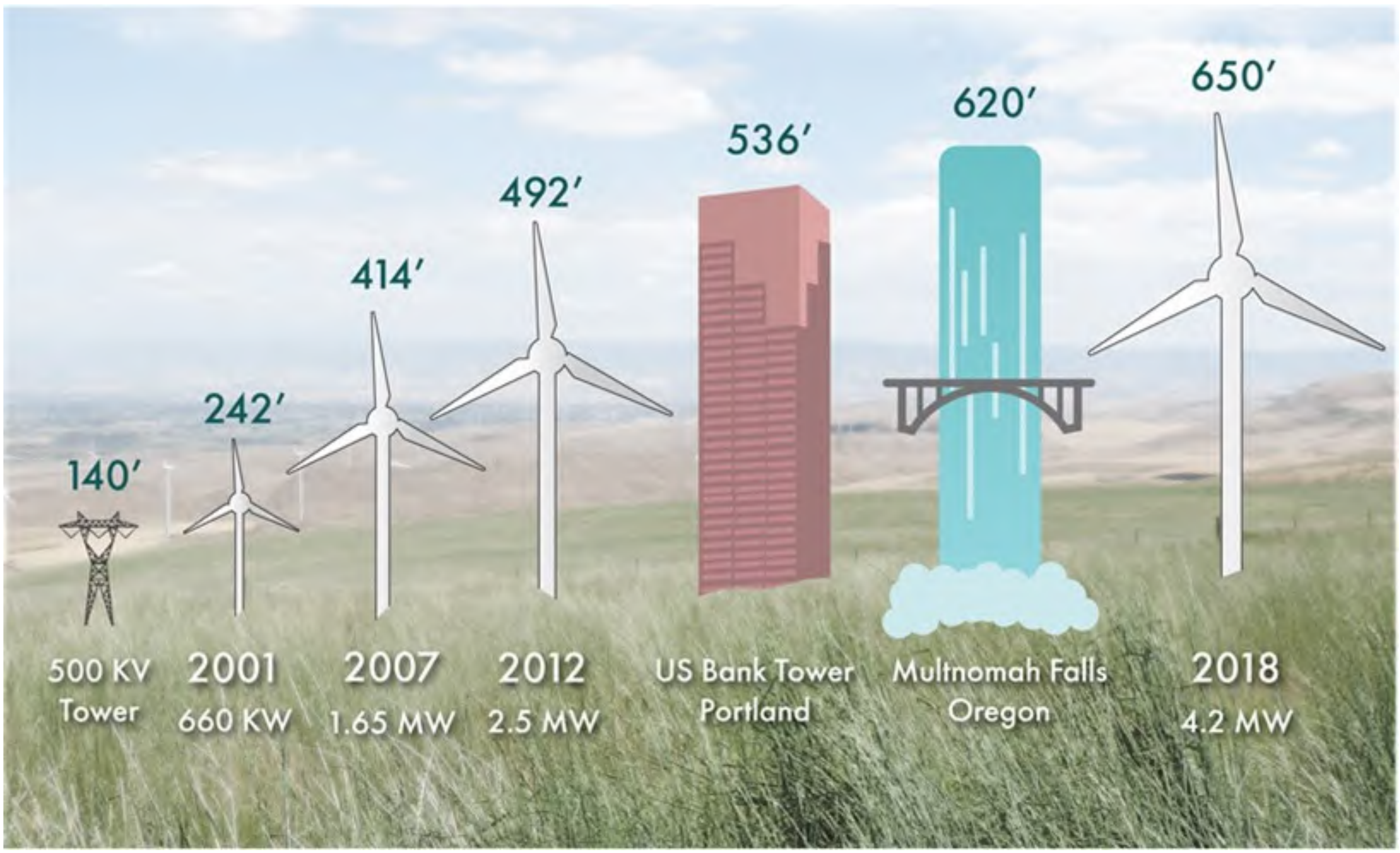

References: 1, 2, 9, 15, 23, 30

## Resource Potential

The most recent large-scale wind facility was completed in 2012. Oregon has significant undeveloped wind energy potential, including near the Cascades, in southeastern Oregon, and in coastal areas (both onshore and offshore). As noted above, transmission access can be a barrier and the development of major new wind resources may require significant transmission investments.




Some facility owners are evaluating whether to repower some older wind projects with new, larger turbines and longer blades to increase generation output. The graphic below compares different sized turbines operating or proposed in Oregon to notable landmarks.




## Environmental Effects

Wind energy projects are a zero-carbon emitting resource and have a low lifecycle carbon footprint associated primarily with the embedded GHG emissions from manufacturing and construction.

Wind turbines can cause collisions with birds and bats, although newer designs with slower blade speeds and the elimination of lattice towers have reduced collisions and fatalities. Wind turbines are often sited in dryland agricultural areas versus irrigated high-value farmland, and while some land is removed from production for turbine sites and access roads, ranching and farming can coexist with many wind energy projects.

*References: 1, 23, 27, 31, 32, 33, 34*

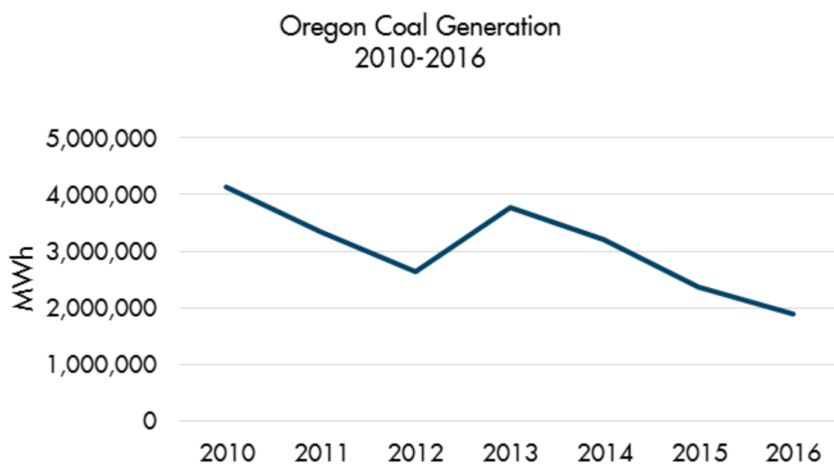
## COAL

601 MW of Capacity
1 operating facility
State authorization issued in 1975
Boardman facility due to cease coal operations by December 31, 2020

Of electricity generated in the state of Oregon, about 3 percent comes from coal.

## Coal in Oregon

Oregon's only coal plant is jointly owned by Portland General Electric (90 percent) and Idaho Power (10 percent). PGE operates the facility, which is located in Boardman. In 2010, Oregon's Environmental Quality Commission approved PGE's plan to end coal operations at the Boardman plant by December 31, 2020.




Oregon currently meets about one-third of our electricity needs through imports from out-of-state coal-fired power plants. With the passage of the "Clean Electricity and Coal Transition" bill (2016), imported electricity from coal plants will be eliminated from the rates of Pacific Power and PGE customers by 2035. Between now and then, Oregon will continue to see decreases in coal generation as coal-based electricity is gradually phased out of the resource mixes of Oregon's investor-owned utilities.

Historically, electricity from coal plants has been low cost relative to alternative sources. As a result, coal plants have tended to operate at a high capacity, near full output, much of the time.

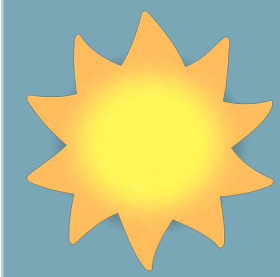
## Resource Potential

As noted above, coal use in Oregon will shrink over the next decade. Its use across the country continues to decline as well.

## Environmental Effects

Coal mining has large land use impacts in other states. Oregon is affected by air emissions from coal combustion that happens in Oregon and outside the state. Sulfur dioxide emissions from coal plants cause haze and acid rain, while deposition of atmospheric sulfur and nitrogen can cause chemical changes to water and soil. Water deposition of air-borne mercury from coal plants bioaccumulates in certain fish species and animals that prey upon them, and land deposition of mercury has been shown to accumulate in crops. Carbon dioxide and nitrous oxide emissions contribute to climate change.

*References: 1, 2, 5, 6, 15, 23, 31, 35, 37, 38, 39*

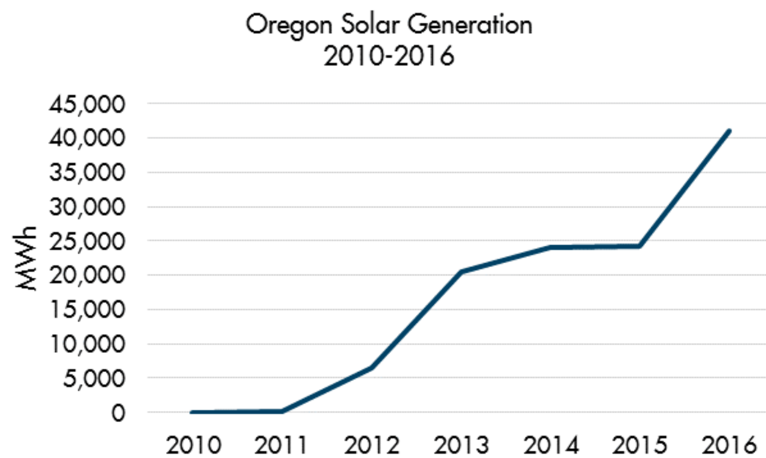


# SOLAR

296 MW of capacity for projects 1 MW or larger
More than 15,000 residential solar projects
Median number of residential solar projects by county: 114
First facility greater than 75 MW approved in 2018
685 MW of capacity proposed, approved, or under review

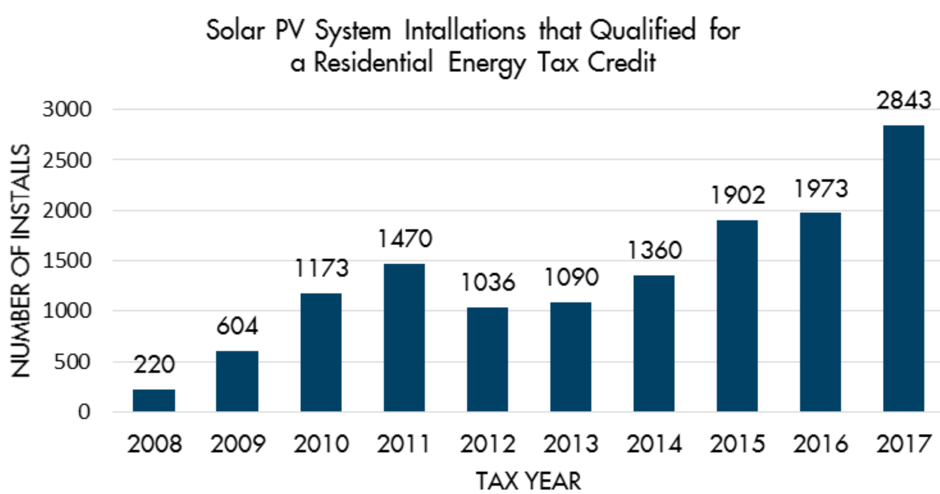
Solar photovoltaic systems make up a small percentage of electricity generation in the state — less than 1 percent. But our output has grown exponentially, and solar is growing at a faster rate than any other energy resource in the country.

## Solar in Oregon




*The chart above shows solar generation from facilities over 1 MW through 2016. Oregon's output in 2017 and beyond has grown dramatically over this data, and future reporting will include solar rooftop and smaller commercial generating facilities.*

In 2017, solar was the third largest source of renewable energy in the United States after hydropower and wind power. In Oregon, total solar capacity at the end of 2017 also included 70 MW from more than 15,000 residential solar PV systems and more than 40 MW from commercial projects. The 56 MW Gala solar project in Prineville is located on over 300 acres of rangeland and is currently the largest solar project in the state. By comparison, California has installed solar capacity in excess of 20,000 MW.




*Residential solar projects are increasingly common. This chart shows installations per year under the state's residential energy tax credit program.*

Solar is available on unshaded sites across the state, including individual customer sites such as residential or commercial rooftops. As a result, many solar PV projects in Oregon, as elsewhere, are located at customer sites and are commonly called "behind-the-meter" solar. Most of these projects are designed to serve on-site demand when the systems are generating and then to export excess to the grid. These type of solar projects are widely distributed across the state.

*References: 1,2, 15, 19, 23, 30, 40, 41, 42*

Larger solar PV projects (typically in excess of 1 MW) that do not directly serve on-site customer demand and that export to the grid are referred to as utility-scale projects. These systems are typically ground-mounted, and in Oregon, most of these projects are located east of the Cascades.

## Resource Potential

Solar PV is a mature technology that's likely to expand in the coming years. Solar energy technologies work throughout Oregon and generate electricity in all parts of the state, but given Oregon's variable climate, the output of solar facilities varies depending on location. The solar resource east of the Cascades is typically 30 to 40 percent greater than the Willamette Valley or coast, although even the Oregon Coast has a resource potential on par with Germany, which is a global leader in solar generation.

Most residential solar PV projects are installed in the Willamette Valley. While a large majority of utility-scale projects to date have been located east of the Cascades, more are being proposed on the west side. As solar PV costs continue to fall, Oregon has the potential to see a dramatic increase in solar development across the state. The number of recent applications to install solar PV projects and interconnect to the grid suggests that generation from solar PV projects in Oregon is likely to continue to grow in the coming years.

## Environmental Effects

Solar PV projects are zero-carbon emitting resources that have a low lifecycle carbon footprint associated primarily with the embedded GHG emissions from manufacturing and construction.

Solar PV projects can have a large physical footprint that may impact wildlife habitat and remove farm lands from agricultural production. The majority of Oregon's utility-scale solar PV projects are installed on un-irrigated rangeland, and the state's energy facility siting laws are designed to protect wildlife habitat and farmland. The Oregon Department of Land Conservation and Development is undertaking a rulemaking related to solar PV projects proposed for siting on high-value or irrigated farmland. The Oregon Energy Facility Siting Council has also established a rulemaking advisory committee for large-scale solar facilities.

# Energy Jobs

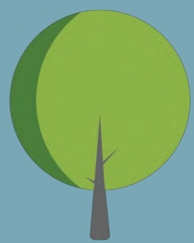
Oregon's diverse energy generation, efficiency, and manufacturing industries require a diverse workforce. The *U.S. Energy and Employment Report*, issued earlier this year by the National Association of State Energy Officials, included figures for energy-related employment in Oregon.

Nearly 26,500 Oregonians work in the electric power generation, fuels, or transmission/distribution/storage fields. Of those, more than 6,000 work in the solar industry, while another 1,500 work in hydroelectric generation. Just under 1,300 Oregonians work in the wind industry.

Nearly 42,000 Oregonians work in the energy efficiency sector. Around 25,000 of these jobs are in the construction industry, with another 7,200 in manufacturing.

Transportation fuels represent more than a third of the state's energy use. The report also highlights the more than 25,800 Oregonians who work the motor vehicles sector.

*References: 43, 44, 45, 46, 47, 48, 49*



# WOOD AND OTHER BIOMASS

331 MW of capacity
36 operating facilities
Facility capacity ranges from .2 MW to 51.5 MW
Facilities are in 16 Oregon counties
Oldest came online in 1936, newest in 2015

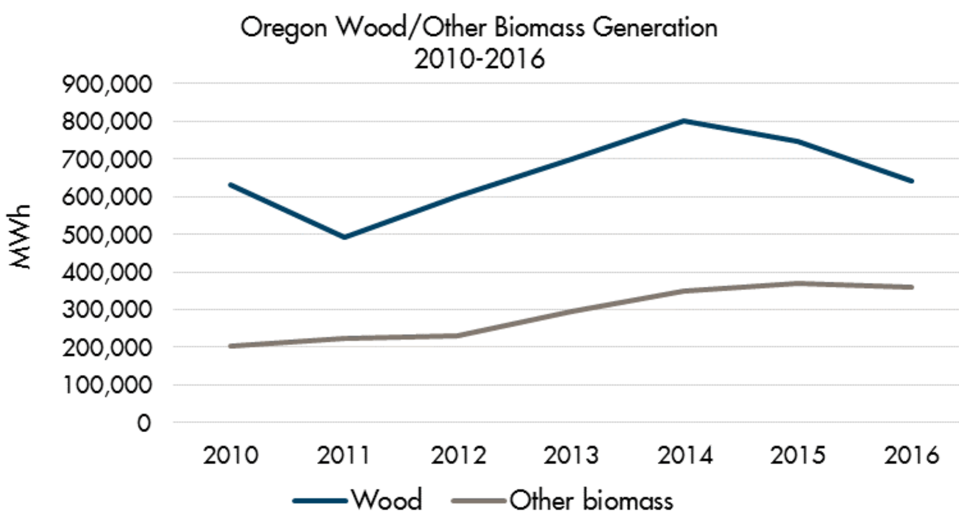
Electricity generated from wood and other biomass fuels amounts to around 1.7 percent of Oregon's annual generation. Materials used to generate electricity include wood such as lumber mill residue and logging slash, animal manure, food waste, landfills, and waste water.

## Wood and Biomass in Oregon

In Oregon, wood is the most common source of biomass-based electricity generation. Direct-fired combustion is the most common method for generating electricity from woody biomass. This process involves burning the woody biomass in a boiler to generate steam, which turns a turbine to generate electricity. Biomass plants are typically sized less than 50 MW. It is often not cost effective to collect and haul the biomass feedstock necessary to sustain a larger plant due to the high costs of collection and transportation. In 2016, 641,447 MWh of electricity was generated in Oregon from wood and wood-derived fuels; 75 percent of that was from industrial combined heat and power facilities – mostly pulp and paper or lumber mills.

## Resource Potential

An inventory recently completed by the Oregon Department of Energy looked at six organic material pathways and found that they could be used to generate energy equivalent to 49 trillion Btu, or about 5 percent of Oregon's total energy needs.




## Environmental Effects

Biomass-based energy that replaces fossil fuels can reduce some greenhouse gas emissions, criteria pollutants, and air toxins. Direct combustion of wood can emit significant quantities of GHGs and air pollution contaminates depending on the equipment used. Thermal gasification of organic waste has the potential to reduce air pollution due to changes in how the raw materials are used. Removing some level of logging by-products and thinning some small diameter trees from the forest could reduce the intensity of catastrophic wildfires.

References: 1, 2, 15, 20, 23, 50, 51, 52

# BIOGAS AND RENEWABLE NATURAL GAS

51.1 MW of Capacity
25 Operating Facilities
10-20% of state's total yearly use of natural gas could be replaced by RNG if potential is realized

Some Oregon facilities currently generating biogas simply flare the biogas, while others burn it in a special internal combustion engine that is connected to a generator that produces electricity. Those facilities either consume that electricity on-site or sell it onto the grid through a Power Purchase Agreement with an electric utility. Another option is emerging in Oregon: cleaning up biogas to meet natural gas pipeline quality standards – at which point it is called Renewable Natural Gas (RNG) – and then injecting it into an existing natural gas pipeline. The RNG can be sold as either a direct use stationary fuel or as a transportation fuel.

## Biogas and Renewable Natural Gas in Oregon

Oregon recently quantified opportunities to convert persistent, long-term waste streams into useful energy as biogas and RNG. Municipal waste streams — garbage, wastewater, and waste food — and agricultural waste streams like manure, all generate methane, a powerful greenhouse gas. Redirecting these waste streams into controlled processes can capture and use the methane, reducing greenhouse gas emissions and air pollutants when the resulting RNG is substituted for fossil fuels in our transportation and stationary fuels sectors. If Oregon's potential volume of RNG could be captured and used to displace fossil-based natural gas for stationary combustion, we would prevent the release of approximately two million metric tons of greenhouse gases into the atmosphere. Redirecting this fuel source into these sectors can also potentially result in increased economic opportunity, and provide energy security and resilience for Oregon communities.

## Resource Potential

The gross potential for RNG production when using anaerobic digestion technology is around 10 billion cubic feet of methane per year, which is about 4.6 percent of Oregon's total yearly consumption of natural gas. The gross potential for RNG production when using thermal gasification technology is nearly 40 billion cubic feet of methane per year, which is about 17.5 percent of Oregon's total yearly use of natural gas. While there are technical and regulatory barriers to overcome, these waste streams represent an opportunity for Oregon to produce between 10 and 20 percent of our current conventional natural gas consumption with locally produced, low carbon renewable natural gas.

## Environmental Effects

Greenhouse gas emissions and air pollutants can be reduced when RNG is substituted for fossil fuels in the transportation market or used instead of traditional natural gas in applications like heating, cooking, or commercial and industrial processes. Improved water quality can result from different management practices of the wastes used to generate biogas and RNG. Air pollution reductions can result from using RNG as a substitute for diesel in the transportation market. RNG produces about 30 percent less air pollution and 30 to 40 percent fewer GHG emissions.

*References: 20, 53*

# GEOTHERMAL

33 MW of capacity
99 MW of planned capacity
3 facilities; the largest is 28.5 MW
Also used as a direct use fuel for heating

Geothermal energy makes up less than 1 percent of Oregon's electricity generation.

## Geothermal in Oregon

The state's first geothermal power plant began operating in 2010 at the Oregon Institute of Technology in Klamath Falls, with an initial electricity-generating capacity of 280 kW. A second plant at OIT generates 1.2 MW of power. In 2012, a 28 MW geothermal power plant near Vale came online. Additional geothermal opportunities are being explored at Crump Geyser and Glass Butte in Lake County and at Newberry Crater.

Geothermal power plants have the unique ability to provide near constant carbon-free output all year, compared to more variable output renewables such as wind and solar. Geothermal energy is also used in direct heating applications, displacing conventional natural gas and electricity consumption. See page 36 for additional information.

## Resource Potential

Geothermal resources are reservoirs of hot water that exist at varying temperatures and depths below the Earth's surface. Mile-or-more-deep wells can be drilled into underground reservoirs to tap steam and very hot water that can be brought to the surface for use in a variety of applications. In the United States, most geothermal reservoirs are located in the western states, and Oregon has one of the best geothermal resources in the country. The U.S. Geological Survey's Assessment of Moderate and High Temperature Geothermal Resources of the United States identified 595 MW of high probability capacity in Oregon from conventional geothermal resources.

The same report also identified more than 43,000 MW of potential capacity in Oregon from enhanced geothermal systems (EGS). EGS requires the injection of high-pressure water to modify subsurface conditions to enhance flow and permeability. While the potential to develop EGS in Oregon is significant, the technology is still in the research and development phase, and the U.S. Department of Energy has targeted 2030 for commercialization of the technology.

## Environmental Effects

Geothermal power projects are zero-carbon emitting resources that have a low lifecycle carbon footprint associated primarily with the embedded GHG emissions from manufacturing and construction. These projects typically have small footprints and localized land impacts. Geothermal energy generation typically involves extracting and then reinjecting groundwater, but can require the use of additional water.

*References: 15, 23, 28, 54*

# ENERGY STORAGE

10 MW of capacity
2 facilities with approximately 5 MW of capacity each
Another 150 MW currently approved or under review
Technology types include pumped storage and battery storage

While not an electricity generating resource, energy storage holds great promise for Oregon. This section addresses emerging technologies that are intended to convert electricity—often surplus, carbon free electricity—into another form of storable energy for use at a more optimal time.

## Use in Oregon

Portland General Electric's Salem Smart Power Center—a 5 MW (1.25 MWh) battery energy storage system deployed in 2013—was one of the first utility-scale, grid-connected battery energy storage systems in the U.S. Since that time, the adoption of HB 2193 (2015) made Oregon the second state in the nation to require investor-owned electric utilities to deploy energy storage systems. PGE and PacifiCorp recently submitted proposals for new battery energy storage systems to the PUC.

Energy storage systems deliver a wide range of benefits. These systems can capture surplus carbon-free generation during times of the day or year when more electricity is being generated than can be consumed at the time. These systems can help maintain grid stability and allow utilities or individual customers to take advantage of lower prices during certain parts of the day. Finally, some of these systems play a key role in helping to provide resilient back-up power. As costs for lithium-ion battery systems have declined, Oregonians have shown interest in distributed battery systems.

## Resource Potential

Costs for different types of energy storage technologies continue to fall. The deployment of specific types of energy storage systems will depend on the particular benefits they provide. For example, while battery storage systems are more scalable and can offer resilience benefits to customers, other types of energy storage systems (such as pumped storage hydro or power-to-gas) might deliver more value in the form of benefits to the bulk power system or in being able to meet longer duration needs for energy storage.

## Environmental Effects

Characterizing the environmental effects of energy storage systems is challenging given the wide range of different technologies. The development of lithium-ion battery systems, for example, requires the mining and extraction of lithium and other rare earth metals with associated land impacts. There are also potential concerns about battery disposal after systems' storage capabilities are exhausted. Other types of energy storage systems, like pumped storage hydro or power-to-gas conversion, may require the availability of large amounts of water to operate.

*References: 23, 30, 55, 56, 57, 58*

# MARINE ENERGY

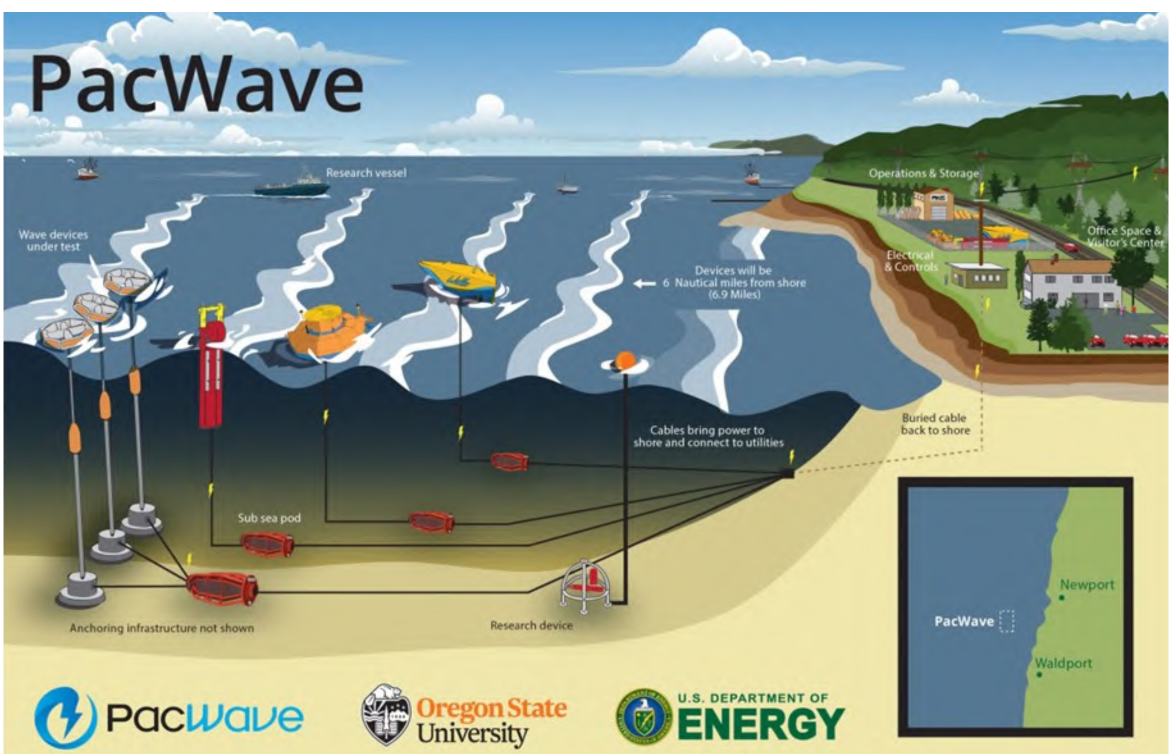
Emerging technology
2 test sites: 1 operating and 1 under development
Excellent resource potential off of Oregon coast

Marine energy encompasses both wave power – i.e., power from surface waves – and tidal power, which is obtained from the kinetic energy of large bodies of moving water. Oregon's coast has among the best marine energy resources in the world, making it an ideal location for developing marine energy.

## Use in Oregon

While there are no marine energy projects yet in commercial operation in Oregon, the state is a global leader in the research and development of these technologies. These efforts have been led by Oregon State University, which received a $40 million award from U.S. DOE in 2016 to develop a utility-scale, grid-connected marine energy test site. That award followed an earlier $4 million award from U.S. DOE in 2012, which established two test sites as part of the Pacific Marine Energy Center.

The North Energy Test Site is located two nautical miles from shore, north of Newport, and is not grid connected. The site tests wave energy devices that are connected to the Ocean Sentinel buoy, which collects data on the devices and is powered by the electricity generated from the attached wave energy device. The site measures power generated and characteristics of the wind, waves, and current.




The South Energy Test Site, rebranded in September 2018 as PacWave, is currently under development as the first grid-connected wave energy test site in the United States. PacWave is located five nautical miles off shore between Newport and Waldport. Oregon State University submitted its Draft License Application and Preliminary Draft

Environmental Assessment for the PacWave site to Federal Energy Regulatory Commission in April 2018. Pending approval of U.S. DOE funding from Congress, PacWave is expected to be operational by 2020 and will be able to test utility-scale wave energy devices in the ocean. These wave generators will be connected via subsea cable to the Central Lincoln PUD electric grid. This site will enable four separate wave energy devices to be tested simultaneously.

While marine energy projects are not yet in commercial operation, they have the potential to support Oregon's existing power resources. Marine energy projects can provide more constant power output than wind or solar resources. Wave energy output is strongest during the winter months, which coincides with peak electricity demands in Oregon and complements other carbon-free resources (e.g., hydro peaks in spring, while solar peaks in summer).

## Resource Potential

According to the Electric Power Research Institute, total annual technical potential from Oregon's wave energy resource is 143 billion kWh per year, or enough energy to power more than 13 million homes. Currently, the high costs of these technologies compared to other generating sources, combined with limited transmission access in costal Oregon, are the primary barriers to the cost-effective development of this potential resource.

## Environmental Effects

Marine energy projects would be zero-carbon emitting resources and are expected to have a low lifecycle carbon footprint associated primarily with the embedded GHG emissions from manufacturing and construction. Wave energy devices being developed come in various shapes and sizes; they can be fully or partially submerged, anchored or float, or affixed to a dock or jetty. Wave energy devices can be integrated into the natural landscape so they do not cause a negative visual effect from shore. Research to evaluate the potential impacts—both positive and negative—on marine life from the operation of these devices is ongoing.

# Federal and Local Energy Facility Permitting

How energy facilities are reviewed and authorized at the state level was briefly discussed on Page 24. For other types of facilities—such as interstate petroleum and natural gas pipelines and liquefied natural gas export terminals — the federal government may have permitting authority. Federal projects are subject to the National Environmental Protection Act. Key agencies may include the **Federal Energy Regulatory Commission**, an independent agency that regulates the interstate transmission of electricity, natural gas, and oil, and licenses hydropower projects; **federal land management agencies** such as the **Bureau of Land Management** and the **U.S. Forest Service**, which own and manage large amounts of land in Oregon; and the **Bonneville Power Administration**.

Facilities that are not under exclusive federal jurisdiction and that do not meet the definition of "energy facility" for state jurisdiction are subject to review and approval by the local jurisdiction where the facility is proposed. For example, wind facilities with average capacity under 35 MW are reviewed by county commissions.

*References: 60, 61, 62, 63, 64*

# Direct Use Fuels Production in Oregon

Oregon currently produces only small amounts of direct use fuels.

## Production in Oregon

**Natural Gas**: The Pacific Northwest's only natural gas field is located in Mist, northwest of Portland. The field is owned and operated by NW Natural. The Mist field produced about 801,491,000 cubic feet of natural gas in 2016, which represents less than 1 percent of Oregon's annual use. Mist's main purpose is gas storage. NW Natural pumps methane into the underground rock formations for use during cold weather events and to help balance additions and withdrawals to its pipeline system.

**Solar Thermal**: See page 15 for more details.

**Geothermal Energy**: Often used in direct heating applications, displacing conventional natural gas and electricity consumption. For decades, the city of Klamath Falls has used geothermal heat sources to heat buildings, residences, pools, and even sidewalks. In Lakeview, a geothermal well system is now being used to heat school properties and hospital buildings. Other examples of direct use of geothermal heat in the state include drying agricultural products, aquaculture (raising fish), heating greenhouses, and heating swimming pools.

**Wood Pellets**: In Oregon, residual material from forest harvest and mill operations is frequently converted into wood pellets to be used for residential and commercial heating. In 2016, an estimated eight Oregon companies produced about 250,000 tons of pellets per year.

**Charcoal Briquettes**: Oregon is home to one of the largest charcoal briquettes plants in the western United States. The plant produces around three billion briquettes per year. The source of their raw material is waste wood from local saw mills.

**Renewable Natural Gas**: Five locations in Oregon are currently taking steps to convert the biogas they produce into RNG and inject it into a natural gas pipeline. Once in the pipeline, the RNG can be used as a stationary fuel or a transportation fuel. It is estimated that the five locations could potentially produce about 1.6 billion cubic feet of RNG per year.

## Environmental Effects

Many of these energy sources are generated from waste streams. Natural gas, wood pellets, charcoal briquettes, and RNG are all combusted in order to release their stored energy, and in that process release carbon dioxide and some levels of other greenhouse gases and air pollutants. The carbon dioxide intensity depends on the amount of processing it takes to convert the waste material into a useful energy source. Due to needed change in how some of the waste streams are managed in order to convert them into a useful fuel, there may be reductions in air and water pollution.

*References: 1, 15, 20, 23, 66*

# Transportation Fuels Production in Oregon

Less than 2 percent of transportation fuel used in Oregon was produced in the state in 2016. The majority of this in-state production was ethanol and biodiesel. The Oregon Department of Energy recently completed an inventory of the state's opportunities to produce renewable natural gas from waste water treatment plants, landfills, and dairies. This market is still developing. Electricity is also a growing source of transportation fuel, and much of that can be produced in the state as well. For more on electricity as a transportation fuel, see chapter 4.

## Use in Oregon

**Ethanol**: Oregon has one commercial ethanol producer. The Columbia Pacific Ethanol production plant in Boardman is the largest transportation fuel producer in the state. The plant produced 37.5 million gallons of ethanol in 2017, which was sold to terminals in Portland and Eugene. The plant also produced 285,000 tons of livestock feed and more than eight million pounds of corn oil used at feed lots and for poultry feed. Carbon dioxide emissions from the plant are used by a neighboring company, Kodiak Carbonic, that turns the emissions into a beverage-grade liquid used to carbonate soft drinks and make dry ice.

**Biodiesel**: SeQuential Pacific Biodiesel is the second largest producer of transportation fuels in Oregon. SeQuential produces biodiesel from used cooking oil from local restaurants and businesses. The company's plant in Salem produced 7.7 million gallons of biodiesel in 2016 and 8.5 million gallons in 2017. SeQuential says it is on track to increase production by another 40 to 50 percent by the end of 2019. About 85 percent of the fuel is sold in-state as part of a biodiesel blend, while the remainder is exported to Washington, California, Hawaii, and British Columbia.


**Renewable Natural Gas**: This emerging biofuel has potential to displace some transportation fuels. See previous page for details.

## Environmental Effects

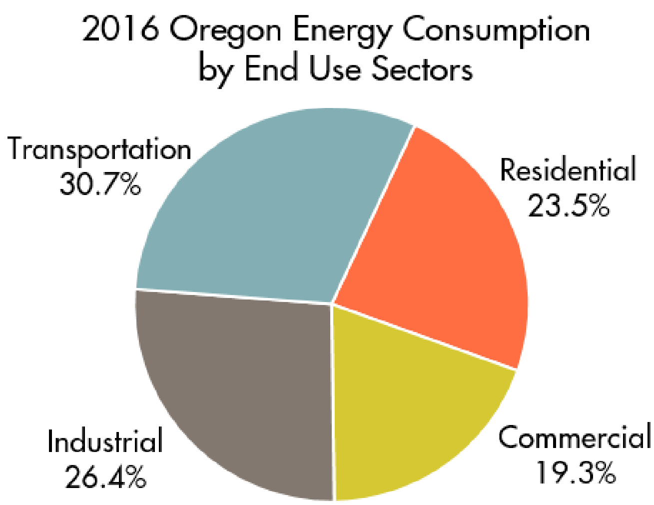
Transportation fuels move through Oregon by pipeline, rail, barge, and truck, all of which have associated risks of spilling and leaking onto land and water. The combustion of fossil fuels for transportation emits pollutants such as carbon monoxide and volatile organic compounds, particulate matter, and air toxics such as benzene and formaldehyde, all of which have significant impacts on human health and wildlife. Fossil fuel combustion also causes significant greenhouse gas emissions, mainly carbon dioxide and nitrous oxide, with associated climate impacts. Most transportation fuel sold in Oregon is blended with either ethanol or biodiesel, which is predominantly made from crops grown outside of the state with localized environmental impacts.

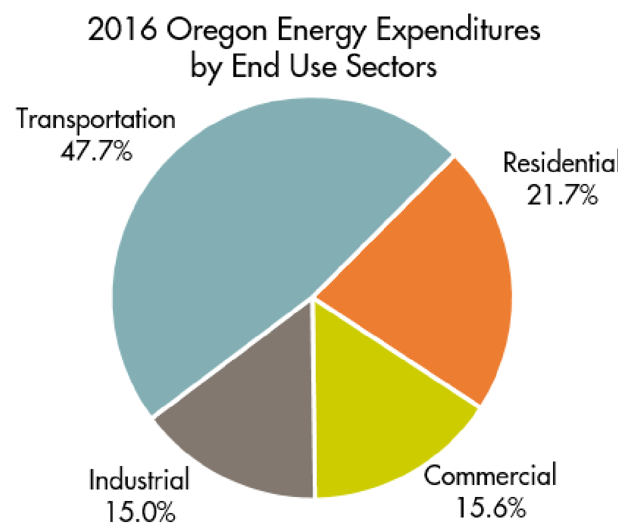
*References: 21, 67-71*

# Energy Sector Profiles

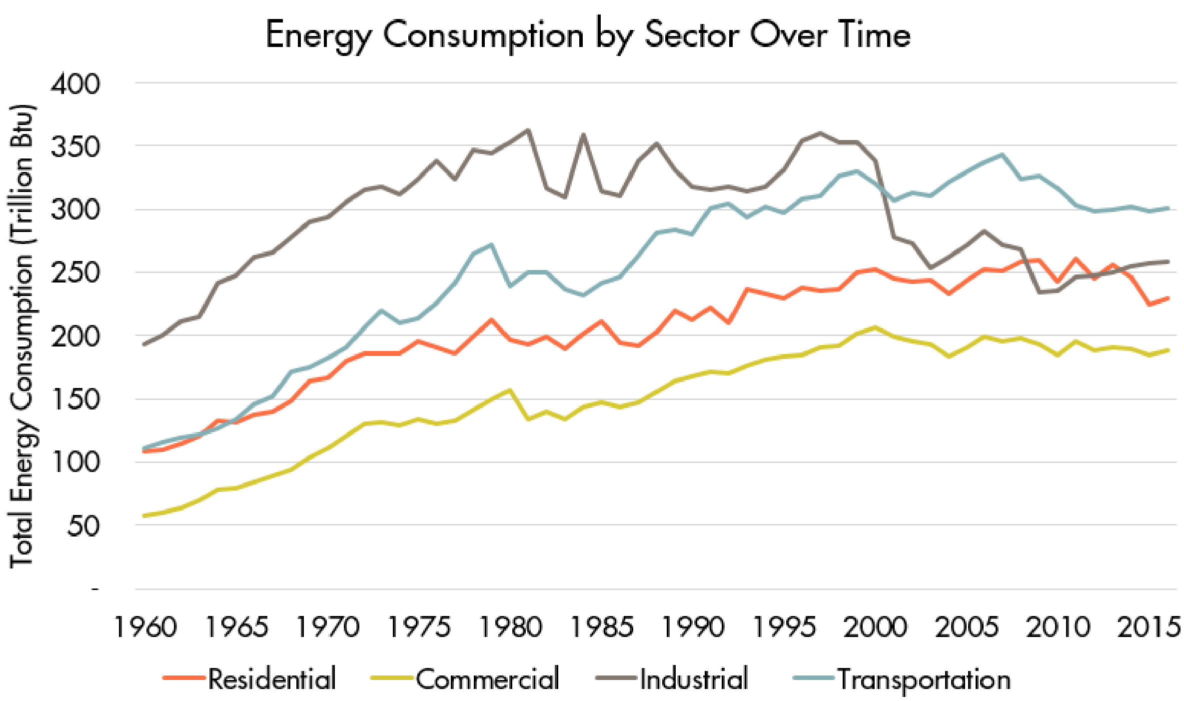
## Energy is commonly divided into four end-use sectors: Residential, Commercial, Industrial, and Transportation.

**Consumption and cost of energy** for each sector varies. For example, while transportation represents about 31 percent of energy consumption, it accounts for almost half the expenditures due to higher per-unit cost of transportation fuels.




**Sector energy consumption** for residential, commercial, and transportation has remained fairly steady in recent years. The industrial sector saw consumption decrease in Oregon around 1999. Learn more on the following pages.



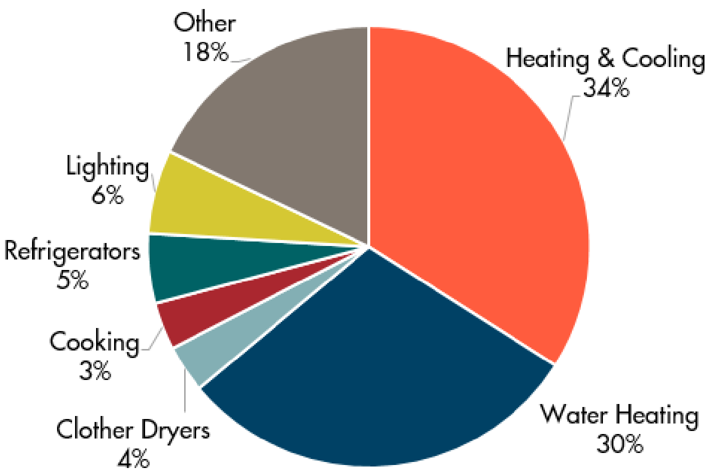

References: 1, 2

# Oregon's Residential Sector

23.5%

**Residential sector's share of total energy use in Oregon**

**Residential Sector:** Homes, apartments, and other structures used for housing people. In the Pacific Northwest, energy — from all sources, including electricity, natural gas, or other fuels — is used for heating, cooling, and other residential needs:




**1,768,494** homes in Oregon

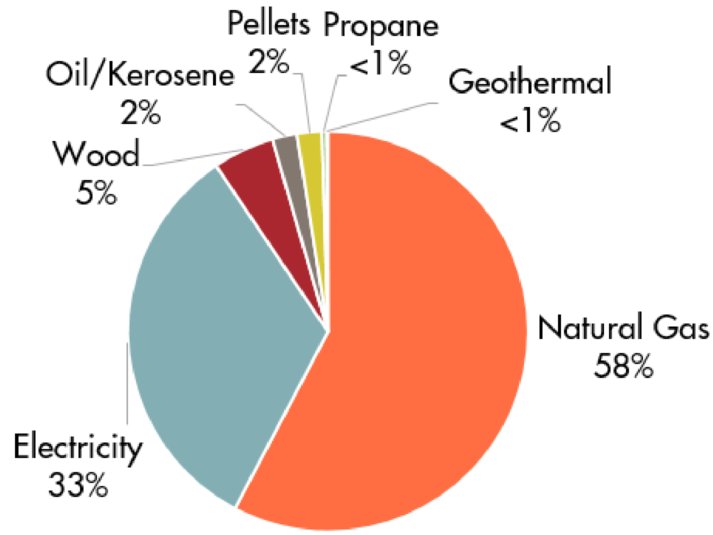
77% single-family | 23% multi-family

**17,600** average annual new residential building permits

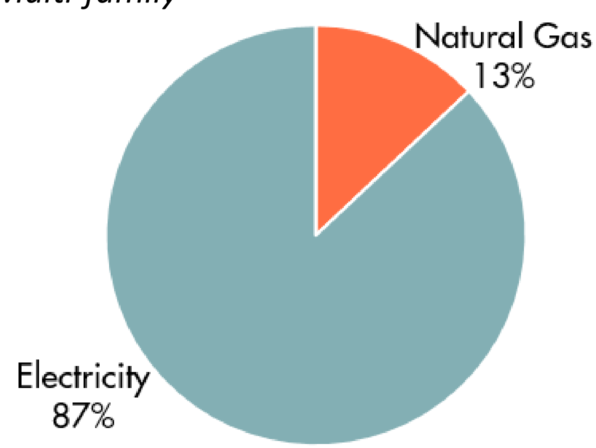
56% single-family | 44% multi-family

**Nearly 50 percent of Oregon homes use electricity for heating. Natural gas is also a popular heating fuel, especially in newer single-family homes.**

*Single-family*




*Multi-family*




8th

**Oregon's national ranking for lowest per capita residential energy use**

8.8%

**Percent decrease in residential energy use since 2000**

**Heating and cooling** uses the most energy in Oregon homes. Common appliances are central furnaces or boilers, individual devices like baseboard heaters or AC units, or mini-split heat pumps.

*References: 1, 2, 18, 72, 73, 74*

## Water Heating

A majority of single-family home water heaters are gas or electric storage heaters. Large multi-family buildings are more likely to have central water heating. While increasing, only a small number of heaters are tankless or heat-pump style.

## Lighting

Since 2012, the use of efficient LED home lighting use has increased 17 percent, while incandescent and fluorescent lighting decreased (44 percent and 7 percent).

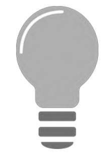
## Appliances and Electronics

Energy-intensive appliances include refrigerators, clothes dryers, and devices like TVs and related electronics. Many of these still consume energy when not in use.

## Trends in Home Energy Use

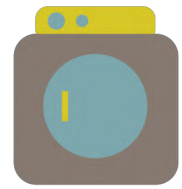
Increased Solar PV

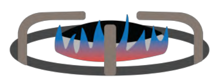
Adoption of LED lighting




"Smart" devices, like thermostats and lights

Many homes have appliances past their useful life





Using gas for primary heating, water heating, and cooking

6,600

**Number of Portland homes scored through Oregon's Home Energy Score program, which evaluates home performance and energy savings**

## Oregon's Residential Energy Code

Year-over-year improvements to Oregon Energy Code:

| 2008 | 2011 | 2017 |
|---|---|---|
| 15% | 10% | 6% |

2017 energy code changes expected to save more than **$750,000**/year in consumer energy costs.

*References: 13, 72, 75, 76, 77*

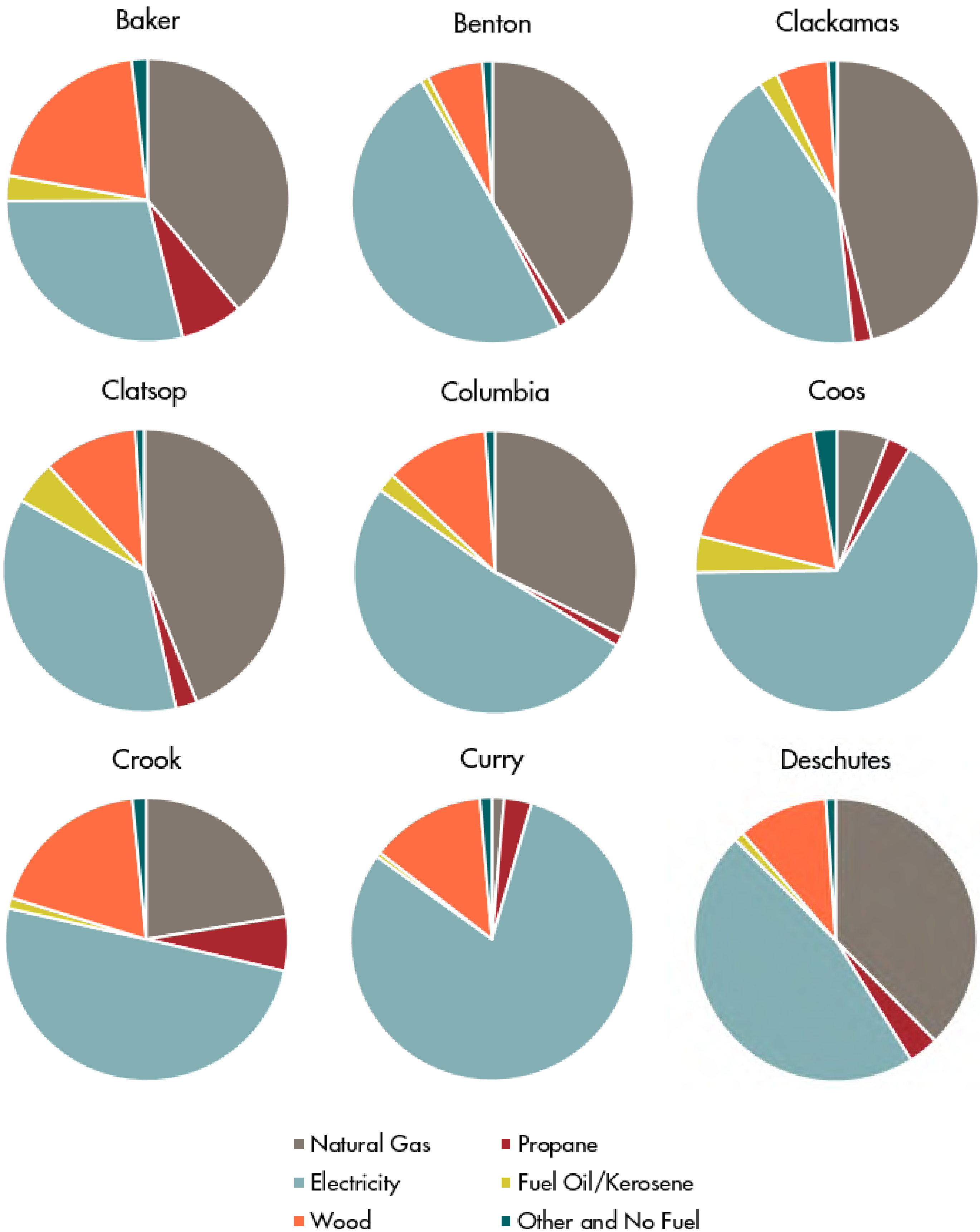
**Energy performance** is measured by comparing a home's annual energy use to its size, and depends on a home's construction, equipment, location, and how its occupants are using energy.

Financial incentives for homeowners and landlords, improved residential code and appliance standards, and home energy scoring all help Oregon's housing stock — and its residents — improve energy performance.

Portland now requires Home Energy Scores to be included in real estate listings to increase transparency for homebuyers and renters. Learn more in chapter 6.

# Residential Sector

## How Oregonians Heat Their Homes

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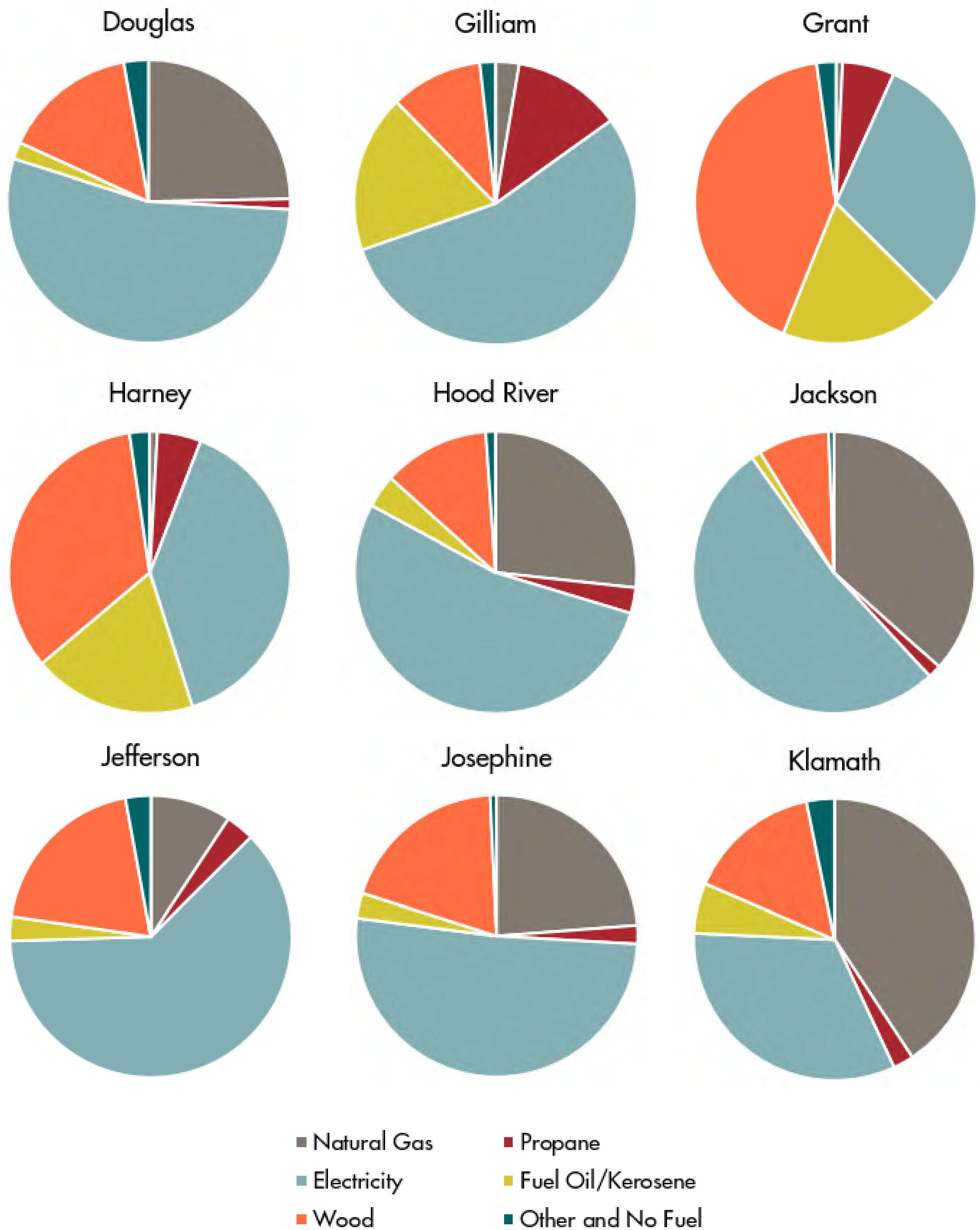
# Residential Sector

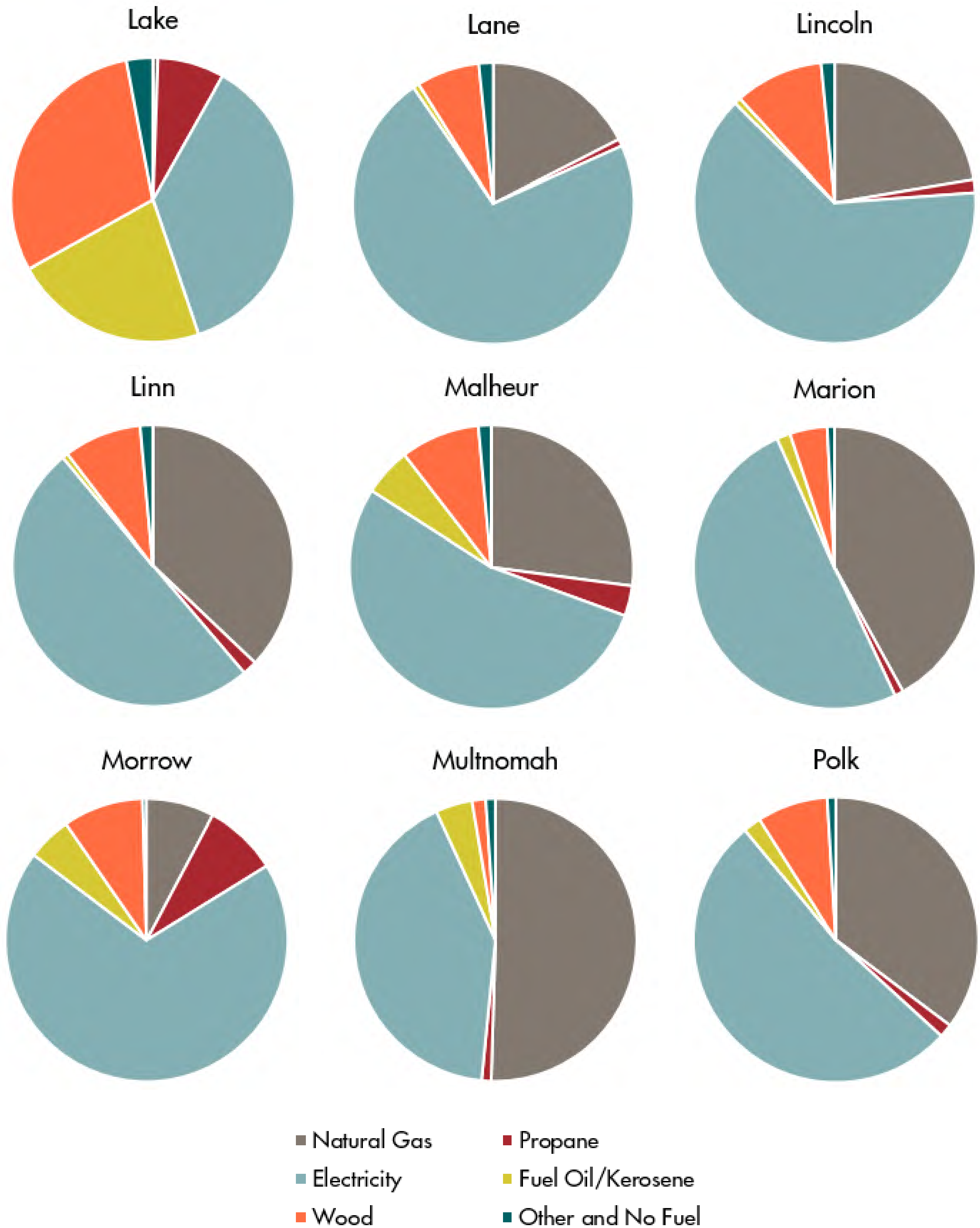
## How Oregonians Heat Their Homes




References: 78

# Residential Sector

## How Oregonians Heat Their Homes

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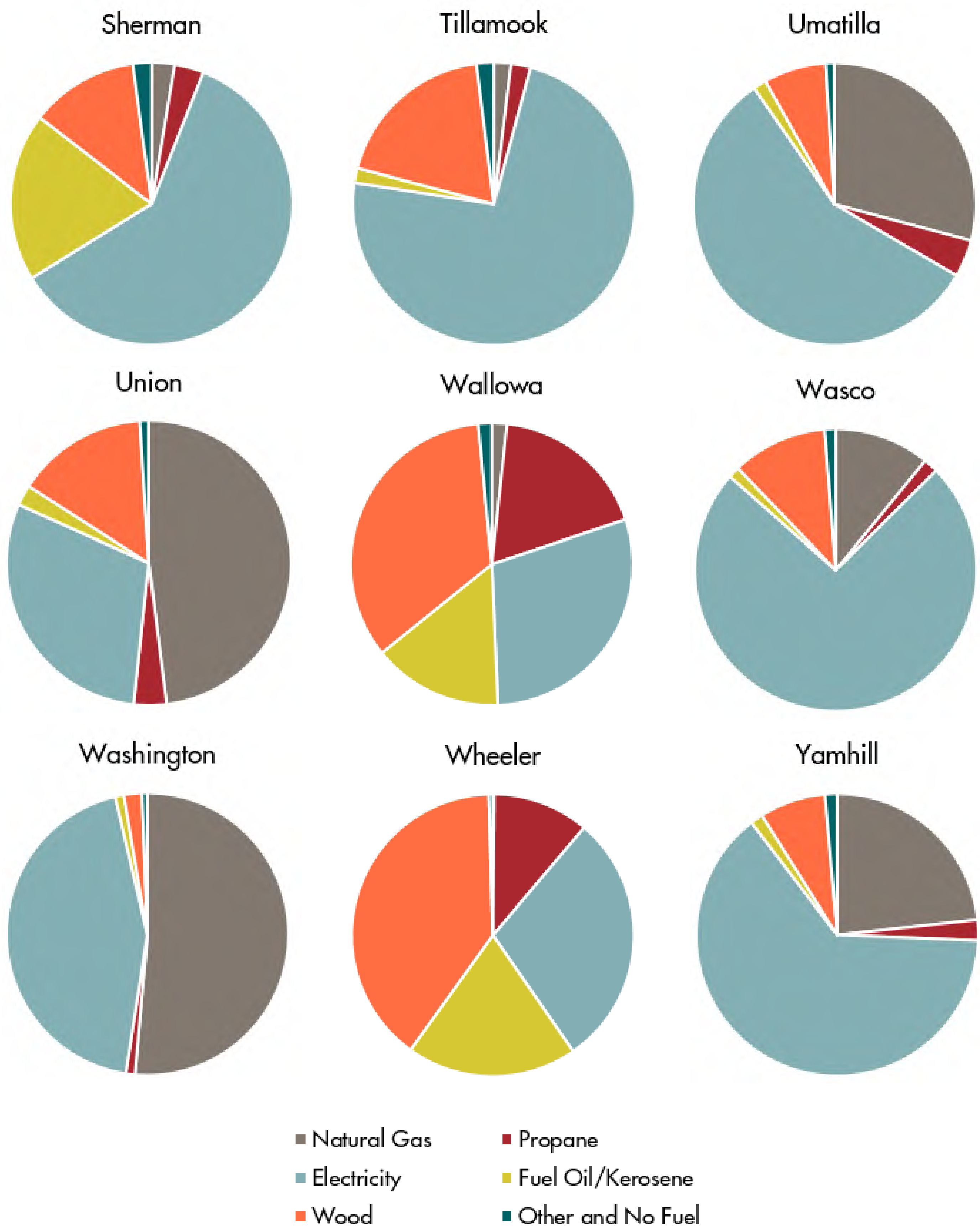
# Residential Sector

## How Oregonians Heat Their Homes



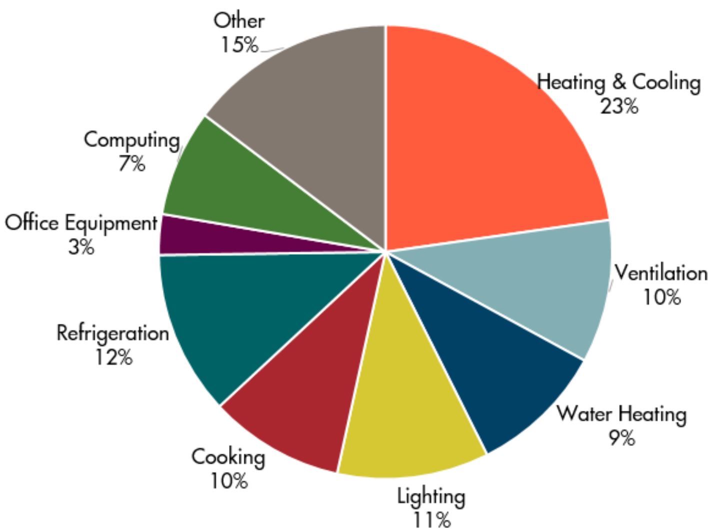

References: 78

# Oregon's Commercial Sector

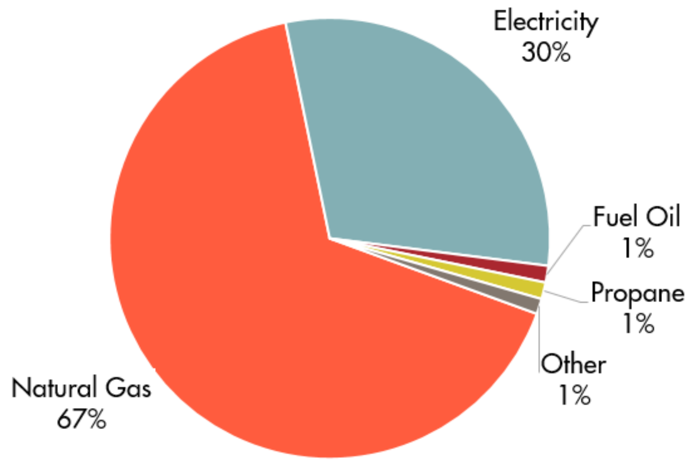
19.3%

**Commercial sector's share of total energy use in Oregon**

**Commercial sector:** offices and businesses, government, schools, and other public buildings, hospitals and care facilities, hotels, malls, warehouses, restaurants, and places of worship and public assembly. In the Pacific Northwest, energy — from all sources, including electricity, natural gas, or other fuels — is used for HVAC, lighting, computing, and other commercial needs.




**97 percent of Oregon commercial buildings use electricity or natural gas for heating:**




**Heating, cooling, and ventilation**, which is responsible for the largest share of electricity and natural gas use in a commercial building, is provided through central systems, individual units, or a combination of both.

**Lighting** is the third largest share of energy use. Efficiency and type of lighting are evolving as incandescent and fluorescent lighting is replaced with energy-efficient LEDs.

Oregon's commercial sector has reduced energy use by **8.4 percent since 2000**. The amount of energy used per square foot in the region also decreased:

| 2000 | 2015 |
|---|---|
| 18.7 kWh/sf | 15.6 kWh/sf |

Energy used per dollar (in 2012 dollars) of economic output in the region has also decreased since 2000:

| 2000 | 2015 |
|---|---|
| 1.2 million BTUs per $1 | 810,000 BTUs per $1 |

*References: 1, 2, 79, 80,81*

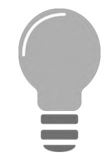
**Refrigeration and cooking** use a lot of energy, with refrigeration accounting for about 18 percent of overall electricity use and cooking about 25 percent of natural gas use in commercial buildings.

**Water heating** is the second largest user of natural gas. Water heating tanks or boilers are present in 86 percent of buildings in the region, and are predominately natural gas fueled.

## Trends in Commercial Energy Use

Increased Solar PV

Adoption of LED lighting



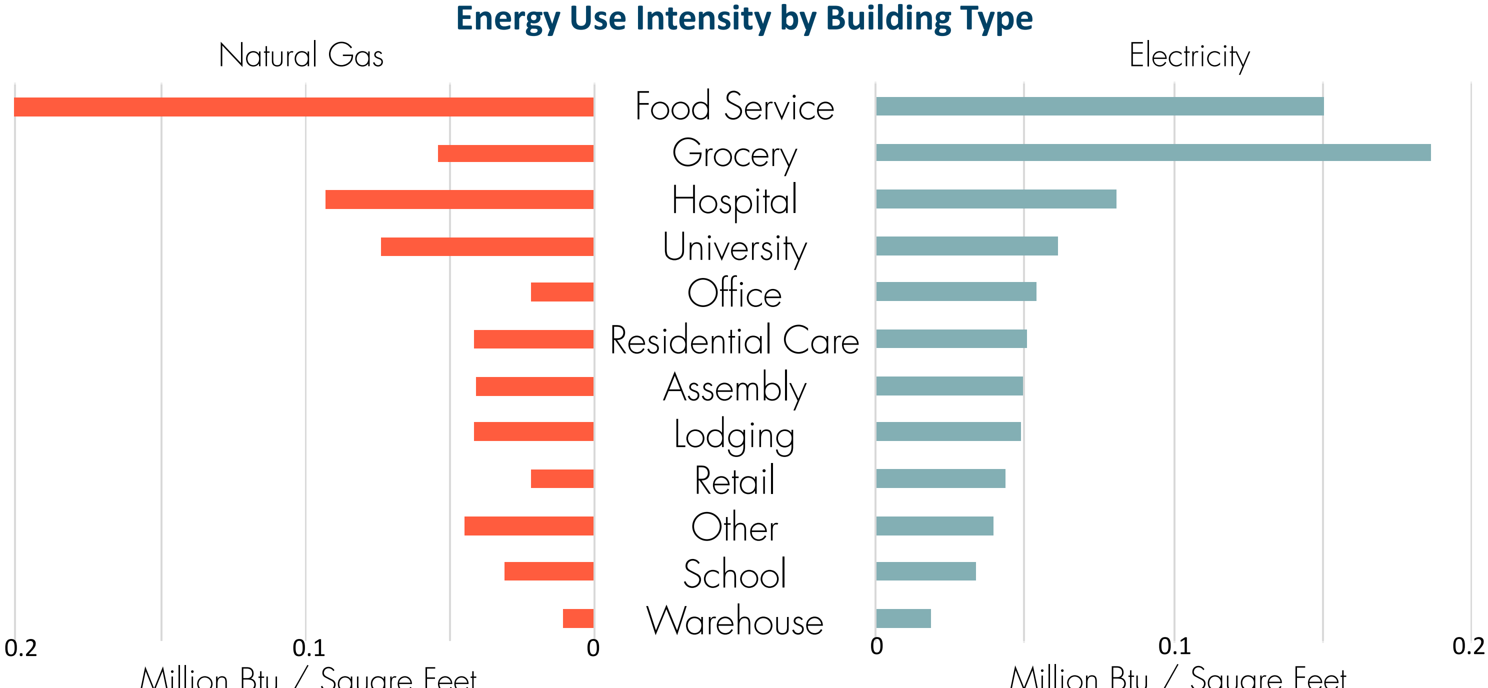
Commercial buildings are using energy management and benchmarking

Almost 75% of the region's schools report having energy management staff

**Energy Performance** is measured by comparing a building's annual energy use to its size, and depends on a building's construction, equipment efficiency, operation, and location. In commercial buildings, floor space, the type of building, and its activities drive energy use.

Financial incentives, improved building code and appliance standards, and energy efficiency programs are helping commercial buildings improve energy performance. The Portland Commercial Energy Performance Reporting policy requires buildings to benchmark and report annual energy use. Learn more in chapter 6.

### Energy Use Intensity by Building Type




*References: 79, 80, 81*

# Oregon's Industrial Sector

26.4%

**Industrial sector's share of total energy use in Oregon**

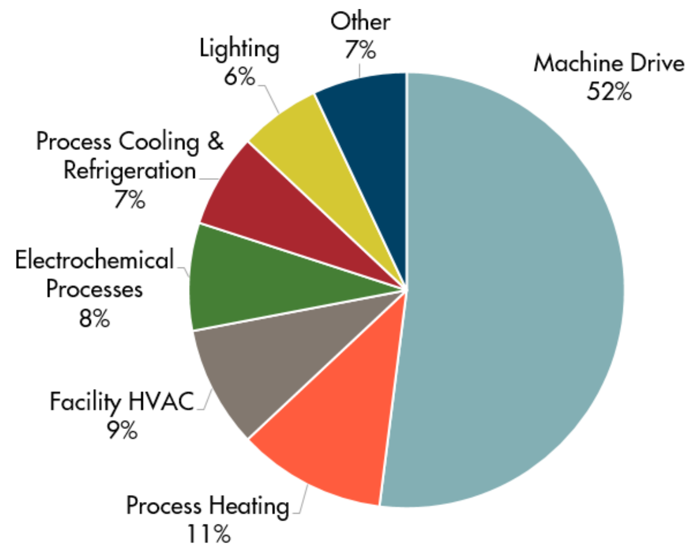
**Industrial Sector**: Facilities and equipment used for producing and processing goods and services, including manufacturing, forestry, mining, and construction. Oregon's extensive agricultural industry is also included in this sector profile. The industrial sector's primary use of energy is for process heating and powering machinery. Energy in the form of feedstock fuels are also used as raw material for production.

**Oregon's industrial sector:**

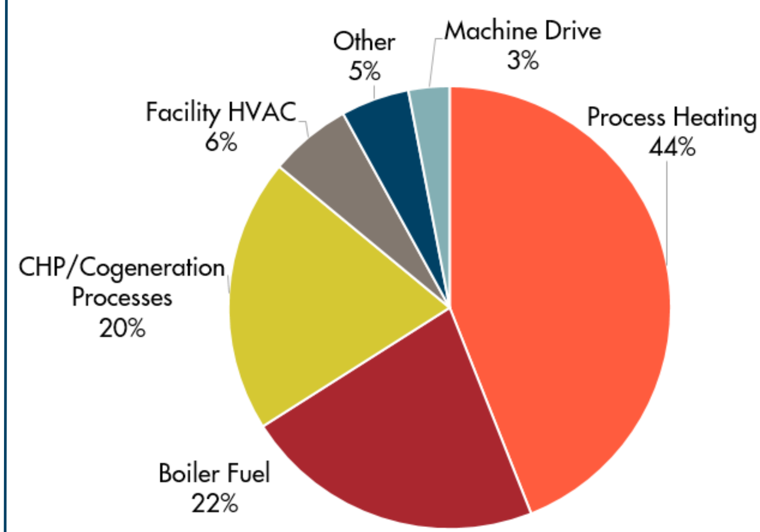
- Manufacturing
- Semiconductor fabrication
- Agriculture
- Food processing
- Forestry
- Wood and paper products
- Construction

**The industrial sector uses electricity and other fuels in a number of ways:**

*Electricity*




*Other Fuels*




15%

**Industrial sector's share of total energy costs in Oregon**

23.7%

**Reduction in total energy use in Oregon since 2000**

A significant reason for the decline in energy use in the industrial sector is due to the closure of Oregon aluminum smelters and a shift to less energy-intensive industries.

*References: 1, 2, 82*

## Energy-Intensive Industries

Energy-intensive industries in the U.S. include food processing, pulp and paper, chemicals, refining, iron and steel, metals, and minerals (primarily aluminum and cement). Bulk chemicals, refining and mining, and manufacturing are large users as they require high amounts of energy to turn raw materials into new products.

### Boiler Fuel

- Steam generation
- Water heating for industrial processes
- Electricity generation

### Fossil Fuels and Renewable Energy

- Heat in industrial processes
- Space heating

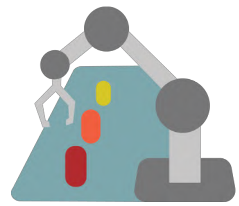
### Electricity

- Industrial motors
- Machinery
- Lights
- Computers
- Office equipment
- Irrigation pumps

### Petroleum

- Agricultural equipment

## Trends in Industrial Energy Use



Manufacturing is incorporating electronic and robotic devices, which may increase labor productivity

Natural gas use in manufacturing is increasing

96 percent of regional industrial facilities use energy management techniques

Energy used per dollar (2012 dollars) of economic output in the region has decreased since 2000:

| 2000 | 2015 |
|---|---|
| 17 million BTUs per $1000 | 10 million BTUs per $1000 |

**Energy performance** is measured in terms of productivity (energy cost per unit of product or per dollar of output).

Energy is a substantial cost for industrial facilities. Financial incentives and adoption of strategic energy management approaches such as ENERGY STAR and ISO 50001 will continue to improve energy performance in the industry.

*References: 81, 83, 84, 85*

# Oregon's Transportation Sector

30.7%

**Transportation sector's share of total energy *use* in Oregon**

47.7%

**Transportation sector's share of total energy *costs* in Oregon**

93%

**Percentage of Oregon's transportation fuel that comes from petroleum-based products**

85%

**Percentage of transportation sector energy consumed on our roadways**

3.5 million

**Total number of registered passenger vehicles in Oregon (2017)**

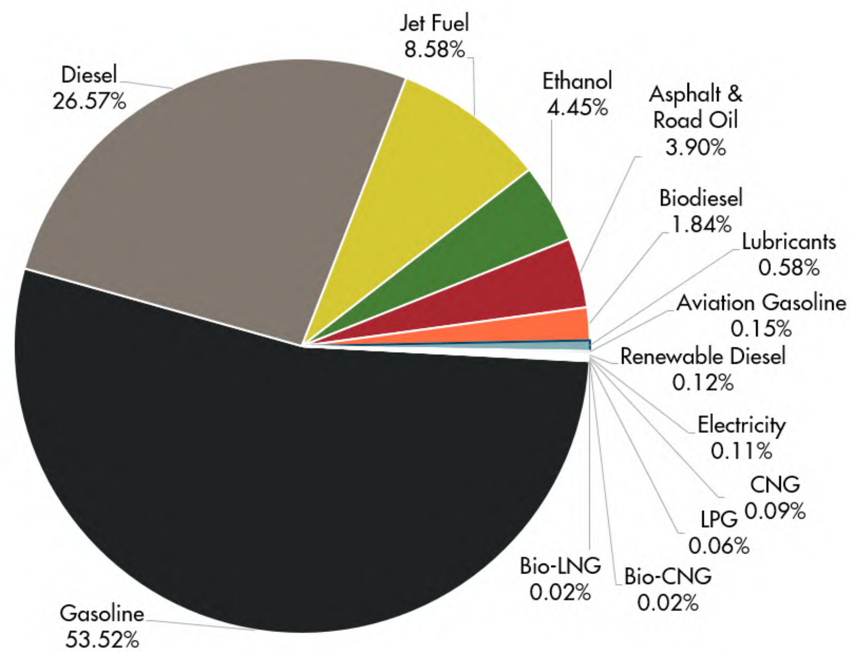
17,893

**Number of electric vehicles registered in Oregon (June 2018)**

References: 1, 2, 21

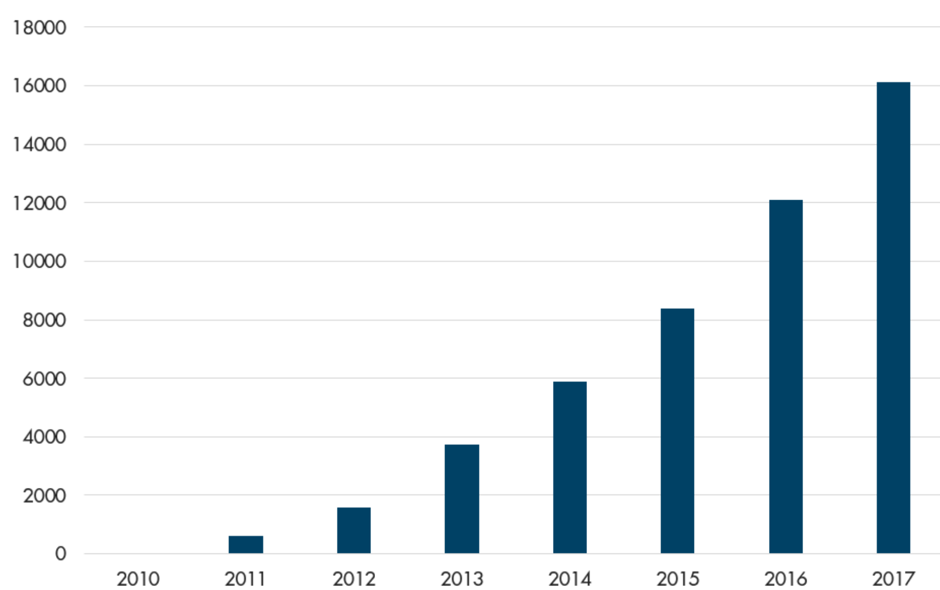
**Transportation Sector**: The movement of goods, services, and people—including passenger and commercial vehicles, trains, aircraft, boats, barges, and ships. Energy, mostly in the form of petroleum products, is used directly for transportation vehicles and to fuel equipment.

**Transportation Fuels Used in Oregon in 2016**




**Cumulative Total Electric Vehicle Registrations in Oregon**

*25% Year-Over-Year Increase Since 2010*



**Between 2005 and 2017, Oregon reduced:**

**Passenger vehicle emissions by**

12.5%

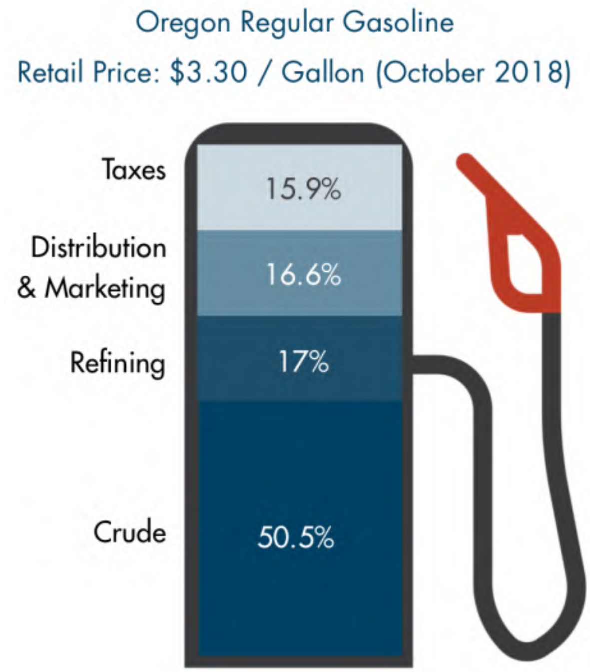
**Fuel consumption in passenger vehicles by**

10%

Transportation fuel costs tend to be higher in Oregon because of the region's distance from fuel supplies and a limited number of refineries.

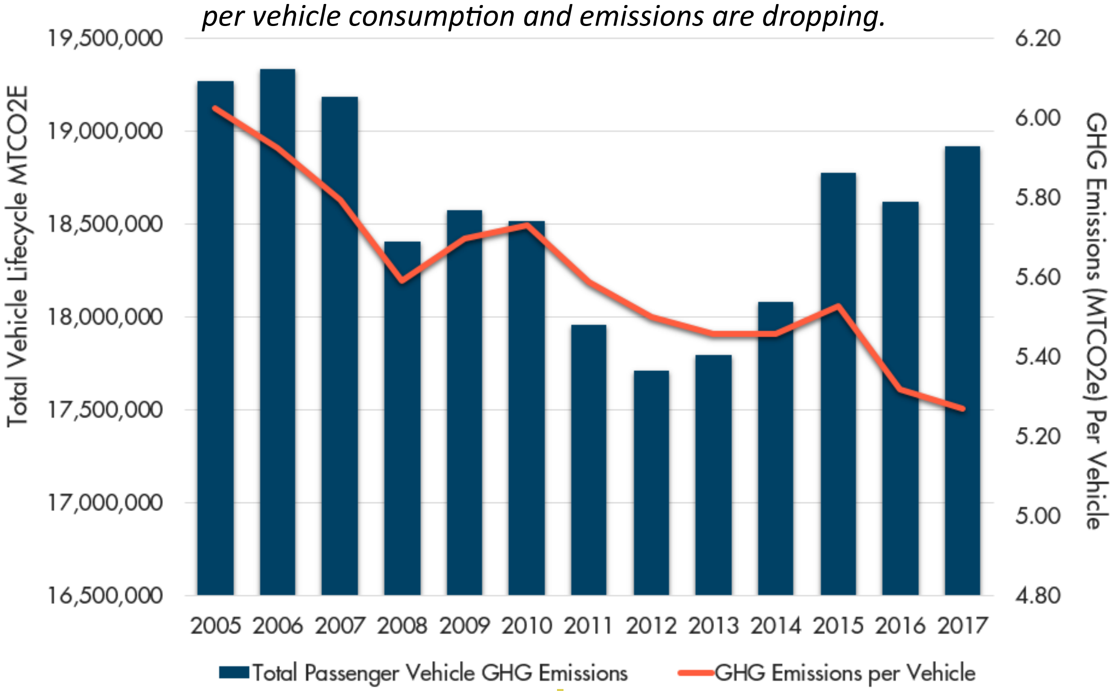
**Oregon's transportation sector:**

- The percentage of SUVs and pickup trucks registered in Oregon is greater than national average
- Passenger vehicles—including cars, trucks, and SUVs—in Oregon are older than the national average
- Largest portion of the transportation sector's energy use comes from passenger vehicles
- Passenger vehicle stats includes miles driven on highways, gravel roads, and all roads in between




**Total and Per Passenger Vehicle GHG Emissions**

*While overall on-road fuel consumption and emissions are on the rise in Oregon, per vehicle consumption and emissions are dropping.*




Typical Oregon vehicle in 2005:

**490 gallons fuel/year**

**6 MTCO2e**

Typical Oregon vehicle in 2017:

**439 gallons fuel/year**

**5.3 MTCO2e**

68%

**Share of Oregon's total transportation fuel costs attributed to gasoline**

98%

**Percentage of transportation fuels used in Oregon that are imported into the state**

*References: 21*

# Greenhouse Gas Emissions

This section provides a brief overview of Oregon's sector-related greenhouse gas emissions. Most of Oregon's GHG emissions come from the energy we use every day. For a deeper dive into Oregon's energy-related greenhouse gas emissions, current policies, and mitigation efforts, see chapter 2.

2050

**Target year for Oregon to reduce GHG emissions by 75 percent below 1990 levels**

9%

**of Oregon's 2016 GHG emissions**

**Agriculture**: This is primarily from waste streams such as methane and nitrogen-based fertilizers used for soil management. This sector is distinct because emissions primarily come from methane and nitrous oxide, versus carbon dioxide.

7%

**of Oregon's 2016 GHG emissions**

**Industrial**: When electricity and natural gas use are accounted for separately, industrial accounts for 7 percent of the state's emissions and is comprised primarily of emissions from petroleum combustion, industrial waste and wastewater, and manufacturing. With electricity and natural gas use included, this sector accounts for about 20 percent of Oregon's total GHG emissions.

7%

**of Oregon's 2016 GHG emissions**

**Residential & Commercial**: When electricity and natural gas use are included, these sectors comprise 32 percent of Oregon's GHG emissions. When electricity and natural gas use are accounted for separately, residential and commercial GHG emissions drop to 7 percent and stem primarily from fuel oil for heating and emissions from waste and wastewater originating from these sectors.

12%

**of Oregon's 2016 GHG emissions**

**Natural Gas Use**: Percentage accounts for direct use of natural gas in all sectors, plus fugitive emissions from distribution.

26%

**of Oregon's 2016 GHG emissions**

**Electricity Use**: This accounts for electricity used in other sectors. This number is down from 30 percent in 2015 and includes emissions associated with electricity used in the state, regardless of where it is generated. Emissions from electricity generated in Oregon but used out of state are not included.

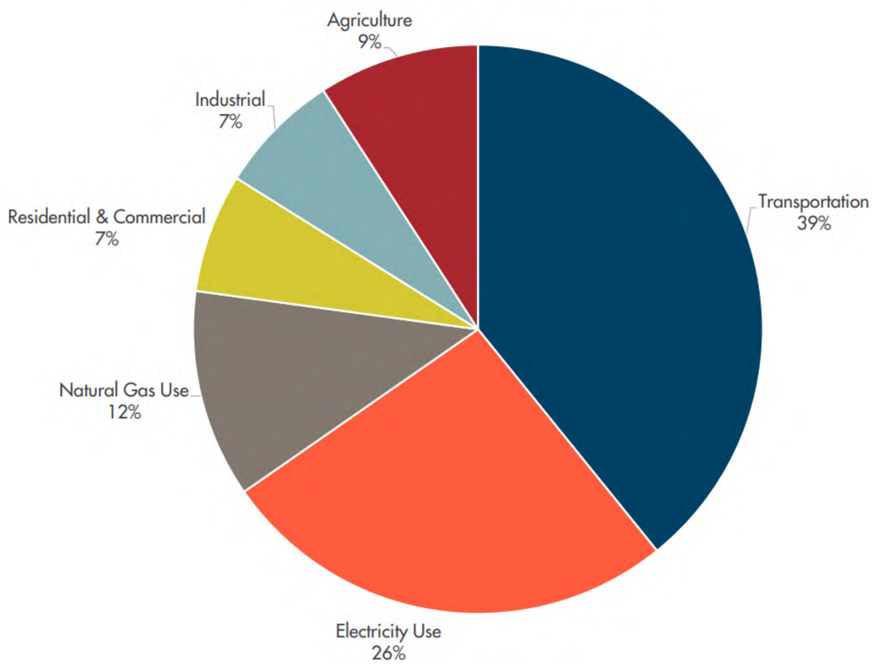
39%

**of Oregon's 2016 GHG emissions**

**Transportation**: This sector is the state's largest single source of GHG emissions: 36 percent of the statewide total in 2015 and 39 percent in 2016. Estimates from 2015 indicate that 47 percent of transportation emissions are generated from passenger cars and trucks, while approximately 23 percent are from heavy-duty vehicles.

*References: 86*

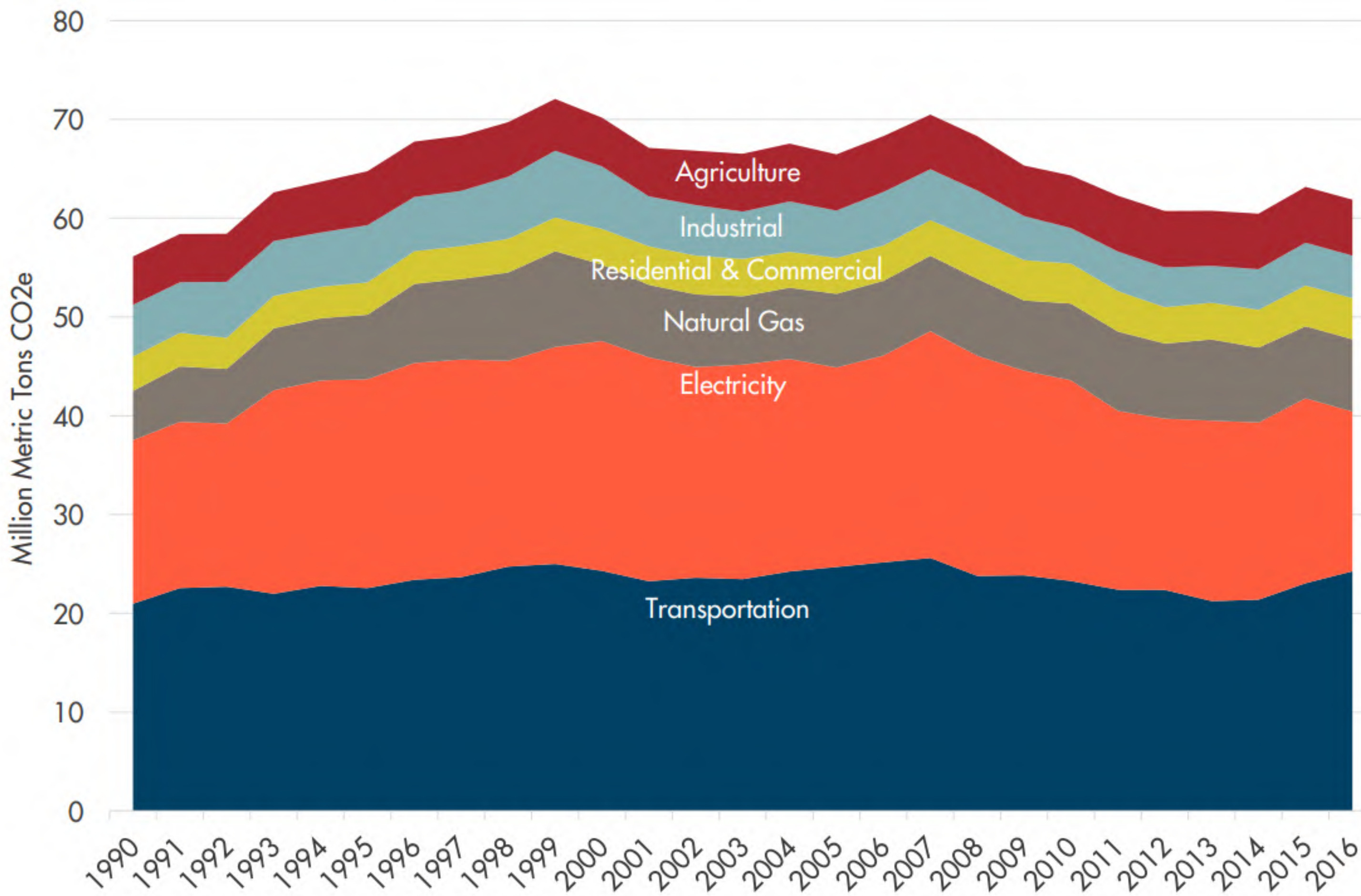
*Oregon 2016 GHG Emissions*




# Transportation Emissions

Transportation emissions have grown as a share of Oregon's statewide GHG emissions total compared to emissions from electricity use. Specifically, transportation went from 35 percent of the statewide total in 2014 to 39 percent in 2016, while electricity use emissions decreased from 30 percent to 26 percent of the state's total emissions. All other sectors stayed relatively constant over the same period. While total transportation emissions have fluctuated over the years, GHG emissions per vehicle have gone down thanks to improved fuel efficiency.

*Oregon Greenhouse Gas Emissions by Sector Over Time*



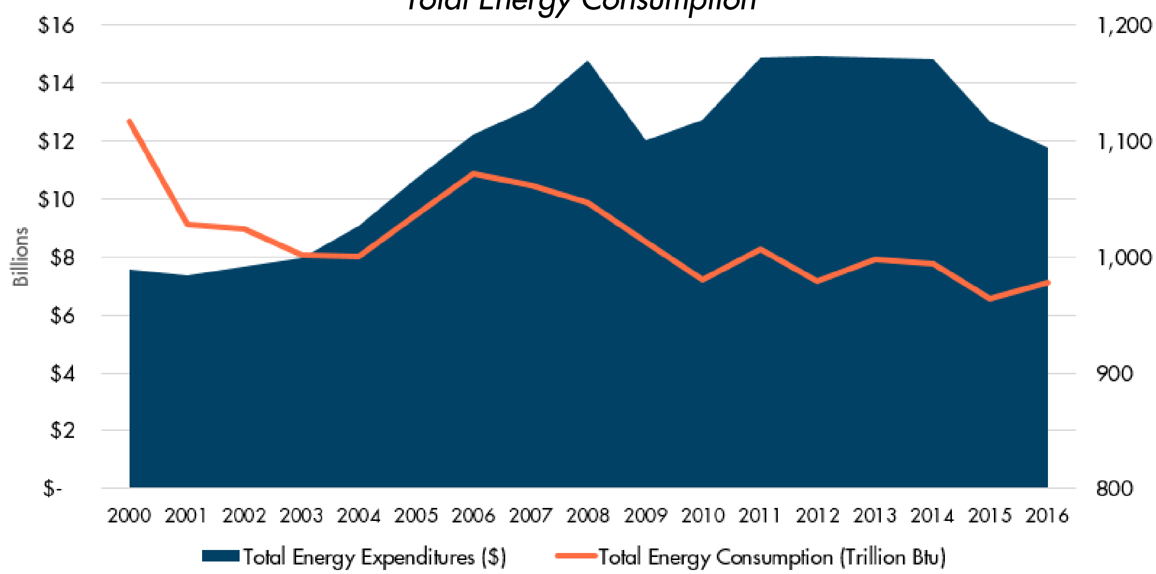

*References: 86, 21*

# Energy Costs and Expenditures

## What We Spend on Energy

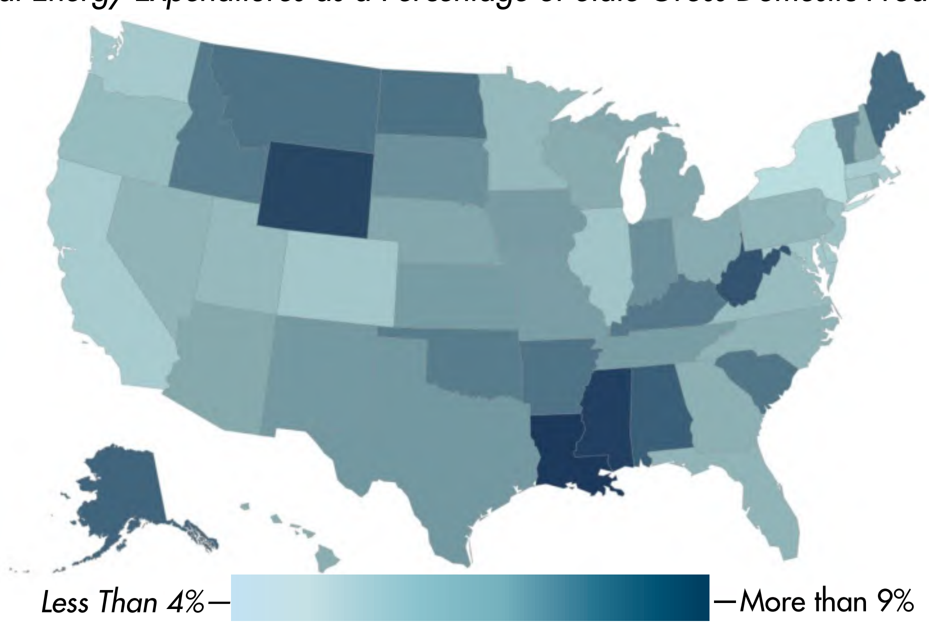
Oregon spent $11.7 billion on energy in 2016 – the lowest amount since 2005. This includes electricity and fuel for homes and businesses, industrial energy uses, and petroleum used in the transportation sector. Transportation accounts for nearly 50 percent of our state's energy expenditures and also sees the largest swings in price. The variability in what we spend on energy is driven primarily by transportation fuel costs.

*Oregon's Total Energy Expenditures Compared to Total Energy Consumption*




Oregon's energy costs are also comparable to what other states spend. Where we differ is on costs per category—our electricity rates tends to be less expensive than other parts of the country, while our transportation fuel costs are somewhat higher.

*State Total Energy Expenditures as a Percentage of State Gross Domestic Product — 2016*




*In 2016, Oregon spent 5.2 percent of the state's GDP on energy – right in line with the U.S. median of 6.3 percent. The District of Columbia was lowest at 1.6 percent, and Louisiana highest at 11.1 percent.*

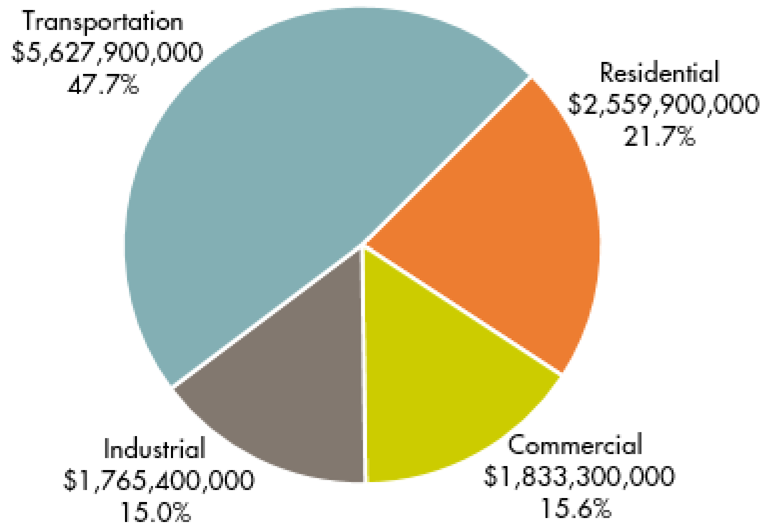
References: 1, 2

# Energy Costs and Expenditures

Oregon's 2016 per capita energy expenditure was $2,885 per person – one of the lowest states in the U.S. The primary reason we rank so low is due to the amount of energy we consume. We use less energy than other states and therefore spend less.

Oregonians' 2016 energy expenditures can be separated by sector. While the transportation sector represents 31 percent of energy consumption, it accounts for almost half of expenditures due to the much higher per unit cost of transportation fuels. Because nearly all our transportation fuel is imported, most of this money goes out of state.

