ENERGY 101

Just about everything involves energy. It's part of our daily lives – from driving our cars and heating our homes to turning on our computers and firing up the grill after a long day.

This section builds the foundation of the energy story: how energy is produced, used, and transformed. These Energy 101s were developed for people new to energy or specific energy topics, along with those looking for a resource to help tell the story of how energy systems affect their work and interests. Energy policy is complex and, without being armed with technical information and understanding, it is sometimes difficult to be part of the conversations.

101s this year touch on a variety of topics. We dive into how utilities plan for future energy needs – including long-duration energy storage, an emerging technology. We share insights on electrifying the agricultural sector and provide a history lesson on the Public Utility Regulatory Policies Act (PURPA). You'll find information on Oregon's Fuel Action Plan, which outlines how we'd ensure fuel delivery to critical services in the event of an emergency, and the basics on Oregon's radioactive waste management activities. We also provide background information on the Infrastructure Investment & Jobs Act and what it will mean for energy in Oregon, and captured a list of climate programs and actions in Oregon State government.

We hope these 101s continue to build foundational knowledge so readers can make informed choices about the energy resources, uses, and investments that can change our work, lives, and communities.

TABLE OF CONTENTS

Energy 101: Oregon's State Government Energy Landscape

Many of Oregon's state agencies have a role to play on energy issues in the state. This Energy 101 highlights state agencies that do the most energy-related work, as well as a few associated organizations that work closely with Oregon's state government. Understanding which agency has which responsibilities is sometimes hard to decipher. This piece helps to answer questions like: What's the difference between the Oregon Department of Energy and the Oregon Public Utility Commission? Which agencies provide energy incentives? Who supports energy education and data analysis?

After a brief description of the roles of the Governor, Legislature, and Oregon Department of Energy, each agency or organization is listed in alphabetical order. For each agency or related organization, you will find basic information about their roles and responsibilities, followed by examples of their work in the energy landscape. Each agency or organization is connected to Oregon's energy landscape in a different way through their missions, programs, and activities. Not every energy-related task of each agency is captured, but rather a snapshot of their work, as it relates to energy, is provided. Relatedly, not every agency with a role in energy is mentioned here; for example, for several agencies, their primary nexus to energy is as a reviewing agency for energy facility siting (see call-out box on page 210 below).

Adapted from the National Association of State Energy Officials, five categories provide examples of energy-related work occurring across agencies and organizations, and related icons are used in the narrative.[1]

Energy Programs to support shifts in behavior around energy consumption and production, which can include clean energy and clean fuel financial incentives, implementation programs, energy efficiency programs, contractor licensing, energy audits, home energy scoring, and public energy education.

Regulation to create and enforce standards and rules in the energy industry, which can include siting and permitting energy facilities and infrastructure; environmental regulations; economic regulations; consumer protection requirements; and oversight, monitoring, and compliance of other requirements.

Energy Policy Analysis and Education to support decision-makers in enacting policy changes, which can include developing legislative and budget proposals, conducting administrative rulemaking, engaging with energy industry and advocacy groups during policy development, and sharing data and analysis to inform the Legislature, Governor, and other decision-makers.

Safety and Resilience to protect public health and the environment from the impacts of the energy system, which can include safety regulations, energy security and resilience planning, nuclear and hazardous waste clean-up, emergency preparedness and response to shortages and disruptions in energy or fuel supply and delivery.

Energy System Planning to analyze and plan for future energy needs and policies to support them, which can include integrated resource plans, resource adequacy, transmission planning, and other energy resource analysis.

Oregon's Governor

The Governor is the leader of the executive branch of state government and uses convening powers to set priorities and solve problems. In addition to being responsible for vetoing or signing each bill passed by the Legislature, the Governor selects the director of many state agencies and appoints members to oversee 300 policymaking, regulatory, and advisory boards and commissions.[2] This includes appointing directors and commissioners for several agencies with a strong nexus to energy. It also includes hiring policy advisors who advise the Governor on energy policy and engage with state agencies to advance the Governor's vision and priorities. The Governor also exerts significant control over the function of the government by proposing two-year budgets, with input from agencies, for approval by the Legislature, as well as introducing bills to recommend policy changes.[3] This includes budgets and bills affecting the state agencies and related organizations below. The Governor can also manage the actions of state agencies by issuing executive orders, which are directives from the Governor on the focus, priorities, and operations of state government. Many state agency energy initiatives and programs are in response to an executive order, such as Executive Order 20-04, directing state agencies to reduce greenhouse gas emissions.[4]

Regional Solutions is a program within the Oregon Governor's Office.[5] Created via executive order by Governor Kitzhaber in 2014 and later enacted through the Legislature, Regional Solutions focuses on promoting economic and community development for each region in Oregon. Regional Solutions staff work locally to set priorities, identify roadblocks, and develop collaborative interagency approaches to accomplish statewide and regional goals. Regional Solutions takes advantage of community resources of all types, public, private, and civic, to develop sustainable communities and support Oregon's economy.[6]

Oregon's Legislative Assembly

Oregon's Legislative Assembly is bicameral, consisting of the House of Representatives and the Senate. The Senate includes 30 members elected to four-year terms, with half of the Senate seats up for election every two years. The House of Representatives includes 60 members elected to two-year terms. Oregon's legislators are elected from single member districts, meaning that each Oregonian is represented by one Senator and one Representative. The Legislature is responsible for enacting new laws and revising existing laws, and these laws have created agencies, funded them, and directed them to do much of the work described below. The Oregon Legislature deliberates and make changes to legislation at the committee level. As of October 2022, the following committees address energy issues and energy-related agencies: Senate Energy and Environment, Senate Natural Resources and Wildfire Recovery, House Environment and Natural Resources, House Wildfire Recovery, House

Veterans Emergency Management, Senate Veterans and Emergency Preparedness, Joint Ways and Means, and Joint Ways and Means Subcommittee on Natural Resources.

Equity and Justice: Both the Governor and the Legislature have directed state agencies to focus on equity. For the agencies that work on energy and natural resource issues, this started with the establishment of the Environmental Justice Task Force with Senate Bill 420 in 2007 and continues with new requirements for equity impact statements for agency budgets and rulemaking with House Bills 2167 and 2353 in 2021. Each state agency has their own equity-related goals and programs, and each state agency works to better engage with communities traditionally excluded from decision-making.

Oregon Department of Energy, Energy Facility Siting Council, and Oregon Hanford Cleanup Board

The Oregon Department of Energy (ODOE) acts as a central hub for energy-focused activities and is Oregon's dedicated state energy office. The Energy Facility Siting Council, staffed by ODOE, is a seven-member, Governor-appointed and Senate-confirmed council responsible for certifying and overseeing the development of large electric generating facilities, high voltage transmission lines, gas pipelines, radioactive waste disposal sites, and other projects. The Oregon Hanford Cleanup Board is a 20-member, Governor-appointed advisory group that represents Oregon's interests in the Hanford Nuclear Site cleanup project by acting as a watchdog and ensuring that the cleanup process is progressing.[7]

Examples of Work in the Energy Landscape

Programs: The Oregon Department of Energy manages and administers statutorily authorized energy programs to save energy, support the state's decarbonization efforts, make communities more resilient, and position Oregon agencies to lead by example. Recently, the agency has launched new financial incentive programs to support renewable energy and energy efficiency, such as such as the Community Renewable Energy Grant Program, Oregon Solar + Storage Rebate Program, Rural & Agricultural Energy Audit Program, and Energy Efficient Wildfire Rebuilding Incentive.[8] Two heat pump incentive programs will open in 2023.

Energy System Planning: ODOE managed the Oregon Renewable Energy Siting Assessment (ORESA), a collaborative project and online mapping tool that supports data-driven approaches and early coordination for renewable energy development.[9] The Department's planning work also includes providing Oregon's perspectives in other energy system planning processes, such as regional energy planning.[10] Finally, the Department helps policymakers assess pathways to meeting Oregon's energy and climate goals, including tradeoffs associated with various policy choices that could be made. For an example, please see the Charting the Course for Oregon's Energy Future Policy Brief.

Energy Policy Analysis and Education: The Department serves as a repository for energy research and data by generating reports, analyses, and tools, such as the Biennial Energy

Report, Oregon Electric Vehicle Dashboard, Electricity Resource Mix, renewable hydrogen study report, and floating offshore wind study report. The Oregon Hanford Cleanup Board helps hold the federal government, its contractors, and the state of Washington accountable by advocating for an increased budget and commenting on USDOE actions related to the Hanford Site cleanup.[11] ODOE provides input to policymakers, the Legislature, and the Governor on energy policy and program development and seeks input through advisory and stakeholder groups, such as the Energy Advisory Work Group. ODOE can advocate for energy bills proposed by the agency or supported by the Governor during even-year, long sessions, and is working on two legislative concepts for the 2023 session.[12] Finally, the agency provides information and analysis on energy-related bills as requested.

Safety and Resilience: One of ODOE's main responsibilities is ensuring that Oregon's energy systems are resilient, so that they can better withstand and recover quickly after a disruption such as a natural disaster.[13] The department developed and manages the Oregon Fuel Action Plan, which outlines how Oregon's emergency services and essential service providers would maintain access to necessary fuels in the face of a disruption to normal supply.[14] In preparation for an emergency at nearby nuclear sites, ODOE has developed a Nuclear Emergency Preparedness program, outlining how to keep Oregonians safe.[15] The Oregon Hanford Cleanup Board has a direct focus on protecting the health and safety of the Columbia River from radioactive waste located upstream at the Hanford Nuclear Site.[16]

Regulation: ODOE serves as staff for the Energy Facility Siting Council, which is responsible for overseeing the review of large electric generating facilities, high voltage transmission lines, gas pipelines, radioactive waste disposal sites, and other projects. Developers of these types of energy facilities must have their project proposal approved by the Energy Facility Siting Council and obtain a site certificate before they can build or operate the facility, which can influence where proposed facilities will be located.

The Role of Agencies and Other Entities in Energy Facility Siting

State agencies are critical partners to the Energy Facility Siting Council when it comes to siting energy facilities within state siting jurisdiction. Providing specialized analysis as part of the comprehensive energy facility permitting process, the following agencies review each application:

- The Department of Environmental Quality
- The Water Resources Department
- The Oregon Department of Fish and Wildlife
- The Department of Geology and Mineral Industries
- The Department of Forestry
- The Public Utility Commission of Oregon
- The Oregon Department of Agriculture
- The Department of Land Conservation and Development
- The Oregon Department of Aviation
- The Northwest Power and Conservation Planning Council
- The Office of State Fire Marshall

- The Department of State Lands
- The State Historic Preservation Office

Through the siting process, the Energy Facility Siting Council consults with Tribes identified by the Legislative Commission on Indian Services, as affected by the proposed facility. Nearby cities and counties, as affected by the proposed facility, are also consulted. If a proposed site is on federal land, federal land management agencies are included in the siting process. More information on the procedures used for the siting of renewable energy can be found here: https://oe.oregonexplorer.info/externalcontent/renewable/2022-ORESA-Procedures-Report.pdf.

Bonneville Power Administration

The Bonneville Power Administration (BPA) is a nonprofit, federal power marketing administration housed within the U.S. Department of Energy.[17] BPA was created by the U.S. Congress in 1937 to market electric power generated by the Bonneville Dam and to build the necessary transmission infrastructure to do so. Today, BPA markets electric power from 31 federally-owned dams and controls around 75 percent of the high voltage transmission lines in the Northwest – including Oregon, Washington, Idaho, and part of Montana. BPA uses analysis and plans from the Northwest Power and Conservation Council to inform its energy and transmission system plans.

Examples of Work in the Energy Landscape

Programs: In addition to power marketing,[18] BPA has invested millions of dollars into its Environment, Fish, and Wildlife Program, intended to reduce and mitigate the impact of hydropower dams.[19] Other programs and initiatives at BPA include wildfire mitigation, community education, pollution prevention, and cultural protection and preservation.[20]

Energy System Planning: BPA analyzes on power generation, transmission, and energy efficiency inform a wide range of decisions related to energy resources and rates.[17] For example, BPA establishes rates to be charged for power and transmission services in a rate proceeding, a formal evidentiary hearing process. Prior to the rate proceeding, BPA determines its spending levels through a public process, the Integrated Program Review (IPR). BPA’s initial rate proposal is then prepared based on the outcome of the IPR. BPA's rates must be set so that BPA will be able to recover its total costs, including obligations to repay its debt to the Federal Treasury. BPA's initial rate proposal is then evaluated in a rate proceeding during which BPA staff presents its rate proposal to customers and other parties for review. At the conclusion of the rate proceeding, the Administrator issues a Final Record of Decision, which includes BPA's final proposed rates. BPA then files its rates proposal with the Federal Energy Regulatory Commission for confirmation and approval.

Safety and Resilience: BPA’s wildfire mitigation plan includes a mix of vegetation management and asset management programs to mitigate the risk of wildfire. The wildfire mitigation plan also focuses on resilience, outlining BPA’s protocol for restoring service following a wildfire.

The Federal Government in Oregon's Energy Landscape

The federal government is also a major player in Oregon's energy landscape. The Bonneville Power Administration works especially closely with the state's consumer-owned utilities and provides most of the transmission capacity in the state. BPA is listed here as one of the organizations working closely with state agencies but many other federal agencies also have a role. For instance, the U.S. Departments of Energy, Transportation, and Agriculture are critical partners in funding projects and programs – and this is increasingly true with the recent passage of the Infrastructure Investments and Jobs Act and the Inflation Reduction Act. The U.S. Department of Defense funded and worked in close partnership with state agencies on the recent Oregon Renewable Energy Siting Assessment.[9] The U.S. Environmental Protection Agency administers the well-known ENERGY STAR program, which helps Oregonians access more efficient appliances, and regulates pollution that comes from many energy generation facilities. The Federal Energy Regulatory Commission and the Bureau of Ocean Energy Management also have jurisdiction over energy facility siting in certain cases. And of course, federal legislation and executive orders can direct climate and energy policy from coast to coast.