*Oregon's Total Energy Expenditures by Sector—2016*



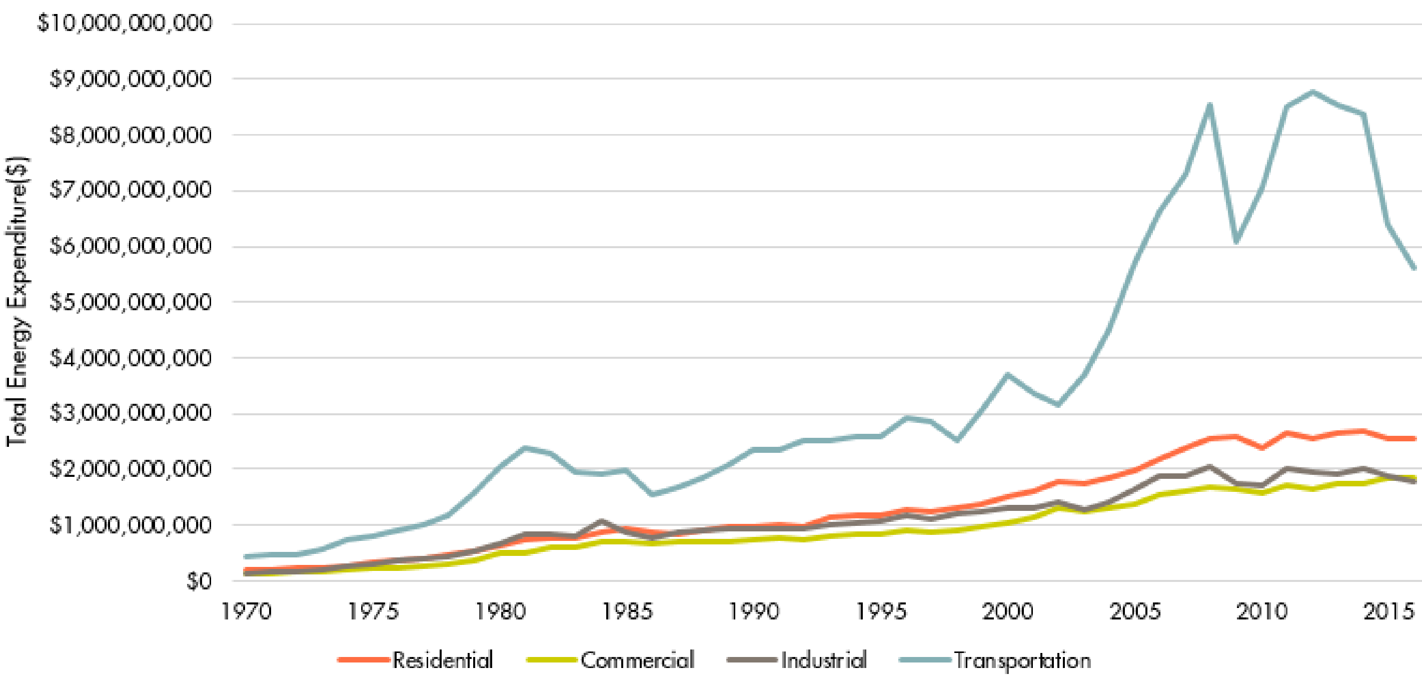

3%

**Percentage of median household income Oregonians spent on *energy* in 2016**

5%

**Percentage of median household income Oregonians spent on *transportation fuel* in 2017**

*Oregon's Total Energy Expenditures by Sector Over Time*




*While Oregon's residential, commercial, and industrial sectors have experienced gradual increases in what we spend, transportation sector expenditures reflect more price volatility in the transportation fuels market.*

*References: 1, 2, 18, 21*

# Energy Bill Basics

## This month's charges (Turn over for details)

**Meter #123ABC4567, Schedule 07**

| | | |
|---|---|---|
| Energy Charges (395 kWh) | 57.73 | |
| Adjustments | 1.66 | CR |
| | **56.07** | |
| **Total Taxes and Fees** | **3.13** | |
| **Current Energy Charges** | **59.20** | |

| Period Ending | Avg Daily Temperature* | Monthly kWh | Monthly Cost |
|---|---|---|---|
| Sep 2018 | N/A | 395 | 59.20 |
| Sep 2017 | 66 | 454 | 60.04 |

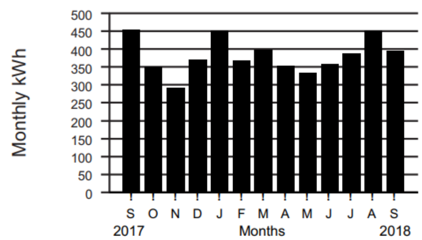
***Temperature source: Portland International Airport**

## Your energy use

**Meter #123ABC4567**

**Schedule 07** (residential rate)

| **Service Period** | **Meter Reading** |
|---|---|
| 09/12/18 | 37113 |
| 08/13/18 | 36718 |
| 30 days of service | 395 kWh |




## Details of this month's charges

**Meter #123ABC4567, Schedule 07**

| | | |
|---|---|---|
| Basic Charge | 11.00 | |
| Energy Use Charge (395.000 kWh x $0.0651) | 25.71 | |
| Transmission Charge (395.000 kWh x $0.00209) | 0.83 | |
| Distribution Charge (395.000 kWh x $0.04311) | 17.03 | |
| Green Source [sm] (395.000 kWh x $0.008) | 3.16 | |
| **Subtotal - Energy Charges** | **57.73** | |
| 102 RPA Exchange Credit (395.000 kWh x $-0.01016) | 4.01 | CR |
| 105 Regulatory Adjustments (395.000 kWh x $-0.00016) | 0.06 | CR |
| 109 Energy Efficiency Funding Adj (395.000 kWh x $0.00493) | 1.95 | |
| 110 Energy Efficiency Customer Svc (395.000 kWh x $0.00005) | 0.02 | |
| 112 Customer Engagement Transformation Adjustment (395.000 kWh x $0.0003) | 0.12 | |
| 123 Decoupling Adjustment (395.000 kWh x $0.00009) | 0.04 | |
| 135 Demand Response (395.000 kWh x $0.00014) | 0.06 | |
| 137 Solar Payment Option Cost Recov (395.000 kWh x $0.00047) | 0.19 | |
| 143 Spent Fuel Adjustment (395.000 kWh x $-0.00019) | 0.08 | CR |
| 145 Boardman Decommissioning Adj (395.000 kWh x $0.00027) | 0.11 | |
| **Subtotal - Adjusting Schedules** | **1.66** | **CR** |
| | **56.07** | |
| City of Portland Tax (1.5%) | 0.81 | |
| Multnomah County Tax (0.027%) | 0.01 | |
| Low Income Assistance | 0.69 | |
| Public Purpose Charge (3%) | 1.62 | |
| **Subtotal - Taxes and Fees** | **3.13** | |
| **Current Energy Charges** | **59.20** | |

*Your Federal Columbia Benefits are supplied by Bonneville Power Administration (BPA).

## Meter

**Meters measure how much energy is consumed. Some utilities are making the switch to digital "smart meters," which help track when energy is used, in addition to how much.**

## Rate Schedule

**Rates vary between residential, commercial, and industrial customers.**

## Basic Charge

**A minimum cost of service, regardless of the amount of energy used. This funds the utility provider's costs like maintenance and customer support.**

## Use Charge

**Utilities charge by how much energy is used measured in kilowatt hours.**

## Public Purpose Charge

**For PGE, Pacific Power, and all three natural gas utility customers, a 3 percent Public Purpose Charge is added, which funds conservation projects, renewable resources, weatherization for low-income households, and energy efficiency improvements in schools.**

## Go Green

**Most utilities offer programs for customers who want to use renewable energy. In this sample bill, the customer is enrolled in PGE's Green Source program. Oregon has the country's highest participation rates in voluntary green energy programs.**

# Energy Bill Basics


## Energy Rates

Utilities provide energy to customers using a series of Rate Schedules. The schedules vary based on the type of customer and their needs: residential, commercial, industrial, and others. More than one rate can be used for the energy a building or facility uses. Schedules can be created for specific uses, like traffic signals, street lights, irrigation and drainage pumping, or for time-of-day service or special pilot programs like demand response.

## Demand Charges

Utility customers are charged based on the amount of energy they use. Utilities may add demand charges, particularly for commercial and industrial customers based on the customer's highest energy use in a particular interval. Customers with large equipment that uses significant energy may incur high demand charges.

## Power Factor

Power factor is the ratio of working power to apparent power. Working power is the actual power used to run equipment, and apparent power is the combination of working power and additional reactive power resulting from an inductive load like a motor. Utilities work with customers to maximize power factor to ensure the full benefit of their electricity use, with the additional advantage of supporting longer equipment life.

*Most of this section has focused on electricity bills. Here are a few ways natural gas and other heating bills may differ.*

### Natural Gas

Natural gas is measured in therms. Natural gas bills have a basic and meter charge. They also commonly have declining or ratcheting rates, as well as firm or interruptible rates, where customers who are willing to have their service interrupted will be charged lower rates.

### Fuel Oil and Propane

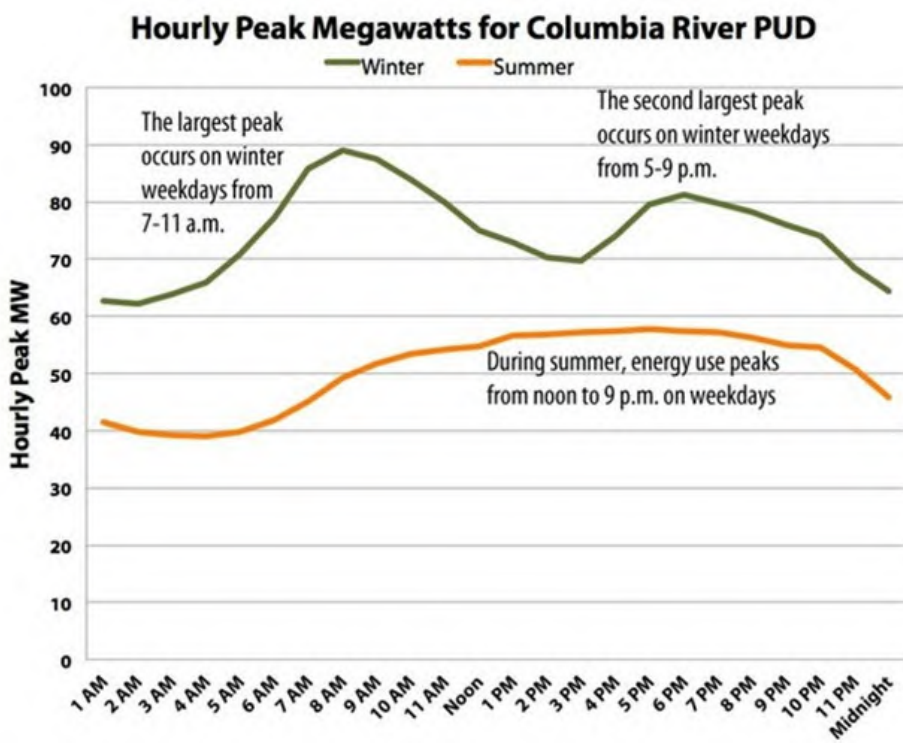
Fuel oil and propane are typically sold in gallons by individual suppliers, which often offer discounts based on the volume purchased. There is no meter involved, so the charge is based on the volume delivered, not ongoing consumption.

# Meeting Energy Demand

Making sure there's electricity available to power Oregonians' lives regardless of seasonal or daily variations in power outputs or customer demand is the core challenge of the electric utility industry. While technologies are improving all the time, electricity has limited storage options and instead must be generated nearly instantaneously to meet consumer demand. As a result, the electric system is sized to be able to satisfy the largest requirements for electricity—called peak demands—at all times, even through consumers use less during most hours of the year. This results in a generation and transmission system that is underutilized much of the time by design, especially when compared to the liquid fuels and natural gas sectors. Natural gas and transportation fuels are comparatively easy and inexpensive to store, so fuel production can occur at a more constant rate when they are needed.

## Hourly Energy Demand

Electric utilities closely watch and manage the timing of consumer demand for electricity, from minute to minute and hour to hour. The image below shows two representative 24-hour electric load demand curves for Columbia River People's Utility District—one from a typical winter day and the other a typical summer day. This example illustrates the change in demand for electricity that can occur on a utility's system over the course of a single day. For example, the peak demand in winter, 90 megawatts at 8 a.m., is nearly 50 percent greater than the minimum demand of 60 megawatts at 2 a.m. These swings in demand across the day can impose stresses on electric generators and the transmission network needed to deliver that electricity to consumers. While wholesale prices for electricity tend to reflect these conditions—with prices going up during high demand hours and dropping during low demand hours—the regulatory structure for residential consumers means that rates are flatter and less volatile.




## Seasonal Energy Demand

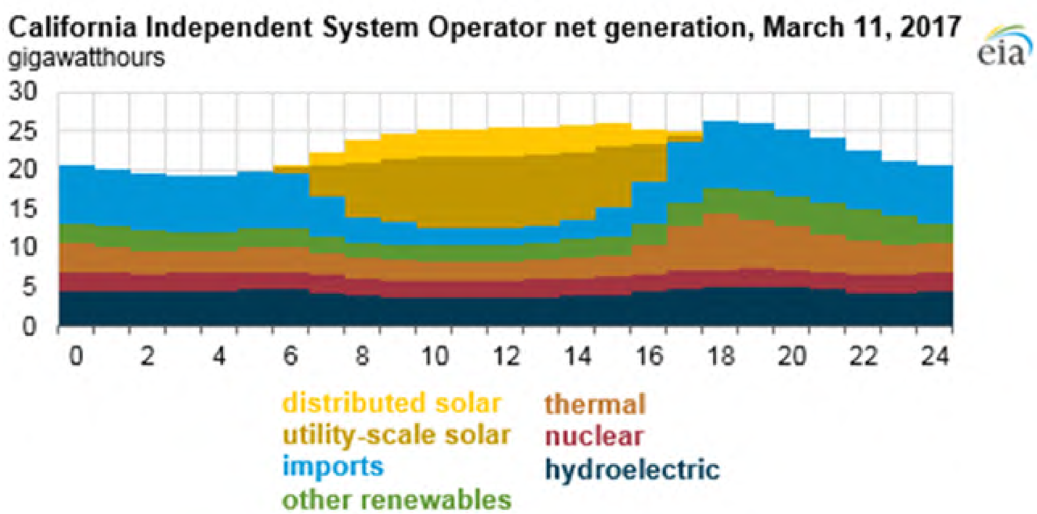
Energy demand also changes with the seasons. Colder wintertime temperatures in Oregon result in increased demand for natural gas and electricity to heat homes and buildings. As Oregon summers get warmer, the state is seeing increasing use of air conditioners in the hottest months. Meanwhile, demand for liquid fuels peaks during the summer months when Oregonians are more likely to take advantage of long days and warmer weather to drive longer distances for vacation.

## Change in Supply

Just as consumers' needs vary by the hour and season, so can the supply of energy. If an Oregonian turns on an overhead light at 11 p.m. in early May, there is a high likelihood that the electricity powering that light bulb originated with a carbon-free hydroelectric power plant. That's the time of year when the Pacific Northwest's hydroelectric system tends to have high output due to spring runoff in our rivers.

If that same Oregonian turns on the same light at 7 a.m. on a chilly November morning, the electricity powering the light will more likely have originated with another type of resource, such as a coal or natural gas power plant.

In the same vein, the availability of different types of energy can vary hour by hour. The amount of wind energy on the grid depends on whether the wind is blowing. Similarly, solar photovoltaic energy is dependent on the sun being out. In parts of the country with large amounts of solar power, like California, this hour-to-hour variation can be fairly pronounced, as shown in the graph to the right.




## Demand Response

One strategy used by utilities to better align demand with the availability of supply is demand response. Demand response is a deliberate change in a customer's normal electricity usage pattern in response to a change in price, contract, or request from a utility or grid operator. This can be most useful to a utility during the hottest or coldest days of the year, when the system's existing resources may be strained to meet high levels of demand from air conditioning or heating. Rather than building or buying a new generating resource, utilities or grid operators can sometimes find it cheaper to pay or offer an incentive for customers to temporarily use less energy.

More than most regions, the Pacific Northwest has historically had sufficient excess capacity because of the robust hydroelectric system at the foundation of our electric system. Primarily for this reason, the region has developed little demand response capacity. This is changing as coal capacity retires and as more energy demand is met by output from renewables. In the Seventh Power Plan, the Northwest Power and Conservation Council identified the development of a significant amount of demand response capacity, combined with additional savings from conservation, as the most cost effective way address system constraints by the early 2020s.

Demand response programs can also be developed to encourage an increase in demand at times that are beneficial for the utility or grid operator. This might occur during times when wholesale power prices are particularly low, or at times when excess carbon-free power is available in the market.

# Oregon Utilities Overview

Oregon is served by investor-owned and consumer-owned utilities and by energy service suppliers. The state is also served by the Bonneville Power Administration (BPA), a federal agency that markets electric power from 31 dams in the Pacific Northwest and the Columbia Generating Station nuclear power plant in Washington. BPA also owns and operates 75 percent of the high-voltage transmission system in the Northwest.

**Types of Utilities**

| | Investor-Owned Utilities | Consumer-Owned Utilities |
|---|---|---|
| ELECTRICITY | PacifiCorp/Pacific Power<br>Portland General Electric<br>Idaho Power | 36 electricity cooperatives, municipal corporations, and people's utility districts |
| GAS | Northwest Natural<br>Avista<br>Cascade Natural Gas | |
| | • For-profit corporations<br>• Facilities owned by shareholders<br>• Governed by private boards<br>• Regulated by the Oregon Public Utility Commission | • Not-for-profit entities<br>• Facilities owned by customers<br>• Governed and regulated by locally elected boards |

## How Utilities Are Regulated

**Federal Regulation**

The Federal Energy Regulatory Commission (FERC) is an independent federal agency with a five-member board appointed by the president. FERC regulates the interstate transmission of electricity, natural gas, and oil. It also has jurisdiction over the siting of interstate natural gas pipelines, natural gas storage facilities, liquid natural gas terminals, and hydroelectric plant relicensing. FERC also monitors and investigates the operations of wholesale energy markets. The many areas outside of FERC's jurisdiction are handled by state regulatory bodies.

**Regional Regulation**

In the western United States, the Western Electricity Coordinating Council (WECC) provides reliability compliance monitoring and enforcement for electric utilities consistent with rules established by the North American Electricity Reliability Corporation (NERC). WECC also coordinates the regional development of reliability standards and operating and planning activities.

The country's first long-distance transmission of high-voltage electricity took place in Oregon in June 1889 between Oregon City and Chapman Square in downtown Portland—13 miles away.

Reliability coordination services—including real-time monitoring and situational awareness—are also conducted at the regional level. WECC used to provide this service, and Peak Reliability Corporation, a nongovernmental organization, has served in this role since 2014, with services scheduled to end by 2019. As of October 2018, balancing authorities across the WECC are evaluating their options for reliability coordination services after 2019. The Bonneville Power Administration, PacifiCorp, and Idaho Power have

*References: 64, 65, 87, 88*

committed to receiving reliability coordination services from the California Independent System Operator (CAISO) following CAISO's anticipated certification from federal authorities.

There is no entity analogous to NERC with the responsibility for establishing and enforcing reliability standards for the natural gas system.

**State Regulation**

The rates charged to retail customers by Oregon's investor-owned electric and gas utilities are regulated by the Public Utility Commission (PUC), a state agency with a three member commission appointed by the Governor. In exchange for a protected monopoly, the IOUs provide energy services to the customers within their designated service territories, and the PUC guarantees their costs plus a reasonable rate of return on their rate-based capital investments. The PUC evaluates the prudency of IOU investments and the continued usefulness of previous investments as part of a rate case that results in the approval of IOU rate schedules and tariffs designed to recover the utility's revenue requirement through rates.

Consumer-owned utilities are regulated by locally elected boards of directors. These boards set rates based on their cost-of-service, and because they are not-for-profit utilities, there is no rate of return on top of the costs. The board approves the rate, resource, and investment decisions of the COU.

## How Utilities Buy and Sell Energy

Electric and gas utilities in Oregon buy and sell energy in similar ways. The following core steps are involved in each case:

### Long-Term Planning

- Evaluate current energy demand and develop forecasts of expected future demand
- Assess current supply resources (e.g., utility-owned, long-term contracts, liquidity in wholesale markets)
- Develop a plan to meet expected future demand with existing resources, new contracts, market purchases, or the development of new resources, including energy efficiency

### Wholesale Transactions

When a utility needs to purchase energy from another party for resale to their retail customers to meet demand, the utility may purchase energy at a wholesale rate in one of the following ways:

- Long-term contracts – e.g., 20 year power purchase agreement with a new third-party owned power plant
- Medium-term contracts – e.g., three- to five-year power purchase agreement with an existing third-party power plant)
- Short-term or real-time transactions – e.g., purchases over time intervals as short as five minutes to meet shortfalls in available supply

### Retail Transactions

No matter how the utility acquires the necessary resources to meet demand, the utility will ultimately deliver energy to end-use customers at a retail rate approved either by the PUC (for electric and gas IOUs) or by the boards of COUs.

References: 89, 90

# Recent & Upcoming Oregon Energy Milestones

**2007** — Oregon enacts Renewable Portfolio Standard, sets statewide greenhouse gas reduction targets

**2008**

**2009** — Oregon Clean Fuels Program first initiated

**2010** — Oregon Global Warming Commission launched Roadmap to 2020 project

**2011**

**2012**

**2013** — Clean Fuels Program initial reporting begins; Oregon Renewable Energy Development grants program passed

**2014** — Sunset of Oregon's Business Energy Tax Credit program

**2015**

**2016** — Legislature passes Solar Development Incentive and second energy storage bill in the nation
Plan for removing coal from energy mix developed, RPS increased, and community solar added

**2017** — Governor's Executive Order 17-21 sets goal of 50,000 electric vehicles by 2020;
SB 978 sets process to look at electricity regulation and utility business model

**2018** — New residential energy code goes into effect

**2019** — Legislature expected to take up proposed cap-and-invest legislation

**2020** — Oregon's only coal plant scheduled to cease coal operations

*References: 5, 9, 91-100*

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CHAPTER 2: CLIMATE CHANGE

One of the most important challenges confronting Oregon's energy sector is curtailing the energy-related greenhouse gas emissions that contribute to climate change.

About 80 percent of GHG emissions in Oregon come from daily energy use, and current energy and climate policies in Oregon are not sufficient to meet statewide GHG reduction goals.

Read on for an overview of GHG mitigation options and opportunities across Oregon's energy sectors.

## KEY TAKEAWAYS

- In recent years, Oregon has been able to **meet more of its growing population's energy needs** with low carbon resources that will help the state meet its climate and greenhouse gas reduction goals. Despite this, Oregon is not yet on a pathway to fully transition its energy systems to a deeply decarbonized, clean energy future.

- Climate scientists have identified a two degree (Celsius) threshold on global temperature rise, beyond which there are **significant and unprecedented risks to society and the environment**. Oregon's current greenhouse gas emissions trajectory is far above its fair share contribution to that global limit. In Oregon, projected climate effects to health, livelihoods, and ways of life are avoided or substantially reduced in a lower global emissions scenario vs. the world's current path.

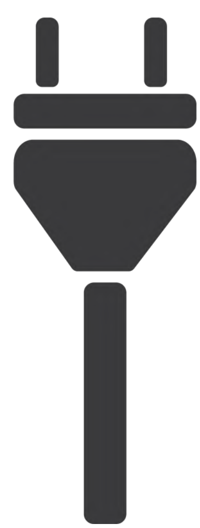
- Further actions are necessary to complete Oregon's low carbon energy transition, and looking to the experiences of other states and jurisdictions provides a menu of some potential actions. Selecting appropriate further action will require policymakers to examine costs and benefits of action—including the **costs of climate change itself**—and to consider multiple perspectives and issues, such as social and intergenerational equity and environmental and health tradeoffs.

- Oregon has an opportunity to capitalize on advancements and falling costs of low carbon technologies, as well as the state's unique position in how energy is made and used in the state, to make a **deep decarbonization pathway** feasible across all sectors of the economy.

- **Early action** would allow Oregon to gain a first-mover competitive advantage in a global clean energy economy, increase its energy independence through development of local renewable energy resources, and realize the substantial health and environmental co-benefits of reduced pollution.

# Introduction

One of the most important challenges confronting Oregon's energy sector is the need to curtail energy-related greenhouse gas (GHG) emissions that are contributing to climate change. About 80 percent of the state's GHG emissions come from the amount and type of energy Oregonians use every day,[1] and current energy and climate policies in Oregon are not sufficient to meet statewide GHG reduction goals. This chapter takes stock of where Oregon is in relation to its GHG goals and other climate commitments, describes the policies and GHG mitigation efforts underpinning the state's current emissions trajectory, and synthesizes the best available science on the implications of staying on Oregon's current "Business as Usual" GHG emissions pathway (current policies plus forecasts of energy demand) versus a pathway to "deep decarbonization" (transitioning to a future with very little reliance on fossil fuels for energy). The chapter presents an overview of current literature on strategies to reach deep decarbonization, with consideration of policy design issues including timing, costs and benefits, equity and environmental justice



concerns, and environmental tradeoffs. The chapter concludes with recommendations for future statewide climate planning efforts.

# Oregon's GHG Reduction Goals and Climate Commitments

Oregon has recognized climate change as a major policy issue for 30 years, when the Oregon Task Force on Global Warming was created in 1988. The task force concluded that, "Climate change from global warming is a serious threat," and that "Oregonians can insure themselves against some of the changes by taking prudent actions to slow the emission of greenhouse gases and by planning to adapt to changes."[2] More recently, Governor Kate Brown stated that "Climate change poses the greatest threat to Oregon's environment, economy, and our way of life. Future generations will judge us not on the facts of global climate change, but what we've done to tackle it."

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In 2007, the Oregon Legislature (ORS 468A.200-250)[132] set statewide GHG emission reduction targets:

- **By 2010, Oregon will arrest the growth of GHG emissions and begin to reduce emissions;**
- **By 2020, Oregon will achieve GHG levels that are 10 percent below 1990 levels; and**
- **By 2050, Oregon will achieve GHG levels that are at least 75 percent below 1990 levels.**

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These climate change mitigation goals were set based on what climate scientists considered at the time to be the level needed to have the best chance of avoiding the worst effects of climate change. This risk-avoidance approach to setting climate goals is now commonly associated with a threshold of a global average temperature increase of no more than two degrees Celsius[3]. Although two degrees Celsius, which equates to a 3.6 degree Fahrenheit temperature increase, is the goal most often used in climate mitigation policy discussions, many countries and individuals have concluded that a 1.5°C, or 2.7°F, upper bound limit has a higher probability of minimizing risks to human health and the environment.[4]

In practice, these temperature targets most commonly translate to goals to reduce GHG emissions 80 to 95 percent below 1990 levels.[5] Other baseline periods or slightly modified goals are sometimes seen. Therefore, while Oregon's 2050 goal is over a decade old, it is still generally consistent with contemporary thinking around GHG emission reduction goals.

These GHG reduction goals are the catalyst for what is being called "deep decarbonization." Though the climate community has not yet settled on one definitive definition of deep decarbonization, it generally refers to a future in which global society meets the goal of limiting temperature rise to below 2°C through transformation of energy systems to those that emit little or no GHGs. This means an almost complete transition away from use of non-renewable hydrocarbons (e.g., the primary components of fossil fuels and chemicals that are classified as high global warming potential gases), which is why clean energy technologies are often referred to as zero-carbon, low-carbon, or decarbonized.

Since the early 1990s, major international and U.S. scientific assessments have concluded that both climate change mitigation and adaptation efforts are necessary in response to climate change.[6] Climate adaptation is often thought of as actions "to prepare for and adjust to new conditions, thereby reducing harm or taking advantage of new opportunities" or simply to reduce society's vulnerability to climate change impacts.[7] Although Oregon does not currently have specific statewide climate adaptation goals, entities around the state have implemented a number of adaptation planning processes. Examples of individual project-level or sector-based plans include Oregon Department of Transportation's Climate Adaptation Strategy[8] and Oregon Health Authority's Oregon Climate and Resilience Plan.[9] In addition, a statewide adaptation framework was developed in 2010,[10] for which the Department of Land Conservation and Development (DLCD) is beginning an interagency process to update. See Chapter 5 for a more detailed discussion of climate adaptation and energy resilience.

## Climate Action Partnerships

Oregon has become a signatory to a number of regional, national, and international coalitions to advance climate action. A number of these are related to the Paris Agreement, a global agreement by parties to the United Nations Framework Convention on Climate Change (UNFCCC) that formally went into effect on November 4, 2016. Countries that are party to the Paris Agreement agree to individual, country-specific efforts aimed at "holding the increase in global average temperature this century to well below 2 degrees Celsius and pursuing efforts to limit the temperature increase even further to 1.5 degrees Celsius above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change."[11] The Paris Agreement also commits signatories to "increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience."[11] Each country agreed to determine, plan, and regularly report its own GHG emissions reduction contribution, and many countries' climate plans also included their adaptation goals, priorities, actions, and needs. The United States' intended contribution was to reduce its emissions 26 to 28 percent below 2005 levels by 2025.[12]

In the months leading up to the negotiations of the Paris Agreement, Oregon signed on to the Subnational Global Climate Leadership Memorandum of Understanding, which has now evolved into the Under 2 Coalition, and the Compact of States and Regions. The Compact provides a way for states, provinces, and regions to measure, analyze, and report progress on GHG emission reductions, while the Under 2 Coalition encourages an ambitious emission reduction commitment.

Oregon joined the U.S. Climate Alliance in summer 2017, following President Donald Trump's decision to withdraw the United States' government from the Paris Agreement. The U.S. Climate Alliance is a bipartisan coalition of governors from 16 states and Puerto Rico. Each member commits to implement policies that advance the goals of the Paris Agreement and to track and report progress to the global community. Members also agree to accelerate new and existing policies to reduce GHG emissions and promote clean energy deployment at the state and federal level.

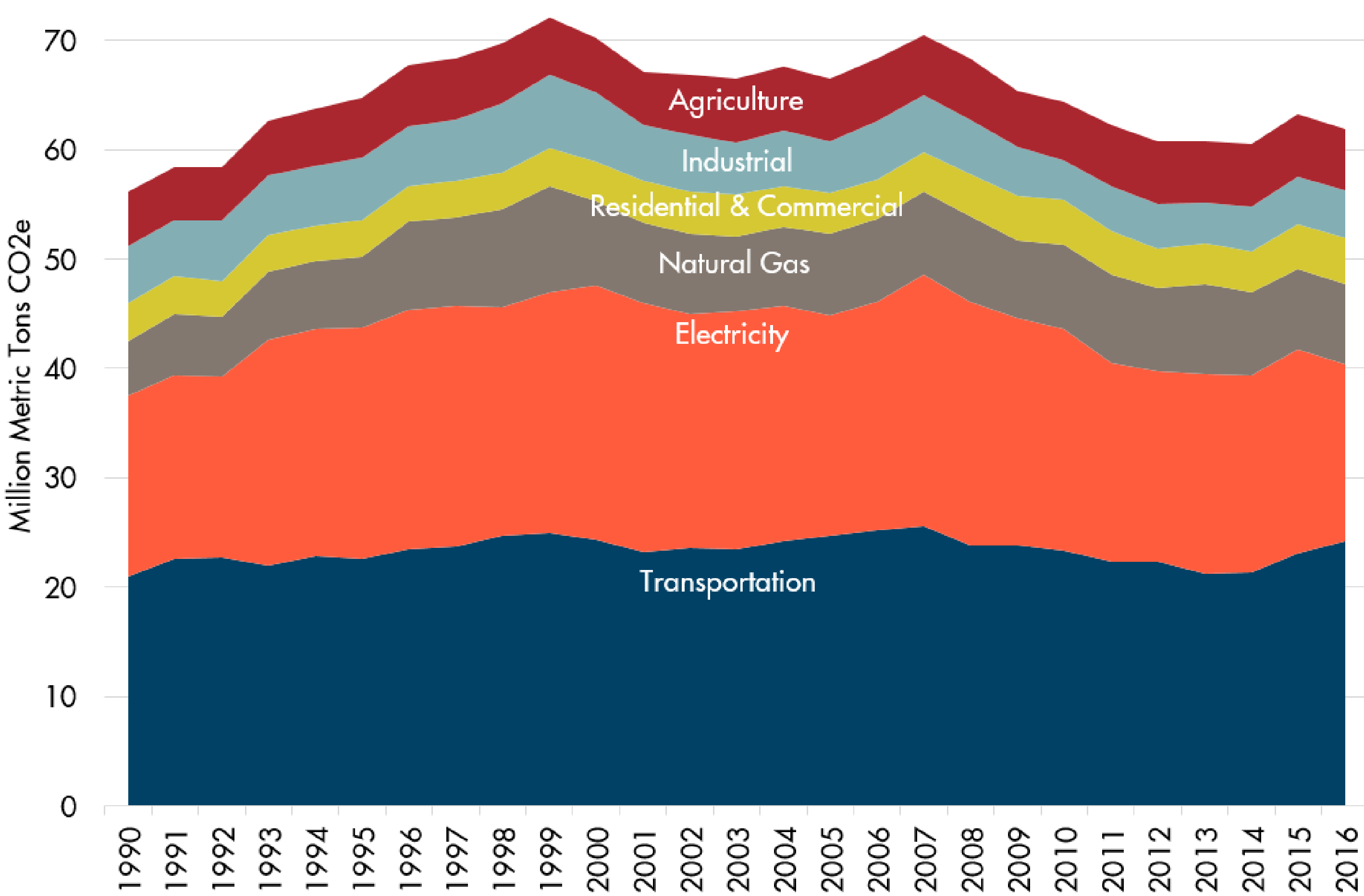
Oregon also signed America's Pledge, which brings together private and public sector leaders to ensure the United States remains a global leader in reducing GHG emissions and meets the country's ambitious climate goals under the Paris Agreement.

Oregon is a founding and long-standing member of the Pacific Coast Collaborative, a multi-state partnership between Oregon, California, Washington, and British Columbia that formally began in 2008. The PCC provides a forum for cooperative action, leadership, and information sharing, and is a common voice on issues in the Pacific North American region. Oregon has been engaged for many years on various PCC technical working groups to enhance a sustainable, low-carbon regional economy. In March 2018, the Governors and Premier reaffirmed their commitment to meaningful action on climate change, including how carbon pricing can effectively, efficiently, and fairly reduce GHG emissions. Their joint statement also noted that climate change disproportionately affects low-income and vulnerable populations, and discussed the importance of ensuring all climate policies provide support to these vulnerable groups.

# GHG Reduction Goals: Oregon's Progress

Oregon's statewide sector-based GHG Inventory[1] provides GHG emissions going back to 1990 for four main sectors of economy—transportation, residential and commercial, industrial, and agriculture—and can also break out emissions associated with electricity and natural gas. For Oregon, this includes GHG emissions associated with electricity used in the state, regardless of where it is produced, but not emissions associated with electricity produced in Oregon but used out-of-state.

**Figure 2.1: Sector-Based GHG Emissions with an Energy Lens: 1990-2016[1]**



As seen in Figure 2.1, statewide sector-based GHG emissions peaked in 1999 and almost reached the same level in 2007, before they generally declined or stayed flat through 2013. Within the state's largest emitting sector, transportation, emissions were second highest in 1999, peaked in 2007, generally declined or stayed flat until notable increases each year in 2015 and 2016. Within the state's second largest emitting sector, electricity use, emissions peaked in 2000, were almost as high again in 2007, then generally declined or stayed flat with small increases in 2013 and 2015 followed by a notable decrease in 2016.

For the data in Figure 2.1, GHG emissions associated with electricity and natural gas use in all sectors is aggregated and displayed separately. For the Industrial and Residential and Commercial sectors, electricity and natural gas use are the largest source of emissions. The remaining emissions for these sectors are primarily associated with petroleum combustion (e.g., fuel oil for heating), waste and wastewater, and industrial process manufacturing emissions (e.g., production of cement, paper products, ammonia, urea, etc.). For a detailed analysis of emissions sources within sectors, see DEQ's inventory.[1]

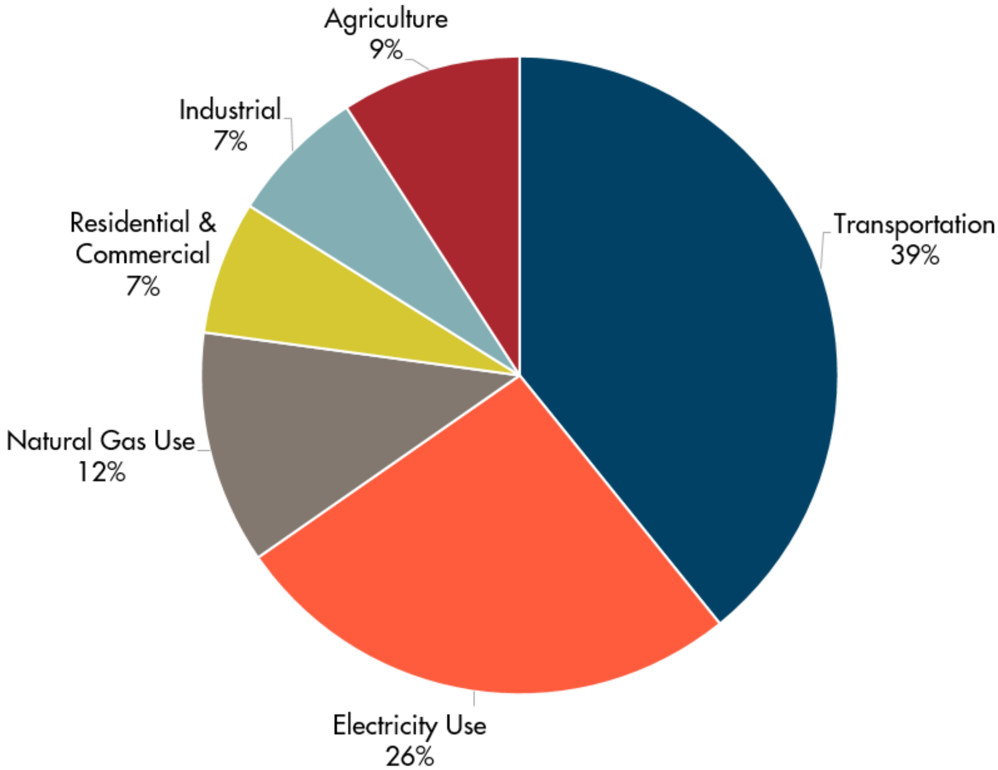
DEQ's sector-based inventory relies on data reported at the state level, following internationally-accepted GHG accounting protocols from the Intergovernmental Panel on Climate Change (IPCC).[14] It presents gross anthropogenic (human-caused) emissions, rather than lifecycle or net emissions inclusive of natural carbon sources and sinks, to facilitate data tracking and reporting on Oregon's statewide GHG emissions reduction targets. Consistent with this approach and with IPCC guidance, GHG emissions that are biogenic in origin—from biologically based materials rather than from fossil fuels—are not included in Oregon's sector-based inventory.* Biogenic emissions associated with wildfires and other biomass burning are therefore not included in Oregon's sector-based totals.

Given the normal time delay for data verification processes, the latest Oregon GHG Inventory contains verified data for 2015 and preliminary estimates for 2016 that use a small amount of 2015 proxy data. Inventory data for 2016 are unlikely to change substantially during the final verification process that relies on the latest federal GHG emissions data that have not yet been published by the U.S. Environmental Protection Agency.

Total statewide GHG emissions reflect the trends in the underlying sectors, increasing from 60 to 63 million metric tons of carbon dioxide equivalent (MTCO2e) between 2014 and 2015. The most recent 2016 estimates show Oregon's emissions at 62 million MTCO2e, with the breakdown by sector in Figure 2.2. Transportation emissions have grown as a share of Oregon's statewide GHG emissions total compared to emissions from electricity use. Specifically, transportation went from 35 percent of the statewide total in 2014 to 39 percent in 2016, while electricity use emissions decreased from 30 percent to 26 percent of the state's total emissions, and all other sectors stayed relatively constant over the same period. (For a deeper dive on the transportation sector see Chapter 4.) Almost half of transportation emissions are due to gasoline and diesel use by passenger cars and trucks, or about approximately 17 percent of emissions from all sources.[1]

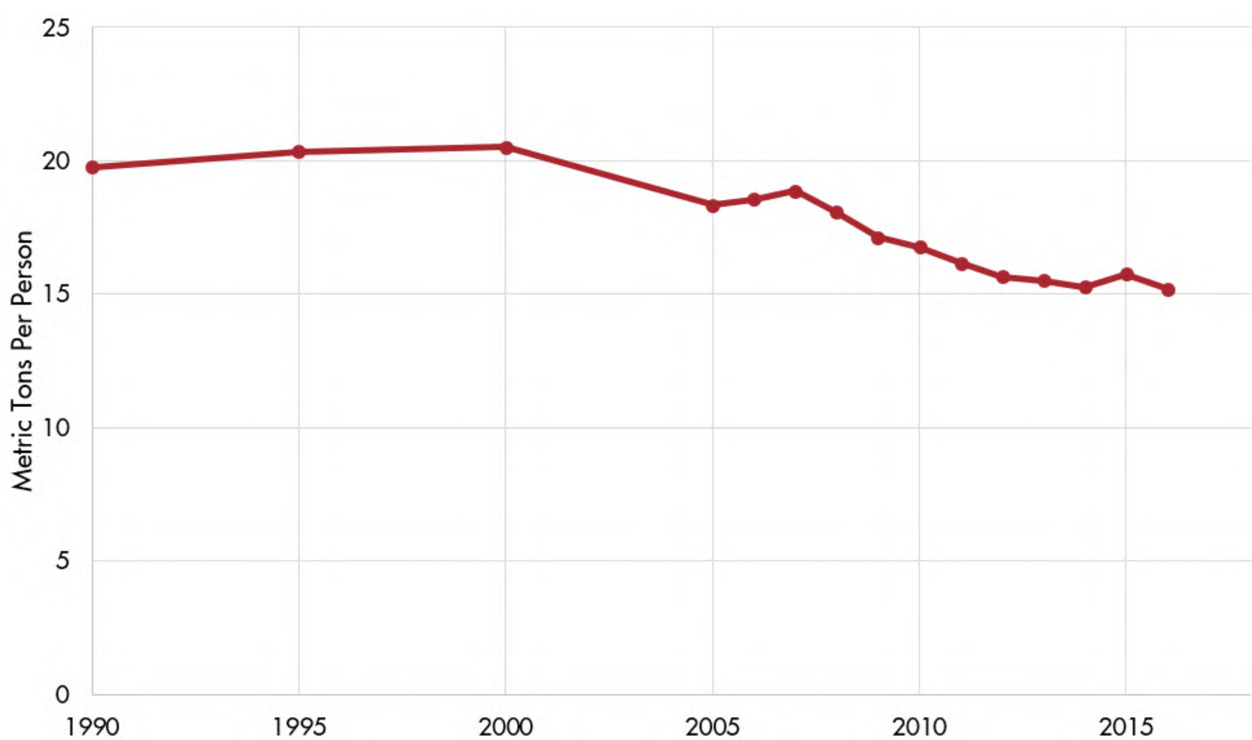
* Biogenic emissions are included in an accounting method known as net carbon flux, which considers the net effect of GHG emissions and carbon sequestration associated with land use, land use change, and forestry. Net carbon flux estimates are presented separately in the national emissions inventories submitted to the UNFCCC. Oregon Department of Forestry is currently conducting a process to estimate net carbon flux for the state's forests.[13]

**Figure 2.2. Breakdown of Oregon GHG Emissions By Sector (2016)**[1]




The state's GHG emissions trends can also be considered in the context of population growth within the state, which has increased 43 percent since 1990, and as of 2016 totaled 4.1 million people. Oregon's per capita GHG emissions peaked in 2000, a year after the peak in gross emissions, and then trended generally downward before ticking up again between 2014 and 2015, consistent with the total emissions trend.

**Figure 2.3: Statewide Per Capita GHG Emissions**[1,15]



For additional context, Oregon's sector-based GHG emissions total is roughly comparable in amount to the GHG emissions of some countries, such as those shown in Figure 2.4. Examples are shown from Western European countries with similar levels of GHG emissions as Oregon; however, these are rough comparisons for scale only, since their emissions totals are not completely comparable given differences in inventory method for GHG emissions from their respective electricity sectors.[16] Oregon uses a consumption approach (i.e., emissions from electricity used in Oregon regardless of where the electricity was produced), while country-level GHG inventory datasets use an electricity production approach. Given the normal time delay in compiling and certifying global emissions data, the most recent available 3-year averages are shown. When comparing per capita emissions (Fig. 2.5), these four example countries have lower emissions than Oregon, in some cases substantially lower, despite having larger populations (ranging from Ireland with about 4.7 million people to Portugal with about 10.5 million people).

**Figure 2.4: Average Annual GHG Emissions (2012-14)[1,16]**

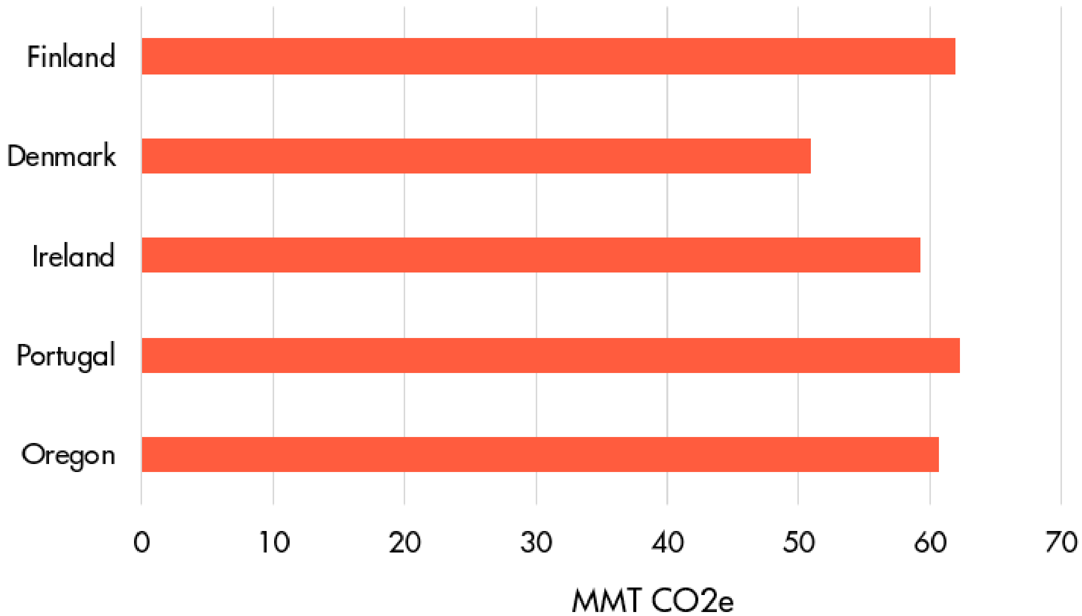
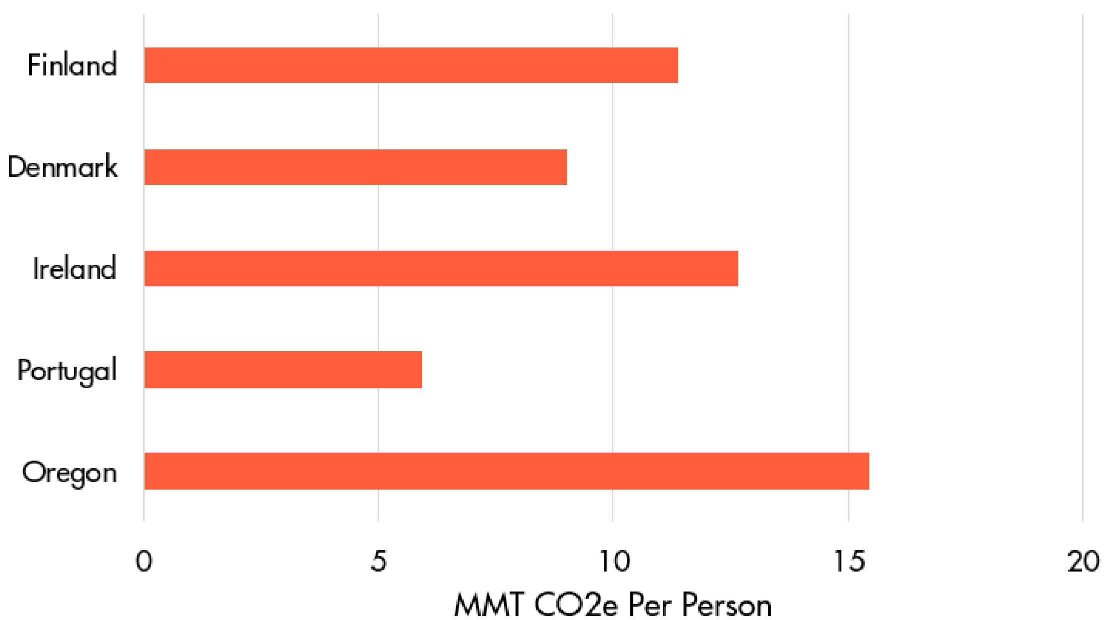



**Figure 2.5: Average Annual GHG Emissions Per Capita (2012-14)[1,15,16,17]**



## Climate Policies

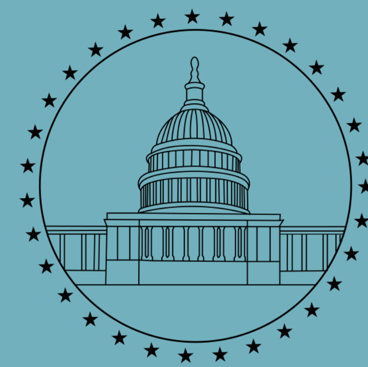
Policy, economic, and social factors have contributed to the state's ability to maintain relatively level GHG emissions while growing its population and economy. All of these factors together have contributed to where Oregon stands today in relation to its GHG emissions goals. Current policies together with known forecasts of energy efficiency and energy demand can be thought of as Oregon's "Business as Usual."

Policy factors include statutory mandates, regulations, and programs that affect or have the potential to affect Oregon's GHG emissions. Oregonians have a long tradition of being good stewards of the environment and climate, going back to the 1980s with some of the nation's most aggressive energy efficiency efforts (Chapter 6) and to 1997 with the passage of the first-in-the-nation carbon dioxide emission standard for large -scale fossil-fueled energy facilities sited in Oregon (ORS 469.503(2)).[133,134] Oregon's 2007 climate change statute (ORS 468A.200-250)[135] adopted GHG emission reduction goals and established the Oregon Global Warming Commission and the Oregon Climate Change Research Institute to advise on climate issues, but it did not create an implementation mandate or mechanism within executive branch agencies to plan for or carry out comprehensive climate mitigation or adaptation measures.

Starting in 2015, following the notable rise in emissions and increasing observations of climate impacts affecting the state[18], the Oregon Legislature and the Governor authorized a number of policies, standards, and programs aimed at or relevant to reducing GHG emissions from certain sectors. Some highlights of these efforts include the following, which are discussed in more detail in other chapters of this report:

- Governor Kate Brown's Executive Order 17-20 on energy efficiency in the built environment (Chapter 6).[136]
- An increased Renewable Portfolio Standard for the electricity sector (Chapter 3).
- The Clean Fuels Program, Zero Emission Vehicle requirements, and Governor Kate Brown's Executive Order 17-21 in the transportation sector (Chapter 4).[137]
- The provision in the Oregon Clean Electricity and Coal Transition Law (Chapter 28, Oregon Laws 2016) that eliminates imported coal-based electricity from Oregonians' rates by 2035.[138]

## FEDERAL CLIMATE POLICIES



Federal policies and regulations began to explicitly target GHG emissions reductions in the 2007-16 timeframe, following the U.S. Supreme Court decision in *Massachusetts vs. EPA* in which the court held that GHGs are considered air pollutants subject to regulation under the Clean Air Act. The U.S. Environmental Protection Agency then issued the *Endangerment and Cause or Contribute Findings for Greenhouse Gases under section 202(a) of the Clean Air Act*. This formal determination that GHGs constitute a **threat to public health and welfare** paved the way for regulation of light-duty vehicle tailpipe emissions, which complemented action by the National Highway Transportation Safety Administration to tighten federal fuel efficiency standards.

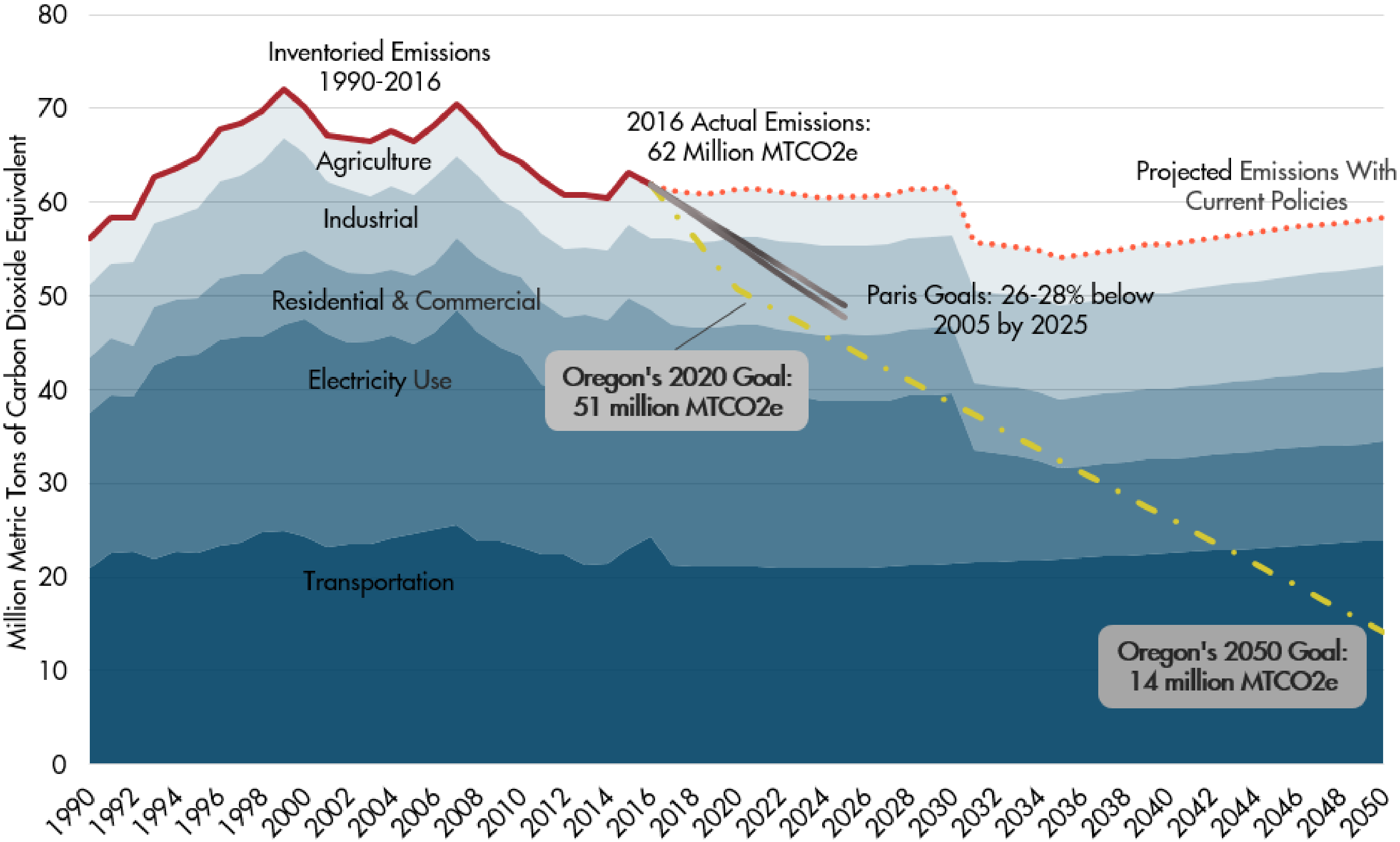
Additional regulation of GHG emissions followed, such as those for medium-and heavy-duty vehicles, stationary sources that require air pollution permits, power plants, oil and gas facilities, and landfills. Other federal climate actions were outlined in Second Biennial Report of the United States of America to the UNFCCC. In addition, on the legislative side, the U.S. House of Representatives passed the American Clean Energy Security Act in 2009,[139] which was the first bill approved by a chamber of the U.S. Congress to explicitly address GHG emissions that are causing climate change. The bill would have established a national emissions trading program, but did not become law.

Economic and social factors that have and continue to affect GHG emissions include the falling costs of renewable energy technology as described in Chapter 3, and changing consumer preferences for energy conservation, efficiency, and low carbon sources of energy, as described in Chapters 5 and 7. Additionally, the following section describes the efforts underway in other jurisdictions within the state, including Tribal, regional (metropolitan), and local (county and city) governments. All of these efforts together have contributed to where Oregon stands today in relation to its GHG emissions goals.

## Business as Usual

The 2015 and 2017 reports from the Oregon Global Warming Commission[19] concluded that Oregon's Business as Usual will not be enough to meet the state's 2020 GHG reduction goal and does not put the state on a course to meet its 2050 goal. Meeting the 2020 goal would require reducing emissions by 11 million metric tons of carbon dioxide equivalent (MTCO2e) within the next two years, from 62 million MTCO2e (2016 preliminary total) to 51 million MTCO2e. The dotted line in Figure 2.6 shows the trajectory of Oregon's emissions under its Business As Usual. The yellow and dark gray lines represent the emissions levels needed to meet Oregon's statutory goals and the Paris agreement goals, respectively.

**Figure 2.6: Oregon's Projected GHG Emissions vs. Goals**[20]




Projected emissions are a forecast of Oregon's emissions assuming compliance with existing state policies like the Renewable Portfolio Standard and Clean Fuels program. Industrial, Residential, and Commercial sectors exclude emissions from electricity, because electricity use emissions is presented as its own sector. Because the United States' goals for the Paris agreement were expressed as a range to reduce its emissions 26 to 28 percent below 2005 levels by 2025, there are two emissions projections associated with that range.

# Local, Regional, and Tribal Government Climate Action in Oregon

Climate action in Oregon consists of the cumulative efforts of Oregonians throughout the state to quantify and reduce their GHG emissions and to plan for the effects of climate change. While these types of actions are not formally aligned or coordinated with state-level actions, they contribute to GHG emissions trends that are tracked at the state level. Because GHGs accumulate over time and mix globally in Earth's atmosphere, any emissions (e.g., from an individual, community, company, country) contribute to the collective problem and affect others.[21] So individual actions, from reducing energy and fossil fuel use to choosing low-carbon products, are essential contributors to the state's ability to meet its climate goals.

This chapter focuses on institutional efforts to address climate change in ways that support collective action and enable individuals to make climate-friendly choices. City, county, and Tribal governments in Oregon are leaders in pursuing local climate initiatives for their communities. Academic institutions such as Lane Community College, Lewis and Clark College, Oregon Institute of Technology, Oregon State University, Portland Community College, Portland State University, and University of Oregon have publicly committed to various climate or carbon neutrality goals and actions.[22] Metropolitan planning organizations are pursuing local and regional solutions for GHG reductions in the transportation sector. Although these types of actions are not formally aligned or coordinated with state level actions, they contribute to GHG emissions trends that are tracked at the state level.

## Cities and Counties

Table 2.1 provides a snapshot of which counties and larger cities (with populations over 20,000) in Oregon are taking actions that help achieve climate mitigation and adaptation as part of Climate Action Plans, Sustainability Plans, Clean Energy Plans, or other types of existing planning processes. This table's focus on larger cities should take nothing away from the important work being done in smaller cities and at the community or neighborhood level.

### LIVING CULLY COMMUNITY ENERGY PLAN

Published in 2017, the Living Cully Community Energy Plan identifies a set of priority energy conservation and renewable energy generation pilot projects for the Cully neighborhood in Portland. Listen to ODOE's *Grounded* podcast for more information.

https://go.usa.gov/xP93d

Given the diversity of the types of plans that local governments have chosen to pursue, it is not surprising that there is also a diverse set of climate mitigation goals that jurisdictions are aiming to achieve. Such goals are not always expressed quantitatively or for any specific timeframe, but even when they are, the goals are not always directly comparable. Some cities, for example, have set goals for internal operations within the government's direct control, while others have set goals for the community or population as a whole. Similarly, the scope of their GHG inventories can vary, with some quantifying only internal operational emissions and others accounting for community-wide emissions. The table places a check mark next to the general types of climate mitigation strategies that local governments have identified in their plans, but this is not necessarily inclusive of all their planned actions and does not indicate implementation status. Some recognized challenges for implementation of climate plans include funding, organizational capacity, and political/public support.

Table 2.1 was compiled by ODOE from publicly available information. This list is continually evolving – additions and corrections to the entries are welcomed and can be made by contacting ODOE at askenergy@oregon.gov.

**Table 2.1: Jurisdictions in Oregon Taking Climate Change Actions**

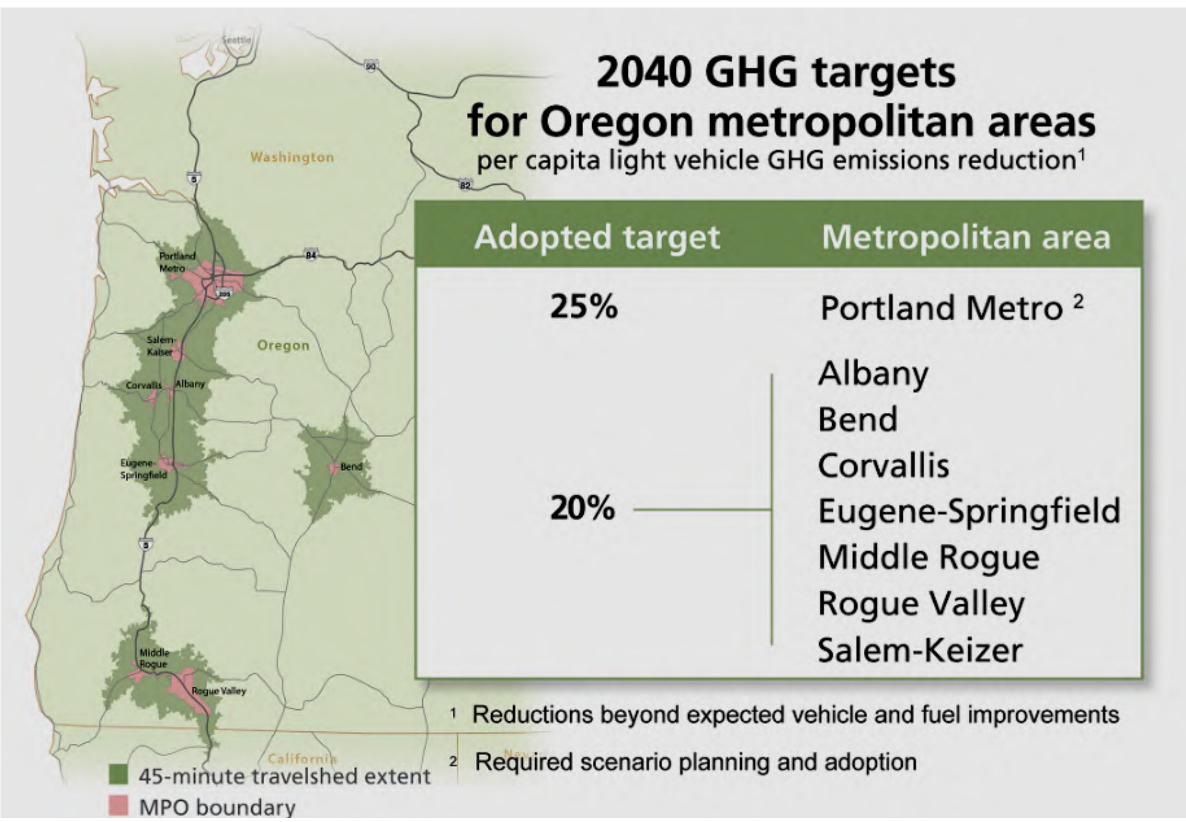
| ✓ = complete<br>→ = in progress | GHG Inventory | GHG Mitigation Goal | Climate Adaptation Goal | Focus Areas for GHG Mitigation: Renewable Energy | Transportation & Land Use | Buildings | Materials Management | Carbon Sequestration |
|---|---|---|---|---|---|---|---|---|
| Ashland | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
| Beaverton | ✓ | Carbon neutral by 2050; 1.5°C goal | → | ✓ | ✓ | ✓ | ✓ | |
| Bend | ✓ | ✓ | → | → | → | → | → | |
| Clackamas County | ✓ | 80% reduction by 2050 | | ✓ | ✓ | ✓ | ✓ | |
| Corvallis | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
| Eugene | ✓ | Carbon budget for city residents consistent with 350 ppm in atmosphere by 2100, requiring an annual average emission reduction of 7.6% | | ✓ | ✓ | ✓ | ✓ | |
| Forest Grove | | | | | ✓ | ✓ | ✓ | |
| Gresham | ✓ | → | | | | | ✓ | |
| Hillsboro | ✓ | ✓ | | ✓ | ✓ | ✓ | | |
| Hood River County | ✓ | Replace 30%, 50%, and 80% of fossil fuel power with renewable energy by 2030, 2040, and 2050 compared to 2016 | ✓ | ✓ | ✓ | | | |
| Lake Oswego | ✓ | | → | ✓ | ✓ | ✓ | ✓ | |
| Milwaukie | ✓ | Carbon neutral by 2050 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Portland and Multnomah County | ✓ | 80% reduction from 1990 levels by 2050 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Salem | → | ✓ | | | ✓ | ✓ | | |
| Washington County | ✓ | | | ✓ | ✓ | ✓ | ✓ | |

## Metropolitan Planning Organizations

“Metropolitan areas” are designated by the federal government in urban areas with at least 50,000 residents. Each metropolitan area has a Metropolitan Planning Organization (MPO) that prepares a regional transportation plan that aims to guide investments and promote consistency among the various policy objectives of state, regional, and local jurisdictions, such as growth management, economic development, transportation system safety and accessibility, and environmental protection. Two out of every three Oregonians live within an MPO boundary[23], which includes Portland Metro, Salem-Keizer, Corvallis, Albany, Eugene-Springfield (Central Lane), Grants Pass (Middle Rogue), the Rogue Valley, and Bend. The majority of Oregon’s transportation GHG emissions stem from gasoline and diesel use by light-duty vehicles (passenger cars and trucks), so in bills passed in 2009 and 2010, the Oregon State Legislature directed the Land Conservation and Development Commission to adopt rules that set targets for metropolitan areas for GHG emissions reductions from light-duty vehicles.[140,141]

Figure 2.7 shows the targets for each MPO, but only Portland Metro is required by the Department of Land Conservation and Development to implement a strategy to achieve its target. The figure also notes that these regional targets are separate from transportation GHG emissions reductions that would be expected from other federal and state policies that encourage cleaner vehicles and fuels. Chapter 4 discusses the role of vehicle efficiency standards, clean fuels policies, and other related programs in more detail.

**Figure 2.7: State Targets Adopted for Metropolitan Area Passenger Vehicle GHG Emissions[24]**



Three MPOs have conducted scenario-planning efforts to evaluate the GHG emission reduction potential associated with their regional plans, which generally focus on a combination of increased transit, transportation options, and compact, mixed-use development:

- Between 2011 and 2014, Metro conducted the Climate Smart Communities project to evaluate 144 scenarios. In December 2014, Metro adopted a preferred scenario that is expected to reduce GHG emissions by 29 percent per capita by 2035.
- Between 2012 and 2014, the Central Lane MPO and jurisdictions within the Eugene-Springfield area completed the Central Lane Scenario Planning project. In June 2015, Central Lane adopted a preferred scenario that is anticipated to meet its 20 percent per capita reduction target.
- In 2014, the Corvallis MPO took initial steps toward more detailed scenario planning by conducting a "strategic assessment" of its adopted plans.

## Tribal Governments

The nine federally-recognized Tribes in Oregon are experiencing firsthand the threat that climate change poses to their traditional ways of life and are engaged in both climate mitigation and adaptation actions. All nine Tribes are members of the Affiliated Tribes of Northwest Indians, which has had an energy program since 1995 and more recently launched a climate change program (http://atnitribes.org/climatechange/). All of the Tribes also participate in the University of Oregon's Pacific Northwest Tribal Climate Change Network, which since 2009 has fostered "communication between tribes, agencies, and other entities about climate change policies, programs, and research needs pertaining to tribes and climate change."[25]

In December 2017, tribal members from Oregon participated in a ground-breaking regional Tribal & First Nations Climate Summit, jointly organized and hosted by ATNI and the PNW Tribal Climate Change Network, among others.[31] The Summit brought together more than 150 participants from Tribes and First Nations in the Pacific Northwest and Canada to learn from past work and chart courses for the future. The Summit indicated that areas of focus for the region's Tribes and First Nations include the role of traditional knowledges in addressing climate change, effects on cultural resources, climate resiliency and adaptation, and advancing policy.

Tribes in Oregon have been involved in various types of climate change-related work for many years. The summary below is not comprehensive; rather, it is meant to highlight the diversity of tribal climate actions that are occurring around the state.

## SELECT TRIBAL CLIMATE MILESTONES

The **Burns Paiute Tribe** is one of the four member tribes of the Upper Snake River Tribes Foundation that participated in a collaborative Climate Change Vulnerability Assessment in 2016, with technical assistance from Adaptation International, University of Washington, and Oregon State University. A profile of this effort is posted on the U.S. Climate Resilience Toolkit.[27]

Wind turbine and solar array at the Tamástslikt Cultural Institute

The **Confederated Tribes of Coos, Lower Umpqua, and Siuslaw Indians** are incorporating climate change considerations into some of their natural resource planning, including their Wetlands Inventory and Assessment and their Terrestrial and Aquatic Invasive Species Management Plan.

The **Grand Ronde Tribe** joined the West Coast Electric Highway in 2013, installing a charging station at their Spirit Mountain Casino, and have installed solar PV panels on the Grand Ronde Tribal Housing Authority carport and at a low-income housing community for tribal elders. The Tribe received funding and technical assistance from the Energy Trust of Oregon and the U.S. Department of Energy.

The **Confederated Tribes of Siletz Indians** have implemented various clean energy projects through their Siletz Tribal Energy Program, focusing on weatherization and energy efficiency, conservation, renewable power, and solar for tribal buildings and homes. With funding and technical assistance from the Energy Trust of Oregon, the Tribe installed energy-efficient lighting and upgraded air handling equipment at their Chinook Winds casino.

The **Confederated Tribes of the Umatilla Indian Reservation** (CTUIR) is compiling climate vulnerabilities and impacts of particular concern to the Tribe through its climate change story map.[28] The Tamástslikt Cultural Institute, a nonprofit interpretive center on the reservation, has installed a wind turbine as part of its goal to become a net-zero building. The Tribe has also implemented a number of energy-efficient LED lighting and solar PV projects in keeping with the climate and renewable energy goals outlined in the CTUIR Comprehensive Plan and Energy Policy.

The **Confederated Tribes of Warm Springs** (CTWS) participated in a project with the Oregon Health Authority[29] to profile the health effects their tribal members are facing due to climate change. In addition, CTWS is the only Tribe in Oregon to have completed an Improved Forest Management project on a portion of its 650,000 acre reservation to generate carbon offset credits that can be sold into the Western Climate Initiative cap-and-trade market (see section X.X below for more on cap-and-trade and offsets). Revenue from these sales will support CTWS "tribal member services, economic development, and improved forest management, among other benefits."[30]

The **Cow Creek Band of Umpqua Tribe of Indians** is the only Tribe in Oregon with its own electric utility cooperative and the first in the Northwest that is both owned and operated by a tribe. The Umpqua Indian Utility Cooperative distributes electricity solely from Bonneville Power Administration, of which about 95 percent comes from zero-carbon emitting resources, mostly hydropower and a small amount of nuclear power.

The **Coquille Indian Tribe** is developing a climate adaptation plan to adapt to the challenges and threats to its land and natural resources, infrastructure and transportation systems, and in turn, the Tribe's culture, economy, health, and safety. In addition, the Tribe installed solar PV panels and a solar water heating system on the roof of its Community Center, and has implemented lighting and other efficiency upgrades in tribal buildings and residences.

**The Klamath Tribes** are involved in a number of Klamath Basin-wide climate projects spanning southern Oregon and northern California. A 2010 report, sponsored in part by the University of Oregon, assessed climate impacts and identified climate adaptation strategies relevant for Klamath Basin Tribes and local communities.[31] The Klamath Tribes participate in the Klamath Basin Tribal Food Security Project (administered by the University of California, Berkeley and the Karuk Tribe) to build capacity in identifying, monitoring, harvesting, managing, and preparing traditional foods, especially in the face of changing environmental conditions from climate change.[32]

# Risks and Impacts Under High and Low Emissions Scenarios

Oregon's climate actions that are being or will be implemented in the near future — its Business as Usual pathway — put us on a trajectory that is far above the state goal to achieve our fair share contribution to the global level of GHG emissions that scientists have concluded is needed to have the best chance of avoiding the most severe projected impacts of climate change. This section summarizes key findings of research on the implications of a future in which local and global GHG emissions keep rising. The latest global climate models used by the scientific community to make future climate projections are based on a consistent set of future emissions pathways called representative concentration pathways (RCPs).[33] The higher global emissions pathway is known as RCP 8.5 — what many consider as a "worst-case" scenario of rising emissions, which is currently the path the world is on — while one of the most commonly studied lower emissions pathways is called RCP 4.5. The RCP 4.5 scenario represents efforts to reduce global GHG emissions such that they peak near mid-century then decline, and is often cited as the top end of the range of future scenarios that could potentially meet the UNFCCC goal of "stabilization of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.[11]"

Understanding the upper and lower bounds of expected changes is consistent with a risk management approach to climate change[34,35,36]; it enables us to understand what is at stake and what society stands to gain if the world moves from a high to a low emissions scenario. Oregonians strongly value the state's natural beauty, outdoor recreation opportunities, and clean air and water. Climate change is threatening these values, as well as the state's economy, environment, and way of life. Although risks are not limited to one area of the state, certain populations—including low-income communities, communities of color, and rural areas—are particularly vulnerable and less able to respond to and cope with climate change.

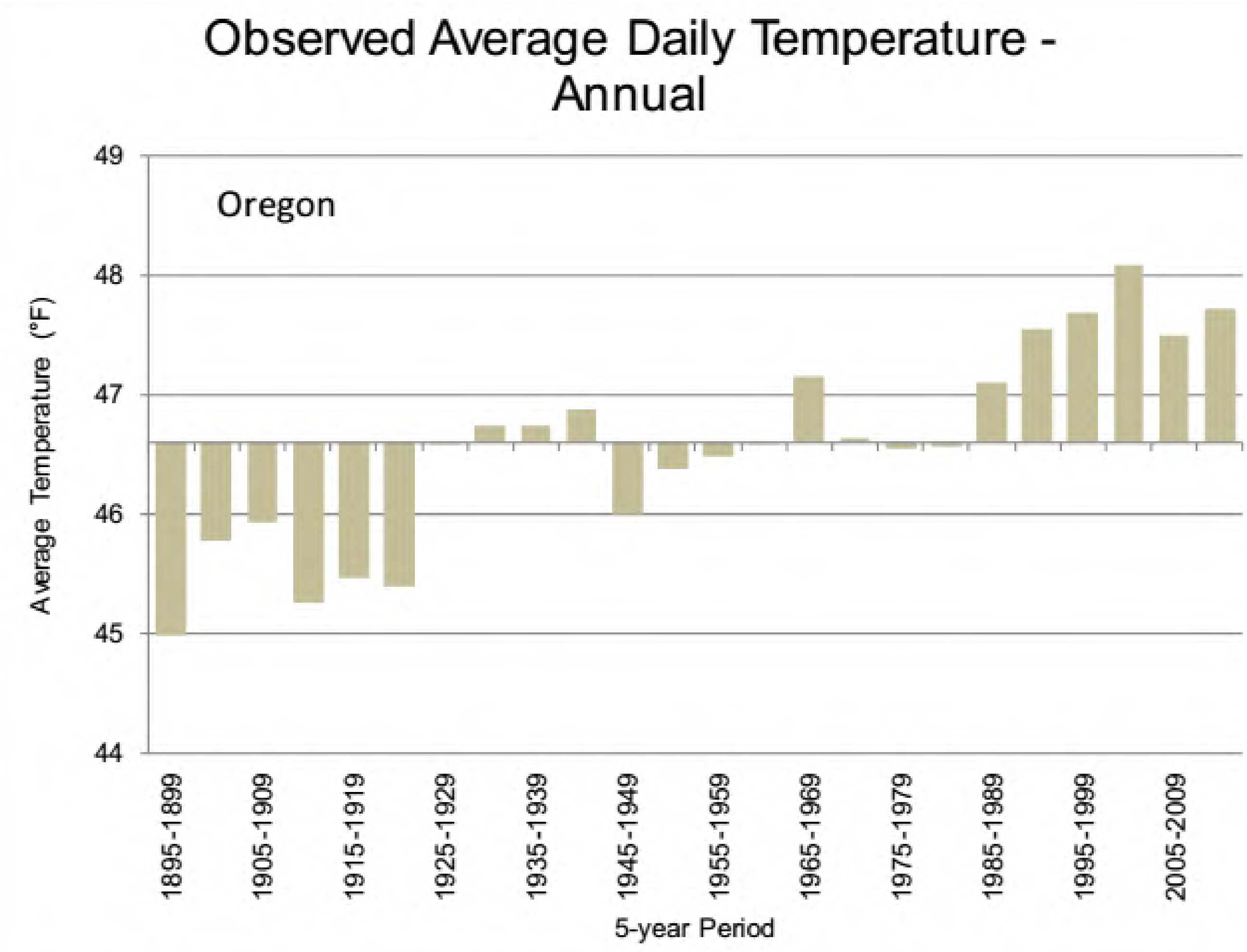
The following subsections provide a broad, high-level look at key trends and projected climate impacts affecting the United States and Oregon. This is for the purposes of comparing high-level risks under different global GHG mitigation futures; the studies and reports referenced in this section cover climate impacts in more comprehensive detail. See Chapter 5 for more background on climate vulnerability assessments used for the purposes of climate adaptation planning, which are designed to go into more detail on risks to the various sectors of Oregon's economy and society.

## Warming and Extreme Heat in Oregon

Long-term increases in temperature due to anthropogenic GHGs have ripple effects throughout the Earth's climate system. The evidence base that global temperature is increasing comes not only from direct measurements of temperature itself, but also from changes such as altered regional precipitation and storm patterns, rising ocean heat content, and rising global sea level resulting from the thermal expansion of water and increased melting of land ice.[37] The most recent climate science volume of the U.S. National Climate Assessment, a federal scientific consensus report, concluded that the pace of change is more rapid compared to the pace of the natural variations in climate that have occurred throughout Earth's history, that there is no convincing evidence that natural cycles can explain the observed changes in climate, and that it is extremely likely (indicating a 95 to 100 percent probability of occurrence) that human influence has been the dominant cause of the observed warming since the mid-20th century.[37]

Since the beginning of the 20th century, temperatures in Oregon have risen approximately 2°F, and temperatures since the 1990s have been higher than any other historical period since records began in 1895.[38,39] Since the 1970s, warming in the Pacific Northwest been accelerating faster than over the last century.[39]

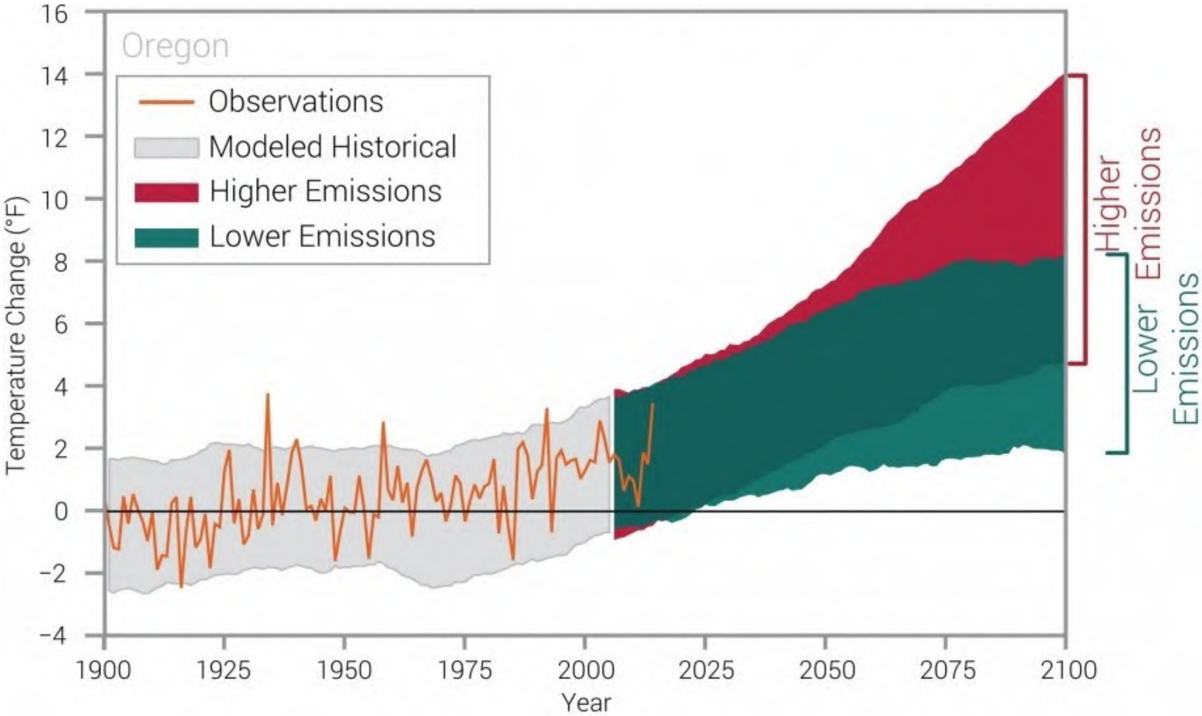
**Figure 2.8: The Observed Average Daily Temperature for the Years 1895-2014, Averaged Over 5-year Periods.**[38,35]




Under a higher global GHG emissions scenario (RCP 8.5, as shown in the red shaded area of Figure 2.9), historically unprecedented warming is projected for Oregon by the end of the century.[38] On average, Oregon can expect a 5.0°F increase (with a possible range from 2.9° to 6.9°F) by the 2050s and an 8.2°F increase (4.8° to 10.7°F) by the 2080s.[39] Even under a lower global GHG emissions scenario (RCP 4.5, as shown in the green shaded area), average annual temperatures are projected to most likely exceed historical record levels by 2050.[38] Oregon can expect an average increase of 3.6°F by the 2050s and 4.6°F by the 2080s.[39]

In either future scenario, warming temperatures will result in extreme heat events with increased frequency, duration, and intensity.[39] In the next few decades, recent record-setting years like Oregon's summer of 2015 may become common.[37,39] But overall risks associated with warming temperatures would be reduced on the lower emissions pathway because there is a greater possibility of staying only slightly warmer than historical records[39], which means closest to the gray shaded area in Figure 2.9.

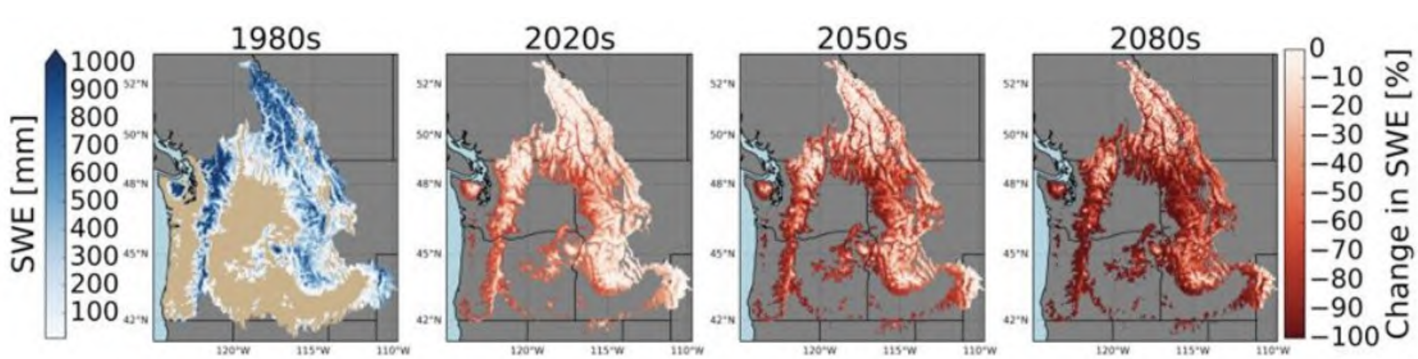
**Figure 2.9: Observed and Projected Annual Average Temperature Change in Oregon (1895-2100).[38,35]**




## Water Resources in Oregon

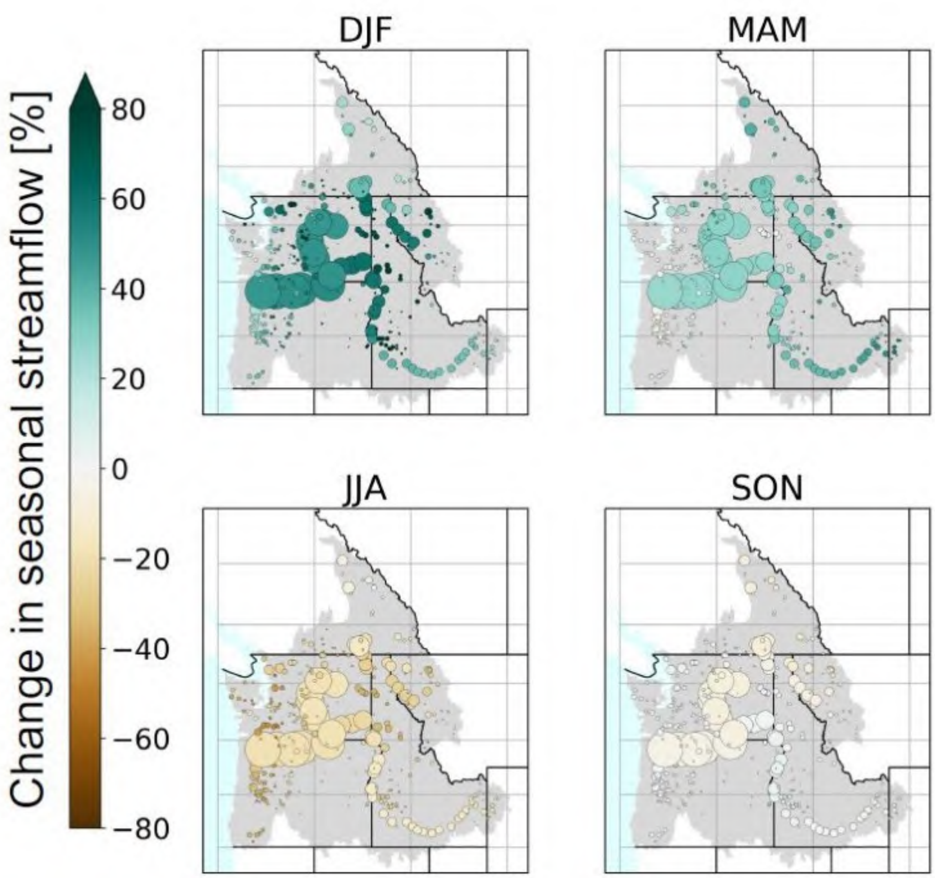
Climate change will affect water resources in Oregon and the Northwest, such as the amount and seasonal timing of water in rivers and streams, winter flood risk, and summer extreme low flows and drought risk.[39] A key indicator for these impacts is mountain snowpack, which is a natural source of water storage that has provided a vital supply during the summer dry season for irrigated agriculture and municipal and industrial water uses in Oregon and throughout the western U.S.[41] Oregon State University researchers track snowpack trends across the western U.S., and nearly all measurement stations in Oregon have documented snowpack declines[41], with an average 37 percent decrease from 1955 to 2015.[39] For every 1°F of future warming, the snow line—the average lowest elevation at which snow falls—increases by about 300 feet.[38] In the Cascade Range, mountain snowpack as measured in peak snow water equivalent is expected to decline 22 to 30 percent for every 1.8°F of temperature rise.[39] Therefore, a lower emissions pathway (RCP 4.5) would reduce risks associated with loss of snowpack because it would limit the likely range of temperature increase. Under a higher emissions scenario (RCP 8.5), snowpack in the Cascades is projected to decline by up to 81 to 90 percent, as shown in Figure 2.10.

**Figure 2.10: Observed and Projected Columbia Basin Snow Water Equivalent (SWE)[42,43]**



Wet season precipitation will increasingly fall as rain rather than snow as temperatures continue to rise, further reducing the accumulation of snowpack, particularly in low to mid elevations (about 3300 to 6600 feet).[39] As shown in Figure 2.11, this is projected to shift streamflow magnitude and timing in the Northwest toward higher winter runoff, lower summer and fall runoff, and an earlier peak runoff in the region from summer toward spring.[39,43,44] This means there will be less water available in Oregon's rivers and streams during the summer, and the frequency, intensity, and geographic extent of summer drought and extreme low stream flows is expected to increase.[39]

**Figure 2.11: Projected Changes in Seasonal Streamflow in the Columbia River Basin by the 2030s[43]**



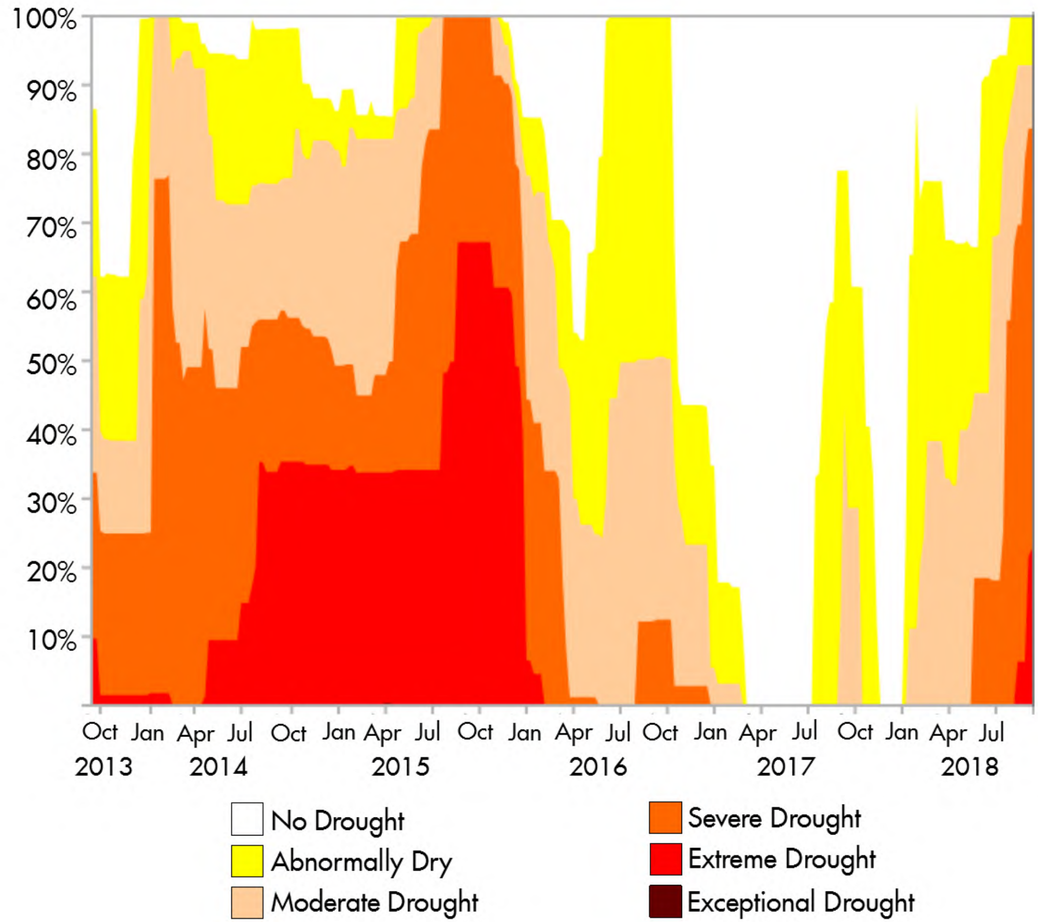

The figure shows percent change in annual water volume under a higher emissions scenario compared to a historical period of 1976-2005 (larger circles have larger annual volumes in the historical period). Darker green colors indicate larger projected runoff volumes in winter and spring, while browner colors in summer months indicate an expected decrease in available water.

## Implications for Oregon's Economy and Natural Resources

Oregon's diverse natural resources support high quality native ecosystems and rare plant and animal species, are major contributors to the state economy, and sustain livelihoods for Oregonians across the state, particularly rural, coastal, and tribal communities. An overview is provided below of ways in which many of these resources are already experiencing effects of climate change and are projected to be affected by future changes.

The summer dry season is expected to become drier at the same time that rising temperatures and more frequent and intense extreme heat events increase evapotranspiration and soil dryness.[39] **Drought** reduces forage and water availability for livestock grazing, and warmer temperatures reduce beef and dairy production and may enable crop diseases, pests, and invasive weeds.[39] The severe lack of water for irrigation in 2015 led to damaged crops, reduced yields, and fewer crops being planted[45], with monetary losses estimated to be in the hundreds of million dollars.[38] Figure 2.12 shows that from 2013 to 2018, there were only short periods of a few months in 2017 where Oregon was not experiencing abnormal dryness or moderate drought.

**Figure 2.12: Drought Intensities: Percent Area for Oregon**[54]




More frequent large **wildfires**, an increase in the total area burned, and a longer fire season have been documented over the last several decades in the Western U.S.[39] Wildfire frequency and area burned are expected to continue increasing in the Pacific Northwest.[39] Droughts and heat waves contribute to greater fire severity; all are expected to increase in Oregon.[18] The 2015 drought conditions and lack of snowpack led to a historically severe wildfire season with more than 1.6 million acres burned across Oregon and Washington, resulting in more than $560 million in fire suppression costs.[39] As of October 2018, the Oregon Department of Forestry estimated gross costs of $101 million to fight wildfires in 2018, which will net to over $40 million after federal cost-sharing.[46]

Oregon's extensive **forest resources** are at risk from increasing temperatures, changing precipitation patterns, wildfire, pests (such as mountain pine beetle in Ponderosa pine) and disease (such as Swiss needle cast in Douglas fir trees), and extreme events such as droughts and floods.[39] These climate impacts are also expected to adversely affect the ability of the forest to provide ecosystem services, such as flood protection or water purification, and goods, such as species habitat or forest products.[18] **Winter flood risk** is expected to increase for many Oregon watersheds (particularly those classified as mixed rain-snow basins) due to slightly more average rainfall in the wet season and slightly more frequent or intense extreme rainfall events.[39]

Changes in **river and ocean temperature**, ocean acidification, and marine hypoxia have serious implications for Oregon commercial fisheries, particularly salmon, groundfish, and crab, as well as shellfish hatcheries:

- Summer water temperatures in streams and rivers in Oregon and throughout the Northwest are projected to rise due to the effects of reduced summer flows, along with higher air temperatures and the loss of the protective cooling effect of snowmelt runoff.[18,39]
- The world's oceans have absorbed about 93 percent of the excess heat caused by greenhouse gas warming since the mid-20th century.[37] For salmon, warmer ocean waters could alter their ranges and migration, and could cause thermal stress and increase susceptibility to disease and predation, and change their habitat structure and availability of food.[39]
- Surface ocean waters absorb part of the increasing CO2 in the atmosphere, which causes a variety of chemical changes in seawater termed ocean acidification. Acidification along the Pacific Northwest coast is increasing as a result of ocean upwelling that brings increasingly acidic deep ocean waters to the surface, and the rate of acidification is thought to be unparalleled in at least the past 66 million years.[37] Under the high emissions scenario (RCP8.5), the global average surface ocean acidity is projected to increase by 100 to 150 percent.[37]
- Over the last half century, major oxygen losses (hypoxia) have occurred in inland seas, estuaries, and in the coastal and open ocean.[37] Ocean oxygen levels are projected to decrease by as much as 3.5 percent under the higher scenario (RCP8.5) by 2100 relative to preindustrial levels.[37]

Additional effects on recreational and tribal fisheries are described later in this chapter.

## Human Health Threats

In 2014, the Oregon Health Authority published the state's first climate and health risk assessment[47] that identified key climate-related health hazards in the state, including extreme heat events, wildfires, floods, and changes in infectious and waterborne disease trends. There is potential for climate change to have a positive influence on some health outcomes in Oregon, such as longer summer seasons that could lead to an increase in outdoor recreation. But on the whole, the rate of change and the evidence to date indicate current and growing adverse health impacts from climate change in the Pacific Northwest and Oregon[18,39,47]:

- Warming temperatures, changes in precipitation, and more extreme weather are projected to increase populations of disease-carrying vectors like mosquitoes with West Nile Virus and of the types of bacteria and toxic algae that contaminate shellfish and recreational waters for activities like swimming and boating.[48]
- Air quality is expected to worsen under future climate change and increased incidences of ozone-related illnesses and premature death are projected nationally under a higher emissions scenario.[48] Fine particulate matter emissions from wildfires are projected to increase by at least 160 percent by mid-century in the western U.S. under a higher emissions scenario.[49]

- The projected increase in flooding related to extreme rainfall (combined with sea level rise at the coast) threaten infrastructure like roads, hospitals, and drinking and wastewater treatment plants that are essential to safeguarding physical safety and human health.[48]
- Indigenous peoples are uniquely vulnerable to mental health impacts associated with climate change, which can include increased rates of mood and anxiety disorders, strong emotional responses, and loss of connections to homeland and social networks.[48] Community health is tied to sacred places and natural resources like water and salmon that have strong cultural, religious, and spiritual significance to many Indigenous peoples, and that are being adversely affected by climate change.[82]

## SALEM DRINKING WATER CRISIS

As greenhouse gas emissions continue to drive global climate change, Oregon will experience negative environmental and economic effects – from increased heating and cooling costs to smoke from wildfires to compromised water sources. In 2018, samples from the City of Salem's drinking water supply, Detroit Reservoir, showed evidence of harmful cyanotoxins from an algal bloom. Salem residents were under a water quality advisory for weeks, during which older adults, children, and people with weakened immune systems could not drink the tap water. Algal blooms thrive in warm waters, which means as water temperatures increase from climate change or drought-reduced water levels, communities are likely to experience more frequent algal blooms, Tufts University environmental engineering professor Steve Chapra told Oregon Public Broadcasting in June.[52] In Salem, the City government implemented a new treatment process: adding powdered activated carbon to the water if and when cyanotoxins are detected. The estimated cost to update the infrastructure for the treatment solution was about $2.6 million. To add carbon to the water supply for one week costs the City over $150,000.[53]

## Oregon Ways of Life and Heritage Resources at Risk

Oregon's coast is home to iconic landmarks and landscapes that are a significant piece of Oregonians' heritage, as shown by the landmark 1967 legislation known as "The Beach Bill"[142] that guarantees free unrestricted public access to all the state's beaches.[51] Along significant portions of Oregon's coast, sea levels are expected to rise about 1 to 4 feet by the end of the century.[39] Nearly a fifth of all housing in the state is located in vulnerable coastline counties, and property damages have been estimated to reach $33 million by 2040.[54] Global average sea level has risen by about 7–8 inches since 1900, with almost half (about 3 inches) of that rise occurring since 1993.[37] Human-caused climate change has made a substantial contribution to this rise since 1900, contributing to a rate of rise that is greater than during any preceding century in at least 2,800 years.[37] Locally, sea level change can be very different from the global average rate change due to geographic differences in natural geologic processes known as subsidence (land sinking) or uplift (land rising). Coastal storms and storm surge can combine with sea level rise to exacerbate coastal erosion and inundation hazards.

Outdoor recreational opportunities in Oregon span all seasons and include fishing, hunting and wildlife viewing, swimming, boating, hiking, and skiing. Oregon's outdoor recreation industry is estimated to support $12.8 billion in consumer spending, $955 million in local and state tax revenue, $4 billion in wages and salaries, and 141,000 jobs.[54] Sixty-eight percent of Oregon residents participate in outdoor recreation, with fish and wildlife-based recreation in Oregon valued at around $2.5 billion annually.[54]

Ski resorts are expected to be negatively affected by reductions in snowfall and snowpack that would result in later resort opening dates and earlier closing dates, a greater reliance on snowmaking during shorter viable time periods, and increased costs to skiers.[18] Declining snowpack and warmer summers increase the risk of stream temperatures that are lethal to fish (generally greater than 68°F, although this varies among populations).[55] The overall effect of climate and hydrologic change on salmon during all life cycle stages is likely to be negative and reduce salmon populations in the Pacific Northwest, especially given existing stressors and natural variability that act as additional stressors to fish populations.[39]

## EFFECTS OF CLIMATE CHANGE ON FIRST FOODS

Tribal Salmon Bake.
*Photo: Oregon State University.*

Of paramount importance are "first foods," the traditional plant and animal species used for physical and spiritual sustenance over generations, to the Indigenous peoples across the United States. Beyond the nutrition they provide, first foods are central to traditional community practices, sacred ceremonies, physical and mental health, and subsistence and commercial economic activities.[50] In Oregon, these foods are gathered, harvested, and hunted in a variety of ecosystems that are projected to be affected by climate change.[56] This includes urban ecosystems, such as the city of Portland, which is home to the ninth largest urban Native American population in the country, including an estimated 58,000 or more people from more than 380 tribal nations.[57] The summary table[50,58,59,60] below highlights climate vulnerabilities of a number of first foods in Oregon, but is not comprehensive. Effects on fish and shellfish species of concern have been well-studied and documented, while more studies are needed on climate effects on berry, root, and game species.

| Types of First Foods in Oregon | Habitat Vulnerability to Climate Change |
|---|---|
| **Fish**, including salmon, steelhead, lamprey | Ocean and rivers (anadromous species spend time in both) affected by rising water temperatures and ocean acidification |
| **Shellfish**, including several types of clam (Gaper clam, Nuttall's Cockle, butter clam, razor clam) | Nearshore and coastal habitats affected by sea level rise, rising water temperatures, and ocean acidification. |
| **Berries**, including huckleberries and chokeberries | Potential drought, wildfire, invasive species, flooding effects on: subalpine slopes, forests, bogs, and lake basins; and low- and mid-elevation, typically riparian zones. |
| **Roots**, including Wapato, Camas, Couse or Kowsh (also known as biscuitroot) | Potential drought, wildfire, invasive species, flooding effects on: marshes and wetlands; prairies and grasslands; and open, rocky slopes and meadows. |
| **Game,** including elk and deer | Potential stress related to wildfire, drought, pests, and disease effects on forests |

## Climate Risks Not Distributed Evenly

Certain populations face more exposures to hazards, have fewer resources to recover from climate change-related impacts, and are affected by existing environmental and health disparities.[47,48] In this way, climate change is likely to exacerbate current social, economic, environmental burdens on certain individuals and communities.[48,44] Those that depend upon natural resources and ecosystems, particularly tribal communities, are among the first to experience the impacts of climate change (Bennett et al. 2014; Norton-Smith et al. 2016). Multiple studies of regional climate impacts have found that Oregon's tribes are uniquely affected by climate change threats to their traditional culture and lifeways, sovereignty, health, and subsistence and commercial economies.[18,39]

The table below identifies many of the vulnerable populations in Oregon; however, these are not mutually exclusive categories, and there is often overlap. For example, older adults—those aged 65 years and older—comprise about 14 percent of Oregon's total population, but have greater representation in rural areas of the state.[47] Such uneven risks associated with certain geographic and demographic factors are some of the reasons why climate mitigation and adaptation policies are often discussed in terms of equity and environmental justice. For more information, see subsections on equity below and in Chapter 5.

| Contributing Factors to Vulnerability | Populations Identified in the Oregon Climate and Health Profile Report[47] |
|---|---|
| **Demographic factors and social determinants of health** | • People with existing illness<br>• People with disabilities<br>• Older adults<br>• Mothers, infants and children<br>• Low-income communities<br>• Indigenous peoples (e.g., American Indian or Alaska Native)<br>• Immigrants, refugees, and linguistically isolated<br>• Communities of color |
| **Geographic and housing characteristics** | • Urban heat islands<br>• Wildland-urban interface<br>• Agricultural communities<br>• Coastal communities<br>• People reliant on private water systems<br>• People living in residences located on steep slopes |
| **Occupation** | • Wildland firefighters<br>• Outdoor workers<br>• Growers, ranchers and farmworkers<br>• First responders and health care workers<br>• People who work in agricultural communities |

# Exploring Deep Decarbonization Pathways for Oregon

2016 GHG Emissions
**OREGON TOTAL**
61.87 million metric tons

There are different strategies available to the State of Oregon to reduce GHG emissions to a level consistent with a deep decarbonization scenario. Because deep decarbonization requires accelerating large-scale changes to energy systems, there is broad consensus across the climate policy community that both cross-sector mitigation policies, such as economy-wide market-based programs, and sector-specific actions are needed. [12,61,62,63,67]

Sector-specific strategies are sometimes described as complementary to economy-wide climate policies because although they can deliver significant emissions reductions in individual sectors, they inherently cannot account for shifts in emissions between sectors.

The following subsections introduce economy-wide and sector-specific strategies that could serve as options to help Oregon meet its climate goals. These categories of potential strategies are broad, and there is no one set of off-the-shelf, prescribed actions for deep decarbonization. Strategies will likely need to be modified as technology continues to progress and circumstances change. Periodic statewide deep decarbonization analyses and strategic planning can help evaluate and prioritize cost-effective actions to pursue that also have the greatest certainty to achieve the necessary emissions reductions.[61,62,63]

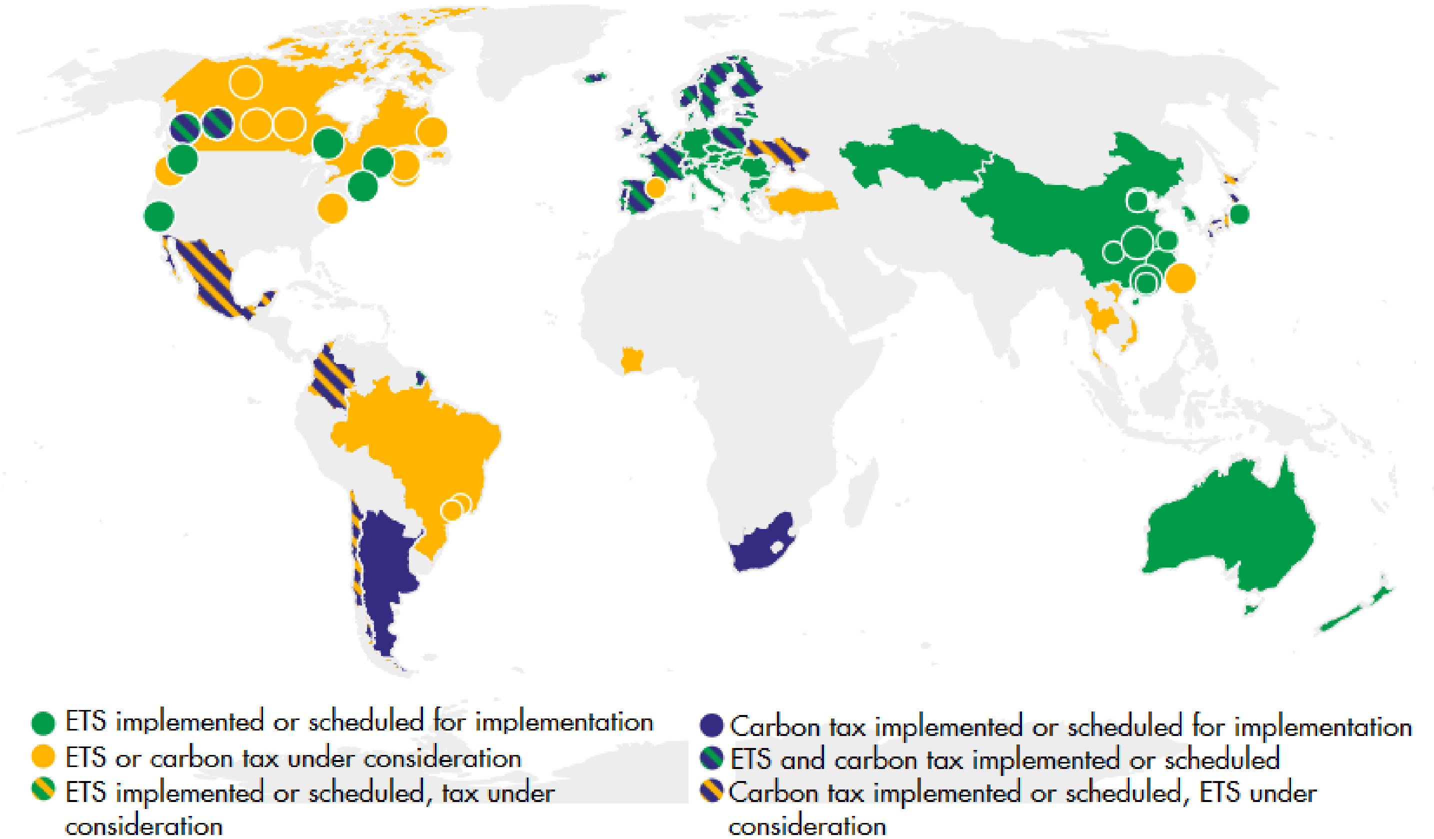
## Economy-Wide Climate Policies

Two common focus areas for subnational jurisdictions with regard to economy-wide climate policies include carbon pricing and beneficial electrification.[12,64,65] These two policy approaches are introduced below.

### Carbon Pricing to Reduce GHG Emissions

National and subnational governments around the world are increasingly turning to market-based carbon pricing policies to reduce GHG emissions (Figure 2.13). The two primary systems of carbon pricing—a carbon tax or a cap-and-trade system (also known as an ETS or Emissions Trading System)—are policy mechanisms that hold emitters of pollution financially accountable for the environmental and health costs of their pollution, thus creating an economic incentive to pollute less. These policies can also include the collection of revenue that is further invested in GHG reduction or transition strategies. Cap and trade as a policy mechanism rose to prominence in the U.S. with the Acid Rain Program established by the Clean Air Act Amendments of 1990. Based on the success of that program in achieving sulfur dioxide emissions reductions at comparatively lower cost than traditional environmental regulation, the mechanism began to be considered to reduce GHGs in the late 1990s.[102]

**Figure 2.13: Global Map of Carbon Pricing Initiatives**[68]




In World Bank's map (Figure 2.13), note that although Washington State has a green circle, in March 2018 a court invalidated parts of the state's Clean Air Rule, which would have required large GHG emitters to cap and reduce their emissions. The state has appealed that ruling to the Washington State Supreme Court.

The European Union was the first jurisdiction in the world to create an ETS for GHGs, which began trading in 2005. In the U.S., a group of northeast and mid-Atlantic states* developed a regional cap-and-trade program addressing carbon dioxide emissions from power plants. This program, called RGGI, or the Regional Greenhouse Gas Initiative, began trading in 2009. From 2009-12, western states including Oregon participated in a coordinated process to negotiate the framework for a linked cap-and-trade system known as the Western Climate Initiative, or WCI. California and the province of Quebec formally agreed to establish the WCI and began linked trading in 2013. With RGGI and WCI, roughly a quarter of the U.S. population lives in an area with a cap and trade program. As of 2018, 51 carbon pricing initiatives have been implemented or are scheduled for implementation globally. This consists of 25 emissions trading programs, mostly located in subnational jurisdictions, and 26 carbon taxes primarily implemented on a national level.[70]

* Existing participants include Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont; New Jersey and Virginia are currently in process to join.

## STUDYING CAP-AND-TRADE IN OREGON

At the request of the Oregon Legislature (SB 5701 (2016)[69]), the Oregon Department of Environmental Quality wrote "Considerations for Designing a Cap-and-Trade Program in Oregon,"[20] which is excerpted below to explain the major features of this type of carbon pricing program in relation to a carbon tax:

**How does a cap-and-trade program work?**

A cap-and-trade program establishes an overall limit (the cap) on GHG emissions from certain sources of pollution, such as electricity providers, industrial facilities, and fossil fuel suppliers. Permits or "allowances" are issued by the state to regulated entities. Each allowance permits a business to emit or supply fuel that emits one ton of emissions. For example, if a program has a cap of 50 million tons of pollution in a given year, the state would issue 50 million allowances in that year. These allowances can be bought and sold on the market (the trade). Companies covered by the program must acquire allowances to match their emissions. As the cap declines over time, the entities covered by the program must make collective cuts in emissions. However, because of the formation of a marketplace for allowances, emission reductions won't be uniform across the covered entities but instead will occur where reductions are cheapest. Entities that can most cheaply reduce their emissions will do so, while others will pay to acquire sufficient allowances. This should reduce emissions where it is cheapest to do so, while spurring innovation to develop new methods for greater reductions.

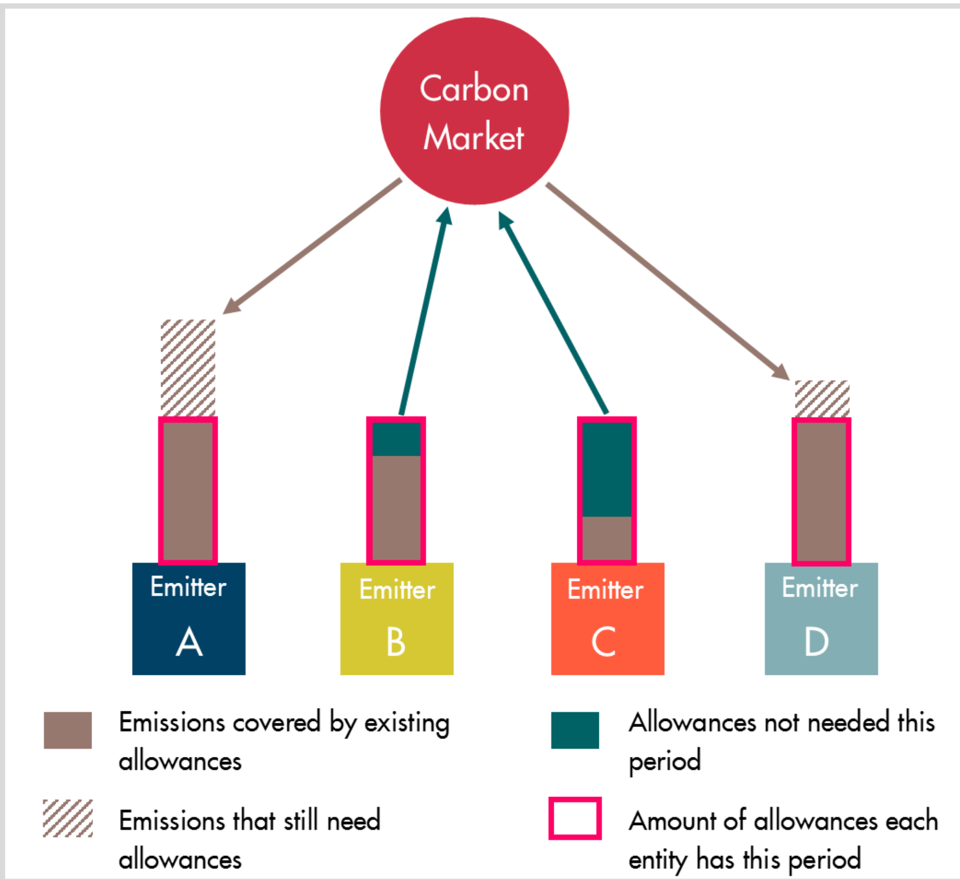
**How does cap-and-trade differ from a carbon tax?**

Both cap-and-trade and a carbon tax establish a price on GHG emissions. Cap-and-trade specifies a certain amount of emissions reduction and allows the price to pollute to adjust based on market demand, while a carbon tax does not prescribe an amount of emissions to be reduced but specifies a price to emit GHGs. Cap-and-trade sets a firm limit on emissions, providing certainty that pollution will be reduced to the level of the cap. This program does not establish a specific price on GHG pollution, letting the marketplace determine this based on the supply of allowances and the demand from regulated entities to pollute. In contrast, a carbon tax does not require specific emission reductions, but does set the price to emit GHGs. The flexibility offered by cap-and-trade provides some benefits compared to a carbon tax. In addition to providing certainty on emission reductions, cap-and-trade offers the state tools to better directly mitigate impacts to specific businesses and should produce emission reductions at a lower overall cost.

In designing a cap-and-trade program, policymakers can choose the sectors, sources, and types of emissions to be covered by the cap. Generally these markets function more effectively and efficiently when the cap is broad because that provides more options to find the most cost effective emission reductions. A multi-sector program also benefits from fewer perverse incentives for fuel switching to unregulated sectors without actually reducing emissions.[20] Figure 2.14 shows a hypothetical example of Emitters A through D that represent entities covered by a cap on GHG emissions across multiple sectors of the economy. This is a simplified depiction; actual details of the mechanics of a cap-and-trade program would depend on how that specific program is structured. The economy-wide emissions limit creates a budget of overall emissions allowances for a given compliance period. These allowances act like permits that each allow one metric ton of GHG emissions. Regulated entities are required to turn in an amount of allowances—or, depending on how the program is structured, a combination of allowances and offset credits (defined below)—that matches their emissions each compliance period.

In this example, the cap-and-trade program has been in operation for a few years. Emitters A through D have existing accounts with an equal number of allowances (shown as pink rectangles) that could have come from various sources—for example, free allocation from the state or purchases made in previous compliance periods that were held, or banked, for present use.

**Figure 2.14: Simplified Illustration of Regulated Entities During One Compliance Period**




Emitters B and C have more allowances than they need to cover their emissions this compliance period. This could be due to, for example, successful past investments in various GHG mitigation strategies. Emitters B and C now have an economic opportunity to sell their extra emissions allowances (shown as teal rectangles) in the carbon market or possibly keep them for use in future compliance periods depending on how the program is structured.

Emitters A and D will need to get additional allowances to cover the amount of emissions that exceeds their existing amount of allowances (shown as gray striped rectangles). They can go into the carbon market to purchase allowances either in a state-run auction or in the private secondary market (such as purchasing directly from Emitters B or C). In future compliance periods, Emitters A and D could also invest in strategies to reduce the GHG emissions for which they are responsible, such as reducing energy use or increasing operational efficiency—in other words, producing the same amount of product for less energy input. This would not only help reduce or avoid their need to purchase additional allowances for compliance, but would also help them save money on energy bills.

Policymakers designing a cap-and-trade program can choose to incorporate opportunities to count emissions reductions from sectors not covered by the cap in order to introduce an additional source of compliance options, called offset credits. This can help to reduce the compliance costs of the program by providing additional flexibility, though the approved use of offset credits is typically limited to a small percentage of the economy-wide emissions limit for a given compliance period. The DEQ report further explains that:[20]

**Offset credits** represent emission reductions from sources not covered by the cap. These credits can be incorporated into a cap-and-trade program and used like allowances. An offset is generally equivalent to an allowance; both permit the emission of one ton of carbon dioxide equivalent from an emission source covered by the cap. Offset credits also offer an opportunity to spread the incentive for emission reductions to sources not directly covered by the cap-and-trade program. For example, methane from agricultural sources may not be feasibly covered by the cap, yet offset credits awarded to dairy digesters could nonetheless allow the program to encourage reductions from these sources.

In Figure 2.14, Emitter B has more allowances that it needs this compliance period (illustrated by the blue rectangle) due to successful past investments in various GHG mitigation strategies. Emitter B now has an economic opportunity to sell the emissions allowances it does not need in the carbon market or possibly keep them for use in future compliance periods depending on how the program is structured. The buying and selling of emissions allowances during each compliance period occurs either in a state-run auction or directly between market participants like Emitters A through D. These market transactions determine the price of any given emission allowance, or what is often simply referred to as the carbon price. As with any traded commodity, the carbon price fluctuates with market signals and what entities are willing to pay. When regulated entities buy allowances from the state, that revenue can be used for any purposes identified by the policy-makers. Examples may include research and development programs, tax reductions, or grant programs that fund sector-specific mitigation strategies or projects in specific geographic locations or to benefit specific types of populations—for example, tribes, low-income and historically underserved communities, or those on the frontlines of climate change.

Compared to non-market based environmental programs, carbon pricing polices like cap and trade programs have demonstrated that they achieve desired environmental outcomes at an overall lower cost to society [72,73] At the same time, there are a number of important policy design considerations discussed later in this chapter, related to ensuring that costs of a program do not disproportionately harm certain populations and that the benefits of programs are equitably distributed.

### Beneficial Electrification

Electrification as an economy-wide decarbonization strategy refers to transitioning end uses that have historically used fossil fuels (e.g., natural gas, propane, heating oil, gasoline) to electricity. End uses could include space heating, water heating, public transportation, personal vehicles, industrial equipment and machinery; electrification examples in individual sectors are also discussed throughout the sectoral decarbonization section below. This approach is about taking advantage of the emissions efficiency—the emissions per unit of energy output—inherent in many electric end uses, enabling consumers to produce less pollution per vehicle mile traveled or gallon of water heated, for example, with technologies that are becoming even more emissions efficient as the electric grid decarbonizes.

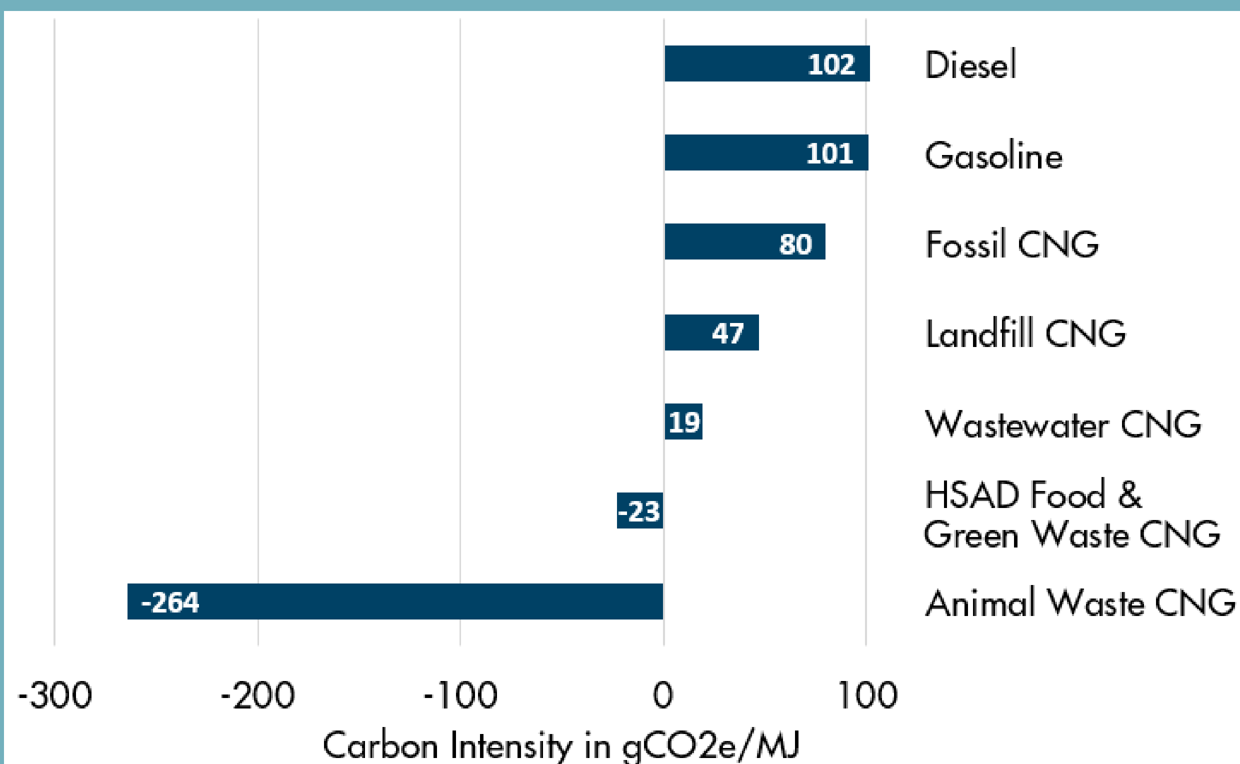
Multiple studies find that policies to promote economy-wide electrification should be designed to achieve multiple benefits, such as reducing greenhouse gas and other air pollutant emissions, enhancing energy security, increasing energy efficiency, saving consumers money, and enabling better grid management—hence the terms “beneficial” or “strategic” electrification are often used.[74,75,76,77] The Regulatory Assistance Project states that, “For electrification to be considered beneficial, it must meet one or more of the following conditions, without adversely affecting the other two: (1) Saves consumers money over the long run; (2) Enables better grid management; and (3) Reduces negative environmental impacts.”[77]

## CARBON MARKET OFFSETS

The California Cap-and-Trade Program[78] issues offset credits for projects that meet certain qualifications and follow specific protocols. Currently there are approved project types in the areas of agriculture, forestry, methane capture from mines, and destruction of ozone depleting substances. Offset projects can be promising alternatives to polluters who do not wish to or cannot afford to lower their emissions. In Oregon, several opportunities exist for offset projects in the realm of renewable natural gas (RNG).

RNG can be produced through anaerobic digestion of municipal food waste, animal manures, municipal sewage sludge, and generated naturally from landfills. It can also be produced through thermal gasification of woody wastes, such as commercial timber harvest slash, as well as agricultural residuals such as wheat straw or corn stover. These are called *production pathways*, and they vary in their carbon intensity – the amount of carbon emitted over the entire lifespan of the fuel. Figure 2.15 shows the carbon intensities of different transportation fuels and shows that several RNG-based fuels emit less carbon over their lifetime than traditional transportation fuels such as gasoline and diesel.

**Figure 2.15: Carbon Intensity of California Air Resources Board Low Carbon Fuel Standard Program-Approved RNG Pathways**[79]



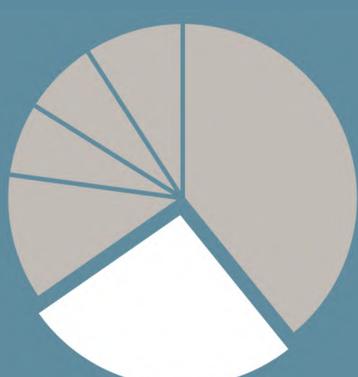
## Sectoral Strategies That Support Deep Decarbonization

This overview is drawn from recent publications of climate researchers, government and non-governmental reports, and Oregon state agency climate documents to find areas of alignment on deep decarbonization options for Oregon's largest categories of GHG emitters: the electricity and natural gas inputs into sectoral activities, residential and commercial buildings, transportation, and industrial activities. This compilation is not exhaustive, should not be considered an "action plan," and does not reflect any particular state agency or state government policy priorities; rather, it is meant to summarize relevant findings from published studies on effective paths forward for deep decarbonization in individual sectors. These strategies rely heavily on using today's commercially available technologies and scaling up proven policies within individual sectors, often taking advantage of existing policy mechanisms and tools available to the state. In some instances, newer or near-commercial technologies feature in certain sectoral strategies, so the timing of when these could be feasibly implemented as part of a decarbonization strategy will depend on how quickly they become widely commercially available.

### OREGON GLOBAL WARMING COMMISSION

In its 2015 Biennial Report to the Legislature, the Oregon Global Warming Commission analyzed a suite of GHG reduction options (called the "wedge" analysis), drawing on previous economic studies of Oregon-specific marginal abatement costs and macroeconomic modeling of carbon pricing. The Commission first identified sets of cost-effective individual measures for Oregon's largest sectors and then estimated the amount of reasonably achievable GHG emissions reductions. They found that an economy-wide carbon price filled in an important "wedge" of cost-effective emission reductions that could not be achieved with sector-based actions alone. In fact, the Commission's interim emissions reduction goal for 2035 could only be met with both the economy-wide policy and sector-specific actions.

2016 GHG Emissions
**ELECTRICITY — 26%**
16.17 million metric tons



## Electricity

Electricity comprised 26 percent of Oregon's GHG emissions in 2016, down from 30 percent in 2015.[1] See section above on "Beneficial Electrification" for more discussion of the role of decarbonized electricity as an economy-wide decarbonization strategy. As an individual sector, scenarios of deep decarbonization consistently find that the electricity sector needs to quickly transition to nearly entirely GHG-free resources by 2050. Main features of this strategy are described briefly below.

*Matching and Exceeding Past Growth in Renewable Energy and Energy Efficiency.*

PGE commissioned a deep decarbonization study of its service area to inform its integrated resource planning efforts and statewide carbon policy discussions.[82] PGE's findings are consistent with other research results for Washington State,[82] the U.S.,[62,67] and other countries that identify three key features of a deeply decarbonized energy system:

1. **Electricity supply decarbonization.** Decarbonizing electricity generation is a key component of every study of cost-effective GHG mitigation.[61] Electricity suppliers in the Northwest have a relative advantage over other parts of the United States given the large amount of existing hydropower in the region. In both the PGE and Washington state decarbonization studies, by 2050 most new generation comes from renewables like wind and solar and about 90 percent or more of the overall electricity generation mix is GHG emissions-free, primarily from onshore wind, solar, hydro and geothermal resources. PGE's gas-fired resource fleet shifts from being a baseload energy resource to mostly a capacity and balancing resource.[82]

   Electricity supply decarbonization will also require new capabilities to efficiently integrate variable renewable resources into the electric grid. In both the PGE and Washington state studies, new sources of flexibility like energy storage solutions and flexible loads become widespread and complement traditional sources of flexibility, such as hydro and thermal resources. See related strategies below in *Natural Gas, Buildings*, and *Transportation*, as well as Chapter 3.

2. **Improved energy efficiency across sectors**. Energy efficiency is the first "go-to" resource today when evaluating resource need, and this remains true under deep decarbonization scenarios: "Energy efficiency is widely considered the first option to pursue in a low carbon portfolio…"[62] Most clean energy end-use technologies are designed to have low or zero GHG emissions and to maximize energy efficiency as much as possible, which means providing more desired services per unit of energy consumed. For example, electric vehicles are significantly more efficient that conventional internal combustion engine vehicles, consuming up to four times less energy per mile than conventional vehicles (see Chapter 4 for more information on EVs). As these technologies are adopted throughout the economy, multiple decarbonization studies forecast reductions in both primary and final energy consumption even as population and GDP grows. In PGE's study, overall energy demand in their service territory decreases 25 to 33 percent compared to a baseline case by 2050[83], which is on par with U.S.-wide studies that estimate an approximately 20 to 30 percent decrease compared to a baseline scenario by 2050.[62,67] These reductions are driven by efficiency gains across sectors, particularly in the transportation sector due to the deployment of EVs, and do not depend on reducing energy service demand such as for driving, home heating and cooling, etc. See related strategies below in *Buildings* and *Industrial*.

3. **Increased electrification as a share of total energy consumption**. As described above, U.S. decarbonization studies project reduced overall energy consumption in 2050 resulting from efficiency gains across sectors, particularly transportation. The third key feature of a deeply decarbonized energy system is through the total energy demand pie is expected to be smaller, electricity's share of the pie is expected to be larger given that most deep decarbonization scenarios call for significant and rapid deployment of clean technologies that run on electricity. So consumption of decarbonized electricity increases although total energy consumption decreases. PGE's study found that in order to support decarbonization strategies across the Oregon economy, particularly the transportation sector, it would need to access more zero-carbon electricity resources (either through additional generation that it owns and operates, or through contracts or market purchases) than ever before.[83] In the U.S., electricity generation is projected to increase 60 to 113 percent between 2005 and 2050 due to increased electricity usage in transportation, buildings, and industry[67] (see related strategies later in this chapter).

## PGE'S PATH TO DECARBONIZATION

Oregon has an aggressive goal to reduce greenhouse gas emissions in our state by 2050. Local communities are taking action too: Multnomah County and the City of Portland have pledged to make the switch to 100 percent renewable electricity by 2035, and 100 percent renewable energy by 2050.

Portland General Electric emitted 6.4 million metric tons of carbon dioxide equivalent in 2016[84], and has committed to reducing its GHG emissions by more than 80 percent by 2050, consistent with its proportionate share of the state's economy-wide GHG reduction goal. To understand the complexities of reaching this goal and assisting the state and communities to reach their own GHG reduction and clean energy goals, PGE commissioned a deep decarbonization study of its service area.[83] The study identifies three pathways to reaching an 80 percent economy-wide reduction goal in its service territory. To reach the 80 percent economy-wide GHG reduction goal, the study found all energy services in PGE's service area would need to reduce carbon dioxide emissions to 4.3 MMT by 2050.

PGE's study and analysis found that deep decarbonization of the energy economy is possible, with multiple pathways to achieve it. Each pathway has three common elements or pillars that are essential to achieving decarbonization goals:

1. **Continuation/Increase in Deploying Energy Efficiency**
2. **Generating Electricity with Very Low to Zero Carbon Emissions**
3. **Substituting Fossil Fuel Use with Electricity**

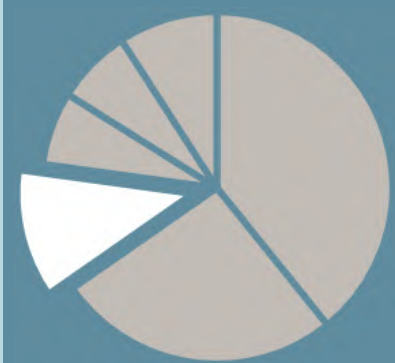
Changing the energy system to achieve deep decarbonization will be challenging, and will require major changes to how all forms of energy are produced and supplied. While 2050 is over 30 years away, planning must start today. Key to successful economy-wide decarbonization will be investing in technologies that enable a balance of electricity supply and demand, developing more flexible energy resources, such as storage and demand response programs, and making a pronounced shift in the transportation sector to low- and no-emission vehicles.

As the system adjusts to take a path to deep decarbonization, it must also meet changing needs in Oregon, including a growing population, electrification of vehicles, and other home and business devices that are likely to increase electricity demand.

"PGE is committed to helping Oregon achieve a clean energy future by reducing our greenhouse gas emissions by more than 80 percent by 2050. By using clean, affordable, reliable and safe electricity to power our lives – especially in the transportation sector – we can help reduce the threat of climate change, improve air and water quality, and create a more sustainable way of life for all Oregonians."

— Maria Pope
PGE President & CEO

2016 GHG Emissions
**NATURAL GAS — 12%**
7.32 million metric tons



## Natural Gas

Direct use of natural gas (i.e., not for electricity generation) was 12 percent of Oregon's GHG emissions in both 2015 and 2016.[1] Although it is a less GHG emissions-intensive fuel than coal, natural gas is primarily comprised of the greenhouse gas methane, which is a stronger climate warming agent pound-for-pound than carbon dioxide and is a precursor to ozone that itself is a GHG. But methane does not last as long in the atmosphere as CO2 (about a decade vs. about a century) and is not emitted in as large a quantity as CO2. Burning methane/natural gas for uses such as heating or cooking releases carbon dioxide, whereas methane can be directly released into the atmosphere through leaks or venting in natural gas production and distribution systems. Despite this, a number of studies find roles for "decarbonized" natural gas (defined below) in future scenarios of deep decarbonization.[62,81,85]

*Decarbonizing Pipeline Gas While Also Reducing Waste in Other Sectors*

A study of scenarios for California found that using the state's existing natural gas distribution network to deliver decarbonized gas could complement a low-carbon electrification strategy and still allow California to achieve its 2050 GHG reduction goal.[85] Deep decarbonization scenarios also rely on significant levels of energy efficiency to reduce GHG emissions in the sectors where natural gas is used[85]; see related strategies below in the *Buildings* and *Industrial* sections. Decarbonized gas can also be looked to in cases where it may be difficult to fully transition to electricity, either for technical, cost, or customer acceptance reasons. These include: "(1) certain industrial end uses, such as process heating, (2) heavy duty vehicles, and (3) certain residential and commercial end uses, such as cooking, and existing space and water heating."[85]

Decarbonized natural gas refers to natural gas produced through alternative processes — such as those described below — to reduce or offset its climate effects compared to traditional fossil natural gas:

1. **Renewable natural gas.** RNG as a decarbonization strategy replaces some percentage of the methane in the pipeline that comes from fossil sources with methane from biogenic (resulting from living organisms or biological processes) sources. There are two main processes to create RNG:

    - **Anaerobic digestion:** Digesters allow for "waste-to-energy" projects that have multiple benefits of creating an economically useful product while also reducing waste and emissions. This technology is being used currently in Oregon: NW Natural is partnering with the City of Portland to produce RNG from the city's Columbia Boulevard Wastewater Treatment Plant for pipeline injection as well as a natural gas vehicle fueling station[87], and Eugene-Springfield's Metropolitan Wastewater Management Commission is developing an RNG pipeline injection project. There are a wide variety of other RNG sources, including landfills, dairies, and programs that divert food waste.

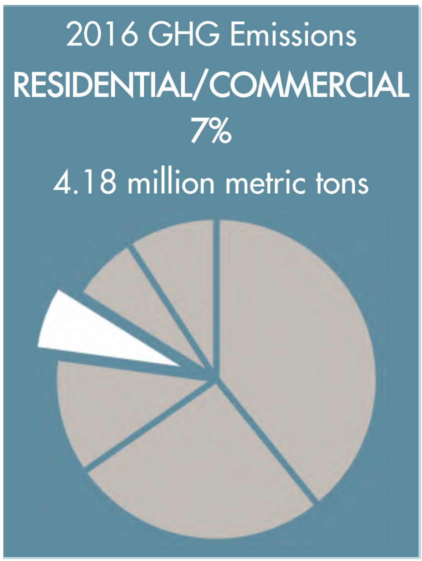
    - **Thermal gasification of biomass:** This thermochemical process converts biomass fuels into synthesis gas, or syngas, which is made up primarily of carbon monoxide and hydrogen. Syngas can be converted to methane with additional processing. Woody biomass or corn stover are typical feedstocks, but recently the use of municipal solid waste has been proposed. Several thermal gasification technologies are available, with variations using different temperatures and feedstock heating approaches. High temperature approaches produce syngas while medium temperature approaches make “producer” gas, which has a slightly different chemical make-up but can also be converted to methane with additional processing.[88] There are currently no commercial-scale thermal gasification plants in the United States that take the conversion process from biomass all the way to methane. The existing plants produce syngas, which is burned and used to generate heat and electricity. There are significant research efforts underway to bring down the cost of the conversion of syngas to methane.

2. **Power-to-gas (P2G).** This technology uses electrolysis to convert electricity to hydrogen gas, which can then be converted to methane (termed synthetic natural gas), directly injected as hydrogen into the existing natural gas grid, or directly used as a transportation fuel in hydrogen fuel cell vehicles. P2G can be a decarbonization strategy if the electricity it uses as a “feedstock” comes from excess renewable electricity generated by wind, PV, hydropower, or other zero-carbon sources.[85] This technology is being piloted at several locations in Europe and the United States, but not yet in Oregon. Studies have identified beneficial roles for P2G technology in providing a balancing resource for the integration of variable renewable electricity generation, helping to address issues related to renewable curtailment by producing synthetic natural gas or hydrogen when renewable electricity supply exceeds net demand.[62,81] Additionally, P2G could provide a valuable source of low or carbon-free inter-seasonal storage, allowing excess renewable energy in the spring and summer to be used during peak demand in the cold winter months when less renewable output is available.[86]

In July 2017, the Oregon Legislature passed Senate Bill 334,[143] which directed ODOE to conduct a statewide survey of resources that could be used to develop and utilize biogas and RNG. This inventory quantifies the opportunity to take persistent, long-term waste streams and convert these waste streams into useful energy. Municipal waste streams like household refuse, wastewater, waste food, and agricultural waste streams like manure all generate methane as they break down in the environment. Redirecting these waste streams into controlled processes for optimization, capture, and utilization of the methane can be economically, socially, and environmentally beneficial to Oregon. Redirecting this fuel source into the transportation fuels sector, and eventually into the stationary fuels sector, can result in increased economic opportunity, energy security, and resilience for both rural and urban communities in Oregon. The results of the inventory indicate that there is potential for a substantial amount of RNG to be produced in Oregon from a variety of biogas production pathways. The gross potential for RNG production when using anaerobic digestion technology is around 10 billion cubic feet of methane per year. This is about 4 percent of Oregon’s total yearly use, which includes gas used for electricity production, or 7.5 percent if comparing only to direct use of natural gas where RNG is expected to be used. At a future point, once technical obstacles are overcome, thermal gasification technology could produce up to 40 billion cubic feet per year — about 17 percent of the state’s total annual natural gas use or 29 percent of annual direct use. The full report is available on ODOE’s website.[89]

The Oregon Global Warming Commission's "wedge" analysis in its 2015 Biennial Report to the Legislature also examined biogenic waste streams.[19] Their report identified the following as some of the most cost-effective strategies for addressing these sources of GHG emissions:

- **Development of dairy anaerobic digestion and methane utilization projects.**
- **Increasing co-digestion of dairy manure and food processing waste, which provides a carbon neutral energy source for producing electricity or thermal energy.**
- **Increasing biogas energy production from municipal solid waste and at wastewater treatment plants.**
- **Installing landfill gas collection and destruction systems at landfills where they do not already exist.**
- **Preventing edible food waste to reduce the amount of biogenic waste entering landfills.**




## Buildings

The residential and commercial sectors, when including electricity and natural gas use, comprise 34 and 32 percent of Oregon's GHG emissions in 2015 and 2016, respectively.[1] When electricity and natural gas use are accounted for separately, residential and commercial GHG emissions drop to 7 percent and stem primarily from petroleum combustion (e.g., fuel oil for heating) and emissions from waste and wastewater originating from these sectors. This indicates a substantial potential for residential and commercial buildings and systems to reduce energy use and switch to low-carbon energy sources in order to reduce GHG emissions; some of the main approaches are summarized below.

*Benchmarking and Transparency: Understanding and Communicating Building Performance*

A cornerstone of reducing GHG emissions in this sector is understanding, measuring, and communicating information on building performance. While energy management has been voluntarily undertaken for decades, there has been a recent and significant rise in government laws and programs to drive standardized and centralized reporting. Mandatory benchmarking and reporting programs are available in over two dozen cities and several states.[90] For example, the City of Portland has mandatory commercial and residential reporting programs, completed on an annual basis or at time-of-listing, respectively. Once measured, building and home owners can compare their energy performance – with low-performing buildings being identified as likely having the highest potential for improvement.

These reporting programs have also quickly become the most available and reliable data source to understand energy use and the associated emissions of these buildings. The City of Portland found that the lowest-performing buildings use two to four times as much energy per square foot as the most efficient buildings.[91]

*Retrofit Existing Buildings at Key Trigger Points*

To reach major emission reductions in the residential and commercial sectors, the existing building stock needs to be addressed. The most well-established and cost-effective strategy for reducing emissions from buildings continues to come from improving the energy efficiency of buildings. In general, the most effective retrofitting that also reduces GHG emissions strikes a balance between fixing the building's envelope and upgrading systems and equipment within buildings to maximize energy efficiency and use of low carbon fuels.[92]

These improvements are commonly triggered when equipment reaches its end-of-life, the building is remodeled, or when provided incentives. Some jurisdictions are also implementing mandatory retrofits supported by energy performance reporting. For example, New York City requires that buildings over 25,000 square feet conduct periodic audits and retro-commissioning and report to the city every 10 years. The City of Boulder requires that after reporting, the building owner must conduct retro-commissioning and implement measures that have a financial payback of two years or less. These programs can accelerate the standard improvement cycle that occurs in the building stock, while avoiding long-term "lock in" of equipment that is low efficiency and reliant on fossil fuels. They can also allow for GHG emissions reduction to be used as a decision-making criterion rather than solely energy savings, which may allow electricity-based equipment and systems to more easily compete with minimum efficiency fossil-fuel versions.

*Integrating Net-Zero Design and Performance into New Buildings*

Newly built structures can incorporate design and performance requirements so their overall energy footprint is low-to-no CO2 emissions. The "net-zero or zero-energy" building or home is a highly-efficient structure that is fully powered or offset by carbon-neutral energy sources. While there are an increasing number of projects tackling net-zero retrofits to existing buildings, the most cost-effective and holistic approach is to incorporate these elements into the design and construction of new buildings and major remodels. Critical components to this process include: energy modeling towards performance requirements, use of high-efficiency equipment and low-energy use design, integrated and whole-building planning, and performance verification and ongoing monitoring. For both retrofits and new construction, using building materials that are less carbon intensive where possible, such as wood instead of concrete and steel, may also have benefits for the climate, though these would not be traditionally quantified under most GHG accounting protocols.[93,94]

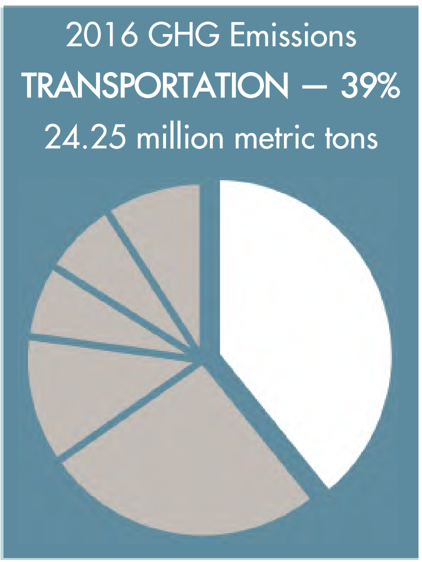
*Fueling Buildings with Low Carbon Electricity While Also Providing Decarbonized Gas*

Most deep decarbonization scenarios project that most or a significant portion of appliances and equipment used in residential and commercial settings will be fueled by low carbon electricity.[62,82] But studies also acknowledge that full electrification of these end uses will be challenging for reasons such as cost or customer acceptance.[62,81,85] As discussed above, RNG can help reduce emissions of remaining natural gas end uses (see *Electricity* and *Natural Gas* strategies).

*Increasing Efficiency Throughout the Refrigeration Lifecycle*

Fluorinated GHGs are in products used in all types of buildings, including commercial refrigeration, cold storage warehouses, air conditioning, heat pumps, foams, and aerosols. Hydrofluorocarbons are of particular concern because they are the fastest growing source of GHG emissions in the U.S. and their effect on the climate is hundreds to thousands of times greater than CO2.[16] For example, just one pound of R-404A, an HFC refrigerant used in supermarkets, is comparable to two tons of CO2 in terms of its effect on the climate.

Some estimates indicate that nationwide, GHG emissions from refrigeration and air conditioning can be reduced by 77 percent below baseline levels by 2030, and that over half of those reductions can be had at negative cost.[95] Reductions can be achieved through: (1) switching to alternatives that have a much lower climate effect than HFCs, while also not harming the Earth's ozone layer, and (2) through proper handling, servicing, and recycling or safe disposal of refrigerants at the product's end-of-life.[95] There are a number of natural refrigerant alternatives to HFCs that are commercially available or expected to be available soon, including CO2, ammonia, hydrocarbons, and hydrofluoroolefins (HFOs). Climate and ozone-friendly natural refrigerants have been found to have better thermodynamic properties compared to standard synthetic refrigerants, which means that their use can also increase energy efficiency in some applications.[96]




## Transportation

Oregon's transportation sector is the state's largest single source of GHG emissions, at 36 percent of the statewide total in 2015 and 39 percent in 2016.[1] Estimates from 2015 indicate that 47 percent of emissions are generated from light-duty vehicles, while approximately 23 percent are from heavy-duty vehicles.[1] In its Statewide Transportation Strategy, ODOT identified strategies related to vehicles and fuels as the most direct and high-impact options for switching to low-carbon transportation energy sources and reducing the sector's GHG emissions.[97] This is consistent with recent research that identifies sets of related strategies to support deep decarbonization for the transportation sector, which are summarized below.

*Integrated Approaches for Passenger Transportation*

Climate studies for passenger transportation emphasize an integrated, multi-modal climate change mitigation strategy given its cost effectiveness and ability to generate co-benefits such as human health, air quality, and traffic congestion improvements. For more detail about policies and strategies, see Chapter 4.

- **Accelerating build out of electric vehicle charging infrastructure:** Studies consistently identify developing a widespread and robust electric vehicle (EV) charging network, both public and privately-owned, as key for increased EV adoption. This will require collaboration with private sector developers on moving towards an industry standard for all classes of vehicles, as well as for development of fast chargers.
- **Expanding access to light-duty electric cars and trucks as they come to market:** Existing market barriers to more widespread adoption of EVs can be addressed through converting a greater share of fleets to EVs, providing other opportunities to enhance consumers' familiarity with driving EVs, and consumer and dealer education.
- **Electrifying public transit**: A number of cities around the country are shifting away from diesel-powered to electric public transit to save money, improve health, and cut air pollutant and GHG

emissions. Nashville and Park City, Utah are some of the first cities to have integrated electric buses into their routes, and the mayors of 12 major cities, including Los Angeles, Seattle, London, Paris and Mexico City, have committed to purchasing only zero-emissions buses by 2025.[98] TriMet in Portland has committed to replacing its diesel bus fleet by 2040. Its 2018 Non-Diesel Bus Plan evaluated different non-diesel bus technologies (battery electric, renewable natural gas, and hydrogen fuel cells), and the agency is moving forward with testing five electric buses on what will be Oregon's first all-electric bus route in Beaverton.[99] TriMet is partnering with PGE to install and manage six bus charging stations.[100]

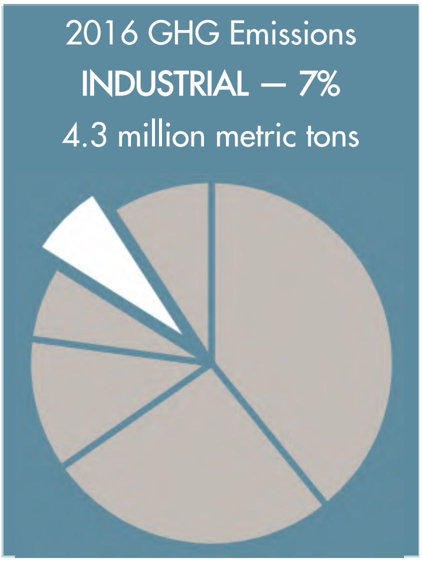
- **Continued focus on multi-modal alternatives**: The most effective programs include a combination of qualitative improvements to alternative modes (walking, cycling, and public transit including bus and light rail) and integrated transport and land-use planning, which creates more compact, mixed, and better connected communities with reduced need to travel.[101] These are key strategies that some of the MPOs in Oregon are evaluating and pursuing in their regional transportation plans (discussed earlier in this chapter in the section *Metropolitan Planning Organizations*).

*Decarbonized Natural Gas for Medium- or Heavy-duty Fleets*

Decarbonization strategies for medium- and heavy-duty vehicles are still evolving. The U.S. Mid-Century Strategy[67] concluded that there are substantial opportunities for additional research and innovation in this area. This includes, among other examples, hydrogen powered trucks and buses, fuel cells in medium- and heavy-duty transport applications (delivery vans, short-haul freight trucks, etc.), and improved freight logistics and modal shifting of freight from long-haul trucks to rail and barge.


Medium– or heavy-duty trucks, like this Waste Management fleet truck, can run on CNG.

As noted in ODOE's biogas and renewable natural gas inventory[89], there is substantial opportunity to develop RNG supplies for use as a transportation fuel. This may be particularly true for many medium- and heavy-duty trucks that already run on compressed natural gas or liquefied natural gas. There are examples of these types of projects throughout the country either in the planning phase or in operation. In Oregon, the Dry Creek Landfill in Medford is installing technology to RNG from landfill gas and are converting their garbage hauling fleet to CNG/RNG. They partnered with ODOE and Avista Natural Gas and built a publicly-accessible CNG fueling station. In California, CR&R Environmental Services in Perris, California converts food waste to biogas in a state of the art digester, cleans the biogas to produce RNG, and then both fuels its garbage trucks and sells that RNG into the transportation market.[102] A similar project is being planned in Philadelphia, PA.[103]




## Industrial

The industrial sector accounts for about 20 percent of Oregon's total GHG emissions, primarily from direct use of electricity and natural gas.[1] When electricity and natural gas use are accounted for separately, this drops to 7 percent of the state's emissions and is comprised primarily of emissions from petroleum combustion, industrial waste and wastewater, and industrial process manufacturing (e.g., production of cement, paper products, ammonia, urea, etc.). This indicates that key decarbonization strategies for the industrial sector include increasing efficiencies to reduce overall energy use and switching to low-carbon energy sources where possible.

*Increasing Energy Efficiency*

Oregon has engaged with large industrial utility customers for many years to increase energy efficiency. ODOE administers the Large Electric Consumer Public Purpose Program where large electric consumers (over one average megawatt or 8,760,000 kilowatt hours per year) may be eligible to self-direct a portion of their public purpose charges and implement qualifying energy efficiency or renewable energy projects. The biennial reports to the Oregon Legislature on Public Purpose Expenditures provide insight into the types of industrial efficiency projects large customers have pursued and estimates of their energy savings.[71] From 2015 to 2016, self-directed efficiency projects included implementing energy management systems, industrial process modifications, lighting modifications, and installing energy efficient pumps. These projects collectively achieve about 3 MWh of energy savings annually. Other climate mitigation studies identify various operational (e.g., waste heat utilization) and maintenance measures (e.g., reducing air or steam leaks) that can have benefits for GHG mitigation.

*Fueling Equipment with Low Carbon Electricity While Also Providing Decarbonized Gas*

The U.S. Mid-Century Strategy[57] and the U.S. Deep Decarbonization Pathways report[62] find that by 2050, a significantly larger portion of industrial energy demand is met with low carbon electricity compared to today. In many cases, small-scale industrial equipment such as forklifts, pallet jack, or scissor lifts fueled by fossil fuels like diesel, gasoline, or propane now have battery electric versions available. According to the National Renewable Energy Laboratory, electric technologies exist for certain low-temperature energy needs, such as curing and drying, and could lead to increased electrification in the industrial sector.[80] Where electrification of industrial processes is challenging for physical or economic reasons (e.g., some high-heat applications), the use of decarbonized pipeline gas can reduce GHG emissions intensity in this sector.


Electric battery forklift.
*Photo: Toyota Material Handling*

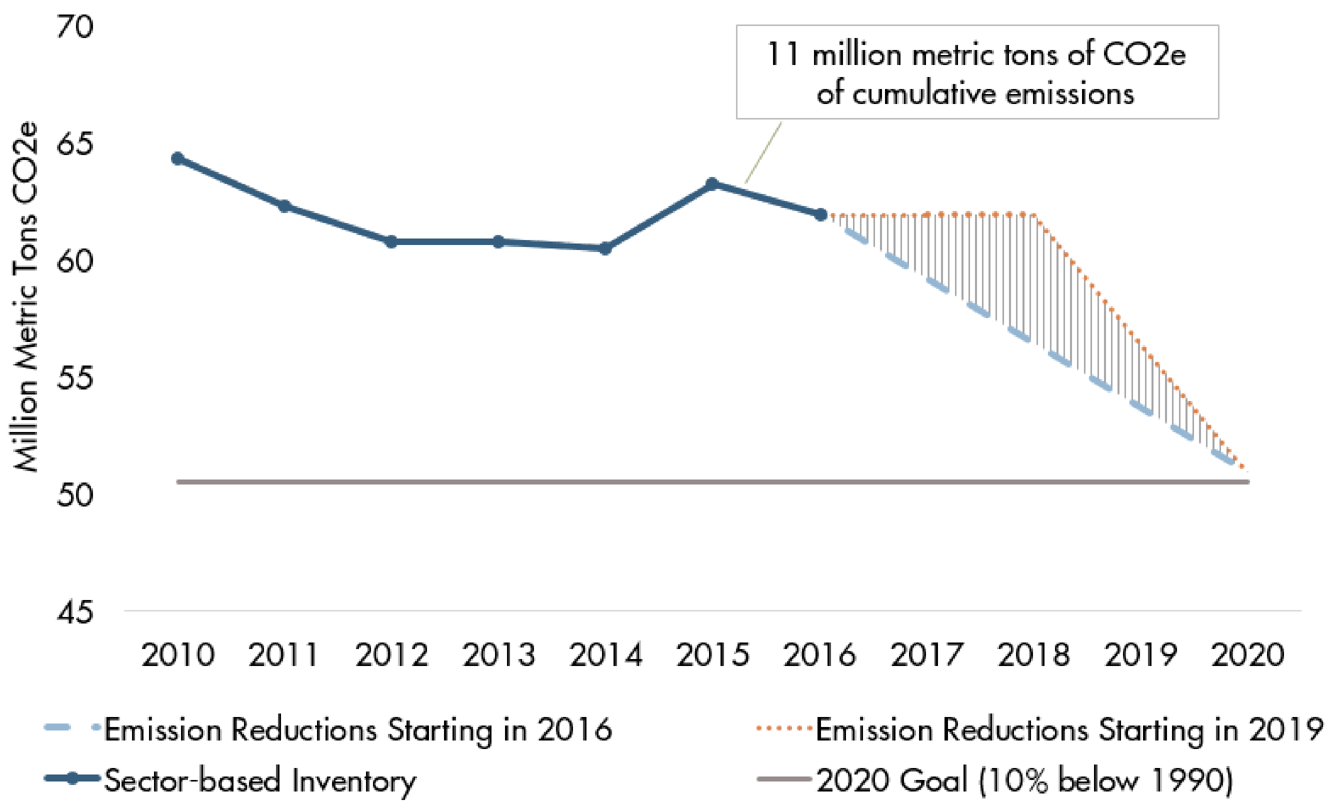
## Deep Decarbonization Considerations and Potential Tradeoffs

As with any large-scale transformation, transitioning Oregon's energy systems to achieve the state's climate mitigation goals will create challenges and tradeoffs that are important factors influencing policy design. Key considerations include timing of when action begins, costs and benefits, social and intergenerational equity, and potential policy interactions and tradeoffs.

### Timing of Action

The IPCC concluded that "delaying mitigation efforts beyond those in place today through 2030 is estimated to substantially increase the difficulty of the transition to low longer-term emissions levels and narrow the range of options consistent with maintaining temperature change below 2°C relative to pre-industrial levels (high confidence)."[61] This means that the longer we take to address climate change, the harder it will be to make the transition. For example, Figure 2.16 shows two hypothetical pathways from 2010 to 2020, the year when Oregon set a goal to reduce its emissions 10 percent below 1990 levels. A steady, smooth progression illustrated by the blue dashed line down to the target level from the most recent year of emissions data, 2016, to the year 2020 requires an annual reduction of approximately 3 million $MTCO_2e$.[1] If emissions reductions are delayed until 2019, Oregon would have a much steeper pathway illustrated by the orange dotted line, and would need to annually reduce emissions by 5 million $MTCO_2e$ in 2019 and again in 2020 to achieve the same goal.

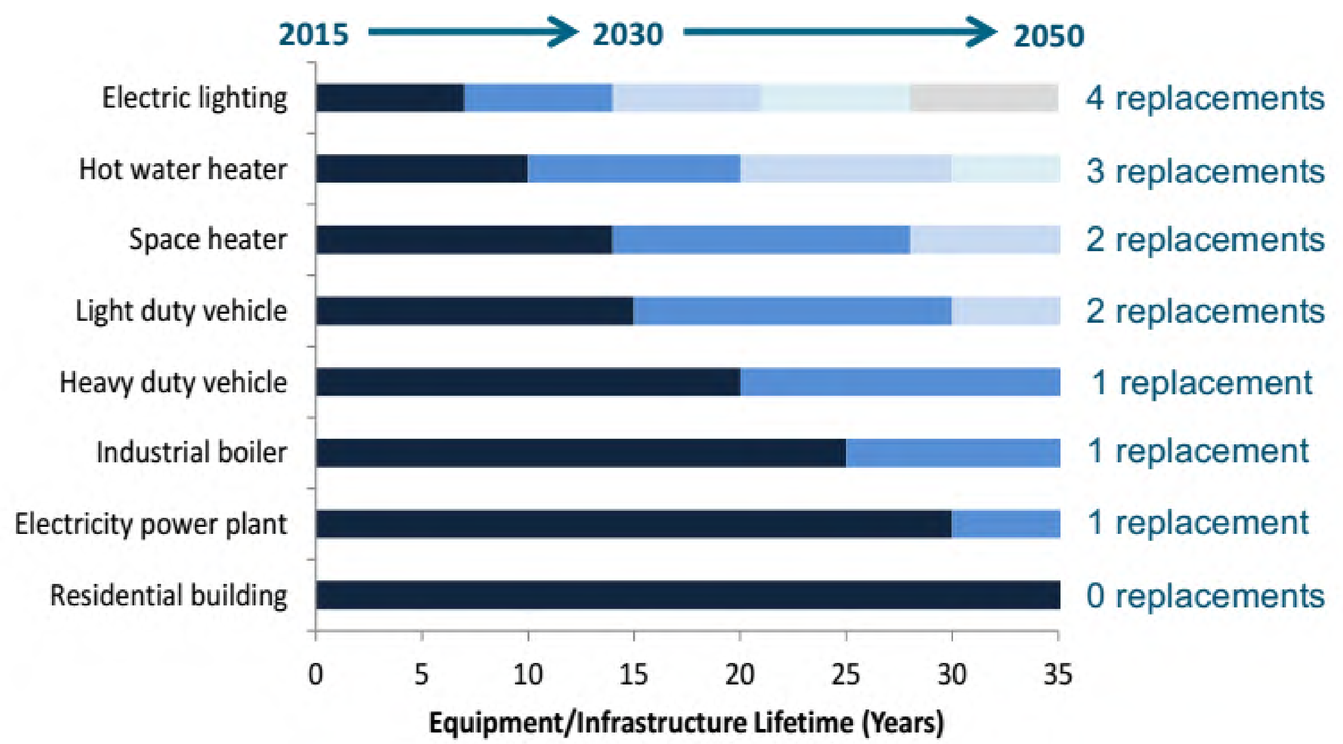
**Figure 2.16: Hypothetical emission reduction trajectories for scenarios beginning from the most recent year of GHG emissions data, 2016[1]**




So "bending the curve" on emissions sooner means fewer reductions will be needed annually, while waiting to begin would mean that steeper reductions are required each year in order to reach the state's reduction target. Importantly, delaying action for 3 years also results in an additional 11 million $MTCO_2e$ being released into the atmosphere, increasing the cumulative environmental impact of the state's emissions.

Another important aspect for climate mitigation policy design is optimizing timing for replacing high-carbon equipment and infrastructure with low-carbon alternatives. Figure 2.17 shows best estimates of natural stock turnover cycles of various types of goods or infrastructure, comparing the number of replacement opportunities in the timespan leading up to when 2050 climate goals should be met. For example, by 2050, electric lighting is expected to need four replacements, while an industrial boiler needs one. This underscores the need and importance of advance planning, particularly for long-lived infrastructure like power plants and buildings, to pave the way for selection of low-carbon alternatives when that natural replacement window of opportunity opens. The U.S. Deep Decarbonization report[62] concluded that 2050 climate goals could still be met by relying on natural stock turnover. This would largely avoid stranded assets or other lost economic value related to "early retirement" (compared to assumed life at the original time of investment) of equipment or infrastructure.

**Figure 2.17: Equipment and Infrastructure Stock Turnover Cycles**[63]




## Costs and Benefits

Closely related to issues of timing are issues of costs and benefits. There is broad consensus that delayed action makes climate mitigation more expensive.[61,63] This is because larger GHG emissions reductions would be required over a shorter, more compressed timeframe, which limits the available range of mitigation options (i.e., less flexibility to choose cost-effective options), affects the optimal timing of replacements and other measures, and may create carbon intensive "lock-in" if long-lived equipment or infrastructure is purchased or built during the period of delay. Lock-in can make meeting long-term climate goals substantially more expensive to achieve.[104]

Delayed climate action at the global scale also delays the time it will take to stabilize atmospheric concentrations of GHGs and in effect, stabilize Earth's climate. This increases the risks associated with climate change itself that were discussed above, which have very significant economic implications for Oregon. Quantifying the costs of climate impacts and the economic benefits of avoiding those impacts is still an evolving area of research. Some of the studies breaking ground in this area have used a variety of economic valuation methodologies at the global level[105] and for the United States.[106,107] But most analyses of climate mitigation policies rely on traditional cost-benefit methodologies that only account for economic costs of implementing the policy.

Another valuation approach has been to use the social cost of carbon, which according to the U.S. National Academies of Science, Engineering, and Medicine[108] is a measure of global economic damages associated with releasing one ton of CO2 into atmosphere, expressed as a dollar per ton metric. Social cost of carbon can be easily used to compare two different investment decisions, one with relatively higher and one with lower GHG emissions—applying a social cost of carbon value will make the higher-emitting option more expensive relative to the lower emitting option to reflect the damage it is causing to the environment and human health. A social cost of carbon value can also be used in traditional cost-benefit analyses for regulatory policies—first by quantifying the GHG emissions reductions achieved by the policy and then multiplying that by social cost of carbon values to estimate a dollar value for climate benefits of the policy (see below for more discussion of policy co-benefits in addition to climate benefits).

In addition to approaches for estimating more macro-level costs, there are methodologies for estimating costs of individual emissions reductions measures, also called abatement options. This tool, Marginal Abatement Cost Curves or MACCs, creates estimates of the cost of reducing one more unit of pollution (dollars per ton of CO2 reduced) and the size of potential emissions reductions from a suite of abatement options. Some advantages of MACCs are that they provide an easy-to-digest visual comparison of the relative cost of certain measures, and can incorporate regional, state, and local data to further refine estimates to be specific to a certain geographic area. MACCs are perhaps most useful as directional indicators of potential cost, while their specific dollar values and relative rankings of abatement options should be considered provisional.[109] For example, an Oregon MACC was developed in 2012 that showed that certain types of measures could be implemented for net negative cost (paybacks would be greater than costs)[110], which is a useful starting point for further investigation.

Some critiques of MACCs are that their results are one-dimensional or overly simplistic because they do not account for costs other than direct technology costs (i.e., they do not estimate indirect or transaction costs that would accrue during actual implementation of a measure), and they have difficulty capturing interactions between different measures that would affect cost-effectiveness in reality.[109] In addition, it can be difficult to find accurate or timely data on which to base MACC calculations, especially as the methodology is not easily updatable and cannot easily keep up with the rapid advances in and falling costs of clean energy technology.[111]

Based on its review of hundreds of climate mitigation studies, in 2014 the IPCC[61] drew a number of general observations regarding individual cost-effective mitigation strategies:

- **Well-designed systemic and cross-sectoral mitigation strategies are more cost-effective in cutting emissions than a focus on individual technologies and sectors.**
- **Given substantial recent performance improvements and cost reductions, a growing number of renewable energy technologies have achieved a level of maturity to enable deployment at significant scale.**
- **Building codes and appliance standards, if well designed and implemented, have been among the most environmentally and cost-effective instruments for emission reductions.**

## Equity and Justice Perspectives on Climate Change

As researchers, analysts, and policymakers make progress in understanding and quantifying the costs and benefits of climate change and the policies enacted to address it, it becomes equally important to understand how those costs and benefits are distributed across society. Equity and justice, which are concepts explored more in Chapter 2.5, are often considered in two main ways in the context of climate change.

First, an intergenerational equity viewpoint stems from the premise that there are moral duties owed by present to future people, that it is our obligation to avoid triggering dangerous levels of climate change that will impose both near- and long-term harms on future generations that bear no responsibility for creating the problem.[112] From an intergenerational justice perspective, inaction on climate change is not a viable option; global climate action is necessary to reduce the harms future people will face and pass on an environment that supports healthy lives and livelihoods.

Second, a social and environmental equity viewpoint recognizes that certain populations bear a larger, disproportionate share of harmful effects from climate change, are less able to prepare for and respond to climate threats, and that this is occurring within a legacy of social, political, and economic inequalities and a lack of recognition and power to participate in decision-making and shape policy outcomes. Although more research is needed to fully understand how different parts of Oregon's population are experiencing climate change, in general, vulnerable populations include those that have low incomes, are in poverty, or are otherwise economically vulnerable; some communities of color; or those who are already affected by inequitable exposure to pollution and environmental health risks.[67,113]

From a social and environmental justice perspective, climate policies and actions should be designed to avoid potential adverse side effects or unintended consequences so as not add to the current economic, health, and environmental burdens of vulnerable populations. Policymakers should instead proactively and meaningfully involve affected populations in decision-making to ensure that the benefits of climate policies and programs flow to communities that need it the most. Local community organizing groups in Oregon like APANO and OPAL Environmental Justice, as well as national civil rights organizations like the NAACP, among others, have included climate change as a priority focus area for their social and environmental justice work.[114,115,116,117,118]

The following section examines some of the key potential challenges and co-benefits of climate policy, identifying those that may be particularly relevant to considerations of social and environmental justice in Oregon.

## Policy Interactions and Potential Tradeoffs

Climate policy intersects with other societal goals, such as those related to human health, food security, environmental quality, energy access, livelihoods and jobs, and sustainable economic development.[61] Depending on their design, polices in these areas can be mutually reinforcing or can hinder the achievement of each other's objectives. There can also be opportunities for co-benefits if these interactions are well-managed, or adverse side effects and unintended consequences if they are not. A number of commonly cited examples of these issues with relevance to Oregon are described below.

### Land Use and Natural and Working Lands

Like with any new energy infrastructure, the development of new renewable energy facilities to meet Oregon's climate goals have the potential for conflicts with other values Oregonians hold related to natural and working landscapes, wildlife conservation, and natural and cultural resources. Such conflicts could occur if, for example, areas in which large-scale renewable energy facilities are constructed and operated provide habitat to endangered species and other wildlife, are on high-value agricultural land, or have cultural resources or support traditional lifeways of Oregon's Native American tribes.[119] Similar considerations would apply if additional renewable generation requires additional transmission infrastructure to be built in Oregon or in the region. Strategic renewable energy siting principles have been proposed in the literature to reduce or avoid such tradeoffs, including land use policies and electricity planning processes that focus on development in already-impacted places and emphasizes ecosystem service values (e.g., biodiversity, carbon sequestration, groundwater protection) and other environmental concerns within traditional business case evaluations of local transmission capacity, etc.[120,121] The siting of renewable energy facilities is discussed in Chapter 3.

Some renewable energy technologies can be deployed to meet both climate mitigation and adaptation needs on natural and working lands, while also providing local economic benefits. Examples include:

- Biomass sources eligible for the Renewable Portfolio Standard (see Chapter 3 for more details) could work in tandem with forest restoration/fuel load reduction projects that are intended to reduce wildfire risk that is increasing in the Western U.S. due to climate change.
- Irrigation in-pipe hydropower energy recovery systems generate power from pressurized irrigation water. Conversion to piped irrigation systems improves water use efficiency by eliminating evaporation and seepage and allows agricultural enterprises to better manage the effects of drought that are projected to increase in Oregon due to climate change.

# IRRIGATION: WATER MEETS ENERGY

Forty-two percent of Oregon's agricultural land is irrigated, which multiplies its productivity.[123] However, pumping water for irrigation is energy intensive. Updating and improving irrigation systems results in less water wasted and lower energy cost for farmers, while also providing other important benefits.

Several irrigation districts in Oregon are currently working on irrigation modernization.[124] Projects typically involve a variety of energy and conservation organizations, and use federal, state and nonprofit funds.

| Modernizing Action | Examples |
|---|---|
| **Install more efficient irrigation equipment.** Reduces water use and farmers' energy costs, as well as increases water in-stream. | Switching to variable frequency drives for irrigation pumps saves energy, while replacing leaking nozzles saves water and energy. |
| **Pipe irrigation canals, providing pressurized water.** Eliminates the need for pumping energy, and potentially reduces water waste. It can also provide cleaner water for crops, reduce maintenance costs, and increase water in-stream. | Farmers Conservation Alliance[124] analyzed potential benefits of piping in nine Oregon irrigation districts, which would return over 550 cubic feet per second of water to streams and save nearly 60,000 megawatt hours of electricity annually. |
| **Install hydropower generation where appropriate.** Replaces fossil fuel-powered energy on farms, provides rural resilience, and provides income to irrigation districts for additional environmental projects. | Farmers Conservation Alliance found 38 megawatt potential in nine irrigation districts. For example, Three Sisters Irrigation District has 400 kilowatts of potential. |

### Energy Costs, Energy Independence, and Economic Growth Potential

Arguments against deep decarbonization assume that it will necessarily entail high costs or restricted energy services that are barriers to economic development.[63] But the long-term goal of the transition to a low-carbon energy economy is to move away from dependence on fossil fuels as a primary energy source, creating a highly efficient, modern energy system that provides the same or more diversified energy services without the negative effects of the current system.[63] However, getting to this end state requires a period of transition where some individuals and businesses will still need to rely on old fossil fuel-based systems that will become comparatively more expensive to operate or maintain under policies that explicitly put a price on the carbon in fossil fuels, or simply as investors, insurers, and banks eventually seek to limit their carbon liability.[122] Policymakers can manage this transition through program designs that aim to limit cost increases facing consumers and ensure that benefits are prioritized in impacted communities.

Examples include:

- Coordinating energy efficiency improvements with decarbonization of energy supplies limits increases in total consumer bills even if per unit energy prices increase.[63]
- Policies to reduce the level of consumer up-front spending required to transition their homes and vehicles to low carbon technologies is key to keeping net household costs low, or even producing a net savings.[63]
- Policy design choices with a cap-and-trade system can require regulated utilities to return revenues to specific customer classes to mitigate potential price increases.
- The concept of "just transition" emphasizes that investments in workers should be prioritized, for example, through job training and re-training programs. Just transition and ensuring costs do not disproportionately fall on low income and other vulnerable populations are key social and environmental justice considerations.

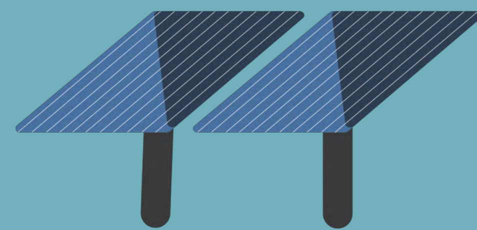
Economic and security benefits of a deeply decarbonized energy system for Oregon include: (1) increased energy independence, (2) native sources of energy that create local jobs and enhance resiliency (see Ch. 2.6 for additional detail on resiliency benefits of distributed energy and microgrids), and (3) larger proportion of Oregonians' dollars spent on energy staying in the local or state economy.[70] Reduced dependence on imported fossil fuels, particularly petroleum, means that a low carbon economy will be more shielded from the impacts of price volatility and insecurity over resource availability, particularly for a globally traded commodity like oil, considering the outsized influence in the global oil market of the Organization of the Petroleum Exporting Countries (OPEC) and the history of political instability in many oil-producing regions[63] (see Chapter 4 for additional discussion of energy independence). Less exposure to financial risk associated with price shocks creates a more stable investment environment that has more predictable energy costs for consumers and reduces business risk.[63,106] The deep decarbonization transition has also been identified as a catalyst for business innovation, with potential to create new jobs across multiple types of clean energy-related industries and to capture a first-mover competitive advantage in global markets for low-carbon energy technology, meaning Oregon businesses would have an edge as one of the early entrants into a new market segment for low-carbon energy solutions.[63]

### Air Quality and Human Health

Fossil fuel-based energy systems have well-studied adverse environmental and human health effects for both children and adults.[125] Industrial fossil fuel use also has implications for occupational exposures and negative health effects for workers.

Exposure to air pollution has been linked to increased risk of heart disease, respiratory disease, stroke, and cancer[48], and these health burdens disproportionately affect low income and minority populations.[127] These diseases are four of the five leading causes of death in Oregon.[128] Nationally, incidences of air pollution-related premature death are attributable to primarily to fossil fuel combustion emissions from road transportation and electricity generation, followed by industrial emissions.[129] A deeply decarbonized energy economy, by moving away from fossil fuels and through use of clean electricity generating technologies, would substantially reduce air pollutants that are co-emitted with greenhouse gases. These co-pollutants include particulate matter, nitrogen dioxide, sulfur dioxide, polycyclic aromatic hydrocarbons, mercury, and volatile organic compounds. Improved air quality reduces the risk of respiratory, cardiovascular, and other documented negative health effects from exposure to air pollution, and can reduce doctor and hospital visits, and therefore health care costs for people with chronic illnesses like asthma and chronic obstructive pulmonary disorder.[130,131]

## CONCLUSIONS



The transformation of energy systems throughout the West and in Oregon have begun. Continuing this process to **achieve deep decarbonization** and the state's climate goals will not be without its challenges, but advantages include supporting the state's competitiveness in a global clean energy economy, increasing energy independence, and realizing the substantial health and environmental benefits of reduced pollution. Based on the experiences of other states and jurisdictions, a menu of policy options is available to the State of Oregon to make a deep decarbonization pathway feasible across all sectors of the economy.

**Equity, environmental justice, and potential policy** interactions and tradeoffs should be considered early on in the design of such policies to account for how costs and benefits are distributed across society. Some data needs are evident that would help refine understanding of appropriate strategies for Oregon, prioritize timing of investments, and track and evaluate outcomes. However, enough is currently known that actions can be taken even now, while gaps in information are addressed and as Oregon determines a path forward for statewide climate action.

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# CHAPTER 3: RENEWABLE ENERGY

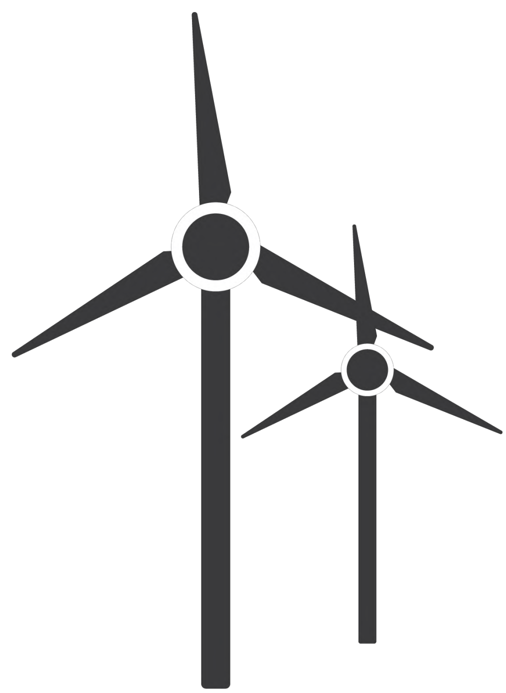
Oregon's renewable electricity capacity has grown over the years, thanks to some of the early supporting policies, a growing voluntary demand for cleaner electricity, substantial decreases in the costs of renewable electricity technologies, and recent policies like a strengthened Renewable Portfolio Standard.

Oregon will face a number of challenges and opportunities as we work toward a clean energy future.

KEY TAKEAWAYS

- Installed capacity and consumption of **renewable electricity in Oregon** have grown over the years, thanks to policies like the Renewable Portfolio Standard (RPS); federal and state incentives; growing interest from consumers and businesses to purchase renewable energy voluntarily; and significant decreases in the costs of renewable energy technology.
- To increase renewable energy in Oregon while maintaining reliability and low costs, the state will need to understand and address a wide web of interrelated issues and make choices on how to meet our **state energy goals**.
- To meet the challenge of efficiently and cost-effectively integrating increasing amounts of variable renewable electricity onto the grid, Oregon should investigate how to **leverage and combine flexible electricity resources** and technologies; flexible control over demand through innovative new rate structures and demand response programs; and access to more flexible markets, such as the Energy Imbalance Market.

# Introduction



Oregon's renewable electricity capacity has grown over the years, thanks to some of the early supporting policies, a growing voluntary demand for cleaner electricity, substantial decreases in the costs of renewable electricity technologies, and recent policies like a strengthened Renewable Portfolio Standard. Oregon will face a number of challenges and opportunities as it works toward a goal of 50 percent renewable electricity consumption by 2040. Changes within the utility industry itself, new technologies, and changing customer demands will affect how Oregon reaches its RPS target.

While *energy* and *electricity* are not fully interchangeable terms, this chapter uses the term *energy* when discussing electricity in Oregon. Energy typically includes uses other than electricity, including transportation, industrial processes, and home heating; these types of energy are discussed in other chapters of this report.

## Renewable Energy 101

Renewable energy is generally defined as energy from sources that are naturally replenishing on a relatively short time horizon, including solar, wind, geothermal, hydropower, biomass, and marine energy.* Certain renewable energy policies have a narrower definition for renewable energy that is used for compliance, such as a renewable portfolio standard.

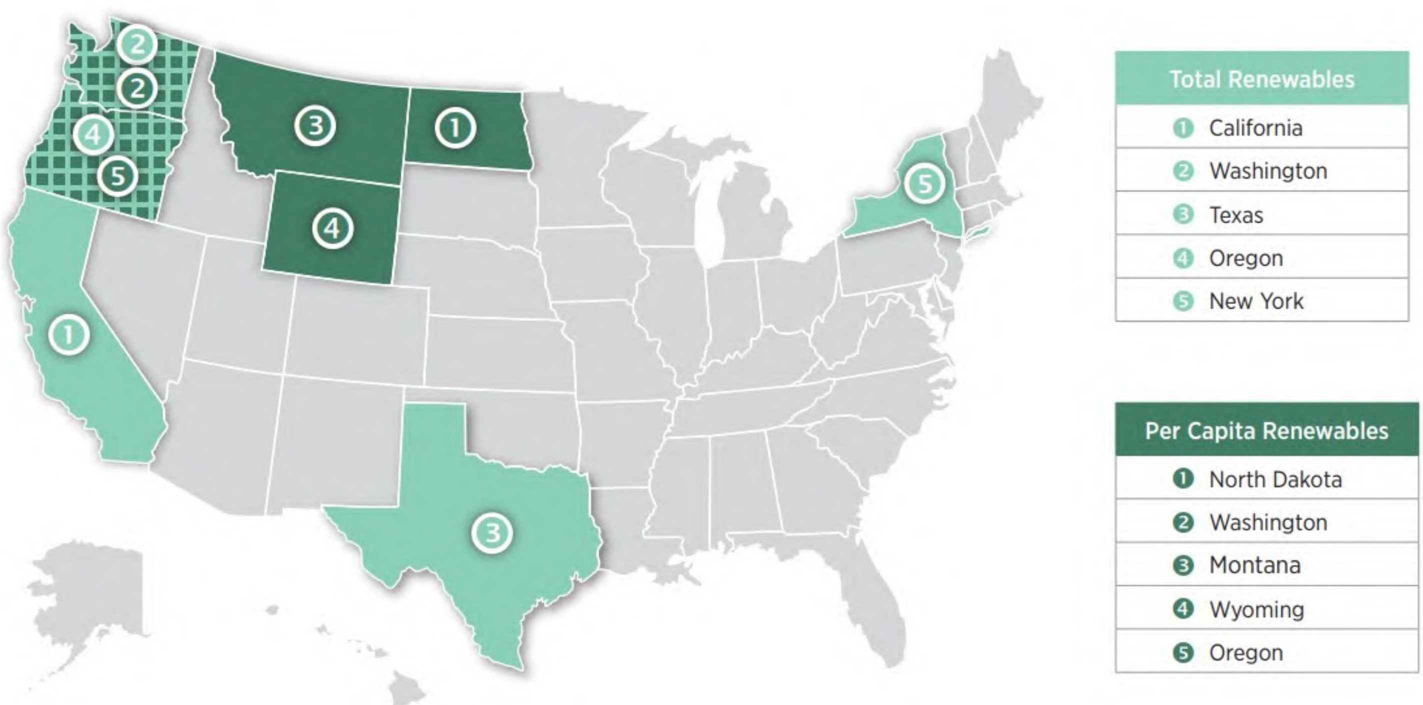
*__Marine energy__ is an emerging renewable resource, which includes wave, tidal, and current energy.

Oregon's RPS outlines which sources are eligible and under what constraints. All of the sources listed above are eligible for Oregon's RPS. Some of the sources — such as the direct combustion of municipal solid waste, certain categories of biomass, and hydropower — are limited in eligibility due to facility age or concerns around particulate emissions, chemical preservatives, or land management. For more information on the eligibility of various resources for the RPS, see ORS 469A.[1]

## Renewable Electricity Installations in Oregon

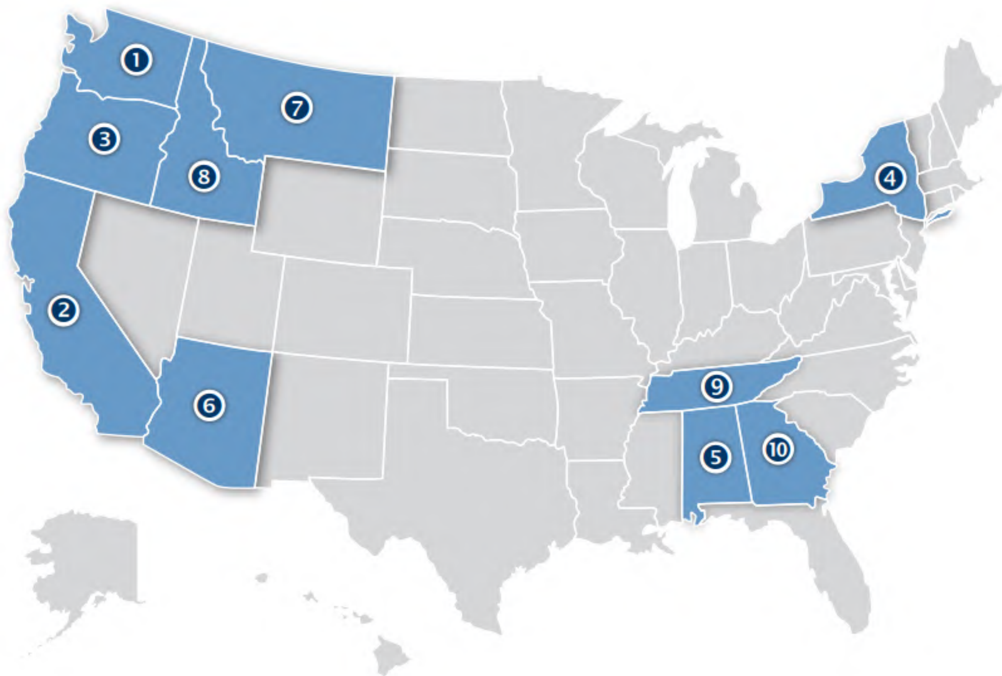
Beginning in 1977 with the creation of the Residential Energy Tax Credit (RETC) program, the Oregon legislature passed a series of bills promoting renewable energy resources, including the public purpose charge, net metering, the RPS, funding for wave energy, zoning measures, and requirements for public buildings. This legislative momentum, as well as the region's hydropower, has helped place Oregon as one of the leading states for renewable energy installations. As of 2016, Oregon was fourth in the nation for cumulative renewable electricity installed capacity, and fifth in terms of per capita installed capacity.[2]

**Figure 3.1: Top States for Cumulative Renewable Electricity Installed Capacity for 2016[2]**




With approximately 12,211 MW of installed renewable capacity in 2016, Oregon also ranked high for installed capacity of both hydropower (third) and geothermal generation (fifth).[2]

**Figure 3.2: States Leading Hydropower Electricity Installed Capacity in 2016[2]**



| Total Installed Capacity (MW)[1] | |
|---|---|
| 1 Washington | 21,106 |
| 2 California | 10,051 |
| 3 Oregon | 8,446 |
| 4 New York | 4,672 |
| 5 Alabama | 3,319 |
| 6 Arizona | 2,718 |
| 7 Montana | 2,628 |
| 8 Idaho | 2,541 |
| 9 Tennessee | 2,499 |
| 10 Georgia | 1,965 |

# Renewable Energy Drivers in Oregon

Many factors have driven the increase in renewable energy generation and consumption in Oregon, such as state and federal policies, increased customer demand, and sharply declining costs of technology. This section will explore these drivers:

- **Required Procurement:** Policies requiring renewable procurement;
- **Voluntary Procurement:** Programs and market opportunities that meet consumers' voluntary renewable energy demand;
- **Financial Incentives:** Incentives for renewable energy; and
- **Falling Costs:** Falling costs associated with renewable energy technology and project development.

## Required Procurement

Oregon has a number of policies that require entities to procure and consume renewable energy. While there has been no comprehensive assessment of the impact of these policies on the development of renewable energy, the three policies described below – PURPA, RPS, and the Green Energy Technology program – have required utilities and public entities in Oregon to develop renewable energy.

### PURPA

One of the original drivers of renewable energy development in Oregon was the federal Public Utility Regulatory Policies Act of 1978, or PURPA,* which obligates utilities to buy output from qualifying small

*PURPA is codified in numerous sections of 16 U.S.C., including, § 796, § 824a-3 and §§ 2601, et seq.

renewable generators and cogeneration facilities (“qualifying facilities”) at the utility’s “avoided cost”* of procuring that energy elsewhere. PURPA removed barriers to development of renewable generating resources and created a fair and open market for independent (non-utility) electricity producers. PURPA has been a major driver for renewable energy project development in the West, including Oregon, and analysts expect it to be one of the main drivers for utility-scale solar development in the U.S. in 2018 and beyond.[3]

### The Oregon Renewable Portfolio Standard

A renewable portfolio standard is a policy requiring retail electricity providers to meet a certain percentage of their annual electricity sales with eligible renewable energy generating resources. Nationally, state RPS policies have been responsible for approximately 50 percent of the growth in non-hydro renewable energy generation since 2000. In the West, between 70 and 90 percent of renewable energy additions were built to meet RPS requirements.[4]

Oregon established its RPS in 2007 with Senate Bill 838 (Oregon Laws 2007, Chapter 301), providing a requirement for the largest utilities[1] – Portland General Electric, PacifiCorp, and the Eugene Water & Electric Board – to provide 25 percent of retail sales from eligible renewable sources by 2025, with interim goals along the way. The state’s many smaller consumer-owned utilities (COUs) were given lower targets, depending on the percent share of the state’s total retail electricity load supplied by the COU. Other than EWEB, only Umatilla Electric Cooperative has had enough sales to trigger the large utility RPS threshold, which is three percent or more of total statewide retail electricity sales in any three consecutive years.

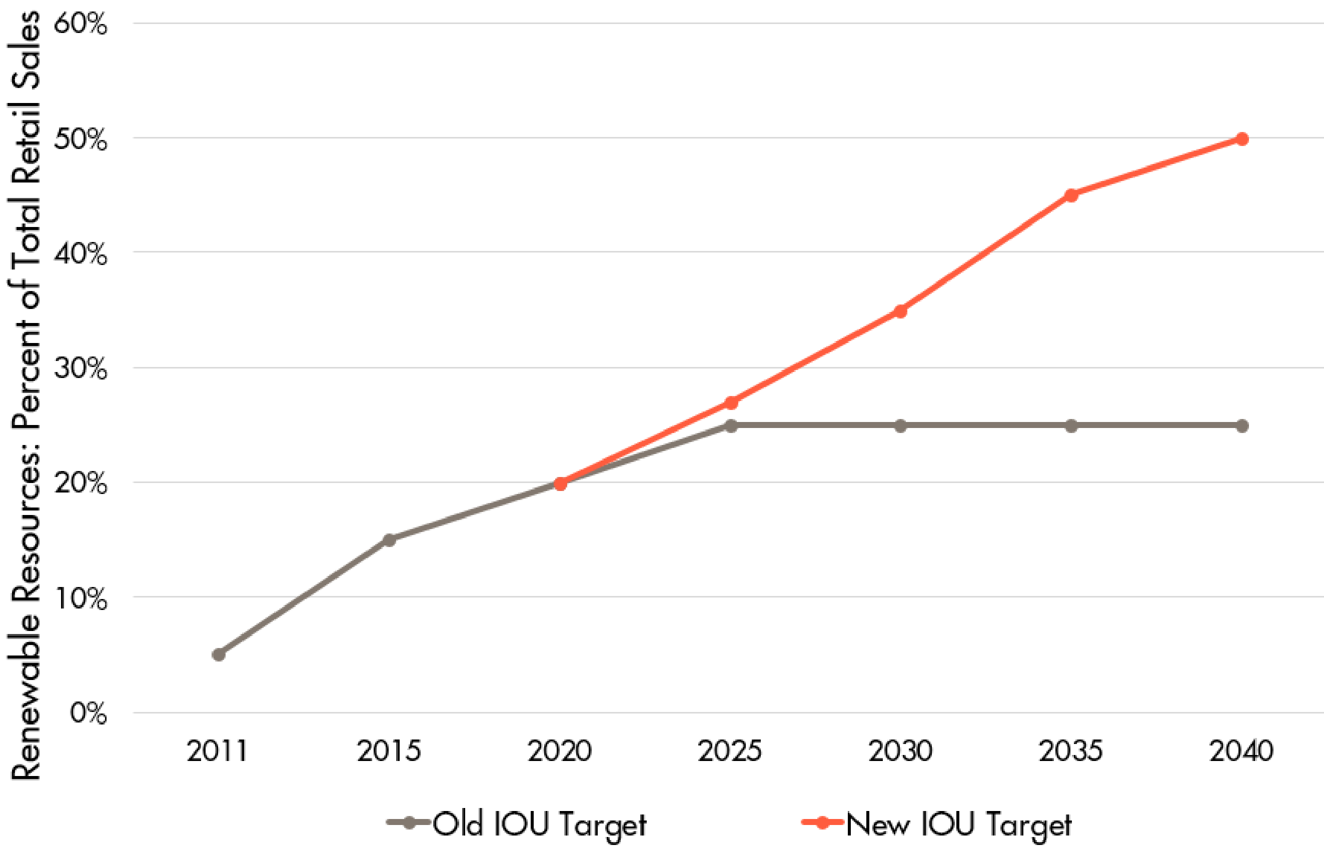
**Table 3.1: Annual Percent Share of Total Retail Electricity Sales in Oregon for the Largest Utilities for 2015-2017[5,6,7]**

| Entity | Utility Type | Percent Share of Oregon Retail Sales | | |
|---|---|---|---|---|
| | | 2015 | 2016 | 2017 |
| PGE | Investor-owned | 37.50 | 36.60 | 35.80 |
| PacifiCorp | Investor-owned | 27.20 | 27.30 | 26.60 |
| EWEB | Municipal-owned | 4.88 | 4.85 | 4.95 |
| Umatilla | Cooperative | 3.35 | 3.80 | 4.29 |
| Central Lincoln | People’s Utility District | 2.63 | 2.68 | 2.73 |
| Clatskanie | People’s Utility District | 1.92 | 1.91 | 2.24 |
| Springfield | Municipal-owned | 1.55 | 1.57 | 1.50 |

The Oregon Clean Electricity and Coal Transition Plan increased Oregon’s RPS target in 2016 through Senate Bill 1547 (Oregon Laws 2016, Chapter 28).[92] Also known as the “Coal to Clean” legislation, SB 1547 increased the RPS from 25 percent by 2025 to 50 percent by 2040. This 50 percent target applies to the large investor-owned utilities (IOUs) that provide three percent or more of total state retail electricity sales. COUs’ compliance is capped at 25 percent by 2025.

*In Oregon, utilities establish different avoided costs rates based on the technology. Learn more about avoided costs later in this chapter.

**Figure 3.3: Original Oregon IOU RPS Targets and New Targets after 2025**




*Eligibility*


Gresham Wastewater Treatment Plant

Eligibility of resources for the Oregon RPS is based on two factors: the source of the renewable energy and the age of the generating facility (also referred to as the commercial operation date). Generation sources eligible for the Oregon RPS include solar, wind, geothermal, certain biomass sources, some hydropower, and a handful of others. SB 1547 provided an additional eligible RPS generating resource: thermal energy generated at a facility that also generates electricity using RPS-eligible biomass sources. As of fall 2018, four facilities in Oregon have applied for RPS certification for thermal energy. The Gresham Wastewater Treatment Plant is the first facility to be certified.

The goal of the RPS legislation was to promote "research and development of new renewable energy sources in Oregon" and to "increase their [utilities] use of renewable energy sources."[8] For this reason, aside from a few exceptions, only facilities that became operational on or after January 1, 1995, are eligible for participation in the RPS. The facility age requirement serves to incentivize the development of *new* renewable electricity sources, which is one reason why much of the existing hydropower in the region is not eligible for the RPS. However, the importance of the region's existing hydropower resources was realized by two exemptions for pre-1995 hydropower facilities: any incremental generation attributable to efficiency upgrades made at existing hydropower facilities after 1995 would be eligible, as would generation from an existing facility if it became certified as a low-impact hydroelectric facility* after 1995. Additionally, new hydropower projects could qualify for the RPS if they are certified as low impact or if they are located outside certain protected areas.

*RPS Exemptions*

Oregon's RPS allows for four exemptions to a portion of a utility's RPS compliance requirement, two of which further acknowledge the value of zero-emissions hydropower:

- **Cost cap:** An entity is not required to comply with the RPS to the extent that the costs of compliance exceeds four percent of the entity's annual revenue requirement for the compliance year.
- **Excess load:** An entity need not comply to the extent that it would have to acquire electricity in excess of its load requirement.
- **BPA Tier 1 power:** COUs are not required to comply with the RPS to a point where they would be required to reduce their consumption of non-RPS eligible BPA Tier 1** hydropower.
- **Older renewables:** An entity is not required to comply to the extent that it would have to substitute newer renewable electricity for electricity from older, non-RPS sources that are not fossil-fueled, such as legacy hydropower.

*RPS Tracking – Renewable Energy Certificates*

As electrons from, for example, a natural gas plant become indistinguishable from those from a wind farm once they stream onto the grid, renewable energy certificates, or RECs, are used to track renewable energy and to determine where it is ultimately consumed. At the simplest level, a REC is a tradeable certificate that represents the renewable attributes of one-megawatt hour (1 MWh) of qualifying renewable electricity delivered to the grid.

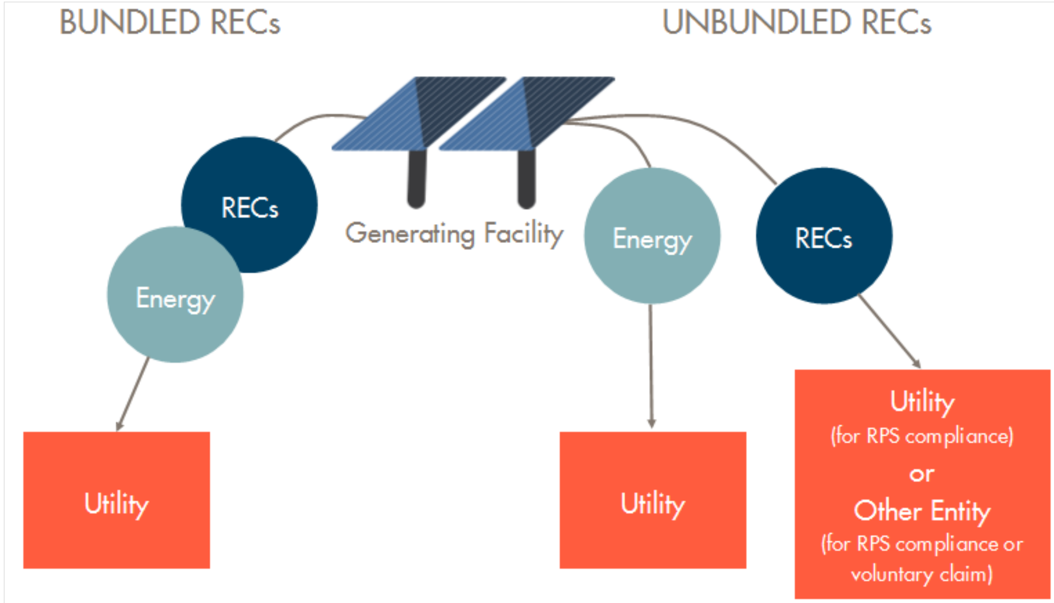
A majority of jurisdictions define RECs to include environmental attributes associated with the renewable energy generated, but there are some differences across jurisdictions in how those attributes are defined. Oregon defines a REC as including the "environmental, economic, and social benefits" associated with renewable energy.[9] If the renewable electricity and its corresponding RECs are sold together to the same customer, the RECs are considered to be "bundled" and to include all of the attributes of the renewable generation. Simply put, bundled means that 1 MWh of renewable electricity *and* the REC created for that

*The Oregon RPS requires a certification from the Low Impact Hydropower Institute (LIHI) for a facility to be considered low impact. LIHI certification is awarded to facilities according to eight dimensions related to environmentally sound hydropower generation, such as water quality, fish passage, watershed protection, endangered species protection, and avoidance of impacts on cultural and historic resources.[89]

**BPA has a two-tiered power rate design for public power customers. Tier 1 is the base rate for the agency's low cost resources. Tier 2 represents incremental power BPA must purchase to meet the power needs of any BPA customers beyond what is covered by Tier 1 rates. The tiered approach is meant to not only provide an incentive for utilities to practice energy efficiency but also to provide a price signal should a public utility wish to build its own resources in place of purchasing Tier 2 power from BPA.