Building Codes Division, Construction Energy Industry Board, and Other Industry Boards

The Oregon Building Codes Division (BCD) within the Department of Consumer and Business Services is responsible for administering Oregon's Statewide Building Code – a set of uniform standards to ensure that newly-constructed residential and commercial structures are safe to occupy.[21] BCD also participates in the Built Environment Efficiency Working Group, an interagency effort to implement Executive Order 17-20 and increase the energy efficiency of Oregon's built environment, including residential, commercial, and public buildings. Seven Governor-appointed boards assist BCD, including the Construction Industry Energy Board that evaluates and approves or disapproves proposed state building code standards and administrative rules relating to the energy use and energy efficiency aspects of the electrical, structural, prefabricated structure, and low-rise residential specialty.[22]

Examples of Work in the Energy Landscape

Regulation: Oregon's Statewide Building Code includes energy efficiency standards for residential and commercial structures. Two major energy efficiency standards, the 2021 Oregon Energy Efficiency Specialty Code (OEESC), and the 2021 Oregon Residential Specialty Code (ORSC), outline energy efficiency requirements for windows, insulation, lighting, and other equipment.[23] Proposed standards evaluated by the Construction Industry Energy Board may include energy-conserving technology, construction methods, products, and materials.

Business Oregon and Oregon Business Commission

Business Oregon is the economic development agency for the State of Oregon. The agency works with communities and businesses and uses its programs and expertise to help businesses grow, add jobs, diversify the economy, and increase Oregon prosperity. It works with communities to enhance and expand infrastructure and community safety with projects such as water and wastewater systems, seismic rehabilitation for schools, or rural broadband development. This work also sets the stage for future business development. The agency's mission is to invest in Oregon's businesses, communities, and people to promote a globally competitive, diverse, and inclusive economy, all carried out with an agency strategic plan.[24]

Examples of Work in the Energy Landscape

Programs: Two of Business Oregon's incentives programs are involved in Oregon's energy landscape: the Rural Renewable Energy Development (RRED) Zone program and the Strategic Investment Program (SIP). Energy is an essential component of most businesses, even more so in rural areas that may not have the access to necessary infrastructure. Recognizing this, Business Oregon has assisted in the development of the RRED Zone Program, which offers eligible rural businesses a 100 percent tax abatement from local property taxes associated with a renewable energy project for the first three-to-five years of project operation.[25] Renewable energy projects can increase the value of a property, leading to more revenue from property taxes over the life of a project. Renewable energy development can also be eligible for the SIP, which is a tax exemption that applies to the portion of the project's real market value that exceeds a particular cut off. The size of the initial taxable portion depends on the total value and location of the project.[26]

Department of Administrative Services

The Department of Administrative Services is the central administrative agency of Oregon state government. DAS works to effectively implement the policy and financial decisions made by the Governor and the Oregon Legislature. The department also sets and monitors high standards of accountability to ensure that state government uses tax dollars productively. To fulfill its mission, DAS supports state agencies by providing a strong and stable management infrastructure. As part of this effort, DAS works with private enterprise, citizens, and other government entities to develop an efficient service delivery system.[27] The Department of Administrative Services leads state government by providing an array of services that include asset management (fleet and buildings), budget development, procurement, human resources, IT support, surplus property management and many others.[28]

Examples of Work in the Energy Landscape

Programs: As the central administrative agency for state government operations, DAS develops energy-related policy and practices, helps implement energy-related executive orders, and supports enterprise-wide energy management efforts. DAS developed the statewide Energy and Resource Conservation Policy[29] to direct agencies in managing energy in existing buildings, and a Fleet Policy[30] to provide agency direction on use of fleet vehicles, including electric vehicles (EVs). DAS Procurement Services also provides guidance on procurement of energy efficient equipment, from appliances and IT equipment to vehicles and fuels, through statewide policy and technical specifications in statewide price agreements with vendors. DAS also actively manages energy in its portfolio of state-owned buildings, most of which are leased to tenant agencies, and staffs an energy technical team to oversee energy-related operations and maintenance, as well as capital improvement projects to increase energy efficiency in new construction and major renovations. The DAS Office of Sustainability, along with the Oregon Sustainability Board, supports agency energy management efforts through sustainability planning, resources and technical support, and communications and education.

Department of Environmental Quality and Environmental Quality Commission

Oregon's Department of Environmental Quality (DEQ) is the state's main regulatory agency responsible for restoring, maintaining, and enhancing the quality of Oregon's air, water, and other natural resources.[31] The responsibilities of DEQ are numerous and include collecting and analyzing environmental data, monitoring and enforcing compliance with environmental regulations, as well as the restoration of valuable property. When DEQ proposes rules and policies, they must be adopted by the Environmental Quality Commission (EQC) before they take effect. The EQC, DEQ's policy and rulemaking board, is a five-member, Governor-appointed panel that adopts rules, establishes policies, issues orders, judges appeals of fines or other DEQ actions, and appoints the DEQ director.[32] Recently, through rulemaking, the EQC played a central role in defining Oregon's Climate Protection Program, the state-wide emissions reduction program.[33]

Examples of Work in the Energy Landscape

Regulation: One of DEQ's major responsibilities is running Oregon's Climate Protection Program, which sets a declining limit on the greenhouse gas emissions from the use of fossil fuels in transportation, residential, commercial, and industrial settings. Under the policies and regulations within the Program, DEQ aims to achieve a 90 percent reduction in the greenhouse gas emissions from fossil fuels over the next 30 years.[34] Additionally, DEQ is responsible for issuing certain permits that would be needed for energy infrastructure, such as the Title V Air Permits and 401 Water Quality Certification permits.[35]

Energy Policy Analysis and Education: Policies created and passed by the Legislature typically include broad policy mandates, and individual agencies and their rulemaking boards, such as the Environmental Quality Commission, develop detailed rules and policies to accomplish those broad policy mandates set by the Governor or Legislature.[36]

Safety and Resilience: Large quantities of oil are shipped along the Columbia River and along the coast. Hazardous materials are shipped along the highways and by rail. DEQ's Emergency Program focuses on collaborating with other agencies and industry officials to prevent and respond to spills.[37] DEQ also focuses on the reduction and elimination of toxic materials and substances, including efforts to reduce air toxics from transportation fuels such as diesel soot, benzene, and polycyclic aromatic hydrocarbons.[38]

Programs: DEQ's Clean Vehicle Rebate Program offers Oregon drivers a cash rebate for purchasing or leasing an electric vehicle.[39] DEQ's Vehicle Inspection Program, initially created to help Oregon comply with the federal Clean Air Act, continues to ensure vehicles driven in Oregon meet emissions standards.[40] The Greenhouse Gas Reporting Program requires major emitters of greenhouse gases, such as electricity and natural gas providers, to report their annual emissions to DEQ which is then audited and made publicly available.[41] DEQ's Clean

Fuels Program reduces the carbon intensity of transportation fuels used in Oregon. As of fall 2022, the reduction targets are 10 percent below 2015 levels by 2025, 20 percent lower by 2030, and 37 percent lower by 2035. From 2016 to 2022, the Clean Fuels Program supported the reduction of 7.3 million tons of greenhouse gas emissions and has displaced nearly 1.5 billion gallons of fossil fuels with cleaner options.[42]

Department of Land Conservation and Development and Land Conservation and Development Commission

The Oregon Department of Land Conservation and Development (DLCD) is responsible for administering Oregon's land use planning program, established through Senate Bill 100 (1973), which recognizes the importance of planning in protecting farm, forest, and coastal areas, conserving natural resources, managing urban growth, and creating livable communities. DLCD also assists cities and counties in adopting and maintaining comprehensive plans and zoning codes that adhere to Oregon's 19 planning goals.[43] The Land Conservation and Development Commission (LCDC), staffed by DLCD, is a seven-member Governor-appointed, Senate-confirmed board. LCDC adopts state land-use goals and rules, assures local plan compliance, and oversees the coastal zone management program.[44]

Examples of Work in the Energy Landscape

Energy Policy Analysis and Education: DLCD helps set goals, targets, and policies for the cities and counties they assist in the development of comprehensive plans, which often outline energy plans and goals, including the provision of renewable energy resources.[45]

Regulation: DLCD developed and LCDC adopted rules for the siting of wind and solar energy projects to help balance land uses involving agriculture and conservation. Intended to direct renewable energy development toward areas with limited value to wildlife and agriculture, rules limit local approval of photovoltaic solar energy projects larger than 12 acres on high-value farmland or 20 acres on arable lands through a conditional use proceeding, which is commensurate with rule provisions for siting most energy generation projects on lands protected for agricultural purposes. LCDC's agricultural lands rule also provides a conditional use opportunity for photovoltaic solar projects of up to 320 acres on nonarable lands.[46] On lands protected for forest uses, the threshold for all energy generation projects is 10 acres. Projects exceeding the acreage thresholds identified for agricultural or forest lands that remain subject to local jurisdiction may be considered through a post acknowledgement plan amendment process.

Energy Trust of Oregon

Energy Trust of Oregon is an independent nonprofit organization that administers energy efficiency and renewable energy incentive programs in the service areas of Portland General Electric, Pacific Power, NW Natural, Cascade Natural Gas, and Avista. Following the establishment of the Public Purpose Charge in Senate Bill 1149, Energy Trust has been responsible for investing ratepayer funds in cost-effective electric and natural gas efficiency resources, paying the above-market cost of small-scale renewable energy system installations, and supporting market transformation that promotes the development, availability, and adoption of energy-efficient products and practices, primarily through the Northwest Energy Efficiency Alliance.[47] Energy Trust's activity is reported in quarterly and annual reports to the Oregon Public Utility Commission (OPUC) and in a biennial report to the Legislative Assembly on Public Purpose Charge Receipts and Expenditures.

Starting in 2022, House Bill 3141 changed how ratepayer funds administered by Energy Trust are collected and expanded what qualifies for renewable energy funding to include projects that improve reliability and resiliency of the electric grid. The law requires at least 25 percent of Energy Trust's renewable energy revenues flowing from a public purpose charge paid by PGE and Pacific Power customers be used to serve low- and moderate-income customers, and it requires the OPUC to set equity metrics for all funds invested by Energy Trust. Lastly, it requires Energy Trust continue jointly planning and delivering programs in coordination with the aforementioned utilities.[48]

Examples of Work in the Energy Landscape

Programs: Energy Trust administers services and programs to help customers and communities save energy and benefit from renewable energy. This scope includes residential, commercial, industrial, and agricultural customers of the five participating utilities.[49] Energy Trust offers incentives for homes including heating and cooling systems, windows, and insulation; business incentives include operations and maintenance changes, lighting, heating and cooling, irrigation, industrial equipment, and custom projects. Incentives are also provided for above-code construction of residential and commercial buildings. Solar incentives are available to residential and commercial projects, including community solar, and project development assistance and installation incentives available for small-scale in-conduit hydropower, biopower, geothermal and small-scale, municipally owned wind projects. Contractor coordination and training help enable a skilled workforce to install energy-efficient equipment and renewable energy systems in Oregon**.**

Energy System Planning/Analysis: Energy Trust contributes program data and analysis in OPUC dockets and proceedings to inform utility resource and system planning. It coordinates with participating utilities to develop energy efficiency supply estimates, savings scenarios, targets and funding for annual energy savings that provide customers with reliable, low-cost energy. Energy Trust offers incentives for feasibility studies and the construction of renewable energy projects, such as hydropower and biopower, to help reduce barriers to renewable energy development in the state.

Safety and Resilience: Energy Trust staff supports community energy planning for cities and counties and helps identify strategies and actions that can increase the resilience of communities and the entire energy system. These include developing microgrids that can continue to function without the main grid, further promoting energy efficiency, and expanding access to distribution-system connected technologies and distributed energy resources.[50]

Environmental Justice Council (EJC)

Since its creation in 2007, the Environmental Justice Taskforce has advised the Governor and Oregon's natural resource agencies on environmental justice, which is defined as "equal protection from environmental and health hazards, and meaningful public participation in decisions that affect the environment in which people live, work, learn, practice spirituality, and play."[51] In 2022, the Legislature passed HB 4077, renaming and codifying the existing Environmental Justice Taskforce as the Environmental Justice Council. HB 4077 provides the Environmental Justice Council with additional resources, including staff support from Department of Environmental Quality, to enable further outreach and meaningful engagement with environmental justice communities across the state. The Environmental Justice Council is responsible for working with natural resource agencies to identify minority and low-income communities that are likely to be impacted by the work done by the agencies.[52]

Examples of Work in the Energy Landscape

Energy Policy Analysis and Education: The Council meets directly with environmental justice communities to understand the perspectives and concerns of these communities firsthand and to advise the Governor's Office, policy makers, and the state's natural resource agencies on environmental justice. This role includes working with natural resource agencies to address community concerns and improve the public participation process as well as developing policy recommendations. In the near-term, this work also includes developing an equity mapping tool to aid state agencies in their work.

Federally Recognized Oregon Tribes

There are nine federally recognized Tribes in Oregon; these Tribal governments have been in what is now Oregon since time immemorial: Burns Paiute Tribe, Confederated Tribes of Coos, Lower Umpqua & Siuslaw Indians, Confederated Tribes of Grand Ronde, Confederated Tribes of Siletz Indians, Confederated Tribes of the Umatilla Indian Reservation, Confederated Tribes of the Warm Springs Reservation, Coquille Indian Tribe, Cow Creek Band of the Umpqua Tribe of Indians, and the Klamath Tribes. Village sites and traditional ways are known to date back many thousands of years. Tribal governments are separate and unique sovereign nations with powers to protect the health, safety, and welfare of their enrolled members and to govern their lands. This tribal sovereignty predates the existence of the U.S. government and the State of Oregon. Most Oregon Tribes are "confederations" of three or more Tribes and bands. Each Tribe's area of interest may extend far beyond its Tribal governmental center or reservation location.[53]

Examples of Work in the Energy Landscape

Regulation: Many tribal governments have authority for permitting on their reservation lands as well as land use planning and building requirements.