1 MWh are delivered together to a single entity. However, if the REC is "unbundled" (i.e. sold separately) from its corresponding 1 MWh of electricity generated, the attributes of renewable generation stay with the REC and the remaining electricity is no longer counted as "renewable" – sometimes referred to as "system power." Whoever purchases the unbundled REC may make a claim of consuming renewable electricity while the buyer of the MWh of electricity – now without its corresponding REC – cannot make any renewable claims about the consumption of that unit of electricity.

**Figure 3.4: Flow of Bundled and Unbundled RECs**




Oregon entities may comply with the RPS using bundled RECs, unbundled RECs, or Alternative Compliance Payments (ACP). ACPs are a cost-containment mechanism to protect Oregon ratepayers. The Oregon Public Utility Commission sets the ACP rate for IOUs and Electricity Service Suppliers (ESSes) each compliance year at a level that is high enough to incentivize compliance using RECs rather than ACPs but that provides for a compliance cost ceiling should the costs of procuring renewable energy rise considerably. So far, no Oregon IOUs or ESSes have used ACPs to comply with the RPS. The 2018-2019 ACP rate for IOUs and ESSes is $90/MWh.[93] For COUs, individual COU boards sets the ACP rate.

Unbundled RECs may only be used for up to 20 percent of an IOU's annual compliance obligation; COUs may use up to 50 percent unbundled RECs for annual compliance. Starting in 2021, ESSes, entities that may sell electricity services through the Direct Access program, may only use unbundled RECs for up to 20 percent of their annual RPS compliance requirement. Learn more about Direct Access later in this chapter.

*RPS Compliance*

Oregon's two biggest IOUs – PacifiCorp and PGE – report to the Oregon Public Utility Commission annually on what resources they used to comply with the RPS and at what cost.

Both PGE and PacifiCorp have met their RPS requirements every year since the first compliance year of 2011 without exceeding the cost cap or using the ACP mechanism. While PacifiCorp has primarily met its RPS compliance obligations with wind resources, especially in earlier RPS years, PGE has relied on both hydropower and wind resources. Some of the hydropower PGE uses for compliance each year is from generation attributable to efficiency upgrades at older hydropower facilities.

Both utilities' compliance portfolios have also included some solar, geothermal, biogas, and biomass resources. Solar resources did not provide much of the early RPS compliance for either utility, but both PGE and PacifiCorp have been adding solar to their compliance portfolios.

**Figure 3.5: PacifiCorp RPS Compliance Resources 2011-2016**

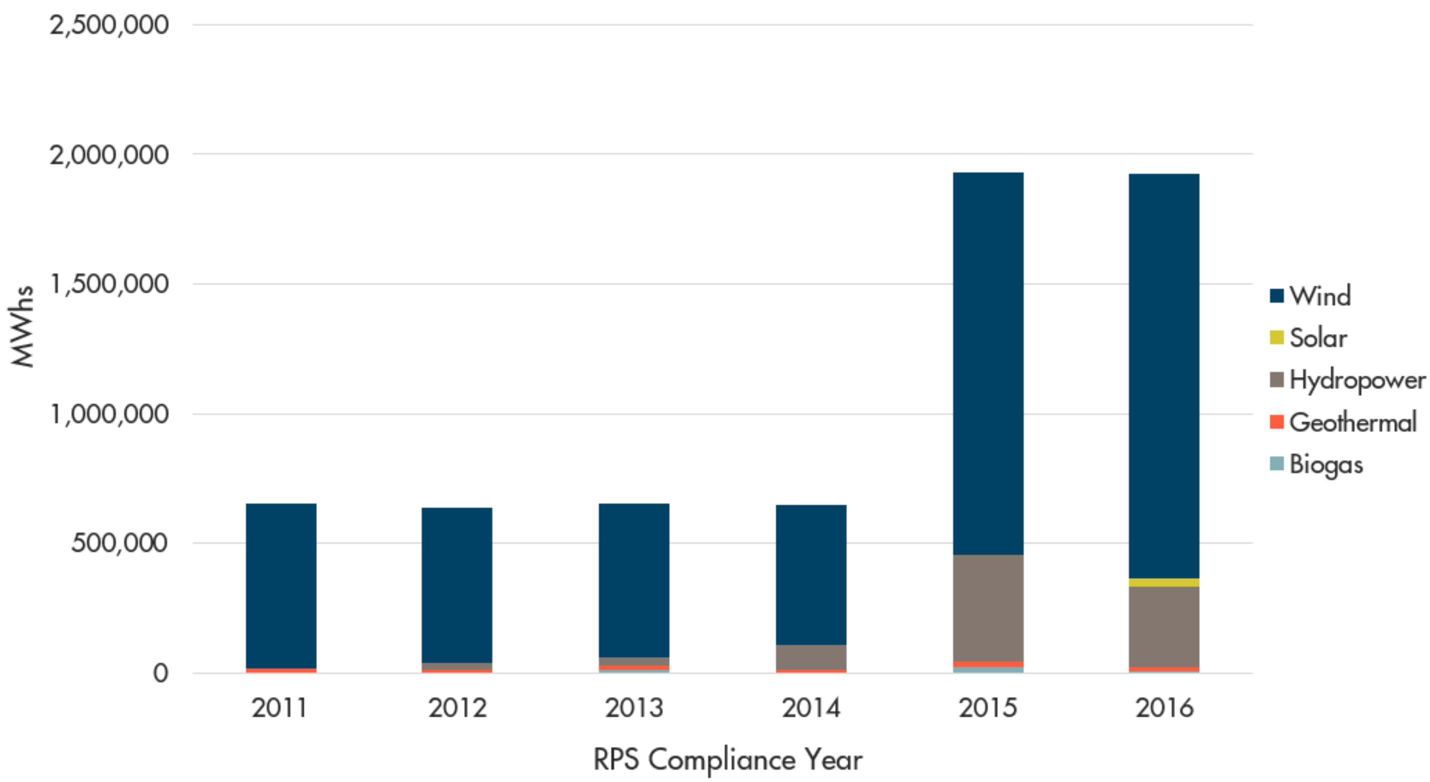
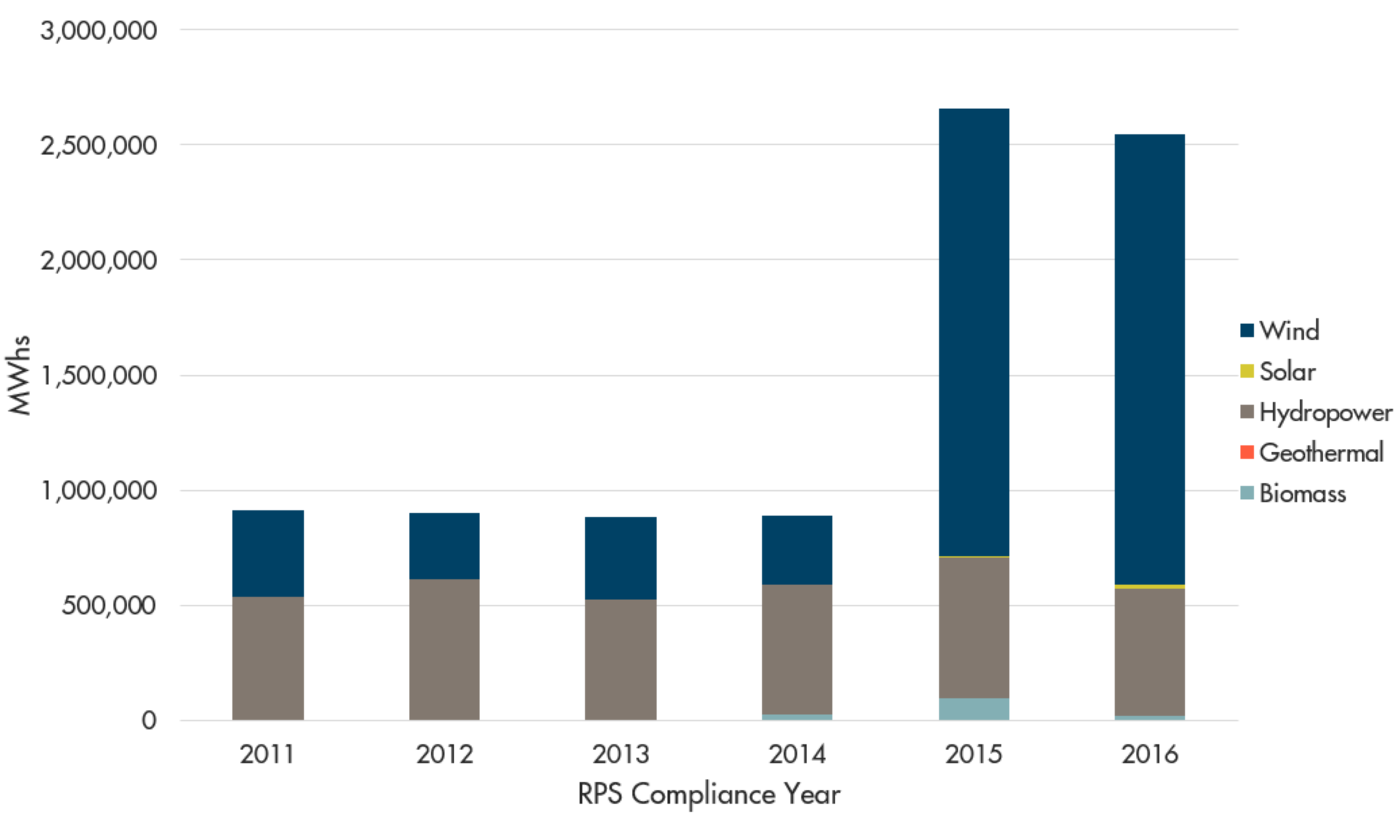



**Figure 3.6: PGE RPS Compliance Resources 2011-2016**



In 2015, the RPS target took its first big jump from five to 15 percent, and both PGE and PacifiCorp met this higher interim target with a mix of renewable resources located in Oregon and within the region. The next RPS target increase is from 15 to 20 percent in 2020.

While IOUs must demonstrate RPS compliance to the OPUC, COUs must report their compliance to their respective members or customers, usually through the COU's board. As noted above, EWEB is the only COU that currently has an RPS requirement, and it reports directly to its Board of Commissioners on its RPS compliance each year. However, due to some of the RPS compliance exemptions listed above, EWEB has not yet had an RPS compliance requirement above zero. EWEB purchases a quantity of Tier 1 electricity from BPA, and also meets a portion of its load with legacy hydropower generation from non-BPA sources. For example, in 2017 EWEB had total retail sales of 2,526,200 MWh, with a resultant 15 percent RPS requirement of 378,900 MWh. However, because all of its retail sales were from exempt sources (BPA Tier 1 and legacy hydropower), EWEB was left with a 2017 RPS compliance requirement of zero.[10]

### The Small-Scale Community-Based Renewables Target

ORS 469A.210[94] states "by the year 2025, at least eight percent of the aggregate electrical capacity of all electric companies that make sales of electricity to 25,000 or more retail electricity consumers in this state must be composed of electricity generated by one or both of the following sources:

a) Small-scale renewable energy projects with a generating capacity of 20 megawatts or less **that generate electricity utilizing a type of energy described in ORS 469A.025**; or

b) Facilities that generate electricity using biomass that also generate thermal energy for a secondary purpose."

The law applies to PGE and PacifiCorp.

While the statute defines facility types that are eligible for the RPS as well as a clear target, there are a number of terms and provisions within the statutory language that lack formal definitions. For example, the term "aggregate electrical capacity" does not have a statutory definition. As a result, a facility database was developed with analysis tools to consider different compliance scenarios. In addition, the term "community-based renewable energy project" is also not defined in statute and does not have a broadly accepted definition.

To understand different ways utilities might meet the eight percent target, ODOE staff developed a database of renewable energy facilities serving PGE and PacifiCorp, along with scenario analysis tools to consider different compliance options. For the purposes of the analysis, it was agreed that utility peak load could serve as a proxy for aggregate electrical capacity.

The five types of facilities included in the database:

1. **Net metered facilities:** facilities that are installed on the customer side of the electric meter and serving onsite loads.

2. **Non-RPS compliant facilities:** facilities constructed before 1995 that do not meet the definition of renewable energy projects established under ORS 469A.025[94] but that may meet the qualifications described in the small-scale community-based renewable energy facilities target.

3. **Out-of-state facilities:** renewable energy facilities located outside of Oregon that contribute to Oregon's load. When included, these facilities are considered based on the estimated share of their output serving the Oregon market.

4. **Contracted facilities:** the utilities provided data on projects that are under contract but not yet online by February of 2018.

5. **Interconnection applications:** the utilities provided data on projects that have submitted an application for interconnection but are not yet contracted. Historically many facilities in the interconnection application queues have not been built. Conversely, by 2025, many facilities may be built that are not currently in the interconnection application queues.

Using utility peak load assumptions as a proxy for "Net Aggregate Capacity," the tables below show the facilities that could contribute towards the eight percent target for PGE and PacifiCorp.

Table 3.2 shows facilities reported by PGE. Each row represents a facility classification and the relative contribution of those facilities towards the eight percent target.

**Table 3.2: PGE Facilities Potentially Contributing to Eight Percent Target**

| PGE Facilities | | 2016 | 2025 |
|---|---|---|---|
| Peak Load Assumptions | | 3,652 MW | 3,800 MW |
| **Facility Scenarios** | **Facilities Capacity (MW)** | **% of Peak Load** | **% of Peak Load** |
| Baseline Contributing | 75 | 2.1% | 2.0% |
| Net Metered | 48 | 1.3% | 1.3% |
| Non RPS Compliant | 18 | 0.5% | 0.5% |
| Out of State | 5 | 0.1% | 0.1% |
| Contracted Facilities | 513 | 14.0% | 13.5% |
| Interconnection Applications | 1013 | 27.7% | 26.6% |

Table 3.3 shows facilities reported by PacifiCorp. Each row represents a facility classification and the relative contribution of those facilities towards the eight percent target.

**Table 3.3: PacifiCorp Facilities Potentially Contributing to Eight Percent Target**

| PacifiCorp Facilities (De-rated Capacity) | | 2016 | 2025 |
|---|---|---|---|
| Peak Load Assumptions | | 2,267 MW | 2,400 MW |
| Facility Scenarios | Facilities Capacity (MW) | % of Peak Load | % of Peak Load |
| Baseline Contributing Facilities | 83 | 3.7% | 3.5% |
| Net Metered | 34 | 1.5% | 1.4% |
| Non RPS Compliant | 104 | 4.6% | 4.3% |
| Out of State | 51 | 2.2% | 2.1% |
| Interconnection Applications | 47 | 2.1% | 2.0% |

Table 3.3 includes capacity values based on PacifiCorp's allocation of resources over its entire western service territory. As a result, all facilities, including in-state facilities, are de-rated to about 25 percent of their nameplate ratings. If the PacifiCorp facilities that are located in Oregon are counted at their full nameplate capacity, they have a significant impact on progress toward the target. Table 3.4 below describes the existing projects and interconnection applications for PacifiCorp facilities located in Oregon.

**Table 3.4: Existing Projects and Interconnection Applications for PacifiCorp Facilities**

| PacifiCorp Facilities (Full Capacity) | | 2016 | 2025 |
|---|---|---|---|
| Peak Load Assumptions | | 2,267 MW | 2,400 MW |
| Facility Scenarios | Facilities Capacity (MW) | % of Peak Load | % of Peak Load |
| Existing Facilities in State | 471 | 20.8% | 19.6% |
| Interconnection Applications in State | 119 | 5.3% | 5.0% |

Figures 3.7 and 3.8 describe the nature of the small-scale renewable energy projects by facility type reported by PGE and PacifiCorp. The charts report all projects in the database regardless of the eligibility scenario analysis. As can be seen, solar facilities make up the majority of planned capacity.

**Figure 3.7: Cumulative Capacity (MW) of Existing Facilities Reported in the Small Scale Renewable Energy Facilities Database; Reported Online as of February 2018**

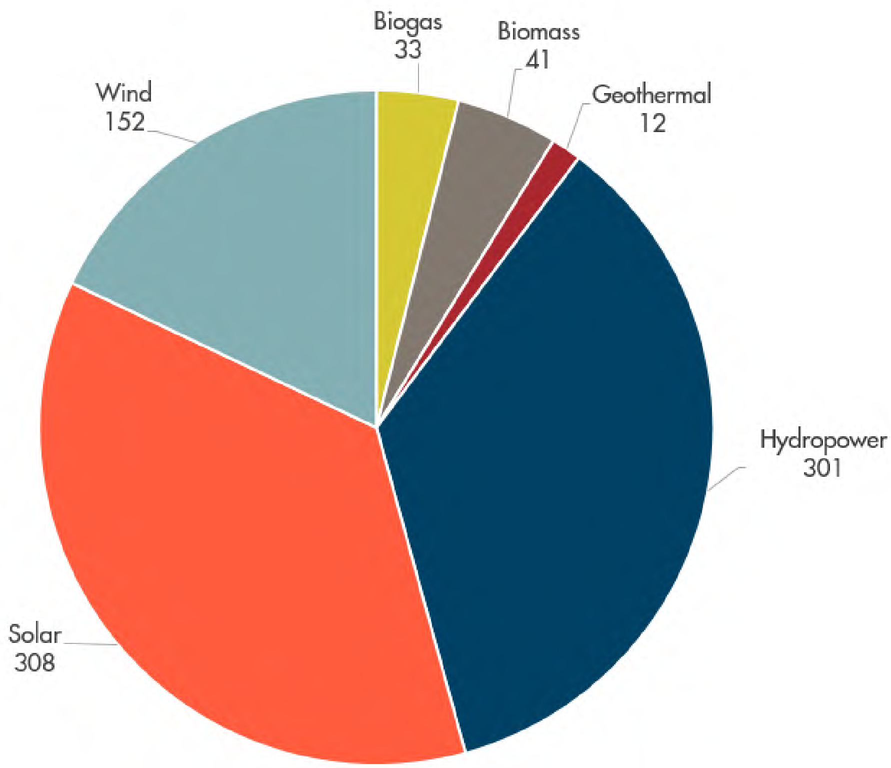
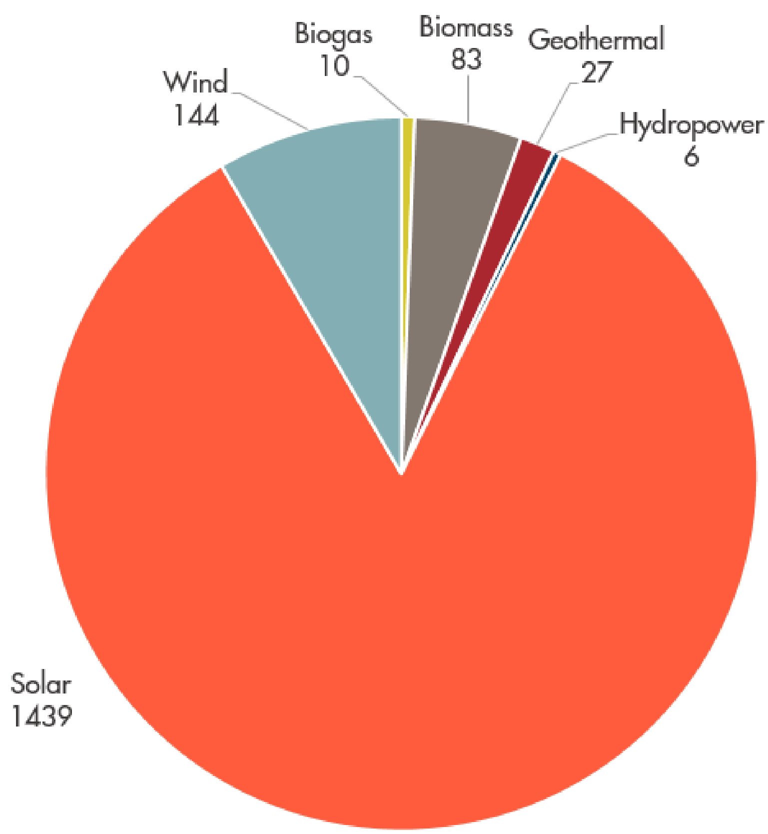



**Figure 3.8: Capacity (MW) of Planned Facilities Reported in the Small Scale Renewable Energy Facilities Database; Reported as of February 2018**



In 2018, the OPUC began a rulemaking (Docket AR 622[95]) to clarify terms and create implementation rules. This docket is ongoing and tentatively scheduled to be completed by the end of 2018.

The Oregon Youth Authority's New Bridge High School installed solar as part of its GET program requirements.

### 1.5 Percent for Green Energy Technology

Oregon requires public bodies to spend 1.5 percent of public improvement construction costs on green energy technology or woody biomass energy technology (WBET). The requirement is for new public buildings with construction costs exceeding $1 million or building renovations with construction costs exceeding $1 million and 50 percent of the insured value of the building.[96]

Eligible green energy technologies include solar PV, solar hot water, passive solar, day lighting, and geothermal systems. As of January 1, 2018, public bodies may choose woody biomass energy technology as an alternative to green energy technology. WBET technologies must use certain types of woody biomass as a feedstock in boilers with a combustion efficiency of at least 80 percent.[11] As of January 1, 2018, 81 public projects were reported, with 75 percent of those being photovoltaic projects. Few projects attempt the passive solar path as the passive elements must reduce whole building energy use by 20 percent. One geothermal project has been completed. As of the date of this report, no woody biomass projects have been reported.

## Voluntary Procurement

Another clear driver of renewable energy development in Oregon and the West has been voluntary demand from residential customers and corporate and industrial entities, which has been increasing alongside growing concern about climate change and also decreasing costs of renewable technologies. Voluntary renewable energy purchases are those where the buyer was not required to purchase renewable energy but chose to, usually for reasons related to cost-savings, risk management, corporate social responsibility, or corporate marketing.

### COMMUNITY CLEAN ENERGY GOALS

Multnomah County

In 2017, the City of Portland and Multnomah County committed to 100 percent renewable electricity by 2035, and **100 percent renewable energy** – across sectors – by 2050.

"Cities that invest in renewable energy are making the responsible choice for our global future and bringing our significant purchasing power to bear in the transition to a clean energy economy. I am a firm believer in the power of local government to lead the change we want to see in the world. After all – this is an issue that our very life depends on. The world is looking to states and cities to be bold and resourceful with policy and action at the local level." — *Portland Mayor Ted Wheeler*

# VOLUNTARY GREEN POWER PROGRAMS IN OREGON

As part of the electric power industry restructuring required in Oregon by SB 1149 (1999),[97] Oregon's electric IOUs are required to offer customers a portfolio of rate options, including renewable energy options since October 2001. While PacifiCorp and PGE's programs were not the first to launch in the U.S., they quickly became two of the most successful programs nationwide, according to annual ratings from NREL.

There are a few program options in Oregon for PGE and PacifiCorp customers, but most customers participate in one of two options:

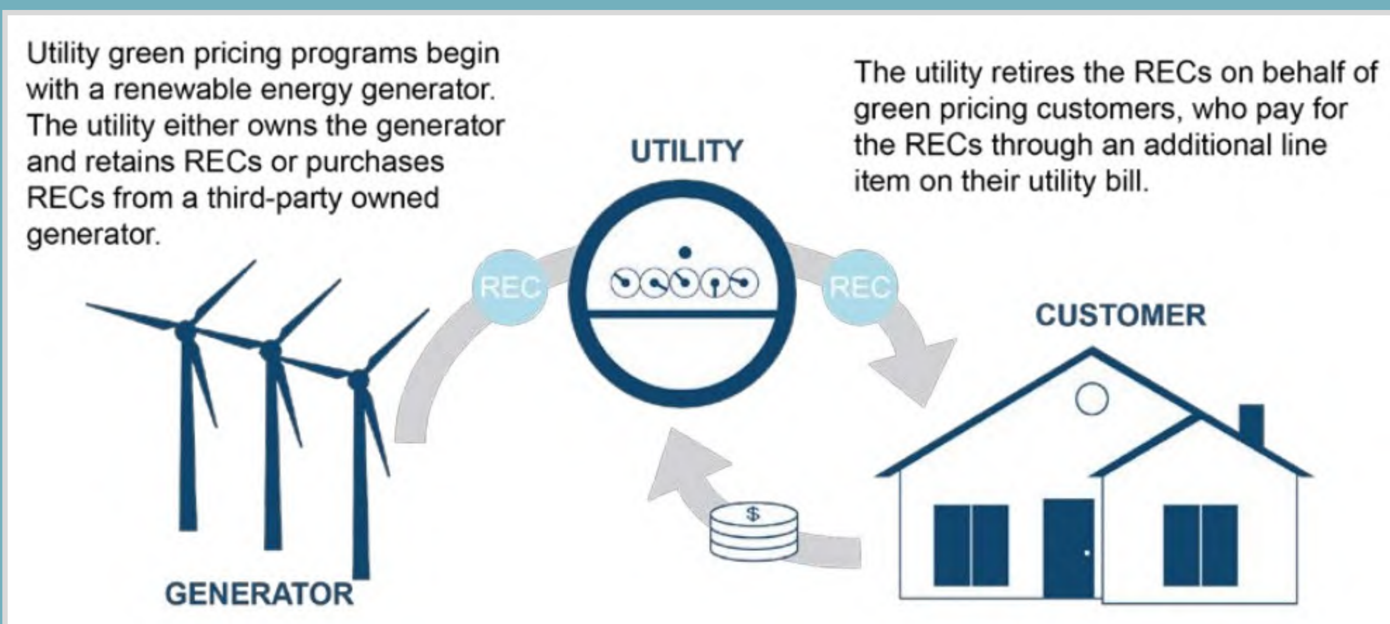
1. A block rate that allows participants to pay a fixed cost for a "block" of kWhs of electricity; or
2. A volumetric rate where participants fund the purchase of RECs equal to 100 percent of their electricity consumption.

Additionally, customers participating in voluntary green power programs may elect to pay a small monthly fee to support native fish habitat.

In 2017, PGE's voluntary green power program was ranked first in the country, and yielded the highest total number of participants (173,856), the highest rate of participation (almost 20 percent of all eligible customers), and the highest total sales of MWh of green power (over 1.8 million MWhs).

2017 marked the ninth consecutive year that PGE topped the NREL rankings for total program participants and the sixth consecutive year for most MWhs sold through the programs. PacifiCorp has followed close behind PGE in the rankings, and in early years of the programs (2004-06), its programs outranked PGE's in terms of total participants. Since 2009, PacifiCorp has consistently ranked second in the country in terms of total program participants (NREL did not collect data in 2011) and second or third in total sales of MWh of green power.

**Figure 3.9: How Oregon's Utility Green Power Programs Work[13]**



### Green Power Programs – Residential and Small Commercial Customers

Oregon's largest electric IOUs – PGE and PacifiCorp – have two of the most successful voluntary green power programs in the country, as tracked and ranked annually by the National Renewable Energy Laboratory.[12] In Oregon in 2016, over 200,000 voluntary green power program participants were responsible for purchasing more than two million MWhs of green power.[13]

One of PGE's voluntary green power programs, *Green Future Solar*, allows customers to buy blocks of solar energy, like the energy generated from this array near Willamina, OR.

Voluntary green power programs allow residential and small commercial consumers in Oregon to opt in and pay a premium on their electricity bills for the purchase of renewable energy certificates, and to contribute toward the above-market costs of various renewable energy projects in Oregon and in the West.

Though COUs predominantly get their electricity from BPA hydropower and are not required to provide green power programs, some choose to offer such programs to their customers. For example, EWEB's Greenpower program allows customers who purchase green electricity to support local incentives for residential and commercial solar projects, and grants for renewable energy projects at local nonprofit, government, or academic organizations.

### Large Customer Options

Large commercial and industrial customers are also driving renewable energy development in Oregon and in the Northwest. Corporate social responsibility and sustainability-related targets at companies have driven the quickly-growing trend of corporate renewable energy procurement, as have reductions in the costs of renewable energy and new, easier ways of purchasing off-site renewable energy.[14] The result has been contracting for over 10 GW of off-site renewable energy development for corporate customers nationwide since 2015.[15] A number of companies with operations in Oregon have signed onto pledges such as the RE100 Pledge, a global campaign to get some of the largest companies in the world to commit to using 100 percent renewable energy, including Apple, Facebook, Google, Nike, and Salesforce.[16] Separately, Intel has committed to powering all of its U.S. operations with 100 percent renewable energy,[17] and a number of other Oregon-based companies, including Adidas, Columbia Sportswear, Keen, and PGE, have committed to reducing GHG emissions, which will include greater use of renewable energy sources.[18]

In Oregon, these large customers have had two primary pathways for procuring voluntary renewable energy:

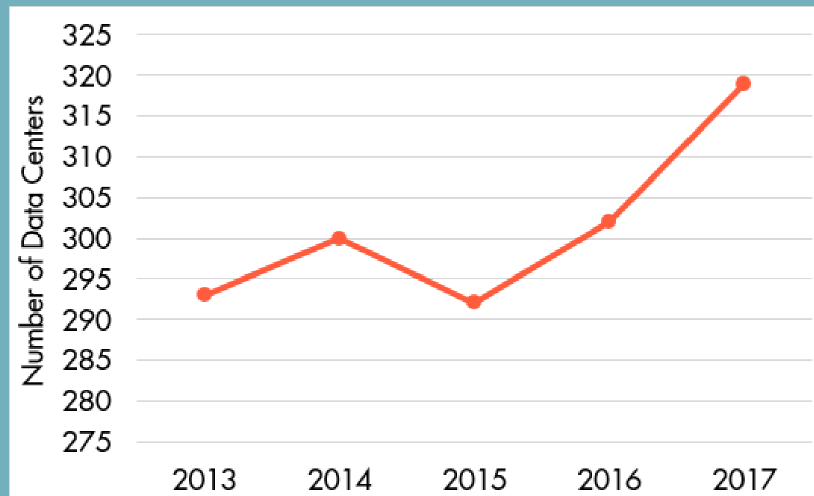
1. The state's Direct Access program; and
2. Utility green power programs for large customers.

A third option, a green tariff, has been discussed in Oregon, and in 2018 PGE filed with OPUC for approval of its proposed green tariff option for large customers.[98]

## CORPORATE RENEWABLE ENERGY PROCUREMENT

The number of data processing, hosting, and related services, known here collectively as data centers, grew nearly six percent in the last year. Since 2013, the segment as a whole grew just over eight percent. These facilities house thousands of computers in the form of servers and are linked together via thousands of miles of wiring.

**Figure 3.10: Growth of Data Center Industry in Oregon (2013-2017)[43]**




The largest issue facing developers of data centers? Cooling their facilities. For this task, they require energy – and lots of it! According to the Northwest Power and Conservation Council, data centers could become the region's largest consumers of electricity since the aluminum industry of the 1980s.[40] More specifically, companies developing these facilities are in search of Oregon's plethora of clean, low-carbon and low-cost energy. Companies such as Facebook, Apple Inc., Google, Amazon, and others have populated Central and Eastern Oregon with their facilities. With these facilities, many procure nearly 100 percent clean energy from separate energy projects or nearby utilities. Google recently opened a facility in The Dalles without relying directly on fossil fuels, while Facebook will power its next Prineville facility with 437 MW of solar power.[40,41] The company already has three datacenters in Prineville with two more on the way.[41] Some companies cannot find enough renewable energy, such as Microsoft. After some disagreement, the software giant reached a settlement with its electric utility, Puget Sound Energy, which uses fossil fuels for nearly 60 percent of its generation, to create a new tariff for large industrial or commercial customers if the customers opt-out of buying electricity from the utility.[42]

Through **Direct Access**, commercial and industrial entities that are customers of the state's largest IOUs may choose a retail provider of electricity other than their incumbent utility. This allows firms to seek out a new electricity supplier that can address their needs related to price or generation source. Direct Access was conceived as a way to allow for a more competitive electricity marketplace by allowing independent providers of electricity, called Electricity Service Suppliers (ESSes), to compete directly with vertically-integrated IOUs. ESSes have historically provided electricity from natural gas resources, but recently some ESSes have added more renewable energy to their portfolio. Both PGE and PacifiCorp have experienced recent growth in the percentage of their load attributable to the Direct Access program, with PGE at over 17 percent and PacifiCorp at almost five percent for 2017. While there is no indication that the majority of Direct Access customers have historically chosen to procure renewable resources, there are a few noteworthy new entrants to the program for whom sourcing renewable energy has been one of the main motivations.

Apple Inc. is one company that has chosen to purchase electricity for its Prineville data centers through the Direct Access program instead of from its incumbent utility, PacifiCorp. Apple has committed to powering its corporate facilities with renewable energy, and the company's preference is to own the renewable energy generation sources whenever feasible. Apple seeks to enter into long-term power purchase agreements for renewable energy when ownership is not feasible.[19] While Oregon customers do not currently have a pathway long-term contracting of this sort, PGE is in the process of launching such a pathway with its green tariff (see below).

To power its Prineville facilities, Apple entered into long-term agreements to purchase renewable electricity from two Avangrid Renewables projects in Oregon: 200 MW from the Montague Wind Project in Gilliam County and 56 MW from the Solar Star Oregon PV project in Prineville.[19] The Montague wind project is expected to ramp up construction in 2019 and the Solar Star project is operational.

The PUC is required to ensure that the provision of direct access service "not cause the unwarranted shifting of costs"[20] from direct access participants to the utility's other customers. As a result, non-residential customers accepting direct access service must pay transition charges (sometimes referred to as an "exit fee") for a period of time not to exceed 10 years. This charge is designed to compensate the utility for costs it reasonably incurred in the past to serve that customer and that it must continue to reasonably incur to maintain the capability to provide the customer with default electric service in the event that its direct access arrangement fails for any reason.

Like residential customers who can take advantage of voluntary green power programs, **large customers can elect to pay more through green power programs**, generally through the purchase of unbundled RECs. While both PGE and PacifiCorp offer large commercial and industrial customers programs that are Green-e Energy certified,* the way these programs are structured, customers typically cannot specify the projects from which they will receive RECs. The utility picks the renewable projects and aggregates them into a single green energy product.

PacifiCorp has offered its Schedule 272 to large non-residential customers as a way to purchase unbundled RECs since 2004. Before 2016, under a Schedule 272 agreement, the customer pays the base rate for its electricity consumption to PacifiCorp and then also pays the cost of unbundled RECs. However, the customer would not necessarily know in advance the generation resource, location, or facility age associated with the unbundled RECs. In 2016, PacifiCorp amended its existing Schedule 272 tariff to allow customers the ability to purchase unbundled RECs from a specific facility or facilities, allowing customers greater control over how to "green" their energy supply and addressing concerns over additionality.

In 2018, Facebook entered into an agreement under Schedule 272 to purchase unbundled RECs from PacifiCorp. Under its agreement with PacifiCorp, Facebook will pay the base rate in addition to the cost of unbundled RECs associated with specific new renewable projects. Because Facebook is purchasing RECs from new projects, it can make a defensible claim that it is supporting new renewable energy development. PacifiCorp will purchase the power and the RECs from generating facilities, which were identified as least-cost, least-risk for customers and use the energy towards fulfilling its system capacity needs, then sell the unbundled RECs to Facebook. The electricity purchases will not count toward PacifiCorp's RPS requirements, as Facebook will own the RECs and therefore the property right to the renewable attributes of the electricity.

*Green-e Energy is an independent consumer protection program providing certification and verification for renewable electricity and renewable energy certificates (RECs) sold to households and organizations.

Utility **green tariff programs** differ from green power programs in that they allow commercial and industrial customers to voluntarily purchase RECs bundled with the corresponding renewable energy from specified projects within a utility's service territory. In this way, large customers receive the financial benefits of renewable energy and long-term contracting, as opposed to paying a premium for an unbundled REC as they would in a voluntary green power program, or paying large exit fees to participate in the Direct Access program. As of February 2018, 21 green tariffs in 15 states have been approved by their respective PUCs.[21]

A green tariff, commonly referred to as a voluntary renewable energy tariff, or VRET, is not currently an option in Oregon. However, both PacifiCorp and PGE have worked with the OPUC to develop a program since 2014 and PGE has an open docket at the OPUC for a Green Tariff Program, where stakeholder discussions are ongoing.

In 2014, the Oregon Legislature passed a law[22] requiring the OPUC to investigate the potential for a VRET in Oregon that would balance policy factors such as further development of renewable energy, effects on the competitive retail market, and potential cost-shifting. After two years of evaluation and discussion amongst stakeholders, a VRET was not adopted.[23] In April 2018, PGE petitioned OPUC to reopen the process, citing pledges the utility had made to continue action toward meeting the United States' Paris Agreement commitments and to support the climate and renewable energy goals of cities in its service territory, including Portland, Milwaukie, Hillsboro, Salem, Gresham, and Beaverton.[24]

At the same time, PGE filed a VRET proposal whereby PGE would execute long-term PPAs of 10 or 20 years with renewable energy generators, and then allow VRET customers to participate by paying, on top of their cost of service, the energy and capacity costs associated with the power purchase agreement (PPA).* Program participants would need to have an annual peak demand of at least 30 kW, though entities like municipalities could aggregate smaller loads to meet the threshold, and commit to a contract length of 5, 10, 15, or 20 years. PGE's proposal suggested that there would be no cost-shifting to non-participants, nor risk-shifting.[24] As mentioned above, OPUC has opened a new docket (UM 1953) to address PGE's proposal to offer a VRET and stakeholder discussions are ongoing.[98]

## Financial Incentives for Renewable Energy Development

A number of state and federal incentive programs available over the years have supported renewable energy development in Oregon. While these programs served to reduce the costs associated with development and operation, it is not known to what extent development was driven by these incentives, especially since many of them could be combined.

### Oregon Incentives

Oregon's Business Energy Tax Credit Program (BETC) began in 1979 and sunset on July 1, 2014. The program, which grew and evolved over time, was used to help Oregon businesses, governments, nonprofits, and other entities invest in energy conservation, renewable energy resources, rental weatherization, and cleaner

*"Customers receiving service under the VRET will pay the cost of service rate, plus the difference between the QF rate and the PPA cost. PGE shareholders will pay the VRET rate for the unsubscribed portion of the PPA. VRET customers may also pay a risk premium depending on the commitment length and PPA subscription rate." Testimony from OPUC Staff. Staff/100 Response Testimony. OPUC Docket UM 1953 (July 18, 2018).

transportation fuels. In the 35 years of the program's operation, ODOE certified 24,738 BETC projects that helped save energy, displace conventional energy sources, or generate renewable energy. Of those, 1,724 renewable projects received over $653 million in tax credits. The program provided tax credits to qualifying projects not to exceed 35 percent of the eligible project costs. In 2007, the Oregon Legislature (HB 3201)[99] increased the incentive percentage for renewable projects from 35 percent to 50 percent through the sunset of the program.

The Residential Energy Tax Credit Program (RETC) was also administered by ODOE until it sunset in 2017. ODOE received the first RETC applications in 1978 and issued more than 630,000 tax credits totaling more than $258 million to help residential consumers power their homes with renewable energy, charge alternative fuel vehicles, and reduce the energy use of their homes through conservation measures and energy efficient appliances. Eligible renewable energy devices under the RETC program included solar electric (PV), geothermal energy, solar water heating, solar space heating, and wind. In 2017, the program's final year, ODOE issued 3,946 solar electric credits, 102 for geothermal devices, 128 for solar water heating, and five for solar space heating. Over the lifetime of the program, more than 15,000 solar projects were approved, with a production estimate of about 75 million kWh/year.

The Renewable Energy Development (RED) Grant program, a current program administered by ODOE, promotes investment in renewable energy by awarding grants to Oregon individuals, businesses, nonprofits, tribes, or other organizations that install and operate a renewable energy system.[101] Grants are awarded through a competitive selection process and can total up to $250,000, not to exceed 35 percent of eligible project costs. Eligible RED Grant projects include systems that use biomass, solar, geothermal, hydroelectric, wind, landfill gas, biogas, or wave, tidal, or ocean thermal energy to produce electricity. In 2018, 18 renewable energy projects, predominantly solar projects, were selected for grant awards totaling approximately $2 million. Projects that have been completed through the RED program have a combined capacity of 28 million kWh/year.

The Bend Area Habitat for Humanity ReStore received a RED Grant in 2015.

Energy Trust of Oregon provides financial incentives to customers of PGE and PacifiCorp in the form of cash rebates for solar, hydro, bio power, wind, and geothermal electricity generators. The incentives help to buy down the above-market costs associated with renewable energy projects and are funded through the public purpose charge described in ORS 757.612.[100] Standardized incentives are offered for residential and commercial solar projects. Incentives for large solar facilities and non-solar technologies are based on projects costs compared to the market value of the energy produced. Large incentives may be offered on a competitive basis.

Business Oregon oversees the Solar Development Incentive (SDI), a cash incentive paid to solar project developers for each kWh of electricity generated at a solar project in Oregon with a nameplate capacity between two and 10 MWs. Each project can receive $0.005 per kWh of electricity generated for a period up to five years. This program was created by Oregon Laws 2016, Chapter 63[25] with enrollment for eligible projects closing on January 2, 2017. Business Oregon selected 19 utility-scale solar projects to receive the SDI, representing over 146.5 MWs of projects valued at upwards of $362 million and located primarily in central, southern, and eastern Oregon.[26]

## SOLAR DEVELOPMENT INCENTIVE PROGRAM

In 2016 the Oregon legislature passed HB 4037 creating a program to encourage the development of utility-scale solar energy projects.[25] The program, known as the Solar Development Incentive and administered by Business Oregon, provides a cash incentive of a half a cent per kWh of electricity generated for a period of five years. Business Oregon awarded the incentive to 19 projects totaling 146.5 MW and representing seven different facility owners in eight Oregon counties. To put this into perspective 146.5MW is about twice as much capacity as the entire residential solar sector in Oregon and nearly four times the solar capacity that was installed under the Oregon Business Energy Tax Credit program.

The solar development incentive has provided valuable information regarding the economic impact and geographical distribution of utility-scale solar projects in Oregon. Projects supported by the SDI program are anticipated to bring at least $361 million in private investment to the state, as well as $115 million of federal tax credits through the Solar Investment Tax Credit program. To date, these projects have resulted in at least 1,514 construction jobs and more than 23 operations and maintenance jobs. More than 90 percent of the capacity in the program is located east of the Cascades, demonstrating the financial benefits associated with the higher solar resources and lower valued land in central and eastern Oregon.

**Table 3.5: Business Oregon Solar Development Incentive-funded Projects**

| County(ies) | Number of Projects | Number of Construction Jobs | Number of Operations & Maintenance FTE | Payments to Date | Estimated Investment | Estimated 2016 Property Taxes | Capacity (MW) |
|---|---|---|---|---|---|---|---|
| Deschutes/Jefferson | 4 | 261 | 4 | $305.4 K | $93.7 M | $140.8 K | 39.9 |
| Klamath/Jackson | 6 | 447 | 6 | $244 K | $121.5 M | $218.3 K | 49 |
| Lake | 3 | 255 | 1.55 | $240 K | $66.7 M | $140.5 K | 28 |
| Malheur | 3 | 316 | 6 | $407 K | $64.4 M | $12.7 K | 23 |
| Yamhill/Marion | 3 | 105 | 6 | $36.3 K | $15.4 M | $1,229 | 6.6 |
| **Totals** | **19** | **1384** | **23.55** | **$1.2 M** | **$361.7 M** | **$513.5 K** | **146.5** |

*Information provided by Business Oregon.*

The Strategic Investment Program in ORS 285C.600 – 635[102] offered a 15-year property tax exemption on a portion of certain large capital investments. The program was created in the 1990s to induce large, capital-intensive facilities to locate in Oregon. More than 20 wind farms qualified for the program, resulting in upwards of 2,117 MW of capacity and $4.27 billion in project investment by the end of the 2015.[27]

### Federal Incentives

In addition to drops in the capital costs associated with renewable electricity installations, numerous federal incentives have also helped spur greater renewable energy development. The two main federal incentives have been the Investment Tax Credit and the Renewable Energy Production Tax Credit. The ITC provides a one-time tax credit based on the investment costs to develop a new solar energy project. It originally provided a tax credit of up to 30 percent of eligible project costs, but recent federal legislation initiated a reduction of the ITC over time for certain solar and geothermal technologies, and a phase-out for all other technologies. For residential and commercial solar PV projects, the ITC stays at 30 percent for projects that have started construction by 2019, and steps down to 26 percent for projects begun in 2020 and then to 22 percent for those begun in 2021. The residential ITC sunsets after 2021 while the commercial ITC drops to 10 percent and continues at that level.[28]

The PTC provides a tax credit for each kWh generated and sold in a year, though it too has been reduced and sunset at the end of 2017 for all non-wind technologies, and sunsets for wind at the end of 2019. The PTC has been a big driver for new wind power projects across the U.S., and the importance of it to project development can be seen in the precipitous dip in new projects coming online every time there is uncertainty about whether the tax credit will be renewed by Congress. This policy uncertainty, coupled with the long ramp-up period needed to get a wind project moving forward, leads to a boom-and-bust cycle of wind power development.

## Falling Technology Costs

In the past eight years, the costs of renewable energy project development nationally have fallen precipitously. Between 2010 and 2017, the costs associated with a utility-scale one-axis PV solar installation in the U.S. dropped by 77 percent.[29] About 71 percent of that drop in costs can be attributed to reductions in the costs of hardware, with another 10 percent due to labor cost reductions and 19 percent due to lower soft costs, such as legal fees and sales taxes (Figure 3.11).

Single-axis solar tracking systems have solar panels that can rotate on one access, which increases energy output by 25 percent or more over fixed-tilt installations (where the panels are mounted at a fixed angle and do not move to track the sun).[30]

**Figure 3.11: NREL PV System Cost Benchmark Study (inflation adjusted) for 2010-2017**[31]

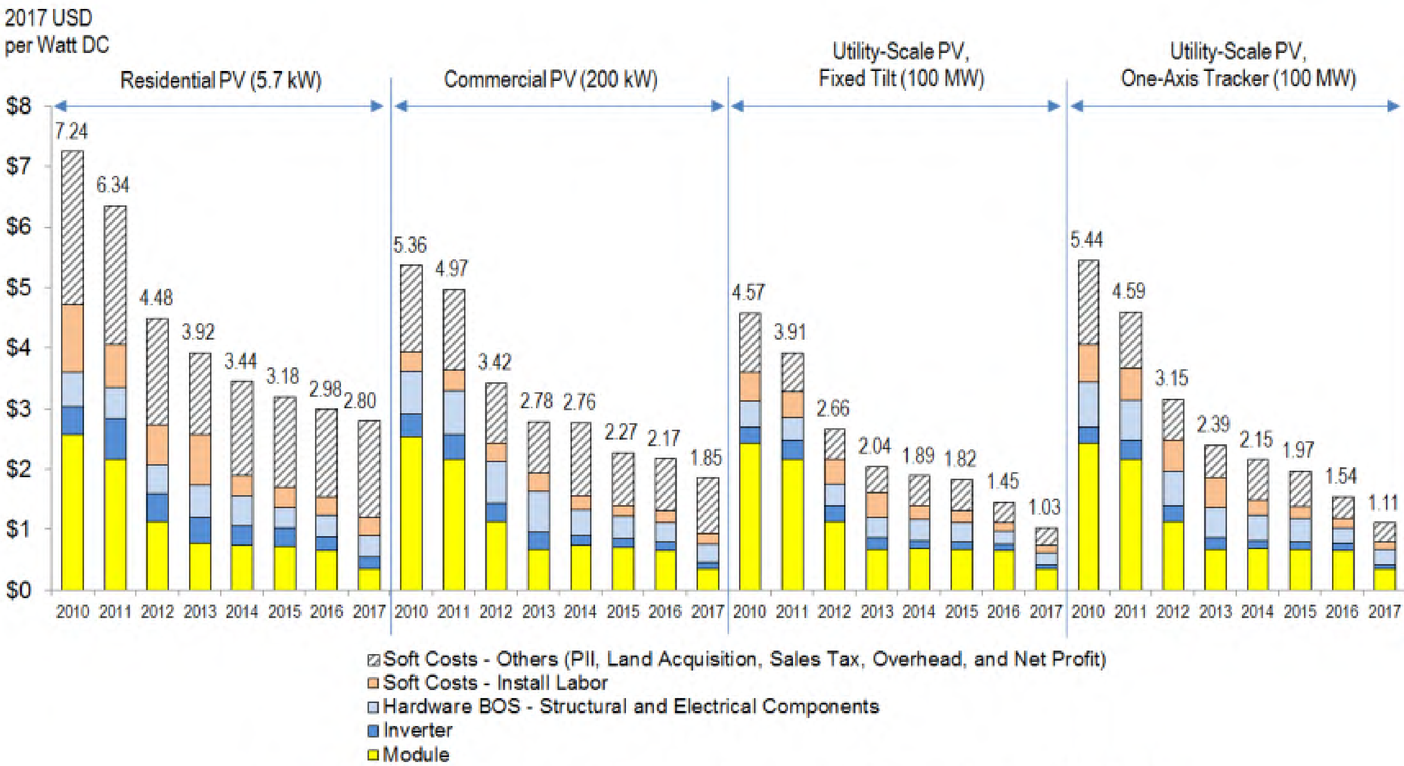
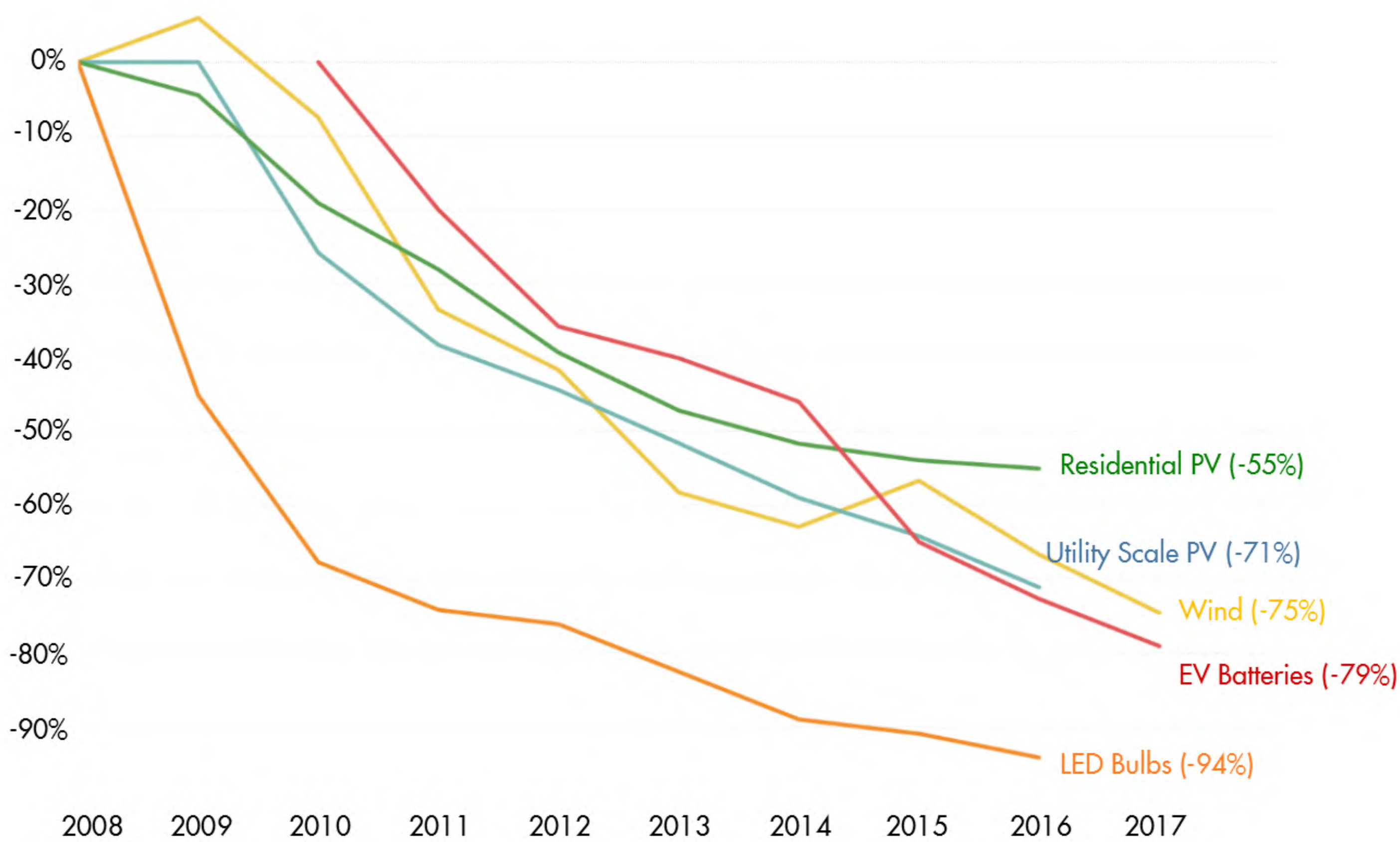



**Figure ES-1. NREL PV system cost benchmark summary (inflation adjusted), 2010–2017**

Between 2008 and 2017, the average levelized cost of wind energy dropped by 75 percent (See Figure 3.12). A levelized cost of energy is an accepted way of comparing the costs of various technologies, and includes the costs of building and operating a generation facility over its assumed financial life, expressed in a dollars per megawatt hour (MWh) cost in discounted real dollars. While these costs fell, installed wind and solar PV capacity in the U.S. surged, with wind representing over 40 percent of all new installed electricity capacity in 2015, and with the total installed capacity of utility-scale solar PV growing by 43 percent from 2014 to 2015.[32] Costs are expected to continue to decline, especially as energy storage options become more technically mature, which can reduce the intermittency of variable renewable energy resources. For example, in late 2017 Xcel Energy received what were then unprecedentedly low bids for renewable energy and storage resources for Colorado: just over $18/MWh for wind ($0.018/kWh) and $21/MWh for wind plus battery storage ($0.021/kWh).[33] These prices are well below the unsubsidized levelized cost of energy range of $30 to $60/MWh for wind power as estimated by Lazard in 2017.[34]

**Figure 3.12: Cost Reductions in Major Clean Energy Technologies**[35]




While costs have dropped for renewable energy technologies, some traditional fossil fuel generating facilities have not experienced the same reductions, like coal. These facilities' costs are closely linked to the commodity price of their input fuel (i.e. coal, natural gas, etc.) as well as the rising costs associated with pollution mitigation. However, given the current low price for natural gas as an input fuel, the upcoming reduction of federal incentives for renewable generation (the ITC and PTC), and other drivers related to the integration of variable renewable energy, much of the aging electricity generation sources in the U.S. are being replaced with natural gas generation and numerous studies predict that new natural gas plants will replace a great deal of this aging electricity generation in the future as well.[36,37] Whether aging and retiring resources are replaced with natural gas resources or renewable resources will depend on factors such as the commodity price for natural gas as a fuel and to what degree the costs of renewable generation and energy storage continue to fall.

# What's Next for Renewable Energy in Oregon

The electricity industry is in flux. Required procurement policies, voluntary renewable purchases responding to consumer demand, and falling technology costs are likely to continue driving renewable energy development in the near future. Policymakers in the state will determine to what extent state-level financial incentives and further policies to level the playing field for renewables, such as a price on carbon, will play a role. As Oregon seeks to meet its renewable energy and greenhouse gas reduction targets in the most flexible, affordable, and equitable way, a number of challenges emerge. After examining trends in renewable energy, this section focuses on three challenges in particular: the integration of new policies with the existing energy policy landscape, balancing competing goals for land and resources, and the integration of a growing amount of variable renewable energy into the existing electricity grid.

## Integrating New Policies into the Oregon Energy Policy Landscape

As Oregonians discuss the development of a carbon policy framework for the state, there have been questions about how a cap-and-trade program would integrate with existing policies that affect greenhouse gas emissions, including the RPS. More information about cap-and-trade programs can be found in Chapter 2.

### Integrating a Potential Cap-and-Trade Program with the Oregon RPS

While there are similarities in the broader goals of RPS and cap-and-trade programs, they each have distinct objectives – the purpose of the RPS is to increase deployment of renewable electricity generation and the purpose of a cap-and-trade program is to leverage market mechanisms to reduce greenhouse gas emissions. Jurisdictions that have both RPS and cap-and-trade can increase the likelihood of meeting each of these goals.

An RPS creates a competitive market for renewable energy, which in turn leads to reductions in the costs of renewable energy technologies. Additionally, it provides certainty to developers of renewable energy projects that they will receive benefits from investing in renewable energy. Alternatively, by putting a price on GHG emissions, cap-and-trade increases the cost-competitiveness of renewable energy development as compared to fossil fuel energy development. All ten states in the U.S. that have implemented various types of cap-and-trade programs have also kept existing RPS programs in place.

**Table 3.6: Goals, Expected Outcomes, and Compliance Pathways for RPS Policies Compared to Cap-and-Trade Policies**

| | RPS | Cap & Trade |
|---|---|---|
| **Primary Goal** | Increases the share of new renewable electricity consumed in a state. Oregon's goal is 50 percent by the year 2040. | Reduces a state's annual GHG emissions to reach a long-term target level of emissions. |
| **Primary Outcome** | Leads to development of new renewable energy projects and a decrease in the carbon intensity of the state's resource mix, but not for an exact quantity of emissions. | Produces a quantity of emissions reductions but does not set sectoral targets – encourages least-cost reductions wherever they may be found. |
| **How to Comply** | Renewable energy certificates (RECs). | Emissions reductions, allowances, offsets. |

*Separate Compliance Instruments*

RECs, which Oregon uses to track RPS compliance, are used to track renewable energy and to determine where it is ultimately consumed.

Allowances represent the authorization to emit a unit of GHGs measured in a common unit known as carbon dioxide equivalent, or CO2e, and are the primary compliance instruments of a cap-and-trade program. Every entity regulated under the cap-and-trade program would have to acquire and then surrender a set number of allowances each compliance period as determined by the program to cover its emissions.

An offset represents a reduction in emissions equal to one metric ton of CO2e. Offsets are generated from sectors of the economy not covered by a cap-and-trade program and can be used to meet a portion of a regulated entity's compliance with cap-and-trade.

*Separate Programs*

Integrating a cap-and-trade program with Oregon's RPS would be relatively straightforward. The main area of program overlap is how to account for renewable electricity imports from neighboring states. As discussions on the design of potential cap-and trade legislation continue in Oregon, this will be an area needing further clarification.

### Integrating a Potential Cap-and-Trade Program with Oregon's Voluntary Renewable Energy Programs

Though not a part of the RPS, the voluntary renewable energy market would likewise be affected by cap-and-trade legislation. To qualify for the voluntary market, renewable energy must be what is called "surplus to regulation," which means it was not generated to comply with any regulatory requirement, such as an RPS. There are a handful of standards for voluntary RECs, one of the most stringent being Green-e, and many of the REC tracking programs used for RPS compliance RECs are also used to track voluntary market RECs. Both PGE and PacifiCorp's voluntary green power programs are certified by Green-e, as was recommended by the Portfolio Options Committee for purposes of quality control and consumer protection.[38]

Other jurisdictions with cap-and-trade programs have protected the voluntary market by setting aside allowances and retiring them according to how much voluntary renewable energy is produced in a given period. Such a set-aside effectively removes this renewable energy from being considered by the cap and it can again be considered "surplus to regulation." California and eight of the nine states (excluding Delaware) currently in the Regional Greenhouse Gas Initiative (a cap-and-trade-program across nine states in the Northeast and Mid-Atlantic) have included set-asides for voluntary renewable energy in their programs.[39]

## Balancing State Land Use and Natural Resource Demands

Renewable energy development is one of many potential uses for Oregon's landscape and natural resources. The state has a number of energy, environmental, land use, and economic development policies, statutes, and goals, which interact in complex ways and are sometimes in conflict. As renewable energy development increases, these conflicts can be exacerbated and tradeoffs may be necessary. Two examples of the need for balancing competing demands highlighted in this chapter are the intersection of renewable energy project development and other uses of the land and the operation of the Federal Columbia River Power System (FCRPS). Siting of solar facilities and the interactions with Oregon's land use laws are covered further in the case study on solar, below.

### Renewable Energy Project Development and Land Use

Oregon's goals and values are reflected in numerous ways within statute. When it comes to energy facility siting, Oregon's energy goals must be considered alongside a broad set of 19 statewide land use goals, which cover a host of issues, from air and water quality to protection of natural resources and open spaces. The land use goals include specific mandates related to citizen involvement, economic development, transportation, recreation, and energy conservation.

These goals are designed to help implement the mission of the statewide land use planning program, which is to conserve farm land, forest land, coastal resources, and other important natural resources; encourage efficient development; coordinate the planning activities of local governments and state and federal agencies; enhance the state's economy; and reduce the public costs that result from poorly planned development.[44] All city and county land use and development ordinances and comprehensive plan provisions that are used to evaluate local jurisdictional energy projects must align with these state level land use goals.

Smaller scale renewable energy projects are approved at the county level. Oregon's Energy Facility Siting Council (EFSC) is responsible for overseeing the siting of most large-scale energy facilities and infrastructure in Oregon.[45] State-level oversight of energy facilities helps ensure a comprehensive, coordinated review that results in projects that are sited, constructed, and operated consistent with the protection of public health and safety, and that are in compliance with energy policy and environmental protection policies of the state.[46] (More information on EFSC can be found on ODOE's website.[47])

State jurisdictional energy facilities must meet 14 general standards in order to receive approval for construction, which includes Oregon's land use goals. There are specific standards for non-generating facilities and for wind. The general standards also cover a range of issues, such as fish and wildlife habitat, historic and cultural resources, recreation, and scenic resources.

Energy facilities use land in different ways, depending primarily on the type of energy generation resource. Fossil-fueled electricity generating facilities often have smaller land-use footprints than some renewable energy generating facilities, but only if the calculations do not take into account the footprint needed for resource extraction, processing, and transportation.[48] For example, the Hermiston Generating Project, a natural gas-fueled electric generating facility with a generating capacity of 474 MW, takes up approximately 10 acres. In contrast, a solar facility typically uses land at a rate of 6 to 10 acres per megawatt of capacity; the recently approved Boardman Solar Energy Facility has a generating capacity of 75 MW and has a site boundary of 798 acres. Additional land may be needed for transmission or preserving cultural or environmental aspects of the site. Wind facilities may have a large project boundary, though much of the land may still be used for farming or grazing, enabling multiple land uses to continue and thereby reducing conflict.

Both Oregon's land use laws and the siting process, established in the early 1970s, ensure that important natural, historic, or cultural resources are not negatively affected, and that impacts are minimized if they cannot be avoided. However, at times these programs come into conflict with the state's efforts to increase renewable energy development. For example, it can take significant time and resources for project developers to demonstrate that their projects are consistent with the state's goals and standards, and this can have a dampening effect on development. In designing and implementing land use and energy policy, state policymakers and regulators must balance competing demands of environmental protection and energy development.

# RENEWABLE ENERGY: COMMUNITY EFFECTS

## The Economy

Like many places in Oregon, Sherman County is largely defined by its geography and weather. For decades, the county in north-central Oregon had its economic wagon tied to dryland wheat and barley, and cattle. When the rains came at the right time, times were good. But the rains didn't always come.

Much more dependable than rain on the Columbia Plateau is the wind, which regularly blows between the Cascade Mountains to the west and the rolling desert to the east. The wind industry noticed this about 20 years ago and came knocking on doors in Sherman, Gilliam, and Morrow counties. At the time, Sherman County was second-to-last in Oregon's per capita personal income. Since that time, a host of large and small wind farms have cropped up in Sherman; the big ones sited through the state (Biglow Canyon and Klondike III) and the smaller ones going through the county (Biglow I & II, Pa'Tu, Hay Canyon and Star Point).

Gary Thompson, Sherman County Judge for the past 18 years, saw it all coming and was convinced the nascent industry would help diversify the agriculture-dominated region. It did, and Thompson looks back with great pride at what the industry and County put together for the residents. "Since wind energy projects came to Sherman County, the County has received more than $25 million in property taxes, over $14 million in community service fees, and in excess of $57 million in Strategic Investment Program fees," he said.[49]

The taxes and fees have allowed the County to fund two dozen buildings or projects, including a new school and library, a Residential Incentive Program, two scholarships, fiber for 911 emergency services, a new weed district building, a courthouse addition and renovation, and the Rufus Industrial Park. The Residential Incentive Program awards $590 each year to the head of a household that has proven a year's residency. Since the program began in 2009, it has distributed $3.66 million.[49]

# RENEWABLE ENERGY: COMMUNITY EFFECTS

## The View

While renewable energy has been touted for its many benefits – mainly no carbon dioxide emissions and free fuel – there are some drawbacks. Just ask Barry Beyeler, chair of Oregon's Energy Facility Siting Council, who testified as much to an Oregon legislative committee in 2016.[50]

Beyeler, who lives in the northeastern Oregon town of Boardman and has been on EFSC since 2010, regularly hears from Oregonians about the hundreds of wind turbines that pepper the high desert landscape southwest of his town. The average wind turbine in the United States is taller than the Statue of Liberty, and they are on track to get larger. This can pose a significant visual impact to both the communities in which they are sited and those traveling through.

When EFSC was created in the 1970s, the Council was largely evaluating baseload electricity generating plants fueled by natural gas and coal. "Where baseload energy facilities are measured in acres, wind farms are measured in square miles," Beyeler told the legislative committee. Moreover, Oregon's standards by which EFSC evaluates the large facilities allow for each project to be judged on its own merit and not by the cumulative effects of others nearby.

While many of the state's natural gas plants are located in industrial areas, the same cannot be said for wind and solar farms, which are permitted in agricultural zones and on rangeland. Both wind and solar have large land footprints and must be located near large transmission lines. That's why the sunny and windy farms and ranches on the Columbia Plateau near the Bonneville Power Administration's transmission grid became a prime target for the industry.

"Over the past 20 years, the vast majority of large-scale energy projects have been sited in rural portions of the state," Beyeler told the committee. "We, those living in rural areas, see every day the impacts. We see the good, the bad, and the ugly."

"The Willamette Valley, where the energy demand lies, has no utility-scale generation, so the majority of Oregonians might not be familiar with the day-to-day impacts of either baseload or renewable energy."

## Balancing Interests: the Many Uses of the Columbia River Basin

As noted in Chapter 1, hydroelectric power is the single largest source of electricity in Oregon, with the majority of that power coming from the Federal Columbia River Power System (FCRPS).

The Columbia River existed long before construction of the first hydroelectric project, and the operation of the FCRPS is still evolving today to accommodate its many uses. Important among historic uses are those of the 13 Native American tribes whose ancestral homelands are located within the Columbia River Basin – many of these uses continue to be protected today under tribal treaty rights. The Federal Action Agencies (BPA, the Army Corps of Engineers, and the Bureau of Reclamation) have a trust responsibility established in law that provides the foundation of their government-to-government relationship with these federally recognized tribes.

The Federal Action Agencies operate the FCRPS to meet core purposes like flood control, fish and wildlife habitat, and power generation as shown Figure 3.13.[51] These different uses can come into conflict, as they often call for different ways of operating the river. One particular conflict, with implications for energy prices and for hydropower's ability to integrate variable renewable energy in the region, involves dams and the threatened and endangered fish species.

**Figure 3.13: Columbia River Uses[52]**


The restoration of endangered and threatened fish species and the protection of habitat within the Columbia River basin have been priorities for Oregon and the other states surrounding the FCRPS. While there are numerous threats to fish species in the Columbia River Basin, from habitat loss to predation by sea lions to climate change, this section focuses on the conflict with dams and the modifications made to hydropower in an effort to improve fish survival.

## A LITTLE MORE ABOUT FISH...

The interactions of native fish species and the FCRPS are complex. The following provides a brief overview of some key terms and concepts:[53,54]

Fish ladder at the Bonneville Lock and Dam. *Photo: U.S. Army Corps of Engineers, Portland Corps.*

**Adult Fish:** Many adult fish species navigate upstream to spawn, and the construction of dams in the early twentieth century impeded this passage. The installation of fish ladders and the way that water flows are managed at particular dams can improve adult passage upstream.

**Juvenile Fish:** The construction of dams also created significant new challenges for the downstream navigation of juvenile fish. Juveniles can be killed passing through hydroelectric turbines, and the creation of reservoirs behind dams can create greater risks of predation.

**Fish Ladders:** Fish ladders are gradual stair-step systems with pools of water at different elevations to allow fish migrating upstream to climb from lower to higher elevation to navigate past dams.

**Spill:** Spill is a term used to describe spilling water over a dam's spillways, rather than running the water through the powerhouse to generate electricity. Increasing the amount of water spilled at a dam reduces the percentage of juvenile fish that pass through the dam's hydroelectric turbines by diverting more approaching juvenile fish over the spillways, but can also result in increased total dissolved gas levels (see below) and decreased power generation.

**Total Dissolved Gas (TDG):** TDG is an important measurement of water quality that assesses the concentration of total dissolved gas saturation in the water relative to atmospheric pressure. High levels of TDG can negatively affect water quality and wildlife health. TDG levels can increase at the bottom of the dam's spillway as spill levels are increased at that dam. State water quality agencies, including the Oregon Department of Environmental Quality, have established maximum TDG levels to protect water quality and the health of fish.

**Fish Passage Plan (FPP):** The U.S. Army Corps of Engineers, in coordination with BPA and other partners, develops the FPP annually. The FPP describes specific year-round operations at each of the four dams on the main stem of the Columbia River and the four lower Snake River dams to provide for fish passage and protection consistent with the Biological Opinion issued by the National Marine Fisheries Service, an office within the National Oceanic and Atmospheric Administration (also known as NOAA Fisheries).

**Biological Opinion (BiOp):** Pursuant to the Endangered Species Act (ESA), NOAA Fisheries develops and publishes a BiOp that evaluates the effects of operating the FCRPS on ESA-listed threatened and endangered species. The BiOp also includes a table of recommended actions and strategies designed to avoid jeopardizing ESA-listed species.

In 1995, NOAA Fisheries released a biological opinion (1995 BiOp) describing new operations for the FCRPS designed to improve fish passage. Over the next two decades, NOAA Fisheries developed several supplements to the BiOp, along with entirely new BiOps in 2000 and 2008. Through these BiOps, actions were taken to help support fish, including: habitat restoration; establishing additional hatcheries; and articulating research, monitoring, and evaluation objectives. These BiOps also included new juvenile fish passage objectives resulting in increased spill in spring and summer months to help juvenile salmon migrate safely back to the ocean. More recently, new, safer fishways that align with the migratory paths of Columbia River salmon have been constructed:[55]

- Spillway weirs that allow fish to pass smoothly over a dam in the surface water;
- A corner collector at the Bonneville Dam;
- A spillwall guide at The Dalles Dam that guides fish to the deepest, safest part of the river; and
- Fish screens and bypass systems to divert fish away from the hydroelectric turbines.

Despite these improvements, 13 fish species within the Columbia River Basin are listed as either threatened or endangered under the Endangered Species Act.[56] The State of Oregon, along with a number of conservation organizations and the Nez Perce Tribe, have been engaged in litigation with the Federal Action Agencies since 2001 over their management of the FCRPS and specifically over whether that management has been sufficient to avoid jeopardizing the survival of the fish species listed pursuant to the ESA.[56] The Courts have ruled in the plaintiffs' favor, finding that NOAA Fisheries violated the ESA when it concluded that the operation of the FCRPS, described in the 2014 supplement to the 2008 BiOp, would *not* jeopardize the fish species listed as threatened or endangered.

One mitigation effort called for by the plaintiffs has been to increase the level of water "spilled" over the dams to increase the safe passage of juvenile fish species over the dams. In April 2017, the District Court granted the plaintiffs' request for more spill and ordered it to begin in the 2018 "spill season" – the time of year that fish biologists have identified as being when the greatest number of fish migrate back to the ocean through the FCRPS. To comply with the court order, the federal defendants were required to spill water up to the maximum TDG levels ("gas caps") allowable by state law at the dams on the main stem of the Columbia River and the lower Snake River.

### Looking to the Future: The Role of the FCRPS and a Low-Carbon Regional Grid

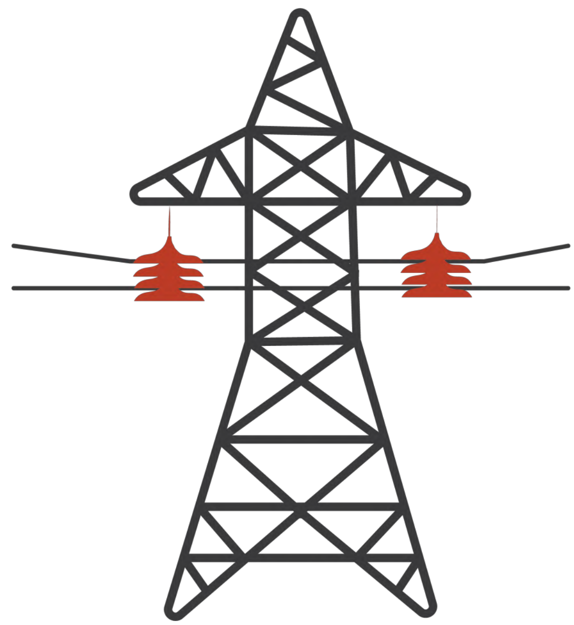
As the state and the region take more aggressive action to address climate change, the ability of the Federal Action Agencies to flexibly operate the FCRPS' 22,458 MW of carbon-free hydroelectric power will become increasingly valuable.

Regionally, as more variable-output renewable sources of energy come online, more flexibility will be needed in the electric sector—both in terms of demand for electricity that can shift to better align with the availability of renewable output, and in terms of other sources of electricity supply that can be re-dispatched to complement the variable output of renewables like solar and wind. While many fossil fuel power plants have the ability to operate flexibly to complement and integrate renewables, hydroelectric power plants are able to do the same without emitting greenhouse gasses.

Through the summer and into the fall of 2018, interested parties in the region have been exploring opportunities to increase the flexibility that BPA has to dispatch the FCRPS, while also doing more to restore threatened and endangered fish populations. Historically, BPA has relied upon selling a significant amount of its surplus power to utilities across the West. The revenue from these so-called "secondary sales" has been utilized by BPA to help maintain lower long-term power rates for their customers in Oregon and across the Northwest. To the extent that a new paradigm can be developed that allows BPA to better monetize its flexible, carbon-free surplus power, the more it will be able to continue to maintain low long-term power rates for its customers in Oregon.

## Integration Challenges: Adding More Variable Renewable Resources to the Grid

As Oregon and other states consider various GHG emissions reduction programs and RPS targets, and as renewable energy technologies become increasingly cost-competitive with traditional resources, the conversation has turned to how to integrate increasingly higher percentages of variable renewable energy onto the grid at least cost and in a way that provides the most value.



Historically, utilities have designed and built the electric system to accommodate variability in customer demand by building transmission and distribution systems capable of carrying enough electricity from generators to customers to meet the highest level of demand expected, even if that level of demand only occurs a few hours of the year. This also required building out complementary resources, such as natural gas peaking facilities, that could deliver enough supply to meet variability in customer demand throughout the day and during different times of the year.

While the deployment of renewables presents new challenges, they are not dissimilar from the types of challenges faced by the industry in the past. The word often used when discussing solutions for integrating renewables is flexibility. Unlike conventional generators that utilities could dispatch to match variability in customer demand, the output of renewable generators is variable, requiring other electric generators to operate with more flexibility to complement the variability of renewables. Technology advancements are also making it increasingly possible to harness the variability of customer demand and better align that demand with the availability of renewable output. Meanwhile, energy storage technologies can provide flexibility of either supply or demand, as required, to complement the availability of renewable output. Finally, participation in larger electricity markets (such as the Western Energy Imbalance Market (EIM)) provides flexibility to utilities by giving them access to more liquid markets to buy and sell electricity to complement the variable output of renewables. Ultimately, the cost-effectiveness of any one of these solutions will need to be evaluated against the others to determine the least-cost pathways to integrating renewables. And with each potential solution, new policy mechanisms may be required to ensure that the value of the integration benefits are being appropriately compensated with the right price signals.

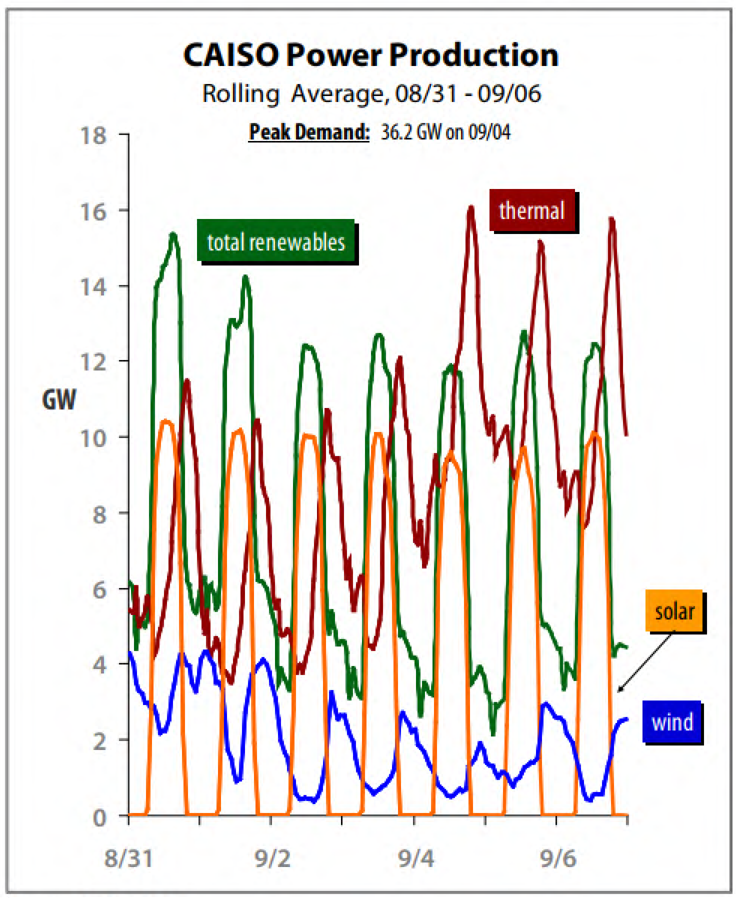
### Flexible Supply

While many fossil fuel power plants take time to start up or shut down, most of them can provide electricity continuously once they are up and running (as can hydroelectric facilities). Such plants have traditionally also been relied upon for providing ancillary services such as frequency support, voltage control, and reserves, and are often referred to as "baseload" generators. "Baseload" has no industry-accepted definition but has come to be understood as facilities that are usually large, designed to operate at or near capacity, and provide the cheapest power when operating at high capacity.[57]

The round-the-clock output of baseload facilities is in contrast to the variability of renewable resources like solar and wind power. Figure 3.14 demonstrates how fossil fuel generators (also known as thermal generators) are ramping up and down during hot summer days to integrate massive levels of solar generation. These thermal plants have several important physical limitations that should be noted. Each thermal plant will have a "ramp rate" that indicates how much it can increase or decrease output over a specific time horizon (e.g., 50 MW per hour). Pairing battery storage with these thermal plants can help to supplement these ramp rates. Additionally, these plants also have minimum output levels below which the plants would need to cycle off completely before restarting, a process that could take many hours or days, depending on the plant.

Oversupply is a term used to describe situations when the availability of variable output generation from sources such as wind or solar is greater than the net demand for that generation after accounting for the ability of other resources to ramp down to minimum levels of output. This has occurred in the Northwest in recent years during certain hours in the springtime when there is very low demand coupled with high output from hydropower and wind generators. Oversupply has become a much more significant issue in places with more renewable energy generation, such as Germany and California. As California continues to add more renewables to its electricity mix, the California Independent System Operator (CAISO) expects oversupply conditions to occur more frequently during certain times of year.[58] This is already becoming especially common during the day in the spring and fall, for example, due to the combination of a high level of output from the state's solar PV, with relatively low heating and cooling energy demands.

**Figure 3.14: Rolling Average of Electricity Production by Source in CAISO for 8/31/18 – 9/06/18**




Sources: CAISO and BPA

The most commonly used strategy to address renewable oversupply has been curtailment, or temporarily reducing the output of electricity from a generator from what it could have otherwise produced. While California has curtailed significant amounts of solar generation, most often during the spring and fall, Oregon does not yet have the same problem with solar. Most of the curtailment in Oregon occurs due to high wind output during the spring in the overnight hours between midnight and 4 a.m. – the spring runoff leads to more water in the hydropower system, winds are also strongest during overnight hours, and consumer consumption is at its lowest at those times.[59]

There are alternatives to curtailment when addressing renewable oversupply. One alternative is to re-dispatch other types of generation resources to complement the variability in output of renewables. For example, having a dispatchable generator that can quickly ramp down output as renewables come online can help to mitigate the need to curtail renewable oversupply. On the flipside, there will also be a commensurate need to have that same generator (or another) able to just as quickly ramp up output as the renewables stop generating. This type of quick-ramping capability has typically been provided by natural gas plants or hydropower in the past. Increasingly, new technologies like battery storage, pumped hydro storage, or more flexible renewables like geothermal, bioenergy, and wave energy can help provide this type of ramping capability.

At this point, the development of more flexible renewable resources involves significant costs and uncertainties to overcome technical, financial, legal, and regulatory barriers. Non-variable renewable resources (e.g. geothermal power) and less variable/more predictable renewable resources (e.g. off-shore wind and wave power) have fewer integration challenges than variable renewable resources but face significant technical and financial hurdles to achieve commercial development. Additionally, established variable renewable technologies (e.g. wind and solar) may be combined with emerging storage technologies, demand response programs, and related demand-side management strategies to be able to more closely resemble conventional, dispatchable resources.

### Flexible Demand

Electricity demand has *always* been highly variable – the demand for electricity on a utility's system can be twice as large during the peak hour of demand in a day as it is during the lowest hour of demand on the very same day. Similarly, the peak demand over an entire year can be several times greater than the lowest point of demand in the same year. As noted above, the electric system has been designed, by and large, to meet these types of large swings in demand for electricity over different hours of the day and times of the year.

One method in the electric industry for minimizing the peaks is demand response. The Demand Response Advisory Committee at the Northwest Power Council* defines demand response as "a non-persistent intentional change in net electricity usage by end-use customers from normal consumptive patterns in response to a request on behalf of, or by, a power and/or distribution/transmission system operator. This change is driven by an agreement, potentially financial, or tariff between two or more participating parties."[60] Ideally, demand response programs allow retail customers to know when system costs are high,

*The NWPCC formed the Demand Response Advisory Committee in 2016 to develop and implement the NWPCC's recommendation in its 7th Power Plan to develop 600 MW of demand response in the region by the early 2020s.

typically due to high demand, and then shift their demand to lower-cost times when demand is lower. Utility time-of-use (TOU) rates are one example of a demand response mechanism that accomplishes this by charging higher or lower rates at different times of the day or year based on system conditions. Alternatively, customers may opt in to allow a utility (or a third-party aggregator) to have direct control over their demand for electricity from some processes or appliances, especially those related to heating and cooling, based on market signals or grid conditions. Demand response resources can be gathered at the moment of need or scheduled ahead of time. By reducing the magnitude of peak demands on the system, demand response assets can postpone, reduce, or even eliminate the need for costly upgrades or even for new generating resources to provide additional peak capacity. Flexible demand allows for the easier and more cost effective integration of variable renewable resources – demand can be dynamically increased or decreased in alignment with the availability of renewables. Increasingly, new technologies are creating opportunities for customers to automate these types of demand response activities, including the use of so-called "smart" thermostats or water heaters that can be optimized based on signals from the grid.


Many parts of the country already have significant amounts of demand response capacity deployed. For example, the PJM Interconnection in the mid-Atlantic region of the U.S.—the largest regional transmission organization in the country with peak summer loads near 150,000 MW—has more than 9,000 MW of demand response deployed throughout its territory.[61] In Oregon, the capacity provided by the region's hydroelectric system has historically dampened the need for demand response. A variety of factors working in combination are beginning to change this, including continued (albeit slowed) regional load growth, retirement of fossil fuel resources, increasing penetration of variable renewables, additional constraints on the hydro system, and a growing summer peak load during a time of the year when output from the hydro system is lower. As a result, utilities in Oregon and across the region have been actively evaluating and deploying a variety of demand response pilot projects.

Many utilities across the region (including PGE, PacifiCorp, and BPA, among others) were participants in the Pacific Northwest Smart Grid Demonstration Project, a five-year, $178 million project co-funded by the U.S. Department of Energy through the American Recovery and Reinvestment Act of 2009.[62] The project concluded in 2015 and resulted in the deployment of dozens of innovative grid modernization and smart grid pilot projects, many of which incorporated demand response and load control functions. More recently, PGE has been actively developing a proposal, in response to guidance given in OPUC Order 17-386,[90] to develop a demand response test bed. The Smart Grid Test Bed, as envisioned, would result in PGE deploying demand response assets at scale, downstream of three different substations across its service territory. The goals of the project for PGE include: identify compelling and sustainable value propositions that demand response can provide to customers; determine the maximum amount of demand response capacity achievable; develop a plan to replicate demand response deployments beyond the test bed; and improve internal understanding of operational control of demand response assets to meet utility needs.

### In Between Supply and Demand: Energy Storage and DERs

Depending on the circumstances, energy storage and other distributed energy resources (DERs) may exhibit the characteristics of either supply or demand. Learn more about DERs in Chapter 5.

**Energy Storage.** The electric grid must be kept in balance at all times with respect to supply and demand; failure to maintain this balance can destabilize the grid and lead to brownouts, blackouts, and even safety threats. Unlike other forms of energy, such as liquid fuels, natural gas, or coal, it can be difficult and costly to store electricity in large quantities. That said, storage technologies are becoming more cost effective, and will likely prove critical to integrating higher levels of variable renewable energy and addressing peak loads.[63]

The most common residential and commercial energy storage systems use batteries. Utility-scale facilities may use batteries or other storage technologies, such as pumped hydro storage systems, mechanical systems such as flywheels or compressed air, or thermal storage systems that store heated materials for winter heating or ice for summer cooling. Storage systems may be designed to charge and discharge over a short-term daily basis, or over the long-term to balance seasonal energy cycles or for use during emergencies or outages.

In 2015, the Oregon Legislature established an energy storage mandate through HB 2193,[91] requiring PGE and PacifiCorp to procure a minimum of 5 MWh of energy storage by 2020, not to exceed battery capacity equal to one percent of the utility's peak load from 2014. With significant stakeholder engagement, the utilities developed an evaluation of the potential to site energy storage on their systems, as well as proposals for the procurement of energy storage projects consistent with the requirements of HB 2193.

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In August 2018, the OPUC approved PGE's proposal to develop up to 39 MW of energy storage. PGE's proposal includes five separate projects:

1. **A 17 to 20 MW battery system located at one of its distribution substations;**
2. **A 2 MW battery system co-located with an existing solar project;**
3. **A 4 to 6 MW battery system interconnected to the transmission system and co-located at a utility-scale natural gas plant;**
4. **Multiple microgrid projects at customer sites, including up to 12.5 MW of battery systems; and**
5. **Up to 500 behind-the-meter, but grid-connected, battery systems at residential customer sites.[64]**

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Meanwhile, in September 2018, the OPUC approved PacifiCorp's proposal to develop two separate energy storage projects: (1) a 2 MW / 6 MWh battery system located at a single customer site to evaluate energy storage alongside a blend of renewable and conventional generation; and (2) provide financial and technical assistance for the development of up to four energy storage projects intended to enhance community resiliency.[65]

### Energy Markets

Energy markets provide a fourth type of flexibility for integrating renewable energy. Electric utilities must balance the availability of generating resources with loads on the electric grid. To do this, utilities commit generating resources over a variety of time horizons to meet expected future demands. With dispatchable resources, like fossil fuel plants, utilities can be assured of the level of generation output that the plant can deliver at a specific point in time in the future. The variable nature of renewable output, however, makes it more difficult for the utility to anticipate exactly how much output can be expected at a specific point in time in the future.

If a utility is attempting to secure commitments from generators to meet expected demands the next day, it may underestimate the output expected from variable renewable generators to avoid having insufficient resources committed to meet load. For the same reason, that utility may also overcommit its dispatchable resources because of the certainty of the output that those resources can deliver. Continual improvement in the industry's forecasting of the output of variable renewable generators helps utilities to be more accurate when making these types of commitments in advance. But having the ability to re-dispatch renewable generators over shorter time intervals provides another valuable tool for utilities to more efficiently utilize the output of renewable generators when their output varies from the advanced forecast.

Participation in the Western Energy Imbalance Market (EIM) provides participants (including PGE and PacifiCorp in Oregon) with access to real-time markets that can re-dispatch generators across a wide area of the western United States over five-minute time intervals. Allowing for optimization over such near-term time intervals allows participants to utilize more variable renewable output and lowers overall system costs.

## CONCLUSIONS

While Oregon has a long history of supporting renewable energy, with this history comes a need to **update and align programs and associated policies** to meet the evolving energy needs of this state.

Meeting the new RPS requirements while also addressing increased demand for voluntary renewable electricity means addressing a number of interrelated challenges and opportunities, including efforts to increase system flexibility, integration of variable renewable resources, energy storage, demand response, smart grid technologies, greenhouse gas mitigation policies, changing energy imbalance markets, and nascent renewable energy technologies.

To address these challenges the Oregon Department of Energy recommends **exploring new strategies for energy planning**, a review and analysis of the role of incentives to determine whether phase outs will materially affect project development, and continued evaluation of regional market opportunities.

# Advances in Solar Energy
# *Case Study of Renewable Energy Market Transformation*

## Technology Overview

Solar photovoltaic (PV) systems generate electricity from sunlight. They are unique in the renewable energy sector because of the wide distribution of the resource. Unlike wind, geothermal, or hydropower facilities, which are dependent upon specific sites, a solar energy project may be located on any unshaded site across Oregon. PV systems range from remote off-grid cattle watering stations in Eastern Oregon to grid-tied facilities connected to utility distribution systems in the rainiest locations on the coast.

**Grid-tied solar energy facilities** may be categorized as residential, commercial, or utility-scale systems. While these categories do not have strict definitions, residential systems are typically net metered and less than 25 kW in size. Commercial systems are also net metered and may be up to 2 MW in size, though most of them are considerably smaller. Utility-scale systems are not net metered and instead sell energy directly to a utility; these systems are typically 2 MW or larger.

**Net metered systems** are typically interconnected to an electric service panel and offset some of the electricity used on-site during certain hours of the day and year. With net metering arrangements, excess solar energy production (i.e., output that's in excess of what the customer consumes on-site) is exported back to the utility and generates a credit on the host customer's electric bill. In Oregon, all electric utilities are required to offer net metering to their customers, though the terms of net metering agreements differ widely, particularly between IOUs and COUs. Oregon's IOUs are required to offer "annualized" net metering, where a monthly surplus of energy may be carried forward to future months, and the customers are compensated for any excess exported to the utility with a bill credit equivalent to their full retail rate had they purchased the same amount of electricity from the utility. This is especially valuable in Western Oregon, where a summer surplus may be carried into the less sunny winter months to continue offsetting their utility bills during those months. The state's COUs, meanwhile, are mandated to offer net metering, however the treatment of surplus production differs by utility. Some offer "monthly" net metering where surplus energy is not carried forward to future billing periods. COUs may offer annualized net metering on a voluntary basis. Additionally, while each COU implements net metering differently, COUs are not required to offer bill credits equivalent to the customer's full retail rate.

**Utility-scale solar facilities** are either owned by a utility, sell energy to a utility or sell energy directly to a corporate partner through a direct access agreement. These facilities are typically interconnected on a utility distribution or transmission system. The energy payments from utilities to project owners for most projects are based on the utility's avoided cost for energy or negotiated power purchase agreements. The avoided cost is a value representing what the utility would pay for energy under their standard energy procurement contracts.

## Global Trends in Solar

### Increasing Capacity and Investments

Solar energy has become a global leader in new added capacity and new financial investments. In 2017, more than $160 billion was invested in solar energy development – more than the investments in coal, natural gas, and nuclear combined.[66]

While the pace of solar development has skyrocketed, solar still makes up a relatively small share of our energy mix nationally. In 2017, solar generation accounted for 1.9 percent of total U.S. generation.[67] As the price to develop solar projects continues to decline, it is expected that solar projects will increasingly be developed to replace retiring coal and natural gas plants.

PacifiCorp's 2-megawatt Black Cap Solar facility in Lakeview, OR.

### Cost Reductions

A number of factors are working together to increase the deployment of solar energy facilities. The primary factor has been cost reductions. As discussed earlier in this chapter, the cost of PV modules, the primary component of a PV facility, has dropped by more than 85 percent since 2010. Other hardware components have also seen significant price reductions during the same time period.

In some parts of the country, cost reductions have led to PV facilities competing with conventional coal and natural gas plants on price for as-available energy in some instances. Recent examples include the Xcel Energy bid in Colorado, announced in January 2018, where solar plus battery storage was bid at a median price of $36 per MWh, or 3.6 cents per kWh.[33] In June 2018, NV Energy in Nevada received bids for solar energy below 2.3 cents per kWh.[68] An RFP from the Central Arizona Project solicited bids from a 30 megawatt solar facility to provide energy at $2.499 per kWh.[69] The Arizona project was proposed to replace energy delivered by the coal-fired Navajo Generating Station. In this case the energy supplied by the coal facility cost around 5.0 cents per kilowatt-hour, or twice as much as the proposed solar contract. While these solar facilities are competing in the market based on their cost of as-available energy, they are not designed to completely replace thermal power plants which are still providing additional grid services and are capable of operating at much higher capacity factors.

### PV Module Efficiency

In addition to cost reductions, PV modules have also become more efficient over time. PV modules are measured in Direct Current (DC) Watts based on their power output under standard test conditions. In 2010, SolarWorld in Hillsboro, which was recently purchased by Sunpower, produced one of the most efficient PV modules in the world, generating 220 to 235 watts of power. Today, the same-sized SolarWorld module will generate 300 watts of power, representing an increase of more than 25 percent.[70]

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## Efficiency improvements affect several factors in deployment and pricing of PV projects:

1. **Reduced system footprint / land use: As the efficiency of PV modules increases, the amount of roof space or land necessary for a given system capacity decreases. Just as PV modules are measured in DC Watts, PV facilities are measured in units of 1000 Watts (Kilowatt or kWdc). A 100 kWdc system installed in 2010 would have required about 7,700 square feet of PV modules. The same 100 kWdc system installed in 2018 will require about 6,000 square feet.**

2. **Reduced labor costs: The labor associated with handling and installing PV modules is a major component of overall system pricing. Increased efficiencies results in fewer PV modules and a reduction in labor costs for a project with the same generation capacity.**

3. **Reduction in balance of system equipment: Similar to labor reductions, increased module efficiency reduces the balance of system equipment necessary to install a PV system. Balance of system equipment refers to racking, mounting hardware, wires, and other materials but does not include the PV modules or inverters.**

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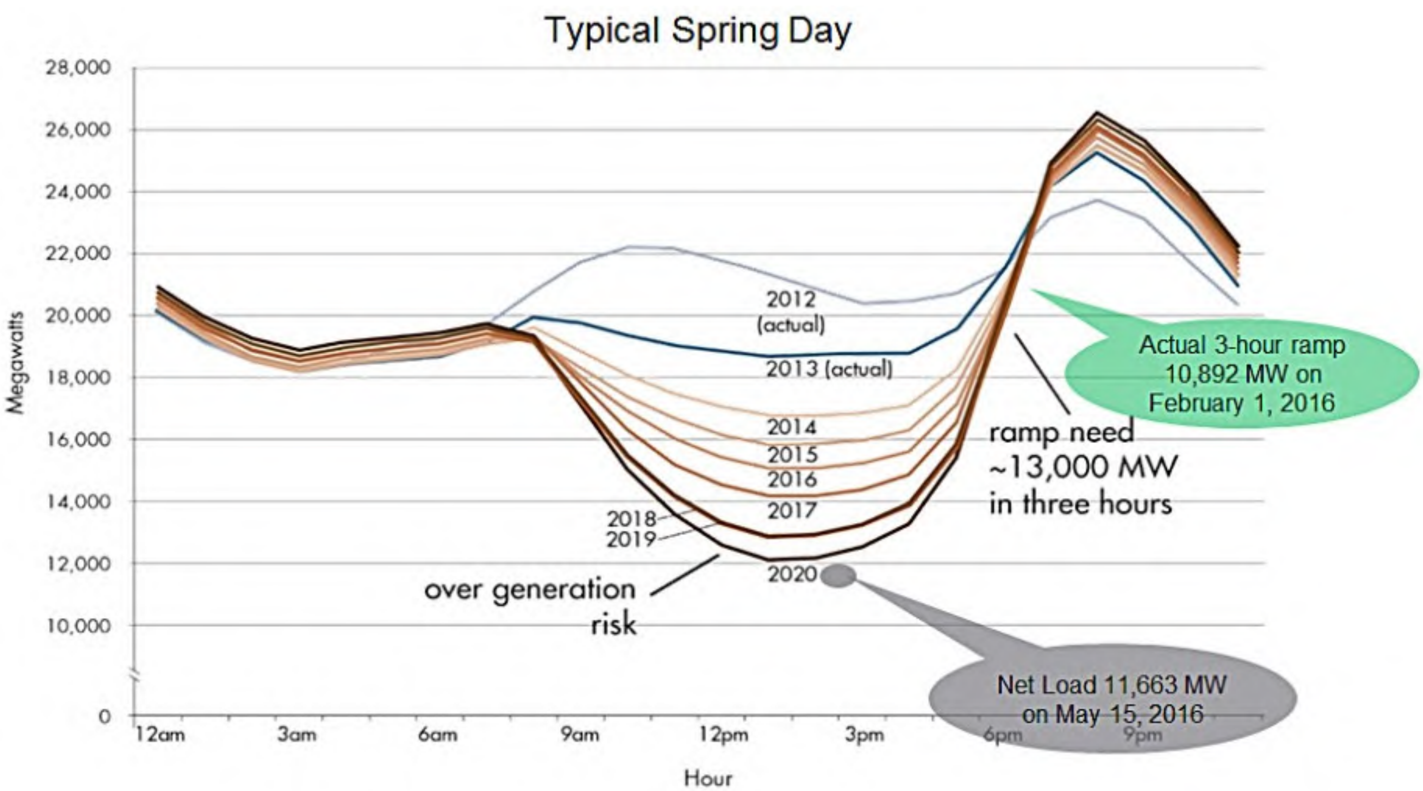
### Integration Challenges

Solar PV facilities are variable generators that only produce energy during daylight hours. Solar generation ramps up quickly in the morning, provides peak generation during the middle of the day, and ramps down quickly in the evening. This pattern has proven to be a challenge for grid operators to integrate with system loads. As solar output is declining in the early evening, customer energy demand on the grid tends to be increasing. Net load or net demand is a term used to describe system energy demand, less the demand that is met by solar output on the grid. In areas with high solar penetration, the resulting net demand curve can drop steeply in the morning as solar output increases rapidly, and then climb steeply in the evening as solar output declines. When plotted over the hours of the day, the net demand curve resembles the profile of a duck and so has been colloquially named "the duck curve." The "belly" of the duck represents low net power demand on the grid due to peak solar output on the grid. The "neck" of the duck represents the steep ramp up of net power demand as people come home from work and turn on lights and appliances at the same time the sun is going down and solar output declines. This neck of the duck requires a large amount of non-solar capacity to be dispatched on the grid over a relatively short timeframe. This phenomenon occurs when two factors are present: (1) significant solar output, and (2) comparatively low net load during mid-day hours. As a result, to date the duck curve has occurred in markets with large amounts of solar, especially California and Hawaii, during springtime months when mild weather results in low mid-day net loads.