Energy Policy Analysis and Education: Some tribes have worked with U.S. Department of Energy, Office of Indian Energy Policy and Programs and the National Labs to develop Energy Visions or Strategies to help pursue their goals.[54] There are also regional collaborations among tribes to develop energy strategies, as illustrated in the 2022 CRITFC Energy Vision: https://critfc.org/energy-vision.

Local Governments

There are 241 incorporated cities in Oregon. Among the services that city governments typically provide are fire and police protection, streets and street maintenance, sewer and water treatment and collection systems, building permit activities, libraries, parks and recreation activities, and other numerous social services that are determined locally. Cities also have considerable responsibilities for land use planning within their city limits and urban growth boundaries. City councils serve as the highest authority within city government in deciding issues of public policy.[55] There are 36 counties in Oregon. Twenty-eight counties, including nine with charters, are governed by a board of commissioners comprised of three-to-five elected members. The remaining eight, less populated counties are governed by a "county court" consisting of a county judge and two commissioners. Nine counties have adopted "home rule" charters, wherein voters have the power to adopt and amend their own county government organization. Counties provide a range of important public services, including, land-use planning, building regulations, refuse disposal, air pollution control, economic development, and urban renewal.[56] In addition to cities and counties, several other forms of local government exist in Oregon such as Regional Governments, Metro, Port Districts, and Special Service Districts.[57]

Examples of Work in the Energy Landscape

Regulation: Local governments have, for example, a role to play in energy siting and energy efficiency through their land use planning and building regulation authorities.

Programs: Some cities, such as City of Portland, have financing programs like the Portland Clean Energy Fund. Also, some cities have instituted home energy scoring to help potential homeowners better understand the energy use and cost associated with a home before buying.

Energy Policy Analysis and Education: Several local governments have developed clean energy, climate, or sustainability plans that prioritize actions that they can take within local authorities and jurisdiction to pursue goals around affordable energy, energy resilience, and clean energy (among others). More examples can be found in the Community Energy Planning in Rural Oregon Guidebook - https://tinyurl.com/BPCEP

Northwest Power and Conservation Council

The Northwest Power and Conservation Council was created in 1980 when the United States Congress passed the Pacific Northwest Electric Power Planning and Conservation Act.[58] The council represents a compact unique in the nation among Idaho, Montano, Oregon, and Washington to address the Pacific Northwest's energy and environmental needs. The Power Act requires the Council to develop a long-term energy plan for the region and to develop a fish and wildlife program to address the impacts of the hydroelectric system on fish and wildlife populations. The Council's work acknowledges and analyzes the many changes in the planning environment: the evolving science about the Columbia

Basin ecosystem; the Northwest's economy; the availability of BPA funding for fish and wildlife restoration; the cost and availability of generating resources; the availability and cost-effectiveness of energy efficiency measures; the engagement of the public; and the operation of the Columbia River power system.

Examples of Work in the Energy Landscape

Energy System Planning/Analysis: The Northwest Power and Conservation Council is required to produce an electric power plan for the region every five years, outlining projected energy demand, evaluating electricity resources and their costs, and analyzing new technologies and strategies.[58] Information in the power plans guide how the Pacific Northwest will meet its future electricity needs and acts as an early warning system – alerting the region of any potential energy shortfalls.[59] The power plans typically include a major focus on demand response and energy efficiency as tools to meet future load growth and reduce emissions.[60] These power plans are a valuable resource for electric utilities to use when conducting their own resource planning, offering a regional perspective and providing technical modeling of how various resources will perform.[61]

Oregon Department of Emergency Management

The Oregon Department of Emergency Management coordinates and maintains a statewide emergency services system for emergency and disaster communications. OEM awards grant funding to local governments, coordinates search and rescue efforts, and manages the state 9-1-1 Program. The Drought Readiness Council and Oregon Seismic Safety Advisory Commission (OSSPAC) also operate out of OEM.

Examples of Work in the Energy Landscape

Energy System Planning/Analysis and Safety and Resilience: Working with the Public Utility Commission and the Oregon Department of Energy, OEM coordinates energy-related planning ahead of potential disasters to mitigate issues related to power outages or lack of access to fuel. In the event of an actual disaster, OEM leads state government efforts in a coordinated response to the disaster, which would include coordinating with ODOE, OPUC, and private sector partners related to energy needs.

Oregon Department of Fish and Wildlife and Oregon Fish and Wildlife Commission

The Oregon Department of Fish and Wildlife (ODFW) is a regulatory agency working to protect and enhance Oregon's fish and wildlife as well as their habitats for use and enjoyment by present and future generations.[62] ODFW's regulatory role involves the take of state-managed species – for example, hunting or fishing. ODFW also serves an advisory role within many permitting arenas, working directly in support of agencies and departments responsible for project permitting. ODFW is structured with three divisions, the Fish Division, the Wildlife Division, and the Habitat Division. Species and habitat conservation can shape the type and location of energy systems. The Oregon Fish and Wildlife Commission consists of seven members appointed by the Governor, appoints the ODFW director, formulates general state programs and policies concerning management and conservation of fish and wildlife resources, and establishes seasons, methods, and bag limits for recreational and commercial take.

Examples of Work in the Energy Landscape

Regulation: ODFW sets regulations related to hunting and fishing as well as wildlife and habitat conservation. ODFW generally serves an advisory role in energy development actions, working directly with responsible regulatory agencies regarding potential impacts of a proposed action, including energy production and transmission on fish, wildlife, and habitats. At the early stages of project development, ODFW advises developers on siting and helps determine what impact studies should be conducted to help avoid, minimize, and mitigate potential impacts from a project.[63]

Oregon Department of State Lands and State Land Board

Since statehood in 1859, the Land Board has been composed of the Governor (chair), Secretary of State, and State Treasurer. Oregon's Constitution directs the Land Board to manage lands under its jurisdiction to obtain the greatest benefit for the people of Oregon, consistent with resource conservation and sound land management. The Land Board oversees the Common School Fund and state lands dedicated to providing revenue for the fund. On behalf of the State Land Board, the Department of State Lands manages Oregon's school lands and other resources that contribute revenue to the Common School Fund. Additionally, the state owns the submerged and submersible land underlying all navigable and tidally-influenced waterways. DSL is responsible for management of these publicly owned submerged and submersible land and for the protection of wetlands and waters of the state.

Examples of Work in the Energy Landscape

Regulation: DSL has primary jurisdiction for leasing land within state waters, waters within 3 miles of shore, for projects such as offshore transmission cables or other infrastructure related to marine-based energy development. In addition, DSL has responsibility over removal-fill permits that can be required for energy infrastructure projects.

Oregon Department of Transportation and Oregon Transportation Commission

The Oregon Department of Transportation (ODOT) helps ensure that Oregon's transportation system is safe and reliable, and acts as the central agency for planning the future of Oregon's transportation systems. ODOT is responsible for the licensing of vehicles and operators in Oregon, as well as the maintenance of the state's transportation system including bridges, highways, and public transportation.[64] The Oregon Transportation Commission is a five member Governor-appointed and Senate-confirmed board that establishes state transportation policy, oversees ODOT's activities, and guides the planning, development, and management of a statewide integrated transportation network.[65]

Examples of Work in the Energy Landscape

Regulation: Within ODOT, the Fuels Tax Group is responsible for collecting various fuel taxes, including Motor Vehicle Fuel Taxes and Use Fuel Taxes.[61] This tax revenue is used to further update and improve Oregon's transportation infrastructure, including efforts to reduce congestion and therefore, greenhouse gas emissions. ODOT's Rail Division inspects freight railroad activities, including hazardous material transportation, in order to ensure compliance and prevent spills and leaks.

Energy System Planning: Around 35 percent of greenhouse gas emissions in Oregon come from the transportation sector. As the overall manager of the transportation system, ODOT works continuously to reduce those emissions. Strategies include supporting public transportation and other alternative ways to travel; making it easier to own and use an electric vehicle; using and encouraging use of clean fuels; and helping local governments identify ways to reduce emissions. Additionally, the agency regularly performs energy audits in its facilities around the state, making improvements to conserve resources.

Safety and Resilience: ODOT works with the Oregon Department of Environmental Quality and the Federal Railroad Administration to manage hazardous substances and materials. ODOT's Hazardous Materials Group also ensures agency compliance with environmental regulations during the use of hazardous materials, water discharges, site cleanups and more.

Oregon Global Warming Commission

The Oregon Global Warming Commission, created through HB 3543 (2007),[66] is a 25-member advisory group.[67] The Governor appoints 11 voting members to the commission. The commission is directed in statute to submit a biennial report to the Legislature describing Oregon's progress toward achieving the state's greenhouse gas emissions reduction goals. The commission can also make recommendations for additional actions to reduce emissions, which often relate to energy given the carbon intensity of Oregon's current energy systems. The commission's key priorities include decreasing greenhouse gas emissions, protecting the health and wellbeing of Oregonians, and ensuring that Oregon's economy remains vibrant and healthy.[67] Oregon Department of Energy provides energy expertise and staff support for the commission.

Examples of Work in the Energy Landscape

Energy Policy Analysis and Education: In 2010, the Oregon Global Warming Commission published the Roadmap to 2020 report, outlining a ten-year plan to combat climate change. Currently the Oregon Global Warming Commission, with ODOE staff support, is developing a Roadmap to 2035 – outlining additional actions the state could take to further decarbonize Oregon's economy.

Oregon Housing and Community Services

Oregon Housing and Community Services (OHCS), the state's housing finance agency, administers programs that aim to increase access to stable housing by preventing homelessness, assisting with utility payments, preserving and financing the building of affordable housing, and encouraging homeownership.

Examples of Work in the Energy Landscape

Programs: The Oregon Low Income Weatherization Program (WAP) provides weatherization and energy conservation services at no cost to qualified households. OHCS also directly administers the Oregon Multifamily Energy Program (OR-MEP), which facilitates energy-efficiency in affordable multifamily housing through design assistance, cash incentives, coordination with other regional energy programs, as well as contractor and public educational opportunities.[68] OHCS also provides funding and program support through two billing assistance programs. The federally-funded Low Income Home Energy Assistance Program (LIHEAP) includes bill payment assistance, energy education, case management, and home weatherization services. The ratepayer-funded Oregon Energy Assistance Program (OEAP) provides assistance to low-income households at risk of having their electricity service disconnected. These services are delivered by local community-based organizations, including Community Action Agencies (CAAs), senior centers, and housing authorities.[69]

Oregon Public Utility Commission

The Oregon Public Utility Commission (OPUC) is responsible for rate regulation of Oregon's investor-owned electric utilities (Portland General Electric, Pacific Power, and Idaho Power), natural gas utilities (Avista, Cascade Natural, and NW Natural), telephone service providers (landline only), as well as select water companies. The OPUC also enforces electric and natural gas safety standards and handles utility-related dispute resolution on behalf of Oregon residents. In the event of an emergency, the OPUC is part of the Oregon Emergency Response System to coordinate and manage state resources. OPUC consists of three full-time commissioners that are appointed by the Governor and confirmed by the Senate, and is supported by staff with a wide range of utility, financial, legal, and energy expertise.

Examples of Work in the Energy Landscape

Regulation: The OPUC regulates investor-owned electric and natural gas utilities providing service to Oregon residents to ensure they offer safe and reliable energy at reasonable rates. The rates charged by investor-owned utilities must be approved by the OPUC and cannot be changed without going through the quasi-judicial rate case process. During this process, the OPUC examines the utility's operating expenses to determine whether the proposed rate change is warranted, and consumer protection is a central element of the process. The OPUC also regulates Oregon's power system by creating and enforcing safety and reliability standards, conducting field inspections and vegetation audits, and analyzing outage events as well. The OPUC also works with the Pipeline and Hazardous Material and Safety Administration to enforce the Pipeline Safety Act by conducting inspections of natural gas pipelines in Oregon.[70]

Safety/Resilience: The OPUC requires investor-owned utilities to proactively manage emerging safety and reliability risks such as earthquakes, wildfire, or cybersecurity threats, as well as offer reliable and secure operation of electric power and natural gas supply infrastructure. As an economic regulator of these utilities, the OPUC ensures that the utility has sufficient revenue to pay for reasonable costs to operate and maintain its systems in a safe manner. This includes costs for infrastructure, vegetation management, and facility maintenance. The OPUC also conducts inspections and provides general safety oversight for the 38 consumer-owned utilities (Cooperatives, Peoples' Utility Districts, and Municipal Utilities). OPUC works with Oregon Utility Notification Center (Call 811 Before You Dig) to coordinate and avoid damaging underground utilities, Oregon Utility Safety Committee (OUSC) made up of public and privately-owned utility service providers to propose recommendations on utility safety-related issues, and Oregon Joint Use Association an industry advisory group established by the Oregon Legislature to advise the OPUC on safety issues related to utility poles. In 2021, Oregon passed SB 762 to address the impact and increased risk of wildfires. SB 726 requires OPUC to convene workshops focused on helping both investor-owned and consumer-owned utilities develop wildfire protection plans.[71]

Energy System Planning: Oregon IOUs are required to file Integrated Resource Plans, outlining the utility's expected upcoming demand and its plan for meeting that demand. Integrated Resource Plans describe the utility's plan for procuring additional energy resources and are used to help inform future decisions whether to approve a rate change for a utility. Integrated Resource Plans are intended to help the utility determine their "least-cost/least-risk" combination of energy generation, demand-side management, and purchased energy to meet future energy needs and legal requirements. The OPUC oversees Energy Trust operations (as required by SB 1149) through a funding Grant Agreement (2005) and sets annual performance goals. The Energy Trust provides energy efficiency services for customers of Portland General Electric, Pacific Power, Northwest Natural, Cascade Natural Gas, and Avista, which are part of energy efficiency resource acquisition in integrated resource plans. Additionally, OPUC is responsible for reviewing and approving the "Clean Energy Plans" submitted by utilities outlining their plan to comply with the House Bill 2021.[72] These Clean Energy Plans require PGE and Pacific Power to work with the Community Benefits and Impacts Advisory Group to ensure that community considerations are part of their Clean Power Plans.[73]

Energy Policy Analysis and Education: The OPUC conducts policy analysis through an inclusive stakeholder process to evaluate differing viewpoints on key issues, such as an on-going investigation about potential bill impacts that may result from limiting the GHG emissions of regulated natural gas utilities. The OPUC's stakeholder processes and analysis also provide an understanding of how changes in the electricity sector, such as an increase in distributed generation, storage, and smart grids, will impact how the electric grid is regulated.

Oregon Sustainability Board

The Oregon Sustainability Board was created in 2001 and encourages activities that best sustain, protect, and enhance the environment, economy, and community for the present and future benefit of Oregonians. The Legislature adopted the Oregon Sustainability Act (ORS 184.421-435), which established the state's overall sustainability policy. The legislation created the OSB and established legislative goals for the Board, and more generally for state government around sustainability. Appointed by the Governor, eleven members represent a variety of stakeholders across the State of Oregon.

Examples of Work in the Energy Landscape

Energy Policy Analysis and Education: Subsequent executive orders and communications from the Governor directed the Board to oversee, review, and approve sustainability plans developed by state agencies, all of which address energy used by state agencies in their operations. The Board, which meets quarterly, is actively involved in the oversight of agency sustainability plans and initiatives, as well as statewide projects working to enhance the environment, economy, and community.

REFERENCES

1. National Association of State Energy Officials. (2022). State Energy Offices. Retrieved October 20, 2022, from https://naseo.org/state-energy-offices
2. Office of the Oregon Governor. (n.d.). Boards & Commissions. Retrieved August 24, 2022, from https://www.oregon.gov/gov/pages/board-list.aspx
3. Oregon Secretary of State. (n.d.). Oregon Blue Book – Governor Kate Brown. Retrieved August 22, 2022, from https://sos.oregon.gov/blue-book/Pages/state/executive/Governor-bio.aspx
4. State for Oregon, Office of the Governor. (2020). Executive Order No. 20-04. Retrieved August 24, 2022, from https://www.oregon.gov/bcd/Documents/eo-energy-20-04.pdf
5. State of Oregon, Office of the Governor. (2011). Executive Order No. 11-12. Retrieved August 24, 2022, from https://www.oregon.gov/gov/Documents/executive_orders/eo_1112.pdf
6. Regional Solutions Program, Definitions. ORS 284.752 (n.d.). Retrieved August 24, 2022, from https://www.oregon.gov/gov/regional-solutions/Documents/ORS%20284.752%20Regional%20Solutions%20Program.pdf
7. Oregon Department of Energy. (n.d.). Oregon Hanford Cleanup Board. Retrieved August 22, 2022, from https://www.oregon.gov/energy/safety-resiliency/pages/oregon-hanford-cleanup-board.aspx
8. Oregon Department of Energy. (2022). Incentives. Retrieved August 22, 2022, from https://www.oregon.gov/energy/Incentives/Pages/default.aspx
9. Oregon Department of Energy. (2022). Oregon Renewable Energy Siting Assessment (ORESA). Retrieved August 22, 2022, from https://www.oregon.gov/energy/energy-oregon/Pages/ORESA.aspx
10. Pacific Northwest Hydrogen Association. (n.d.). Our Board. Retrieved August 24, 2022, from https://pnwh2.com/our-board
11. Oregon Department of Energy. (2017). Bylaws of Oregon Hanford Cleanup Board. Retrieved August 22, 2022, from https://www.oregon.gov/energy/safety-resiliency/Documents/OHCB-Bylaws.pdf

12. Oregon Department of Energy. (2022). Proposed Legislative Concept. Retrieved August 29, 2022, from https://www.oregon.gov/energy/About-Us/Documents/2023-ODOE-Legislative-Concepts.pdf
13. Oregon Department of Energy. (n.d.). Energy System Resilience. Retrieved August 22, 2022, from https://www.oregon.gov/energy/safety-resiliency/Pages/Resilience.aspx
14. Oregon Department of Energy. (n.d.). Energy Assurance Plan. Retrieved August 22, 2022, from https://www.oregon.gov/energy/safety-resiliency/Documents/Oregon-Fuel-Action-Plan.pdf
15. Oregon Department of Energy. (n.d.). Nuclear Emergency Preparedness Program. Retrieved August 22, 2022, from https://www.oregon.gov/energy/safety-resiliency/Pages/Emergency-Preparedness.aspx
16. Oregon Department of Energy. (n.d.). About Hanford. Retrieved August 22, 2022, from https://www.oregon.gov/energy/safety-resiliency/Pages/About-Hanford.aspx
17. Bonneville Power Administration. (n.d.). About. Retrieved August 22, 2022, from https://www.bpa.gov/about
18. Bonneville Power Administration. (n.d.). Marketing Resources . Retrieved October 26, 2022 from https://www.bpa.gov/energy-and-services/efficiency/marketing-resources
19. Bonneville Power Administration. (n.d.). Environmental initiatives. Retrieved August 22, 2022, from https://www.bpa.gov/environmental-initiatives
20. Bonneville Power Administration. (n.d.). Cultural Resources. Retrieved August 22, 2022, from https://www.bpa.gov/environmental-initiatives/efw/cultural-resources-bpa
21. Building Codes Division. (n.d.). About us. Retrieved August 22, 2022, from https://www.oregon.gov/BCD/Pages/about-us.aspx
22. Building Codes Division. (n.d.). Construction Industry Energy Board. Retrieved August 24, 2022, from https://www.oregon.gov/bcd/boards/Pages/cieb.aspx
23. Building Codes Division. (n.d.). Energy Code Program. Retrieved August 22, 2022, from https://www.oregon.gov/bcd/codes-stand/Pages/energy-efficiency.aspx
24. Business Oregon. (n.d.). About Business Oregon. Retrieved August 22, 2022, from https://www.oregon.gov/biz/aboutus/Pages/default.aspx
25. Business Oregon. (n.d.). Rural Renewable Energy Development (RRED) Zone. Retrieved Aug 22, 2022, from https://www.oregon.gov/biz/programs/RuralRenewableEnergyDevelopment(RRED)Zone
26. Business Oregon. (n.d.). Strategic Investment Program (SIP). Retrieved August 22, 2022, from https://www.oregon.gov/biz/programs/SIP
27. Department of Administrative Services. (n.d.). Agency Information. Retrieved October 21, 2022, from https://www.oregon.gov/das/pages/index.aspx
28. Department of Administrative Services. (n.d.). Programs of DAS. Retrieved August 22, 2022, from https://www.oregon.gov/das/Pages/Programs.aspx
29. Department of Administrative Services. (2020). Energy and Resource Conservation Policy. https://www.oregon.gov/das/Policies/107-011-010.pdf
30. Department of Administrative Services. (2022). Fleet Management Policy. https://www.oregon.gov/das/Policies/Fleet.pdf
31. Department of Environmental Quality (n.d.). About DEQ. Retrieved August 22, 2022, from https://www.oregon.gov/deq/about-us/Pages/default.aspx
32. Department of Environmental Quality. (n.d.). Oregon DEQ’s Policy and Rulemaking Board. Retrieved August 22, 2022, from https://www.oregon.gov/deq/about-us/eqc/Pages/default.aspx
33. Department of Environmental Quality. (n.d.). Greenhouse Gas Emissions Program 2021. Retrieved August 22, 2022, from https://www.oregon.gov/deq/rulemaking/Pages/rghgcr2021.aspx

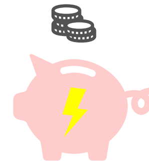
34. Department of Environmental Quality. (n.d.). Climate Protection Program, Program Brief. Retrieved August 22, 2022, from https://www.oregon.gov/deq/ghgp/Documents/CPP-Overview.pdf
35. Department of Environmental Quality. (n.d.). Title V Forms and Guidance. Retrieved August 24, 2022, from https://www.oregon.gov/deq/aq/aqPermits/Pages/TV.aspx
36 Department of Environmental Quality. (n.d.). Rulemaking. Retrieved August 22, 2022, from https://www.oregon.gov/deq/rulemaking/Pages/default.aspx
37. Department of Environmental Quality. (n.d.). Emergency Response Program. Retrieved August 22, 2022, from https://www.oregon.gov/deq/Hazards-and-Cleanup/er/Pages/default.aspx
38. Department of Environmental Quality. (n.d.). Oregon Air Toxics Program. Retrieved August 22, 2022, from https://www.oregon.gov/deq/aq/air-toxics/Pages/default.aspx
39. Department of Environmental Quality. (n.d.). Oregon Clean Vehicle Rebate Program. Retrieved August 22, 2022, from https://www.oregon.gov/deq/aq/programs/Pages/ZEV-Rebate.aspx
40. Department of Environmental Quality. (n.d.). Vehicle Inspection. Retrieved August 22, 2022, from https://www.oregon.gov/deq/Vehicle-Inspection/Pages/default.aspx
41. Department of Environmental Quality. (n.d.). Greenhouse Gas Reporting Home. Retrieved August 22, 2022, from https://www.oregon.gov/deq/ghgp/Pages/GHG.aspx
42. Department of Environment Quality. (2022, September 23). EQC votes to expand the Oregon Clean Fuels Program. https://www.oregon.gov/newsroom/Pages/NewsDetail.aspx?newsid=76193
43. Department of Land Conservation and Development. (n.d.). About DLCD. Retrieved August 22, 2022, from https://www.oregon.gov/lcd/About/Pages/About-DLCD.aspx
44. Department of Land Conservation and Development. (n.d.). Land Conservation and Development Commission. Retrieved August 24, 2022, from https://www.oregon.gov/lcd/Commission/Pages/index.aspx
45. Department of Land Conservation and Development. (n.d.). Comprehensive Plan Updates. Retrieved August 22, 2022, from https://www.oregon.gov/lcd/CPU/Pages/Comprehensive-Plan-Updates.aspx
46. Oregon Secretary of State. (n.d.). Oregon Administrative Rules, Chapter 660. Retrieved August 22, 2022, from https://secure.sos.state.or.us/oard/displayDivisionRules.action?selectedDivision=3083
47. Energy Trust of Oregon. (2022). Northwest Energy Efficiency Alliance. Retrieved August 22, 2022, from https://www.energytrust.org/about/explore-energy-trust/about-neea-partner
48. Public Purpose Charge, House Bill 3141, 81st Oregon Legislative Assembly (2021). [Testimony of Oregon State Legislature]. Retrieved October 26, 2022 from https://olis.oregonLegislature.gov/liz/2021R1/Downloads/MeasureDocument/HB3141/Enrolled
49. Energy Trust of Oregon. (2022). Participating Utilities. Retrieved October 26, 2022 from https://energytrust.org/about/explore-energy-trust/about-utility-community-partners/#:~:text=Participating%20Utilities,natural%20gas%20customers%20in%20Oregon.
50. Rubado, P. L., Iplikci, J., & Engel, B. (2018). Community Resilience Board Learning Paper. Retrieved October 26, 2022 from https://www.energytrust.org/wp-content/uploads/2018/05/Board_Learning_Topic_Papers.pdf
51. State of Oregon. (2016). Environmental Justice: Best Practices For Oregon's Natural Resource Agencies. Retrieved August 22, 2022, from https://digital.osl.state.or.us/islandora/object/osl:16954
52. Oregon Department of Agriculture. (n.d.). Environmental Justice. Retrieved August 22, 2022, from https://www.oregon.gov/ODA/AboutUs/Pages/EnvironmentalJustice.aspx

53. Oregon Secretary of State. (n.d.). Oregon Blue Book - Introduction to Oregon's Indian Tribes. Retrieved October 20, 2022, from https://sos.oregon.gov/blue-book/Pages/national-tribes-intro.aspx
54. Office of Indian Energy Policy and Programs. (n.d.). Confederated Tribes of the Umatilla Indian Reservation – 2017 Project. Retrieved October 20, 2022, from https://www.energy.gov/indianenergy/confederated-tribes-umatilla-indian-reservation-2017-project
55. Oregon Secretary of State. (n.d.). Oregon Blue Book - About City Government. Retrieved October 24, 2022, from https://sos.oregon.gov/blue-book/Pages/local/cities/about.aspx
56. Oregon Secretary of State. (n.d.). Oregon Blue Book - County Government in Oregon. Retrieved October 24, 2022, from https://sos.oregon.gov/blue-book/Pages/local/counties/about.aspx
57. Oregon Secretary of State. (n.d.). Oregon Blue Book - Other Local Government Entities. (n.d.). Retrieved October 24, 2022, from https://sos.oregon.gov/blue-book/Pages/local-other.aspx
58. Northwest Power and Conservation Council. (2022). Northwest Power Act. Retrieved August 22, 2022, from https://www.nwcouncil.org/reports/columbia-river-history/northwestpoweract/
59. Simmons, S., Northwest Power and Conservation Council (2022). Keeping the Lights On. Retrieved August 22, 2022, from https://www.nwcouncil.org/news/2022/05/25/keeping-the-lights-on-improving-how-the-northwest-assesses-power-supply-adequacy/
60. Northwest Power and Conservation Council. (2022). Demand Response Advisory Committee. Retrieved August 22, 2022, from https://www.nwcouncil.org/energy/energy-advisory-committees/demand-response-advisory-committee/
61. Oregon Department of Transportation (n.d.). About Us: Fuels Tax History. Retrieved October 26, 2022, from https://www.oregon.gov/odot/ftg/pages/about-us.aspx
62. Oregon Department of Fish and Wildlife. (2022). About Us. Retrieved August 22, 2022, from https://www.dfw.state.or.us/agency/
63. Oregon Department of Fish and Wildlife. (2018). Ocean Energy. Retrieved August 22, 2022, from https://www.dfw.state.or.us/MRP/ocean_energy/overview.asp
64. Oregon Department of Transportation (n.d.). About ODOT. Retrieved August 22, 2022, from https://www.oregon.gov/ODOT/About/Pages/Directory.aspx
65. Oregon Department of Transportation. (n.d.). Oregon Transportation Commission. Retrieved August 24, 2022, from https://www.oregon.gov/odot/Get-Involved/Pages/OTC_Main.aspx
66. Legislative Findings, House Bill 3543. 74th Oregon Legislative Assembly. (2007). [Testimony of Oregon State Legislature]. Retrieved October 26, 2022 from https://olis.oregonLegislature.gov/liz/2007R1/Downloads/MeasureDocument/HB3543/Enrolled
67 Oregon Global Warming Commission. (n.d.). About Us. Retrieved August 22, 2022, from https://www.keeporegoncool.org/about-the-commission
68. Oregon Housing and Community Services. (n.d.). Home Weatherization Services. Retrieved October 21, 2022, from https://www.oregon.gov/ohcs/energy-weatherization/Pages/weatherization-services.aspx
69. Oregon Housing and Community Services. (n.d.). Utility Bill Payment Assistance. Retrieved October 21, 2022, from https://www.oregon.gov/ohcs/energy-weatherization/Pages/utility-bill-payment-assistance.aspx
70. Oregon Public Utility Commission. (n.d.). Natural Gas Pipeline Safety. Retrieved August 22, 2022, from https://www.oregon.gov/puc/safety/Pages/Gas-Pipeline-Safety.aspx
71. Oregon Public Utility Commission. (2021). Wildfire Omnibus, SB 762 summary. Retrieved August 22, 2022, from https://www.oregon.gov/puc/Documents/SB762-Summary.pdf