**Figure 3.15: The Duck Curve on California's Grid**




The challenges associated with solar integration can be mitigated with four primary and interactive strategies:

1. **Change the shape of the load profile:** Late afternoon and evening loads are primarily attributed to increasing residential demands that naturally occur at the end of the work day. Some of these loads, such as water heating, dish washing, laundry, and air conditioning could be shifted to earlier or later in the day.

2. **Change the shape of the solar production profile:** While the output from PV modules will always correspond with the amount of sunlight, the output of the overall PV facility may be changed with energy storage. Adding batteries to a solar facility can shape the production profile to match the load profile.

3. **Increase flexible capacity resources:** Flexible capacity resources are able to ramp up and down to serve the variable loads on the grid. Battery storage systems, natural gas "peaker" plants, pumped storage hydro systems and the existing BPA hydro system are all able to provide flexible capacity in the Northwest.

4. **Export, curtail, or transform excess solar generation.** Curtailment is currently being implemented in California during periods of excess solar generation. Regional energy markets may be able to provide an export option. Transforming excess generation could be accomplished by using solar energy to create hydrogen or liquid fuels. This is also known as power-to-gas.

## Where does Oregon Stand?

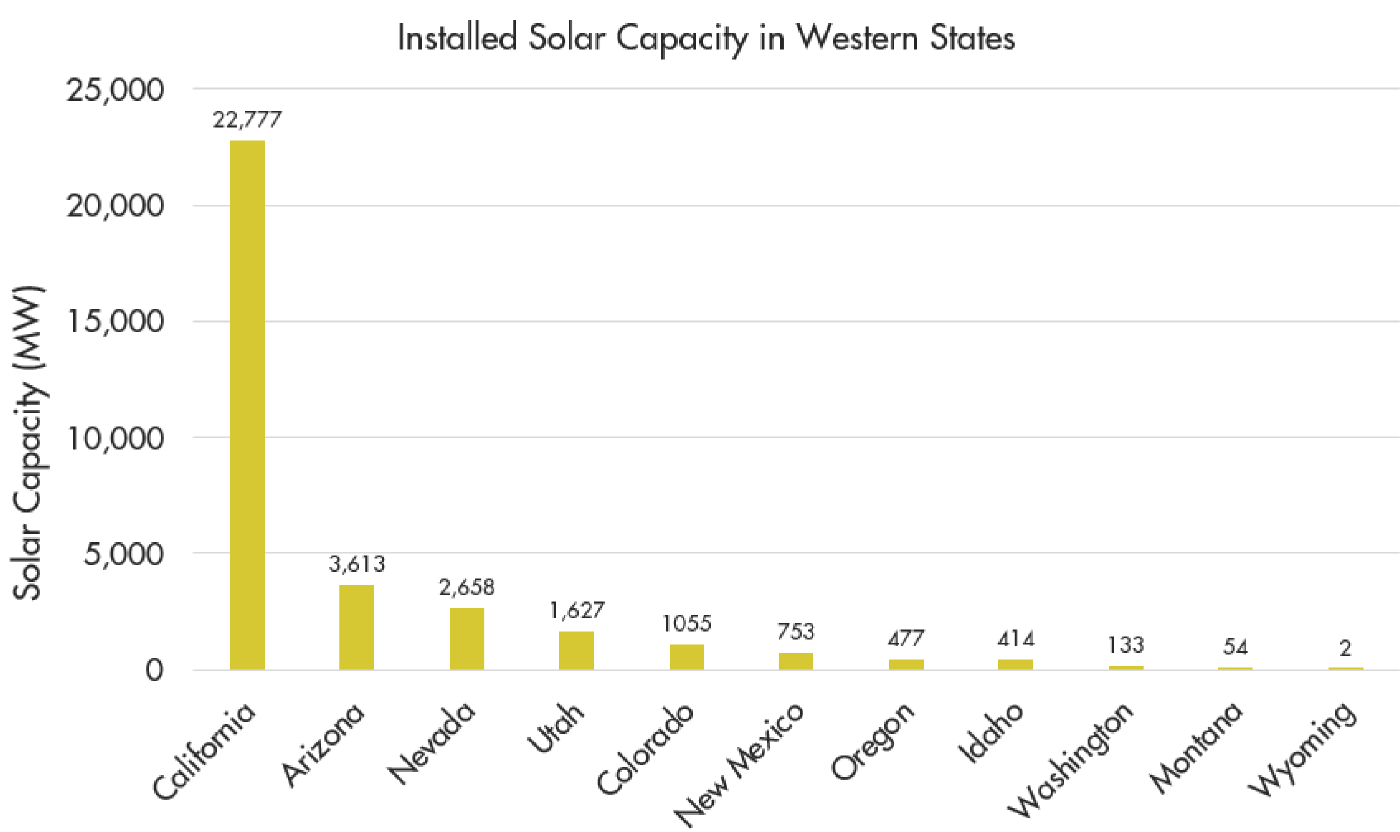
Despite being known for its rainy climate, Oregon has significant solar potential. For example, a residential PV system installed in Astoria will generate only about six percent less energy than the same system in Portland. The same system installed in Newport will generate three percent more energy than the Portland system.[71] Despite the wide differences in resource potential around the state, nearly half of the residential PV capacity in the state is installed in Multnomah, Clackamas, and Washington counties.[72]

Oregon's coastal solar resource, in fact, outperforms much of Europe where a significant amount of solar capacity has been installed. A PV system in Astoria will generate about 5 percent more energy than the same system in Munich, Germany. Germany has installed more than 44 GW of solar, or about 100 times as much as Oregon and Munich is located in the part of the country with the best solar resource.[73]

As of Q2 2018, there was at least 477 MW of total solar capacity installed in Oregon. More than 70 percent of the total solar capacity in Oregon was installed since the beginning of 2017,[74] and there has been an increase in the size of projects. For example, the 56 MW Gala Solar project installed in Prineville in 2017 will generate more energy in 2018 than all of the residential systems in the state combined.

According to the Solar Energy Industries Association (SEIA), Oregon ranks 20th in the U.S. for total installed solar capacity.[74] Figure 3.16 shows installed PV capacity in western states, as of Q2 2018. It is difficult to track the exact cumulative capacity of solar installed in Oregon in real time, as many projects come online before utility data reports are updated.

**Figure 3.16: Installed Solar Capacity in the Western States[75]**

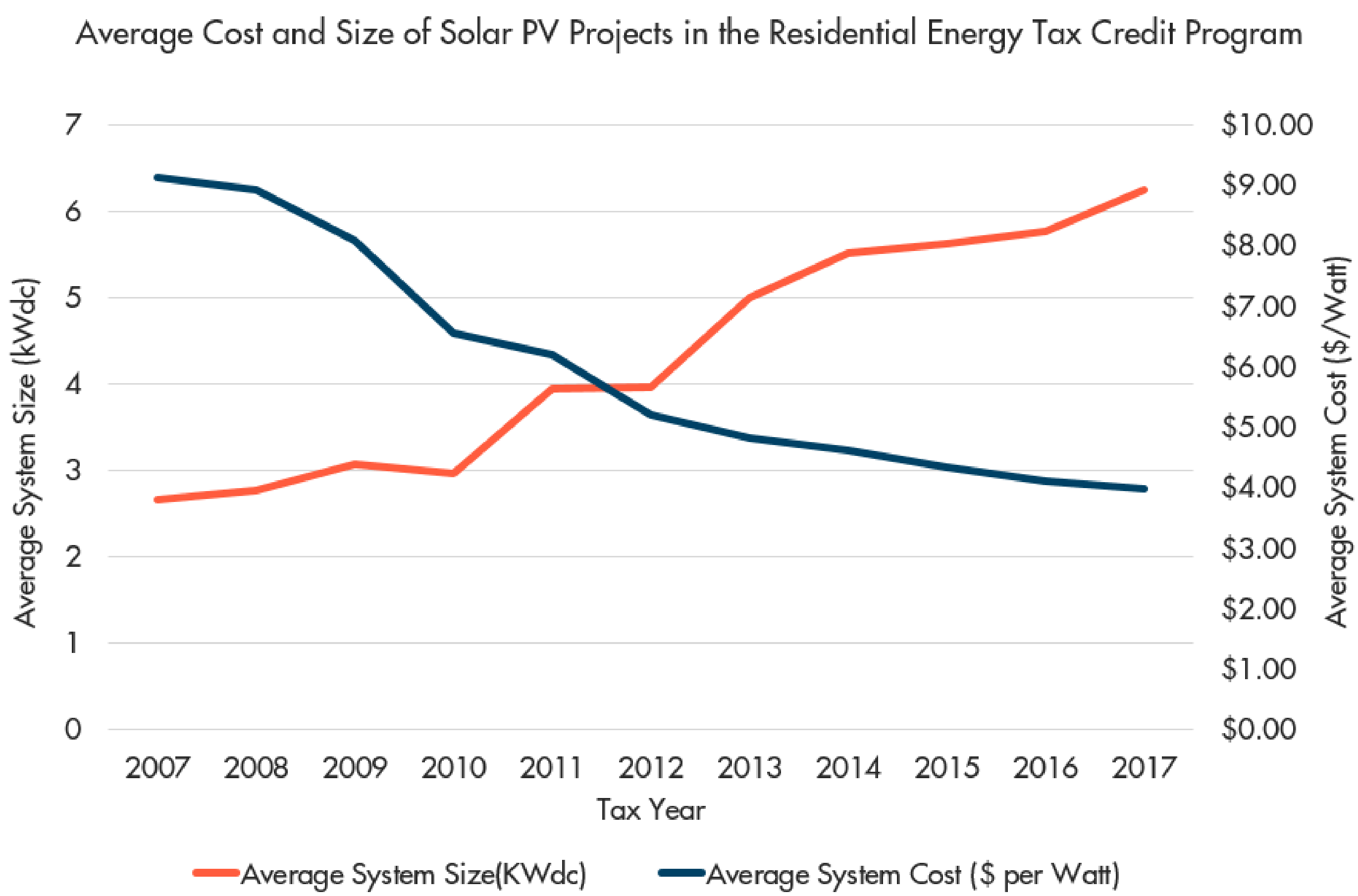



Oregon's solar capacity is divided between residential, commercial, and utility-scale projects. Approximately

Oregon's solar capacity is divided between residential, commercial, and utility-scale projects. Approximately 85 percent of the residential capacity is west of the Cascades while about 90 percent of the utility-scale projects are east of the Cascades.

Reduced costs for PV equipment have resulted in larger systems being installed. As figure 3.17 demonstrates, in the Oregon residential market, the average PV system size has increased from 2.5 kWdc in 2007 to more than 6 kWdc in 2017. Over the same period, the cost of these systems has decreased from over $9.00 per watt to about $4.00 per watt. Over the same period the number of systems installed per year increased from less than 250 in 2007 to more than 2,800 in 2017.

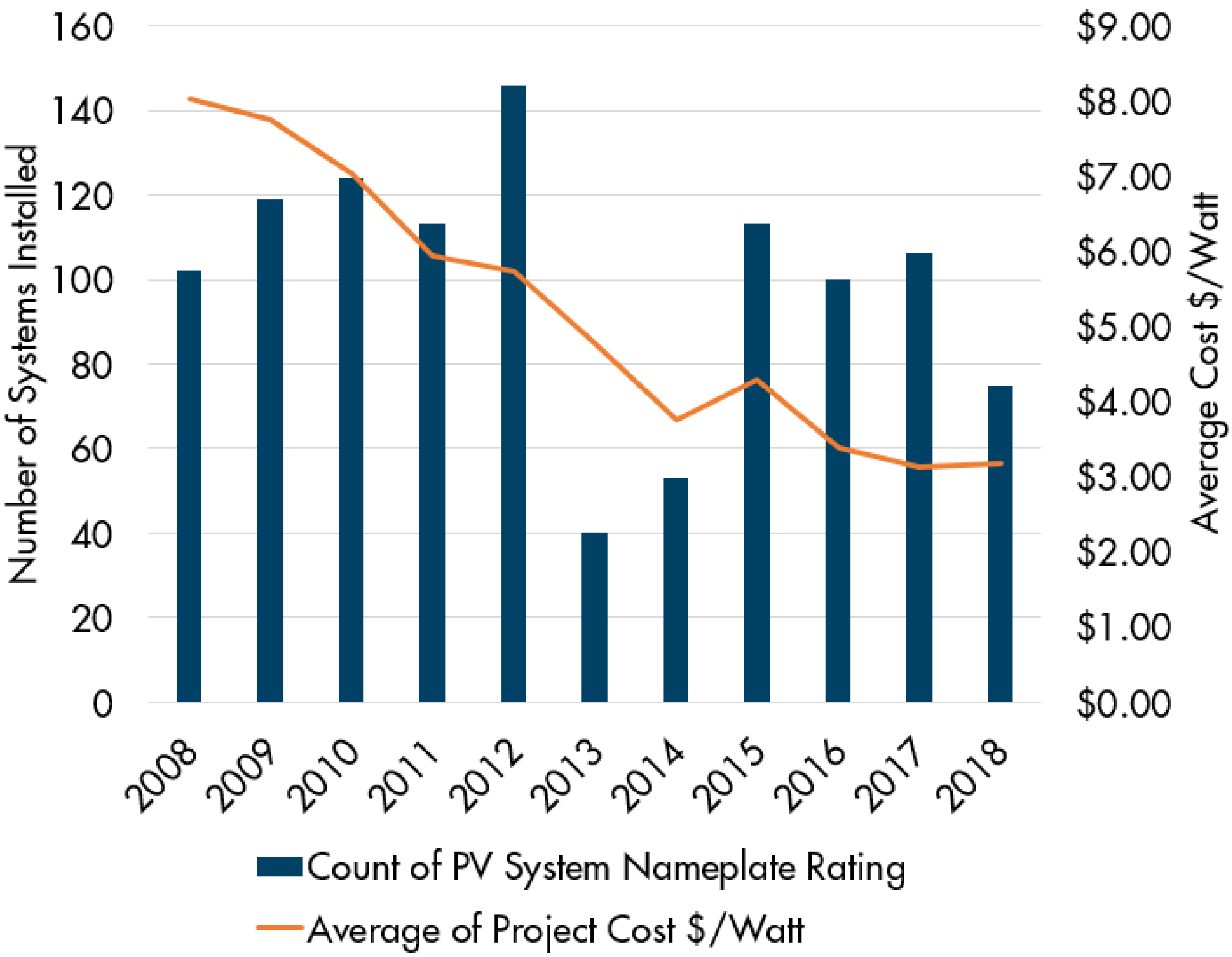
### Figure 3.17: Average Cost and Size of Solar PV Projects in the RETC Program[72]




While the cost of residential solar energy projects in Oregon has declined, the rate of decline has not kept up with the national average pricing of $2.80 per watt in 2017 demonstrated in the NREL 2017 benchmark study,[31] due in part to the relatively small solar market in Oregon compared to some other states. In 2017 there was a total of 20 MW of residential solar installed in Oregon, which makes up less than one percent of the 2,227 MW installed nationwide.[72,76]

Oregon's commercial PV sector has also seen significant cost reductions. The average cost for commercial PV systems in the Energy Trust of Oregon incentive programs was about $8.00 per watt in 2008 compared to about $3.00 per watt today. The sharp drop in projects seen in the figure below is a result of changes to the Business Energy Tax Credit program.

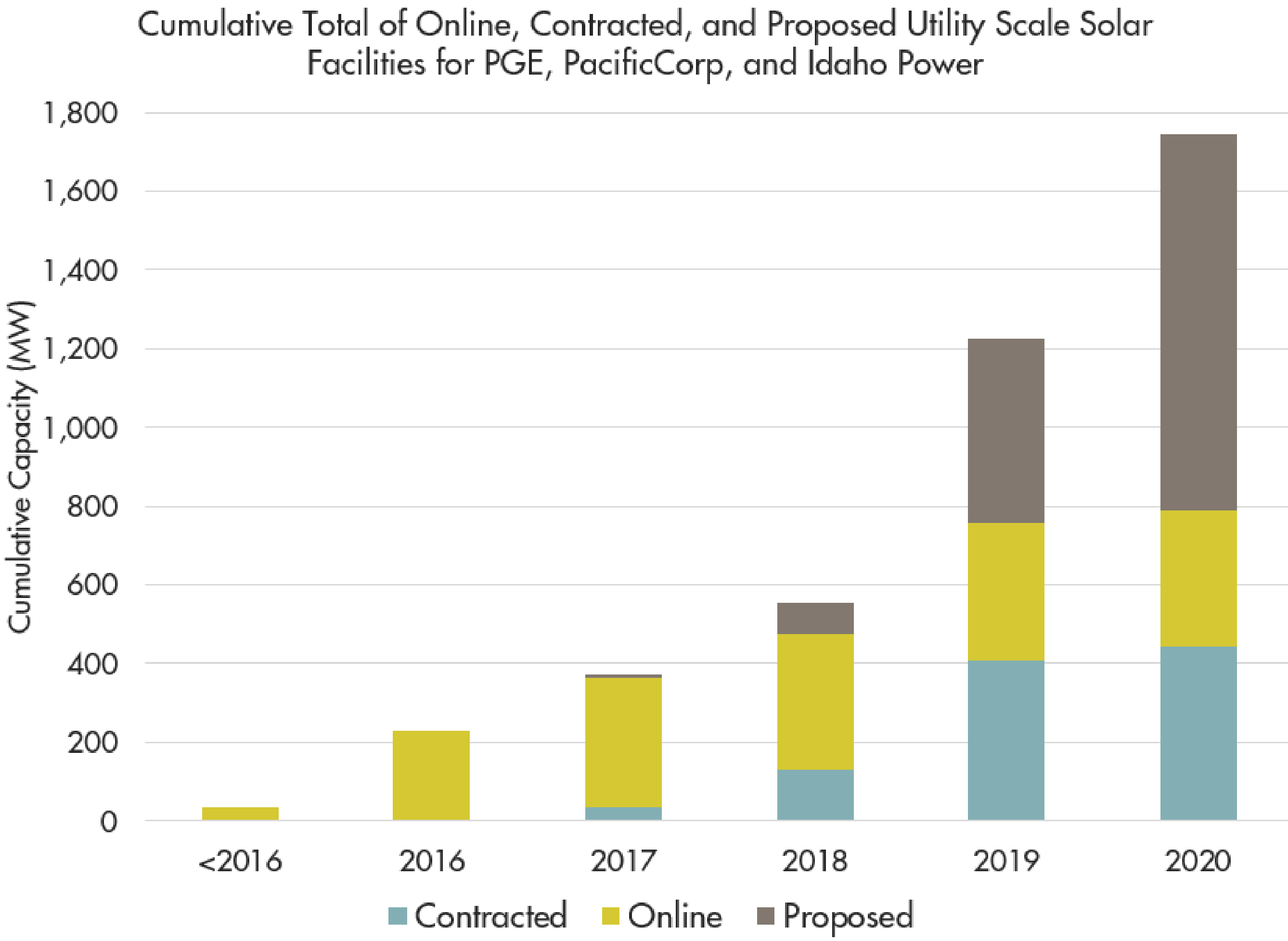
**Figure 3.18: Average Cost and Number of Solar PV Projects in the Energy Trust of Oregon Commercial Incentive Programs**[77]




Utility-scale projects have also grown in size. In 2013, the Outback Solar facility in Christmas Valley was, at 5.2 MW, the largest single solar project in Oregon.[78] By the end of 2016, there were an additional 22 facilities exceeding 5 MW and totaling more than 180 MW of combined capacity. In 2017, the Gala solar project in Prineville became the state's largest at 56 MW. The Boardman Solar project is the first solar facility to be approved for a Site Certificate through Oregon's Energy Facility Siting Council, and is proposed to be 75 MW. In California there are many facilities between 100 and 500 MW in size. Globally, PV facilities exceeding 1,000 MW in capacity have been installed in India and China.

Development of utility-scale solar facilities has rapidly increased in Oregon since 2016. More than 50 percent of Oregon's total solar capacity (260 MW) is in utility-scale facilities installed or scheduled for operation in 2017 and 2018. Nearly 1,000 MW of additional capacity is currently proposed for development by the end of 2020. These proposed projects are reported in utility interconnection queues which have traditionally had a high attrition rate. As solar project costs continue to fall, more facilities will be constructed in Oregon.

**Figure 3.19: Cumulative Existing Capacity and Interconnection Applications for Utility Scale Solar Capacity Reported by PGE and PacifiCorp**




## Federal Tariffs

In January 2018, the Trump Administration established tariffs on imported solar modules. The tariff is initially set at 30 percent, reducing 5 percent each year, and ending in 2022. As most of the solar modules used in Oregon and the U.S. as a whole are imported, these tariffs could significantly increase the cost of solar projects. In addition, tariffs on steel and aluminum products also threaten to reverse the downward cost trends seen in the solar industry. Cypress Creek Renewables, a solar developer active in Oregon, announced the cancellation of 1,500 MW of new solar projects across the country as a result of the tariffs.[79] Nationally, more than $2.5 billion in new solar investments have been cancelled.[80] Some domestic manufacturers, including Hillsboro's Solar World, advocated for the tariffs in order to provide a boost for U.S. solar manufacturers. The overall impact in Oregon from these tariffs is not yet known.

In June 2018, the IRS issued a ruling regarding treatment of the federal Solar Investment Tax Credit (ITC) ramp-down. The ruling allows the 30 percent ITC to be taken by project owners who commit at least five percent of the budget by the end of 2019. These projects then have until 2023 to complete construction. This means that 2022 and 2023 will be years where projects can avoid tariffs and still claim the full 30 percent ITC.

## Policies Affecting Solar in Oregon

There are a number of new solar programs and policies under development in Oregon that have the potential to significantly alter local solar markets. The Oregon Legislature passed SB 1547[92] in 2016, which established the state's first legislative mandate for a community solar program and development of a resource value of solar.

### Community Solar

Community solar projects have been installed in 42 states, 19 of which have implemented community solar programs. By Q1 of 2018, there were more than 1,000 MW of community solar projects nationwide.[81] These community solar projects typically differ from conventional solar facilities in a couple of ways. First, ownership of community facilities may include a cooperative of participants, a utility, or private developers and investors. Second, the output of a community solar project is typically allocated among participants. This allocation may be accomplished with or without involvement from a utility partner. Projects installed with a utility partner may utilize virtual net metering where the output from a central solar facility will be allocated to each participant in the form of a credit on their existing utility bills.

Oregon Laws 2016, Chapter 28 (SB 1547)[92] directs the OPUC to establish a program that enables owners and subscribers of a community solar project to share in the costs and benefits of the project. The program applies to customers of PGE, PacifiCorp, and Idaho Power, and enables subscribers to realize electric bill savings associated with a share of a community solar facility. The program is still in development at OPUC and has not yet resulted in any projects.

Community solar projects have been built in Oregon outside of the OPUC community solar program. In 2007, the City of Ashland installed a 63 kW community solar system known as Solar Pioneer II at the City of Ashland Service Center. Shares of the project were made available to any Ashland Utility customer. In 2016, Central Electric Cooperative completed installation of the 200 kW Shared Solar community solar project in Bend. Similarly, Emerald People's Utility District launched their Sharing Sun community solar project in 2017.

Community solar projects present numerous opportunities for utilities, home owners, renters, low-income communities, solar contractors, and program delivery contractors:

- Increased access to solar for Oregonians who cannot or have not installed individual solar facilities of their own. A 2015 report from NREL indicates that 49 percent of American households and businesses lack adequate solar resources for an onsite solar installation.[82]
- Increased solar market activity for Oregon solar contractors. Community solar projects may help to offset market losses associated with the end of the RETC program in 2017, described in more detail below.
- Utilities will be given the opportunity to provide additional services to their customers. While there may also be an increase in utility administrative costs, this may be offset by increasing customer choice and satisfaction among customers.
- Increased access to solar by low-income Oregonians. For many Oregonians, conventional solar

installations are not affordable, so community solar could provide options for participation with minimal financial burden. Oregon's community solar program has a provision to make 10 percent of the program available to low-income communities. While implementation of the low-income provisions has yet to be defined, it is expected to increase the equitable distribution of solar in Oregon.

- Centralized community solar projects are able to leverage economies of scale compared to an equivalent capacity of distributed solar facilities.
- Centralized community solar projects are more likely to be optimized for annual solar energy production. This may be accomplished through strategic site selection to minimize shading obstructions and through the use of solar trackers for ground mounted systems.

There are also a number of challenges specific to community solar projects:

- Administrative burden for utilities to implement programs, including development of virtual net metering protocols.
- Additional administrative costs associated with ownership and membership of the projects. Administrative costs make up one component of "soft costs" associated with all solar projects. Community solar projects may have additional costs associated with marketing to participants, legal fees associated with ownership models, and ongoing bookkeeping costs associated with allocating facility production among members.

### Resource Value of Solar

Oregon Laws 2016, Chapter 28[92] directs the OPUC to establish a resource value of solar (RVOS). The RVOS is an analysis to determine the net costs and benefits that distributed solar facilities bring to the ratepayers of Oregon's investor-owned utilities. The OPUC currently has four dockets dedicated to examining the RVOS. They are:

- UM 1716 (Investigation to Determine Resource Value of Solar)
- UM 1910 (PacifiCorp Resource Value of Solar)
- UM 1911 (Idaho Power Resource Value of Solar)
- UM 1912 (Portland General Electric Resource Value of Solar)[83]

UM 1716 determined the methodology for calculating the RVOS. The docket started with a scoping task to determine which elements to include in the RVOS calculation. The OPUC determined that only elements directly attributable to utility electric ratepayers should be included, and that any additional societal benefits associated with distributed solar should not. Table 3.6 includes the 11 elements identified in UM 1716 to be included in the RVOS. Positive values are described as a benefit while negative values are described as costs.

**Table 3.7: Elements Considered in the Oregon Resource Value of Solar Calculations**

| Benefits | Costs |
|---|---|
| • Avoided Energy Cost | • Administration |
| • Avoid generation capacity | • Integration |
| • Avoided transmission and distribution capacity | |
| • Avoided line losses | |
| • Market price response | |
| • Avoided hedge value | |
| • Avoided environmental compliance | |
| • Avoided RPS compliance | |
| • Grid services | |
| **Total Resource Value of Solar: Net Benefit** | |

Distributed solar cost/benefit analyses have been completed in more than 20 states with a variety of results. Some states, such as Pennsylvania and New Jersey, have included societal benefits in the analysis.[84] Societal benefits included elements such as local economic development, health and environmental benefits associated with reduced fossil fuel combustion, water and land savings, and other environmental benefits. The Oregon PUC decision to not include societal benefits is consistent with the HB 2941 solar incentives report published by the PUC in 2016.[85] In that report the PUC recommended, "If the Legislature sees value in promoting the development of solar PV in Oregon for social and economic development reasons, it should consider adopting incentives available to all Oregonians."

Once established, the RVOS in Oregon will be used as the reimbursement rate for utilities to credit community solar participants. In an effort to enable community solar projects to proceed as RVOS is developed, the Oregon PUC has established an interim RVOS rate equal to residential retail rates. This value will be revisited upon completion of RVOS proceedings. While community solar reimbursements are the only statutorily directed use for the RVOS, the 2016 report from the OPUC recommended alignment of community solar and net metering reimbursements rates. The report also indicates that following the RVOS valuation proceedings, the OPUC will open future dockets to determine additional applications for the RVOS.[85]

### Incentives for Residential PV Systems

Oregon's low energy rates affect the cost-effectiveness of solar energy projects in the state, and policymakers have created financial incentive programs to support development. While the cost of PV systems has decreased, residential and commercial PV projects still have considerable above-market costs in Oregon. Above-market costs are the difference between the market value of a project's energy production compared to the actual costs to produce the energy. Figure 3.20 shows how much a residential PGE customer could anticipate paying for a solar system in 2018 and how long it would take to pay off with estimated bill savings. The analysis does not account for escalating energy prices or the time value of money.

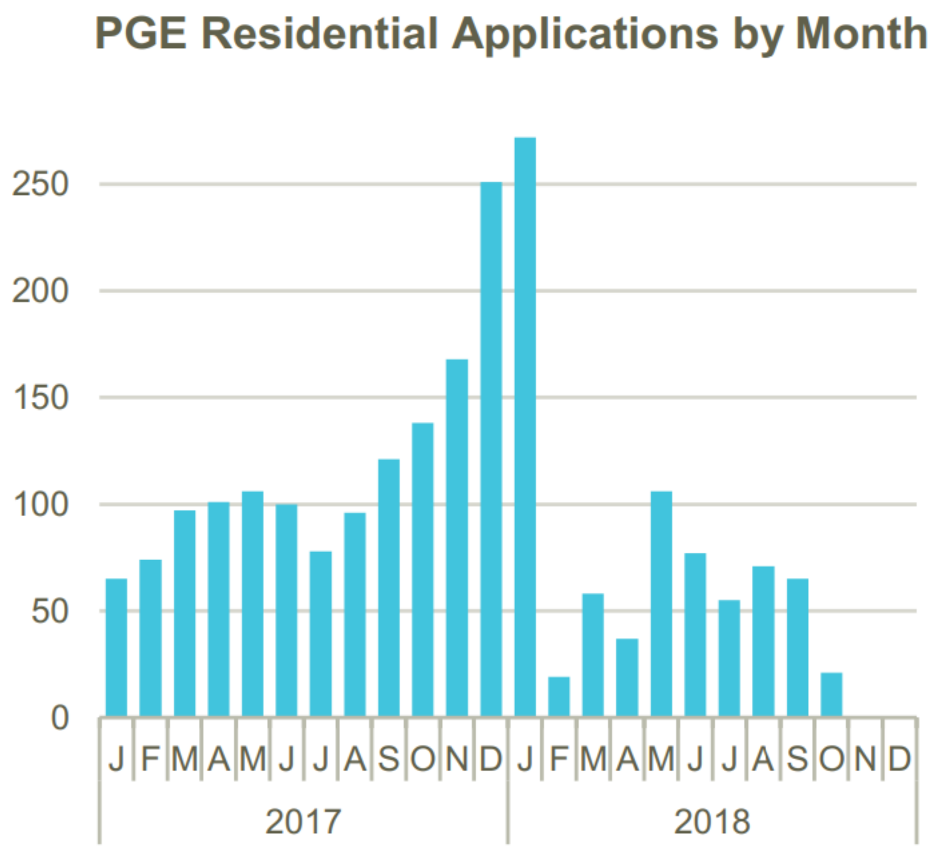
**Figure 3.20: Typical Solar Cost for PGE Residential Customer**

| | |
|---|---|
| **System Size:** | 6 kWdc |
| **Cost:** | $22,500 ($3.75/watt) |
| **Energy Trust of Oregon incentive:** | -$2,700 |
| **Federal Tax Credit** | -$5,940 |
| **Net Cost to Owner** | **$13,860** |
| **Estimated Annual Energy Production** | 7,200 kWh |
| **Estimated Annual Bill Savings:** | $800 ($0.11/kWh) |
| **Simple Payback:** | 17 years |

The Oregon Legislature has created a variety of incentive programs through the years, including tax credits, cash rebates, volumetric incentive rates, production payments, and property tax abatements. The Energy Trust of Oregon offers incentives for solar installations for consumers in PGE and Pacific Power service territories and some consumer-owned utilities offer incentives to their customers. While these incentives have successfully supported the development of a solar industry in the state, they have also contributed to periods of volatility, especially in the residential market. In 2012, about 1,500 residential solar projects were installed in Oregon; one year later, less than 900 systems were installed. The decline was primarily attributed to reductions in Energy Trust of Oregon incentives. During the 2017 tax year, ODOE's Residential Energy Tax Credit program processed applications for more than 2,800 systems. System installations are expected to drop by nearly half in 2018, due to the sunset of the RETC program on December 31, 2017.

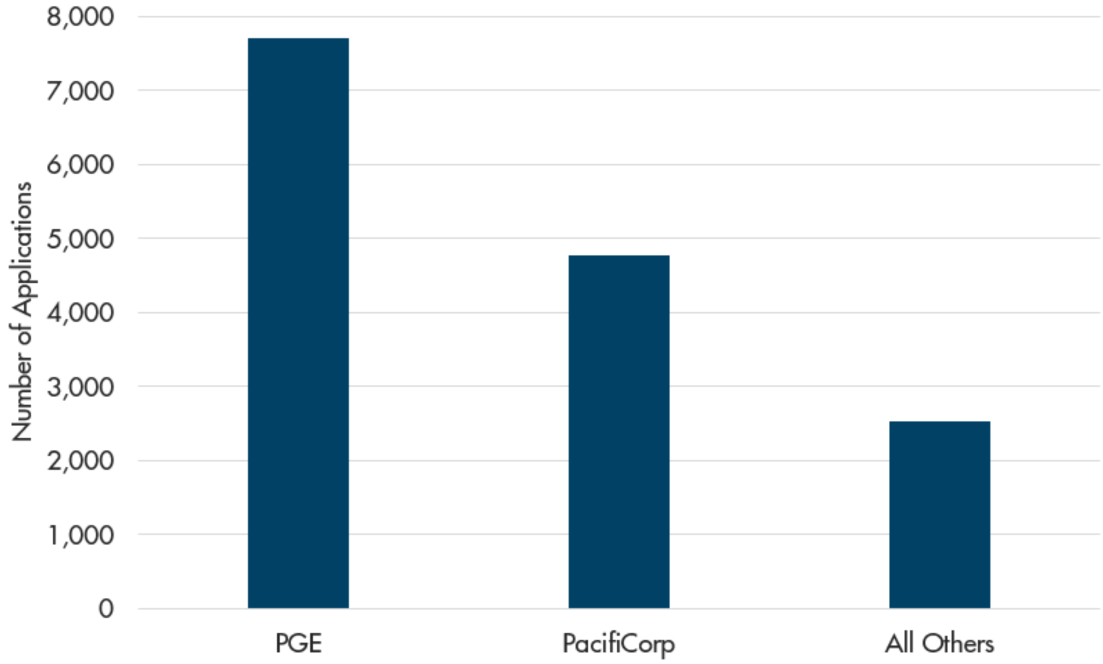
The RETC program provided up to $6,000 in tax credits taken over four years, and reduced the simple payback period to around 10 years for the sample system in PGE territory described above. A reduction in residential PV applications at Energy Trust of Oregon provides an indication of the impact associated with the sunset of the RETC. Prior to 2018, participants in the Energy Trust of Oregon PV incentive program were also eligible for the RETC. The RETC sunset resulted in increased program activity in 2017 followed by a decrease in activity in 2018. Figure 3.21 demonstrates the number of applications received by Energy Trust of Oregon in 2018 compared to 2017, following the sunset of the RETC program. In the first six months of 2017, Energy Trust received 1,040 applications compared to 545 over the same period in 2018. The second half of 2017 saw a spike in applications from homeowners racing to take advantage of the RETC. Energy Trust increased residential solar financial incentives to correspond with the RETC sunset. The Energy Trust residential PV incentive in December 2017 in PGE territory was $0.25 per watt, up to $1,500. In January 2018, the incentive rate more than doubled to $0.60 per watt, and the incentive cap more than tripled to $4,800. Even with Energy Trust's higher incentive for residential PV, out-of-pocket costs for customers went up when RETC ended.

**Figure 3.21: Residential Solar Applications from PGE Customers Received by Energy Trust in 2017 and 2018 (Energy Trust of Oregon Solar Status Update 9/7/2018)[103]**




Systems installed under the Energy Trust incentive program still receive a financial incentive and are easy to track. In 2017, there were 2,800 residential PV systems that received a RETC. Of those, 500, or about 18 percent, were outside of Energy Trust territory, which only includes customers of PGE and PacifiCorp. The effect of the loss of the RETC incentive is expected to be higher outside Energy Trust territory. Complete 2018 data from these markets is not yet available. Figure 3.22 demonstrates how projects have been distributed across utility service territories in the RETC program.

**Figure 3.22: RETC Project Distribution Across Utility Service Territories**




As solar costs continue to come down, financial incentives will play a smaller role in market adoption. Financial incentives aimed at solar market transformation are meant to serve as a bridge to a future market where solar is cost-competitive or at parity with conventional grid electricity. This can be seen in the design of the federal investment tax credit which begins a ramp down in 2020, and drops to zero in 2022. In a 2012 report, NREL determined that Oregon would be among the last states to reach grid parity due primarily to low energy costs and lower solar resources than many other U.S. states.[86] While many of the market conditions have changed in the last six years, it is true that Oregon still has larger financial hurdles than many other states.

### Land Use

Solar land use laws in Oregon primarily affect utility-scale systems, and vary by the system size and the classification of soils on the site. While the rise of utility-scale projects in Oregon is relatively new, farmers have been installing solar energy systems to support on-site energy loads for years. Many of these systems used barn roofs or uncultivated land adjacent to irrigated fields, and were interconnected to electrical services for farm operations and irrigation pumps.

In 2012, Outback Solar, the state's first utility-scale project, was installed on 50 acres of rangeland in Christmas Valley (right).

Permitting authority for utility-scale solar projects is dependent on the proposed size and location of the projects. Smaller projects are subject to county (or city) jurisdiction, and larger projects are subject to EFSC jurisdiction. The majority of these projects are proposed on farmland that is zoned as "Exclusive Farm Use." "Goal 3" of the Oregon statewide land use planning goals[44] protects farmland, and the Land Conservation and Development Commission has issued rules implementing Goal 3 protections. Projects that permanently remove farmland from production over certain thresholds must receive a Goal exception as part of their approval in order to construct these projects. Those thresholds are tied to agricultural productivity and include the following:

- Facilities that occupy more than 12 acres of high-value farm land;
- Facilities that occupy more than 20 acres of arable lands; or
- Facilities that occupy more than 320 acres of non-arable lands.

Like all energy generation projects, for solar projects to be as financially viable as possible, they are sited near transmission lines to minimize the cost of creating inter-tie transmission lines, which are very expensive. This limits the locations in Oregon where energy generation development, including solar energy development, can occur.

Future site of the approved Boardman Solar Facility.

There is a lot of variation in the size of utility-scale solar facilities. The vast majority of these projects are between 12 and 100 acres. However, there are several larger projects of note. The largest operating is the 320-acre Gala Solar project located in Crook County. The largest approved but not yet constructed project is the Boardman Solar project in Morrow County, which is proposed to be 545 acres when completed. Finally, the Oregon Department of Energy just received the Obsidian Solar Center project application in north Lake County which is proposed to be 3,921 acres.

Locations in Oregon that can support such large-scale industrial development, and that are located in close proximity to transmission lines with capacity, tend to be either farmland, rangeland, or undeveloped native habitat. Effects from solar development on farmland or native habitat have caused considerable interest and concern from many parties. As a response to solar development proposals on Willamette Valley farmland, both Marion County and Yamhill County have passed ordinances restricting future solar development until additional assessment, land use rules, and protection measures can be developed, and the effects of solar on farmland can be further considered by the counties.

Similar opposition has come from other groups concerned about solar development on native habitat, particularly in central, southern, and eastern Oregon's high desert regions. Solar projects in these areas functionally remove habitat from use by native species, and, at a very large scale, can disturb movement by larger species, including big game. Solar projects under EFSC jurisdiction must comply with the EFSC Fish and

Wildlife Habitat standard, which is connected to the ODFW Fish and Wildlife Mitigation Policy, and which includes requirements to attempt to avoid and minimize effects, and provide compensatory mitigation commensurate with the affected habitat in accordance with the policy. Solar projects under local jurisdiction, however, do not have to meet the same requirement unless county governments enforce such a requirement.

There are many areas in Oregon that are good locations to site a solar project – areas with minimal or no effect on native habitat or farmland, and areas with access to transmission. To date, approximately 90 percent of utility-scale solar projects have been installed east of the Cascades due, in part, to better solar resources and lower cost of land. As communities consider local energy resiliency initiatives, there may be additional value recognized in developing more distributed energy facilities in close proximity to loads and population centers.

### Net Metering

ORS 757.300[100] describes Oregon's net metering laws, including the treatment of surplus generation and a cap on aggregated net metering capacity. Figure 3.22 above demonstrates that 85 percent of the residential solar capacity in Oregon has been installed in PGE or PacifiCorp territories.

The aggregate capacity cap described in ORS 757.300 establishes a limit of how much solar can be installed within a utility service territory before the utility is no longer mandated to offer net metering. In Oregon the cap is set at 0.5 percent of the utilities' peak hourly load. Once the cumulative capacity of net metered systems reach this cap, the utility is no longer required to offer net metering. PGE and Pacific Power have exceeded the 0.5 percent cap but have so far continued to offer net metering on a voluntary basis. Other western states have aggregate capacity limits ranging from 0.5 percent on the low end (Oregon and Washington) to 20 percent on the high end (Utah). Many states do not specify a limit.

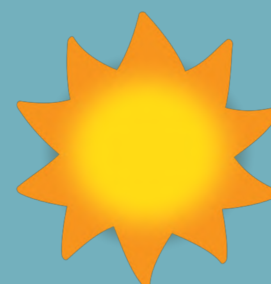
### PURPA Contracts

As described earlier in this chapter, Oregon utilities must contract with renewable energy facilities to purchase energy at the utilities' scheduled avoided costs rates. In Oregon, utilities establish different avoided costs rates based on the technology installed on their system. Solar facilities provide intermittent power which is valued less than "baseload" facilities that provide constant, steady power. For example, PGE developed Schedule 201, establishing different fixed avoided cost rates for baseload, wind, and solar facilities. Under PGE's Schedule 201,[87] a baseload facility has an average monthly fixed price of $58.95 per MWh for energy delivered during on-peak periods in 2025. A solar facility under the same time period would get an average fixed price of $38.62, about 35 percent lower than the baseload facility. As battery storage systems become more affordable, it will be possible for solar facilities to provide many of the services currently provided by baseload facilities, and this may raise questions about whether the existing avoided rate methodology is appropriate. The issue is already under discussion in Idaho, where Idaho Power and the Idaho Public Utility Commission are in a dispute with a solar developer about whether two proposed solar plus battery storage projects should be eligible for contract terms associated with "Other Projects," which are preferable to the contract terms associated with solar projects.[88]

### Property Taxes

Local jurisdictions currently have two options for levying property taxes on utility-scale solar facilities. The first is known as a centralized assessment, which aims to establish a property value in a manner similar to other power plants in Oregon. The second option is to levy a fee in lieu of property taxes, currently valued at $7,000 per megawatt of capacity per year. The fee in lieu of taxes was established in Section 1, Chapter 571, Oregon Laws 2015[104] as a simplified approach to property tax evaluation. As solar costs continue to decrease, the value of future facilities will also decrease, which will decrease property taxes calculated under a centralized assessment. This may result in the $7,000 per MW fee falling out of line with the market. Some solar industry stakeholders may wish to revisit the $7,000 per megawatt value of the fee in future years.

## CONCLUSIONS



Solar energy has experienced significant technological advancements and dramatic cost reductions in the past decade. The result is that solar energy facilities now represent a significant share of new energy acquisitions globally and in some markets are **cost competitive** with conventional resources such as coal and natural gas.

Oregon has traditionally had a small share of the national solar market, but has been a **leader in solar energy policies**. Some sectors still struggle in Oregon to achieve consistent market growth. 2018 is proving to be a challenging year in the residential sector with the sunset of the RETC program. Commercial projects have seen similar volatility year over year. Oregon's utility-scale solar sector is poised for rapid growth based on the number of interconnection applications to Oregon utilities however challenges such as low avoided cost rates and federal trade tariffs may jeopardize many of those projects.

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# CHAPTER 4: TRANSPORTATION

The efficient movement of goods, services, and people is the backbone of a thriving economy and quality of life for all Oregonians.

Operating vehicles, and building and maintaining roadways, railways, and other transportation corridors, requires significant energy resources.

Most of the energy used in the transportation sector comes from fossil fuels, which have significant effects on our economy, environment, and public health.

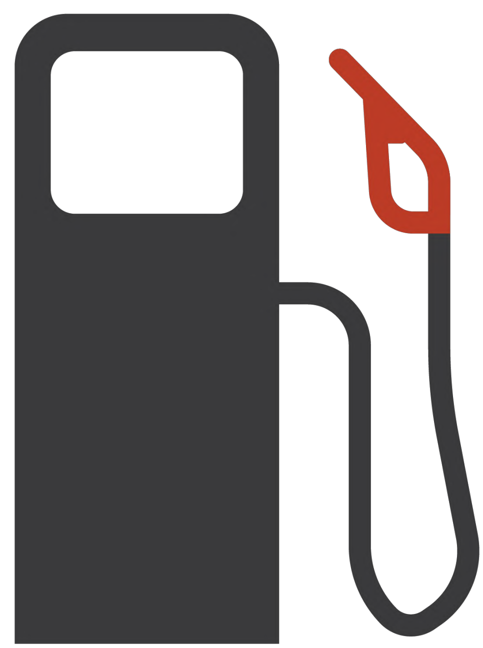
KEY TAKEAWAYS

- The transportation sector accounts for the **single largest category of greenhouse gas emissions**, at 39 percent of total Oregon emissions. Oregonians also spend $7.4 billion annually on transportation fuels, more than any other energy sector. Ninety-eight percent of transportation fuels are imported into the state; the majority of those dollars are not retained in Oregon.

- While per vehicle fuel consumption and GHG emissions have declined because of improved fuel efficiency and increased adoption of alternative fuels, overall transportation sector fuel consumption, GHG emissions, and vehicle miles travelled (VMT) are rising in Oregon, mainly due to population growth and the choices we make in a growing economy. This makes increased support for walking, biking, multiple-occupancy modes of transportation including flexible public transit options, and especially adoption of electric vehicles, necessary to conserve transportation fuels and **reduce GHG emissions** from the transportation sector.

- Oregon will need to adopt additional transportation policies, strategies, and programs to meet the state's **climate change goals**.

# Introduction



The efficient movement of goods, services, and people is the backbone of a thriving economy and quality of life for all Oregonians. Operating vehicles, and building and maintaining roadways, railways, and other transportation corridors, requires significant energy resources. Most of the energy used in the transportation sector comes from fossil fuels, which have significant effects on our economy, environment, and public health.

As Oregon's population grows, so does the number of light duty vehicle registrations. As a result, gasoline consumption continues to rise in the state. Low fuel prices coupled with a growing economy and population growth have led to an increased number of vehicle miles traveled. Transportation sector fuel consumption has cost Oregonians, on average, from 2005 to 2016, $7.4 billion annually; and because 98 percent of transportation fuels are imported into the state, the majority of those dollars are not retained in Oregon.[1] Ninety-three percent of the state's transportation fuel demand is met with petroleum products. Gasoline at the pump accounted for 68 percent of all transportation fuel costs. In October 2018, the retail price of gasoline was about $3.30 per gallon. Over half of that cost is for the raw crude oil, and the rest is for refining, distribution and marketing, and taxes.[71]

The cost of transportation fuels tends to be higher in Oregon than in most of the continental United States due to the higher-cost sources of crude, and the Pacific Northwest's isolation and distance from fuel supplies as well as limited refineries in the region. Ninety percent of our petroleum products come from four refineries located in the Puget Sound near the Canadian border.[2] Coupled with the high degree of volatility in the petroleum market, transportation fuel costs can create financial burdens for Oregon businesses and families, especially in rural areas where a greater percentage of household income is spent on transportation (see Chapter 7 for more detail).

As discussed in Chapters 2 and 5, greenhouse gas emissions affect our health, our environment, and our economy. Transportation petroleum fuel consumption increases air pollution and can have negative effects on public health. The American Lung Association estimates that the health and climate effects associated with passenger vehicles cost Oregon $1.3 billion in 2015.[3] The transportation sector is also the highest emitter of greenhouse gases in the state. In 2016, transportation produced 39 percent of total in-state emissions,[4] and in large part due to the increases in transportation sector emissions, Oregon is not on track to achieve our statewide 2020 GHG reduction goals.

Table 4.1 shows the transportation sector fuel mix by type of fuel, and for ease of comparison each fuel is converted to gasoline gallon equivalent (gge). The amount of lifecycle GHG emissions is shown (in metric tons of CO2 equivalent), as well as their percentage of overall transportation fuel GHG emissions.

**Table 4.1: Transportation Fuels and Associated GHG Emissions[5]**

| Transportation Fuel | GGE | Lifecycle GHG Emissions (MTCO2e) | Percent of Total GHG Emissions |
|---|---|---|---|
| Gasoline | 1,430,179,140 | 17,651,807 | 54.69% |
| Diesel | 709,580,224 | 8,835,152 | 27.38% |
| Jet Fuel | 229,569,368 | 2,858,423 | 8.86% |
| Ethanol | 125,325,574 | 968,678 | 3.00% |
| Asphalt & Road Oil | 104,230,084 | 1,371,075 | 4.25% |
| Biodiesel | 49,067,998 | 311,377 | 0.96% |
| Lubricants | 10,014,595 | 124,694 | 0.39% |
| Aviation Gasoline | 4,052,883 | 50,463 | 0.16% |
| Renewable Diesel | 3,309,077 | 41,202 | 0.13% |
| Electricity | 2,673,688 | 10,175 | 0.03% |
| Compressed Natural Gas | 2,592,953 | 25,381 | 0.08% |
| Liquefied Petroleum Gas | 1,682,828 | 17,121 | 0.05% |
| Bio-Compressed Natural Gas | 575,528 | 4,508 | 0.01% |
| Bio-Liquid Natural Gas | 410,997 | 4,049 | 0.01% |
| **Total All Fuels** | **2,673,264,937** | **32,274,105** | **100%** |
| Gasoline & Ethanol Only | 1,555,504,714 | 18,620,485 | 57.69% |

This chapter primarily focuses on fuel use and emissions of fuels used in light-duty vehicles, a segment of the transportation sector that is the biggest cost to Oregonians and the highest emitter of greenhouse gases. In 2016, gasoline consumption – which includes both gasoline and the additive ethanol –accounted for nearly 58 percent of overall transportation emissions.[5] However, understanding and addressing emissions and fuel use in the medium- and heavy-duty sectors is also necessary for the state to achieve our GHG reduction goals.

## MEDIUM- & HEAVY-DUTY DOING THEIR PART

One of UPS's hybrid delivery trucks.
*Photo: UPS*

As electric vehicle technology advances, companies across Oregon are looking at how they can take advantage of zero- or low-emissions options for their fleets. **United Parcel Service (UPS)** has deployed what it calls a "rolling laboratory" to determine in real-world operating conditions how a diverse set of approximately 9,300 alternative fuel and advanced technology vehicles perform. Over the next decade and beyond, the logistics industry is poised to take a significant leap forward through the electrification of transportation. UPS expects to continue to lead the charge on electrification of medium-duty vehicles. Within Oregon and as part of their rolling laboratory, UPS deployed 20 plug-in hybrid electric vehicles into their Portland and Tualatin fleets. The PHEVs can run about 50 miles on battery power between recharges, and use a small gas-sipping two-cylinder gasoline range extender engine if necessary to complete a daily route. On many UPS routes, no gasoline use would be necessary at all. A large delivery company like UPS faces unique challenges in electrifying their delivery vehicles – from truck size to charging infrastructure to costs. The rolling laboratory tests in Oregon are just another example of how UPS will achieve its sustainability goals in a way that makes sense for the company and its customers worldwide.

**Rogue Waste Inc.'s** Dry Creek Landfill produces enough electricity for 3,000 homes annually. But the company is looking at ways to put landfill-generated fuel to a different use – one in which it powers refuse trucks, improves local and regional air quality, and provides a local resource that could build regional energy resilience. Rogue Disposal & Recycling and its sister corporation, Rogue Clean Fuels, have a long-range vision to capture biogas at their Dry Creek Landfill, clean and upgrade it to renewable natural gas, and inject it into their refuse trucks and the natural gas pipeline. By 2023, their entire fleet of 36 trucks will be converted to CNG, and eventually fueled by RNG from their landfill. This closed-loop system means the garbage being conveyed to the landfill via their RNG-powered trucks will one day decompose into RNG distributed at their pumps. More important to Rogue Waste Inc. are the community benefits: cleaner air, reduced diesel fuel consumption, and local resiliency. With increasing attention on how a Cascadia Subduction Zone earthquake could affect Oregon, Rogue Waste Inc. sees the upside of having a local fuel resource that could be tapped by emergency first responders and recovery operations.

The Oregon Department of Transportation's Statewide Transportation Strategy 2018 Monitoring Report found that no single solution was the answer to GHG reductions, and that a multi-faceted and aggressive approach was needed to address overall reductions from the transportation sector.[6]

With that in mind, this chapter begins with an overview of national and state trends in the transportation sector and what the trends tell us about our progress in meeting Oregon's goals. This is followed by a look at the current policies, programs, and strategies at work in the state and, where available, information on how these are helping the state achieve its goals. More energy-related data would help Oregon be able to draw conclusions about the effectiveness of many of these programs. Finally, the chapter will look at what's next for transportation in Oregon. This chapter discusses the strategies for future progress in reducing Oregon's GHG emissions, fuel consumption, and overall transportation costs for Oregonians; especially how adoption of electric vehicles can help the state meet its goals.

Two notes on the data in this chapter: First, because different state agencies focus on different aspects of the transportation fuel sector, they collect and use different sources of information. ODOE, for instance, focuses on data for all types of transportation fuels including the aviation, marine, and railroad segments, among others; Oregon DEQ collects transportation fuel data only for fuels listed in their Clean Fuels Program; while ODOT necessarily looks only at transportation fuels for roadway use that are taxable fuels. Because of these differences, the collection and reporting of data may differ and may not align perfectly. In most instances, ODOE used Clean Fuels Program fuels data as the basis for its calculations in this chapter. Second, because Oregon produces almost no fuel in-state, we analyzed GHG emissions on a life-cycle basis. Life-cycle calculations include all emissions that are associated with that fuel from extraction to combustion regardless of whether they occur in Oregon. This type of analysis is often called a "well-to-wheel analysis." Therefore the amount of GHG emissions in our analysis may differ from those that only assess GHG emissions that occur within the boundaries of the state of Oregon.

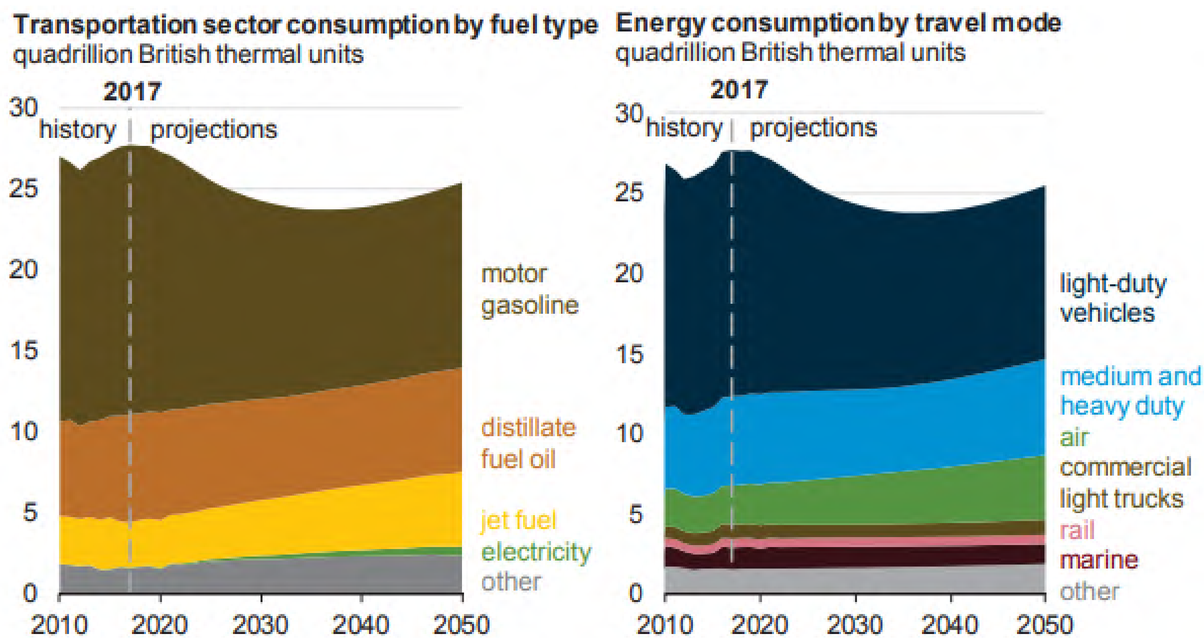
# National Transportation Sector Trends

## Energy Information Administration's Annual Energy Outlook 2018

The U.S. Energy Information Administration's (EIA) Annual Energy Outlook 2018 (AEO) modeled projections for key metrics using different modes of transportation in the domestic energy markets through 2050. Key metrics include: consumption, miles traveled, average fleet miles per gallon, amount of sales, and fuel prices. The "reference case" projection, which is referred to in this report, assumes some technology improvements and economic and demographic trends. In many cases this information is available only through EIA on a nationwide basis. In order to determine more state-specific information, ODOE used the AEO projections as a baseline for our analysis then incorporated Oregon-specific data and information to forecast the energy picture for Oregon.[7]

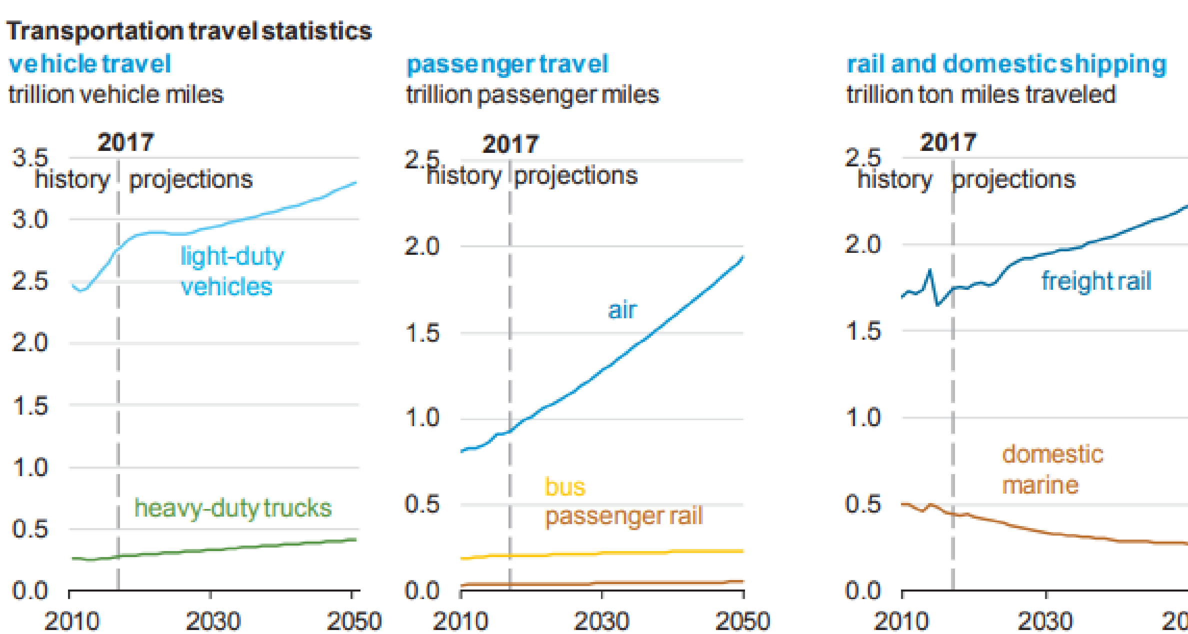
According to AEO projections, gasoline consumption nationwide peaked in 2017 (Figure 4.1). The Outlook projects a downward trend in consumption through about 2035 because of current U.S. vehicle efficiency policies that require efficiency improvements for light-duty vehicles until 2025 and for heavy-duty vehicles until 2027. Consumption begins to increase in 2035 because even though the efficiency standards improve, vehicle miles traveled are projected to increase. Medium- and heavy-duty vehicle energy consumption stays nearly flat and then begins to increase, despite improvements in fuel efficiency standards, because of rising economic activity that increases the amount of heavy-duty truck travel. Jet fuel consumption rises 64 percent over the period, as growth in air transportation outpaces aircraft energy efficiency, and other alternative fuel use increases as different fuels replace traditional gasoline and diesel-powered vehicles. Gasoline and diesel fuels become a smaller part of the overall transportation mix, decreasing from 84 to 70 percent of the total by 2050. Much of the offset is due to the large increase in jet fuels and other transportation fuels such as natural gas. Electricity as a fuel source makes up only one percent of the overall mix by 2050.

### Figure 4.1: Energy Consumption in 2017[7]



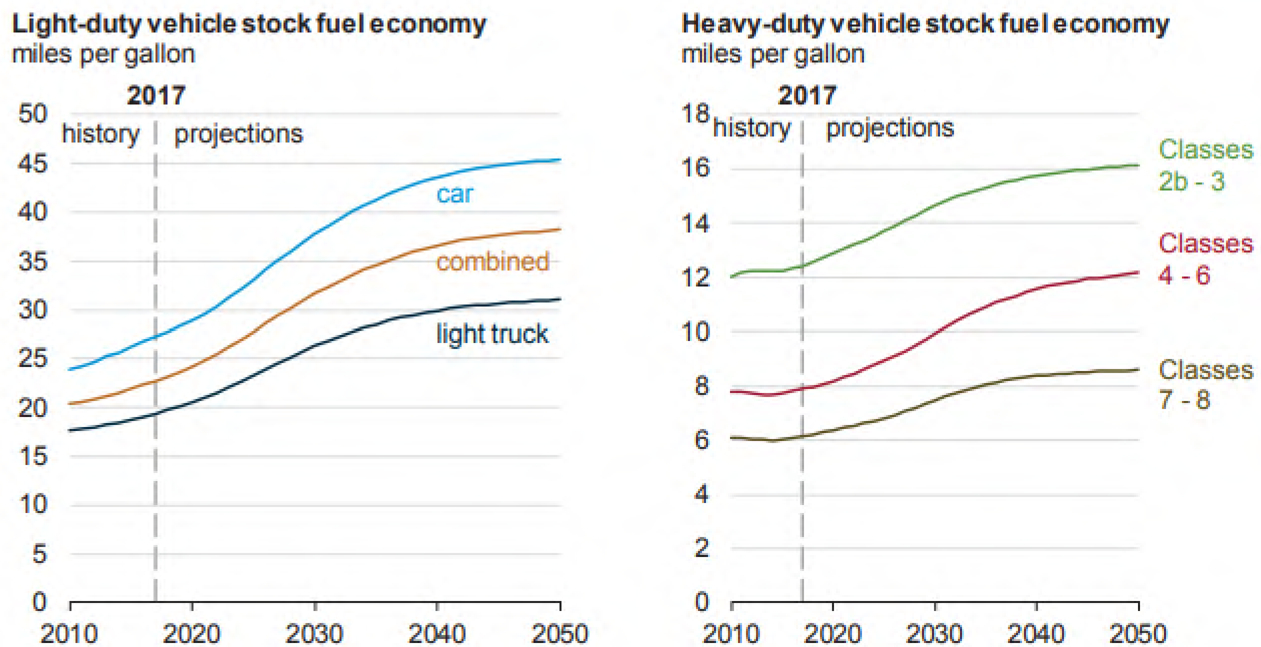

AEO also reports that passenger and vehicle travel will increase across all transportation modes through 2050. Light-duty vehicle miles traveled will increase by 18 percent, and heavy-duty truck vehicle miles traveled (the dominant mode of freight movement) grows nearly 50 percent. Freight rail ton miles grow by 27 percent, and domestic marine shipments decline by nearly half, continuing a historical trend related to logistical and economic competition with other freight modes.

### Figure 4.2: AEO Forecasted Transportation Travel Statistics[7]



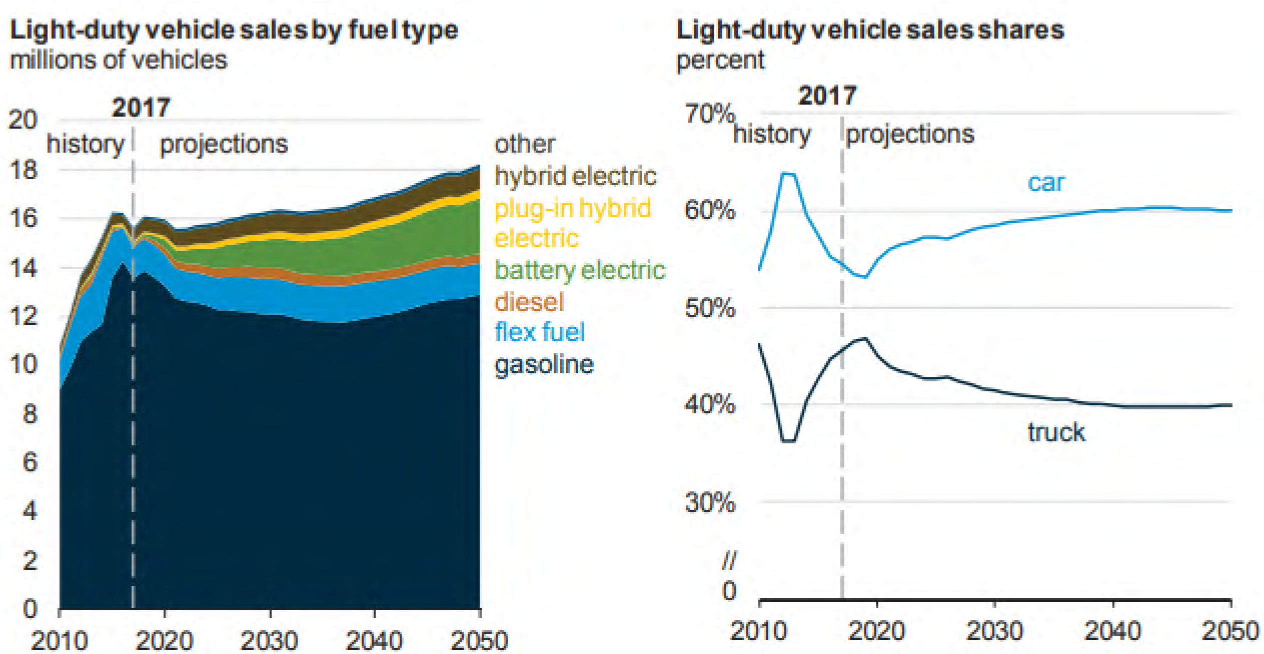
The AEO reference case assumes fuel efficiency gains for all types of vehicles.

**Figure 4.3: AEO Forecasted Fuel Economy**[7]



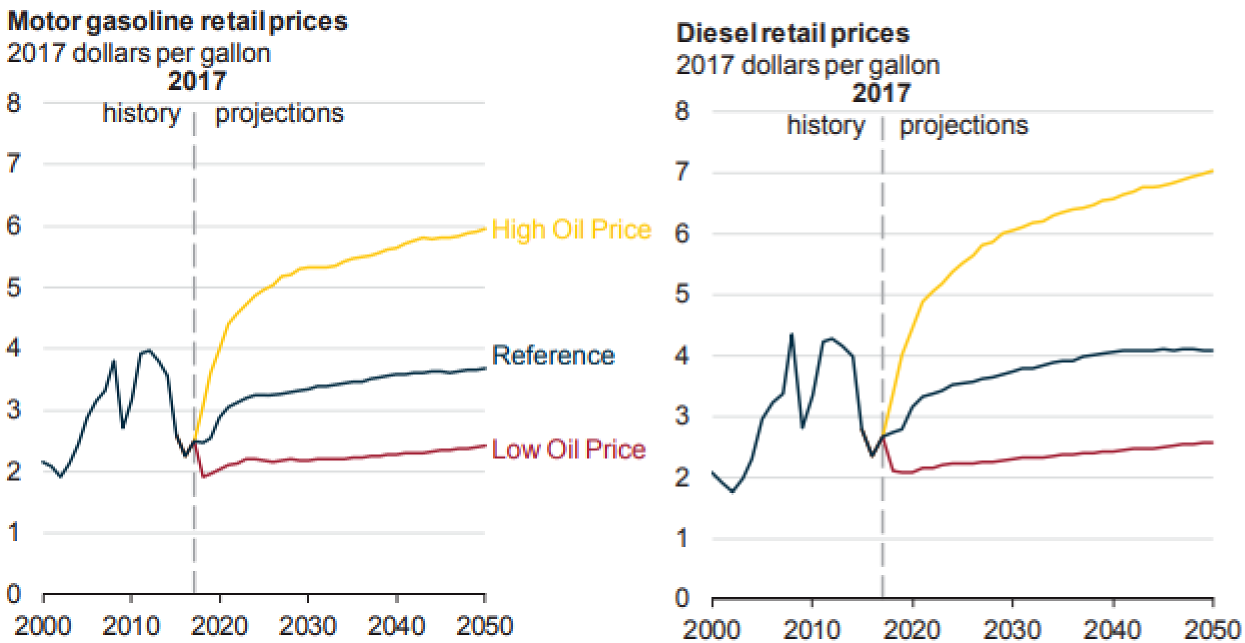

Gasoline vehicles remain dominant, though the market share of electric vehicles increases from four percent in 2017 to 19 percent in 2050. Passenger cars gain more market share over passenger trucks as fuel prices continue to increase.

**Figure 4.4: AEO Forecasted Light-duty Vehicle Sales**[7]




The prices of gasoline and diesel fuel are projected to increase from 2018 to 2050 because of expected increases in crude oil prices. While the spread between diesel fuel and gasoline retail prices on a volume basis has tightened in recent years, this trend reverses through 2041 because of the expected strong growth in global diesel demand for use in transportation and industry. Motor gasoline and diesel fuel retail prices move in the same direction as crude oil prices in the Low and High Oil Price cases. Projected motor gasoline retail prices in 2050 range from $2.41 per gallon to $5.95, and diesel fuel retail prices range from $2.56 per gallon to $7.02 depending on the projected price of oil.

### Figure 4.5: AEO Forecasted Fuel Retail Prices[7]




The national AEO report attempts to average prices for the whole country. The country can also be divided by Petroleum Administration for Defense Districts (PADDs), which were created during World War II to help organize the allocation of petroleum products. Oregon is in the northwest region of PADD 5, a large and diverse area and consists of six distinct regional markets.

### Figure 4.6: Petroleum Administration for Defense Districts[2]

Oregon is part of the Pacific Northwest regional market. As seen in Figure 4.7, the region is geographically isolated from other U.S. refining centers as no pipelines for crude or refined product cross the Rocky Mountains, Siskiyou Mountains, or Cascade Range.

**Figure 4.7: U.S. Energy Mapping System[8]**


Typically, PADD 5 has higher prices than the rest of the country. For example, a comparison of the oil price index for the Pacific Northwest (ANS West Coast) to the oil price index for Texas (WTI Crude) on June 7, 2018, showed an eight percent price difference.[9] This difference shows up in the price at the pump. On June 4, 2018, gas prices in Texas were about 20 percent lower than in the Northwest.[10]

# Oregon Transportation Sector Trends

The AEO projects that petroleum products, gasoline, and diesel will continue to be the dominant fuels in the transportation sector, and light-duty vehicles will continue to be the largest users of that fuel nationwide. Overall, this is also true for Oregon, but there are significant differences that give an alternative outlook for the state.

As noted, the AEO expects national gasoline consumption to peak in 2017 with a downward trend out to 2035. Oregon's estimated gasoline consumption, and thereby our GHG emissions, for the next few decades looks different than the AEO's projection, primarily due to the following:

1. Annually, Oregon is adding more light-duty vehicles than the national average. From 2001 through 2016, the U.S. saw an annual average of 0.7 percent increase in vehicle registrations, while Oregon had an average 1.1 percent increase per year.[11]

2. Oregonians purchase fewer new cars as a percentage of the statewide vehicle fleet than nationally. The national average of new cars compared to existing registrations from 2004 to 2016 was 6.4 percent. In Oregon, the average is estimated at only 3.6 percent from 2004 to 2016.[11]

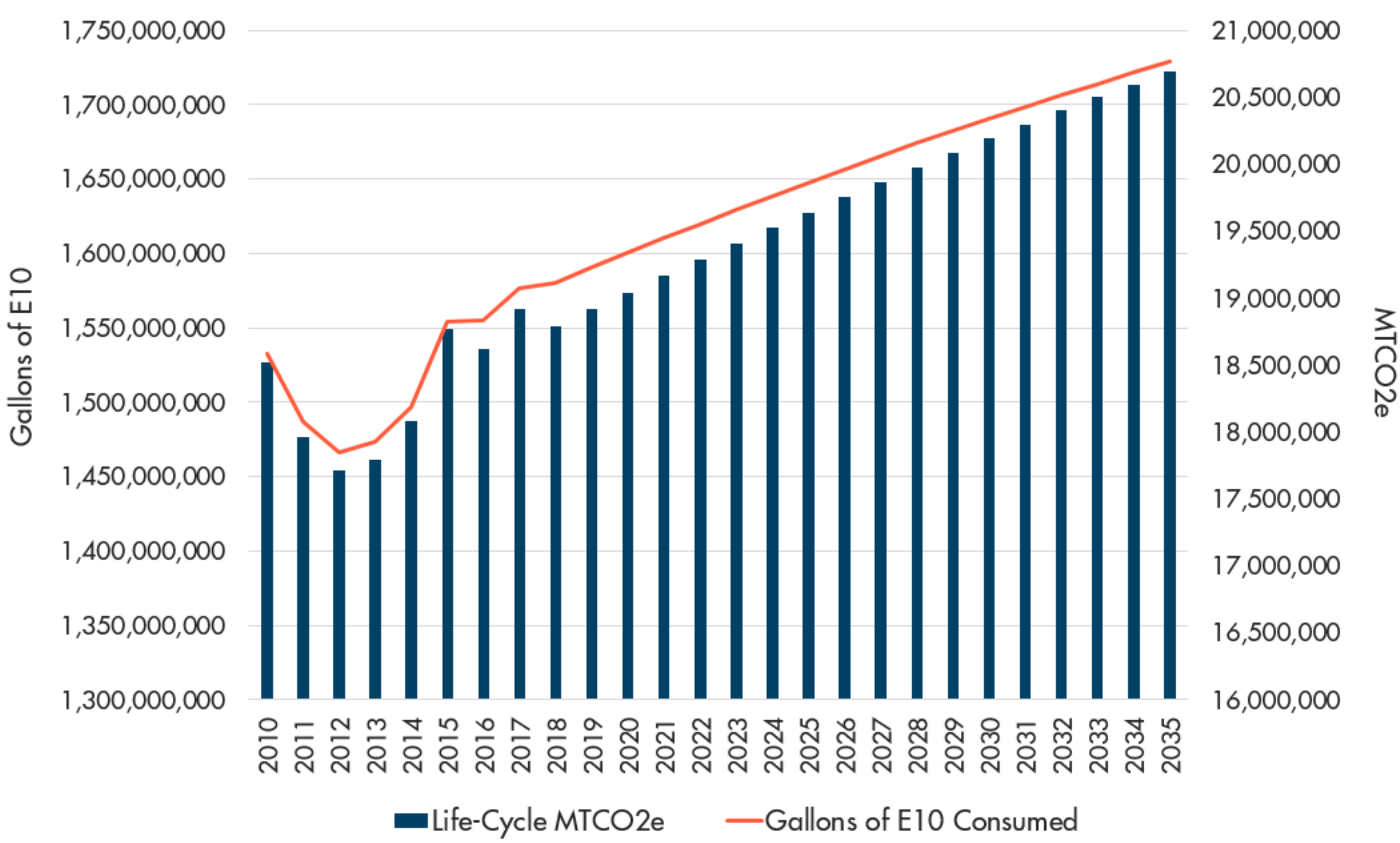
3. The percentage of SUVs and pickup trucks registered in Oregon is greater than the national average. Nationwide, sedan registrations are 8 percent higher than SUV/pickup trucks. In Oregon, truck registrations are 6 percent higher than sedans.[11]

4. Vehicles in Oregon are older than the national average. The Auto Alliance estimates that the average age of Oregon light-duty vehicles is 13.5 years.[12] In comparison, the average age of U.S. light-duty vehicles is 11.6 years.[13]

Oregon may be slower to experience gains from fuel efficiency standards because our vehicle registrations include a smaller percentage of new vehicles, our overall vehicle ages are older, and Oregonians buy a higher percentage of vehicles that use more fuel.

Figure 4.8 is not a state fuel forecast, but uses historical data to show how emissions and fuel consumption will continue to rise, rather than peak in 2017 as the AEO predicts nationally, without additional policies or economic influences. The projection uses multiple state agency fuel data sources, incorporates the AEO 2018 Outlook Reference Case forecast, accounts for the differences listed above in our light duty vehicle fleet, but does not take into account anticipated economic cycle changes, nor does it incorporate high EV adoption rates or other policies that will have an impact on fuel consumption and emissions.

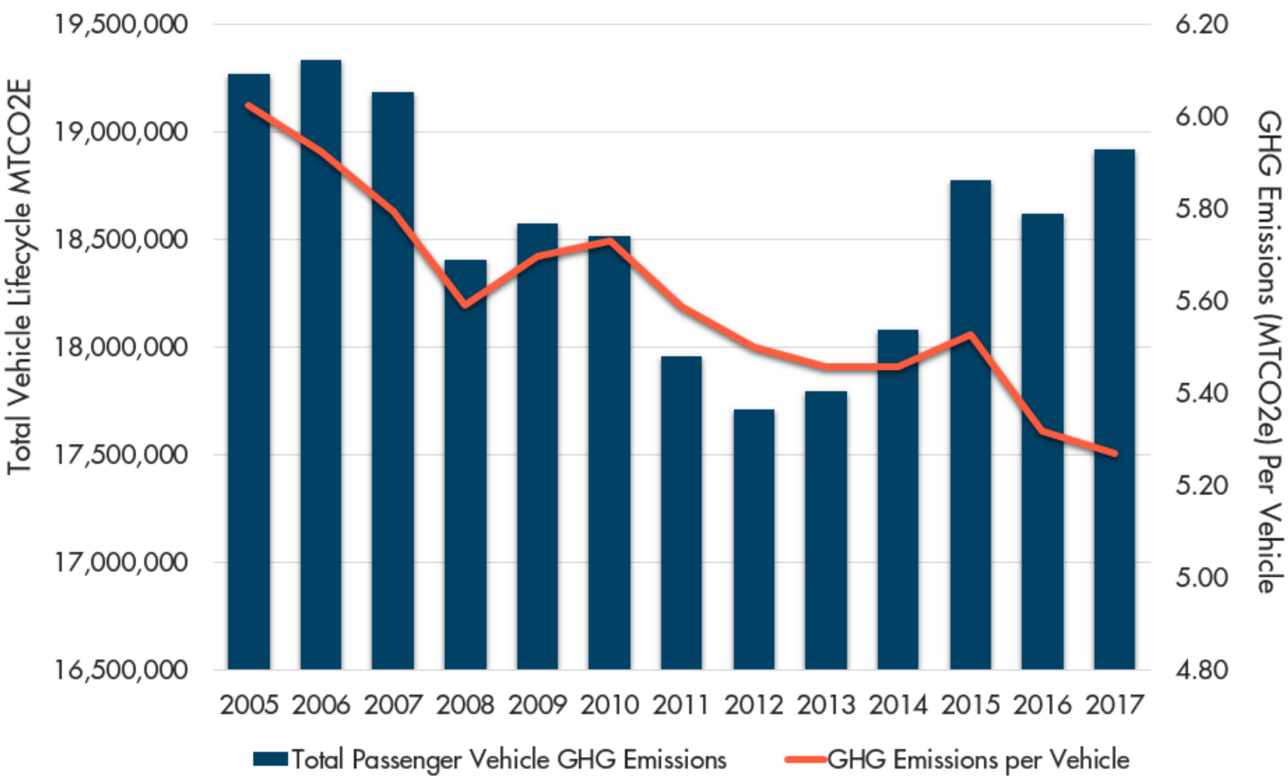
**Figure 4.8: Historical and Forecasted Gasoline/Ethanol (E10) Consumption and GHG Emissions (Based on AEO Reference Case)[1,7]**



## Oregon Fuel Consumption and Emissions: Decreasing on a Per Vehicle Basis

While overall on-road fuel consumption and emissions are on the rise in Oregon, per vehicle consumption and emissions are dropping. Comparing 2005 to 2017, Oregon reduced vehicle GHG emissions by 12.5 percent and fuel consumption by 10 percent in light-duty vehicles due to federal and state policies. In 2005, the typical vehicle consumed 490 gallons of fuel per year and emitted 6 MTCO2e. By 2017, the typical vehicle consumed 439 gallons of fuel and emitted 5.3 MTCO2e.[5]

**Figure 4.9: Total and Per Vehicle GHG Emissions (Passenger Vehicles)[5]**

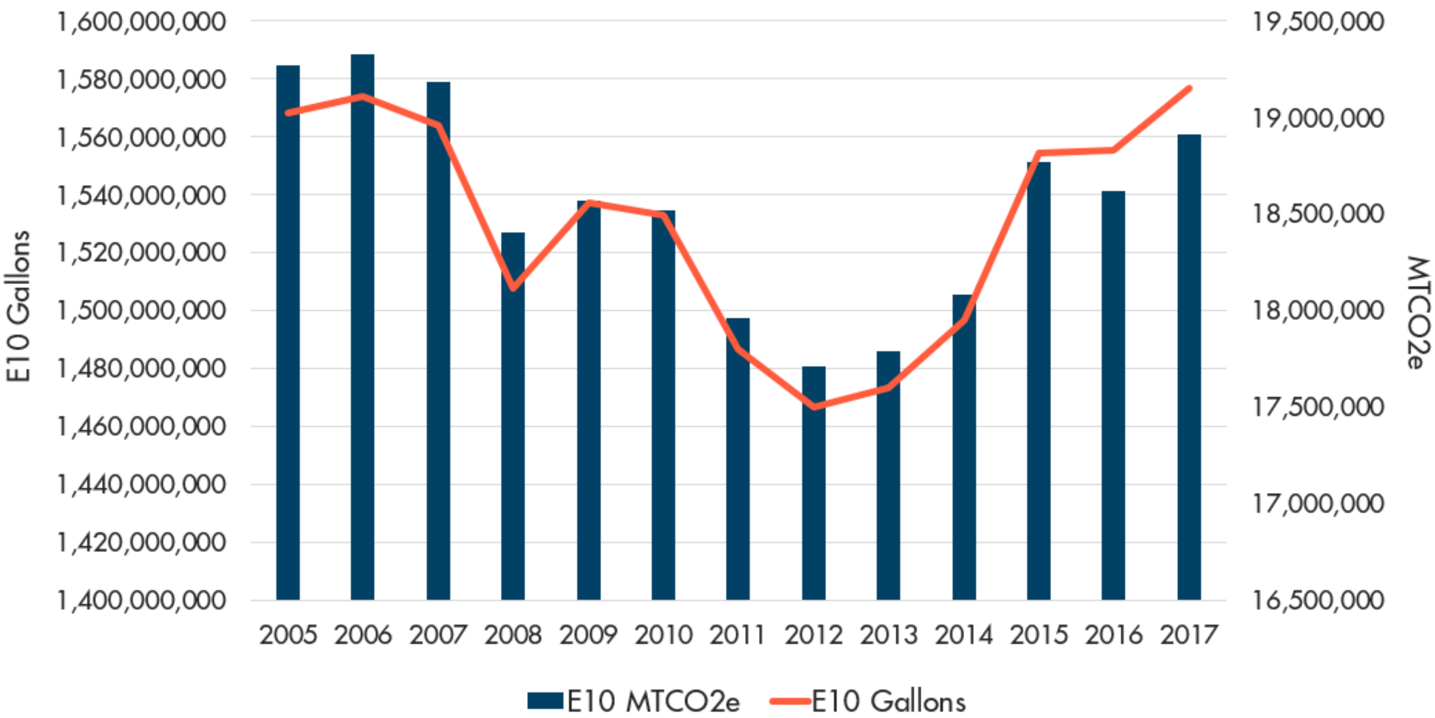



These per vehicle reductions in fuel consumption and emissions have affected Oregon's total light-duty vehicle fuel consumption and emissions. From 2005 to 2017, passenger vehicle registrations went from 3.2 million to 3.6 million, an 11 percent increase. However, E10 (the gasoline/ethanol blend Oregonians generally purchase at the pump) consumption only increased 0.6 percent, thanks primarily to vehicle efficiency gains. GHG emissions fared even better, as gasoline emissions were reduced by two percent from 2005 to 2017, due to vehicle efficiency and lower carbon ethanol blended into gasoline (Table 4.2). The dip in fuel consumption and emissions from 2009 to 2014, shown in Figure 4.10, is due to the economic effects from the Great Recession and high oil prices.[1]

**Table 4.2: Gasoline Use and Emissions for Light-duty Vehicles, 2005 and 2017[1]**

| | 2005 | | 2017 | |
|---|---|---|---|---|
| **Light-Duty Vehicles** | **3.2 Million** | | **3.6 Million** | |
| **Fuel Type** | **gge** | **MTCO2e** | **gge** | **MTCO2e** |
| Gasoline | 1,536,175,262 | 18,960,051 | 1,460,206,893 | 18,022,421 |
| Ethanol | 31,911,377 | 293,696 | 116,583,753 | 892,510 |
| Total for E10 | 1,568,086,639 | 19,253,747 | 1,576,790,646 | 18,914,931 |

**Figure 4.10: Gasoline/Ethanol (E10) Gallons and MTCO2e Emissions[1]**




# Current Policies to Reduce Fuel Consumption and GHG Emissions

The *Oregon Statewide Transportation Strategy: A 2050 Vision for Greenhouse Gas Emissions Reduction* (STS),[6] drafted by ODOT in 2013 and adopted into the Oregon Transportation Plan by the Oregon Transportation Commission in 2018, examines ways that the transportation sector can reduce GHG emissions and help achieve Oregon's GHG reduction goals.

The STS is a comprehensive policy to reducing GHG emissions in the transportation sector and ODOT identified six categories of strategies to help the state reduce GHG emissions:

1. **Vehicle and Engine Technology Advancements**
2. **Fuel Technology Advancements**
3. **Systems and Operations Performance**
4. **Transportation Options**
5. **Efficient Land Use**
6. **Pricing Funding Markets**

Because many of the programs and strategies listed in the STS are not under the authority of ODOT, the agency drafted the STS Short-Term Implementation Plan in 2014. This plan described short-term (2-5 year) activities that ODOT could implement to advance the strategies in the STS. The plan focused on low-cost, existing, and complementary action that are likely to produce fairly rapid GHG reductions including:

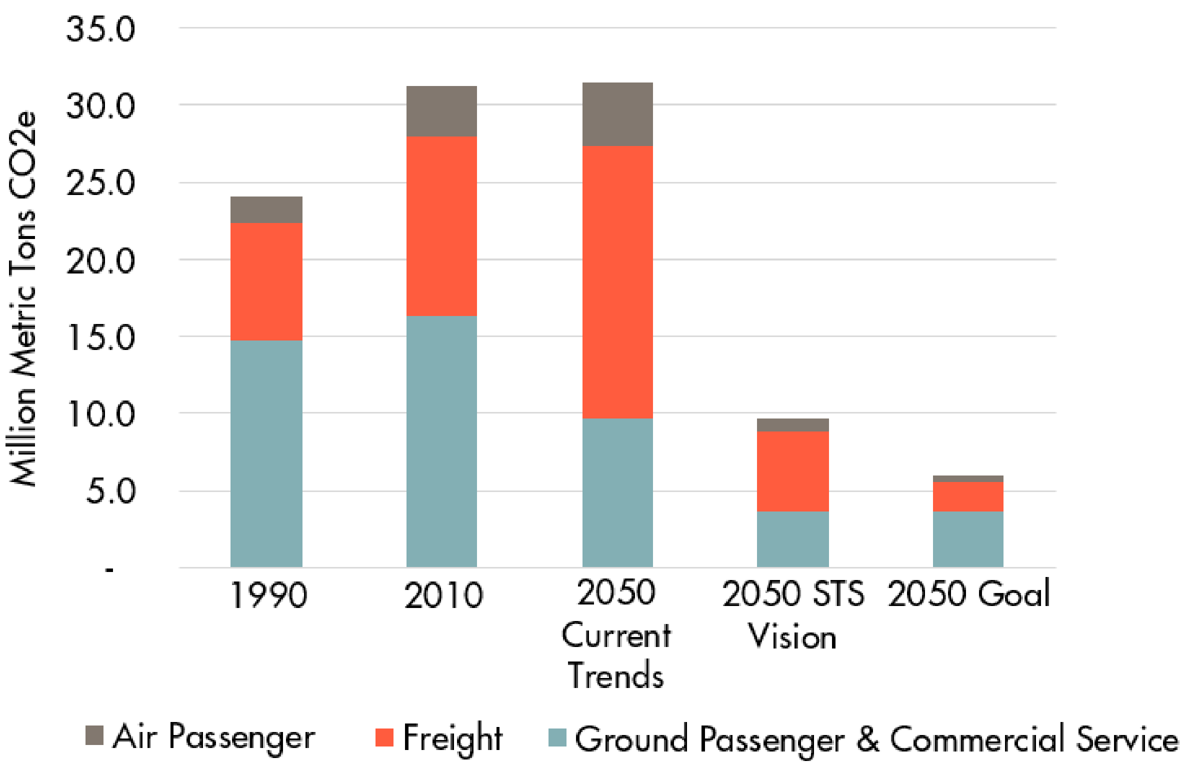
- Supporting the transition to Electric Vehicles and Low-Emission Fuels.
- Implementing the Eco-Driving program, with focuses on a low-cost approach to reducing GHG emissions by providing information to citizens on how to drive in a more fuel efficient way.
- Studying the economic impact of pricing strategies, specifically road-usage fees.
- Partnering with municipal planning organizations to engage in long-range scenario planning efforts that explore local actions for reducing GHG emissions.
- Using Intelligent Transportation Systems (ITS) to reduce emissions in the short-term through operational improvements that reduce congestion and increase the efficient use of fuel.
- Exploring investment programs to support STS implementation.
- Assuring continued coordination with state agencies and other entities working on activities that align with the STS vision.

West Coast Electric Highway Charger in Cascade Locks.

In support of these objectives, ODOT and ODOE funded the installation and maintenance of 44 direct current fast chargers (DCFC) in Oregon and funded two CNG fueling stations in Wilsonville and the Rogue Valley. ODOT has also integrated information on EV charging infrastructure into maps and other publications. The economic analysis of on road usage fees provided data that informed the development of the OReGO program: the nation's first mileage-based revenue program for light-duty vehicles. And many of the strategies in the STS have been incorporated into other ODOT plans, including the Oregon Transportation Options Plan and the Oregon Bicycle and Pedestrian Plan.

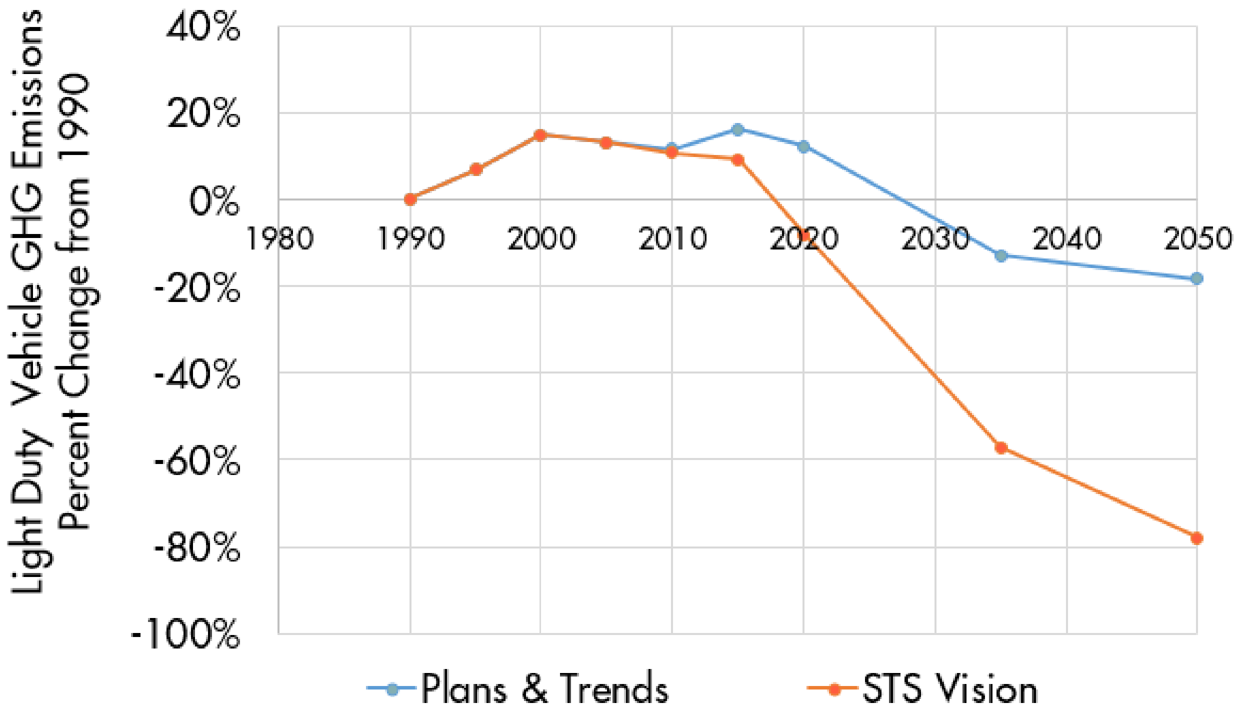
In 2013, ODOT modeled GHG emissions reductions if all strategies in the STS were fully implemented. Figure 4.11 shows that transportation GHG emissions would be reduced by 60 percent in the 2050 STS Vision scenario as compared to 1990 levels. The STS Vision includes 18 distinct strategies with 133 potential elements. Additional efforts to reduce emissions are needed to meet the state goal of 80 percent below 1990 levels by 2050.

**Figure 4.11: Historic GHG Emissions and Potential Future Reductions**[6]




ODOT published the 2018 Monitoring Report to demonstrate the progress on STS implementation since 2013. The blue line in Figure 4.12 shows GHG emissions reductions in the light-duty vehicle sector using current policies and programs in-place in Oregon. At the time the STS was developed, fuel prices were at an all-time high. Consequently, emissions from the light-duty sector are continuing to rise rather than fall. The takeaway from the chart below is that the STS strategies will reduce light-duty emissions by substantial amounts. Even so, these fall short of the GHG reductions necessary to achieve Oregon's emissions goals.

**Figure 4.12: GHG Emissions Reductions in the Light-duty Vehicle Sector[6]**




Actions called for in the STS are moving Oregon in the right direction. However, as discussed earlier, increasing population, relatively low gas prices, and a strong economy have contributed to increases in transportation GHG emissions. Transitioning Oregon to low- and zero-emission vehicles and expanding walking, biking, rail, and public transit programs will be challenging and require increased analysis to ascertain what works and what additional actions are needed. As ODOT points out in its 2018 STS Monitoring Report, it is currently not possible to directly measure the emission reductions for some specific activities. More research and analysis into how to measure individual strategy progress is necessary to ensure the state meets our goals efficiently and cost-effectively.[6]

Pathways to reduce GHG emissions resulting from fuel use in the light-duty sector can be categorized into three broad policy categories:

1. **Cleaner Vehicles: transition to vehicle technologies that are more fuel efficient and have fewer emissions.**

2. **Cleaner Fuels: transition to no-emission or low-emission fuels and technologies.**

3. **Lower VMT: reduce drive alone trips and vehicle miles traveled.**

Multiple policies and programs have been implemented at the local, regional, state, and federal levels that support these three areas.

# Policies that Promote Cleaner Vehicles

## Federal Corporate Average Fuel Economy Standards

Improvements in vehicle fuel efficiency are expressed in miles traveled per gallon and help reduce the amount of fuel we consume per vehicle. The Federal Corporate Average Fuel Economy, or CAFE, standards are the primary policy for improving vehicle fuel efficiency, although technological advances allowing vehicles to communicate with each other and their surroundings could improve vehicle fuel efficiency in the future.

Established by Congress in 1975, federal CAFE standards set fuel efficiency requirements that automobile manufacturers must achieve, or pay a penalty on a per vehicle basis, in the development of new vehicle models. The National Highway Transportation Safety Administration sets fuel efficiency standards. Although not directly responsible for establishing fuel efficiency standards, the EPA sets emissions standards for vehicles, which are directly related to fuel efficiency. The NHTSA and EPA work together when establishing or updating these regulations. As CAFE standards are updated, new more rigorous targets are established for vehicle manufacturers to meet. Congress granted California a special authority to allow the state to set its own, more stringent, emissions standards to help better manage high levels of air pollution in its major cities. Oregon, along with eight other states, signed on with California and agreed to follow their greenhouse gas standards requiring more efficient vehicles.

Since federal CAFE standards were first enacted, the average fuel economy in vehicles has more than doubled. Figure 4.13 shows trends in vehicle fuel economy since 1975 for cars and trucks.[14]

### CALIFORNIA'S WAIVER

As early as 1943, Los Angeles was experiencing some of the nation's worst smog events. In the early 1950s Dr. Arie Haagen-Smit discovered that the smog was the result of pollutants from automobile exhaust. With the passage of the Federal Air Quality Act in 1967, California was granted a waiver to federal air quality rules in order to combat this growing smog issue in its major cities. The waiver granted the state the ability to set more stringent emissions standards, including: the nation's first tailpipe emissions standards, a regulation requiring more Zero Emission Vehicles be made available for purchase, and the nation's first GHG standards for cars.[15,16] Levels of Ozone, which is created when sunlight interacts with oxides of nitrogen or NOx emissions from vehicles, have steadily decreased in the south coast air basin since 1973.

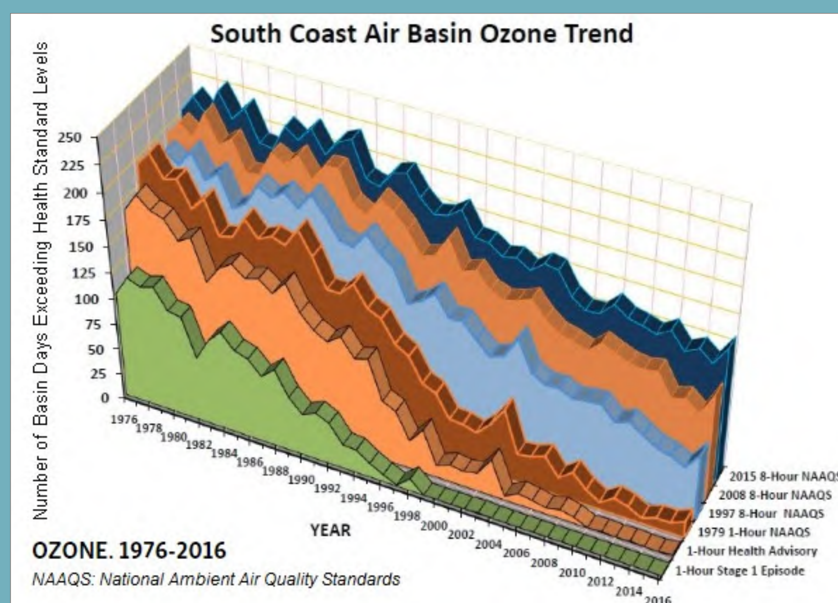
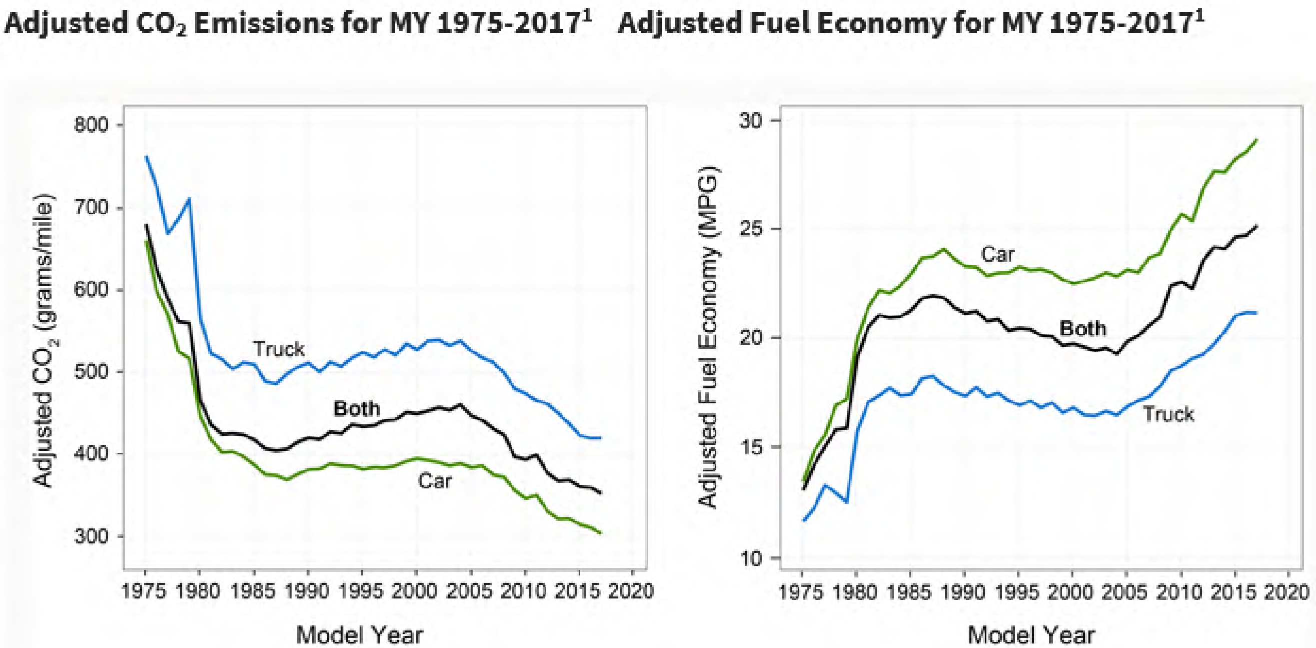


**Figure 4.13: Trends in Vehicle Fuel Economy, 1975-2017**[14]

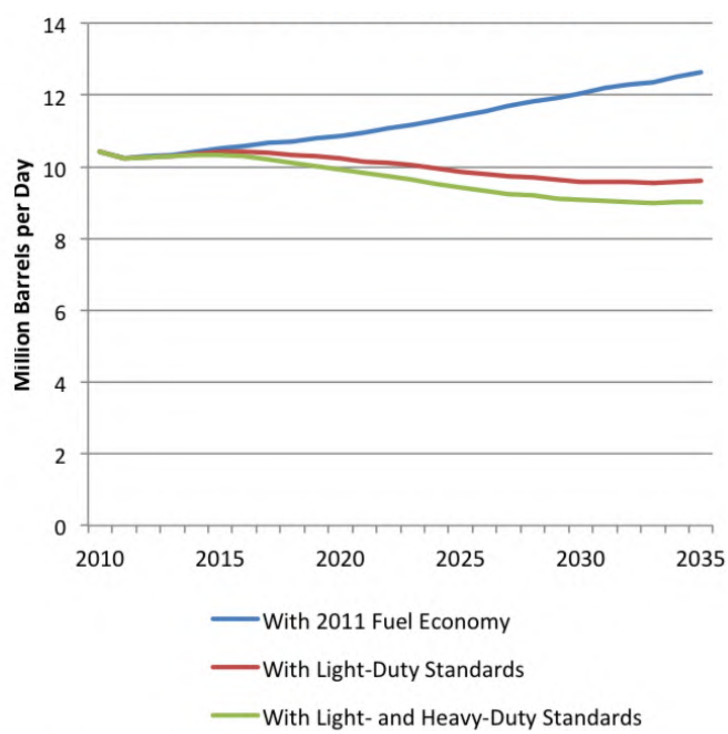



In 2012, the federal government and California adopted harmonized vehicle emissions standards applicable through 2025.[17] On August 2, 2018, the Environmental Protection Agency (EPA) and National Highway Traffic Safety Administration (NHTSA) submitted proposed rules to freeze their respective standards to 2020 levels, making them less stringent on fuel efficiency and carbon emissions for vehicle model years 2021 through 2025. The proposed rules would also remove language concerning the California waiver. The overall impact of this change would weaken fuel economy standards and would lead to increased emissions and fuel consumption. Oregon signed on as party to a preliminary lawsuit filed by California against EPA[19] disputing the legality of such a federal action, and in October 2018 joined comments with California and other states and municipalities opposed to the proposed federal actions.[20]

Fuel efficiency standards create benefits that continue through the lifetime of a vehicle, including decreasing petroleum consumption, reducing costs for consumers, and reducing harmful emissions. CAFE standards have dramatic effects on fuel consumption and GHG emissions over extended timelines as vehicles are kept in service for a long time. As noted above, the average vehicle in Oregon is 13.5 years old.

Figure 4.14 shows projected fuel consumption through 2035 for the 2011 standards (blue line) and the current efficiency standards (red and green lines). The current standards are projected to save more than three million barrels a day by 2035

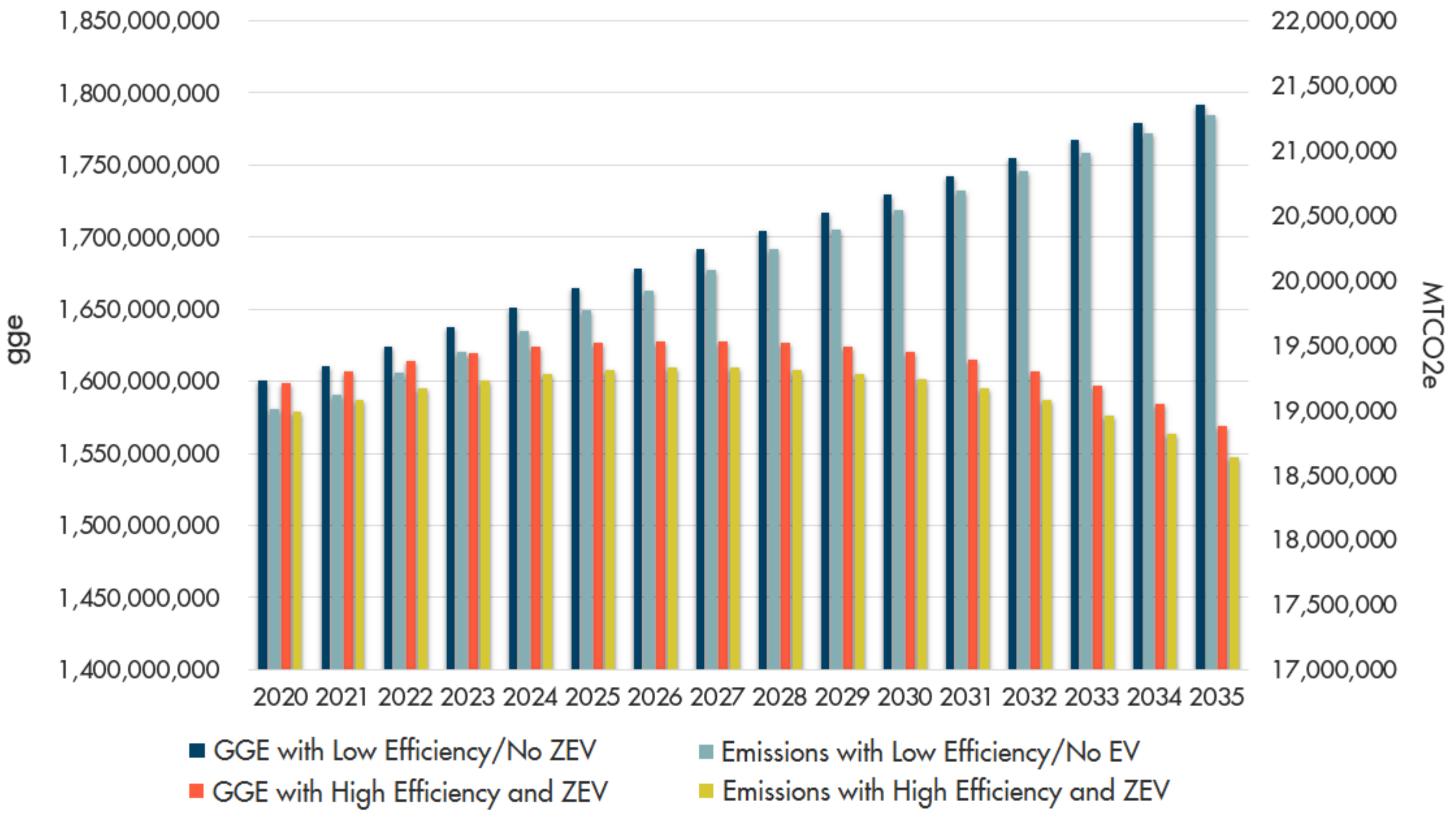
**Figure 4.14: Car and Truck Fuel Consumption with and without Recent Fuel Economy Standards**[18]



compared to the 2011 standards, and this will increase U.S. energy independence in addition to saving consumer's money and reducing emissions.

Even minor efficiency improvements can greatly affect fuel use, emissions, and consumers' budgets. Figure 4.15 shows how CAFE standards coupled with EV adoption can have large effects on GHG emissions and gasoline consumption. The graph shows fuel consumption peaking in 2027 and GHG emissions peaking in 2028 using the policies in place today. This is in comparison to a scenario with no Zero Emissions Vehicle program (learn more later in this chapter) and reduced fuel efficiency standards, which would create continual increases in consumption and GHGs through 2035 and cost Oregonians an additional $4.8 billion in fuel.[1]

**Figure 4.15: Comparison of High Vehicle Efficiency and ZEV Program Benefits to Low Vehicle Efficiency and No ZEV Program Benefits in Oregon[72]**




## Policies Promoting Cleaner Fuels

A number of policies at the federal and state levels promote the use of cleaner fuels by setting standards for transportation fuels and by promoting adoption of vehicles capable of using cleaner fuels.

To date, biofuels have been the most effective lower carbon alternative for curbing petroleum product consumption and GHG emissions. Other no- or low-carbon alternative fuels (e.g., propane, renewable natural gas (RNG), natural gas products such as compressed natural gas (CNG) and liquefied natural gas (LNG), and electricity) have become increasingly important to diversifying Oregon's fuel supply and reducing emissions. These alternative fuels have the potential to grow for specific applications in the transportation sector.

Biofuels such as ethanol, biodiesel, and renewable diesel require little or no modification to vehicles and fueling infrastructure. Other alternative fuels such as propane, CNG, LNG, and RNG may be used in internal combustion vehicles but require engine modifications and special fueling infrastructure. Finally, electric vehicles and hydrogen fuel cell vehicles are distinct from internal combustion engine vehicles and use designated fueling infrastructure. Because of the integral relationship between fuel and vehicle, this section will discuss programs and policies promoting both cleaner fuels and related vehicle and fueling technologies, where applicable.

### Federal and State Renewable Fuel Standards

Congress passed the federal renewable fuels standard (RFS) program in 2005 to reduce the country's reliance on imported fuels by diversifying the transportation fuel mix. This program incentivizes renewable fuels grown and produced primarily in the U.S. In 2007, the RFS was amended to increase the required amount of renewable fuels that must be included in the fuel mix and establish categories for different fuels based on their carbon content. In most cases, categories for lower carbon content fuels can be sold for higher prices in the renewable transportation fuel market.

The Oregon RFS was passed in 2007.[73] The state RFS also sets standards for the amount of renewable fuels, such as biodiesel and ethanol, to be included in most conventional transportation fuels sold in the state. The standard requires Oregon diesel fuel to contain five percent biodiesel and gasoline to contain ten percent ethanol. Although not the primary focus of these programs, the federal and Oregon RFS have greatly reduced emissions from the state's petroleum fuel mix.

### Oregon Clean Fuels Program

The Oregon Clean Fuels Program was established by the state legislature in 2009,[22] with the goal of reducing GHG emissions from Oregon's transportation fuels by 10 percent over a 10-year period. However, it was not until the Legislature passed SB 324 in 2015 that the program was allowed to be fully implemented by DEQ. In 2016, DEQ established annual standards through 2025 for all transportation fuels and calculated the carbon intensity (CI) for each of them, measured in grams of carbon dioxide released per megajoule of energy produced. The CIs in Figures 4.16 and 4.17 were updated in 2017. CIs are regularly added and updated by the DEQ CFP. The full list of Oregon-approved CI values is available on their webpage.[21]

**Figure 4.16: Carbon Intensities of Fuel Sources[21]**

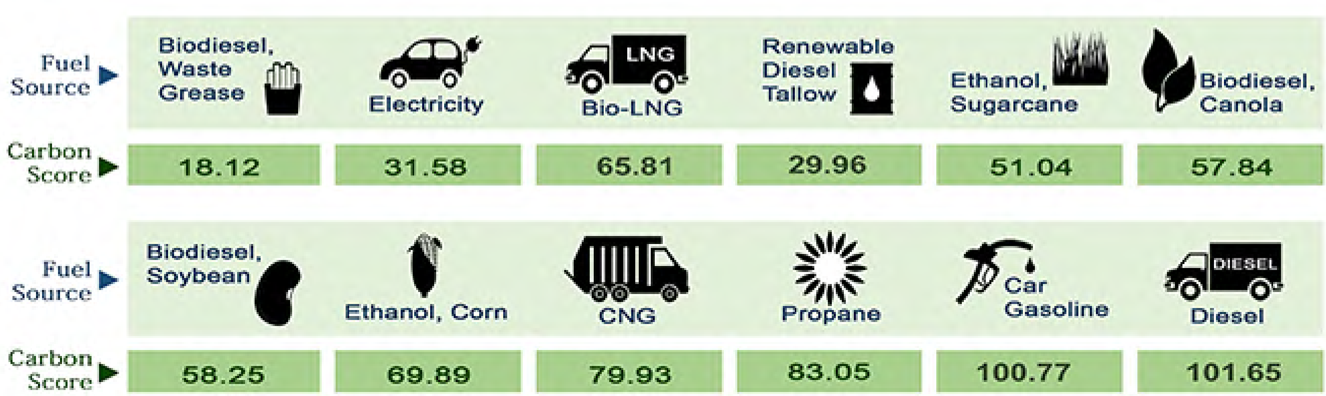
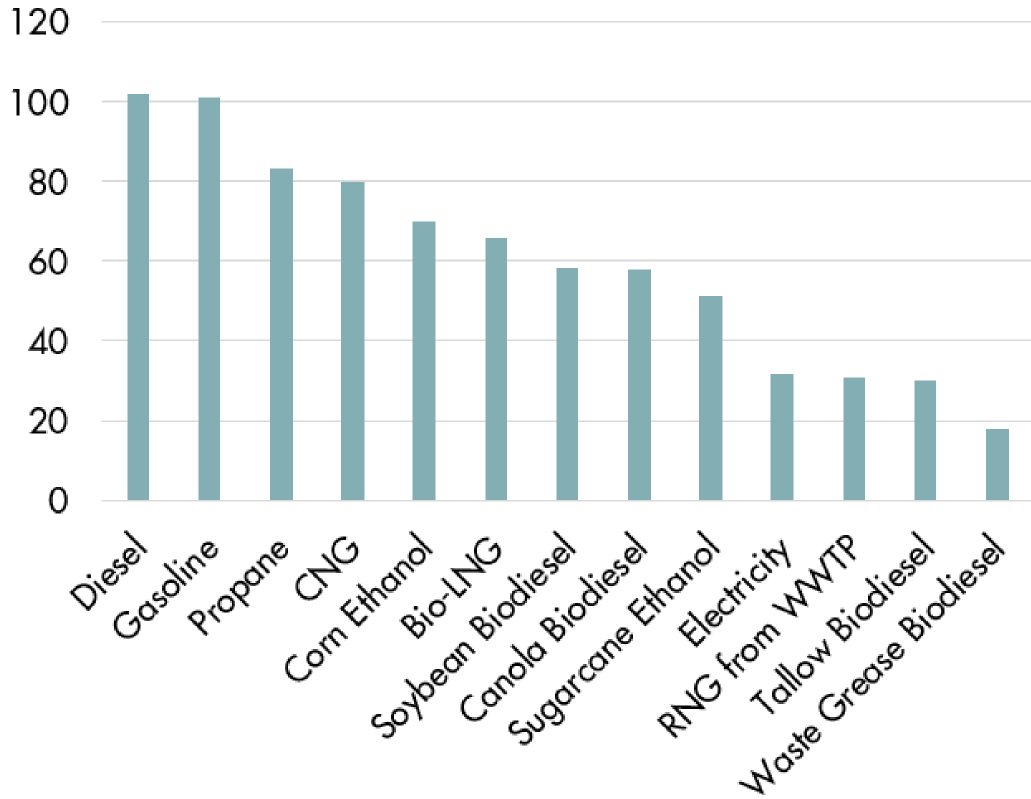


**Figure 4.17: Oregon Fuel Source Carbon Intensities**[21]




Credits under the program are generated when a fuel's carbon intensity is lower than the annual standard. Fuels that generate credits include: ethanol, biodiesel, renewable diesel, natural gas, propane, electricity, and hydrogen. Deficits are generated when the carbon intensity of a specific fuel – principally fossil gasoline and diesel – exceeds the annual standard. Credits and deficits are both calculated as one metric ton of CO2e. The program requires the importers of liquid transportation fuels into Oregon to meet the annual standards; in other words, they must retire enough credits to offset the number of deficits they incur. Providers of natural gas, propane, electricity and hydrogen to vehicles can voluntarily opt in to the program and generate credits. The program has rules for and monitors the market for credits.[22] The program has been fully operational since 2016, and is generating sufficient credits to meet the needs of the market. Credits are being traded in increasing numbers with little effect on the price of fuel.

## OREGON CLEAN FUELS PROGRAM

In its first two years, the Oregon Clean Fuels Program has reduced GHG emissions by 1.75 million MTCO2e and replaced 445 million gallons of gasoline with lower carbon fuels.

Since the program's start, new low-carbon fuels have been introduced into Oregon's transportation fuel mix, including renewable natural gas from wastewater treatment plants and landfills and renewable diesel sourced from a by-product of ethanol production. Some of these fuels are, or can be, produced in Oregon. The program is on track to meet its goal of reducing the carbon intensity of transportation fuels. Overall the federal and state RFS programs, combined with the Clean Fuels program have increased the amount of cleaner alternative fuels used in Oregon's transportation mix from less than two percent in 2005 to 7.3 percent in 2017 on an energy equivalent basis.[1] In 2017, the combined reductions in life-cycle greenhouse gas emissions of blended diesel and gasoline products from the federal and state RFS programs and the Oregon Clean Fuels Program is estimated to be 791,000 MTCO2e in Oregon.[78]

Electricity is a qualifying fuel under the Clean Fuels Program. Utilities are able to receive credits for EVs that charge on their systems. Many utilities have signed up for the program and are receiving credits. For utilities that have not signed up, the non-profit organization Forth was designated as a backstop aggregator for any credits accrued from these territories. The money generated from these credits will be used to promote and support transportation electrification across Oregon.

# Alternative Fuel Vehicles

As noted above, little to no change to vehicles is required to use some alternative fuels, while other alternative fuels require distinct vehicle technologies and fueling infrastructure. In the light-duty sector, the focus in Oregon is on electric vehicles, which are fueled entirely or partially by electricity. In the medium- and heavy-duty sector, there have been a range of changes from electric to cleaner-burning natural gas or propane to biodiesel. Many businesses and organizations in Oregon that use medium- and heavy-duty vehicles have already introduced cleaner transportation fuels into their fleets.

## Oregon Zero Emission Vehicle Program

Oregon has adopted the California Zero Emission Vehicle (ZEV) Program, which requires most vehicle manufacturers to deliver an increasing percentage of new cars sold in Oregon to be ZEVs such as: battery electric, plug-in hybrids, other hybrids, and gasoline vehicles with near-zero tailpipe emissions.[23] California, under its federal waiver, has the authority to establish standards and rules on vehicle emissions including their ZEV program. Once they are established other states may adopt these rules.[24] Nine states, including Oregon, participate in the California waiver program.

### WHAT'S THAT ACRONYM?

*The vehicle industry uses a number of acronyms to refer to traditional and alternative fuel vehicle models:*

**ICE:** Internal-combustion engine; runs on gasoline

**ZEV:** Zero-emissions vehicle

**PHEV:** Plug-in hybrid electric vehicle; runs on electricity, then switches to gas

**EV:** Electric vehicle; can refer to all-electric or plug-in hybrid

**BEV:** Battery electric vehicle; all-electric plug-in

**TZEV:** Transitional ZEV; plug-in hybrid

**BEVX:** BEV that also has gas-powered range extender engine technology

**FCEV:** Fuel cell EV; vehicles use hydrogen to produce electricity

ZEV adoption forecasts for Oregon show considerable EV growth is expected, although the forecasts vary. DEQ anticipates approximately eight percent of all new car sales in Oregon will be ZEVs by 2025, while Bloomberg estimates approximately 30 percent by 2030. Based on that forecast, sales will likely be about 19 percent by 2025.

# SEQUENTIAL BIOFUELS

In 2002, Ian Hill was on a college road trip when his car broke down. Looking at the cloud of black smoke billowing from his engine, Ian decided there must be a better, cleaner way to travel. He and his friend, Tyson Keever, started researching biofuels as students at the University of Oregon. Just three years later, their company, SeQuential Biofuels, collaborated with Pacific Biodiesel to open the first commercial biodiesel production facility in Oregon. By Fall 2008, the SeQuential-Pacific Biodiesel facility in Salem was already completing a major expansion, with a new annual capacity of five million gallons (up from one million gallons). In 2017, production reached 8.45 million gallons, and the team expects to increase production by another 40 to 50 percent by the end of 2019.

Biodiesel is made from used cooking oil, which undergoes a chemical process called transesterification. The process separates materials into distinct elements, including mono alkyl esters: the scientific name for biodiesel. The California Air Resources Board ranks the resulting fuel with a carbon intensity of 18.57, about a fifth of the lifecycle emissions of petroleum diesel (which has a carbon intensity of 98.03).

SeQuential Biofuels also works upstream and downstream from production. The company collects used cooking oil from food processors like Kettle Foods, and from restaurants like Burgerville, Taco Time, and McMenamins. Trucks also gather oil from businesses with large cafeterias, like hospitals, schools, and the Nike campus in Beaverton.

The biofuel is sold at 90 locations in Oregon, including two stations in the Eugene area that are owned and operated by SeQuential. SeQuential's stations also demonstrate sustainable building practices, including a living roof and bioswales for stormwater management, renewable solar PV, and even a heathy snack selection at the convenience store.

Enthusiasm, hard work, and good partners – combined with helpful business incentives and good market conditions – have created a unique Oregon alternative fuel business with 221 employees up and down the west coast (138 of them in Oregon).[25,26,27,28,29,30]

## Electric Vehicle Purchase Incentives

Incentives can be an effective tool to close the gap between the higher up-front costs of electric vehicles compared to conventional gasoline-powered vehicles. Various incentives are available for the purchase of electric vehicles and in some cases for charging equipment. Auto manufacturers, auto dealerships, utilities, or local governments may also offer incentives. The following incentives were available at the time this report was published.

### Federal EV Tax Credit Program

The federal government offers tax credits designed to lower the cost of plug-in vehicles. The amount of the credit is based on the vehicle's battery capacity, and can range from $2,500 to $7,500 for EVs purchased in the U.S. The tax credits are available until 200,000 eligible EVs have been sold by a manufacturer, and then the credit will phase out over 12 to 18 months for that manufacturer's plug-in EV products. The credit is available based on a manufacturer eligibility basis. In 2018, Tesla was the first manufacturer to hit the 200,000 vehicle mark.[31] General Motors is also expected to exceed the cap in the fourth quarter of 2018.[32]

### Oregon Clean Vehicle Rebate and Charge Ahead Rebate

The Oregon Legislature enacted House Bill 2017,[74] the "Keep Oregon Moving" Act, in 2017 which, among other things, established a rebate of up to $2,500 for qualifying BEVs and PHEVs. The bill also included a companion Charge Ahead Rebate program, which offers a separate rebate up to $2,500 for low- and moderate- income households for the purchase or lease of a new or used BEV. Both programs are administered by the Oregon Department of Environmental Quality and are currently taking applications.

### Oregon DEQ Clean Vehicle Rebate Program

| | Standard Rebate | Charge Ahead Rebate |
|---|---|---|
| **Who Qualifies?** | All Oregonians | Low– or moderate-income households. DEQ has not finalized qualification levels for the Charge Ahead Rebate. See DEQ's website for more information. |
| **Vehicle Type** | Purchase or lease of new BEV or PHEV | Purchase or lease of new or used BEV or PHEV |
| **Rebate Amount** | • $2,500 for EVs with battery capacity of 10 kWh or higher<br>• $1,500 for EVs with battery capacity less than 10 kWh | $2,500 for new or used BEV |
| **Eligibility Requirements** | • Applicant must maintain vehicle registration in Oregon for at least two years<br>• Manufacturer's suggested retail price cannot exceed $50,000<br>• Applicant must submit Phase I Application within six months of the date or purchase or lease<br>• Must be purchased or leased from a licensed dealer | |

*More information: www.oregon.gov/deq/aq/programs/Pages/ZEV-Rebate.aspx*

### Utility-Specific Incentives

Some Oregon utilities also offer rebates for EVs purchased by their customers.

- Eugene Water and Electric Board currently offers a $300 Clean Ride Rebate on the purchase or lease of a new or used EV.
- City of Ashland's Municipal Utility offers up to $300 rebates on qualifying EVs.
- Emerald People's Utility District offers $100 for registering an electric vehicle.
- EWEB and Pacific Power are partnering with Nissan to offer a $3000 rebate on the purchase of a 2018 Nissan Leaf.

### VW Environmental Mitigation Trust

VW mitigation funds can help Oregon meet its GHG emissions goals by funding alternative fuel vehicle projects that clean up dirty diesel emissions. In addition, up to 15 percent of the funds can be used for light-duty EV infrastructure. Oregon DEQ administers these funds as authorized by the Oregon Legislature. The 2017 legislature approved VW Mitigation funds to clean up approximately 450 diesel school buses by either installing diesel emission control devices or by purchasing clean diesel or other alternative fuel buses, such as propane, natural gas, or electricity. Future legislation is needed to approve spending the remainder of the VW Mitigation fund.[33] Approved projects eligible for these funds have different impacts on emissions. Clean diesel engines significantly reduce toxic air pollutants. Clean fuel technologies such as RNG, propane, or electricity reduce both toxic air pollutants and GHG emissions.

## DIESELGATE

Volkswagen and its affiliated corporations violated the Federal Clean Air Act when the EPA discovered in 2015 that the automaker had programmed several of its turbocharged direct injection diesel engines to activate emissions controls only during laboratory testing, and to revert to normal operation during on-road driving. The difference in air pollutant emissions was substantial, with up to 40 times NOx emissions in real-world driving scenarios. About 11 million Volkswagen cars worldwide[34] feature this programming software and are affected, of which 500,000 were sold in the U.S. for model years 2009 through 2015.[35]

Through Volkswagen and its affiliated corporations' settlement agreement with the EPA and the California Air Resources Board, Volkswagen and its affiliated corporations' must buy back or compensate owners for their affected vehicles. Buybacks range in value from $12,475 to $44,176, or between $5,100 to $9,852 for those opting for emissions fixes approved through the EPA. The company will also pay $2.7 billion for environmental mitigation and another $2 billion for clean-emissions infrastructure.[36]

States, territories, and tribes will receive funds designated for mitigating excess emissions of nitrogen oxides from Volkswagen diesel vehicles. States will receive between $8 and $423 million in the initial allocations, with Oregon receiving $72.9 million. Each state will develop a plan to use the funds for eligible mitigation actions including diesel engine upgrades or replacements, and installing EV charging infrastructure.[37]

## ELECTRIFY AMERICA

VW launched Electrify America as part of its settlement with the EPA and CARB over the "Dieselgate" scandal. The company is spending $2 billion on a nationwide electric vehicle charging network and on EV education. The company will use these funds to install 50- to 150-kW urban chargers, as well as highway stations with as much as 350 kW of power.


Electrify America charger in Huntington, OR
*Photo: PlugShare.com*

Electrify America will install charging infrastructure over the next 10 years, in four 30-month investment cycles. The company is currently in the process of implementing Investment Cycle 1, which includes the installation of more than 150 long-distance highway fast chargers across the country, and more than 300 chargers in 11 designated urban areas in the U.S., including Portland. As of the date of this report, three highway stations are now operational in Oregon in Huntington, Albany, and Grants Pass, with six more in process.[38]

The Cycle 2 investment period will be from July 2019 through December 2021. As it did with Cycle 1, Electrify America is accepting proposals and input from governments and other entities on data that would inform station siting, current or expected community or state EV policies and charging infrastructure plans, and perspectives on fuel cell electric vehicles. Oregon, in partnership with Washington State, submitted proposals to Electrify America for the first two cycles of project approvals. Electrify America is also accepting suggestions on its approach to educating the public on EVs and promoting access to EVs.[39]

## Executive Order 17-21

Looking for every opportunity to reduce Oregon's contributions to GHG emissions, Governor Kate Brown signed EO 17-21, "accelerating zero emission vehicle adoption in Oregon to reduce greenhouse gas emissions and address climate change," on November 6, 2017.[40] The transportation sector is the leading contributor to greenhouse gas emissions in Oregon. Putting more zero emission vehicles on Oregon roads is a key strategy to reducing these emissions.

This EO sets a goal of 50,000 registered EVs in Oregon by 2020, and encourages the adoption of zero emission vehicles by:

- **Increasing Oregonians' access to EVs and EV chargers.**
- **Providing technical expertise and information on EV use and functionality.**
- **Recognizing businesses and organizations that are early leaders in EV adoption.**
- **Enabling State of Oregon agencies to lead by example by reducing barriers to procuring EVs in fleets and EV chargers at State facilities.**

EO 17-21 is being implemented by the Zero Emission Vehicle Interagency Working Group, comprised of five core agencies: the Oregon Department of Energy, Oregon Department of Environmental Quality, Oregon Department of Transportation, Oregon Public Utility Commission, and the Department of Administrative Services. The ZEVIWG works with other agencies and external partners to drive EV adoption in Oregon and help the state achieve its GHG reduction goals.

## Utility Transportation Electrification Plans

Legislation passed in 2016 has enabled Portland General Electric, Pacific Power, and Idaho Power to implement plans to increase electric vehicle use in their respective service territories after approval by the Oregon Public Utility Commission. The Commission has approved pilot programs submitted by Pacific Power, PGE, and Idaho Power aimed at increasing transportation electrification in their areas. Pacific Power will implement a public charging pilot, an outreach and education pilot, and a demonstration and development pilot. PGE will implement pilots for public charging stations, electrified mass transit with TriMet, and an outreach and demonstration pilot. Idaho Power will be providing educational material, showcasing its EV fleet, and providing training on EVs for electricians, first responders, and auto dealers:

- PGE Docket UM 1811[41]
- Pacific Power UM 1810[42]
- Idaho Power Docket UM 1815[43]

PGE and Pacific Power are also developing plans to spend the revenues earned by selling clean fuels credits under the Oregon Clean fuels Program generated on behalf of their EV-owning customers. Principles in monetization and on how to spend the revenue were approved by the PUC on October 9, 2018, and initial plans are to be submitted by March 31, 2019.

- UM 1826[44]
- AR 609[45]

## Utility-Specific Charger Incentives

Consumer-owned utilities are offering incentives to customers who install EV charging infrastructure. For example:

- Central Lincoln People's Utility District offers a $250 rebate for installing a level 2 charger.
- City of Ashland Municipal Utility offers up to $500 to install workplace charging

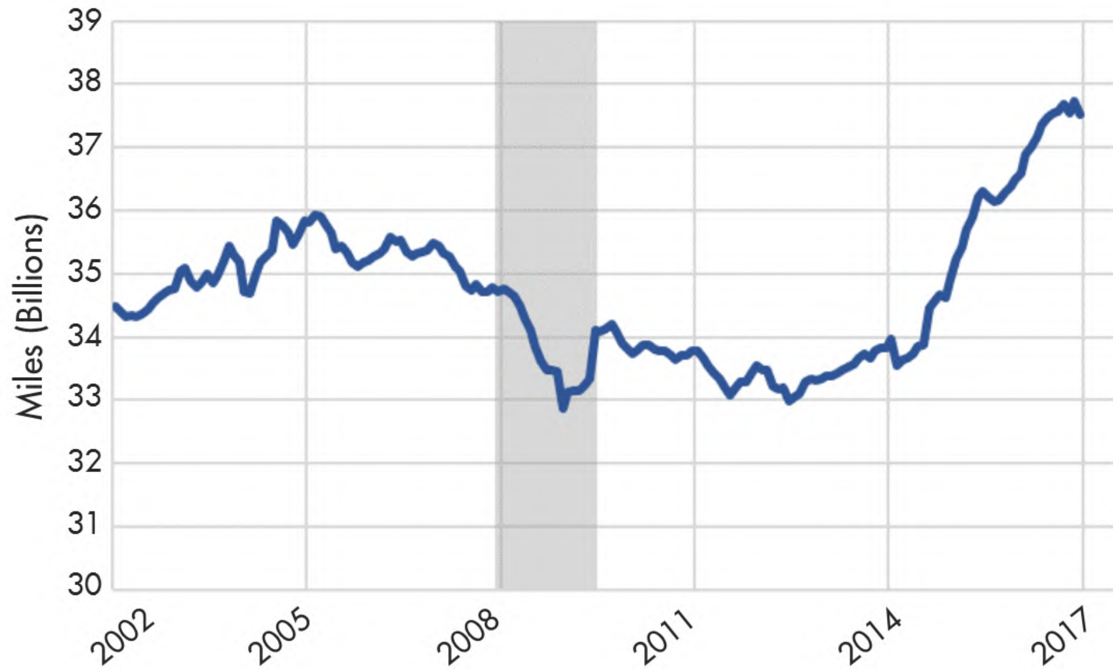

# Policies for Reducing Vehicle Miles Traveled

While vehicles are becoming more efficient and fuels are becoming cleaner, these gains are being offset by the increasing number of vehicles in Oregon[79] and the number of vehicle miles traveled (VMT) per vehicle. Figure 4.18 shows that statewide VMT decreased from 2005 through 2013 due to economic effects of high oil prices and the Great Recession. Since 2014, VMT has risen in the state as the economy rebounded and gas prices fell and remained relatively low. GHG emissions are rising with increased VMT as well. Until a sufficient number of Oregon vehicles are no- or low-emissions, rising VMT will continue to be the most significant driver in rising GHG emissions.

Current trends of increasing VMT aside, Oregon's integration of land use planning and transportation investments, in addition to a growth strategy that emphasizes more compact, pedestrian, and transit friendly development within existing urban areas, have kept VMT lower than they might otherwise have been. Oregon has long been a leader in transportation and land use planning, recognizing that community planning that makes the now-obvious connection between them will reduce VMT and yield more livable communities.

Comprehensive planning by cities and counties to achieve statewide planning goals began in earnest following the passage of Oregon's landmark Senate Bill 100 in 1973.[75] In the early 1990s, the Department of Land Conservation and Development, which oversees implementation of that law, adopted rules to require local governments and state agencies to consider the effects of their zoning decisions on transportation facilities, and the effects of their transportation decisions on land use patterns. In 2009 (House Bill 2001[76]) and 2010 (Senate Bill 1059[77]) the legislature called for Metro and the Central Lane Metropolitan Planning Organization (MPO) to develop planning scenarios that integrated transportation and land-use so that the light duty sector met its share of the overall transportation sector's GHG reduction targets. Modelling was done using ODOT's Regional Strategic Planning Model (formerly the "GreenSTEP" model), and the Integrated Transport and Health Impact Modeling Tool developed by the United Kingdom Public Health Research Center. The preferred scenario in the Central Lane MPO plan, even with a 25 percent expected increase in population over the next 20 years, anticipates significant benefits, such as: a 20 percent reduction in GHG emissions, a 15 percent reduction in VMT per person, no increase in congestion over today's condition, household driving costs as a percentage of income would stay about the same as today, annual fuel expenses could be reduced by as much as $50 million per year, common air pollutants could decrease by two-thirds, and overall community health care savings that could exceed $22 million per year.[46]

**Figure 4.18: Oregon Statewide Total Annual Vehicle Miles Traveled, 2002-2017[47]**




Single occupancy vehicles (SOV) as a primary mode of transportation is one of the leading factors increasing VMT, which increases fuel use and air pollution, including GHGs. Rising use of SOVs also creates more traffic congestion and longer times spent in traffic. According to the 2017 INRIX Traffic Scorecard, people in Portland spend 11 percent of their commute time driving in congested traffic, 10 percent in Bend, and five percent in Salem. Although this does not take into account the reduced VMT resulting from compact urban growth, the stop-start movement during congested times of the day burns fuel at a higher rate, increasing fuel consumption and emissions. More time spent in traffic also results in higher transportation costs for individuals and businesses that rely on transportation.[48]

## Oregon Transportation Plan

Multiple state agencies have policies, programs, and strategies designed to reduce statewide VMT, including advancing walking, biking, transit, and shared transportation. The overarching guidance document for transportation in Oregon is the Oregon Transportation Plan, or OTP. Created and implemented by ODOT, it is the long-range transportation system plan for the state. It establishes a vision and policy foundation to guide transportation system development and investment. The OTP and its associated focus-area plans guide decisions by ODOT and other transportation agencies statewide,

### THE COST OF TRAFFIC

The INRIX Global Traffic Scorecard ranks Portland congestion as the 12th worst in the U.S. The report estimates that the congestion cost $1,648 per driver and **$3.9 billion** to the City of Portland in 2017.[48]

and is reflected in the policies and decisions explained in local and regional plans. Several of the focus-area plans such as the Oregon Public Transportation Plan, the Transportation Options Program, and the Oregon Bike & Pedestrian Plan discuss reducing VMT and conserving energy.

Recognizing that an increasing population has changed the transportation landscape for many Oregonians, the Oregon Transportation Commission adopted the 2018 Oregon Public Transportation Plan (OPTP) on September 20, 2018.[49] The OPTP is one of several mode and topic plans that refine, apply and implement the Oregon Transportation Plan. The new OPTP establishes a shared statewide vision for public transportation and provides strategies to achieve the vision. The plan acknowledges that developing a robust public transportation system advances Oregon's efforts to reduce transportation-related GHG emissions and conserve energy. Goals include increasing accessibility and connectivity, improving the user experience, and strategic land use and investments. The OPTP does not discuss specific projects but helps to provide a policy and strategy framework to inform decisions for local, regional, and state agencies.[50]

## OPTP VISION

"In 2045, public transportation is an integral, interconnected component of Oregon's transportation system that makes Oregon's diverse cities, towns, and communities work. Because public transportation is convenient, affordable and efficient, it helps further the state's quality of life and economic vitality and contributes to the health and safety of all residents, while reducing greenhouse gas emissions."[49]

### Transportation Options Program

When comparing auto trips to transit trips, even a fairly empty bus with seven or eight passengers emits less per passenger mile than an average car trip.[51] As transit agencies integrate more energy efficient and low-carbon fuel vehicles into their fleet, transit-related emissions will continue to decrease. The Oregon Transportation Options Plan identifies opportunities to expand transportation choices; looks to increase funding opportunities for transportation options programs and activities; and provides direction to better integrate transportation options into local, regional, and state transportation planning.

The program administers federal grant funds and collaborates on planning activities with local transit agencies, counties, or Metropolitan Planning Organizations. The program also helps mitigate congestion for major construction projects, safety corridors, and other congestion points. The program manages Drive Less Connect, which helps connect Oregonians with multi-user travel options, as well as the Drive Less Challenge, that encourages the public to become familiar with other transit options such as carpooling, biking, walking, and transit.

### Oregon Bike and Pedestrian Plan

The Oregon Bike and Pedestrian Plan examines walking and biking from an infrastructure and user perspective and recognizes issues, opportunities, and needs. It includes all aspects of delivering a transportation system, including policies and strategies that cover planning, investing, constructing, and maintaining walking and biking facilities and programs. When fully implemented, the Plan envisions a future that builds upon Oregon's strong existing foundation by further increasing walking and biking connections to critical destinations and other modes of transportation. In turn, this will help bring about a safer system for all users that leverages opportunities to enhance the system and creates more equitable access for all users.

It is difficult to estimate actual energy and emissions reductions from biking and walking, but it is widely acknowledged that using these options alone or combining these modes with transit options can reduce VMT from single occupancy vehicles and thereby fuel consumption and emissions.[52]

## 2017 Transportation Bill – HB 2017

The "Keep Oregon Moving" Act[74] included provisions that enable state agencies to build on or start new programs and analyses that promote walking, biking, and transit options in our transportation system. The Act includes provisions that can help some of the programs mentioned above to meet their goals. A statewide transit tax through employee deductions will finance local investments in and improvements to local public transportation with the goal to increase ridership that will thereby reduce fuel consumption and emissions. Light rail projects are excluded from the program. The bill also includes developing a traffic congestion relief program that will manage travel demand and ease traffic congestion which has potential to reduce fuel consumption and emissions. Such a congestion relief program is subject to federal approval.

## Transportation & Growth Management Plan

The Transportation & Growth Management (TGM) program is a partnership of the Oregon Department of Land Conservation and Development and ODOT. The program helps local and county governments across Oregon with skills and resources to plan long-term, sustainable growth in their transportation systems in line with other planning for changing demographics and land uses. TGM encourages governments to take advantage of assets they have, such as existing urban infrastructure, and walkable downtowns and main streets.[53]

While there is significant action at the state level to reduce VMT, many strategies to increase walking, biking, and public transportation are pursued at the local level. Many of these activities are coordinated and implemented by Metropolitan Planning Organizations, that are responsible for developing the transportation plan for a metropolitan area. While this report does not look at local actions in detail, the Metro Regional Transportation Plan is a key example of steps being taken by local jurisdictions.

## Metro 2018 Regional Transportation Plan / Climate Smart Strategy

The Metro Regional Transportation Plan[54] is a blueprint to guide investments for all forms of travel such as motor vehicles, transit, bicycles, and walking; as well as the movement of goods and freight throughout the Portland metropolitan region, and is the main tool for implementing the region's Climate Smart Strategy. The plan identifies current and future transportation needs, investments needed to meet those needs and what funds the region expects to have available over the next 25 years to make those investments a reality.

As directed by the Oregon Legislature in 2009, the Metro Council and the Joint Policy Advisory Committee on Transportation (JPACT) developed and adopted a regional strategy to reduce per capita greenhouse gas emissions from cars and small trucks (light-duty vehicles) by 2035 to meet state targets. Adopted by the Metro Council and JPACT in December 2014 with broad support from community, business and elected leaders, the Climate Smart Strategy relies on policies and investments that have already been identified as local priorities in communities across the greater Portland region. Metro, in partnership with ODOT, conducted a detailed modeling analysis of various greenhouse gas scenarios and identified the types of transportation-related mitigation strategies that would have the greatest potential for reducing greenhouse gas emissions in the long term.

Analysis of the draft 2018 RTP found the plan makes satisfactory progress towards implementing the Climate Smart Strategy and, if fully funded and implemented, can reasonably be expected to meet the state-mandated targets for reducing per capita greenhouse gas emissions from cars and small trucks (light-duty vehicles) for 2035 and 2040. By 2040, the plan, together with advancements in fleet and technology, is expected to reduce total annual greenhouse gas emissions from all on-road vehicles by 19 percent (compared to 2015 levels) and annual per capita greenhouse gas emissions from all on-road vehicles by 40 percent (compared to 2015 levels). The findings also demonstrate that more investment, actions and resources will be needed to ensure the region achieves the mandated greenhouse gas emissions reductions defined in OAR 660-044-0060. In particular, additional funding and prioritization of Climate Smart Strategy investments and policies will be needed. The Metro Council is anticipated to adopt the 2018 Regional Transportation Plan on December 6, 2018.[54]

Even with all these programs, policies, and plans, VMT continues to rise in Oregon. Efforts to reduce single occupancy vehicles are being offset by a growing population of people who are driving more. Increases in VMT and associated traffic congestion will increase overall fuel use and air emissions. Offering viable travel options for those who don't have a car or want options other than car travel reduces VMT which lowers GHG emissions per passenger mile. As long as gasoline and diesel powered vehicles are the primary vehicle on Oregon roads VMT will also drive up the state's GHG emissions. These strategies will do far more than reduce greenhouse gas emissions. Properly designed and implemented, they will also improve the quality of life in our rural and urban communities, improve public health,

**Figure 4.19: Climate Smart Strategy: Strategies Evaluated and Findings[55]**

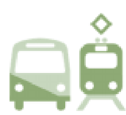
**Strategies Evaluated and Findings**

**Climate Smart Strategy | Largest potential carbon reduction impact***

**Vehicles and Fuels (Investment)**
- Newer, more fuel efficient vehicles
- Low- and zero-emission vehicles
- Reduced carbon intensity of fuels

**Pricing (Policy)**
- Carbon pricing
- Gas taxes
- Per-mile road usage charges (e.g., OReGO)
- Parking management and pricing
- Pay-as-you-drive private vehicle insurance

**Community Design (Policy with Investment)**
- Walkable communities and job centers facilitated by compact land use in combination with walking, biking and transit connections



**Transit (Investment)**
- Expanded transit coverage
- Expanded frequency of service
- Improvements in right-of-way to increase speed and reliability of buses and MAX

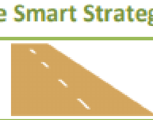
**Climate Smart Strategy | Moderate potential carbon reduction impact***

**Active Transportation (Investment)**
- New biking and walking connections to schools, jobs, downtowns and other community places


**Travel Information and Incentives (Investment)**
- Commuter travel options programs
- Household individualized marketing programs
- Car-sharing and eco-driving techniques


**System Management and Operations (Investment)**
- Variable message signs and speed limits
- Signal timing and ramp metering
- Transit signal priority, bus-only lanes, bus pull-outs
- Incident response detection and clearance

**Climate Smart Strategy | Low potential carbon reduction impact***



**Street and Highway Capacity (Investment)**
- New lane miles (e.g, general purpose lanes, auxiliary lanes)

Source: *Understanding Our Land Use and Transportation Choices Phase 1 Findings* (January 2012), Metro.

and help Oregon compete in the national and global economy.

Data on these programs and their impact on GHG emissions is limited. Measuring the impact of walking, biking, and transit on energy use and GHG emissions is challenging, but can help prioritize where to focus policies, programs, and funding to have the greatest impact on GHG emissions.

# Potential Future Strategies

As detailed throughout this chapter, Oregon has a long history of pursuing policies that reduce greenhouse gas emissions and fuel use in the transportation sector, but these must be expanded upon and accelerated if the state is going to achieve its goals. The state will need to prioritize building on the progress made in the Statewide Transportation Strategy and focusing on a three-pronged approach of promoting cleaner vehicles, cleaner fuels, and lower VMT.

One trend that is gaining increasing attention from transportation experts and has the potential to change how Oregonians travel in the future is Connected and Autonomous Vehicles (CAVs). As automated driving technology continues to evolve, smart sensors and cloud networking may allow vehicles to connect to one another and the surrounding infrastructure. The effects of these technologies are the subject of recent studies and analysis, but results so far are often broad and inconclusive. Some studies have indicated that CAVs may reduce per-vehicle emissions while increasing VMT, which could result in an overall increase in greenhouse gas emissions and fuel use.[56] More research is needed to determine how these technological advancements will impact fuel efficiency, congestion, and safety. For example, ODOT led an Autonomous Vehicle Task Force in 2018 that looked into how CAVs intersect with licensing and registration, insurance and liability, law enforcement and accident reporting, and cybersecurity.[57]

## EVs – The Future of Transportation?

Electric vehicles offer Oregon a cost-effective and efficient pathway to reduce greenhouse gas emissions, reduce fuel use in the transportation sector, and can leverage the increasingly clean electricity mix in Oregon to help reduce GHG and eventually help reduce costs for consumers. Not only are the tailpipe emissions from an EV much lower than an internal combustion engine (ICE) vehicle (and in the case of battery electric vehicles it is zero), but as the electricity grid continues to become cleaner the lifecycle emissions of EVs will continue to drop. The opportunities to reduce GHGs are dramatic. The operation and maintenance costs of an EV are also lower than an ICE vehicle, and because many EVs can be fueled at home or the workplace, the cost for fueling infrastructure is lower than other transportation alternatives — though DCFC is still necessary to accommodate longer trips. The cost of electricity used to fuel an EV is regulated, making annual costs easier to predict and allows the public to engage in the process that establishes the rates for that electricity fuel.

Electric cars have been around since the late 1800s, but were historically unable to compete with ICE vehicles due to range limitations – primarily because battery technology was insufficient. Battery technology has matured and is continually improving, allowing for increased vehicle ranges. Today the major barriers to EV adoption are the upfront cost of the EV, primarily driven by the cost of the batteries themselves, as well as the costs to install and maintain charging infrastructure.


## The EV of the Near Future Is Not the EV You Saw Just A Few Years Ago

As recently as a few years ago, EVs were limited to ranges under 100 miles and there were few models available from a limited number of manufacturers. Today, many new EVs have ranges over 200 miles, and vehicles with 300-mile ranges will be available in the near future.

**Electric Vehicle Trends**

| Typical EV (model year) | 2015 | 2020 |
|---|---|---|
| Total Range in Miles | 80 | 300+ |
| DC Fast Charge: Miles Charged in 15 Minutes | 44 | 134 |

### The Technology

Electric vehicles are about four times more efficient than their ICE counterparts, meaning an EV can go the same distance on 20 to 25 percent of the energy used in an ICE vehicle. EVs convert about 59 to 62 percent of the electrical energy from the grid to power at the wheels. Conventional gasoline vehicles only convert about 17 to 21 percent of the energy stored in gasoline to power at the wheels.[58]

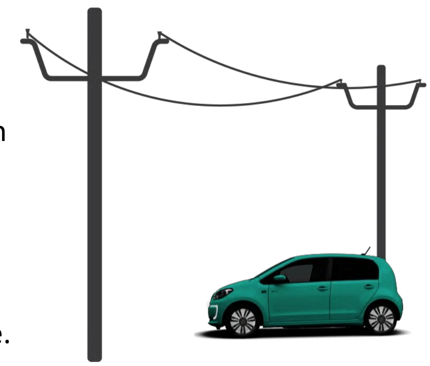
Table 4.3 compares energy use and costs for a typical gasoline-powered vehicle and an electric vehicle. Assuming 12,000 miles traveled in a year, the EV uses far less energy – with an equivalent savings of 373 gallons of gasoline and $1,044 per year. Fueling the EV is 28 percent of the cost to fuel the ICE.

**Table 4.3: Efficiency, Fuel, and Costs for Gas-powered Vehicle vs. Electric Vehicle[5]**

| 12,000 Miles/Year | Gasoline-powered Vehicle | Electric Vehicle |
|---|---|---|
| Efficiency (typical 2017 model) | 25 mpg | 3.33 miles/kWh |
| Fuel Needed | 480 gallons gasoline | 3,600 kWh |
| Fuel Equivalency | = 16,200 kWh | = 107 gallons gasoline |
| Cost per Mile | $3/gallon or $0.12 per mile | $0.11/kWh[59] or $0.03 per mile |
| Annual Fuel Costs | $1,440 | $396 |
| **Annual Savings** | **—** | **373 gallons gasoline<br>$1,044** |

EVs also cost less to maintain, with no engine oil, belts, transmission oil, differential oil, spark plugs, etc. to replace. Regenerative braking on an EV means brakes will last about twice as long as they would on an ICE vehicle because an electric motor contributes a percentage of the energy to stop the vehicle, rather than the brakes doing 100 percent of the job. Because most EV charging happens at home, about 90 percent on average, time going to a gas station is also saved.

### The Fuel - Electricity



In Oregon, electricity is generated from diverse resources, many of which are domestically generated, including hydropower, natural gas, wind, coal, solar, nuclear, and others. Unlike petroleum, electricity prices are regulated and rarely experience supply and cost volatility. An electrified transportation sector increases flexibility and diversity, and decreases dependence on imported petroleum products.

The backbone of electrical energy already exists: the generation, transmission, and distribution of electricity can be found almost everywhere. Generally, all an EV needs is the final connection from the EV to the electric grid. The electric power sector is essentially designed as an on-demand system, and has been built to handle scenarios of high demand.

As more of Oregon's transportation sector becomes electrified, electricity demand will increase. Based on an average annual VMT of 11,343 miles per vehicle and 3.3 miles traveled per kWh of electricity consumed, it is estimated that the average battery electric vehicle will add approximately 3,347 kWh of annual energy demand. Generally the region should have sufficient energy available to meet expected EV demand in the short term. As an example, according to BPA, even in years with low hydropower output, the Pacific Northwest is expected to have a surplus of both available energy (average MW) and of capacity (MW) for operating year 2019.[60] Even in the month with the least amount of surplus energy expected (January), there will be sufficient energy available to meet the charging needs of large numbers of EVs across the Pacific Northwest.

A bigger constraint will be the availability of surplus capacity during heavy demand times. According to the same data from BPA, January will also have the smallest amount of available capacity, limiting the volume of battery electric vehicles that could charge at a given time during the month, particularly during the overall system peak. This trend is likely to bear out across the region as EV adoption increases in coming years—making it more important for utilities to consider ways to incentivize or otherwise encourage battery electric vehicles to charge at times most optimal for the grid to avoid system capacity constraints.  With the ability to shift charging to off-peak hours Oregon could add significant numbers of EVs without needing to build or procure additional generation resources.[61]

In addition to the need for generation to supply the needed electricity for EV charging, there may be a need to strengthen local distribution systems to account for the higher loads that EVs draw. For example, transformers can fail when the local electric demand on their circuit becomes too great. If utilities know where these vehicles are being garaged in their networks, they can plan their transformer upgrades and replacements to accommodate the larger loads as needed.

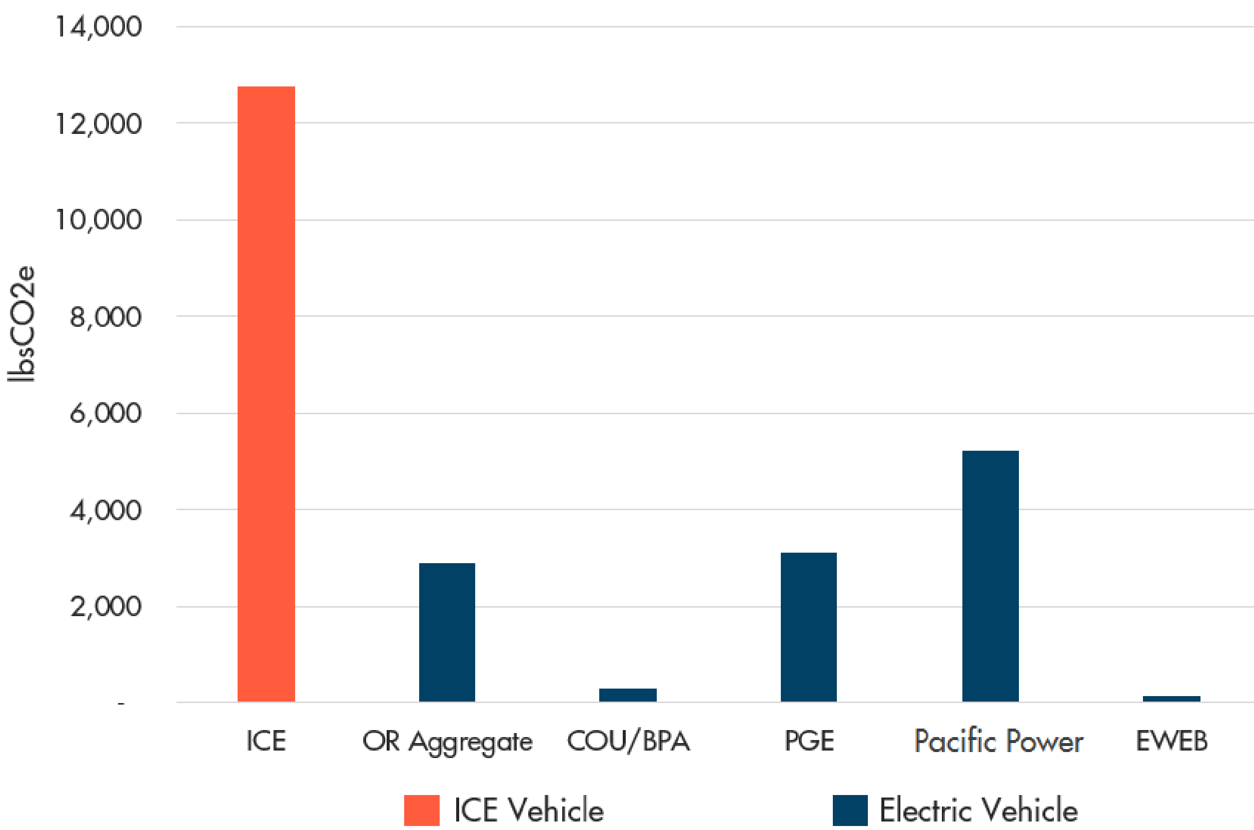
### Emissions

Because EVs do not combust fuel, they have no tailpipe emissions. High levels of EV adoption would improve air quality in urban and high-traffic areas around the state. Improving air quality will improve health outcomes, as air pollution has been found to be associated with increased risk of asthma and lung and heart disease.

GHG emissions associated with driving an EV are largely influenced by what type of generation resources are used to produce the electricity. Overall, emissions from Oregon's electricity sector have been trending downward, and are expected to continue to become less carbon-intensive over the next few decades. Because the electricity generation is the source of emissions (not the EVs themselves), decarbonizing the electricity grid will further reduce emissions from an EV as it ages. In contrast, the fuel source for ICE vehicles is gasoline, which is much more difficult to decarbonize.

Figure 4.20 illustrates the comparison of a Ford Fusion (internal combustion engine or ICE vehicle) versus a Chevy Bolt (EV) charged at five different utility service territories traveling on average 11,343 miles over the course of one year. The EV has anywhere from a 60 percent to more than 95 percent improvement over the ICE counterpart, and as Oregon's utilities invest in cleaner technologies to produce electricity, overall emissions from the transportation sector will also improve with the growth of EV adoption.

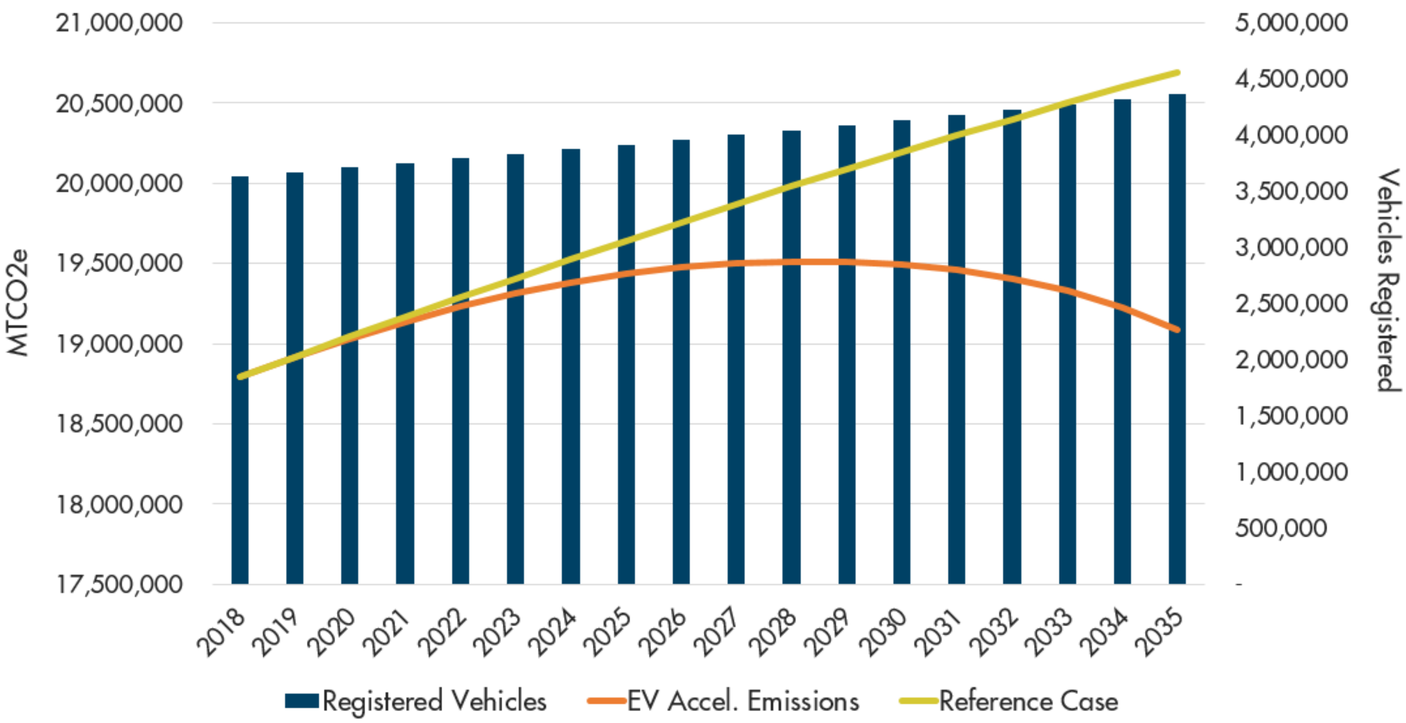
**Figure 4.20: Annual Vehicle GHG Emissions in Oregon — ICE vs. EV**[78]



## The Role for EVs in Achieving Oregon's Climate Goals

Finding significant reductions in emissions in the transportation sector is key to the state achieving its GHG emissions reduction goals. Using the U.S. DOE's Annual Energy Outlook assumptions, ODOE compared the baseline EV growth in the reference case with an enhanced EV growth scenario based on anticipated impacts of state policies and goals currently in place. The baseline scenario assumes EV adoption at about 12 percent of new car sales by 2035, while the enhanced scenario puts EV adoption at 48 percent. Without the level of EV adoption indicated in the enhanced scenario, GHG emissions continue to rise through 2035. The enhanced EV scenario shows emissions plateauing in the late 2020s and beginning to drop by 2030.

**Figure 4.21: GHG Emissions with Accelerated EV Growth vs. AEO Reference Case**[5,7]



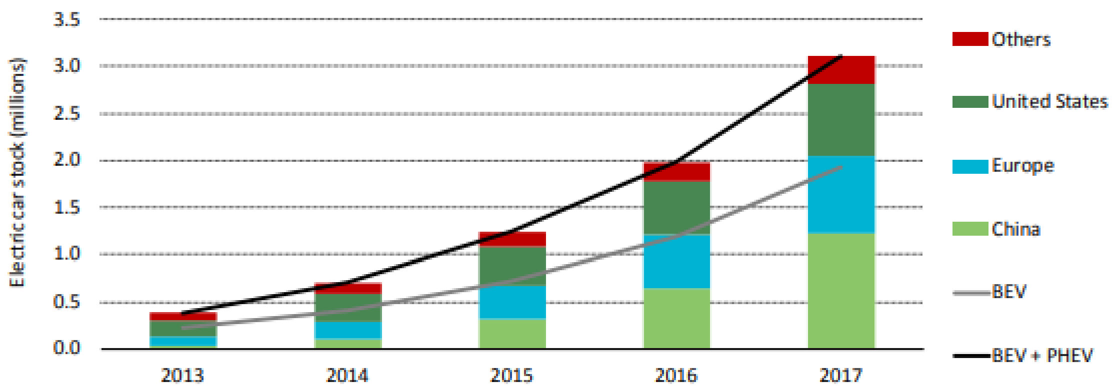

## EVs and the Future of the Grid

EVs have the potential to add other benefits to the electrical system, such as the ability to store and pull energy from batteries in order to better manage the electricity grid. EVs do most of their charging overnight when energy demand is low and electricity generation resources are not being used to their full potential. EVs can help balance electricity production and demand by storing this plentiful nighttime energy during periods of low demand. Although not yet available, Vehicle-to-Grid (V2G) technology has the potential to make it possible to store surplus electricity generated from intermittent renewable resources like solar and wind in EV batteries during non-peak periods and also feed power back to the grid when needed. U.S. DOE's National Renewable Energy Laboratory is working on many facets of this technology, including testing facilities that work on grid-vehicle interactions as well as investigating how energy efficiency, renewable energy, and sustainable transportation technologies can increase the capacity, efficiency, and stability of the grid.[62] Not only can EV batteries help Oregon more fully utilize its renewable electricity resources, but using EV batteries to store and deliver electricity when needed can enhance grid stability, reduce electricity costs at peak hours, or increase resiliency by allowing the batteries in EVs to act as a power source in case of an emergency grid failure.

## EV Trends

According to the International Energy Agency's Global EV Outlook 2018 report, more than one million electric vehicles were sold in 2017, with more than half sold in China. Europe and the U.S. had the next highest EV sales. Overall, there were more than 3 million electric passenger cars on the world's roads at the end of 2017, with 40 percent of those in China and 25 percent each in the U.S. and Europe.

**Figure 4.22: Passenger Electric Car Stock in Major Regions and the Top Ten EVI Countries**[63]

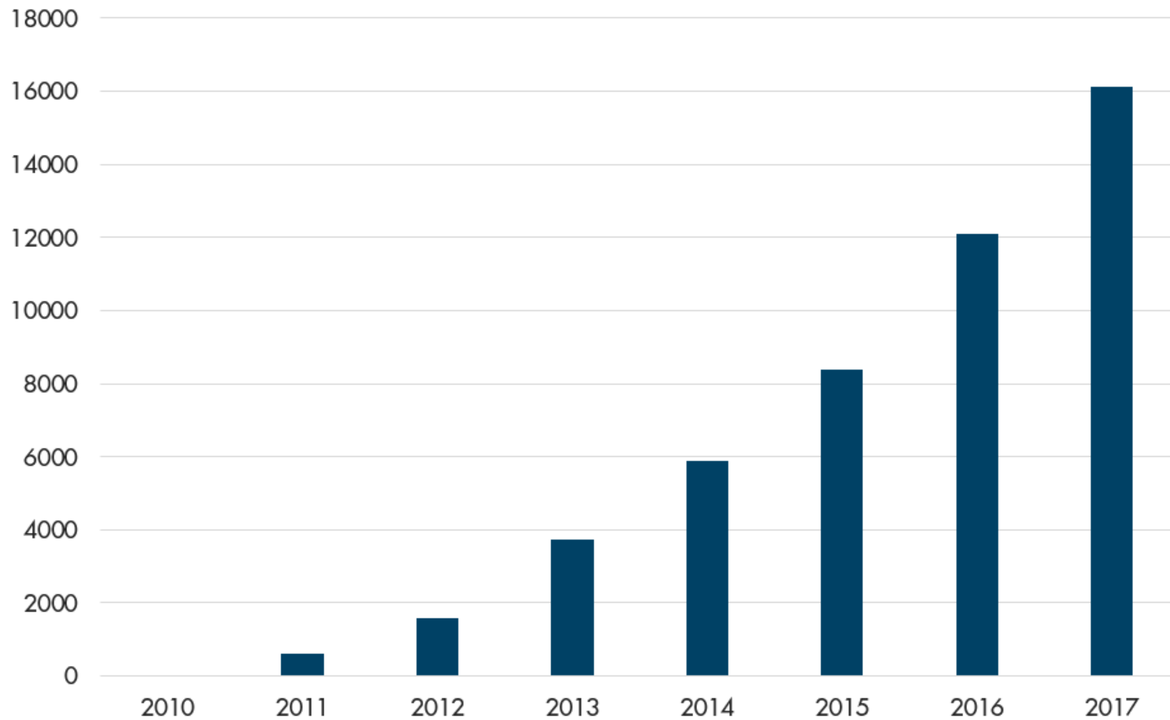



Since 2010, electric vehicles have shown steady growth, as the sales chart below from Inside EVs illustrates.

**Figure 4.23: U.S. Plug-in Car Sales**[64]


The Oregon Department of Transportation tracks registrations of EVs, which show similar steady growth trends in Oregon. As of June 30, 2018, Oregon had 17,893 registered electric vehicles – an over 31 percent year-over-year increase since 2014.

**Figure 4.24: Cumulative Total EV Registrations by Year in Oregon**[79]

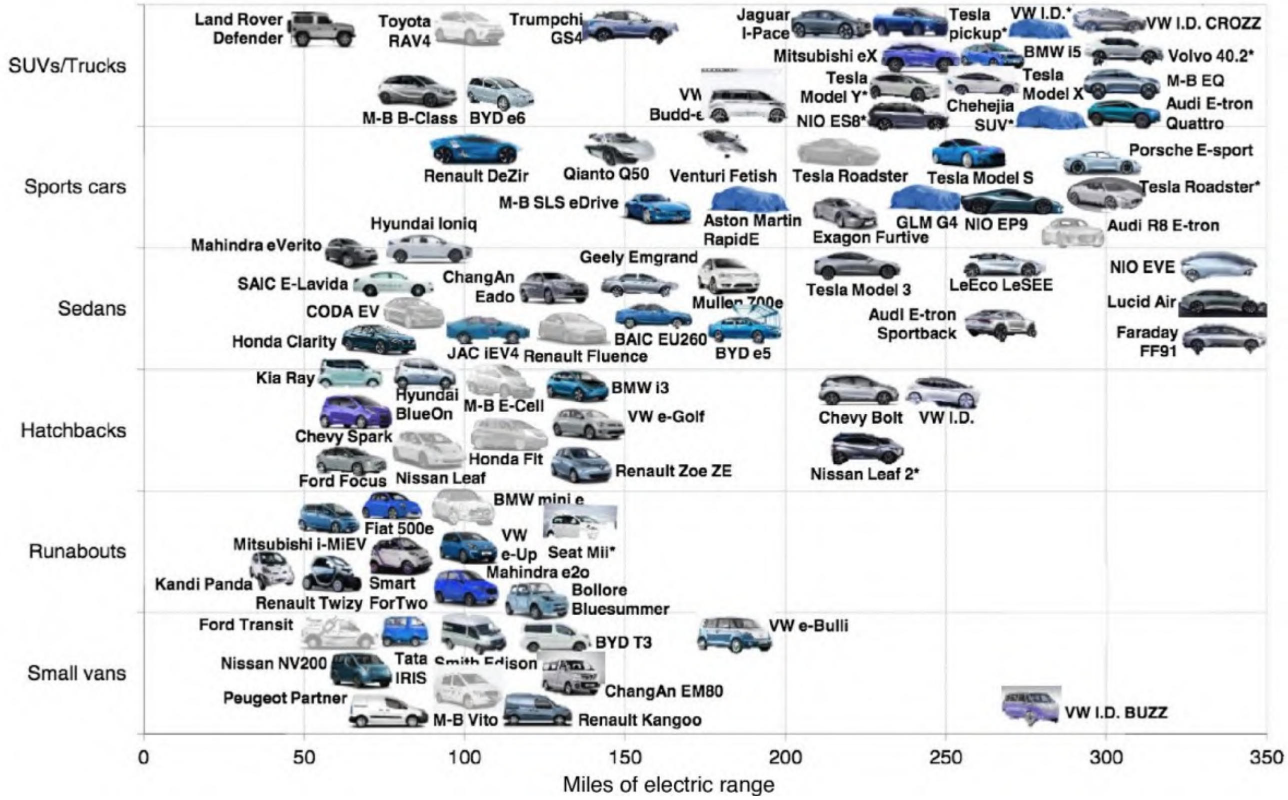



## EV Model Availability

Most of the major automobile manufacturers have EV models available, and even more models are coming in the next few years. In Oregon, based on DMV registration information, the highest selling vehicles today are pickups, SUVs, and compact SUVs, which are not currently available as EV models, or are only available in the luxury vehicle segment. Many manufacturers have committed to providing these EV models in the coming years, and with them comes a new pool of potential EV adopters.

Figure 4.25 illustrates what car manufacturers have committed to producing. No vehicle manufacturer has yet committed to the production of an EV pickup truck, however. Because pickups make up one of the highest sales segment of light-duty automobiles in Oregon, the development of an EV pickup truck is vital to the state moving to a high EV adoption future. In the chart, vehicles that are grayed out are models no longer in production. Used vehicles are available.

**Figure 4.25: Electric Vehicle Models by Style and Range Available Through 2020[65]**

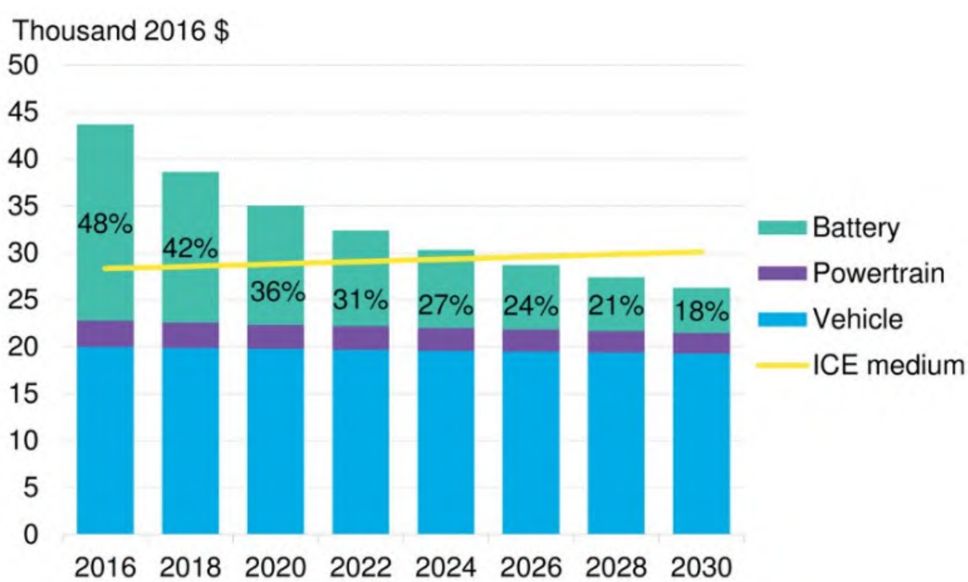



## Cost Parity with ICE Vehicles

EVs today are generally more expensive than their internal combustion engine counterparts, mostly due to the cost of EV batteries. Although EV incentives can help offset the expense, the cost differential is still sufficiently high that it prices many people out of the EV market.

EV battery costs are declining. According to Bloomberg New Energy Finance, battery pack prices have gone from $1,000/kWh in 2010 to an average price of $209/kWh at the end of 2017 – a 79 percent drop in 7 years. Bloomberg estimates the price of a battery per kWh should reach $100 by 2025. $100 is the price that many in the industry point to as the parity price point, or the point at which the costs to produce ICE and electric vehicles will be the same. Beyond 2025, EVs will likely be less expensive than comparable ICE models.

**Figure 4.26: Cost Parity for Battery Vehicles vs. Internal Combustion Engines[66]**



Until parity is reached, incentives can be an effective tool to reduce the price gap, increase sales, and help the industry get to scale more quickly and drive the price down. For example, looking at some of the incentives discussed earlier in the chapter the cost of an EV could be reduced by more than $10,000.

**Figure 4.27: Sample EV Cost After Incentives**

| $37,495 | Kelly Blue Book MSRP |
|---|---|
| - $7,500 | Federal Tax Credit |
| - $2,500 | Oregon Clean Vehicle Rebate |
| - $300 | Local Rebates* |
| $27,195 | Cost After Stacked Incentives |

**Could include City of Ashland Empower EV Incentive Pilot Program or Eugene Water & Electric Board Clean Ride Rebate*

All incentives are subject to eligibility requirements, such as the type of EV purchased. In addition, not everyone will be able to use all of the incentives even if they are eligible. For example, the Federal Tax Credit can only be used by individuals who have a sufficient tax liability, which could exclude many low-income individuals. Many incentives are lower for PHEVs compared to full BEVs, and some incentives are only available to the customers in a specific utility service territory. Most incentives, however, can be used together which may have the impact of making an EV purchase more financially viable.

As discussed earlier the federal tax credit phases out once manufacturers sell 200,000 vehicles, and several manufacturers have reached or are about to reach the limit. Bills to extend or broaden the tax credit have been introduced in Congress. The Electric Cars Act of 2018, sponsored by Senator Jeff Merkley of Oregon and others would extend the tax credit for 10 years. A second bill proposed by Senator Dean Heller of Nevada would lift the cap and extend the credit for four years.

## EV Charging at Home

If EVs are driven the way typical conventional gasoline vehicles are driven, where 70 percent of daily driving is under 40 miles and 95 percent is under 100 miles,[67] EV charging can be completed at home, provided parking and power are readily available. Most EVs can be plugged into a standard outlet to charge, or the plug can be upgraded to a 220 V connection, enabling faster charge times. Figure 4.28 illustrates the theoretical miles of range that can be attained by an EV that averages 3.33 miles/kWh and has a battery large enough to accept the example power capacities over the time frames in the example.

**Figure 4.28: Charging Times for Level 1 and Level 2 Chargers[80]**

| Charger Type | Power Level | Distance After One Hour Charging* | Distance After Eight Hours Charging* |
|---|---|---|---|
| Level 1 | 1.75 kW | 5.78 Miles | 46.2 Miles |
| Level 2 | 6.6 kW | 21.78 Miles | 174.24 Miles |

**Based on an average of 3.3 miles/kWh*

There are many Oregonians, such as renters, who live in areas without dedicated parking or where parking areas lack charging capabilities, and this constitutes a significant barrier to EV adoption. About 25 percent of Oregonians live in multi-family rental housing statewide; in Portland that percentage grows to 47 percent.[68,69] Portland General Electric has committed to investigating a fueling station model for charging EVs that could be located in parts of the Portland metropolitan area that lack EV-capable parking.[41] In her Executive Order referenced earlier in this chapter, Oregon Governor Kate Brown directed the Building Codes Division of the Department of Consumer and Business Services to ensure that all newly-constructed residential and commercial buildings have parking with the electric infrastructure necessary to install a Level 2 EV charger by October 1, 2022.[40]

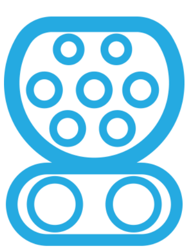
## EV Charging on the Road

In addition to providing adequate charging infrastructure for people to charge at or near their homes, it is also necessary to ensure that sufficient charging infrastructure is in place for travelers who need to travel further or for longer periods of time than the battery range of their vehicle. Unlike home charging, which can generally occur overnight, chargers for extended travel need to be able to recharge a vehicle's battery in a relatively short amount of time so that the traveler can get back on the road quickly.

At the time of this publication, Oregon has 1,272 public charge points at 528 locations or stations.[70] A station can have several charge points, just as a gas station has several pumps. Because several PHEVs can only use Level 1 or 2 charging, a station may have several charge capacities including AC Level 1 and Level 2, as well as DC Fast Charging.

DC Fast Charge (DCFC) stations charge quickly. 109 stations at the 504 statewide public charging sites at the time of this report have DCFC capabilities. However, many of the DCFC stations have multi-charge ports, for a total of 242 DCFC charge points in Oregon. Over 90 percent of these are on the west side of the Cascades.

DCFCs come in three different charging standards: Tesla, CHAdeMO, and Combined Charging Standard (CCS).


Combination Plug (CCS)


CHAdeMO Plug


Tesla SC Plug


Tesla's standard works only on their vehicles. Thirteen of the DCFC stations are Tesla Supercharger sites, with eight charge ports each. The CHAdeMO standard is used primarily for Asian vehicle manufacturers' EVs, such as Nissan, Toyota, and KIA. This is currently the most common standard found in Oregon, at 87 sites. The CCS standard is used primarily by European and North American vehicle manufacturers, although Hyundai has said that a soon-to-be-released all electric model will use this standard rather than the CHAdeMO standard used on some of its earlier models. Thirty locations in the state have the CCS standard. Twenty-one locations have both the CHAdeMO and CCS standards. It is becoming common to include both of these standards at a station, and several manufacturers of charging equipment now manufacture dual-standard equipment. Electrify America has committed to installing both of these standards at all DCFC stations they build.

The rate or speed that that an EV can take on energy is limited by the charger or the EV. In the case of the EV, it is battery size that will determine charge rate; smaller batteries charge more slowly than larger batteries. The first generation of EVs typically had small batteries. Using a DCFC rated up to 50 kW, these could get about 80 miles of range in 30 minutes. Newer, larger capacity batteries allow for much faster charging times. Because of how large capacity batteries are designed, they can be charged quickly, up to 80 percent of the total charge. Additional charging beyond this is tapered or slowed.

The chargers themselves are rated by how much current they can supply. The larger the kW on the charger, the faster it can charge. However, there are also limits depending on the cell's chemistry as to how much current can be applied. Individual batteries may have a limit on the amount of current they can accept. Currently, only the Tesla Supercharger network has chargers over 100 kW in Oregon. Like many other aspects of EVs, this is rapidly changing as Electrify America, PGE, and Pacific Power all plan to install higher powered chargers in the near future. In the next few years, charge rates for vehicles will increase, batteries will be larger, and charge time will decrease dramatically as the theoretical Table 4.4 illustrates.

**Table 4.4: Miles Per Charging Rate and Time for DCFC, For EV Going 3.57 Miles per KWh**[80]

| DCFC (kW) | Miles / Min | Miles / 15 Min | Miles / 30 Min |
|---|---|---|---|
| 24 | 1.43 | 21.42 | 42.84 |
| 50 | 2.98 | 44.63 | 89.25 |
| 80 | 4.76 | 71.40 | 142.8 |
| 100 | 5.95 | 89.25 | 178.5 |
| 150 | 8.93 | 133.88 | 267.75 |
| 300 | 17.85 | 267.75 | 535.5* |
| 350 | 20.83 | 312.38 | 624.75* |

*Charges for 300 and 350 kW would require large batteries to charge for 30 minutes, such as those in heavy-duty vehicles.

At this time, there are eight private networks offering EV charging services in the state. Each network has its own payment model and typically offers a monthly subscription plan or one-time payment. Costs can vary widely and can be dependent on what subscription service is used. Standardizing EV chargers and their transactions would simplify public charging and support increased EV adoption.

## Barriers to EV Adoption

Key barriers to EV adoption include cost, lack of access, and consumers with limited knowledge about this new technology. Incentives can help reduce the initial cost of purchasing the vehicle, as has been discussed in this chapter. In order to make EVs a viable option for Oregonians who are not able to charge at home, state and private investment in public charging infrastructure may be necessary. In rural Oregon, where consumers may have to drive longer distances, this public charging infrastructure along highways and in rural towns is critical.

A companion to incentives and building out a charging network in Oregon is outreach and education. Oregonians have questions about how these vehicles work, whether they will meet their travel needs, and what incentives and support are available to them as they consider purchasing an EV. The state has taken on this education role in response to Governor Brown's executive order on electric vehicles discussed earlier this chapter, using tools such as social media, stakeholder outreach, and a joint website.

### GO ELECTRIC OREGON

In 2018, a collaborative of State of Oregon agencies launched ***Go Electric Oregon***, a website dedicated to helping Oregon achieve our goal of 50,000 registered EVs on our roads by the end of 2020.

In addition to details about Governor Brown's EO 17-21, the website shares details about buying EVs, charging at home and on the go, incentives, and more.

goelectric.oregon.gov

# CONCLUSIONS

Transitioning to a **cleaner, more fuel efficient transportation system** will involve increasing vehicle efficiency, switching to alternative fuels, and reducing vehicle miles traveled. In the Statewide Transportation Strategy, developed by ODOT and informed by DLCD, DEQ, and ODOE, as well as an advisory committee, the state has articulated a long-term vision for reducing transportation-related greenhouse gas emissions that identifies several specific strategies to achieve that vision. ODOT has taken a first step in implementing several activities that fall under their purview. In order to realize significant reductions in this sector all the strategies in the STS need to be implemented. Many of the remaining strategies require engagement and cooperation among state agencies. Development of a clear plan to coordinate the activities of all state agencies, along with strategic engagement with stakeholders, is necessary to implement the remaining activities in the STS.

Implementation of the STS as well as other policies and programs that support **reducing fuel use and emissions in the transportation sector** requires measuring results and the development of key metrics to assess program success. There are challenges in directly measuring GHG emissions or even fuel reductions for many programs that do not have easily measurable activities, such as increasing the amount of biking pathways in a community. Additionally, many strategies to reduce fuel usage are highly dependent on the transportation needs and activities in different regions of the state. There are currently few tools available to collect localized data on vehicle model, vehicle age, vehicle sales, fuel consumption, and vehicle miles traveled. Strategies may need to be specifically designed to accommodate regional differences in Oregon. This information can be used to develop GHG reduction policies or programs designed to target and address the unique needs in different areas in the state.

The state is not on track to achieve the state's GHG emissions reduction goals for 2020, largely due to increases in emissions from the transportation sector. **EV adoption is a key strategy** for the state to reduce GHG emissions from the light-duty transportation sector, which is the largest contributor of GHG emissions. Not only does the initial change to electricity reduce emissions from the tailpipe of the vehicles, but the GHG **benefits to Oregon** of electrifying the transportation sector will continue to grow as the electric grid becomes cleaner.

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# CHAPTER 5: RESILIENCE

The prospect of a major earthquake and tsunami may seem so overwhelming that preparation – by individual Oregonians or their state government – is too big of a task.

But we can do this and we will do it together.

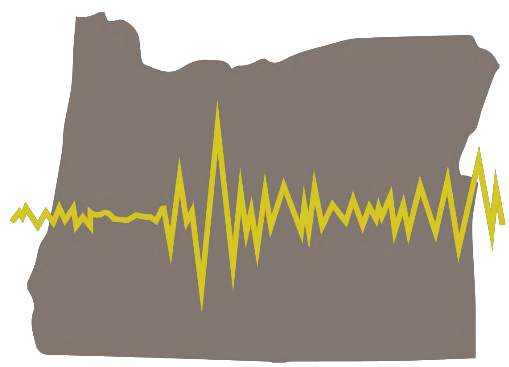
We must build a better prepared and more resilient Oregon, one step at a time.

— Governor Kate Brown, 2016[1]

KEY TAKEAWAYS

- An increased awareness of the threats (e.g., Cascadia Subduction Zone earthquake, climate change, cyber and physical attacks) to Oregon's energy systems, combined with advances in distributed energy resources (e.g., distributed solar and batteries), is creating new interest in **community energy resilience solutions**.
- Entities across Oregon — from state government, to local communities, and individual energy providers — have been taking steps to improve the resilience of the energy sector.
- Oregon can take advantage of technology advancements to make systematic improvements to community energy resilience threats like the Cascadia earthquake and climate change. For example, the state can support the development of community microgrids that can provide emergency back-up power to **support critical public services** following a major disruption to the state's energy systems.
- The state has the opportunity to engage communities to identify mechanisms for funding and deploying community energy resilience and **climate adaptation solutions** that deliver the maximum benefit to those communities.

# Introduction



In 1700, an earthquake struck off the coast of the Pacific Northwest and unleashed a massive tsunami. Geologists have since concluded that the earthquake and tsunami resulted from a major rupture of the Cascadia Subduction Zone (CSZ) fault, and that the region is due for another. When — not if —that occurs, Oregonians are likely to be faced with devastating impacts resulting from a 9.0 earthquake and subsequent tsunami. In addition, the state will experience power outages and disruptions in liquid fuel supply across much of the state that will likely be measured in weeks and months rather than in hours. These energy disruptions have the potential to cripple the response of public agencies and communities to this disaster.

The first part of this chapter explores what activities are currently underway in Oregon to improve the resilience of Oregon's energy sector when facing extreme events, while also considering what more can be done to prepare, with a particular focus on improving community energy resilience. The second part of the chapter focuses on how energy resilience factors into climate change policy discussions. As Americans' understanding of and attention to climate risks has evolved from indistinct future threat to present reality, public and private sector entities around the U.S. and the world are considering how to adapt and build resilience to address long-term, slower changes like sea level rise and changing average temperature and hydrologic conditions, as well as changes to the frequency, duration, and intensity of extreme events like drought, flooding, storms, and wildfires. The chapter summarizes some of the key climate risks and vulnerabilities for Oregon's energy sector and the status of climate adaptation planning efforts.

## Defining Energy Resilience

Improving the resilience of the state's energy systems has emerged as a topic of significant interest within Oregon's energy industry in recent years. This interest stems from several independent factors, including an increased awareness of threats to Oregon's energy systems and rapid advancements in distributed energy resources with the potential to improve community energy resilience.

While resilience has become a commonly used term, there is no widely agreed upon definition within the energy sector. Most definitions, however, include similar themes. For the purposes of this report, resilience is defined as: "the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions. Resilience includes the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents."[2]

The lack of clarity around what energy resilience means specifically is further complicated by the frequent conflation of the term with another that has a longer history in the electric sector: reliability. Resilience and reliability are not interchangeable. In the electric sector, reliability is a well-defined technical attribute for which there is significant government oversight to ensure compliance with established metrics and standards.[3]

These metrics and standards ensure that utilities provide reliable electric service — e.g., avoiding outages or significant disruptions to power quality — to end-use customers under conditions reasonably expected to occur within the grid. These conditions can range from infrequent but predictable events, such as geomagnetic storms that can damage electrical equipment, to routine seasonal weather-related extremes or storms that may affect electricity load or transmission and distribution.

To track service reliability, Oregon's investor-owned electric utilities, for example, file annual reliability reports with the Oregon Public Utility Commission. Portland General Electric, PacifiCorp, and Idaho Power measure and track the overall reliability of their systems using industry standard metrics focused on measuring the frequency and duration of outages and causes.* Resilience has no similar

### RESILIENCE IN THE ENERGY SECTOR

**Resilience:** the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions, including the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents. (Presidential Policy Directive 21.[2])

**Energy Resilience:** the ability of energy systems — from production through delivery to end-users — to withstand and restore energy delivery rapidly following non-routine disruptions of severe impact or duration. (ODOE.)

**Community Energy Resilience:** The ability of a specific community to maintain the availability of energy necessary to support the provision of energy-dependent critical public services to the community following non-routine disruptions of severe impact or duration to the state's broader energy systems. (ODOE.)

*PGE uses the following indices that are based upon methodologies established by the Institute of Electrical and Electronics Engineers (IEEE) Standard 1366: System Average Interruption Duration Index (SAIDI), System Average Interruption Frequency Index (SAIFI), and Momentary Average Interruption Frequency Index (MAIFI).

oversight mechanisms, nor does it have metrics or standards against which a system can be evaluated for compliance.

As this chapter will explore in greater detail, lack of definitions and regulatory oversight notwithstanding, entities across Oregon have been starting to take steps to enhance the resilience of the energy sector. For example, state government has called attention to the need to improve the resilience of the Critical Energy Infrastructure Hub in the Portland metro area. Meanwhile, both investor-owned and consumer-owned electric utilities have been taking proactive steps to reinforce and move infrastructure to make it more resilient to anticipated threats. And lastly, local governments are increasingly thinking about the concept of community energy resilience and the interdependencies of many of their communities' critical public services on the continued delivery of energy following a major disruption to the state's broader energy systems. These efforts will be detailed below in addition to identifying a need to build upon these efforts through a collaborative process to define a community energy resilience vision for the state.

## Identifying Resilience Threats to Oregon's Energy Systems

While reliability standards are focused on how energy systems operate under reasonably expected conditions, energy resilience concerns the ability of energy systems to maintain operation during and recover following an acute non-routine event, typically one of severe impact and/or duration. This section identifies three resilience threats — a Cascadia Subduction Zone earthquake, cyber and physical attacks, and climate change — to consider as the state continues working toward building more resilient energy systems in Oregon.

### Cascadia Subduction Zone

In recent decades, geologists have learned more about the risk to the Pacific Northwest from the Cascadia Subduction Zone (CSZ) — an active seismic fault that parallels the coast of the Northwest approximately 100 miles offshore.[5] By investigating the geologic record, scientists have found that a rupture of the CSZ occurs approximately every 300 to 400 years, with the last rupture occurring on January 26, 1700 — or 318 years ago as of the publication of this report.[5] The chance of a significant rupture of the CSZ occurring within the next 50 years is expected to be between 15 and 20 percent.[6,7,8] The CSZ is capable of producing a megathrust earthquake registering a magnitude of 9.0+ on the Richter Scale with a devastating tsunami to follow.[5] This type of an event has the potential to be similar to the Tohoku earthquake and resulting tsunami that devastated the Sendai region, including the Fukushima nuclear plant, off coastal Japan in March 2011.[5]

*Federal Emergency Management Agency*

The Oregon Resilience Plan (ORP), published in 2013, evaluated the expected effects to different sectors of the economy from a 9.0 earthquake along the CSZ. Chapter 6 of that plan evaluated the expected impacts to the energy sector. The plan identified significant vulnerabilities to the state's Critical Energy Infrastructure

(CEI) Hub, a six-mile stretch of the lower Willamette River northwest of downtown Portland where key liquid fuel and natural gas storage and transmission facilities are located, along with a significant concentration of electric transmission facilities, on soils prone to liquefaction.[5] Given the severe impacts expected to the CEI Hub, there will likely be severe disruptions to liquid fuel deliveries across the state. The plan also found that it could take one to three months to restore electric service in the Willamette Valley, and upwards of six months in coastal areas of the state.[5]

### Climate Change: Redefining Normal

Climate change poses a unique threat to Oregon's energy systems because it has implications for both resilience and reliability. Climate change will affect the frequency and intensity of short-term extreme events like wildfires, floods, and storm surges in certain parts of the state in addition to average weather and hydrologic conditions over longer time horizons.[9,10] Reliability efforts are built around expectations of "routine" disturbances to energy systems that fall within a range of expected conditions based on historical data and experience. Resilience efforts are also typically based on historic data and experience to prepare for extreme, infrequent, or severe impacts.[4] But climate change is projected to alter future conditions to an extent where historical trends are no longer reliable, and a "new normal" for what constitutes expected average and extreme conditions will need to be integrated into decision-making.[11,12]

For example, Oregon is projected to experience higher average temperatures and more frequent and longer-lasting extreme heat events in summer, which could affect reliability if utilities are unprepared for higher electricity loads and reduced transmission capacity of power lines. The metrics and standards that measure reliability may need to evolve accordingly to account for these changes.[20] Climate scientists also expect that climate change is likely to increase wildfire frequency and the area burned in Oregon, which could adversely impact the operation of the electric transmission system. This will heighten the need for enhanced resilience of our energy systems to withstand these still non-routine, though increasingly common, events. Reliability and resilience are concepts that exist on a continuum. If once uncommon events begin occurring with sufficient frequency, they might become reliability issues.[20] A more in-depth consideration of climate vulnerabilities and adaptation in Oregon's energy sector is discussed later in this chapter.

### Cyber and Physical Attacks

The U.S. Department of Homeland Security developed the *National Infrastructure Protection Plan 2013: Partnering for Critical Infrastructure Security and Resilience.*[13] As part of that plan, the U.S. Department of Energy developed a plan for the energy sector in which it identified cybersecurity and physical attacks as a significant threat.[14] In a widely publicized example from 2013, an unknown attacker used a high-powered rifle to destroy several transformers at a substation in California, knocking the substation offline for nearly a month.[14] While that isolated incident did not cause a significant disruption of service, it showed how vulnerable energy systems can be to physical attacks.

Cyberattacks have the potential to cause significant disruptions, particularly given the increasing digital interconnectedness of people's lives. This digital connectivity enables new innovations and savings — such as the deployment of smart meters that allow utilities to remotely monitor energy demand at a particular meter without having to manually check the meter, or the ability of customers to set their home thermostat to respond to specific price signals from the grid, or for electric vehicle chargers to only charge during certain times of day when electricity prices are low. While these new technologies create new opportunities and conveniences, they also create new pathways for cyberattacks. New interconnected entry points into the electric system create an increased risk of cyberattacks that could result in widespread disruptions. These attacks have the potential to target not only the computer software systems that control the energy sector, but also to overload critical infrastructure components beyond their designed operating limits in a manner that results in physical damage.

## Understanding Current Actions

Currently, there is no single state or federal agency charged with evaluating or planning comprehensive improvements to the overall resilience of Oregon's energy systems, inclusive of the production and delivery systems for liquid fuels, electricity, and natural gas. Given this reality and the absence of widely accepted standards or metrics to measure energy resilience, it is difficult to evaluate the current level of resilience of energy systems in the state today. Regardless, as noted above, entities across the state have begun taking actions to address concerns about energy resilience. This chapter provides a snapshot of some of the specific actions currently underway in Oregon at the state level and within individual communities and utilities to improve the resilience of the energy sector and plan for an organized response to a major event.

### State Level Actions

*Energy Assurance Plan*

Supported by federal stimulus funding in 2009, the Oregon Department of Energy, in collaboration with the Oregon Public Utility Commission, developed an Energy Assurance Plan.[15] The plan provides an overview of the state's energy infrastructure and overall energy profile; at a high level, evaluates the role of renewables and smart grid technologies in energy assurance planning; describes different types of energy emergencies that could occur in Oregon; and explains how the state would respond to energy emergencies.

Substation in Canby, Oregon.

ODOE and OPUC are the designated primary state agencies for planning, preparedness, response, and recovery to energy emergencies with potential impacts to Oregonians. OPUC is responsible for developing and maintaining emergency response plans for electricity and natural gas emergencies, while ODOE is responsible for developing and maintaining a fuel sector emergency response plan.

In 2017, ODOE released the Oregon Fuel Action Plan, which details how the state will respond to an event that causes severe shortages of liquid fuels.[16] ODOE developed the Plan pursuant to ORS 175.750-785 to ensure that adequate fuel supplies will be provided to the state's emergency and essential service providers in the event of a severe or long-term fuel disruption or shortage. The Plan, the first of its kind in the nation, identifies nine priority actions ODOE would take to arrange acquisition and delivery of fuel in support of the state's response and recovery efforts in times of crisis. The Plan is a working document and will be updated as needed to ensure that all response strategies remain current and sync with those of our federal, tribal, military, state, local, and industry partners.

## OREGON FUEL ACTION PLAN... IN ACTION

While the Oregon Fuel Action Plan is designed to address even the region's worst-case disaster — a 9.0 Cascadia Subduction Zone earthquake and tsunami, which would devastate the region's fuel infrastructure — all strategies in the plan are flexible and can be scaled down in response to a wide range of events:

Emergency Preparedness Manager Deanna Henry discusses Oregon's Fuel Action Plan on ODOE's *Grounded* podcast:

https://go.usa.gov/xPQVc

- **August 21, 2017 Solar Eclipse:** ODOE activated the Fuel Action Plan in preparation for an influx of visitors to Oregon to view the first total solar eclipse in the United States in 38 years. ODOE worked with the petroleum industry leading up to the August event to maximize fuel volumes to meet the anticipated increase in demand. The agency worked with the industry to add fuel deliveries, and to schedule them at strategic times to avoid heavy traffic congestion. ODOE also successfully secured a temporary waiver from the Oregon Department of Transportation to lift "Hours of Service" restrictions, which ensured fuel haulers would not be fined if they exceeded the 11.5 hour limit to complete deliveries.
- **2017 Wildfire Season:** Oregon battled as many as 17 fires simultaneously during summer 2017, wreaking havoc on fuel deliveries and stressing the supply of aviation fuel, unleaded gasoline, and diesel. In particular, the Eagle Creek Fire closed vehicle traffic on Interstate 84 and barge traffic on the Columbia River in September. ODOE implemented the Fuel Action Plan and worked with the petroleum industry and ODOT to ensure fuel haulers had viable alternate routes to complete deliveries. ODOE also worked with the U.S. Coast Guard to ensure fuel barges were vetted and given priority passage despite USCG's Shutdown Order of the Columbia River. As a result, three fuel barges were cleared for passage, delivering 420,000 gallons of ethanol, 900,000 gallons of aviation fuel, and 1,596,000 gallons of diesel with only minimal delay.
- **December 2016 Winter Storms:** Snow and icy conditions caused wide-spread power outages, including some operations at the CEI Hub. Without power, Kinder Morgan was unable to transport jet fuel by pipeline to the Portland International Airport, which had less than two days' supply of jet fuel. ODOE implemented strategies from the Fuel Action Plan and worked with Portland General Electric to ensure the utility prioritized restoring power to the Hub. Despite treacherous conditions, PGE crews navigated safely through black ice and downed power lines to get power restored, and Kinder Morgan was able to deliver jet fuel to PDX before the airport ran out.