72. Oregon Public Utility Commission. (n.d.). 2021 Legislative Session Summary.pdf. Retrieved August 22, 2022, from https://www.oregon.gov/puc/Documents/2021-Legislative-Summary.pdf

73. Oregon Public Utility Commission. (2021). Clean Energy, HB2021 summary.pdf. Retrieved August 22, 2022, from https://www.oregon.gov/puc/Documents/HB2021-Summary.pdf

Energy 101: Consumer Energy Cost Drivers



Oregonians spent more than $12 billion on energy in 2020—from electricity and natural gas used in homes and businesses, to the fuels that run our vehicles.[i] The methods of production and delivery of energy to consumers varies widely. Depending on the type of energy, there are varying levels of state and federal price regulation and opportunities for policymakers to affect end-use costs to consumers. This brief describes the production-to-consumption supply chains for electricity, natural gas, and gasoline, and identifies opportunities where policymakers can affect various elements of these supply chains. It also summarizes the regulatory processes for establishing the retail rates that consumers pay for electricity and natural gas service.

There are three main types of energy that most Oregonians typically use daily: electricity, natural gas, and gasoline. Each varies significantly in its physical characteristics, industry composition, and regulatory structure. These differences have an impact on the extent to which state policymakers can influence retail prices for Oregon consumers. A little talked-about benefit of electrification and electric vehicles is moving consumers from gasoline—a fuel whose price is unregulated—to electricity, a fuel whose retail price is regulated either by the Public Utility Commission or by local elected boards. Unlike with gasoline, state regulators and elected boards play a central role in setting retail prices for electricity, which can provide a valuable safeguard for consumers.

Energy as a Commodity

Energy is the power derived from the use of physical or chemical resources, especially to provide light and heat or to work machines.[1] In the case of gasoline or natural gas, that fuel is delivered to the consumer as chemical potential energy. Until you start your car's engine, or turn on your gas stove, that fuel is there holding that energy until a spark ignites the fuel, breaks its chemical bonds, and creates useful energy. Electricity, on the other hand, *is* energy—no physical or chemical conversion is required by the consumer to derive useful energy from electricity. Instead, the conversion into usable energy generally occurs at electric power plants, and that energy is transmitted over the grid directly to end-users.

Geographical Influences

Energy supply chains play a big role in overall energy costs and have implications for what can influence consumer prices. The physics of electricity generation and transmission necessitate an electric sector that is more local in nature and built nearer to end-use consumers, which lends itself to state regulation. On the other hand, oil (and its liquid fuel derivatives) and natural gas (to an increasingly similar but still much lesser extent) can be transported as fungible physical commodities. This has resulted in the development of global commodity markets, the prices of which are unregulated.

There are three main types of energy that most Oregonians typically use daily: electricity, natural gas, and gasoline.

[i] Learn more about energy costs and Oregon's economy in the Energy by the Numbers section of this report.

Supply Chains

Gasoline	
Extraction	Crude oil is extracted from underground.
Transport	Crude oil is transported, often via tanker or pipeline, to refineries that produce end-use fuels of various kinds. In some cases, crude oil may cross long distances (and oceans) from its site of extraction to a refinery.
Refining	There are approximately 130 oil refineries in the United States, with most refining capacity located east of the Rocky Mountains and more than 40 percent of national capacity along the Gulf of Mexico.[2] For most Oregonians, the nearest refineries are located in the Puget Sound region in Washington. Oil refineries distill crude oil into various types of end-use fuels, including gasoline, diesel, kerosene, and jet fuel.[3]
Transmission	Refined gasoline is distributed regionally across the U.S. by pipeline or tanker.
Distribution	Gasoline is then often transported the final stage to retail gas stations by truck, where it is stored underground in tanks until pumped into cars.

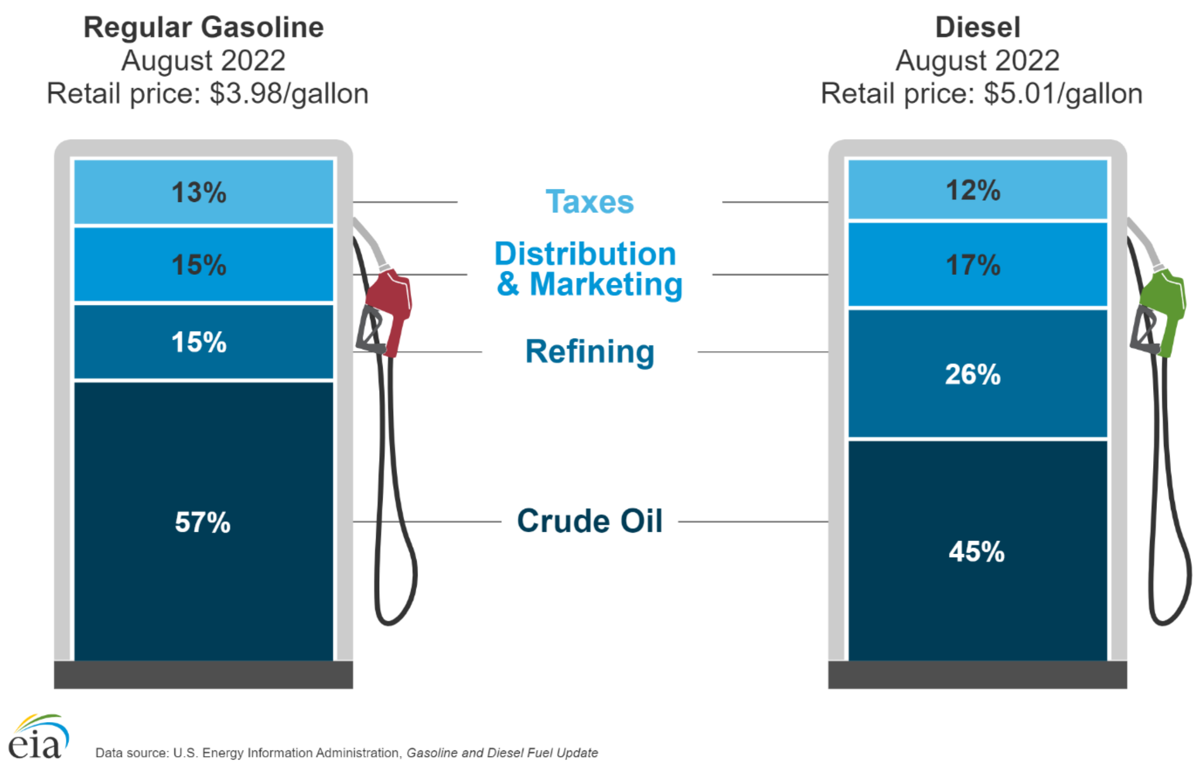
Natural Gas	
Extraction	Natural gas is extracted from underground, sometimes as a byproduct of oil extraction. In recent years, the use of hydraulic fracturing (fracking) has been more widely used to extract natural gas from underground shale formations.
Transport	Raw natural gas is transported via pipeline, often a relatively short distance, to a natural gas processing plant near the wellhead.
Processing	Most of the natural gas processing plants that produce natural gas used in Oregon are located in the northern Rocky Mountains region of British Columbia and Alberta, Canada.[4] These plants process and clean raw natural gas to remove water and other contaminants.
Transmission	Processed natural gas moves through a network of interstate gas pipelines from processing plants to wholesale purchasers, like local gas distribution companies.[5]
Distribution	Local gas distribution companies maintain a network of gas distribution pipelines to deliver natural gas to end-use consumers in Oregon.

Electricity	
Extraction	Many types of electricity generation, such as coal, natural gas, and nuclear (uranium), require the extraction of natural resources.
Transport	Some fuels, like coal, natural gas, and uranium, must be transported from the site of extraction to a power generation facility. Resources like solar, wind, and hydropower do not require the transport of fuels, but are dependent on the availability of these resources in a particular location.
Generation	Conversion of the primary energy source (wind, solar, coal, natural gas, uranium, water) into electricity occurs at a power plant.
Transmission	Electricity is delivered from the source of generation to a retail provider over the electric transmission system.
Distribution	Electricity is delivered from the wholesale transmission system over the distribution grid to reach end-use consumers.

Market Influences

The price that Oregonians pay for energy varies by type of fuel, by time of day or year, and by location in the state. This variability across time is particularly true with gasoline and diesel, where a significant portion of the consumer end-use cost is driven by global crude oil commodity markets. Changes in global oil markets are more likely to result in volatility in retail prices because of the lack of policies and retail price regulation. For example, in early March 2022, gas prices jumped 49 cents in just over a week as Russia attacked Ukraine, disrupting global markets.[6] One year earlier, a large container ship became stuck in the Suez Canal—a major thoroughfare that handles 12 percent of seaborne trade.[7] Even in the midst of the COVID-19 pandemic, which had globally depressed oil prices, this event caused a small, but noticeable, spike in oil prices. More recently, the consortium known as the Organization of the Petroleum Exporting Countries, along with non-OPEC partners, agreed to cut oil production, driving oil futures prices up.[8] As shown in Figure 1 below, crude oil prices typically account for more than half the end-use consumer cost of gasoline, and 45 percent of diesel.[9]

Figure 1: Distribution of Costs for Gasoline and Diesel[43]



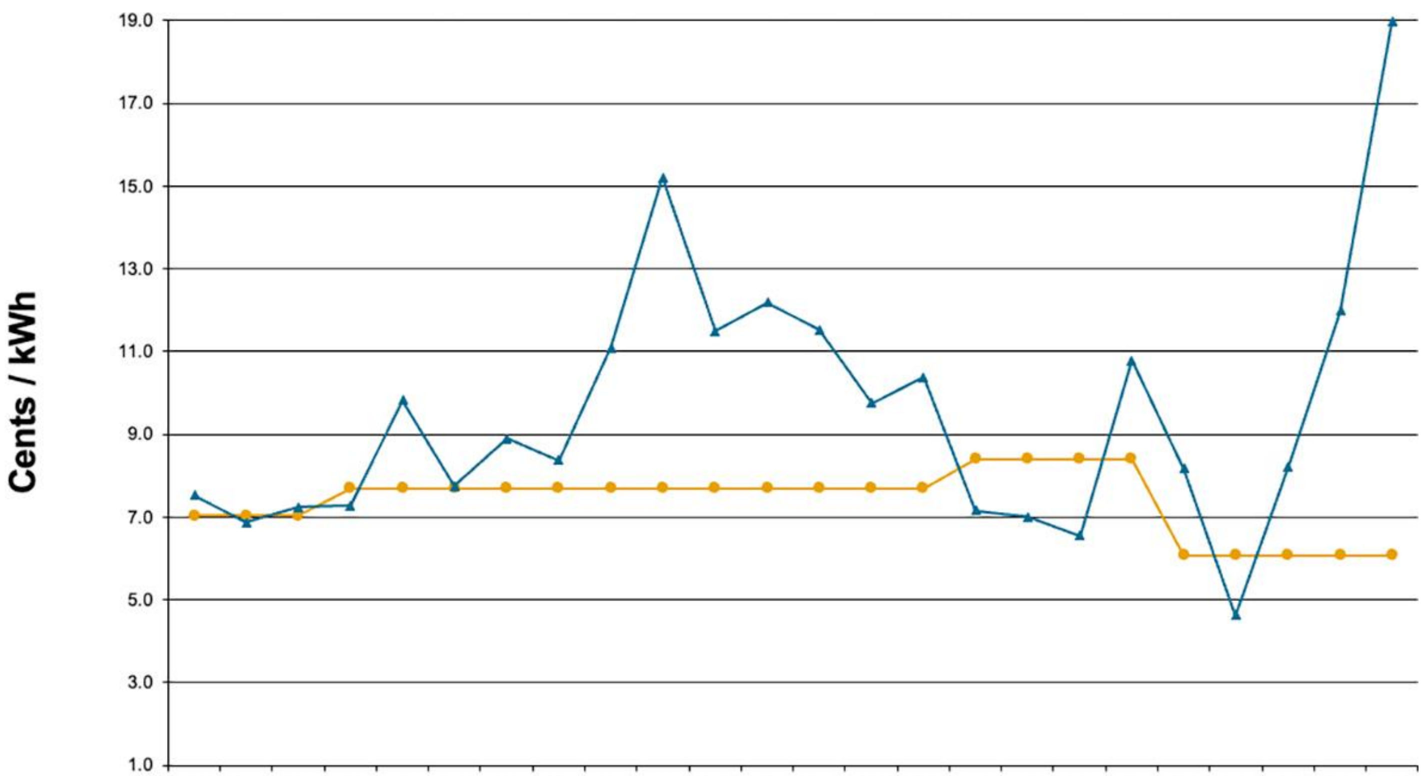
Regulatory Influences

For both electricity and natural gas, wholesale rates are subject to federal regulation while retail rates are subject to state regulation, which allows for some degree of public input on how end-use consumer prices are determined. Investor-owned natural gas and electric utilities are regulated by the Oregon Public Utility Commission, and the utilities participate in retail ratemaking cases that provide insight on utility costs that ultimately lead to setting the retail natural gas and electricity rates paid by

Oregonians. The OPUC commissioners must approve utility retail rate changes.[10] Costs of doing business are taken into account, including costs to plan for, build, and maintain utility systems, and the wholesale rates—which are subject to regulation by the Federal Energy Regulatory Commission—that utilities must pay to acquire bulk quantities of natural gas or electricity for delivery to retail customers.[11] Consumer-owned utilities are regulated by their elected governing boards. Global issues like supply chain disruptions for parts and equipment can also have an effect on rates, but these are rigorously assessed by the OPUC to be investments that are least-cost and least-risk for the utility and its ratepayers before they can be included in the rates that end up on a customer's bill.