There is no single State of Oregon agency with regulatory authority over the petroleum terminals located within the Critical Energy Infrastructure (CEI) Hub northwest of Portland. These terminals are expected to be severely damaged by a CSZ earthquake,[5] yet no single state agency can require these facilities to invest in seismic upgrades to their aging tanks, pipeline systems, and other facilities. The Oregon Department of Environmental Quality, meanwhile, is responsible for working with industry to develop and maintain the Oil Spill Prevention Program to reduce the risk of spills and minimize damage to human health and the environment when responding to spills.[17] DEQ's authority for developing this program is based on legislation adopted in 1991 that did not address seismic resilience, and its authority is limited to marine oil transfer facilities, which is a subset of the facilities located within the CEI Hub.

*Oregon Resilience Plan*

The Oregon Resilience Plan was developed in 2013 by the Oregon Seismic Safety Policy Advisory Commission at the direction of the Oregon Legislature.[5] The ORP evaluates the expected effects of a CSZ earthquake and tsunami to different sectors and regions of Oregon, with recommendations to reduce risk and improve recovery. These recommendations were formulated with the intention that, if implemented over the next 50 years, the state could achieve resilience targets as identified by the ORP with regards to reducing timelines for the restoration of certain services following a CSZ earthquake. Chapter 6 of the ORP is focused on the state's energy sector, and identifies ten recommendations for the state to improve its resiliency.

The ORP also recommended that the state Legislature create a new position in state government—a State Resilience Officer—to "provide leadership, resources, advocacy, and expertise in implementing a statewide resilience plan." The Legislature followed this recommendation, creating the position with the passage of House Bill 2270 in 2015.[18] With the subsequent appointment and confirmation of the state's first Resilience Officer in 2016, Oregon became one of the first states in the nation with a cabinet-level position in state government charged with coordinating resilience efforts.[19]

## CRITICAL ENERGY INFRASTRUCTURE HUB

The CEI Hub is located along a six-mile stretch of the Willamette River in northwest Portland. The Hub includes all of Oregon's major liquid fuel port terminals, liquid fuel transmission pipelines and transfer stations, natural gas transmission pipelines, a liquefied natural gas storage facility, high voltage electric substations and transmission lines, and electric substations for local distribution.

Nearly all of Oregon's refined petroleum products are imported by pipeline or marine vessels through the CEI Hub before being distributed throughout the state to end-use customers. A portion of the state's natural gas fuel supply also passes through the CEI Hub. The Hub is vulnerable to a CSZ earthquake, according to the Oregon Resilience Plan:[5]

- The Hub is constructed on soils susceptible to major movement after an earthquake, including liquefaction — where solid earth behaves like liquid or quicksand
- The 1960s-designed pipeline was not built to withstand ground movements from earthquakes
- Fuel spills could affect the navigable waterway, impeding marine traffic and emergency response
- Substations, transmission lines, and other infrastructure are vulnerable; severe damage could result in an electricity blackout

The ORP recommends a number of actions to strengthen the CEI Hub, including working with energy sector companies to improve the resilience of their infrastructure located at the Hub.[5]

### Community and Utility Level Actions

Consistent with state-level planning, many local governments and utilities are making investments designed to improve energy resilience at the local level. These actions vary, from evaluating whether buildings and energy infrastructure are seismically sound, to relocating key assets, to deploying advanced energy technologies. This section highlights several of these community level activities.

*Assessing and Hardening Infrastructure*

Central Lincoln PUD's Northern Operations Center, completed in 2017.

Particularly with regard to the threat of a CSZ earthquake, many utilities across Oregon have taken steps to assess and address the vulnerabilities of their buildings and infrastructure.* Central Lincoln People's Utility District is one of the state's 36 consumer-owned utilities; its service territory stretches over 100 miles of central Oregon coastline. Given risks to its service territory, in 2017 the utility completed construction of a new Northern Operations Center in Newport. The previous operations center was in an area of Newport at lower elevation and within the tsunami zone (i.e., the area expected by geologists to be affected by a tsunami following a major rupture of the CSZ fault). The new Operations Center has been built at higher elevation, outside of the tsunami zone, and constructed to seismic standards designed to withstand the ground forces from a CSZ earthquake.

Blachly-Lane Electric Cooperative, a consumer-owned utility located northwest of Eugene in the southern end of the Willamette Valley, is seismically retrofitting its headquarters to withstand a CSZ earthquake. The Eugene Water and Electric Board, meanwhile, is working with a team of engineers at Oregon State University to evaluate how its concrete electric transmission towers — utilized in some locations on its system — will hold up to a CSZ earthquake. PGE has also been working to reinforce or replace unreinforced masonry buildings, particularly those associated with older hydroelectric facilities.

In addition, the Bonneville Power Administration has been working for decades to improve the resilience of its transmission network to a major seismic event. For example, BPA has bolted the transformers at all of its transmission substations to their foundations. This helps to prevent these large pieces of equipment from sliding off of their foundations during a seismic event. BPA and many of the state's distribution utilities have replaced inflexible substation components, often made of porcelain, with more flexible components made of polymers. BPA is also currently in the process of seismically retrofitting the control house buildings at each of its transmission substations. BPA and other federal agencies have also evaluated seismic risks to the federal hydroelectric dams themselves, finding those risks to be minimal.

*The examples cited in this subsection are based on statements made by representatives of Central Lincoln PUD, Blachly-Lane Electric Cooperative, Eugene Water and Electric Board, Portland General Electric and the Bonneville Power Administration either at public events, or in meetings with ODOE staff, in 2017-18.

## ENERGY RESILIENCE GUIDEBOOK

In 2019, the Oregon Department of Energy plans to publish a *Guidebook to Enhance Local Energy Resilience in the Consumer-Owned Utility Sector*. The Guidebook is the culmination of two years of work by ODOE staff in collaboration with the Governor's Office and Central Lincoln People's Utility District. The work was made possible by the support of the National Governors Association Center for Best Practices, through its Policy Academy on Grid Modernization.

More information about ODOE's resiliency work is available on its website:

www.oregon.gov/energy/safety-resiliency

The Guidebook is designed specifically for staff working at the state's consumer-owned utilities who have been tasked with developing plans to enhance the resilience of their utility. With that audience in mind, the Guidebook:

- Identifies the role of local electric utilities within the context of the field of emergency management at the county, state, and federal level;
- Identifies incremental actions that local utilities can take to enhance resilience based on the examples of other utilities in Oregon and across the nation; and
- Proposes a framework for local utilities to utilize to prioritize investments in distributed energy resources to enhance resilience.

*Deploying Distributed Energy Resources*

Several Oregon utilities are also deploying distributed energy resources (DERs) as part of projects that enhance energy resilience at the local level. To the extent that these projects have the ability to operate independently from the rest of the grid, they can provide some improvement to community energy resilience in the event of a wider disruption to the state's larger energy systems.

For example, the Eugene Water and Electric Board, which serves about 93,000 electric customers and 53,000 water customers in the Eugene area, has partnered with the two Eugene-area school districts to install back-up power capability and install or upgrade water well equipment at district-owned facilities.[21] Many Eugene-area schools have existing rooftop solar that could provide on-site power for pumping water in addition to the back-up power sources. EWEB is investigating several possible back-up power sources, and is installing a microgrid back-up battery power source at Howard Elementary school in 2018 and a new water

EWEB contractor installs back-up battery power system.

well and pump station in the spring of 2019. This microgrid is sized to run the water well pump at the site for up to three weeks, while the existing solar array will be configured to allow for charging of the battery bank. EWEB's project, which is designed to increase resiliency and support research and design, was funded through a grant with ODOE, Sandia National Laboratories, Advanced Grid Research and Clean Energy States Alliance.[22] EWEB's goal is that five schools will be water resource-ready within five years. Within 5-10 years, microgrids may become more cost effective, which may result in penetration of these power sources to the electrical grid, due to an increase in customer-owned battery storage systems. Research from this first project and the following efforts will inform future policies, and will be used for planning purposes to better understand how integration with these systems will benefit the grid and the customer.

## WHAT'S A DER?

*Distributed Energy Resource* is an umbrella term used to refer to any resource interconnected to the distribution grid of a local utility. While definitions vary on the range of resources included, the Oregon Department of Energy considers DERs to be inclusive of the following:

- Generation sources (e.g., rooftop solar or diesel generators)
- Technologies that modify demand on the distribution system (e.g., energy efficiency and demand response)
- Electric vehicles and associated charging infrastructure; energy storage technologies (e.g., distributed batteries)
- Hardware or software control systems utilized to communicate with the grid and/or to optimize the usage of other DERs

Meanwhile, Portland General Electric is involved in several energy projects around the Portland metro area with resilience benefits. First, PGE manages a Dispatchable Standby Generation (DSG) program that partners with large customers, many of them hospitals, that already have on-site diesel generators.[23] Through the DSG program, PGE upgrades the customers' control and communications equipment, assumes most routine maintenance and fuel costs, expands on-site fuel storage capabilities, and regularly tests the generator. In exchange, the customer agrees to allow PGE to rely on the customer's generator to supply extra capacity to meet system needs if there is ever an emergency need for capacity. PGE benefits by having an additional emergency capacity resource, while the customer benefits through a more robust on-site energy resilience solution.

City of Portland Fire Station 1.

PGE is also involved in the deployment of microgrid projects that combine solar and storage to enhance resilience. In 2017, the utility partnered with the City of Portland's Fire Station 1 through its Renewable Development Fund grant program to deploy a solar and storage project that can provide resilient back-up power for the fire station following a grid disruption.[24] PGE is also seeking authorization from the Oregon Public Utility Commission to develop a customer and community microgrid pilot that would deploy up to 12.5 MW of energy storage across two to five customer sites.[25]

## MICROGRIDS

A microgrid is "a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode."[26]

- **Size and Location.** A microgrid can range in size from a single home or building to an entire campus or even a city. The larger the size, the more complicated and expensive it is to design, build, and control.
- **Energy Efficiency.** The first step in designing a microgrid is to evaluate ways to reduce energy demand for the microgrid by improving energy efficiency.
- **Isolate Critical Loads.** All system loads should be evaluated to identify and isolate only those that are critical. For example, providing power from a microgrid to a building's heating system may be considered critical, while powering the cooling system may not be.
- **Technology Selection.** A microgrid can include virtually any type of energy technology. Additional efficiencies can be achieved through combining technologies. This might include, for example, supplementing an existing diesel generator with a solar plus storage system that can enable the microgrid to utilize its on-site liquid fuel supplies for a longer period of time, and to operate during some hours without the generator at all.
- **Control Equipment.** The key distinguishing characteristic of any microgrid involves its ability to disconnect or "island" itself from the larger electric grid. Advanced control equipment can automatically island the system from the grid and optimize the use of DERs within the microgrid.

# Climate Adaptation for Oregon's Energy Systems

This section takes a closer look at some of the reliability and resilience implications of climate change, both from the effects that Oregon is already experiencing and projected future changes. This includes long-term, slower onset changes, such as average temperature and hydrologic conditions, and changes to patterns of extreme events including drought, floods, storms, and wildfires. Organizations use such climate information as the foundation to assess and create plans to reduce risks and vulnerabilities in energy and other sectors. Such actions are commonly referred to under the umbrella terms climate adaptation or climate resilience. The goal of adaptation or resilience in this context is "to prepare for and adjust to new conditions, thereby reducing harm or taking advantage of new opportunities."[27] Adaptation efforts can reduce the potential for climate change to adversely affect U.S. energy infrastructure and operations.[28,29]

One of the main inputs into and first steps in a climate adaptation planning process is to conduct a vulnerability assessment for the sector or area of interest. Oregon does not currently have a climate vulnerability assessment or adaptation plan that is specific to its energy sector. The subsections below first introduce likely areas of climate vulnerabilities for Oregon's energy systems, and then discuss the current status of state efforts to assess climate vulnerability and create a statewide plan.

## Climate Vulnerabilities

### Electricity Generation

As described in Chapter 1, Oregon's electricity needs are supplied by a variety of in-state and imported sources from throughout the West. Many of these generation technologies are highly dependent on water, and many studies consistently identify temperature and hydrologic changes as key drivers of risks, focusing on vulnerabilities within this "energy-water nexus" under a changing climate.[30]

Hydroelectric power generation capacity — both from the Federal Columbia River Power System and from non-federal dams that provide electricity to Oregon customers — is vulnerable to warming temperatures, reduced snowpack, earlier snow melting and peak runoff, and reduced summer flows.[31,32,33,34] For example, U.S. DOE estimates that the Bonneville Power Administration lost $164 million in fiscal year 2010 due to insufficient hydropower generation to fulfill load obligations resulting primarily from low water volumes in the Columbia River basin.[43]

In addition, salmon and steelhead habitat and populations in the Columbia River Basin are projected to be adversely affected by increasing water temperatures and seasonal streamflow changes,[35] which may have implications for hydropower operations.[9] The River Management Joint Operating Committee for the Federal Columbia River Power System updated its initial climate change study from 2009-2011, focusing on changes to temperature, precipitation, snowpack, and streamflow through the 21st century. The RMJOC's next report will assess the following six categories of system vulnerabilities to warming and streamflow changes in the Columbia River Basin: "hydroelectricity generation, temperature-driven energy demand, flood risk management, water supply, ecosystem/habitat, recreation, biological reservoir operations (e.g., operations targeting reservoir storage and releases favorable to fish), and fixed timing-based reservoir operations (e.g., refill operations derived from historical flow seasonality)."[34]

## HIGHLIGHTING TRIBAL ENERGY VULNERABILITIES

Fisheries management and hydropower generation are inextricably linked as both depend on the region's rivers and streams. Two Oregon tribes — the Confederated Tribes of Warm Springs and the Confederated Tribes of Umatilla Reservation — are founding members of the Columbia River Inter-Tribal Fish Commission, the mission of which is to "ensure a unified voice in the overall management of the fishery resources, and as managers, to protect reserved treaty rights through the exercise of the inherent sovereign powers of the tribes."[36] Climate change is a priority area for the Commission, with a focus on efforts "to prepare for the coming changes, including helping salmon in an altered climate with habitat projects designed to cool down tributaries and exploring alternative hydrosystem operations."[36] As described more in Chapter 2, tribes are uniquely vulnerable to climate change effects on water and fisheries resources that have religious, spiritual, and cultural significance and sustain tribal subsistence and commercial economies.[37]

Pelton Round Butte Hydroelectric Dam
*Photo by U.S. Forest Service*

Some Oregon tribes will also be affected by climate impacts to federal and non-federal hydropower.[32] For example, the Confederated Tribes of Warm Springs has joint ownership with Portland General Electric of the Pelton Round Butte hydroelectric project.[38] The Umpqua Indian Utility Cooperative is the first utility in the Northwest both owned and operated by a tribe, the Cow Creek Band of Umpqua Indians; it distributes solely BPA power to its customers. Climate change vulnerabilities facing the Federal Columbia River Power System will also affect UIUC and any other Oregon utilities that rely on BPA power to serve tribal customers. Additional research in partnership with tribes would be needed to comprehensively identify and evaluate energy system vulnerabilities of relevance to Oregon's tribes.

Thermal power plants depend on water for system cooling and process use (i.e., to run steam turbines). Types of thermal power include natural gas, coal, petroleum (fuel oil), nuclear, geothermal, solar thermal electric, waste incineration, and biomass plants. Each employs various types of cooling technologies that differ in their water usage. In 2015, U.S. thermoelectric power generation drew 133 million gallons of water a day primarily from surface freshwater bodies (rivers, lakes, reservoirs, etc.), which was nearly half of all national surface freshwater withdrawals that year.[39] The Columbia Generating Station in Richland, Washington, which supplies about 3 percent of Oregon's electricity, uses an estimated 24 million gallons of water per day for cooling, then returns about 1.9 million gallons each day to the Columbia River.[40] All thermal power plants must follow applicable state and federal water quality regulations regarding the temperature of their discharge back into water bodies. Thermal power plant operations are expected to be adversely affected by higher ambient temperatures and reduced summer water availability.[28,32,33] U.S. DOE described national examples of these types of impacts.[43] For example, in August 2012, Dominion Resources' Millstone Nuclear Power Station in Connecticut shut down one reactor because the temperature of the intake cooling water, withdrawn from the Long Island Sound, was too high and exceeded technical specifications of the reactor. Water temperatures were the warmest since operations began in 1970.

## Electricity Demand

The Northwest Power and Conservation Council's Seventh Power Plan analyzed the balance of available electric generation with the region's changing electricity needs in scenarios with and without climate change. Through 2026, the Northwest is projected to maintain an adequate supply of electricity to meet expected demand even if climate change is factored in. By 2035, climate-induced shifts in hydrology affecting hydropower supply and increases in electricity demand are expected to strain the already tight summer market for electricity, resulting in a 15 percent likelihood of a shortfall and exceeding the Council's adequacy standard of five percent.[41]

In the Northwest, demand for electricity is projected to increase over the next century due to population growth, increased cooling degree days (a standard measure of need for cooling defined as the number of degrees that a day's average temperature is above 65°F), and increased use of air conditioners as people cope with higher temperatures.[28,29,33] Hotter and longer summers are projected for the Northwest, with an 89 percent increase in cooling degree days per year by mid-century (2041–2070, compared to 1971–2000).[29] Nationally, demand for electricity to pump water for irrigation is also expected to rise as the agricultural sector adapts to increasing frequency and intensity of drought and changing seasonality of water availability.[29] The Power Council similarly found that projected increases in summer electricity demand will be primarily driven by air conditioning and irrigation loads.[41]

Temperature increases by mid-century will likely result in a modest reduction in the region's energy demand for space heating even accounting for population growth, though the increase in cooling needs is expected to be greater than the decrease in heating needs.[28,29,33] This has led some to describe an ongoing shift in the Northwest from being a traditionally "winter peaking" region, with our largest electricity/energy needs in winter, to a "dual peaking" region, with large loads in both winter and summer. The Seventh Power Plan states that regional demand for summer peaking services is increasing faster than winter peaking need.[41]

## Energy Supply Chains and Infrastructure

The changing climate and more frequent or intense extreme events pose risks to the national or regional supply chains that Oregon currently depends on for some types of energy, as well as the energy infrastructure located within the state. Electricity and fuel suppliers' dependence on capital-intensive infrastructure investments for resource extraction, generation/production, and transmission/distribution increases their vulnerability because it is more expensive and time-consuming to bounce back from damages to or loss of high-value assets.[42] Most infrastructure is designed for a historical climate, so present-day examples of infrastructure damage and disruptions caused by extreme events demonstrate existing vulnerabilities that are likely to increase in a changing climate.[29]

As described in Chapter 1, Oregon imports nearly all of the liquid fuels and natural gas used in the state. The infrastructure required to get those fuels to Oregon includes pipelines, barges, roads, bridges, railways, and storage tanks or terminals — all of which are vulnerable to a variety of extreme events that can interrupt supply and/or drive up transport costs.[28,32] For example, in summer 2012, drought and low river water depths grounded barge transportation along the Mississippi River, which is a major route for moving commodities like petroleum and coal.[43] As Oregon progresses towards transitioning its economy away from fossil fuels in line with state climate and energy goals, these types of climate vulnerabilities related to fossil fuel supply chains are expected to be reduced.

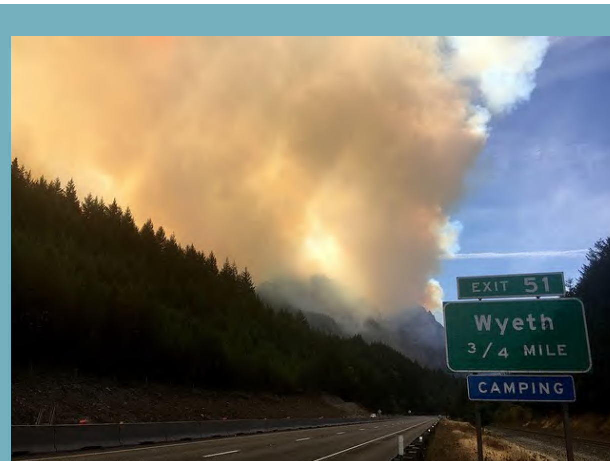
Electricity infrastructure is vulnerable to a variety of climate impacts including drought, extreme heat, flooding, wildfire, wind and winter storms, and coastal storm surges.[28,32,33] For example, increasing average and extreme temperatures reduce the efficiency and capacity of substations, transformers, and power lines, which increases line losses and reduces overall grid capacity during periods of greatest demand for electricity.[32,33] Warmer temperatures can also cause power lines to sag when conductors expand, and although the National Electrical Code[47] requires utility poles and line clearances to account for sag, climate change projections are not currently factored into design criteria. Power line sag increases the risk of tree strikes that can cause brush fires and power outages if sufficient redundancy is not available to reroute power.[32] Grid operators must reduce transformer loading on very hot days or risk causing damage or failures.[29,32] Increased ambient temperatures and heat waves also accelerate aging of insulating materials within power transformers, which can dramatically decrease initial designed lifetimes of one of the more expensive pieces of electrical distribution equipment.[32,44]

Wildfire knocked out BPA's Hot Springs-Rattlesnake 230-kV line in Montana in August 2015[46]
*Photo: Mike Stolfus, BPA*

Both the frequency and severity of wildfires are projected to increase in Oregon and the western U.S.[10,29,45] Wildfire disruptions and damage to electricity transmission have been seen in a number of recent events in California, Montana, Washington, and Oregon.[46] BPA has begun work to develop a proactive plan for wildfires throughout its transmission network.[46]

## EAGLE CREEK FIRE

The September 2017 Eagle Creek wildfire in the Columbia River Gorge burned approximately 49,000 acres[48] through areas that house critical components of the Northwest's transmission system, resulting in power outages and emergency maintenance and repair activities to address direct threats to the reliability of the power grid.[49] BPA removed thousands of burned and damaged trees near transmission lines. Access roads, degraded by the fire where culverts melted or collapsed, were vulnerable to washing out from post-fire surface water flows. Access road repairs were required to maintain power to the city of Cascade Locks and ensure access to the structures during inclement weather. In addition, BPA helped to provide fire crews with safe access to fight the wildfire by taking its transmission lines and facilities in and out of service (de-energizing and re-energizing) as needed.[49]




Eagle Creek Fire, 2017
*Photo: Oregon Department of Transportation*

## Statewide Climate Vulnerability Assessment and Adaptation Planning

The sections above identified some of the likely areas of vulnerability for Oregon's energy sector, but a comprehensive state-specific analysis has not yet been conducted. This is generally the first step in a climate adaptation planning process.[50] One of the advantages of starting with a vulnerability assessment is that it provides information about the magnitude and timing of climate threats at the geographic scale and level of detail that planners and policymakers need to identify and prioritize adaptation strategies for high risk areas.

**UNPREPARED**

Oregon Public Broadcasting's "Unprepared" series asks if Oregon will be ready for a megaquake:

https://www.opb.org/news/series/unprepared/

Oregon state government released a statewide climate adaptation framework in 2010 that provided a high-level summary of climate vulnerabilities from both long-term, slower onset changes and changes in patterns of extreme events, but only touched briefly on energy sector issues. The Oregon Department of Land Conservation and Development is initiating an interagency effort in late 2018 to revise and update the framework. Oregon state government now has an opportunity to conduct a more comprehensive and systematic assessment of vulnerabilities specific to the energy sector, either as part of that interagency effort or as a standalone product used to inform that effort. The following section provides more detail about suggested actions to pursue as first steps.

A climate vulnerability assessment for Oregon's energy sector will help inform the interagency process to identify and prioritize climate adaptation strategies. Other sources include existing federal government analysis and guidance, such as U.S. DOE's climate resilience guidebook for the electricity sector,[51] as well as relevant state government planning documents that recently have begun including climate change considerations, such as the Oregon Natural Hazards Mitigation Plan[52] and the Oregon Integrated Water Resources Strategy.[31] The IWRS includes recommendations to address drought, including increased water conservation and efficiency efforts, expanded natural and built storage, and strengthened resilience of riparian areas, forest lands, wetlands, and floodplains.[31]

Adapting to fundamental, slower onset climatic shifts like rising temperatures and declining water availability could include deployment of technologies that increase water efficiency, use of non-traditional water sources, or alternative electricity generation sources that inherently require less or no water.[32] Expanded deployment of renewable technologies such as wind and solar could reduce water demand for energy.[32] For example, water withdrawals and water consumption are projected to be reduced nationally by 97 percent and 85 percent, respectively, under a future 2050 scenario with very high levels of energy efficiency and renewable electricity generation (wind, solar, geothermal, biomass, and hydropower) across the U.S.[53]

Strategies for adapting to changing patterns of extreme events typically fall into one of two general categories. First is physical change, often called hardening, to make particular pieces of infrastructure less susceptible to extreme event-related damage. For example, this could include elevating energy equipment or structures deemed at risk for coastal flooding exacerbated by sea level rise and storm surge.[32,33] The second general category is actions that increase the ability to recover quickly from damage to components or systems. This could include, for example, creating energy storage and redundant systems as back-ups, or having real-time operational contingencies where, if conditions merit, grid operators will preemptively power down system components to minimize damage.[32,33]

# Next Steps

While actions have been taken to improve the resilience of and prepare for climate change effects on Oregon's energy systems, significantly more can be done. No single entity is responsible for, or has the authority to implement, a comprehensive approach to make the energy systems of a single state more resilient to a range of threats.[33] That said, as described above, Oregon state government has taken significant steps to identify risks and vulnerabilities to some of the key components of the state's bulk energy systems. In addition, electric and gas utilities have made important investments that improve the resilience of other elements of the state's energy systems.

## ODOE has identified two key gaps in current efforts:

1. **Comprehensive Vulnerability and Risk Assessment of Oregon's Energy Infrastructure**

   To date, there has never been a comprehensive evaluation of the vulnerabilities of and risks to Oregon's energy infrastructure. Key components, such as the CEI Hub near Portland, have received significant attention from the state, and utilities have taken steps to reinforce, upgrade, or rebuild some of their assets to better protect against threats. What is missing, however, is a comprehensive analysis of all of the state's energy infrastructure — inclusive of electric, natural gas, and liquid fuels production and delivery systems. Such an analysis should include an evaluation of the risks and vulnerabilities to that infrastructure from all potential threats and should include an analysis of critical interdependencies between different segments of the energy sector (e.g., the need for electricity to power liquid fuel pumping stations, or the need for liquid fuels to operate electric utility trucks, etc.) and between the energy sector and other critical public services (e.g., the dependence of first responders, healthcare providers, and others on energy).

   This type of an analysis would give the state and key stakeholders better context when evaluating specific actions that they might take to improve the resilience of and prepare for climate change impacts to the state's energy systems. For example, a local government may make different decisions with respect to community energy resilience investments depending on the findings of this type of a statewide assessment and what it might portend for their specific community. At the same time, this type of a statewide analysis could provide better guidance to the Legislature and state agencies when prioritizing investments.

2. **Developing a Vision for Community Energy Resilience**

   Within Oregon, multiple entities and jurisdictions will need to work collaboratively to identify location-appropriate solutions to improve community energy resilience. Building upon the findings of the type of comprehensive assessment of the state's energy infrastructure described above, local governments will need to collaborate with utilities and other energy providers to maximize the impact of their efforts at the community level. There is also significant work to be done to explore mechanisms to finance investments in community energy resilience and climate adaptation solutions and to prioritize those investments while considering important trade-offs.

## Technology Advancements Creating Opportunities for Community Energy Resilience Solutions

On-site diesel or propane generators have been the primary source of back-up power at the customer level for decades. Hospitals, first responders, and many other large commercial and industrial customers have long utilized on-site diesel generators to ride through grid disruptions. In addition to the negative impact of emissions from these types of generators, they also depend on liquid fuel re-supply. Many diesel generators, for instance, only have sufficient on-site fuel to run for 48 to 72 hours while the Oregon Resilience Plan found that liquid fuel deliveries could be disrupted for a period of weeks or months (depending on one's location in the state) following a CSZ earthquake.[5] Exclusive reliance on on-site diesel generators for resilient back-up power comes with significant limitations when considering a long duration event.

Ice Storm, 2016
*Photo: Eugene Water & Electric Board*

Technology advancements are creating new opportunities to enhance local energy resilience in a manner that can complement in some cases, or replace in others, the utilization of diesel or propane generators for on-site resilient energy needs. For example, distributed solar and battery storage systems could be more cost-effective options for back-up power capabilities. The increasing availability of electric vehicles creates new opportunities to deploy a more resilient transportation fleet that can be fueled with electricity produced on-site. Advanced software and control systems are also creating new opportunities to incorporate a portfolio of technologies with different capabilities that can be optimized for maximum resilience to extend the amount of back-up power available.

Any utility, community, or customer considering investments in energy resilience technologies should also consider the capabilities of those technologies to provide resilience benefits irrespective of the type of event that might occur. For example, while a solar plus storage microgrid might be particularly effective in providing on-site resilient power during a long duration disruption like a CSZ earthquake, the same installation will also be able to provide resilient power following more routine, shorter duration disruptions, which may become more common due to climate change (for example, extreme heat events, drought, wildfires, severe winter storms). It is also important, of course, to consider whether these energy resilience solutions will physically survive anticipated threats and remain operable.

## Financing Community Energy Resilience and Climate Adaptation Investments

While costs have fallen for technologies that can enhance community energy resilience, there are still barriers to investment. One major financing barrier relates to a common issue in public policy: short- versus long-term time horizons and differing viewpoints on valuing benefits and costs. It is unknown, for instance, whether the next CSZ earthquake will happen in 2019 or in 2099. Should local jurisdictions invest today in community energy resilience solutions that might not be needed for their intended purpose for many decades? On the other hand, climate scientists have modeled some future changes with a great degree of certainty in their magnitude and timing of projected impacts; for example, the latest U.S. National Climate Assessment concluded that increasing U.S. temperature trends are understood with very high confidence (meaning there is strong evidence, including well documented and accepted methods and results, and high consensus) and that impacts are extremely likely (indicating a 95 to 100 percent probability of occurrence).[12] Investment timing considerations may therefore be different for well-understood risks for which society has some long-term predictive ability.

As noted above, one key attribute of energy resilience solutions is that they also have the potential to provide value under a variety of different scenarios. A microgrid system intended to provide long duration back-up power following a major disruption can also provide back-up power during more routine power outages. Importantly, these systems also have the potential to provide value during "blue sky" conditions. For example, distributed microgrid systems can help contribute to a utility's peak capacity needs or provide ancillary services that can help maintain grid stability.

One of the challenges for these systems is identifying ways to monetize these types of values. PGE's DSG program (see page 11) is a local example where the electric utility splits costs with a customer by compensating them for the capacity their on-site diesel generator can provide to the utility under certain conditions. This helps those customers offset the costs of owning and maintaining the diesel generator for its primary intended purpose: resilient back-up power. In other parts of the country, organized wholesale markets exist that allow projects to develop revenue streams by selling these types of services into active markets. And at least one state, Hawaii, has recently initiated a process that will require its electric utilities to develop a tariff that compensates these types of microgrid projects for the benefits that they can deliver to the grid. These types of mechanisms can create sufficient revenue streams that allow communities to finance the deployment of resilient microgrid projects for which the resilience benefit that the project confers becomes an added value.

Other funding mechanisms that have been identified as potential climate adaptation tools at the state or federal level include:

- **Government bonds, loan guarantees, or revolving loan funds.**
- **State, federal, and private philanthropic grants.**
- **Transfer of development rights programs: a voluntary and market-based tool used to incentivize development away from areas of relatively higher climate vulnerability and into areas of relatively lower climate vulnerability that also have desire and capacity for more development.**
- **Insurance and insurance pooling: insurance services can help with absorbing part of the losses due to (weather related) natural disasters, thereby lessening the need for disaster relief. Second, these services can help in reducing vulnerability by setting standards related to buildings and land use planning, such as for the National Flood Insurance Program.**
- **Integrating eligible climate change adaptation considerations into existing infrastructure funding or rebuilding mechanisms — for example, FEMA Disaster Relief Fund and Hazard Mitigation Grant Program, U.S. EPA's Drinking Water State Revolving Fund, etc.**

## FUNDING RESILIENT MICROGRIDS

If Oregon wants to deploy resilient microgrids in a systematic way to enhance energy resilience at the community level, the state will need to identify mechanisms to fund their deployment.

The following highlights several examples of state-level support for resilient microgrid deployments around the country:

**Connecticut:** In 2013, Connecticut created a microgrid program to help support the deployment of local distributed energy generation for critical facilities. To date, the program has held four open calls for applications and has disbursed more than $30 million in grant funding.[54]

Connecticut's Wesleyan University installed solar arrays to support its larger microgrid project.[63] *Photo: John Wareham, Wesleyan*

**Hawaii:** Recognizing a need to standardize the valuation of the services that a microgrid can provide, Hawaii's legislature enacted a law in July 2018 to require its Public Utility Commission to develop a tariff for customers who deploy microgrids and supply services back to the grid.[55,56]

**Washington:** Washington's state legislature established the Clean Energy Fund in 2013 to support the development, demonstration, and deployment of clean energy projects.[57] The CEF has been reauthorized twice and has been funded with a total of $136 million in funds.[58] Microgrid projects are an important focus of this fund, as evidenced by the $7 million awarded to two separate microgrid projects in 2017.[59]

**New Jersey:** Established the New Jersey Energy Resilience Bank to finance investments in microgrids at critical facilities that were directly or indirectly impacted by Superstorm Sandy or other eligible natural disasters. The bank was established with $200 million in funding through New Jersey's second Community Development Block Grant-Disaster Recovery from the U.S. Department of Housing and Urban Development.[60]

**California:** The California Public Utilities Commission established the Electric Program Investment Charge (EPIC) in 2011 to support investments in clean energy research, demonstration, and deployment.[61] Funds (totaling approximately $162 million annually from 2012-2020) for the program come from the rates charged to customers of the state's investor-owned utilities. According to the 2017 EPIC Annual Report, California has invested more than $37 million in EPIC funds into microgrid projects since 2012.[62]

## Prioritizing Community Energy Resilience and Climate Adaptation Investments

As discussed earlier in this chapter, uniform reliability standards (i.e. every customer has the same level of reliable service) in the electric sector is one key characteristic that distinguishes reliability from resilience. By definition, resilience to various types of disruptive events will be non-uniform. This is true even at the stage of assessing vulnerabilities and risks — coastal areas of the state, for example, have greater vulnerabilities to a CSZ earthquake than do areas of eastern Oregon. By virtue of that geographic difference alone, energy infrastructure in eastern Oregon is likely to be less vulnerable to a CSZ earthquake than similar infrastructure located in coastal regions.

How, then, should the state and local governments think about prioritizing investments in community energy resilience and climate adaptation solutions for the energy sector? The following are key elements and related potential tradeoffs that could be evaluated to help inform the prioritization of such investments:

### Vulnerability and Risk Assessment

As described above, a comprehensive analysis of the vulnerabilities and risks to energy infrastructure across the state would provide a strong foundation for identifying gaps and opportunities to make investments that maximize community energy resilience.

### Critical Facilities or Infrastructure

Several of the states highlighted above that are investing in the deployment of resilient microgrids have targeted those investments specifically at critical facilities. By targeting such investments, a state can help to maximize the benefit to community energy resilience. For example, there is likely a greater community benefit if first responders and medical providers in a neighborhood have more resilient back-up power than if a non-critical private business were to have the same. Oregon could benefit from the development of a database of all critical facilities in the state plus relevant energy resilience considerations for the same, such as: an assessment of the building's energy efficiency, the size of the building's electrical load, and whether there currently exists any on-site energy generation or storage.

*Potential Considerations on Safety and Security*

Both of the above elements would require the collection of sensitive information in databases. The safety, security, and storage of that information would need to be ensured to avoid information being inappropriately shared or accessed.

*Potential Considerations with Redundant Infrastructure*

The energy industry has developed clear metrics and standards to justify significant capital investment by electric and gas utilities in technologies designed to improve and maintain a proscribed level of reliable service. For example, a certain level of redundancy (e.g., two distribution lines serving a single neighborhood) is already built into our electric grid, which helps to mitigate against routine disruptions and to allow grid operators to reroute power flows across a secondary route in the event that the primary route goes offline. Utilities and their regulatory commissions are accustomed to evaluating the prudency of these types of redundancy investments. Most investments that are made to enhance community energy resilience — such as deploying on-site diesel generators or solar and battery systems — are likely to be providing a level of redundant power service to a particular location, of course, with an added benefit of having more resilient power during times of disruption to the wider energy system. This benefit comes at a cost and the issue becomes how much redundancy is too much?

### Identification of High-Value Resilience Nodes

Upon completion of a vulnerability and risk assessment of the state's energy infrastructure and the development of a database identifying critical facilities or infrastructure, the state would be in a position to assist local governments to identify clusters of critical facilities and energy infrastructure in areas with the least vulnerability or risk (e.g., areas within communities less prone to landslides or liquefaction from an earthquake). Particularly in these areas, it may be valuable then to identify the technical potential to deploy distributed energy resources to improve community energy resilience. For example, this might include an evaluation of the potential to develop biodigesters at landfills, wastewater plants, or farms. This might also include an evaluation of the potential to develop distributed solar, or small hydro projects, or distributed locations for storing liquid fuels. Of course, the ability of particular distributed energy resources to survive whatever threat(s) a community is planning for must also be considered.

*Potential Considerations Regarding Timing of Investments*

Given the rapid decline in costs for many distributed energy systems, another trade-off concerns the issue of when to make investments in community energy resilience. For example, according to the National Renewable Energy Laboratory, the cost for a 5.7 kW rooftop solar PV system fell more than 60 percent, from $7.24/watt (DC) in 2010 to $2.80/watt (DC) in 2017.[64] Understanding the value of the resilience benefits that these systems can provide will help entities seeking to make these investments better understand when they become cost effective.

### Equity and Environmental Justice

Separate from an evaluation of the location-specific vulnerabilities and risks that might exist to energy infrastructure across the state, there should also be a recognition that some communities and populations will be less able to respond to and recover from a major disruption than others. For example, people with limited economic resources living in areas with deteriorating infrastructure are more likely to experience disproportionate impacts from extreme events such as a hurricane or flood.[65] Adaptive capacity and ability to respond to climate change and disasters are affected by factors including socioeconomic status, certain demographic characteristics, human and social capital (the skills, knowledge, experience, and social cohesion of a community), the condition and accessibility of critical infrastructure, and the availability of institutional resources like emergency response and disaster recover funding.[65] For these reasons, community energy resilience and climate adaptation solutions could be evaluated to determine if and how their benefits flow to vulnerable communities and specific populations with greater vulnerability, and how project designs could be modified to increase social and environmental equity.

*Potential Tradeoffs*

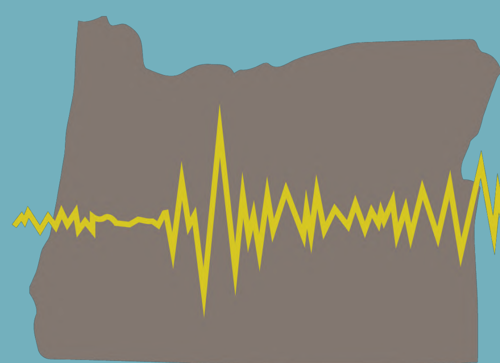
Again, it is helpful to contrast resilience with reliability with regards to equity concerns. In the electric sector, the reliability of the services provided is expected to be uniform to all customers. Investments that improve community energy resilience, however, will enable certain customers or communities to benefit from more resilient energy supply following a major disruption. This will likely create a scenario where some customers and communities have more resilient energy supplies than others. These types of equity considerations should be evaluated when designing public policies to encourage, or incentivize, investments in community energy resilience.

### Community Engagement

One common denominator is that engagement with individual communities across the state in the near-term, before the worst impacts of climate change are realized or a major disruptive event occurs, is important. The work led by ODOE to develop the Fuel Action Plan through outreach with counties across the state serves as a example of this type of engagement. These discussions must necessarily consider location-specific risks, vulnerabilities, assets, and opportunities that communities themselves are best able to address. Solutions that make sense in one part of the state will not necessarily make sense somewhere else.

## CONCLUSIONS

An increased awareness of threats to the state's energy infrastructure combined with advancements in technology have created an opportunity to **enhance community energy resilience** and to better prepare energy systems for the impacts of climate change. While entities across Oregon have begun taking action, the state is well-positioned to build upon these efforts to **lead a collaborative effort** to define a vision for an energy sector that is better prepared for future threats.



To inform this vision, it would be beneficial to develop a comprehensive assessment of the risks and vulnerabilities to energy infrastructure across the state. Additionally, it will also be critical to engage local communities in this effort to better understand unique circumstances across Oregon — including an evaluation of location-specific risks, vulnerabilities, and resources, and an identification of the interdependencies of the provision of **critical public services** in those communities on the energy sector.

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# CHAPTER 6: ENERGY EFFICIENCY

Energy efficiency – doing the same work while using less energy – is the cornerstone of Oregon energy policy. In 2017, Oregon utility and public benefits programs invested more than $182 million dollars in efficiency measures, including $12.7 million in low-income energy efficiency programs.

Oregon ranks seventh in the nation for energy efficiency, and has been ranked by the American Council for an Energy Efficient Economy as a top ten state for 12 consecutive years.

KEY TAKEAWAYS

- **Oregon is a national leader** in electric and natural gas efficiency programs, and we have a long track record of cost-effectively acquiring energy efficiency.[1]
- Energy efficiency has been the least cost and most environmentally benign electricity resource for the region and Oregon, making it our second largest electricity resource behind hydroelectricity. In most cases electric **energy efficiency costs less** than wind, solar, coal, nuclear and natural gas electricity generation.
- Energy efficiency is the priority resource to meet **future load growth**. It is relied on heavily in utility integrated resource planning, and is expected to cover about 85 percent of all regional load growth through 2030.[2,3]
- Oregon's efforts include a wide variety of methods to acquire energy efficiency.[3] Working together on state programs, utility programs, codes, standards, and market transformation efforts will allow us to continue to deliver savings at lower costs. An increased focus on climate action, equity, and resiliency will enable us to better coordinate all available efficiency acquisition mechanisms; and prompt us to **develop new** efficiency funding and delivery channels.

# Introduction

Energy efficiency – doing the same work while using less energy – is the cornerstone of Oregon energy policy. In 2017, Oregon utility and public benefits programs invested more than $182 million in efficiency measures, including $12.7 million in low-income energy efficiency programs. Electric savings exceeded 574,000 MWh, and gas savings were 6.8 million therms – 1.2 percent of the electricity and 0.7 percent of all natural gas retail sales in 2017. Oregon ranks seventh in the nation for energy efficiency, and has been ranked by the American Council for an Energy Efficient Economy as a top ten state for 12 consecutive years.[1]

This chapter discusses policies that promote energy efficiency in Oregon, how efficiency is acquired through programs and incentives, and how Oregon is performing in its energy efficiency activities. Finally, this chapter looks forward to the actions Oregon can take to achieve further energy efficiency. While this chapter discusses electricity and natural gas efficiency, efficiency in transportation – the sector that uses the largest amount of energy in Oregon – is discussed in Chapter 4. In this chapter, energy efficiency is distinct from conservation, such as driving fewer miles or turning down thermostats, which curtails energy use through changing practices or behaviors.

# Meeting Load Growth with Efficiency

Oregon's national leadership in energy efficiency is guided by policies dating back to the 1970s. In 1975, Oregon policymakers declared that the goal of Oregon's energy policy was "to promote the efficient use of energy resources and to develop permanently sustainable energy resources" (ORS 469.010).[4]

## Pacific Northwest Electric Power Planning and Conservation Act

In 1980, Congress passed the Pacific Northwest Electric Power Planning and Conservation Act[5] (also known as the Northwest Power Act) and created the Northwest Power and Conservation Council (NWPCC) to guide electricity planning and electric energy efficiency acquisition in the Northwest.

The Act directed the Council to give first priority in resource acquisition to cost-effective energy efficiency, followed by cost-effective renewable resources. This was the "first time in history that energy efficiency was deemed to be a legitimate source of energy, on par with generating resources."[6] It also introduced Integrated Resource Planning (IRP). IRP differed from traditional utility resource planning in that it identified all potential resource options, both demand-side and supply-side resources, to meet future loads. This meant considering energy efficiency as a resource and including it in the development of the optimal mix of resources that would meet future system needs while minimizing costs. This approach allowed utilities to pass along the cost of efficiency to their customers, since it cost less than the cost of new generation.

### 1980 NORTHWEST POWER ACT

In addition to establishing the NWPCC, the Act directed the Council to adopt a regional energy conservation and electric power plan, as well as a program to protect, mitigate and enhance fish and wildlife affected by hydropower on the Columbia River and its tributaries. The Act also set forth provisions that the BPA Administrator must follow in selling power, acquiring resources, implementing energy conservation measures, and setting rates for the sale and disposition of electric energy.

As part of NWPCC's 2016 Seventh Power Plan,[7] the Council identified energy efficiency and conservation as the priority resource for the region and expects that it will cover about 85 percent of all load growth through 2030. The Seventh Power Plan calls upon the region to aggressively develop energy efficiency with a goal of acquiring 1,400 average megawatts (aMW) by 2021; 3,000 aMW by 2026; and 4,300 aMW by 2035. An aMW is equivalent to the energy produced by the continuous operation of one MW of capacity over one year, or 8,760 MWhs. The Plan states that energy efficiency is by far the least-expensive resource available to the region. It avoids risks of volatile fuel prices and financial risks associated with developing new large-scale resources. Efficiency also helps mitigate the potential cost associated with carbon emission reduction policies because energy "generated" by efficiency is carbon-neutral. In addition, energy efficiency resources not only provide annual energy savings, but contribute significantly to meeting the region's future needs for capacity by reducing both winter and summer peak demands. Finally, energy efficiency boosts resiliency because efficient buildings have lower energy demands, which increases reliability during times of stress on the electric system and helps maintain temperatures so residents can stay cool or warm in times of emergency.[8]

## Integrated Resource Planning

In 1989, the Oregon Public Utility Commission's (OPUC) Order No. 89-507 (UM 180) required investor-owned utilities to treat energy efficiency as an energy resource when developing their IRPs and create a roadmap for acquisition of all cost effective energy efficiency. Large consumer-owned utilities in Oregon also develop individual Integrated Resource Plans.[9]

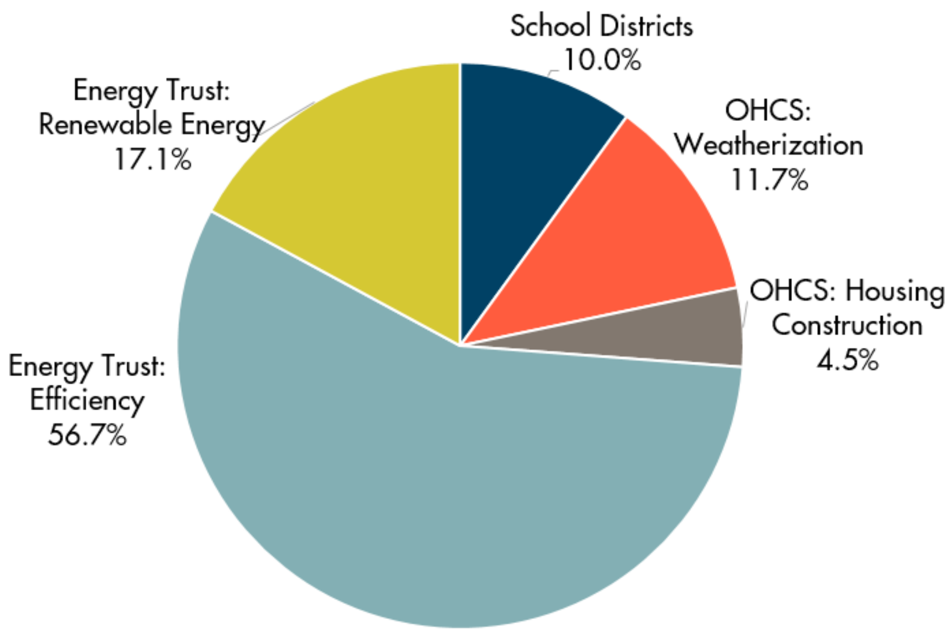
The current integrated resource plans for Portland General Electric and Pacific Power identify cost-effective energy efficiency as a main resource to meet their future load growth. Oregon's natural gas utilities, NW Natural, Cascade Natural Gas, and Avista, also call for significant energy efficiency savings. NW Natural's 2018 IRP[11] also relies heavily on energy efficiency, planning for a 15 percent reduction in annual natural gas load by 2038 over what would be expected absent the energy efficiency programs. These efficiency goals are developed with the Public Utility Commission, electric and natural gas utilities, and Energy Trust of Oregon.[10]

### ENERGY TRUST OF OREGON

Oregon nonprofit Energy Trust of Oregon was selected by the Oregon Public Utility Commission in 2002 to administer energy efficiency and renewable energy programs for investor-owned electric utilities, Pacific Power and Portland General Electric, and natural gas utilities Avista, Cascade, and NW Natural. In its current long-range strategic plan, ETO set energy savings goals of 240 average megawatts and 24 million annual therms of natural gas for 2015 through 2019. These goals include savings from market transformation programs.

Before 2002, investor-owned utilities offered utility-operated energy efficiency programs that were funded through rates. For investor-owned electric utilities, Oregon's 1999 restructuring law, SB 1149,[36] established a public purpose charge equal to three percent of electric investor owned utilities' total revenues to fund energy efficiency and renewable energy resource acquisition. The law stipulated that the first 10 percent of the funds should go to public schools for energy efficiency projects, facilitated by Oregon Department of Energy. The remaining funds are allocated to acquiring energy efficiency (56.7 percent) and renewable energy (17.1 percent) which are administered by Energy Trust of Oregon; low-income programs including construction of new housing (4.5 percent) and weatherization (11.7 percent) are administered by Oregon Housing and Community Services and local Community Action Partners.

**Figure 6.1: Activities Funded by the Public Purpose Charge**




In 2002[10] the OPUC reached a settlement agreement with NW Natural in a decoupling docket which led to the funding of Energy Trust to deliver natural gas efficiency programs. Similar agreements with Oregon's other two natural gas investor-owned utilities went into place over the next several years.

In 2007, SB 838[13] extended the sunset for the Public Purpose Charge from 2012 to the end of 2025. It also allowed investor-owned utilities to collect funds in addition to the Public Purpose Charge through rates for electric energy efficiency. Energy Trust of Oregon develops savings estimates, types of measures, and expenditures targets with the utilities and the OPUC. This funding was about 70 percent of Energy Trust's 2017 electric energy efficiency budget.[12]

# How Oregon Acquires Energy Efficiency

Some states have targets for how much is spent on energy efficiency. In these states, utility planners and regulators agree that a certain amount of energy revenues should be directed toward efficiency, which determines the amount of efficiency that is acquired. In Oregon, it's a more aggressive policy – public utilities are advised by the NWPCC's Power Plan and investor-owned utilities are directed by the OPUC and legislature to acquire all cost-effective efficiency.

## Cost-Effectiveness

Determining the cost-effectiveness of energy efficiency as an energy resource is accomplished through a comparison to the cost of delivered electricity or gas from generation plants or new natural gas supplies. If the energy efficiency can be obtained for less than a new generation plant or energy supply, it should be acquired. Acquiring the lowest cost energy efficiency resources ensures that the total cost of the energy resources we need to serve our loads will be as low as possible.

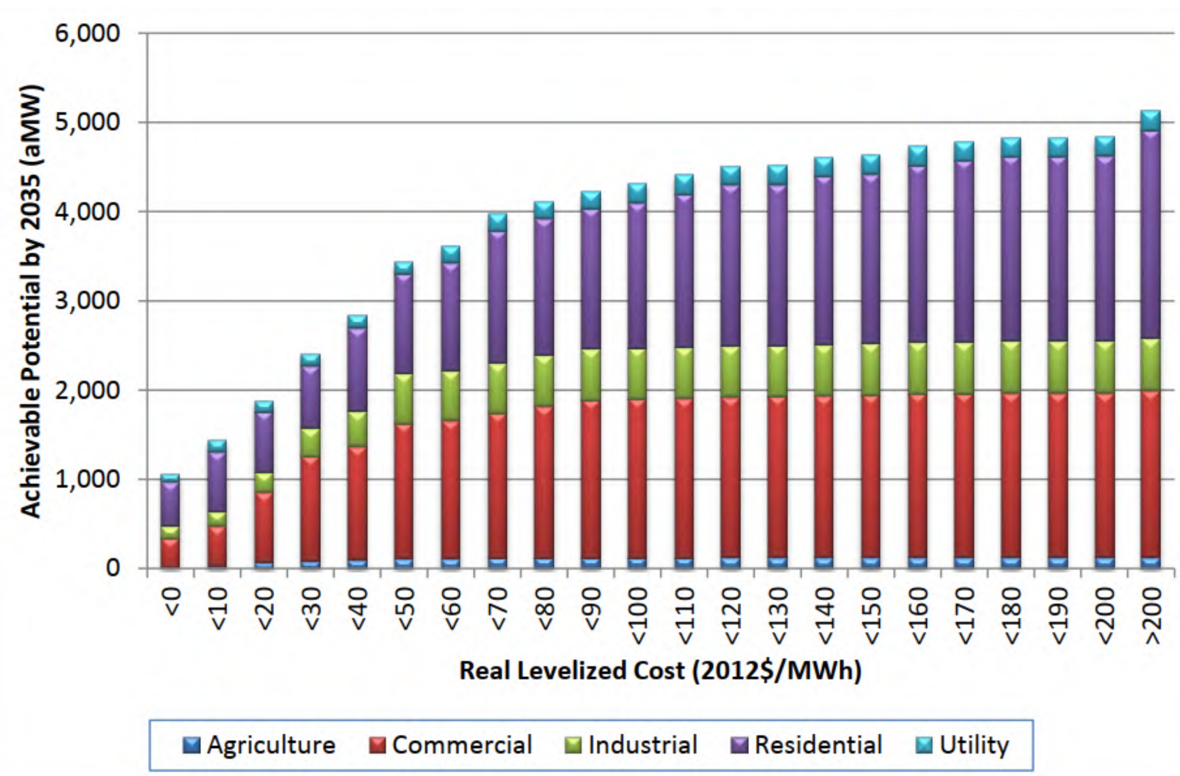
Utility regulators allow certain efficiency measures that do not meet all cost effectiveness tests as exceptions, where the economic calculation may be overridden by non-qualitative factors.

A utility acquires all cost-effective energy efficiency up to the cost of the next most cost-effective generation resource that could be acquired – otherwise known as the "marginal resource cost." Therefore the amount of energy efficiency that can be acquired is directly quantified and included in this test. The test also includes a 10 percent advantage for efficiency to consider benefits that cannot be quantified. The OPUC can create exceptions to this test for reasons specified in Docket UM 551.[14] This last provision does not apply to consumer-owned utilities

Under the primary cost-effectiveness test, the cost that is considered is the whole cost of the efficiency resources to the utility and the consumer. Where possible, benefits beyond energy savings from the measures are related to this marginal cost of resources. Benefit/cost tests employ a present value scheme to compare costs and benefits.

Efficiency costs are compared to forecasts of generation and gas costs, plus adjustments for avoided distribution capital cost, avoided power system losses, and an adjustment for risk. As the forecasted cost of future electricity and gas costs rises, so does the amount of energy efficiency that can be acquired. This is illustrated in Figure 6.2, using the simplified metric of real levelized cost.[14]

**Figure 6.2: Achievable Energy Efficiency Potential by Sector and Levelized Cost by 2035[14]**




## National Energy Efficiency Valuation Efforts

In 2017, the National Efficiency Screening Project produced the National Standard Practice Manual[15] for assessing cost-effectiveness of energy efficiency resources. This manual assessed methods used by all states with efficiency programs, then created a framework for future energy planning and analysis that includes new value considerations, including GHG reduction and non-energy benefits.

The National Energy Efficiency Registry (NEER)[16] is creating a method for energy efficiency savings to be tracked and potentially used as a trading instrument. The NEER was developed for the 2014 national Clean Power Plan, which was never finalized. States that are using energy efficiency as part of their climate change actions can use the NEER to track savings efforts. The Oregon Department of Energy helped inform the development of NEER by convening stakeholder input workshops and developing guidance language with the NEER project team.

Energy Trust recognizes the opportunity for energy efficiency to contribute to state, regional and national climate and carbon reduction goals, noting in its 2015-2019 Strategic Plan that climate policies "are likely to influence demand for energy efficiency and renewable energy, helping push innovation in clean energy and creating new opportunities for Energy Trust to reach and serve customers through collaborative efforts with others."[10]

## Incentives and Consumer Education

The foundation of Oregon's energy efficiency acquisition is influencing customers to choose greater efficiency. Utilities and implementers use funding from utility rates, federal and state tax credits, and federal and local weatherization assistance for low-income households to develop efficiency programs.

Creating awareness about energy efficiency starts with consumer education. Early energy efficiency programs used advertising and outreach through materials in customers' energy bills to deliver the efficiency message. Energy specialists from utilities and community agencies advised customers and recommended efficiency improvements. Contractors offering efficiency services such as insulation or equipment upgrades marketed directly to consumers.

When energy efficiency became recognized as a resource, utilities were allowed to use ratepayer funds to accelerate energy efficiency in the market. Limited only by a cost-effectiveness test that required efficiency to be less costly than other new resources, direct incentives to consumers became a key mechanism to acquire energy efficiency.

Customer education, information and training have always been important components of programs. The information is targeted to the scope and timing that maximizes customer action. Energy Trust, consultants, and utilities have also developed programs that drive savings primarily through information, such as Strategic Energy Management.

Incentives are usually designed to provide a portion of the incremental cost of an energy efficient improvement. As an example, a customer replacing a furnace that is worn out is already prepared to pay for the replacement. An efficiency

### SAVE ENERGY

We often talk about energy efficiency and weatherization with a broad perspective – describing various program requirements or cumulative statewide energy savings. But it's worth remembering that these programs make meaningful improvements to people's lives, where families save energy and money, have an easier time paying their energy bills, improve the value of their homes, and are more comfortable.

Case studies from **Northern Wasco County People's Utility District** illustrate the power of these real-life benefits:

https://go.usa.gov/xPAfu

program might offer an incentive that covers the incremental cost of buying a more efficient model. Incentives can come from many sources and be combined to further lower costs to consumers. Federal tax credits can be combined with state tax credits and utility incentives to help persuade customers to invest in efficiency. Incentives by themselves don't always work because, with some important exceptions, customers are usually required to make a capital investment in energy efficiency, and therefore rebates or incentives rarely cover 100 percent of the cost. Some Energy Trust programs such as manufactured home sealing, lighting and water heating kits, and lighting direct installation provide 100 percent payment for measures where this is cost-effective and the most efficient market strategy. For consumers of modest means, this up-front investment can be a barrier. Federal funding can bridge the gap between utility cost-effectiveness and project costs – and can enable the delivery of efficiency improvements at no cost to low-income customers.

In addition to utility cost-effectiveness limits, many other considerations affect incentive design. To spread the funding the furthest to reach the most customers, incentive programs look for the "right" amount of incentive that will capture all the savings. As the program evolves and costs change, an incentive might be increased or reduced to maintain its effectiveness and achieve results at the lowest cost possible.

## Equity of Energy Efficiency in the Residential Sector

Energy efficiency investments in all sectors have significant value to all utility customers because they reduce the overall system costs. In the residential sector, efficiency program implementers are also mindful that benefits and access to incentives and promotion of energy efficiency products and practices should be available for all energy customers. The Seventh Power Plan[7] acknowledges this concern and recommends that in the pursuit of all cost-effective energy efficiency "all customer segments should participate in programs." The Plan states, "The Northwest Power Act has required that the Bonneville Power Administration distribute the benefits of its resource programs equitably throughout the region.[5] Bonneville and the regional utilities should determine how to improve participation in cost-effective programs from any underserved segments. Although low-income customers are often an underserved segment, other hard-to-reach (HTR) segments may include: moderate income customers, customers in rural regions, small businesses owners, commercial tenants, multifamily tenants, manufactured home dwellers, and industrial customers. Ideally, the customers in the HTR segment should participate in similar proportion to non-HTR customers, assuming similar savings potential." BPA, its utility customers, and community action partners continue to look at how to better address the needs of consumers who may lack the means to participate in utility incentive programs but who may have significant opportunities for energy efficiency in their homes.

A recent NWPCC study[17] examined participation of various types of households in efficiency programs to look at the initial results of actions to ensure that programs reach "all segments of the population in a proportional manner." The study found that in general, utilities have paid attention to the variety of markets within their territories and they customize programs to target specific markets. But the study also determined that some of the segments could be reached "more strongly or consistently."

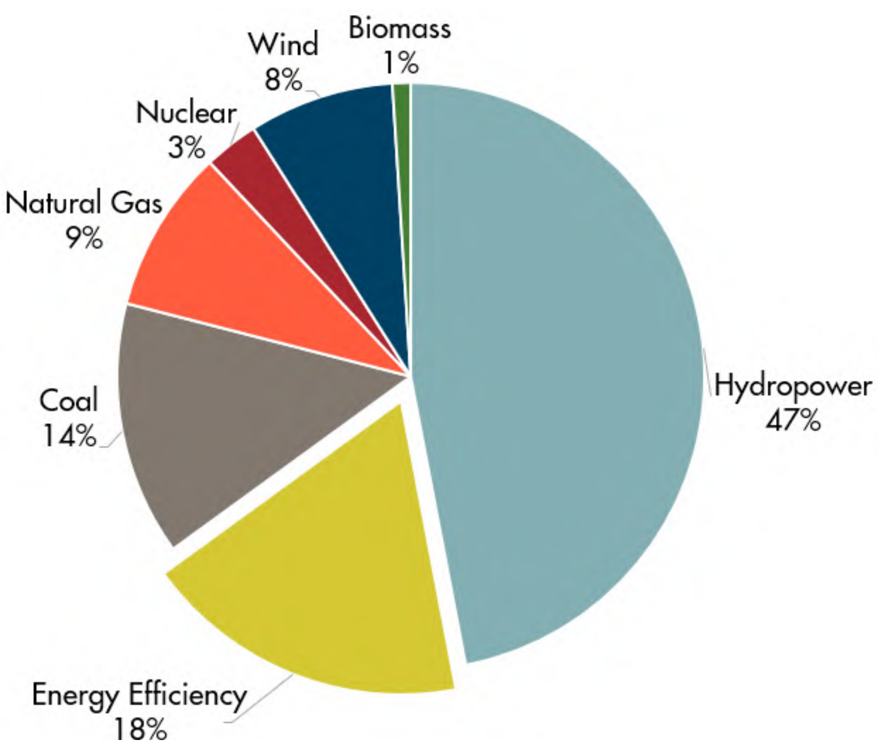
Numerous programs in Oregon target low-income and HTR customers. Energy efficiency for affordable housing has always been a part of Oregon's energy efficiency efforts, with programs supported by utility, state, and federal funding. Upstream market transformation initiatives lower costs of efficient products at the retail level. In addition, energy bill payment assistance with federal and local dollars can help people pay their energy bills, easing part of the energy cost burden experienced by some homeowners and renters.

Direct delivery programs like weatherization are delivered to low-income customers through community action partnerships.  Energy Trust has offered higher incentives for weatherization and heating equipment in moderate income homes, has higher incentives for furnaces in rental homes, and has offered free efficient lights and water-using devices through multiple channels. Consumer-owned utilities and gas utilities also offer a variety of services for limited-income customers. Other programs are geared toward helping with home repairs and making sure housing meets health and safety standards. Local programs, such as Oregon Energy Fund, connects households struggling with energy costs with resources and programs. The equity aspects of energy efficiency are explored more fully in Chapter 7.

# Energy Efficiency Achievements

Efficiency is an important part of the mix of resources that contribute to the electricity load in the region — it's the largest electricity resource after hydropower. Since 1980, the region has met more than half its electricity load growth through efficiency. See a more detailed view of where Oregon's electricity generation comes from in Chapter 1.

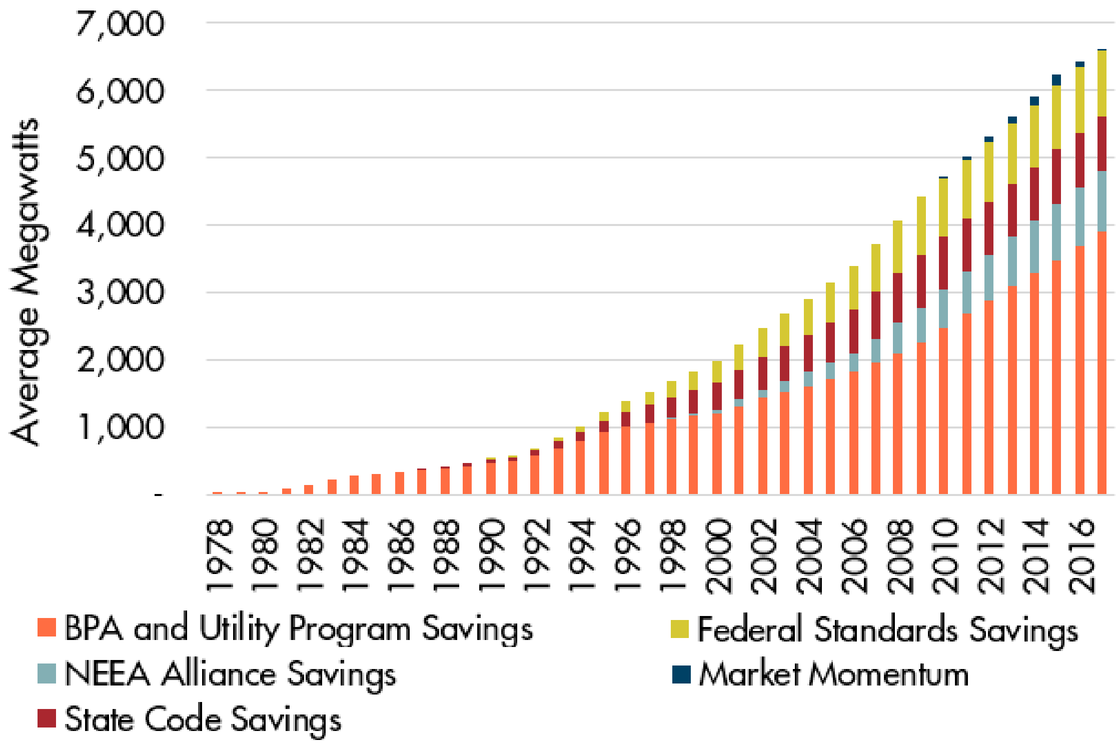
**Figure 6.3: Electricity Resources in the Region, Including Efficiency[3]**




The Northwest Power and Conservation Council (NWPCC) estimates that the combined efforts of all efficiency activities in the region from 1980 to 2017 provide more than 6,600 average megawatts of savings. Oregon's contribution to the region's energy efficiency gains is about 1,900 average megawatts – enough to power more than a million Oregon homes for a year. Efficiency is the also the most environmentally benign electric resource.

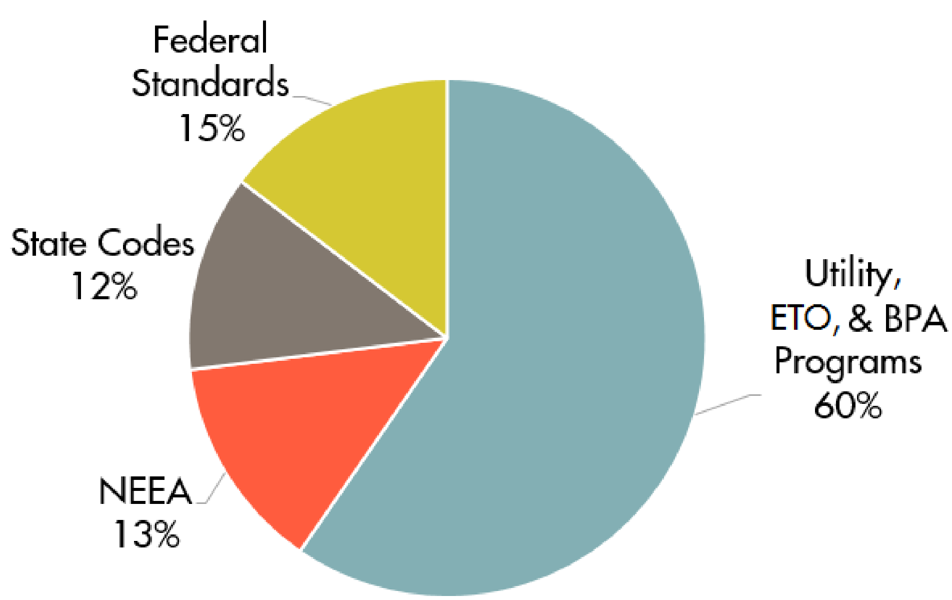
Figure 6.4 shows the cumulative regional savings to 2017 by category: Utility and BPA programs, Northwest Energy Efficiency Alliance market transformation activities, federal appliance standards, and state building codes. Each is explained in detail below. Until recently, the NWPCC only tracked regional savings, so there is no breakdown of category savings for Oregon.

**Figure 6.4: Cumulative Regional Savings from All Mechanisms — 6,623 average MW through 2017**




Of the 6,623 aMW of electric energy efficiency the Pacific Northwest has achieved since 1978, 60 percent comes from utility, Energy Trust, and BPA programs; the remainder is split between federal standards, state codes, and Northwest Energy Efficiency Alliance market transformation efforts.

**Figure 6.5: Energy Efficiency Achievements by Category**

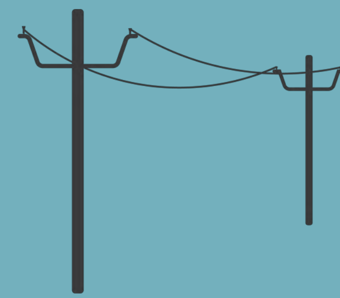


## Utility and BPA Programs (cumulative savings of 3,918 aMW)

Perhaps the most familiar category for many customers is the energy efficiency programs offered by utilities. Consumer-owned utilities served by BPA offer efficiency programs and services to their customers with funding from BPA and their own local utility funding. IOU electric and natural gas energy efficiency programs are administered by Energy Trust of Oregon.

### AVERAGE MEGAWATT (aMW)

Represents one MW of energy delivered continuously 24 hours/day for one year.



## Northwest Energy Efficiency Alliance (cumulative savings of 885 aMW)

“Market Transformation” is a process which uses a combined program of technology refinement, delivery system refinement, education, promotion, and incentives to permanently change behavior and practices to enhance efficiency. This helps bridge the gap between the development of new technology and market acceptance. After the market has adopted these new efficiency measures and products, in many markets codes and standards make them mandatory.

The Northwest Energy Efficiency Alliance (NEEA) is an alliance of more than 140 Northwest utilities and energy efficiency organizations working on behalf of more than 13 million energy consumers, BPA, Energy Trust, and utilities. Their focus on transforming the energy efficiency marketplace includes electric and natural gas market transformation efforts. For example, NEEA has led regional market transformation at the retail level by helping to establish efficiency specifications and tests, enticing manufacturers into offering improved products, promoting products, encouraging product placement in stores, providing rebates, and paying retailers incentives to reduce the retail prices of energy efficient products. Because of these efforts customers get used to buying the more efficient product, and as the demand for the product increases the price decreases. When the market is “transformed,” the lower prices, buying habits, and availability of the more efficient product can allow the incentives to be reduced or discontinued.

Programs that bridge the gap between federal or state standards and market readiness include nationwide efforts like ENERGY STAR and regional offerings from the NEEA. Federal standards often follow state adoption and market experience, so state standards help pave the way for efficiency nationwide. For this reason, appliance standards are an important part of Oregon’s energy efficiency portfolio.

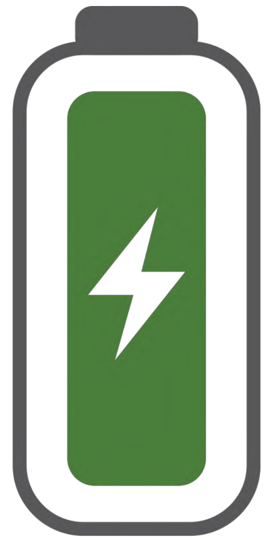
## State Building Codes (cumulative savings of 808 aMW)

The cumulative regional code savings are from energy codes in Oregon, Washington, Idaho and Montana. Oregon’s share of those savings comes from residential and commercial codes.

Oregon has a statewide code for all new and remodeled residential and commercial buildings. Oregon’s codes have led the nation in efficiency, and the commercial and residential codes are among the most efficient of all states.

Oregon's codes are reviewed every three years by Oregon's Buildings Codes Division of the Department of Consumer and Business Services in consultation with the Oregon Department of Energy and an extensive public process. Governor Kate Brown's Executive Order 17-20[32] (discussed in more detail below) sets specific targets for increasing the commercial and residential codes by 2022 and 2023.

## Federal and State Standards (cumulative savings of 963 aMW)



Federal standards set a minimum level of efficiency for equipment and products, whether they are installed as part of construction of a new building or purchased as a replacement. For example, when replacing an old furnace, the new equipment cannot be less efficient than the federal standard.

States may not adopt standards that are more stringent than federal standards, but not all products have federal standards. Oregon, along with a dozen other states, adopts standards for energy efficient appliances where no federal standards exists. For example, in 2013 Oregon set new standards for three products: televisions, battery chargers, and double-ended quartz halogen bulbs. State efficiency standards are promulgated by ODOE under guidelines established by Oregon Administrative Rules.

Oregon's standards coincide with standards set in larger markets, such as California, so manufacturers that meet California standards will also meet Oregon's. This broadens the market and helps build momentum and market acceptance that supports efforts to upgrade federal standards. Oregon passed legislation for energy efficiency standards in 2005 and 2007, creating standards for 17 products, in ORS 469.229 through 469.261.[4] A By January 1, 2010, thirteen of these were preempted by federal standards mandated by the Energy Policy Act of 2005 and the Energy Independence Act of 2007. Savings from those federal standards are what is included here.

Oregon continues to be an active member in the Pacific Coast Collaborative (PCC) Codes and Standards group, along with California, Washington, and British Columbia. The PCC group conducts monthly calls to share information and coordinate appliance standards activity across the region. ODOE closely monitors action on standards at the federal level, and works with stakeholders to ensure strong state standards remain in place.

## Market Momentum (cumulative savings of 52 aMW)

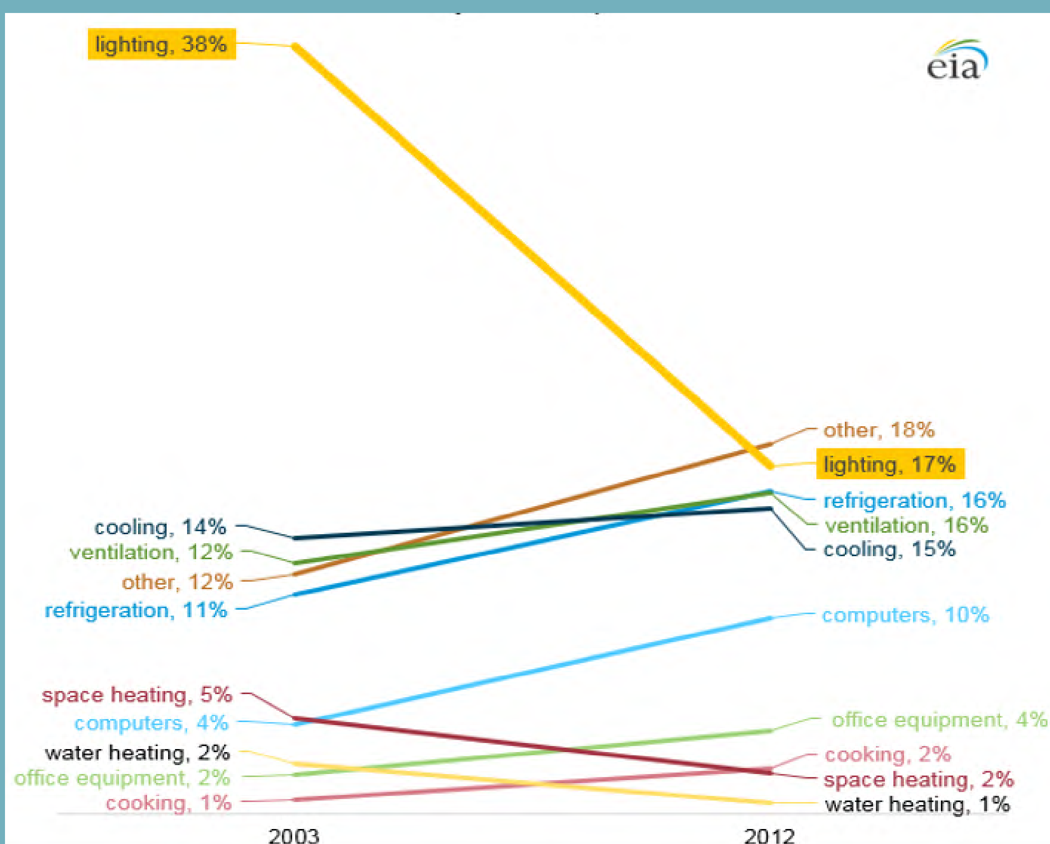
A new and additional category is market momentum, which is savings not tied directly to a utility, implementer, or incentive program. This occurs, for example, when a customer chooses to buy an appliance that is more efficient when shopping for a replacement but does not receive a rebate or other incentive. Another example is Energy Services Companies (ESCOs), which offer financing and guaranteed savings on energy efficiency measures without an incentive other than the savings from a reduced energy bill. This category may also include savings that were influenced by a program where the influence is difficult to trace. In both cases the region still benefits from the energy efficiency choices.

# FEDERAL STANDARDS: LIGHTING

Increasing lighting efficiency has been a focus of many programs conducted by both governmental entities and electric utilities. At the federal level, two major pieces of legislation have had a significant impact on lighting efficiency - the Energy Policy Act of 2005 (EPAct 2005),[18] which provided tax credits for some commercial lighting, and the Energy Independence and Security Act (EISA) of 2007,[19] which incrementally increased efficiency in light bulbs with high efficiency fluorescents or light emitting diode bulbs.

The Commercial Buildings Energy Consumption Survey,[20] conducted by USDOE, collects data about lighting installed under the new standards. The data shows that since 2003, distribution of lighting types has changed, resulting in reduced lighting demand in commercial building spaces. Because of these federal standards, lighting as a percent of overall commercial building energy use has been cut in half from 38 percent of a typical commercial building in 2003 to about 17 percent by 2012. These standards have been possible because local efficiency programs have created large-volume markets for efficient products which have led to higher reliability, lower prices and more consumer acceptance. Evaluation and market research associated with local programs, particularly those in the Northwest, also provide much of the data on savings and market acceptance used in Federal standard setting processes.

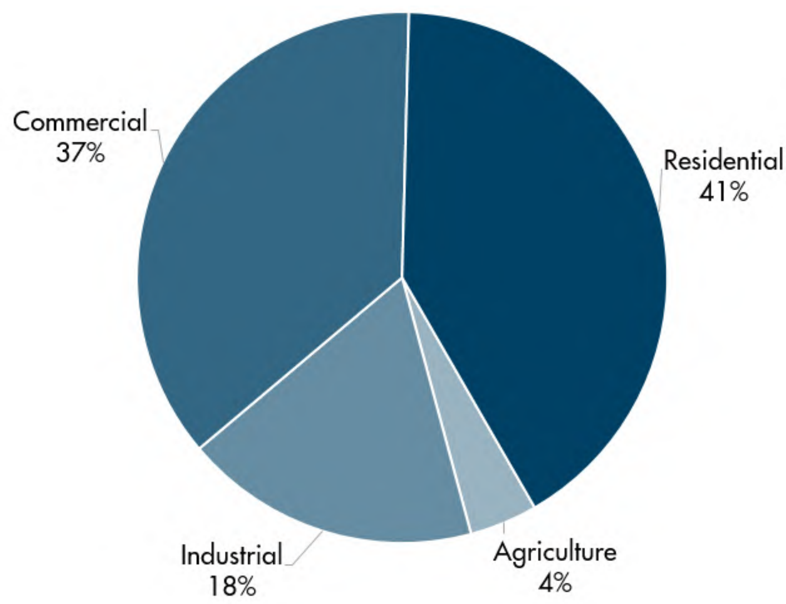
**Figure 6.6: Share of Electricity Consumption, 2003 to 2012[14]**



# Sector Energy Efficiency

These views of sector energy efficiency achieved in the region are provided by the Northwest Power and Conservation Council.[3] NWPCC estimates savings at a sector level for the region, but not currently for individual states. These following figures illustrate sector contributions to overall energy efficiency for the 2010-2014 period, which is the most recent sector level data available. Forty-one percent of the region's electricity energy efficiency savings comes from the residential sector, followed by the commercial sector (37 percent), then the industrial sector (18 percent), and the agriculture sector (four percent).

**Figure 6.7: Energy Efficiency Across Sectors**

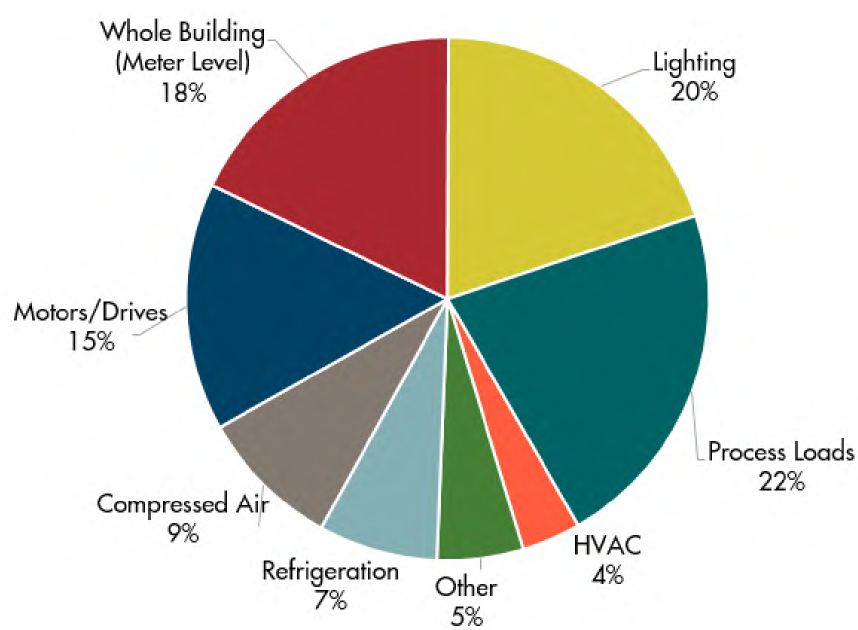



## Industrial Energy Efficiency

Industry is always looking for ways to improve production and lower costs. Operators of industrial facilities have learned that many energy upgrades pay for themselves in energy savings in a relatively short period of time, which helps the price of their products and their bottom line.

Process loads refer to energy consumption for industry-specific machinery used to process, manufacture, or assemble a product and to operate the industrial facility. Equipment can range from heating and drying of materials to conveying and assembly machinery.

**Figure 6.8: Industrial Energy Efficiency**



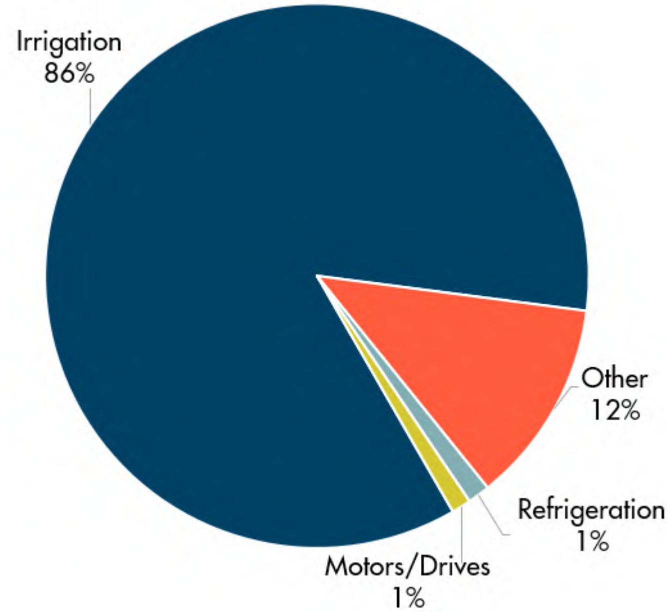

Industrial energy efficiency can include lighting upgrades, originally from incandescent to fluorescent lighting and now incorporating more applications of using light-emitting diode (LED) lights. Lighting efficiency contributes about 20 percent of electric savings in industrial facilities.

Facilities can realize energy savings with motors/drives by installing more efficient, right-sized motors, installing variable frequency drives (VFDs) which save energy through tighter control matched to process requirements, and by simply turning motors off when not in use.

Compressed air is used to drive a variety of industrial processes, e.g., power tools or to atomize paint. Typical efficiency measures include installation of equipment that allow air compression systems to more closely match the loads or system requirements, as well as comprehensive air leak detection and repair. Refrigeration includes frozen food and cold storage for food. Efficiency opportunities range from installing more sophisticated controls to installing VFDs on refrigeration compressors that run at partial load.

## Agriculture Energy Efficiency

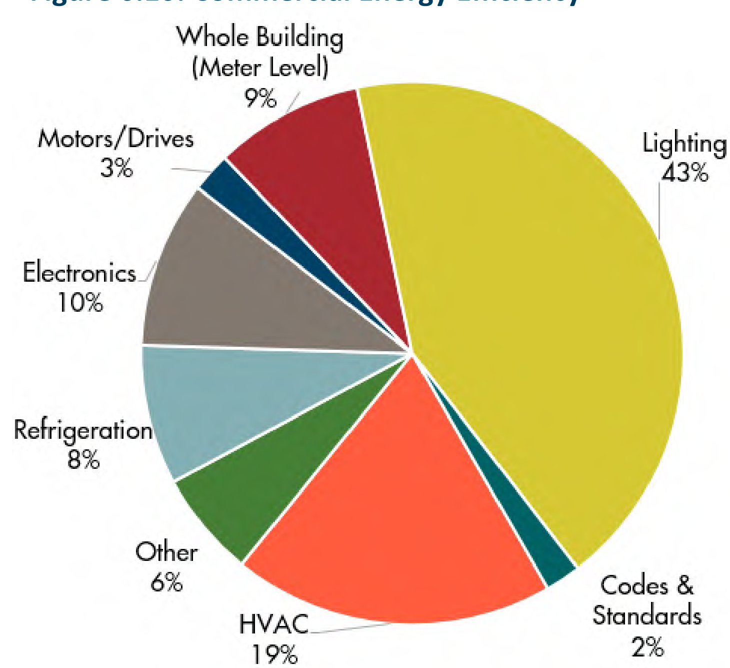
**Figure 6.9: Agriculture Energy Efficiency**




The bulk of agricultural savings though energy efficiency programs are in water pumping for irrigation. Examples include equipment that allows farmers to more precisely control the amount of water they pump and apply to their fields, such as variable frequency drive (VFD) pump motors and new sprinkler fittings, and irrigation controls that monitor weather conditions and soil moisture levels. Piping and pressurizing formerly open irrigation canals are also important irrigation efficiency improvements. Piped systems are pressurized by gravity and can eliminate pumping from the canal to field sprinklers. An added benefit from pipe systems is the opportunity for small hydroelectric generators to be installed in the piped canal. Other significant energy savings in the agricultural sector come from lighting, dairy barn ventilation fans, and energy-free stock watering tanks.

## Commercial Energy Efficiency

**Figure 6.10: Commercial Energy Efficiency**



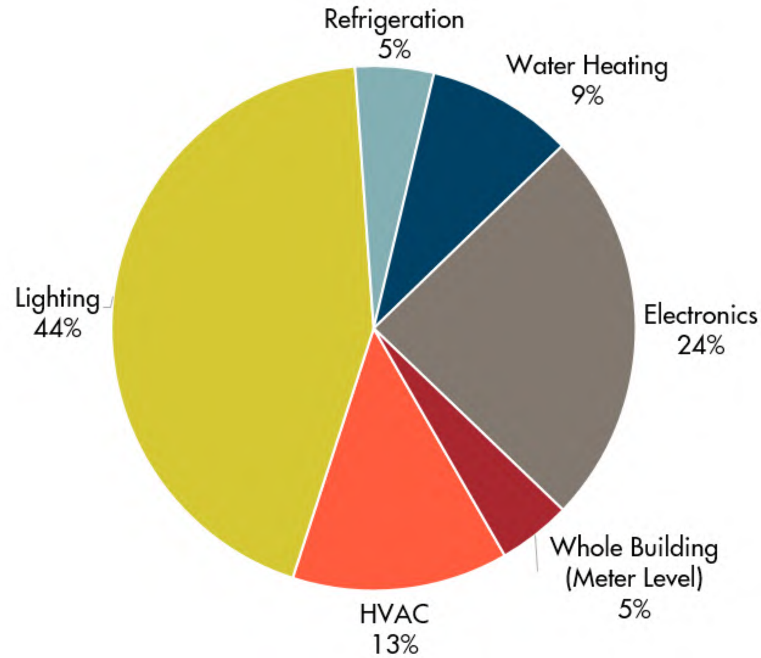

In addition to leaps forward in efficiency for commercial lighting with LEDs, commercial building operators continue to improve their heating and cooling systems, reduce refrigeration energy loss by installing closed product refrigerators and freezers, and commission buildings for efficiency by fine-tuning lighting and equipment.

According to the 7th Power Plan, the largest contributor to commercial savings potential remains upgrading lighting and lighting controls. This includes outdoor lighting, such as street and roadway lighting. Lighting will continue to be the biggest contributor of savings in the commercial sector because we still have a great deal of retrofits left to do and due to innovations in technology. LEDs are the latest generation of new lighting technology to take hold. Advancements in heating, ventilating and air conditioning equipment (HVAC) such as variable refrigerant flow, ductless heat pumps and controls are gaining acceptance in the commercial sector.

## Residential Energy Efficiency

Energy efficiency in homes continues to be a savings opportunity as new technology is adopted and homeowners renovate older homes. Insulation, air sealing, and new windows remain popular. Two promising technologies are gaining acceptance in the marketplace. Ductless heat pumps and heat pump water heaters reduce heating and cooling or water heating energy use by 50 percent. Adoption of high efficiency lighting has grown with more choices in the market for lighting that is efficient, attractive, and affordable.

**Figure 6.11: Residential Energy Efficiency**




## DUCTLESS HEAT PUMPS

Ductless heat pumps, sometimes called mini-split heat pumps, move warm or cool air without needing ductwork. These heat pumps are an efficient option for homes with electric resistance heating, or as an add-on to an existing ducted system to serve specific areas. The portion of the device that is outside the home is about half the size of earlier whole-house heat pumps. Refrigerant lines from the outdoor component supply heating and cooling to the indoor unit, which is usually mounted high on a wall where it can distribute and circulate conditioned air without causing drafts on the occupants. Heat pumps can reduce heating- and cooling-related energy use 50 percent or more.

The 7th Power Plan[22] identifies about two-thirds of achievable potential savings in the residential sector to come from “lost-opportunity measures,” making sure that the most efficient new technology replaces old worn-out equipment. The replacement of water heaters, heat pumps, lighting, and clothes washers are often examples of lost-opportunity measures.

**Figure 6.12: Conservation Potential in All Sectors[22]**

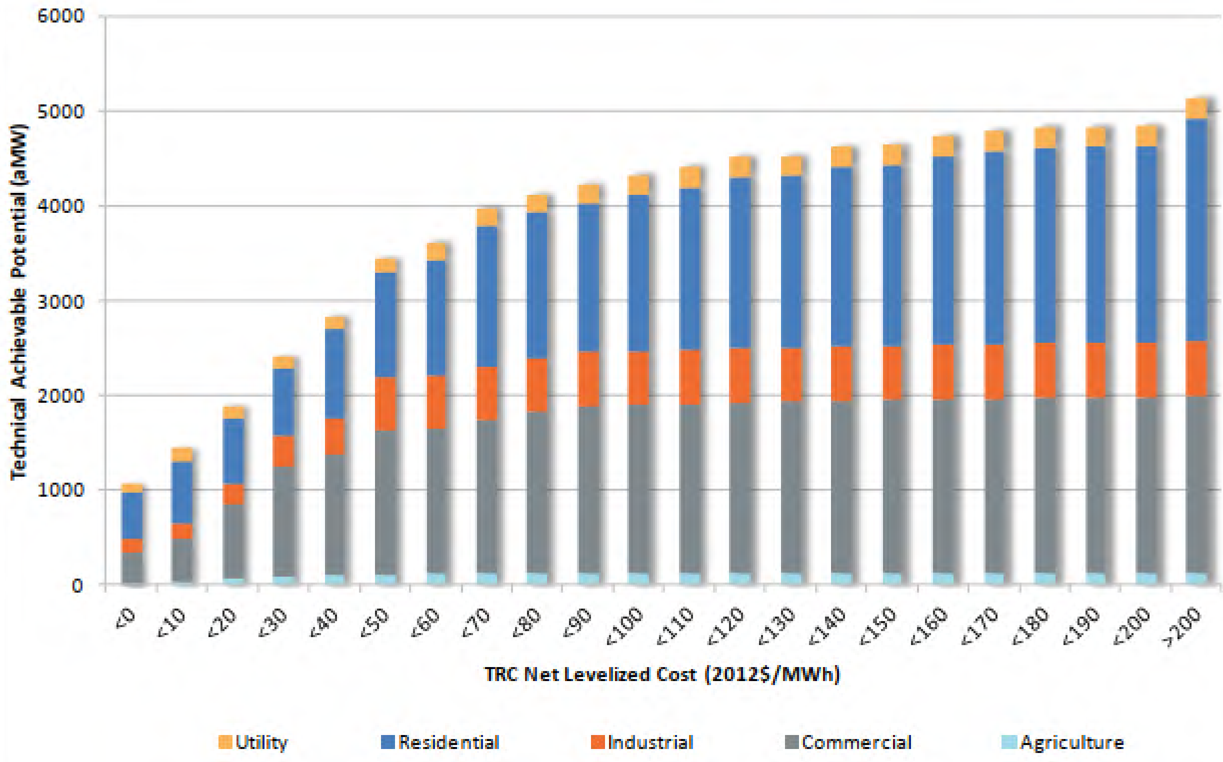



Figure 6.12, from the 7th Power Plan,[22] shows each of the sectors, including "Utility" efficiency improvements that are made in utility infrastructure, such as voltage control in the utility distribution system.

# State of Oregon Programs and Initiatives

In addition to policies that encourage energy efficiency by utilities, Oregon has a long history of lead-by-example state policies for our public buildings and agencies. Oregon government leads by example with numerous programs and initiatives requiring public buildings and fleets to be energy efficient, benchmarking of building energy use, promoting home energy scoring, adopting appliance efficiency standards, providing guidance on energy savings performance contracts, and conducting research and development on new technologies and energy efficiency measures. Each of these programs is explained in more detail below.

## Statewide Building Code and Energy Code

The 2008 Oregon Code exceeded the national Model Code at the time by about 15 percent,[23] paving the way for the pursuit of the energy efficiency improvements called for in Executive Order 17-20, described later in this chapter. In effect, the 2008 Oregon code was equivalent to the national ENERGY STAR voluntary program, making all new homes in Oregon as efficient as an ENERGY STAR home.

In 2009, SB 79[24] established numerous goals and considerations for Oregon's Residential Specialty Code energy requirements. The resulting law required that the Building Codes Division of the Department of Consumer and Business Services periodically review and update the state building code to ensure it keeps pace with advancements in energy efficiency. It established a Reach Code which is "a set of statewide optional construction standards and methods that are economically and technically feasible, including any published generally accepted codes and standards newly developed for construction or for the installation of products, equipment and devices." The Reach Code is a pathway to subsequent code improvements, allowing an opportunity to assess whether any of the standards and methods contained in the Reach Code should be in the state building code. Also, development of the Reach Code or any statewide alternative method that targets increased efficiency should address federal, state, and local financial incentives and advances in construction methods, standards and technologies, and consider changes proposed by the Architecture 2030 challenge, a national initiative to improve energy conservation standards.

By 2017, Oregon's residential code exceeded the most recent 2018 national Model Code standard by about 7.5 percent, among the most efficient codes in the country.[25]

Oregon's code process assesses the national Model Code standard and adds amendments that strengthen our code. It also creates option pathways for energy improvements. For example, there is a federal standard for furnace efficiency. A state code may not require a higher efficiency furnace, but Oregon allows builders to voluntarily choose a more efficient furnace as part of the options paths, as long as it meets the minimum requirements of the federal code. This popular choice means more high-efficiency furnaces operating in the state.

## State Energy Efficient Design Program

The State Energy Efficient Design Program (SEED) was established in 1991 by ORS 276.900-915.[26] This law directs state agencies to work with the Oregon Department of Energy to ensure cost-effective energy conservation measures are included in new and renovated public buildings. The program requires that all state facilities constructed on or after June 30, 2001, exceed the energy conservation provisions of the Oregon State Building Code by at least 20 percent.

Existing buildings were required, by June 2015, to reduce energy use by 20 percent compared to the building's baseline energy use in 2000. State buildings reached that goal ahead of schedule in 2012. Building on Energy Trust program and incentive support, the largest state agencies have implemented two-year Strategic Energy Management initiatives, with an emphasis on building-level data to effectively prioritize retrofits.

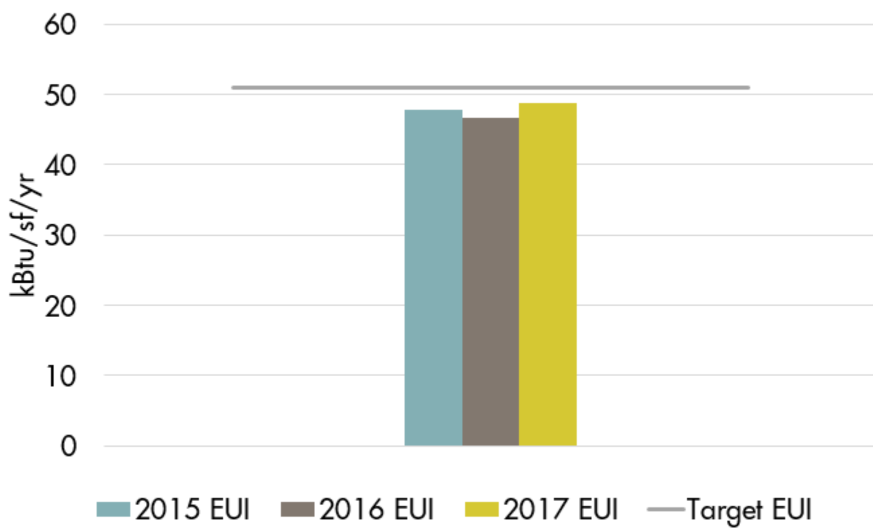
The law establishing the SEED program also requires new state facilities to be designed, constructed, renovated, and operated so as to minimize the use of nonrenewable energy resources and to serve as models of energy efficiency.

## Benchmarking Building Energy Performance

The Oregon Department of Administrative Services directs state agencies to report their energy use to the Oregon Department of Energy. Agencies can compare their current energy use with that of the base year (2000), or any year of their choosing, and can compare energy use indices and check whether mandatory energy savings have been achieved. State-owned facilities over 5,000 square feet, state buildings, and public schools voluntarily disclose energy use via the Portfolio Manager online program. ODOE uses this data to benchmark facilities' energy use and identify potential future energy efficiency investments. The state also conducts outreach, training, and resources to local jurisdictions that are interested in commercial building benchmarking policies and ordinances. So far, ODOE has benchmarked and is collecting ongoing data in Portfolio Manager on 303 state buildings with over 18.3 million square feet.

ODOE also pulls reports from the database to prepare a biennial State Energy Efficient Design report to the State Legislature as required by ORS 276.915(9).