Retail electricity and natural gas costs are more stable for retail consumers even when the costs for the utility may be more volatile. Figure 2 shows the relatively stable costs for retail electricity compared to more volatile wholesale electricity costs.[12] Over the course of the two-year period, customer retail rates in yellow stayed relatively flat, from 5.4 to 7.1 cents per kWh, even as wholesale costs in blue varied by nearly 10 cents over the same time period. The ability to maintain stable retail rates for consumers through retail price regulation is an advantage of the electric and natural gas sectors as compared to the gasoline sector.

Figure 2: Comparison of Wholesale and Retail Electricity Rates[44]



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	Oct-20	Nov-20	Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21	Jun-21	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22
Cost of Service	7.0	7.0	7.0	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	8.4	8.4	8.4	8.4	6.1	6.1	6.1	6.1	6.1
Daily Pricing	7.5	6.9	7.2	7.3	9.8	7.7	8.9	8.4	11.1	15.2	11.5	12.2	11.5	9.8	10.4	7.2	7.0	6.6	10.8	8.2	4.6	8.2	12.0	19.0

Establishing Consumer Prices for Electricity and Natural Gas Through the Utility Ratemaking Processes

Electricity and natural gas energy costs are passed on to consumers through retail rates for utility services provided by regulated monopolies. Utility rates for electricity and natural gas services are established through public, transparent processes for both investor-owned and consumer-owned utilities. Investor-owned utilities are private electricity or natural gas companies. Three electric and three natural gas investor-owned utilities have their retail rates approved by the Oregon Public Utility Commission. Consumer-owned utilities are formed as municipal utilities, people's utility districts, and rural electric cooperatives.[13] For the 38 consumer-owned utilities that operate in Oregon, oversight is provided by publicly elected local boards.

Oregon Investor-Owned Utilities

Electricity:

- Idaho Power Company
- Pacific Power
- Portland General Electric

Natural Gas:

- Avista
- Cascade Natural Gas
- NW Natural

Oregon Public Power

In addition to the investor-owned electric utilities regulated by the Oregon PUC, there are 38 consumer-owned, not-for-profit electric utilities that also serve Oregonians. These utilities have been organized pursuant to authorities granted by the Oregon State Legislature.[45 46 47]

The first municipal utilities in Oregon were established in 1889: McMinnville Water & Light and the City of Milton-Freewater.[14 15] There are now 12 municipal electric utilities that are overseen by Oregon city governments or city-affiliated boards. There are also six people's utility districts and 18 rural electric cooperatives in Oregon that have locally elected boards—plus two additional cooperatives located out of state that have service territory in Oregon.[16] Formed in 2001, the Umpqua Indian Utility Cooperative is the first utility in the Northwest both owned and operated by a Tribe.

Together, consumer-owned utilities and investor-owned utilities provide universal electric service to all Oregonians and have public processes to establish fair rates for consumers.

Ratemaking Process for Regulated Investor-Owned Utilities

The Oregon Public Utility Commission is responsible for ensuring that investor-owned utilities provide safe and reliable electricity or natural gas service to consumers at just and reasonable rates.[17] In accordance with this directive, the OPUC applies a specific regulatory framework to calculate the retail rates that these utilities may charge to customers for electricity or natural gas service. The OPUC determines rates through complex and technical ratemaking proceedings.

Revenue requirement and operating expenses. In the investor-owned utility context, the ratemaking process is designed to enable a utility to recover the total costs it incurs in providing service to its customers and to earn a reasonable rate of return for the utility's shareholders. To establish a utility's retail rates, the OPUC first calculates the utility's "revenue requirement," which reflects the total cost to the utility of providing service to its customers. These costs may vary by utility due to differences in the type of load, distances between loads, and other service territory characteristics. Within the revenue requirement, a utility's costs and expenditures fall into one of two general categories: operating expenses and capital expenditures. Operating expenses include costs the utility expects to incur in providing service to customers. The OPUC allows utilities to recover a variety of operating expenses from ratepayers, including fuel, operations, and maintenance costs; administrative costs, taxes, and fees; and staffing and labor costs, including wages, salaries, and benefits. Depreciation and amortization expenses are also categorized as operating costs within the revenue requirement. Utilities may recover operating expenses from ratepayers, but may not earn an additional profit from these expenditures. Utilities are also not entitled to recover every kind of cost they may incur in the course of their operations. The OPUC may prohibit a utility from recovering certain operating expenses from ratepayers or require a utility's shareholders to cover a portion of those costs. For example, utility shareholders have been held responsible, in whole or in part, for expenses that are not necessary and prudent for serving ratepayers, such as executive incentive pay, lobbying costs, employee gifts and travel expenses, promotional costs, or trade association dues.[18]

Rate base. The second category of costs included in the revenue requirement is referred to as the utility's "rate base." The rate base includes prudent investments in capital projects that are used in service to ratepayers (known as the "utility plant in service"). To recover capital expenditures through the rate base portion of its revenue requirement, a utility must demonstrate that a project is "used and useful." This means the project must be in service during the entire period it is included in the rate base (*i.e.,* "used"), and that the project is needed to provide safe and reliable service to customers (*i.e.,* "useful"). The used and useful requirement is particularly important because a utility is entitled to earn an additional rate of return on capital expenditures in its rate base. Under the regulatory compact between investor-owned utilities and state regulators, utilities are entitled to earn a reasonable rate of return on their rate bases to maintain their financial integrity, attract capital, and compensate investors.[19]

Ratemaking for Consumer-Owned Electric Utilities

In addition to the three investor-owned electric utilities that serve Oregonians, there are also 38 consumer-owned utilities that serve Oregonians—including municipal utilities, rural electric cooperatives, and people's utility districts.[ii] Each of these utilities is self-governed by a locally elected board that sets retail rates separately for the customers it serves.

While each COU ratemaking process is separate, there are common elements involved across all of them. As not-for-profit entities, COUs are not driven by a profit motive, instead reinvesting accrued revenues back into the utility itself and/or the communities they serve. According to the American Public Power Administration, COU ratemaking involves the following core steps:[48]

(1) Identify the utility's **cost of service** across power supply, transmission, distribution, and customer-related expenses to determine the utility's revenue requirement

(2) **Divide the utility's revenue requirement by customer class** to identify the amount to be recovered from each class

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[ii] See the utilities serving Oregonians using the Oregon Department of Energy's interactive Find Your Utility tool: www.tinyurl.com/FindYourUtility

(3) Factor a **rate adjustment strategy** into a financial plan that takes input from utility management and the governing board to develop a rate implementation strategy for three to five years

(4) **Balance the proposed rate structure** after seeking input from the governing board and the public to align the proposal with the needs of the community and the utility's revenue requirement

(5) Publish the draft rates and **seek customer feedback at a public hearing** before the board approves the rates

Most COUs serving Oregonians purchase most (100 percent in many cases) of their power supply from the Bonneville Power Administration. The low-cost, low-carbon power supplied by BPA is the primary reason that Oregon COU retail rates are among the lowest in the nation.

Customer class. Rates are set based on the cost to provide electricity or natural gas service to residential, commercial, and industrial customer classes that have similar usage and cost profiles for the utility system. After the OPUC approves a utility's revenue requirement, it divides the revenue requirement by the utility's estimated retail sales to determine the rates the utility may charge each customer class to recover its operating expenses and earn a rate of return for its shareholders. The ratemaking process aims to allocate total costs across a utility's customers in a just, reasonable, and non-discriminatory manner.[20] The cost of providing electricity or natural gas to customers can vary depending on how different customers receive and use energy. Because of these distinctions, the OPUC and utilities design different rates for residential, commercial, or industrial customer classes. In addition to retail rates, which are levied on each unit of energy consumed during a billing period, there are several other charges on a consumer's bill, such as a fixed basic customer charge that represents the minimum cost of service and reflects the cost to connect a customer to the distribution system. Commercial and industrial rates also include a charge—referred to as a demand charge—for the largest amount of power consumed at a given time over the course of the billing period.[21]

Wholesale purchase costs. Because wholesale electricity and natural gas prices fluctuate in response to market conditions, a customer's retail rates may not reflect the utility's wholesale costs on a month-to-month basis. Both investor-owned electric and natural gas utilities pass through the cost of wholesale purchases of electricity and natural gas to consumers without any associated rate of return for the utility. In addition, to enable these utilities to recover their wholesale electricity and gas costs without imposing additional costs onto consumers, the OPUC applies an adjustment to retail rates on an annual basis based on changes in wholesale purchase costs. For electric utilities, this is referred to as a power cost adjustment, while for gas utilities it is referred to as a purchased gas adjustment.[25] These adjustments allow utilities to update their annual revenue requirements without filing a general rate case, but through a public process that is still subject to prudency review by the OPUC. [26]

Energy efficiency. Recognizing that energy efficiency investments help reduce consumer energy bills, provide public health, environmental, and economic benefits, and reduce reliance on imported fuels, the Oregon legislature took action to support utility energy efficiency investments through the adoption of SB 1547 in 2016.[49] SB 1547 specifically aimed to ensure utilities make prudent investments in energy efficiency before acquiring new electric generating resources. To achieve this, the bill directed electric utilities to "[p]lan for and pursue all available energy efficiency resources that are cost effective, reliable and feasible." The bill also directed the OPUC to "plan for and pursue the acquisition of cost-effective demand response resources."[49] In requiring utilities to plan for and acquire cost-effective energy efficiency resources before investing in new generating resources, SB 1547 made it easier for utilities to recover the value of energy efficiency investments through the ratemaking process. Allowing utilities to include energy efficiency investments in their rate bases removes an inherent financial disincentive for utilities to conserve electricity, which has the effect of reducing revenues from electricity sales. Though the OPUC has worked to "decouple" utility profits from electricity sales for more than a decade by spreading the revenue requirement out over a utility's customer base, SB 1547 created a new financial incentive for utilities to reduce electricity sales through energy efficiency improvements.

Differential rates. In 2021, the Oregon legislature adopted HB 2475, known as the "Energy Affordability Act," which was designed to support a just and equitable clean energy transition by incorporating additional social justice considerations into the ratemaking process. The Act authorized the OPUC to consider differential energy burdens and other economic, equity, and environmental justice factors affecting energy affordability when approving electric and gas rates.[22] This authorization enables the OPUC and regulated utilities to design differential rates that account for ratepayers' ability to pay for electricity and gas services. For example, utilities may now offer discounted rates for "income-qualified" customers.[23] Utilities are required to file interim differential rate proposals prior to January 2023.[24]

The Oregon Citizens' Utility Board

Many proceedings at the OPUC, including ratemaking proceedings, involve complex technical and legal processes. The Oregon Citizens' Utility Board is a nonprofit created in 1984 by ballot initiative to advocate on behalf of and protect the rights of residential customers of investor-owned electric and natural gas utilities. CUB intervenes in regulatory proceedings before the OPUC and advocates on behalf of these customers.

Taxes and Other Charges

Local, state, and federal taxes may be included in electric and natural gas utility bills and are added to the price of transportation fuels at the pump. Tax rates vary by location. For example, current state gasoline taxes in Oregon are $0.38 per gallon and federal taxes are $0.184 per gallon.[27] Some cities also set local tax rates for gasoline, which range from $0.01 to $0.10 per gallon. In Oregon, taxes on transportation fuel are used almost exclusively to fund road and bridge improvements and maintenance. This is because the state constitution requires gas tax revenues to be used for highway-related purposes, such as constructing or repairing roadways or highway rest areas.[50]

Electric and natural gas utilities may also incur local taxes and fees, such as utility franchise fees or license fees, that they pass on to customers.[30] [31] Investor-owned utility revenues are also subject to

Oregon's commercial activity tax, though certain fees and surcharges collected from utility customers are exempt from taxation, including charges that support energy conservation, renewable energy, and low-income assistance programs.[28] If a utility's gross revenues do not exceed $1 million, it is exempt from the corporate activity tax.[29]

In Oregon, Portland General Electric and Pacific Power are required to add a 1.5 percent Public Purpose Charge to customers' bills.[32] This is used to fund programs for low-income weatherization, renewable energy, low-income housing, and school investments in energy efficiency and transportation electrification. The utilities must also collect a 0.25 percent surcharge from their retail customers to support transportation electrification.[51]

Addressing Consumer Energy Costs

When energy prices increase, consumers often wonder how state government intervention could help to alleviate costs. As discussed above, global commodity prices contribute significantly to the retail prices paid by consumers, particularly for gasoline and diesel. In the immediate term, state policymakers have few ways to affect these prices. State and local governments set tax rates, and therefore can increase or reduce fuel taxes, but such actions do not tend to have much of an immediate effect on price increases.[33] As shown in the Figure 1 above, taxes generally account for less than 15 percent of retail gasoline and diesel fuel prices, which limits the extent to which a reduction in taxes would lower transportation costs.[34]

Wholesale natural gas prices also affect retail customer costs, but the effects of month-to-month price volatility are somewhat ameliorated by annual Oregon Public Utility Commission proceedings that oversee fuel cost assessments on ratepayers. The OPUC must ensure that retail rates for electricity and natural gas services are "just and reasonable" for both utilities and consumers. This directive does not ensure that utility ratepayers are insulated from cost increases; if wholesale prices rise, utilities are entitled to pass the higher costs onto consumers through annual retail rate adjustments. But retail rate regulation by the OPUC provides an added level of transparency and oversight over retail electric and natural gas prices that does not exist in the petroleum fuels markets.