**Figure 6.12: Average Energy Use Index for State of Oregon-owned Offices**

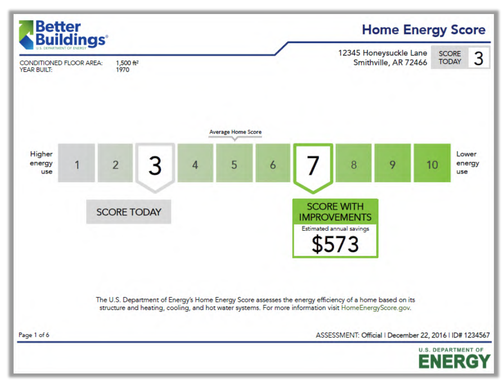



## ENERGY USE INDEX

Energy per square foot per year, calculated by dividing the total energy consumed in a building in a year by its total floor area.

The lower the number, the better!

## Home Energy Scores




A home energy score is based on a standard assessment of energy-related assets to compare energy use across the housing market. In 2010, Oregon was the first state to develop administrative rules that specify how home energy scores can be created and deployed across the state. Though scoring is not mandatory statewide, the administrative rules guide local efforts and keep the market consistent when scoring entities want to operate in Oregon.

The Eugene Water and Electric Board was the first utility to provide Home Energy Scores under the administrative rule. EWEB provides scores to residential owners and tenants to help them better understand energy and water usage in their properties and possibly lower their monthly energy bills. Working closely with national scoring staff at U.S. Department of Energy, as well as ODOE, EWEB developed a professional assessor network using University of Oregon students and produced more than 150 scores in 2017.

The rules also served as a foundation for the Portland Home Energy Scoring ordinance that went into effect in 2018. Under this City of Portland ordinance, all homes listed for sale must obtain a home energy score, and real estate professionals can post home scores to real estate listings. Portland is expected to produce 14,000 home scores in 2018. This valuable consumer-information effort is expected to spur retrofits of homes on the market, improve efficiency of homes, and contribute to Portland's climate change goals through reduced energy use. Homes receive a 1 to 10 rating and estimates of future energy use. Local energy prices and the local greenhouse gas content of electricity are also required on the label.

## Energy Efficient Schools

The passage of SB 1149, mentioned previously in the chapter, created a three percent public purpose charge, first assessed in 2002, on Portland General Electric and Pacific Power customers. School districts in these utilities' service territories receive 10 percent of the funds, which may be used to conduct energy audits or implement energy efficiency measures such as lighting, insulation, or heating system retrofits. Over the last five years, school districts have spent an average $3.8 million a year of public purpose charge funds on energy efficiency measures. In 2017, ten school districts completed more than 60 projects that cost more than $7 million, with $2.7 million coming from the district's public purpose charge funds.

The administration of the school public purpose charge funds is facilitated by the Oregon Department of Energy in cooperation with individual school districts. Public Purpose Charge (SB 1149) Schools Program Guidelines were first developed in March 2002 to assist eligible K-12 school districts in the implementation of cost-effective energy efficiency improvements. Public purpose charge funds must first be used for energy audits, then on approved energy efficient measures recommended by those audits. The Oregon Department of Energy provides business and technical oversight for the energy audits and projects to ensure consistency with the program guidelines.

For schools outside PGE and Pacific Power territory, consumer-owned utilities provide technical assistance and incentives for efficiency upgrades at schools. ODOE provides technical assistance and training for school staff and contractors on constructing highly efficient and environmentally sound buildings. ODOE provides lists of qualified energy auditors and commissioning agents to facilitate contracting for energy efficiency improvements in schools that face challenges in keeping aging facilities operating.

### A BRIGHT ENERGY FUTURE FOR SALEM-KEIZER SCHOOLS

The Salem-Keizer School District is educating the next generation of Oregonians in the mid-Willamette Valley. The state's second largest school district, with more than 40,000 young Oregonians attending 65 schools, is more energy-efficient than ever. The District has completed more than 250 energy efficient measures in more than 50 schools.

Salem-Keizer's Highland Elementary.

The estimated annual savings total $575,000, but over the life of these systems, these savings will continue to add up and save the district money — which can be put back into their facilities.

## Large Electric Consumer Public Purposes Program

Also funded by the Public Purpose Charge, the Large Electric Consumer Public Purpose Program (LECPPP) allows large electric customers to retain their Public Purpose Charge efficiency fees and invest in improvements at their own sites. The customers self-direct their project rather than receive incentives from utility programs. The Oregon Department of Energy administers the transactions with the utilities to credit the Public Purpose Charge to the customers. ODOE also provides technical oversight to projects and reviews project proposals to track energy savings. In 2016, these large customers contributed more than 1.5 million kWh of energy savings through self-directed projects, ranging from lighting and process equipment upgrades to complex manufacturing and assembly line energy efficiency improvements.

## Small-Scale Energy Loan Program

The Small-Scale Energy Loan Program (SELP) provides public, private, and tribal stakeholders access to energy project capital. SELP issues fixed-rate long-term loans for qualified Oregon energy projects that invest in energy conservation, renewable energy, and alternative fuels, or that create products from recycled materials. Over SELP's 35-plus-year history, the program has issued more than 900 loans, with an associated $612 million in financing, to recipients located across all 36 Oregon counties. SELP loans for energy efficiency have been issued across the spectrum of public bodies:

**School Loans:** SELP loans have gone to a number of school districts as part of the High Performance Schools pilot project. The goal of the pilot was to install cost-saving energy measures and controls that allow students to be cool in the summer and warm in the winter thereby improving their learning environment. The resulting energy savings from installed measures reduce the overall cost of the improvements to the school districts. For example, the Newberg School District received a loan for $1 million to finance energy efficient improvements to their lighting, boiler and HVAC systems that save the district nearly 149,000 kWh of electricity and 11,555 therms of natural gas annually.

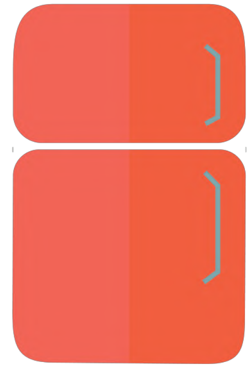
**Higher Education Loans:** SELP loans support Oregon university system projects. For example, Southern Oregon University received a loan for $2.7 million to finance an energy efficient retrofit to Churchill Hall that is anticipated to save 48,756 KWh of electricity annually.

**County Loans:** In 2014, SELP loaned $2.08 million to Lane County to finance renovations and upgrades to its data center in Eugene. It is anticipated that this project will save 506,457 kWh of electricity annually.

## Business Energy Tax Credit Program

The Business Energy Tax Credit (BETC) program, which was administered by ODOE and reached its sunset in 2014, helped schools, tribes, nonprofits, businesses, industries, farms and ranches save energy and invest in renewable energy. From 1979 to the sunset of the program, BETC awarded 24,738 final certificates for projects that leveraged nearly $3 billion in certified project costs for energy investments in Oregon. Many city, county, state, tribal and federally owned buildings were awarded tax credits under the program.

## Residential Energy Tax Credit



The Residential Energy Tax Credit (RETC) program was also administered by ODOE from 1978 until it sunset in 2017. Eligible energy efficiency measures under the program included more than 120,000 heating, ventilation and air conditioning upgrades; 15,000 water heaters; and nearly 50,000 refrigerators. By 2017 nearly 562,000 credits were approved for a total of $135.9 million.

## State Home Oil Weatherization Program

The State Home Oil Weatherization program began in 1981 and has granted more than 12,000 incentives for efficiency measures on oil-heated homes. On average, the SHOW Program provides about $200,000 per year in funding to community action partners for low-income, oil-heated homes.

## Energy Savings Performance Contracting

An Energy Savings Performance Contract (ESPC) is an agreement between a building owner and a qualified Energy Service Company (ESCO) to install energy efficiency measures and guarantee the energy savings or performance. ESCOs work with local governments, schools, public agencies, and private entities to identify, evaluate, recommend, and design the energy efficiency projects. State agencies that want to use an ESPC for energy savings measures must use a firm on a pre-qualified list of ESCOs. ODOE maintains the qualified ESCO list, as well as an ESPC web page that contains several tools to guide choices including: a calculator, an audit guide, and an ESPC Contracting Guidebook.

## Research and Development in Oregon

While most research and development on energy efficiency is done at the federal level by the U.S. Department of Energy and its associated national laboratories, innovative research and development does take place in Oregon at both public and private institutions. Some examples:

- **The Oregon VertueLab,** formerly the Built Environment and Sustainable Technologies Center (BEST), is an independent nonprofit organization established by the Oregon Legislature to help Oregon businesses compete globally by transforming and commercializing university research into new technologies, services, products, and companies. VertueLab provides energy efficiency research grants and has research facilities for the study of energy efficient buildings.[27]

- **The University of Oregon Energy Studies in Building Laboratory** conducts research on buildings and related transportation to develop strategies for maximum energy efficiency in new materials, components, assemblies, and whole buildings.[28]

- **The Baker Lighting Lab at University of Oregon** provides support and opportunities for the exploration of light design ideas. Among other facets, it studies daylighting and the control of lighting systems.[29]

- **Bonneville Power Administration Technology Innovation** research includes a focus on energy efficiency. Recent Technology Innovation Projects include demand response and end use efficiency, waste water heat pump design and pilot and occupancy controlled outdoor lighting.[30]

- **Northwest Energy Efficiency Alliance (NEEA)** is dedicated to accelerating both electric and gas energy efficiency, leveraging its regional partnerships to advance the adoption of energy-efficient products, services and practices. Energy Trust, regional utilities, and the Bonneville Power Administration co-fund NEEA on behalf of Oregon's consumer-owned utilities.

## Executive Order 17-20: Accelerating Efficiency in Oregon's Built Environment to Reduce Greenhouse Gas Emissions and Address Climate Change.

Oregon leaders have long recognized that energy efficiency is an important tool for reducing energy costs to consumers and realizing environmental benefits such as greenhouse gas reductions. Executive Order 17-20 (EO),[32] signed in November 2017, by Governor Kate Brown, connects energy efficiency and climate change, noting "energy efficiency leads to significant greenhouse gas reductions that are essential to meeting our state greenhouse gas reduction goals and addressing climate change."

The State of Oregon's "550" Building has electric vehicle chargers and a 8,300 watt solar array.

### Energy Efficiency Leadership in State Buildings

To increase energy efficiency in state buildings, the EO creates high performance energy targets for existing state buildings, requires carbon neutral operations for new state buildings, requires the development of a plug-load strategy to reduce energy uses not regulated by codes and standards, and directs agencies to purchase equipment that meets high-efficiency energy and water use specifications. In addition, the EO directs ODOE to analyze state building lifecycle energy and water use costs and savings when state building upgrades are considered. ODOE is then directed to work with DAS to develop analysis tools to inform the high performance energy use targets and carbon neutral requirements for state buildings.

### Increasing Energy and Water Efficiency in New Construction

The EO requires higher energy and water efficiency in new construction by calling for revised building codes that require all newly constructed residential and commercial buildings to be solar ready, electric-vehicle ready, and zero-energy ready; the EO also calls for the building code to increase energy efficiency in commercial construction. The EO calls on ODOE and BCD to identify key high-energy use industries that are stable or growing and that have the potential to realize significant cost and energy savings through building code revisions. Finally, the EO directs ODOE to work with stakeholders to determine the potential for new efficiency standards for appliances and water fixtures.

### Increasing Energy Efficiency through Retrofits of Existing Buildings

To increase efficiency at existing buildings throughout Oregon, the EO directs the OPUC to work with the Energy Trust of Oregon on meter-based energy savings pilot programs that focus on buildings that are significantly below current code requirements. It also prioritizes energy efficiency in affordable housing projects to reduce utility bills. ODOE and OPUC are directed to work with private sector partners on data sharing to help show projected energy use reductions in the region, and evaluate the state's distributed energy resources which can help Oregon be more resilient.

### Cost Analysis

The EO makes clear that state agencies are expected to implement this executive order using the least-cost methods available. It directs state agencies to develop and adopt a cost analysis tool to determine whether any directive in the executive order should be deferred for a time due to significant cost at the time of implementation of that directive.

### Implementation

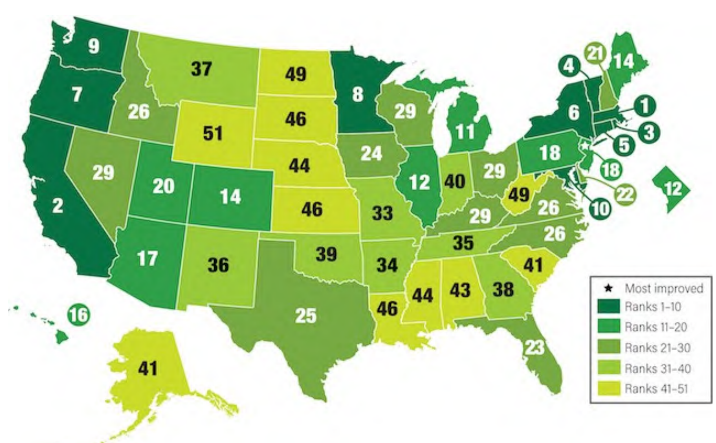
The state has created the Built Environment Efficiency Working Group (BEEWG) to implement the EO. The BEEWG is a collaborative of state agencies including ODOE as the work group leader, Department of Administrative Services, Building Codes Division, Public Utility Commission, and Oregon Housing & Community Services. The group also works with stakeholders across the state as it implements the EO.

# Oregon's National Standing in Energy Efficiency

## ACEEE National Scoring and Ranking

For the twelfth year in a row, Oregon ranks in the top 10 of the most energy efficient states in the country, according to the American Council for an Energy-Efficient Economy (ACEEE).[1] ACEEE's 2018 scorecard ranks Oregon at number seven. Oregon is joined in the top 10 by its west coast neighbors, with California in second and Washington at number nine.

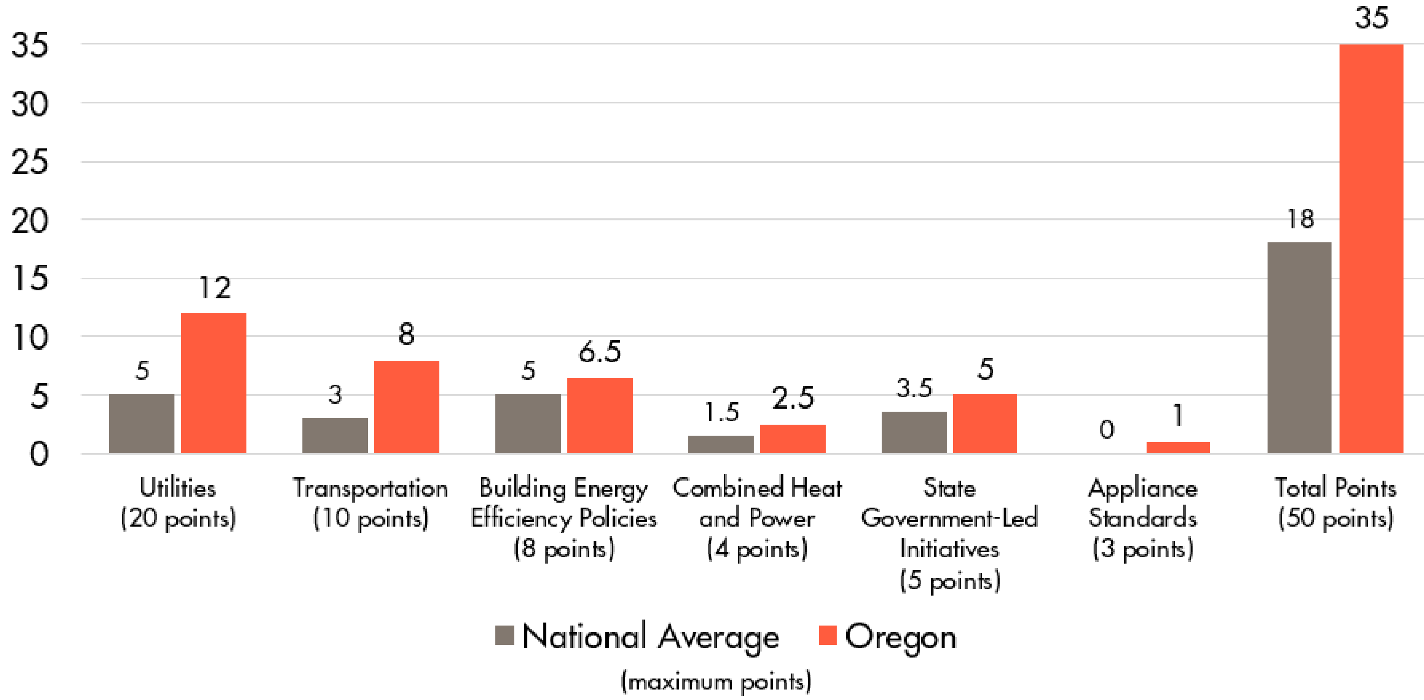
**Figure 6.13: ACEEE 2018 Energy Efficiency Scores[1]**




Each year, the ACEEE releases its *State Energy Efficiency Scorecard*, which compares states based on six categories: utility and public benefit programs and policies, transportation policies, building energy codes, combined heat and power policies, state government-led initiatives around energy efficiency, and appliance and equipment standards. For the most part, scores are unaffected by legacy or prior activities, and each year is considered for the accomplishments in that year. In 2018, ACEEE notes that Oregon's "state government leads by example by requiring energy-efficient public buildings and fleets, benchmarking energy use, and encouraging energy savings performance contracts. Research focused on energy efficiency takes place at several institutions in the state."

In particular, the Scorecard awards Oregon the maximum points for government-led energy initiatives like the State Energy Efficient Design (SEED) Program, which outlines energy requirements and benchmarking procedures for public buildings. Oregon is also recognized for Governor Brown's EO 17-21[32] on energy efficiency and electric vehicles, its strong building energy code programs which includes a voluntary home energy scoring system, and a transportation/land-use system that reduces vehicle miles traveled.

**Figure 6.14: ACEEE State Energy Efficiency Scorecard Results — Oregon Points vs. National Average[1]**




ACEEE noted in its scoring that "Oregon's third-party efficiency administrator, Energy Trust of Oregon, offers a comprehensive portfolio of electricity and natural gas efficiency programs that consistently report savings exceeding the national average. Electricity savings edged upwards in 2017 and the state continues to prioritize outreach to moderate-income, rural, and under-represented customers through a variety of efficiency efforts. The Bonneville Power Administration and the Northwest Energy Efficiency Alliance also work with utilities to generate energy savings within the state. An energy efficiency resource standard is in place that sets long-term energy savings targets."

## Energy Efficiency Jobs in Oregon

In addition to reducing greenhouse gas emissions and saving Oregonians money, the energy efficiency sector employs Oregonians around the state and contributes to economic development. The "2018 U.S. Energy and Employment Report" (USEER),[33] a project of the National Association of State Energy Agencies and the Energy Futures Initiative, estimates that 41,958 Oregonians are employed in energy efficiency jobs, which are those involved in the production and installation of energy efficiency products. These jobs can be found in every county in Oregon, and 20 percent of the efficiency jobs (8,511) are in rural Oregon. Over a quarter of all construction jobs work in energy efficiency, and 14 percent of energy efficiency workers are veterans. Similar to the nation, 74 percent of jobs are at firms of fewer than 20 employees, and 96 percent from firms of fewer than 100 employees.

Nationally, the USEER found that there are 2.25 million American workers in energy efficiency, and 11 percent of these jobs are held by veterans. Energy efficiency added more new jobs in 2017 than any other part of the energy sector, and today there are twice as many jobs in energy efficiency than all the fossil fuel sectors combined. More than 300,000 of these jobs are in rural America. There are more than 350,000 energy efficiency businesses in the U.S.; nearly 80 percent of jobs are in businesses of less than 20 employees, and 96 percent in firms of less than 100 employees. Nearly 60 percent of these jobs are in construction (1.27 million), with the remaining jobs in manufacturing, professional services, and sales.

**Figure 6.15: Oregon Energy Employment, 2017[33]**

## Energy Efficiency

The 41,958 Energy Efficiency jobs in Oregon represent 1.9 percent of all U.S. Energy Efficiency jobs. The largest number of these employees work in high efficiency HVAC and renewable heating and cooling firms, followed by traditional HVAC. Energy Efficiency employment is primarily found in the construction industry.

**Figure OR-8.**

Energy Efficiency Employment by Detailed Technology Application

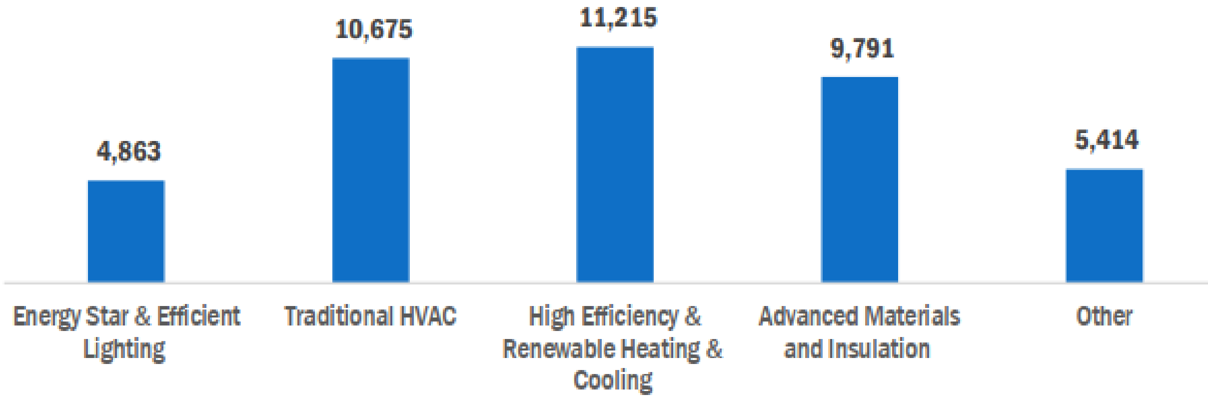
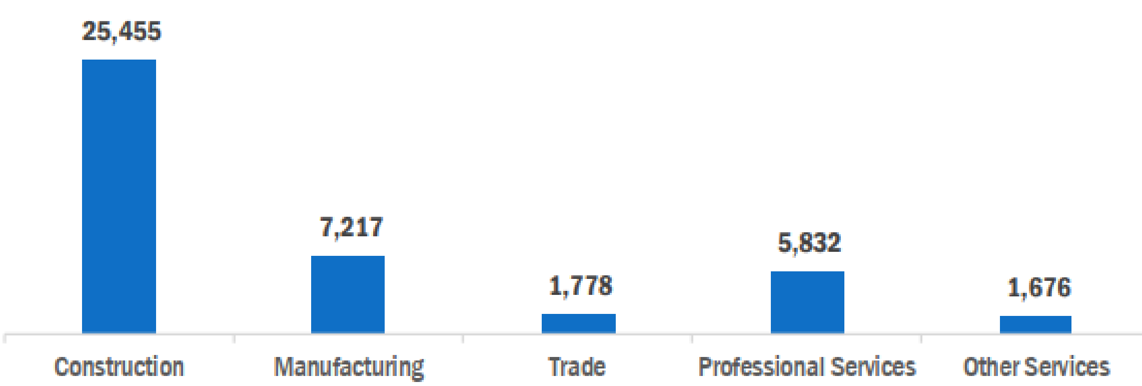



**Figure OR-9.**

Energy Efficiency Employment by Industry Sector



# CONCLUSIONS

Oregon is a **national leader in electric and natural gas efficiency programs**, and the state has a long track record of cost-effectively acquiring energy efficiency. Oregon's and the region's legacy is a portfolio of 6,600 average MW of energy efficiency measures (1,900 aMW from Oregon), which is the second largest resource behind hydroelectricity. According to the NWPCC's 7th Power Plan, the region needs to acquire another 4,300 aMW by 2035. We know how to cost-effectively pursue energy efficiency measures, and existing and new programs in place will enable continued acquisition.

**Working together on state programs**, utility programs, codes, standards, and market transformation efforts will allow us to continue to deliver cost-effective savings.

With an increased focus on **climate action, equity, and resilience,** the state has an opportunity to better coordinate all available efficiency acquisition mechanisms. These outcomes should prompt us to consider new efficiency funding and delivery channels. This could include assessing our methodology for determining the inputs we use to set the cost-effectiveness threshold for acquiring energy efficiency. This additional value could lead to expanded energy efficiency accomplishments that address climate change, improve the equitable allocation of benefits of efficiency programs, and enhance community resilience.

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# CHAPTER 7: PROTECTING CONSUMERS

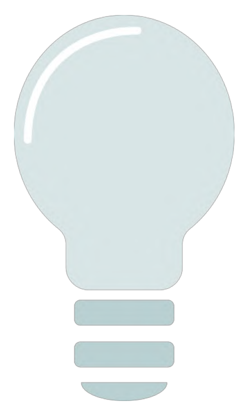
Policy and technology advancements are important to continued progress in the energy sector. All Oregonians should benefit from the changes in the energy sector, with an equitable distribution of costs.

Oregon has a long history of consumer protection that is more important than ever as our energy systems evolve. The state has placed an increased focus on equity — and through intentional engagement with communities, the state can make meaningful, well-informed decisions to ensure clean, affordable energy is accessible to all Oregonians.

## KEY TAKEAWAYS

- The concept of **consumer protection** has been a part of the provision of energy for almost a century, but there continue to be challenges faced by energy-burdened consumers and interest in securing more equitable outcomes in energy-related policies and programs.
- An Oregonian is considered "energy burdened" when their household's energy-related expenditures exceed six percent of their household income. Studies analyzing energy burden typically use household income and utility bills and other home energy costs to do the calculation, however, **energy-burdened households** can also incur other energy-related expenses, such as transportation fuel. In addition, federal, state, and utility programs and policies mitigate energy burden, but there are currently no policies and programs that comprehensively address energy burden from multiple energy sources.
- A better understanding of the **distribution of benefits and burdens** of electricity, heating, and transportation programs and costs for all Oregon residents is needed. This type of comprehensive analysis could inform policies and pathways to achieve the state's environmental and climate change policy objectives while addressing energy burden and equity issues. In particular, as rapid changes in technologies and policies in the energy sector continue, close attention to changes in the distribution of benefits and burdens is needed to ensure equity for all Oregon consumers. To accomplish these objectives, more and better data is needed on how the provision of energy affects public health and people of different demographic characteristics and income levels.

Oregon's energy sector has been and continues to be shaped by technological advancements and leading-edge policymaking. As other parts of this report detail, innovations in key areas such as energy efficiency and renewable energy have resulted in dramatic changes to our energy landscape. The pace of change shows no signs of slowing down, and that holds great promise for Oregon as the state moves toward cleaner energy resources, improved energy efficiency and technologies, and a cleaner transportation system.



While these advancements and innovations are important progress, we must also make sure that all Oregon residents benefit from the changes in the energy sector and that there is an equitable distribution of costs. Oregon has a long history of consumer protection that is more important than ever as our energy systems evolve. More recently, the state has placed an increased focus on equity, which, combined with tools to reduce household energy burdens, can help the state make meaningful, well-informed decisions to ensure clean, affordable energy is accessible to all Oregon residents. Additional analyses and data gaps must be filled as our energy systems are transformed, including data about demographic characteristics, energy costs, public health, and access to new programs and emerging energy technologies.

# Energy Burden

A household can be energy-burdened when their energy-related expenditures exceed six percent of their income.[1] In this case, energy burden is calculated by using the percentage of household income spent on home energy, such as utility bills and other heating costs.

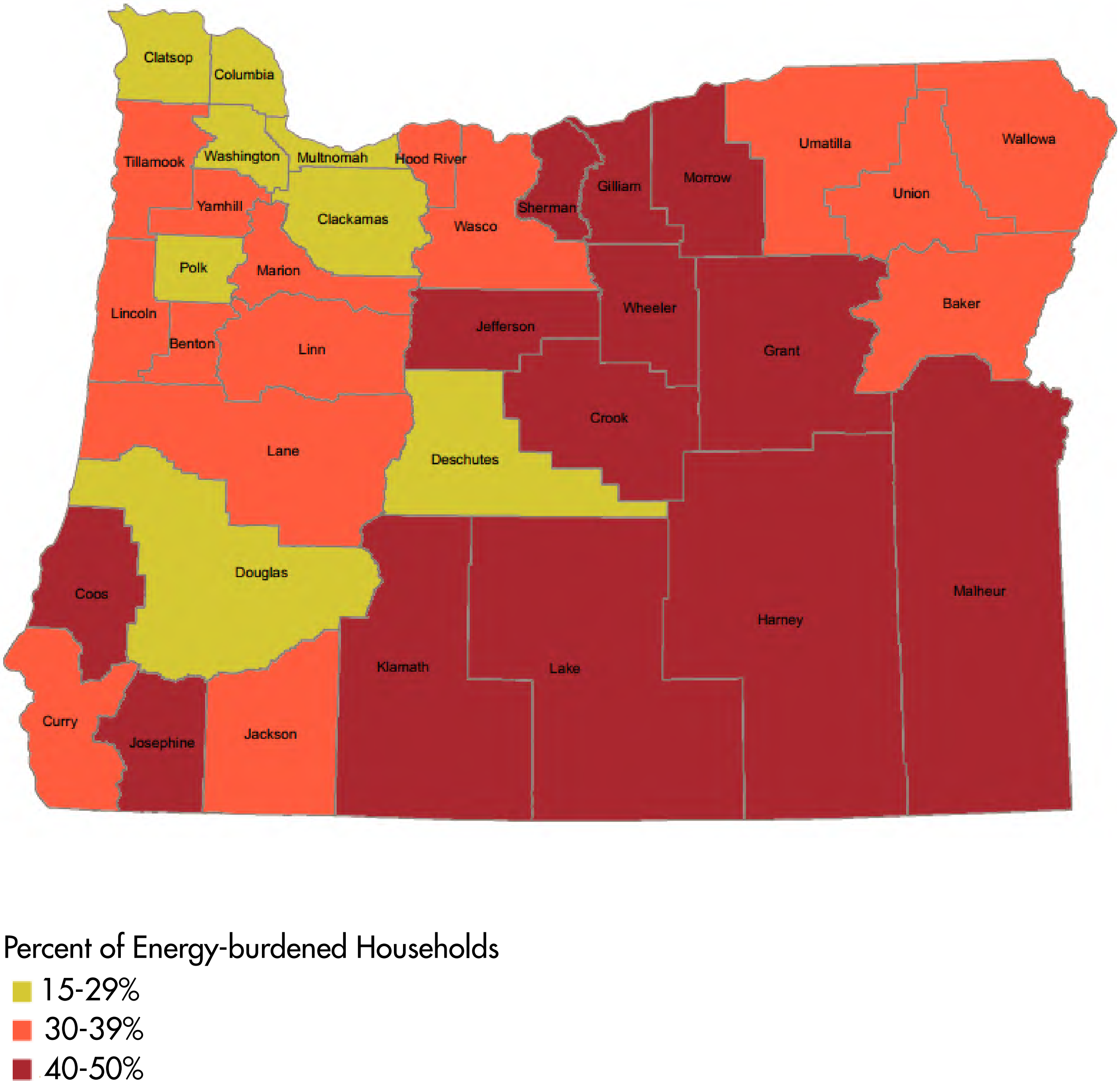
Energy burden involves two key components: energy costs and income. Programs to alleviate energy burden commonly use income thresholds based upon state median income and federal poverty level to determine eligibility. Table 7.1 uses Oregon Housing and Community Services Department (OHCS) income eligibility guidelines and shows when households may be eligible for both energy and weatherization assistance programs.

**Table 7.1: U.S. Median Household Income and Poverty Levels[2]**

| Weatherization Assistance Program | | Energy Assistance Programs |
|---|---|---|
| At or below 200% of Federal Poverty Level | | At or below 60% of State Median Income |
| **Annual Income** | **Household Size** | **Annual Gross Income** |
| $24,280 | **1** | $24,550 |
| $32,920 | **2** | $32,103 |
| $41,560 | **3** | $39,657 |
| $50,200 | **4** | $47,210 |
| $58,840 | **5** | $54,764 |
| $67,480 | **6** | $62,317 |
| $76,120 | **7** | $63,734 |
| $84,760 | **8** | $65,150 |
| $93,400 | **9** | $66,566 |
| $102,040 | **10** | $67,983 |
| $110,680 | **11** | $69,399 |
| $119,320 | **12** | $70,815 |
| $8,640 | **Each additional family member** | $1,416 |

There are 1,603,635 total households in Oregon.[3] According to OHCS, approximately 396,182, or about 25 percent of all households, are considered energy-burdened because of their energy-related expenditures. Figure 7.1, a map of Oregon counties, compares electricity, natural gas, and other home energy costs with household income. It shows the percentage of households in each county with income at or below 200 percent of the federal poverty level. A household is considered energy burdened if six percent or more of its gross income is consumed by energy-related expenses.

**Figure 7.1: Percentage of Oregon Households Considered Energy Burdened and Earning 200 Percent or Below Federal Poverty Level (by County)**[3]



The second component of energy burden is energy costs. National studies have found that even though households that are low-income or in poverty paid less overall on energy bills compared to other households, they paid more per square foot. This factors in on-average smaller living spaces and challenges such as:[4]

- Inefficient and/or poorly maintained heating, ventilation, and air conditioning systems.
- Inadequate insulation and air sealing, leaky roofs and attics.
- Inefficient lighting, water heaters, and appliances like refrigerators and dishwashers.
- Inability or difficulty affording up-front costs of energy efficiency investments.
- Chronic economic hardship or sudden economic hardship like health or family events.
- Lack of access to or knowledge about energy conservation measures or assistance programs.
- Living arrangements, such as renting, with limited ability to improve housing conditions.

Energy burden is just one aspect of a wide range of issues that households with low incomes face. As low-income Oregonians spend a greater share of their income on energy, their energy bills often compete with housing costs, transportation, groceries, medical expenses, and other basic needs. 211Info, a nonprofit, helps people in need navigate and connect with services and resources. They received 6,477 requests for utility assistance in the fourth quarter of 2017, representing 11 percent of all service requests received; and utility assistance was the third most requested service behind housing assistance and social or behavioral support. Another 1,576 requests were submitted for assistance with transportation, including 436 requests for help with gas money.[5] Both of these categories of requests represent facets of household energy burden, and both indicate low-income Oregon households are seeking support to either reduce their energy costs, or in the case of transportation, provide them with other options.

In addition to non-profit organizations, other programs across the state offer assistance. Almost 400 federal, state, and utility programs  and policies address energy burden.[23] Some of these programs offer direct support, helping consumers pay their utility bills, while others aim to reduce bills by reducing energy usage through weatherization and energy efficiency investments. A few categories of energy programs and policies are explored below, along with policies that affect energy-burdened households.

## Ratepayer-Funded Energy Efficiency Programs to Reduce Usage and Utility Bills

Energy efficiency projects, commonly referred to as “measures,” reduce energy use and associated household energy bills. While some efficiency measures, like efficient light bulbs, are available to any occupant, some require structural upgrades or major equipment replacement. These projects typically require that the occupant is authorized to make changes and is financially able to make the improvement. As discussed in Chapter 6, Oregon has encouraged and embraced energy efficiency through a variety of policies and programs. This includes utility and government programs that leverage the system-wide value of energy efficiency to keep customers' overall costs low, while also addressing individual accessibility and costs barriers.

Thanks to a strong history of energy efficiency actions and continuing energy efficiency efforts, utilities avoid adding risky or costly electricity generation facilities, thereby reducing utility system costs. This creates lower overall system costs that allow customers to receive the benefits of energy efficiency, regardless of whether they personally install a measure.[6]

At the utility level, energy efficiency financial support programs use ratepayer funds. Disbursement of those funds is often predicated on whether the energy efficiency measure would be cost-effective by comparing the energy savings against the utility avoiding costs of building new generation or other utility system upgrades. Regulators and utilities use cost-effectiveness tests to determine if financial support from utility ratepayers is reasonable. Oregon utilities and regulators have typically used the Total Resource Cost test that compares the energy-efficiency measure investment to a utility's cost of supplying the same amount of energy to determine whether the measure is the "best energy buy" for all utility customers. All cost-effectiveness tests specify the types and accounting of benefits and costs[7] with a few of the differences illustrated in Table 7.2.

**Table 7.2: Total Resource Cost Test Comparisons[8]**

| Test | Approach | Benefits | Costs |
|---|---|---|---|
| **Program Administrator Cost Test** (PACT) Also called **Utility Cost Test** (UCT) | Utility perspective. Includes all benefits and cost experienced by the utility only. Does it increase or decrease the utility's cost? | Avoided utility costs and expenditures (i.e., avoided energy and fuel costs, avoided capital expenditures, avoided transmission and distribution expenses). | Only utility program costs and expenditures (i.e., administration, delivery, and incentive costs. |
| **Total Resource Cost Test** (TRC) | Utility and customer perspective. Includes all benefits and cost experienced by the utility and all the customers. Are all of the benefits greater than all of the costs (regardless of who pays the costs and who receives the benefits)? Is more or less money required to pay for energy needs? | Same as above, plus customer benefits that do not affect the utility (i.e., fuel, energy, or water savings, O&M savings, improved productivity, increased comfort, increased health and safety). | Same as above, plus net participant costs (i.e., customers share of cost above the utility incentive payment or other increased customer costs). |
| **Societal Cost Test** (SCT) | Utility and customer and society's perspective. Includes all benefits and cost experienced by the utility, all the customers, and others that may not be customers. Is there an overall net benefit to society? Are overall net costs to society lower? | Same as above, plus other societal benefits (i.e., avoided emissions or reduced cost for governmental services). | Same as above, plus externalities (i.e., environmental cost and GHG emissions not paid directly by the utility or customers). |

Several reports have evaluated cost-effectiveness tests and note that some tests result in energy efficiency measures for low-income customers with a "high cost and low benefit."[9] This is because low-income programs often provide more funding to address upfront cost barriers – sometimes covering the entire cost of a measure – and may have higher administrative costs for outreach and implementation. When these costs are included in a test, or if the costs are not outweighed by the benefits and overall system value, low-income programs can become ineligible for ratepayer funding. However, this can be addressed when jurisdictions have direction to achieve a policy objective that can be evaluated in a cost-effectiveness test. For example, jurisdictions could authorize consideration of societal or non-energy benefits such as community health, low-income participant impacts, and emissions reductions.[10] Differences in the costs and benefits that can be included in a test will change the weighting for a measure, but there are tradeoffs that should also be explored (see section below on Emerging Ideas).

Ratepayer funded programs at utilities and the Energy Trust of Oregon have been working to reach a broader set of consumers. For example, Energy Trust provides increased cash incentives for qualified households that are in the moderate income range.[11] Also, other energy efficiency programs have been established to meet policy goals, such as weatherization services, low-income, and underserved market programs. These are often funded or supplemented by state and federal sources, not solely by utility ratepayers, which changes or eliminates the use of the cost-effectiveness tests discussed above. These federal and state weatherization programs may use different assessment criteria, such as a savings-to-investment ratio that calculates the amount of energy savings versus the cost to install a measure.[12]

## Weatherization to Reduce Energy Usage and Costs for Households

Weatherization services are a type of energy efficiency program that targets customers living in existing, and often older, residential and multifamily buildings. Weatherization programs specifically for moderate and low-income households are supported by utility, state, and federal funding. By providing financial assistance in the form of energy efficiency upgrades, weatherization programs can reduce the energy costs of low-income consumers. The state and a community action network, made up of seventeen local community action agencies and a nonprofit corporation are responsible for administering federal funds in addition to any state or local funds set aside for weatherization. Oregon's weatherization program is administered by OHCS,[13] which contracts with organizations in the community action network to work with income-eligible households to conduct energy audits and install energy efficiency measures.[14]

The federal government provides energy efficiency aid through the Weatherization Assistance Program (WAP), funded through the U.S. Department of Energy (USDOE) and the U.S. Department of Health and Human Services (USHHS). The program supports energy efficiency improvements regardless of the heating option or fuel type used in the home at no cost to households that are at or below 200 percent of Federal Poverty Income Level. Priority is given to seniors, people with disabilities, households with children under the age of six, and households with a high energy burden. Federal funding allows for an expanded scope of energy efficiency investments, such as funding for home repairs, health and safety measures, and direct assistance in paying energy bills. For 2018, Oregon received $3,163,650 in federal WAP funding.[15]

Energy Conservation Helping Oregonians (ECHO), funded by Oregon's public purpose charge, supports weatherization projects for households that are at or below 200 percent of Federal Poverty Income Level in Portland General Electric and Pacific Power service territories. Weatherization projects include ceiling, wall, and floor insulation; energy-related minor home repairs; energy conservation education; air infiltration reduction; furnace repair and replacement; or heating duct improvements.[13] OHCS also administers the Oregon Multifamily Energy Program (OR-MEP), which promotes and facilitates energy-efficient design in affordable multifamily housing through design assistance, cash incentives, coordination with other regional programs, and education opportunities. Funding is available on a quarterly basis for new and existing affordable multifamily buildings in Pacific Power and PGE service territories.[16]

The State Home Oil Weatherization (SHOW) Program is funded by an assessment on petroleum suppliers and is administered by OHCS. The SHOW Program provides cash payments to eligible applicants who conduct energy saving upgrades and weatherization measures on homes heated by fuel obtained from fuel oil dealers.[17]

Bonneville Power Administration established low-income weatherization programs in the mid-1980s, which today are part of BPA's Low-Income Energy Efficiency Program (LIEE). In addition to weatherization, the program offers some efficient appliances, heating systems, and energy efficient lighting. Disbursements include $4.6 million of LIEE funds to state programs in Oregon, Washington, Idaho, and Montana, based on Census Bureau data on the number of low-income people in the state, and $515,000 directly to Tribes residing in BPA's service territory. BPA grants follow the USDOE Weatherization Assistance Program guidelines for weatherizing homes, but include some differences that seek to provide greater flexibility in applying the funds towards projects. Similar to the programs above, OHCS receives the funds and sub-contracts with organizations in the community action network, which conduct the weatherization installations. These organizations receive funding from several sources, and are constantly combining and leveraging funding to complete work on low-income housing.[18]

Separate from LIEE is an "Energy Efficiency Implementation" budget. This is designated to consumer-owned utilities that use BPA power for acquiring energy efficiency savings toward the target established by the Northwest Power and Conservation Council to help reduce overall energy demand on the hydropower system.

## COMMUNITY ACTION PARTNERSHIP OF OREGON

Eric and Cherrie Schwartz moved to Central Oregon in 1971, and have lived there ever since.[19] When the couple's heating system failed in Spring 2016, they were worried about how to afford a new one. The couple had to ask hard questions: Would they have to take out a second mortgage? Would they lose their home? Would the stress take a further toll on Eric's health?

For years their primary source of heat was a wood stove and Eric chopped wood during the summer and fall. But after Eric's stroke in 2013, the couple had to rely on their old furnace that, after thousands of dollars-worth of repairs, stopped working in April 2016. And that spring, they learned more about Neighbor Impact's Weatherization Program. Neighbor Impact is a local agency in the Community Action Partnership network. "We received energy assistance for a few years after Eric's stroke so we knew about Neighbor Impact," says Cherrie. "Then, when we attended an Energy Education workshop at the Neighbor Impact office, we found out about your furnace replacement and Weatherization programs and knew right away we needed to learn more."

Cherrie and Eric learned that they qualified for home weatherization and a full heat system replacement. Over the period of a few months, Neighbor Impact Weatherization and Energy Assistance crews collaborated to add fiberglass insulation, install weather stripping, and replace the furnace with a new system. With this weatherization assistance, Cherrie and Eric were prepared for a warm and comfortable winter in their home.

## Financial Assistance for Energy Bills

In addition to programs to reduce energy use, other programs help pay the bills to keep the power and heat on. The Low Income Heating Energy Assistance Program (LIHEAP), funded through USHHS, helps low-income consumers pay their home energy expenses.[20] LIHEAP is a block grant, and Congress determines total funding annually, which is allocated to states using a formula. For 2018, Oregon received $36.7 million, which includes LIHEAP funds directly provided to federally recognized tribes in Oregon.[21]

Oregon Energy Assistance Program (OEAP) was established in 1999 with the purpose of reducing household service disconnections. OEAP assists low-income households in PGE and PacificPower service territory who are in danger of having their electricity service disconnected due to unpaid utility bills.[22] Funding is generated from each utility's customers, and funds are expended solely for low-income home electric bills in the service area of the electric company from which the funds are collected.

Both LIHEAP and OEAP have income eligibility requirements of 60 percent or less of state median family income. Both programs are administered by OHCS – in partnership with organizations in the community action network through contracts to administer the two energy assistance funds.[13]

Finally, all of Oregon's electric and natural gas utilities have funding and programs to help senior citizens and/or low-income customers pay their bills. In addition to OEAP above, a recent inventory by OHCS illustrates the wide range of over 400 programs across the state that provide bill assistance, bill discounts, and weatherization support.[23]

## Cost of Heating Fuels Outside of Regulated Electric and Natural Gas Utilities

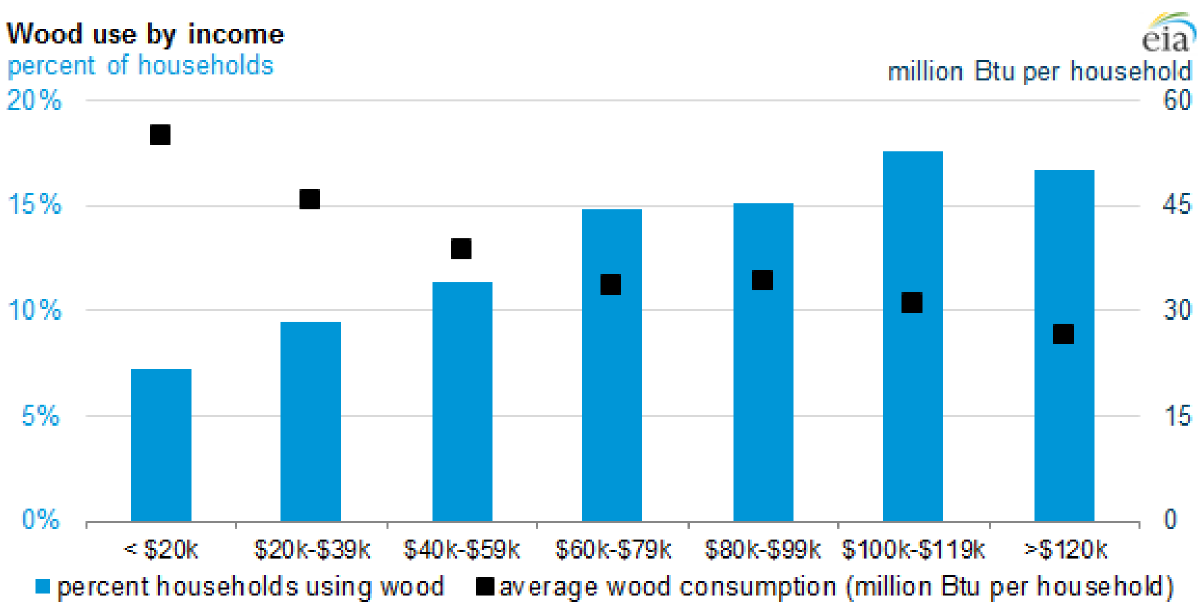
By and large, the above sections emphasized programs available to households heated by electricity and natural gas delivered by regulated utilities. In 2016, 49.7 percent of Oregonians used electricity for heating, while 38.1 percent used natural gas,[24] and from October 2015 to September 2016, LIHEAP funds helped pay heating costs for 48,246 households using electricity and 9,324 households using natural gas.[25]

For many Oregonians, however, propane, wood, and fuel oil are also important heating sources. Federal funding for LIHEAP and WAP can be used to support households that use any type of heating fuel. For example, from October 2015 to September 2016, LIHEAP funds helped pay heating costs for 1,899 households using propane, 239 households using wood pellets, 755 households using wood logs, and 1,513 households using oil.[25]

More than 26,000 Oregon households rely on propane as their primary heating source.[24] In 2017, the cost for propane ranged between $2.31/gal and $2.47/gal,[26] and there are services that allow consumers to compare prices of different propane providers.[27]

Approximately 100,000 Oregon households use wood for heating. The U.S. Census Bureau, the source of this data, does not specify housing type or if these households use wood as a primary or secondary source of heating.[28] National data indicates that lower income households use firewood or pellets for heating,[29] which could help reduce utility bills. Wood pellet fuel is typically sold in 40-pound bags at about $3 to $4 each or about $180 to $250 a ton.[30] Most homeowners who use a pellet stove as a main source of heat go through two to three tons of fuel per year.[30]

**Figure 7.2: Wood Use by Income[29]**



The cost of heating fuels like propane and wood pellets may supplement more common heating methods – electricity and natural gas – which can complicate the multi-tiered, layered programs in Oregon to address energy burden. Also, rates for these fuels are not regulated in the same way as electricity and natural gas (as discussed later in this chapter). The costs are determined by market forces – supply, demand, and competition of the fuels – and can therefore be unpredictable for consumers. Similarly, transportation fuels costs do not involve rate regulation and are instead determined by market forces.


## Transportation Fuels

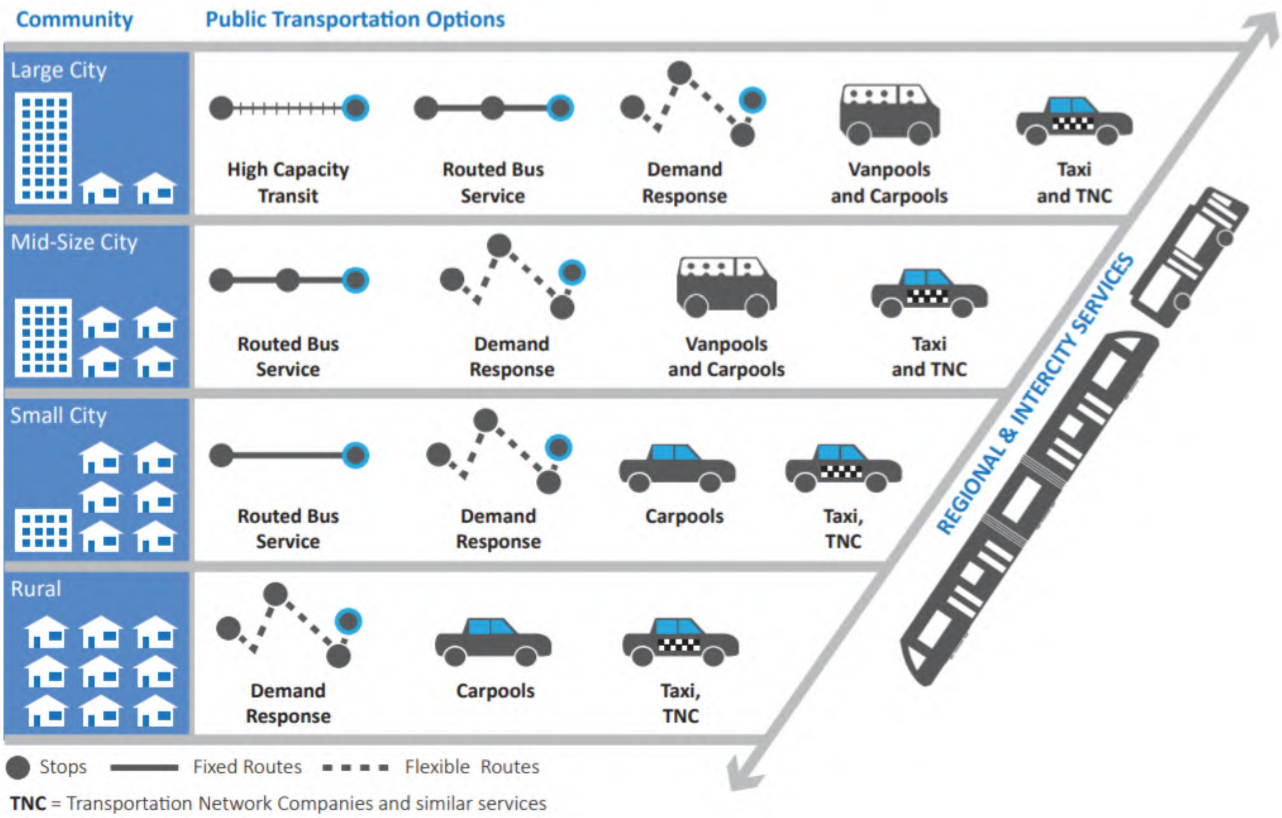
When considering energy burden, heating and electric bills are part of the calculation of energy costs, but this calculation does not typically include transportation fuel costs. Unlike electricity and natural gas service, which are monopoly services regulated by the Oregon Public Utility Commission (OPUC) or local boards and offered at non-discriminatory rates, the amount of money consumers spend on transportation fuel is dependent on global influences that affect the price at the pump.

For many communities in Oregon, public transportation provides a basic, affordable travel option and vital access to employment, services, groceries, and education.[31] Where public transportation is inaccessible or inconvenient, heavy reliance on personal vehicles can mean higher transportation costs.

## Location Dependent Transportation Options

As the Oregon Department of Transportation's recent public transportation plan details, transportation options differ in urban and rural parts of the state.[35] Options range from personal vehicles, high capacity transit such as light rail, routed bus services, shuttles or buses for particular locations that do not have fixed routes, vanpools or carpools, taxis, and transportation network companies (TNCs). Urban public transportation providers offer the widest variety of services in the state, use a range of transit technologies, and must negotiate urban environments and congestion to deliver service. Public transportation providers in smaller communities and rural areas have different circumstances. Many have only demand response service, sometimes operated by volunteer drivers, and serve relatively few customers, traveling long distances to meet riders' needs. ODOT's plan provides a helpful visualization of transportation options.

**Figure 7.3: Public Transportation Options**[35]




Transit organizations have put low-income and/or senior citizen transit fare programs in place to help reduce the costs for low-income riders. For example, TriMet has a low-income fare, for which more than 5,000 people signed up for in just three months,[36] in addition to other programs to improve access to transit.[37] However, transit may not be accessible in all suburban or rural communities, creating greater reliance on personal vehicles.

## Transportation Challenges for People that are Low-Income or Living in Poverty

Nationally, suburban communities have experienced an increase in the number of residents living in concentrated poverty. Between 2000 and 2012, the number of suburban poor living in distressed neighborhoods grew by 139 percent.[38] There is some indication that these trends are visible in Oregon as well.[39]

The Federal Highway Administration published a Poverty Brief using National Household Survey data that shows the mix of transportation options used by people at a range of income levels – with the vast majority of trips occurring in single occupancy vehicles or multi-occupancy vehicles.[40] While this national data is from 2009, trends in Oregon have shown an increase in vehicle miles traveled between 2009 and 2017,[41] suggesting that travel continues to occur mostly in cars. With cars serving as the primary mode of transport – and often cars with low fuel efficiency in the case of lower-income people – expenditures for vehicle, fuel, insurance, and maintenance for these households can be high and unpredictable.

Even as reliance on cars for transportation expanded, this may not be an option for many consumers. Table 7.3 shows that people in poverty or low income households are less likely to have access to a vehicle, with little change over ten years.

**Table 7.3: Percentages of Persons 18 or Older Without Access to a Vehicle[42]**

| Income | 2006 | 2016 | 2006-2016 Change |
|---|---|---|---|
| Living in Poverty | 22.02% | 19.96% | -2.05 |
| 101-200% Above Poverty Line | 11.41% | 10.57% | -0.83 |
| 201-500% Above Poverty Line | 3.89% | 4.06% | 0.17 |
| More than 500% Above Poverty Line | 2.12% | 2.54% | 0.42 |
| All Adults | 6.70% | 6.63% | -0.07 |

The upfront cost of purchasing a new or used vehicle can be a barrier for many lower income Oregonians, and the same is true of maintenance costs and fuel costs. Prices for gasoline or diesel are largely dependent on crude oil prices, which are determined by global supply and demand.[43] Examples of policies that seek to mitigate transportation fuel costs are highlighted below. These policies mitigate the cost of running a vehicle with better fuel efficiency. They also encourage electricity as a cheaper transportation fuel, and seek to reduce the upfront cost of electric vehicles (EVs). However, it will take time to lower costs enough for all Oregonians to access these newer technologies.

- **Efficiency to Reduce Fuel Use and Cost:** Similar to the benefits of improved energy efficiency in the electric and heating sectors, many personal vehicles have become more efficient and use less transportation fuel. Federal standards set fuel efficiency targets that manufacturers must achieve for new car models, which have raised the overall efficiency of all cars and give consumers more fuel efficient options and save money at the pump.[44]
- **Encouraging Electricity as a Cheaper Transportation Fuel:** EVs have low maintenance costs, and the cost of electricity is cheaper than petroleum based fuels. U.S. Department of Energy's eGallon calculator compares the cost of fueling a vehicle with electricity to a similar vehicle that runs on gasoline; in Oregon a gallon of gasoline at $3.24 is equivalent to $1.02 for an eGallon.[45] The cost of fueling a vehicle with electricity is about 28 percent of the cost for a similar gasoline-powered vehicle (see Chapter 4 for more information).
- **Reducing Upfront Costs of Buying an EV:** The base price, without incentives, of new electric vehicles can be about $24,000 and as high as $140,000,[46] while there are some used EVs available for under $6,000.[47] EVs are too expensive for Oregonians that are low-income or in poverty. Also, federal EV tax credits, usually the largest monetary incentive available, can only be applied to individuals with large tax burdens, who are typically higher income. Programs at the federal, state, and local levels have aimed to bring down the upfront vehicle purchase price, including some local utility rebate programs and the Oregon "Charge Ahead" EV Rebate, the latter of which was developed specifically for low- and moderate-income households. (See Chapter 4 for more information).

Outside of the cost to purchase an EV, additional obstacles remain; it is often harder to ensure a reliable charging platform in a multi-family residential building or a rental home. Some nonprofits are partnering with local community development organizations to provide shared electric vehicles;[48] these pilots have the potential to help us understand how to make electric vehicles more accessible to low-income households, reducing their energy burden.

## COMMUNITY-BASED ASSESSMENT OF SMART TRANSPORTATION NEEDS IN PORTLAND

In addition to EVs, Transportation Network Companies like Lyft and Uber are emerging technologies that are changing the transportation landscape. There are barriers, however, to accessing these emerging transportation technologies.

OPAL (Organizing People / Activating Leaders) and Forth recently partnered with Portland State University to conduct a community-based assessment of smart transportation needs in Portland.[49] In the assessment, "smart transportation" was mobility through emerging autonomous, electric, connected and shared vehicles, and "transportation as a service" (ridesharing) technologies. The assessment used a mixture of quantitative and qualitative research approaches with two focus groups of community members from East Portland and a survey with 308 total responses (also concentrated from East Portland). Lower income survey respondents and respondents of color had significantly lower access to drivers' licenses, bank accounts, and credit cards, and also rely more on paying cash for TriMet tickets. In addition, lower income respondents and respondents of color had lower access to internet both at home and at work, and were more likely to need to reduce data use or cancel cell phone plans because of cost or data restrictions. Older survey respondents and focus group participants were resistant to connecting personal financial information to phone and internet-based mobility applications.

### Recommendations from the surveys and focus groups included the following:

1. **Improve public transportation information, scheduling and route finding through smartphone applications;**
2. **Improve public data access (such as through public Wi-Fi);**
3. **Implement policies to lower barriers to purchasing or using electric vehicles; and**
4. **Expand translation for important smart mobility applications into languages other than English.**

This kind of data and analysis can be helpful to transportation and urban planners and policy makers when considering the distribution of benefits and burdens from new technologies in energy and transportation. Among several findings, the assessment showed that smart mobility technology could improve the mobility of transportation disadvantaged. However, access to credit, banking, and affordable cell and internet service are formidable barriers.

# Consumer Protection

Underpinning specific programs discussed above to reduce the energy burden for Oregon households is a long-standing tradition of protecting consumers in the provision of electricity and natural gas from utilities. Indeed, consumer protection is rooted in the history of how the country's energy system was developed, and with it concepts such as regulatory oversight of rate setting, requirements for rates to be publicly posted, oversight of whether utility investments are prudent, and universal service for electricity.

## Universal Electricity Service

Oregon's electric utilities have an obligation to provide universal electric service to all Oregonians in their designated service territories. This means that a home in a particular territory in Oregon must be served by the utility designated for that territory; a household does not choose which utility provides its electricity.[50]

The benefits of providing electricity as an essential service were broadly recognized in the early twentieth century and led to federal and state laws that encouraged rural electrification and created "regulatory compacts." Laws and policies encouraging rural electrification ensured electricity access to all Oregonians, including rural areas that had less infrastructure compared to urban or industrial parts of the state.[51] The concept of a regulatory compact involves the state requiring an investor-owned utility to provide universal electric service in exchange for the state granting a monopoly over a specified service territory with an opportunity to earn a profit on the investor-owned utility's investments.[52] While the term "regulatory compact" is not found in Oregon law, it encapsulates the set of laws and system of regulation that has been developed with regard to investor-owned utilities.[53]

Today, utility rates for electricity service are established through public, transparent processes for both investor-owned and consumer-owned utilities. Investor-owned utilities are private electricity or natural gas companies, while consumer-owned utilities are nonprofit entities formed as municipal utilities, people's utility districts, and rural electric cooperatives.[54] For consumer-owned utilities, regulatory oversight is handled by publicly-elected local boards. Three electric and three natural gas investor-owned utilities have their utility rates approved by OPUC.

Thirty-six Oregon-based consumer-owned utilities also have exclusive service territories in Oregon, but they are nonprofit entities that do not have shareholders that earn a profit on utility system investments. The first municipal utility in Oregon was established in 1889 – McMinnville Water and Light.[55] There are now twelve municipal electric utilities that are overseen by Oregon city governments or city-affiliated boards. There are also six people's utility districts and eighteen rural electric cooperatives in Oregon that have locally-elected boards.[56] Formed in 2001, the Umpqua Indian Utility Cooperative is the first utility in the Northwest both owned and operated by an Indian tribe.

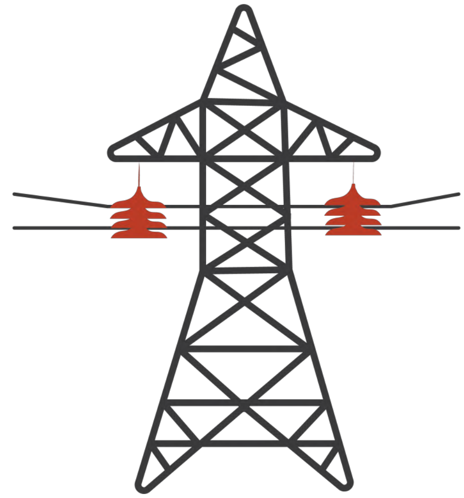
**FIND YOUR UTILITY**

The Oregon Department of Energy has a handy interactive tool on its website to help Oregonians — and future Oregonians — find their energy utilities:

https://go.usa.gov/xPy3y

Together, consumer-owned utilities and investor-owned utilities provide universal service of electricity to all Oregonians and have public processes to establish rates for consumers.

## Oversight of Electric and Natural Gas Utility Rates



The OPUC oversees rates for natural gas services and requires information about rates for natural gas services to be public. Locally-elected boards, cities, or the OPUC oversee how rates for electricity are set and require information about electricity rates to be public. For the most part, an Oregonian's electric bill is a function of the amount of electricity used, the rate established for the electricity services, other charges, and fees.

The public process that establishes utility rates involves an examination of the prudency of a utility's costs to transmit the electricity or natural gas to its customers. For example, prudency involves the OPUC reviewing capital projects or other investments to determine if they have been constructed or implemented as proposed, according to sound management practices, and at a reasonable cost.[57] Integrated resource planning is a public process that helps to reduce risk of non-prudent investments by assessing system needs over a 20-year period and developing an Action Plan over a two- to four-year period. For the investor-owned electric utilities, the OPUC has adopted guidelines that require consideration of electricity generation, transmission, and demand-side resources – such as energy efficiency and demand response – on a comparable basis.[58]

The process to set rates aims to allocate total costs across all the utility's customers in a just, reasonable, and non-discriminatory manner.[59] A utility's cost of providing electricity or natural gas to its customers can vary depending on how different customers receive and use energy. Because of these distinctions, utilities design different rates for several classes of customers, such as residential, commercial, industrial, and sometimes, agricultural customers.

Rates are set based on the cost to provide electricity or natural gas service to customer classes that have similar usage and cost profiles for the utility system. Utility requirements seek to ensure that customers in the same class are treated equally and, in general, utilities are required to provide non-discriminatory access and are prohibited from providing preferential treatment to customers of a certain class or subgroups within a customer class.[60] Specifically for natural gas service rates, the cost of the wholesale natural gas is passed through to consumers without any profit for the utility. Natural gas utilities in Oregon are local distribution companies and purchase natural gas on the wholesale market on behalf of their customers. There is a purchased gas adjustment public process that occurs at the OPUC to ensure the costs are reasonable and prudent, and that the company has taken all actions available to it to keep these costs as low and stable as possible.[61]

Many proceedings at the OPUC require complex technical and legal processes, in particular for the establishment of rates. Oregon Citizens' Utility Board is a nonprofit created in 1984 by ballot initiative to advocate on behalf of and protect the rights of the residential and small business customers of investor-owned electric and natural gas utilities. CUB intervenes in regulatory proceedings before the OPUC and advocates on behalf of these customers.

## ELECTRIC UTILITY RATES 101

At a high-level, utilities establish the retail rates that they charge to customers in a manner that reflects the total cost to the utility of providing service to its customers, which is called "revenue requirement." This revenue requirement includes the capital cost of useful assets, taxes, operations and maintenance costs, and depreciation, which may differ by utility due to differences in the type of load, distances between loads, and other service territory characteristics. In the case of investor-owned utilities, it also includes profit to shareholders on top of those costs.

This ratemaking process is then intended to enable the utility to recoup its revenue requirement to deliver electricity service by allocating its costs across its sales of electricity to ratepayers.

$$\text{Utility Rates} = \frac{\text{Utility's Revenue Requirement (Cost of Service) (measured in \$)}}{\text{Utility's Electric Sales (measured in kWh)}}$$

In addition, there are several other elements to a consumer's bill, such as a basic customer charge that is the fixed and reflects the cost to connect a customer to the grid. For more information about what makes up your bill, see Chapter 1.

# Equity

Between this longstanding history of consumer protection and our state's activities to reduce energy burden, Oregon is well-equipped to deepen our approach with robust engagement on equity. The term *equity* refers to both process and outcomes. Specific to energy, does the process through which energy-related decisions are made include intentional engagement with all potentially affected communities and a comprehensive analysis of potential impacts? These types of process components ideally lead to energy-related decisions and outcomes with a more equitable distribution of benefits and burdens.[62]

Energy programs and policies can involve structural barriers that prevent households that are low-income or experiencing poverty from equitably accessing energy options and associated benefits. Split incentives, for example, are an issue affecting energy access by renters, who tend to earn less than people who own their homes. In 2015, the median household income for renters in Oregon was $32,513, while the median household income for homeowners was $67,070.[63]

Split incentives arise when an owner has control over the upgrades in the building, but the renter is paying the energy costs of the building being less efficient. In the case of multi-family housing, there can be complex needs, ownership, and financial arrangements – in which upgrades that require changes to an entire building or system are more complicated in a dense, multi-unit building.[64] For renters, the energy infrastructure is typically locked in with the rental property; for example the property may have gas-only or electric-only heating. Renters are likely not able to change the energy source or equipment unless they move. They typically do not have control over the building's roof or exterior infrastructure, which may limit their ability to install solar panels, add roof insulation, or improve rooftop heating units. In addition, the rental property owner may not disclose energy costs to potential renters, so a property may have cheaper rent but very high energy bills and a renter may not know it until after a contract is signed. While these barriers may occur for renters of any income level, low-income renters may have less ability to mitigate or pay high utility bills that result from inefficient energy usage.

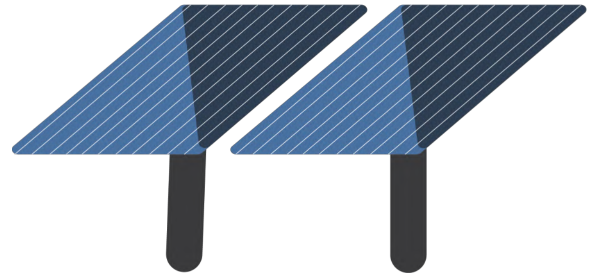
Regional entities, utilities, and government agencies have programs that aim to address split incentives with rentals and more complex issues with multi-family properties. For example, the SHOW Program includes rental property owners and the OHCS Energy Assistance program includes both homeowners and renter households. Energy Trust of Oregon offers a variety of multifamily incentives and EWEB offers targeted help for renters. Also, while the issue of split incentives is a helpful illustration, it is important to note that low-income homeowners, not just renters, may experience issues with equitable access to new clean energy technologies.

When discussions about energy policy and development incorporate equity considerations, programs can be developed to ensure outcomes that include:

- Traditionally underrepresented members of the public and community-based organizations effectively participating and engaging in decisions that shape their energy options.
- Benefits from clean energy and energy assistance programs, in particular those that are publicly funded, accrue to all Oregonians, across all ethnicities and income levels.
- Clean energy and energy assistance programs that increase access to the benefits of energy efficiency, conservation, and renewable energy by all Oregonians, across all ethnicities and income levels people.
- Economic opportunities from clean energy and energy assistance programs are available to all Oregonians, across all ethnicities and income levels.
- Clean energy and energy assistance programs that effectively overcome barriers that many people experience related to property ownership, income, credit scores, and inability to use tax credits.
- Increased access to transportation options to reduce households' reliance on vehicle ownership and transportation fuels for all Oregonians, across all ethnicities and income levels.

Many individuals and organizations, in particular community-based organizations, are asking questions and engaging in discussions to encourage more equitable outcomes in energy policies and programs. Indeed, this report has already touched on some programs – such as the Charge Ahead Rebate – where intentional program design features can help achieve more equitable outcomes. Still, given trends of a rapidly changing energy sector, and uncertainties about what these changes may mean for consumers, it is important that equity considerations are understood more broadly. Broad understanding of equity considerations can benefit from comprehensive energy analysis that includes demographic information such as race, gender, geographic location, and income levels in order to better plan for an equitable future and keep up with the rapid pace of change in the energy industry. This type of work has begun through implementation of Governor Brown's Executive Order 17-20, Directive 5B, which requires OHCS, ODOE, and OPUC, in collaboration with Bonneville Power Administration and Energy Trust of Oregon, to assess energy use in all affordable housing building stock, and develop a ten-year plan for achieving maximum efficiency (see Chapter 6 for more information).[32]

## Trends of a Changing Energy Sector and Access to New Technologies



As discussed throughout this report, the energy industry has experienced several trends that have brought us to our current state of rapid change. Historically, utilities planned and invested in generation, transmission, and distribution assets to meet steady growth in demand for electricity (also called "load"). This trend was a result of electric utilities' obligation to provide universal service, the rise of an energy intensive manufacturing based economy, and technological advancements allowing consumers to furnish their homes with more electrified home appliances and devices.[65] For the last 20 years electricity load is not growing as it traditionally did, due to energy efficiency and a shift from more energy-intensive manufacturing to a less energy-intensive digital and service-based economy.[65,66] Along with these broad economic shifts, there was a drop in load growth due to the recession of 2007-2009, and load growth has remained slow during the recovery over the past decade.[65,67]

More recently, Oregon has seen increased investment in and increased consumer preferences for renewable energy. As discussed in Chapter 3, local jurisdictions have adopted clean energy or climate change goals. For example, in 2017, Multnomah County and the City of Portland announced goals that all of their electricity should come from renewable energy sources by 2035.[68] In addition, a growing number of consumers have subscribed to voluntary "green power" programs or installed rooftop solar. High upfront costs and inaccessible roofs for renters make it difficult for many low-income consumers to afford on-site energy generation like rooftop solar. Responding to concerns of inequitable access to rooftop solar, the state established a low-income carve-out in a 2016 law that enabled community-based solar projects in order to encourage low-income participation. The program is in the implementation phase at OPUC (see Chapter 3 for more information about the community solar program).

Meanwhile, new technologies continue to come online. Examples are sensors and controls that enhance information-sharing across the grid and allow for more dynamic balance of supply and demand across the entire electrical infrastructure, which will help to manage and optimize generation, consumption, and the overall flow of electricity.[69] The electricity system of the future will likely have greater two-way flow capabilities, where customers both receive and supply electricity from and to the grid.[70] As technology continues to evolve, consumers will have more options for clean energy and distributed energy resources – promising for an efficient system and for meeting environmental and climate change goals. And with these changes, there must be strong attention to whether emerging options are accessible to customers and include an equitable distribution of benefits and burdens.

## OPUC 978 Process and Report

The trends of the changing electricity sector, new technologies, consumer preferences, and the policy environment prompted the legislature to pass Senate Bill 978 in 2017. As required by the law, the OPUC conducted an extensive stakeholder process to explore how investor-owned electric utilities are adapting to the trends discussed above and how they are regulated in a changing industry and policy environment.[71] The law directed the OPUC to identify changes that could "accommodate developing industry trends and support new policy objectives without compromising affordable rates, safety and reliable electricity service."

The process to gather information and explore these trends consisted of workshops and input from stakeholders, who identified four themes of interest to address when considering changes to investor-owned utility incentives and the regulatory model. Equity was a significant and important part of the stakeholder discussion:

1. Societal interests in climate change and social equity;
2. Rapid change in capabilities and costs of new technology;
3. Balancing individual choices and collective system goals; and
4. Competition and market development.[72]

The OPUC released a comprehensive report about the process, and in it recognized that the regulatory process itself must allow opportunities for community-based organizations, members of the public, and stakeholders new to the OPUC process to expand participation – exactly the kind of process-oriented approach equity considerations require. Other commitments outlined in the report:[73]

- The OPUC plans to undertake a full and accurate valuation of consumer and non-utility options, such as distribution system planning and transparency, which could encourage alignment with state energy and climate change goals and the utility system. This valuation could be helpful in achieving more consistent pricing methodologies for distributed energy resources, such as solar, energy storage, energy efficiency, and demand response.
- In addition, the OPUC plans to launch a performance-based regulation process, which is permitted under their existing alternative form of regulation statute. (ORS 757.210). This process would explore areas of utility service where investor-owned utilities could earn a rate of return (profit) on outcomes rather than only prudent capital expenditures, which could help align the utility's incentives with customer objectives.
- The OPUC will participate with other states and agencies to promote regional market development, which is a foundation for efficient wholesale competition and regional resource diversity to lower costs and risks to consumers.
- The OPUC will implement a strategy for engagement and participation.

# Emerging Ideas

OPUC's 978 process and report surfaced several ideas that could be applicable to investor-owned utilities, but may be unavailable in the OPUC's statutory authority. For example, the OPUC may be limited by statutory prohibitions against discrimination between customers – and corresponding prohibitions on preferential treatment between customers – based on factors other than cost-of-service or service characteristics.[74] These are the key factors that are used to create separate classifications of service that pay different rates, such as the residential rate class or a small commercial rate class. Some have suggested income differentiated rate classes that would recognize that each residential customer may not have the ability to pay the same rate, regardless of income or housing type. This type of rate design would provide different rates within the residential customer class depending on the customer's income or housing type. However, as discussed above, there is a requirement to have "non-discriminatory" rates – which includes a prohibition on differentiation within rate classes, making income differentiated rate classes unavailable.

What the 978 process shows us is that regulators and utilities are weighing a host of emerging ideas that are likely to face Oregon in the near future. And the state more broadly is evaluating programs and program proposals that seek to expand the benefits of the changing energy sector to all consumers. Emerging ideas to address issues related to consumer protection, energy burden, and equity have been adopted by some utilities, established in other jurisdictions, or have been discussed in research or studies. Below are examples of such ideas, but they may not be the right fit or may have program design issues specific to Oregon. At the same time, an exploration of emerging ideas could help the state gain an understanding of whether they can offer benefits in Oregon.

As previously discussed, cost-effectiveness tests are often used to help determine what types of energy efficiency programs are reasonable for ratepayer funding. In 2017, the National Efficiency Screening Project produced the National Standard Practice Manual for assessing cost effectiveness and introduced the **Resource Value Test**.[75] The Resource Value Test accounts for costs and benefits specific to the policy priorities in a jurisdiction. This can be used for future energy planning and analysis that includes different value considerations, such as greenhouse gas (GHG) reduction and non-energy benefits that may have even greater magnitude in low-income communities – like reduced energy burden and increased health and comfort.[76]

Another example involves aligning an investor-owned utility's revenue and shareholder earnings with specific performance metrics and other non-investment factors like reducing energy burden or meeting environmental targets. **Performance Based Regulation** is a regulatory framework that connects goals, targets, and measures to utility performance or executive compensation.[77] In 2013, the United Kingdom adopted an approach called "Revenue = Incentives + Innovation + Outputs" (RIIO), where their utility earns profit on outcomes rather than on returns on investment.[78] The state of New York is investigating adoption of performance based regulation through a "Reforming the Energy Vison" proceeding at the New York Public Service Commission.[79] As a result of SB 978, the OPUC will be undertaking a process to explore some areas where investor-owned utilities could earn a rate of return (profit) on outcomes or other metrics, which could help align the utility's incentives with customer objectives such as equity and climate change.[80]

**Pay-As-You-Go** or **Prepaid Programs** allow customers to front-load their accounts so they pay in advance for the electricity they will use. Utilities such as Midstate Electric Cooperative[81] and Oregon Trail Electric

Cooperative[82] have had strong interest in their programs, with approximately 4,300 customers participating.[83] Some consumer advocates have raised concerns about these programs.[84] They argue that there are disadvantages to consumers, including potentially different rates, in addition to foregoing consumer protections like notification requirements and protections from service disconnections.[85] The National Consumer Law Center in a 2012 brief about pre-pay programs stated, **"With prepaid utility service as it currently operates, low-income customers who struggle the most to pay bills often end up paying the most while receiving second-class utility service."**[85]

## PAY-AS-YOU-GO PROGRAMS

Some electric cooperative utilities in Oregon are giving their members a new option for paying for electricity: prepay programs. **Midstate Electric Cooperative** has had strong interest in their programs. Rather than paying a bill based on the amount of electricity a customer has used during the past billing period, prepay (or pay-as-you-go) programs allow customers to front-load their accounts so they pay in advance for the electricity they will use. Similar to filling up a car's gas tank or using a pre-paid mobile phone plan, money is deducted from a customer's account as energy is consumed at home. Oregon consumer-owned utilities report that prepay programs have been a hit with their customers, who are given more control over their finances and ability to track their energy use. Customers receive alerts by email or phone when their balance is low – as long as the balance is above zero, they have electricity. Because customers have already paid for their service, there are no large opening account deposits or late fees for missed bills.

*"Our members enjoy that prepay puts them in control – they decide the amount of power they purchase, the timing of their purchase, and their consumption."*

— Dave Schneider, Midstate Electric Cooperative CEO

Several utilities offer **discounts** on bills based on senior status or income bracket. For example, Ashland's municipal electric utility offers a 20 to 30 percent bill discount to seniors and disabled customers,[23,86] and Columbia River PUD offers a low-income senior bill discount of $10 on the monthly fixed charge and 10 percent on the energy charges.[23,87] **Bill caps** or **Percentage of Income Payment Plans** (PIPP) allow consumers' electric or natural gas bills to be capped at a percentage of their household income. Eligible consumers pay a percentage of their income as to what has been deemed affordable in a PIPP program.[88] For example, in an Ohio PIPP program offered through most Ohio utilities, participating households pay six percent of their monthly income or $10 each month to both electric and natural gas utilities – whichever is greater.[89]

Finally, there has been consistent support for maintaining funding for low-income bill-payment assistance and weatherization,[90] but **increased funding** for energy and transportation assistance may help reach more households. For example, Oregon passed a transportation funding package in 2017 that provides state-wide funding for public transit, and California has used revenue from its cap and trade program to support low-income weatherization programs.[91] There could be exploration of improved coordination and leveraging among the various low-income assistance programs that address different energy types to further equitable benefits.

# CONCLUSIONS

**Consumer protection** in the context of energy has been around for almost a century, but there continue to be challenges faced by energy-burdened consumers and interest in securing more equitable outcomes from energy-related policies and programs.

Studies analyzing **energy burden** typically use household income and utility bills or other home energy costs, however energy-burdened households can also incur other energy-related expenses, such as transportation fuel. There are many programs for weatherization and bill assistance to address energy burden, but the reduction of energy use in weatherized homes may still not reduce the energy burden for very low-income households. There are currently no programs that comprehensively address the energy burden of multiple energy sources including transportation. There needs to be a greater understanding of the number of households that need weatherization assistance and how far existing funding is going to meet that need. This type of work has begun though implementation of Governor Kate Brown's Executive Order 17-20, Directive 5B, which requires OHCS, ODOE, and OPUC, in collaboration with Bonneville Power Administration and Energy Trust of Oregon, to assess energy use in all affordable housing building stock and develop a ten year plan for achieving maximum efficiency.[32] Additional research and analysis is needed to characterize the energy burden for a variety of metropolitan areas, income groups, and household types to develop a comprehensive approach to addressing the total energy burden – including transportation costs – for communities.

At the same time, the energy industry is in transition, with policies to **encourage clean energy** and new technologies that may not be accessible to some consumers. Given the rapidly changing energy sector, and uncertainties about what these changes may mean for consumers, it is important that equity considerations are understood more broadly. The state has benefited from the thorough work of the OPUC in the SB 978 process, which highlighted the importance of intentional engagement and stakeholder participation. The state should build upon this understanding of intentional engagement and stakeholder participation for more energy-related processes.

Better understanding of the benefits to and burdens of electricity, heating, and transportation options and programs on all Oregon consumers is needed by the state. More data and comprehensive analysis, including demographic characteristics, public health, and energy costs, would inform programs and policies to achieve a more **equitable distribution of energy benefits and burdens**.

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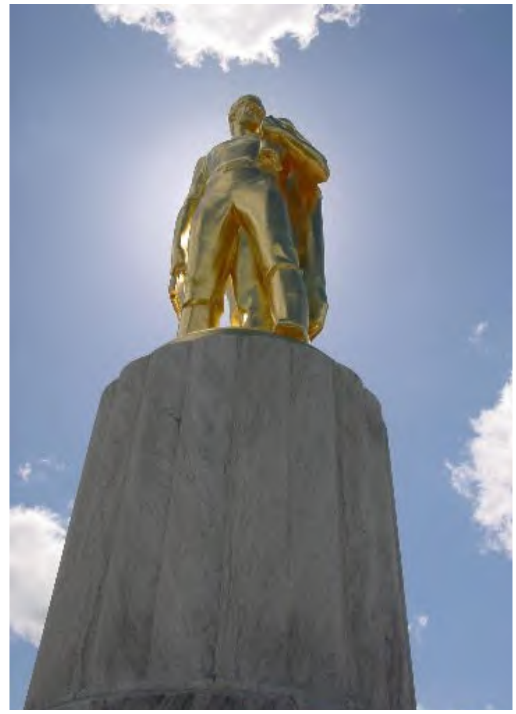
# CHAPTER 8: RECOMMENDATIONS

As shown in each chapter of this report, Oregon's energy sector is in transition. This creates challenges and opportunities for policy makers, regulators, energy leaders, and ultimately every Oregonian.

The state's early investment in energy efficiency, clean energy resources, and conservation has positioned Oregon well to begin tackling today's challenges, which are fueled by a growing demand from consumers for cleaner energy, forecasted population growth, and emerging technologies.

## The Oregon Department of Energy's first comprehensive look at energy policies, trends, and forecasting came soon after the agency's creation in 1975.



This early version of a biennial energy plan was aptly titled *Transition* – accurately describing an energy sector in flux after a fuel crisis. Fast forward 43 years, and the agency has developed a new, comprehensive Biennial Energy Report. Our new report is modernized, yet still captures some of the same drivers and challenges the energy sector experienced in the 1970s – plus new ones, like resilience and climate change.

As shown in each chapter of this report, Oregon is still in transition. This creates challenges and opportunities for policy makers, regulators, energy leaders, and ultimately every Oregonian. The state's early investment in energy efficiency, clean energy resources, and conservation has positioned Oregon well to begin tackling today's challenges, which are fueled by a growing demand from consumers for cleaner energy, forecasted population growth, and emerging technologies.

The Biennial Energy Report frames Oregon's existing policies and programs in the areas of climate change, renewable energy, transportation, energy resilience, energy efficiency, and protecting residential consumers. A main theme running throughout the report is what it means for Oregon to transition to a low-carbon economy. The October 2018 Intergovernmental Panel on Climate Change (IPCC) report underscored the importance of putting Oregon on a path to decarbonization. The IPCC reports on the effects of global warming of 1.5 degrees Celsius, and stresses the need for action to avoid the most serious economic, environmental, and social damages from climate change. Achieving Oregon's energy and climate goals – while protecting consumers – will take collaboration among state agencies, policy makers, state and local governments, and private sector business and industry leaders from across the state.

The report acknowledges many areas where the state will need to increase efforts to reduce or mitigate greenhouse gas emissions. One area is the transportation sector, which is responsible for the greatest share of greenhouse gas emissions in Oregon. Our efforts to make vehicles and transportation fuels cleaner are being overshadowed by an increase in both population and total vehicle miles traveled. With the adoption of the Statewide Transportation Strategy in 2018, Oregon has a long-term vision for reducing transportation-related GHG emissions, and has identified several specific strategies to achieve that vision. But time is of the essence. One key approach addressed in this report is the electrification of light-duty vehicles – passenger cars, pickup trucks, and SUVs. In addition to reducing GHG emissions, electric vehicles can increase Oregon's energy independence, reduce costs for consumers, and leverage our increasingly clean and renewable electric grid as their fuel source.

The report examines current and emerging technologies in Oregon and across the West, which are helping modernize the state's energy systems and take us down the path of decarbonization. More recent technologies and additional uses for these technologies are coming – such as wave energy, renewable natural gas, solar energy, energy storage, power-to-gas, and electric vehicles that have the ability to store excess energy and send it back to our electric grid when needed. These and other advancements yet unimagined will speed our transition to a low carbon economy and reduce the cost of the transition.

Finally, and perhaps most importantly, this report recognizes that all Oregonians can and should benefit from a clean energy future. A key focus of the Biennial Energy Report is to inform local, state, regional, and federal energy and climate policy development. As the energy sector works to decarbonize and modernize, we must understand how all consumers – especially those often left behind, including communities of color, low-income families, older adults, and others – can benefit from the transition to a low-carbon economy.

# Recommendations

The recommendations in this report are a reflection of the work conducted by the Oregon Department of Energy, and informed by our many stakeholders, including our state and regional partners. The report organizes our recommendations around four key themes: gaps in data, addressing equity and energy burden, planning for the future, and assessing the need for state engagement and investment.

## Data Gaps

In drafting this report, ODOE identified a number of areas where additional data would better inform the public and lawmakers. As the central repository within state government for the collection of data on energy resources, we will work to fill these gaps, starting by more closely collaborating with state and regional entities. Better information will make for better planning, enable more thorough and accurate economic analyses, and ensure we can achieve more equitable outcomes.

### Recommendations

**Increase collaboration among state agencies to strengthen data-gathering capabilities and provide additional comprehensive state-specific information.** Many parts of this report incorporate national and regional datasets that provide a foundation for understanding our energy landscape. However, some of these datasets can only provide general estimates for the state or are missing data specific to Oregon.

**Share and collaborate on data analysis to leverage complementary tasks and datasets.** Within the state, there are a variety of organizations and agencies that collect, analyze, and report energy and energy-related information. These entities often have distinct objectives, expressed through unique statutory authorizations and organizational mandates. Partnering will improve collection and analysis and create efficiencies, while ensuring statutory requirements are met.

**Build capacity and understanding of complex and varied data systems that exist in the state**, with the goal of identifying gaps for data collection and areas where additional analysis will benefit the energy sector.

**Foster new relationships between public, private, government, and community organizations** to explore opportunities for data sharing and advanced analytics, and use of this information to better inform stakeholders and decision-making bodies.

## Addressing Equity and Energy Burden

As the energy sector in Oregon continues to transition – due to legislative and executive branch actions, regulations, maturing markets and changes in consumer preferences, new technology, international pressures, and climate change – the state must do more to address issues of equity and energy burden. The same communities that are energy burdened are also on the frontlines of climate change. Energy costs affect people differently based on income levels, demographics, and geographic locations. Energy policies should take into account their effects on all Oregonians, both in terms of their burdens and benefits.

### Recommendations

**Improve data collection and analysis.** Given the uncertainties surrounding what the rapidly transitioning energy sector may mean for consumers, it is important that equity considerations are understood more broadly. The state would benefit from a better understanding of the benefits to and burdens of electricity, heating, and transportation options and programs on all Oregon consumers. Demographic, income, public health, energy impacts, and energy cost data will better inform program and policies to achieve more equitable outcomes.

**Design policies with all Oregonians in mind.** In designing incentives for electric vehicles and programs for community solar, lawmakers acknowledged the additional difficulties faced by low-income consumers who want to benefit from clean energy incentives or programs. The legislature provided additional assistance to enable better access to these clean energy technologies (such as an additional rebate for purchasing or leasing an electric vehicle). As other polices are pursued, similar considerations may be warranted. More granular data and analysis on the energy burden and transportation options for low-income and rural Oregonians will help inform these considerations.

**Improve engagement with Oregon communities.** Any energy-related planning done at the state level should involve intentional engagement with all potentially affected communities, as well as a comprehensive analysis of potential impacts. Including these communities in the process early can lead to energy-related decisions and outcomes with a more equitable distribution of benefits and burdens.

> "Early, continuous, and meaningful public participation for all potentially affected communities will result in a more inclusive consideration of a broader range of perspectives, leading to more equitable and sustainable decision-making and reducing the likelihood of disproportionate impacts."
>
> – State of Oregon Environmental Justice Task Force Handbook[1]

## Planning for the Future

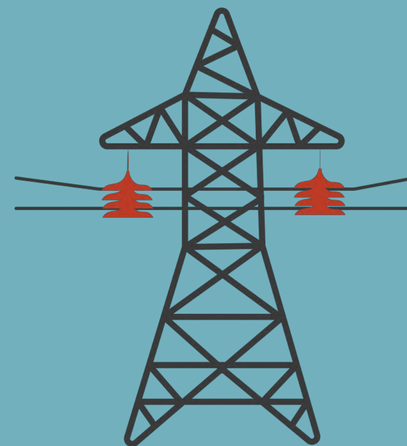
This report identifies many paths and key components of strategies designed to accelerate Oregon's move toward decarbonizing the economy, reducing GHG emissions in the transportation sector, increasing renewable energy resources and energy efficiency, protecting Oregon consumers, and improving the state's energy resilience. It builds on reports and recommendations from other agencies, the private sector, academia, and advocacy organizations that present options to address these challenges. Recognizing that the state has limited resources, Oregon should work collaboratively with partners, including the private sector, and local and regional entities to identify the optimal combination of these options to achieve state goals in the most cost-effective way. Due to the level of urgency facing the state on many of these challenges, this planning must be done concurrently with and build upon existing policies and programs.

### Recommendations

**Analyze and evaluate the cost-effectiveness of strategies to inform energy planners and policymakers** on how to leverage and combine strategies to create the most cost-effective pathway. The renewable energy chapter of this report highlights a number of options to integrate increasingly higher percentages of variable renewable electricity into the grid, including flexible supply, flexible demand, energy storage, distributed energy resources, and participation in larger electricity markets. An analysis should look at how to ensure the value of integration benefits are being appropriately compensated with the right price signals. It could also inventory and assess the cost-effectiveness of existing programs and policies.

**Continue participation in the ongoing dialogue around the creation of a regional independent system operator (ISO) in which Oregon's electric utilities could participate.** Planning should consider how Oregon links with other jurisdictions in order to leverage cooperation, but do so in a way that protects Oregon's interests. For example, as Oregon discusses creating a cap-and-trade program, policymakers are considering linkage with California, Quebec, and other jurisdictions that have programs in place.

## REGIONAL ELECTRICITY MARKETS



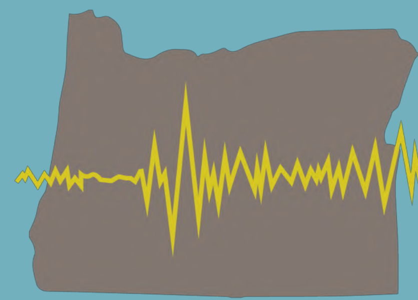
Oregon Governor Kate Brown, responding to an opportunity for stakeholder feedback to California in 2016 on the topic of expanding the CAISO, offered her support for a well-designed regional ISO that "could deliver substantial benefits to [Oregonians] . . . through a more integrated electricity grid."[2] Brown also stated "It is important that the governance of the regional system operator be independent and represent all the states whose jurisdictions are impacted … [because] only with independent representation can we be guaranteed that the benefits will be adequately distributed amongst the participating states."[2]

A regional ISO that represents the interests of all participating states in its operation of the transmission system and of wholesale power markets could significantly lower the cost of integrating more renewable energy across the western grid. Specifically, a regional ISO could help to do this by: 1) allowing for a wider market for the current oversupply of renewable energy at times; 2) lowering prices for renewable energy; 3) reducing the need for expensive storage solutions; and 4) using a wider geographic spread of renewable generation to reduce resource adequacy concerns. There are also costs and risks associated with a regional ISO, and Oregon should continue to work with California and other western states, as well as stakeholders in Oregon, in determining the costs, benefits, and appropriate next steps.

**Plan ahead to adapt and prepare communities and infrastructure for the effects of climate change and natural disasters.** Even if the state is successful in our decarbonization efforts, some impacts of climate change and natural disasters are inevitable. Undertaking a comprehensive vulnerability and risk assessment of the state's energy infrastructure is a first step in improving the resilience of our energy systems. The assessment should address two core components: an identification of critical energy infrastructure assets, inclusive of the electric, natural gas, and liquid fuels sectors; and a detailed assessment of the vulnerabilities and risks to that infrastructure from all hazards, including a Cascadia Subduction Zone earthquake, climate change, and cyber or physical attacks.

**Look at opportunities to encourage and amplify efforts of local, regional, and Tribal governments to develop their own action plans** that fit within and inform a statewide strategy. It should also take into account regional and demographic differences in benefits, as well as burdens of actions. For example, the charging infrastructure necessary to support electric vehicle adoption in Oregon's cities will look different from and involve different policy considerations than in rural Oregon.

## COMMUNITY ENERGY RESILIENCE



As part of our adaptation efforts, the state should create a community energy resilience vision. A collaborative process to define a vision and implement key actions could bring together and engage a diverse group of stakeholders to:

- Raise awareness of location-specific risks to energy infrastructure, particularly in communities with limited capacity to prepare for or respond to threats.
- Identify critical interdependencies within specific communities between the energy sector and public infrastructure.
- Provide technical assistance, in coordination with local energy providers, to help identify and evaluate community energy resilience and climate adaptation options (e.g., relocating or hardening infrastructure, or deploying distributed energy resources at critical public buildings) for energy systems over which they have influence or control.
- Develop a framework to help communities evaluate the costs and benefits of investments in community energy resilience or climate adaptation solutions, including the potential value of benefits from these investments during routine conditions.
- Through engagement with stakeholders, develop a community energy resilience vision for the state that include specific goals designed to improve the resilience of energy systems within individual counties, municipalities, or communities.
- Develop a framework to empower counties, municipalities, or communities to prioritize community energy resilience and climate adaptation solutions.
- Identify needs of counties, municipalities, or communities for additional technical or financial assistance. Evaluate whether new legislative or regulatory mechanisms may be necessary to fund investments in community energy resilience and climate adaptation solutions.

**Improve collaboration among state agencies.** As described in this report, numerous state agencies are working on energy issues. Many are already collaborating to implement Governor Kate Brown's recent executive orders on electric vehicles and energy efficient buildings. Each agency brings unique mission statements, areas of expertise, constituencies, statutory authority, and data to the table. Collaboration can leverage agency resources and strengths, and reduce duplication of efforts to help the state make progress on our goals in the most efficient manner. For example, in order to address transportation greenhouse gas emissions, ODOT has put forward the Statewide Transportation Strategy, drawing on the expertise of DEQ, DLCD, and ODOE. These four agencies should continue coordinating their efforts to advance and build upon the strategies highlighted in the STS.

## Assessing the Need for State Engagement and Investment

State incentives have played an important role in Oregon's GHG reduction, economic development, energy efficiency, and clean energy progress. The costs of clean energy technologies – from batteries to solar panels to electric vehicles – have come down dramatically in recent years. In light of these market forces, it is important for the state to look at the effect this has on our policies and programs and on the outcomes we hope to achieve. Once the desired outcomes and the policy pathways for achieving them are determined, the state should decide the best ways to assist consumers and businesses in achieving those outcomes. This support could come in the form of financial incentives, mandates, voluntary programs, technical assistance, and reductions of soft costs by evaluating and streamlining market barriers.

### Recommendations

**Support local activities.** Numerous local, regional, and Tribal efforts are underway across the state to create and implement climate change, clean energy, and energy resilience plans. The state should assess the role those activities play in achieving state goals and determine how best to support those efforts – which could include creating complimentary policies or programs, offering technical assistance, or providing financial incentives.

**Assess and identify market failures that warrant policy intervention.** Achieving Oregon's climate and energy goals will involve advancements in the areas of renewable energy resources, energy efficiency, and sustainable transportation. Some progress in these areas will continue to be driven by market forces, but state support in the form of incentives might still be necessary. An assessment that identifies the market failures that warrant policy intervention would help the state determine where to put our limited resources. This assessment should include how specific incentives would achieve specific outcomes, such as GHG reduction, energy independence, economic development, and equity, and should acknowledge that the desired outcome must drive the design of the incentive. For example, an incentive designed to achieve the greatest renewable energy capacity may look different from one designed to promote individual energy independence and resilience.

*Electric Vehicle Adoption*

The state currently offers incentives for the purchase of electric vehicles to offset the high upfront costs that can be a barrier to EV adoption. The state should evaluate whether additional financial support is necessary to ensure sufficient options for all EV charging platforms to meet the needs of EV drivers, to ensure accessibility in urban environments where people may not have access to at-home or workplace charging, and in rural environments where people need access to charging stations to be able to travel longer distances more frequently.

*Renewable Natural Gas*

In September, ODOE released an inventory of all potential sources of biogas and renewable natural gas (RNG) available in Oregon. The report found that the gross technical potential for RNG production from anaerobic digestion and thermal gasification technology combined could replace up to 20 percent of Oregon's total yearly use of natural gas. Working with a stakeholder advisory committee, ODOE also identified financial, technical, market, policy, and regulatory barriers to developing and using biogas and RNG as an energy source that can help Oregon reduce greenhouse gas emissions and improve air quality. One of the recommendations included in the report was to explore financial incentives to help drive the nascent industry forward.

**Consider whether to explore methods to assign a value to benefits not traditionally incorporated in cost-effectiveness models.** Policymakers, utilities, and consumers are increasingly recognizing the multiple benefits associated with reducing GHG emissions, increasing energy efficiency, investing in renewable energy, supporting sustainable transportation, and focusing on equity and resilience. Cleaner air, improved health outcomes, less reliance on imported energy, reduced energy burden, livability, and safer communities, for example, are benefits of many of the policies and strategies explored in this report. But it can sometimes be hard to quantify the value of these outcomes. Incorporating these benefits when making energy decisions could result in different outcomes. For example, putting a price on carbon can make carbon-free resources such as hydropower and wind even more competitive with fossil fuels. It could also add a new value consideration for energy efficiency that would make it more cost-effective and enable the expansion of energy efficiency efforts.

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It is our hope that the information in this report, including recommendations regarding data gaps, equity, planning, and state support, will provide Oregon policymakers and the public with the tools they need to work with the Oregon Department of Energy to lead our state to a safe, clean, and sustainable energy future.

# Cited References

1. State of Oregon Environmental Justice Handbook. January 2016. https://www.oregon.gov/gov/policy/environment/environmental_justice/Documents/2016%20Oregon%20EJTF%20Handbook%20Final.pdf
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