In conjunction with transportation electrification, retail rate regulation also offers an opportunity to address transportation energy burden. When consumers shift from a fuel type with unregulated prices that are strongly influenced by volatile global commodity markets (like gasoline) to a fuel type that has regulated prices (like electricity), this shift will almost certainly reduce and stabilize transportation energy costs for Oregonians. Up to 30 percent of low-income households in Oregon are transportation burdened.[42] When charging at their residence or business, consumers that drive electric cars typically pay 70 to 80 percent less than those who drive gasoline cars. Electrification of the transportation sector presents a long-term opportunity for the state to have more influence than the status quo on managing the adverse effects of wholesale energy price volatility on Oregon consumers. Differential rates authorized by HB 2475 will further reduce energy burden associated with transportation electrification.

Global events and environmental factors can also put upward pressure on consumer energy prices that are difficult to address at the state level. Recently, there have been many outside events influencing gasoline and natural gas prices. The examples below describe several events and their effect on energy prices.

COVID-19

Demand for gasoline plummeted in Spring 2020 following stay-at-home orders as the global COVID-19 pandemic emerged.[35] As a result, the price for crude oil plummeted from approximately $60 to less than $20 per barrel in about two weeks, as shown in Figure 3.[36] Given the significant role that crude oil prices play in retail gasoline prices, the average national retail price also fell from about $2.50 to $1.80 per gallon.[37] Following the initial downturn in demand for oil and gas, the recovery caused prices to rebound starting in late 2021.[38] For more information on the effects of COVID-19 on the energy sector, see the COVID-19 Response and Effects of the Energy Sector Policy Brief from the *2020 Biennial Energy Report.*

Figure 3: Crude Oil Prices per Barrel Reported from Brent Market[52]

War in Ukraine

Russia is one of the top three crude oil-producing countries in the world (alongside the United States and Saudi Arabia).[39] As a result, the global instability in crude oil markets created when Russia invaded Ukraine in early 2022 contributed to the national average gasoline price spiking from about $3.35 to over $5.00 per gallon between January and June 2022.[37] A price for a barrel of crude jumped from approximately $75 to over $125 in the same period.[36]

Enbridge Natural Gas Pipeline Rupture

A rupture of a gas transmission pipeline between British Columbia and Washington state in October 2019 sent local natural gas prices skyrocketing as the supply of natural gas sharply decreased. Average next-day prices at the Sumas Hub were in the range of $2 to $3 per million British thermal units but rose to $9.55 per million Btu in the weeks following the rupture.[40]

Summer 2021 Pacific Northwest Heatwave

During June 2021, the Pacific Northwest suffered through an unrelenting heatwave that set records for both its severity and length. Portland recorded a temperature of 115 degrees at the heatwave's peak. During this record heat, wholesale electricity prices in the region climbed 435 percent.[41] The large increase in prices was driven by higher demand for electricity, largely from the widespread and prolonged use of air conditioning. Consumers were spared the real-time increase in price, as retail rates help to insulate consumers from this type of volatility in wholesale prices.

Conclusion: An Opportunity for Less Volatility

Oregon policymakers have oversight of the electric and natural gas sectors through the OPUC and COU governing boards, and this has helped keep electricity and natural gas costs relatively stable for retail ratepayers over the years. In no small part due to the region's robust hydroelectric system, Oregon has some of the lowest retail electricity prices in the country, which has made the state attractive to businesses that require large amounts of electricity. However, wholesale electricity prices in Oregon are still subject to price fluctuations, primarily from natural gas, which fuels 20 to 25 percent of the generation used to meet Oregon's electricity demand. As Oregon utilities move toward using 100 percent emissions-free resources, including solar, wind, and hydroelectricity, the price fluctuations of fossil fuels like natural gas will have an increasingly smaller effect on electricity prices.

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REFERENCES

1. Oxford Dictionary. (n.d.). *Definition of Energy*. Retrieved October 12, 2022, from https://www.google.com/search?q=define+energy
2. U.S. Energy Information Administration. (n.d.). *Much of the Country's Refinery Capacity is Concentrated Along the Gulf Coast*. Retrieved October 12, 2022, from https://www.eia.gov/todayinenergy/detail.php?id=7170
3. U.S. Energy Information Administration. (n.d.). *Refining Crude Oil—The Refining Process*. Retrieved October 12, 2022, from https://www.eia.gov/energyexplained/oil-and-petroleum-products/refining-crude-oil-the-refining-process.php

4. U.S. Energy Information Administration. (n.d.). *U.S. Natural Gas Processing Plant Capacity and Throughput Have Increased in Recent Years*. Retrieved October 13, 2022, from https://www.eia.gov/todayinenergy/detail.php?id=38592

5. U.S. Energy Information Administration. (n.d.). *Natural Gas Pipelines*. Retrieved October 12, 2022, from https://www.eia.gov/energyexplained/natural-gas/natural-gas-pipelines.php

6. Smith, Z. S. (n.d.). *U.S. Gas Prices Near All-Time High As Ukraine War Threatens Energy Market*. Forbes. Retrieved October 12, 2022, from https://www.forbes.com/sites/zacharysmith/2022/03/07/us-gas-prices-near-all-time-high-as-ukraine-war-threatens-energy-market/

7. Stevens, P. (n.d.). *Massive ship blocking the Suez Canal brings billions of dollars in trade to a standstill*. CNBC. Retrieved October 12, 2022, from https://www.cnbc.com/2021/03/25/suez-canal-blocked-ship-billions-trade-standstill.html

8. Meredith, S. (n.d.). *OPEC+ to cut oil production by 2 million barrels per day to shore up prices, defying U.S. pressure*. CNBC. Retrieved October 13, 2022, from https://www.cnbc.com/2022/10/05/oil-opec-imposes-deep-production-cuts-in-a-bid-to-shore-up-prices.html

9. U.S. Energy Information Administration. (n.d.). *Gasoline and Diesel Fuel Update*. Retrieved October 12, 2022, from https://www.eia.gov/petroleum/gasdiesel/index.php

10. Oregon Public Utility Commission. (n.d.). *Public Utility Commission: Rates and Tariffs: Utility Regulation: State of Oregon*. Retrieved October 17, 2022, from https://www.oregon.gov/puc/utilities/pages/rates-tariffs.aspx

11. Federal Energy Regulatory Commission. (n.d.). *Energy Primer A Handbook of Energy Market Basics April 2020*. 26, 35.

12. Portland General Electric. (n.d.). *Pricing Graphs*. Retrieved October 12, 2022, from https://portlandgeneral.com/about/info/pricing-plans/market-based-pricing/pricing-graphs

13. Definitions for ORS 757.600 to 757.689, 757.600 Oregon Regulatory Statute (2003). https://oregon.public.law/statutes/ors_757.600

14. McMinnville Power. (n.d.). *History of McMinnville Water and Light*. Retrieved October 12, 2022, from https://www.mc-power.com/about/history/

15. City of Milton-Freewater Oregon. (n.d.). *Electric Department*. Retrieved October 13, 2022, from https://www.mfcity.com/electric

16. Oregon Department of Energy. (n.d.). *State of Oregon: Energy in Oregon—Oregon Utilities*. Retrieved October 12, 2022, from https://www.oregon.gov/energy/energy-oregon/Pages/Oregon-Utilities.aspx

17. Duty of utilities to furnish adequate and safe service at reasonable rates, 757.020 Oregon Regulatory Statute (1971). https://oregon.public.law/statutes/ors_757.020

18. Order 18-419—NW Natural Request for a General Rate Revision, Public Utility Commission of Oregon (October 26, 2018). https://apps.puc.state.or.us/orders/2018ords/18-419.pdf

19. Federal Power Commission v. Hope Natural Gas, 320 U.S. 591 (1944). https://supreme.justia.com/cases/federal/us/320/591/

20. Lazar, J. (n.d.). *Electricity Regulation in the US: A Guide*. https://www.raponline.org/knowledge-center/electricity-regulation-in-the-us-a-guide-2/

21. Oregon Department of Energy. (2020). *2020 Biennial Energy Report—Energy 101: Bill Basics* (pp. 86–91). https://www.oregon.gov/energy/Data-and-Reports/Documents/2020-BER-Energy-101.pdf#page=86

22. House Bill 2475, 81st Oregon Legislative Assembly, 2021 Regular Session (2021). https://olis.oregonlegislature.gov/liz/2021R1/Downloads/MeasureDocument/HB2475/Enrolled

23. Docket No. UM 2211: HB 2475 Implementation of Differential Rates and Programs in Oregon, (2022). https://edocs.puc.state.or.us/efdocs/HAH/um2211hah81137.pdf
24. Oregon Public Utility Commission. (2021). *HB 2475—Summary*. https://www.oregon.gov/puc/Documents/HB2475-Summary.pdf
25. Oregon Public Utility Commission. (n.d.). *Purchased Gas Adjustment*. https://www.oregon.gov/puc/utilities/Documents/What-is-PGA.docx.pdf
26. NW Natural. (n.d.). *Billing Rates for Natural Gas*. Retrieved October 12, 2022, from https://www.nwnatural.com/about-us/rates-and-regulations/billing-rates
27. Oregon Department of Transportation. (n.d.). *Oregon Department of Transportation: Current Fuel Tax Rates: Fuels Tax: State of Oregon*. Retrieved October 12, 2022, from https://www.oregon.gov/odot/ftg/pages/current%20fuel%20tax%20rates.aspx?wp4401=l:100
28. Corporate Activity Tax, 317A.116, 317A.100(b)(B)(GG)-(II) Oregon Regulatory Statute. Retrieved October 18, 2022, from https://www.oregonlegislature.gov/bills_laws/ors/ors317A.html
29. Corporate Activity Tax, ORS 317A.125. https://www.oregonlegislature.gov/bills_laws/ors/ors317A.html
30. Municipal regulation of public utilities, 221.420 Oregon Regulatory Statute (1971). https://oregon.public.law/statutes/ors_221.420
31. Relating to City Fees, Taxes, and Other Assessments Imposed Upon Electric Companies, Gas Utilities, and Steam Heat Utilities—Oregon Administrative Rules, OAR 860-022-0040. Retrieved October 18, 2022, from https://oregon.public.law/rules/oar_860-022-0040
32. Oregon Department of Energy. (n.d.). *State of Oregon: Energy in Oregon—Public Purpose Charge*. Retrieved October 18, 2022, from https://www.oregon.gov/energy/energy-oregon/Pages/Public-Purpose-Charge.aspx
33. City of Eugene, Oregon. (n.d.). *Local Gas Tax*. Retrieved October 17, 2022, from https://www.eugene-or.gov/1085/Local-Gas-Tax
34. Goulder, R. (n.d.). *Three Reasons Why We Don't Need A Gas Tax Holiday*. Forbes. Retrieved October 17, 2022, from https://www.forbes.com/sites/taxnotes/2022/07/20/three-reasons-why-we-dont-need-a-gas-tax-holiday/
35. Oregon Department of Energy. (2020). *2020 Biennial Energy Report—Policy Brief: COVID-19 Response and Effects on the Energy Sector*. https://www.oregon.gov/energy/Data-and-Reports/Documents/2020-BER-Policy-Briefs.pdf#page=207
36. MacroTrends. (n.d.). *Brent Crude Oil Prices—10 Year Daily Chart*. Retrieved October 12, 2022, from https://www.macrotrends.net/2480/brent-crude-oil-prices-10-year-daily-chart
37. U.S. Energy Information Administration. (n.d.). *Weekly U.S. Regular All Formulations Retail Gasoline Prices (Dollars per Gallon)*. Retrieved October 13, 2022, from https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=EMM_EPMR_PTE_NUS_DPG&f=W
38. Group, S. L., Sinclair Broadcast. (2021, October 12). *Gas prices surge as pandemic's impact on global oil production lingers*. WPMI. https://mynbc15.com/news/nation-world/us-gas-prices-hit-seven-year-high-amid-surging-demand-scarce-supply
39. U.S. Energy Information Administration. (n.d.). *Where our oil comes from*. Retrieved October 13, 2022, from https://www.eia.gov/energyexplained/oil-and-petroleum-products/where-our-oil-comes-from.php
40. Reuters Staff. (2018, November 16). Natgas prices at Sumas Hub in Washington hit record high as weather cools. *Reuters*. https://www.reuters.com/article/enbridge-inc-natgas-pipeline-sumas-idUSL2N1XR0FN

41. Chediak, M., Sullivan, B. K., & Saul, J. (n.d.). *West Coast Heat Wave 2021: Portland, Seattle Post Hottest Temperatures Ever—Bloomberg*. Retrieved October 13, 2022, from https://www.bloomberg.com/news/articles/2021-06-28/heat-wave-intensifies-across-u-s-northwest-shattering-records
42. Center for Neighborhood Technology. (n.d.). *H+T Affordability Index*. Retrieved October 18, 2022, from http://htaindex.cnt.org/map/
43. U.S. Energy Information Administration (EIA). (2022). Petroleum & Other Liquids—Gasoline and Diesel Fuel Update. https://www.eia.gov/petroleum/gasdiesel/
44. Portland General Electric. (2022). Pricing Graphs—Schedule 83 Secondary Voltage. https://portlandgeneral.com/about/info/pricing-plans/market-based-pricing/pricing-graphs
45. Chapter 225—Municipal Utilities, Oregon Revised Statutes. https://www.oregonlegislature.gov/bills_laws/ors/ors262.html
46. Chapter 261—People's Utility Districts, Oregon Revised Statutes. https://www.oregonlegislature.gov/bills_laws/ors/ors262.html
47. Chapter 262—Joint Operating Agencies for Electric Power, Oregon Revised Statutes. https://www.oregonlegislature.gov/bills_laws/ors/ors262.html
48. American Public Power Association (APPA). (2018). How public power sets electricity rates. https://www.publicpower.org/periodical/article/how-public-power-sets-electricity-rates
49. Senate Bill 1547. (2016). 78th Legislative Assembly. https://olis.oregonlegislature.gov/liz/2016R1/Downloads/MeasureDocument/SB1547/Enrolled
50. Oregon Constitution, article IX, section 3a.
51. House Bill 2165. (2021). 81st Oregon Legislative Assembly. https://olis.oregonlegislature.gov/liz/2021R1/Downloads/MeasureDocument/HB2165/Enrolled
52. Macrotrends. (2022). Brent Crude Oil Prices—10 Year Daily Chart. https://www.macrotrends.net/2480/brent-crude-oil-prices-10-year-daily-chart

Energy 101: Oregon Fuel Action Plan

Learn more about how energy has contributed to Oregon's history on ODOE's interactive history timeline: ***energyinfo.oregon.gov/timeline***

The nationwide gasoline shortage of the early 1970s helped lead to the creation of the Oregon Department of Energy in 1975. At that time, ODOE began collaborating with the Federal Energy Administration,[1] other state energy offices, and the private sector to implement strategies to control traffic congestion and reduce panic buying at the pumps resulting from the supply shortages nationwide.

Originally, ODOE's fuel planning efforts focused on supply issues resulting from international geopolitics. Since the 1970s, the agency's fuel policies and procedures have evolved and adapted to the changing threats to the region's petroleum supply and distribution system. In 2017, ODOE developed an Oregon Fuel Action Plan,[2] which identifies strategies for addressing a variety of potential events that could trigger supply disruptions and distribution problems.

The U.S. Department of Energy is Born

For the three-year period between 1974 and 1977, the Federal Energy Administration implemented federal oil allocation and pricing regulations. An independent agency, the Federal Energy Administration was the successor of the Federal Energy Office, a short-term organization created to coordinate the government's response to the Arab oil embargo. By October 1977, when it became a part of the newly established U.S. Department of Energy, the Federal Energy Administration had also assumed the tasks of promoting energy conservation, collecting energy supply and demand information, managing the nation's strategic petroleum reserve, and promoting the development of new energy resources.

Threats to the Pacific Northwest's Fuel Infrastructure

The petroleum industry occasionally experiences supply and distribution problems, but in general is extremely resilient to short-term disruptions. A "just-in-time" business strategy – which means having the minimum amount of inventory available to meet demand – creates an efficient, but tight, supply chain under normal conditions.

Oregon's primary fuel terminals in Portland and Eugene are on a six-day refueling cycle, meaning the state has less than one week's supply of reserves on hand at any given time. Oregon faces additional challenges because all the refined petroleum products used in Oregon are imported from outside the state and any significant disruption to pipeline or refinery operations can quickly become problematic.

Oregon's Petroleum Supply and Distribution System

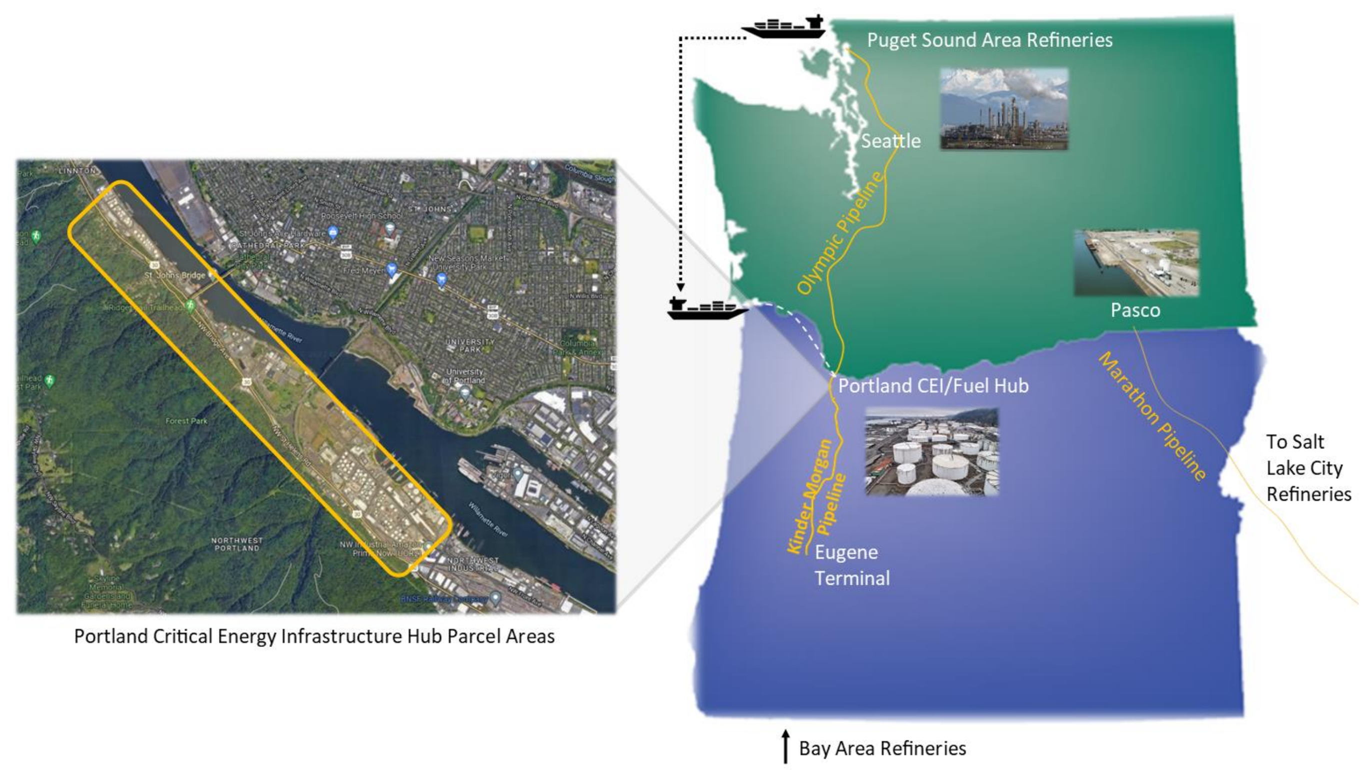
More than 90 percent of transportation fuels used in Oregon are produced in refineries in Washington and delivered via the Olympic pipeline and barge to seven Portland-area terminals. From these terminals, some of the product flows via pipeline south to Eugene, and via another pipeline to the Portland International Airport. The Eugene distribution terminal serves southern, central, and eastern Oregon. Tank barges also carry some refined petroleum up the Columbia River to Pasco, Washington to service eastern Oregon communities. Additionally, an estimated 1,500 tanker trucks deliver fuel from the Portland-area terminals to about 2,400 fueling locations throughout the state. [3]

Less than 10 percent of the refined petroleum products used in Oregon originate from refineries in Salt Lake City and the San Francisco Bay Area.[4] From Salt Lake City, the Marathon Pipeline transports product to a distribution terminal in Pasco, Washington. From the Pasco facility, trucks deliver fuel to eastern Oregon communities.

San Francisco Bay Area refineries supply small quantities of fuel to a Chico, California terminal from which trucks deliver supply to southern Oregon communities.

Learn more about where Oregon gets its petroleum fuels in our *2020 Biennial Energy Report.*

Figure 1: Map of Oregon and Washington Fuel Supply and Distribution System



Threats to the region's fuel infrastructure include natural hazards, intentional acts, equipment failures, and pandemics. Examples of natural hazards include earthquakes, winter storms, wildfires, heat waves, floods, and droughts. Cyberattacks, physical security breaches, mechanical breakdowns, terrorism, and war are examples of intentional acts. Pandemics like COVID-19 and H1N1 also pose risks to the critical workforce at refineries, terminals, pipelines, delivery companies, and retail fueling outlets. A workforce reduction could affect the fuel supply chain and distribution system. As the climate changes, many of these natural hazards are intensifying in frequency and magnitude, posing increased risks to energy systems.

The Pacific Northwest's greatest natural threat is a Cascadia Subduction Zone earthquake and tsunami. Seismic studies show a CSZ event would likely devastate the region's petroleum infrastructure. Widespread damage to refineries in the Puget Sound area of Washington, the Olympic Pipeline, and the Portland-area terminals is anticipated – shutting down the region's fuel infrastructure for weeks to months, if not longer.[5] Oregon can expect to lose most, if not all, of the fuel supply to the terminals due to earthquake damage.[6] The earthquake also has the potential to affect northern California and disrupt the small amount of fuel deliveries from Bay Area refineries to southern Oregon communities. Additionally, with damage to roads and bridges, it may be difficult to transport what supply Oregon does maintain to affected communities.

Fuel Planning Authority, Roles, and Responsibilities

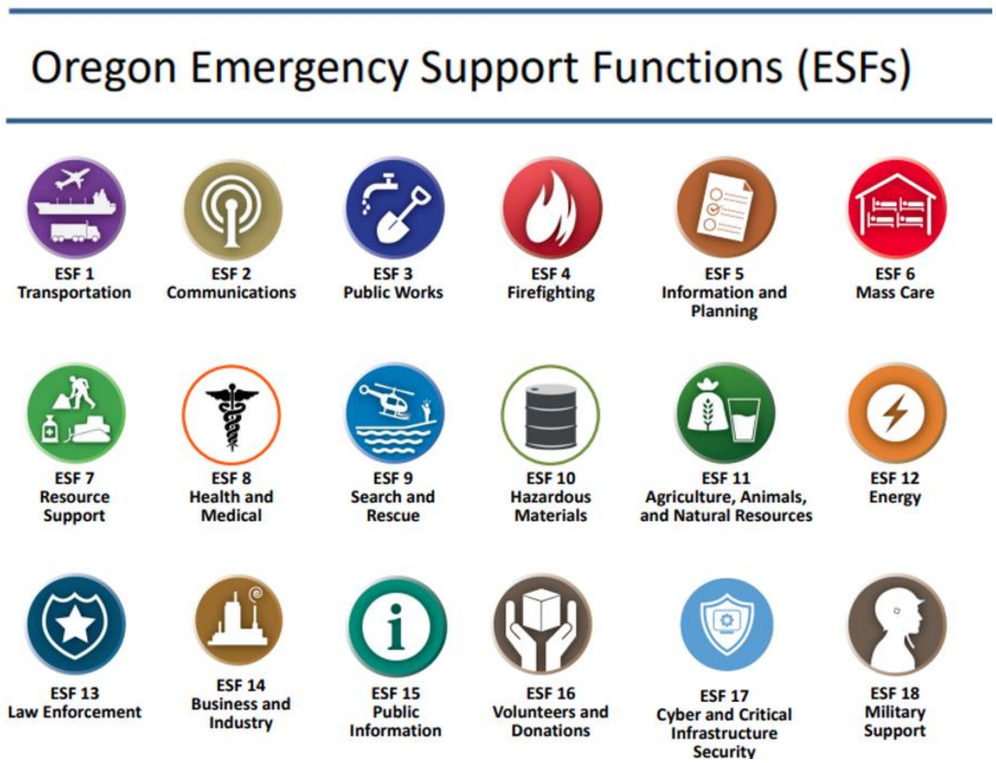
Oregon Revised Statute 401 grants the Governor broad authority to protect the public by declaring a State of Emergency when a disaster occurs.[7] ORS 401.188 provides additional powers to the Governor to control, restrict, or regulate the use, sale, or distribution of fuel and other commodities to support the state's response and recovery activities.[8]

The Oregon Department of Emergency Management (OEM) developed a coordinated response structure identifying 18 Emergency Support Functions or ESFs[9] that ensure if critical lifelines and services are disrupted, vital capabilities and resources can be provided by emergency response agencies. Oregon's ESF structure mirrors the federal framework and ESF 12 addresses the energy subsectors. At the federal level, the U.S. Department of Energy is the lead for ESF 12.

At the state level, OEM designated the Oregon Department of Energy and the Oregon Public Utility Commission as lead agencies for ESF 12.[10] ODOE is responsible for the petroleum, liquified natural gas, and radiological issues and the PUC has the lead for the electricity and natural gas sectors in planning for, responding to, and recovering from a disaster. ODOE works closely with the U.S. Department of Energy (USDOE) to ensure the federal ESF 12 plans integrate and align with state strategies in preparation for responding to and recovering from fuel disruptions affecting Oregon.

In the event of an emergency or natural disaster, the Oregon Department of Energy is responsible for the petroleum, liquified natural gas, and radiological issues.

Figure 2: Oregon's 18 Emergency Support Functions



ORS 176.750-785 authorizes ODOE to develop and maintain a statewide contingency plan and strategies to ensure that adequate fuel supplies are available to maintain emergency services, transportation systems, the economy, and public health and welfare while an emergency exists.

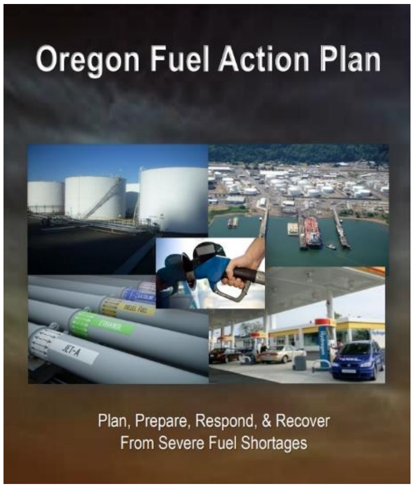
Oregon Fuel Action Plan

As the designated state lead for ESF 12 overseeing petroleum emergency preparedness, planning, response, and recovery, ODOE developed the Oregon Fuel Action Plan in 2017. The plan identifies priority actions the agency would take to direct the state's overall response to petroleum disruptions. This includes establishing scalable procedures for:

- Plan activation and notifications within ODOE and to external partners and key stakeholders.
- Monitoring and assessing the severity, scope, and other consequences of supply shortages and distribution problems.
- Federal, state, local, tribal, and petroleum industry collaboration and coordination in emergencies.
- Issuing voluntary and mandatory fuel conservation measures.
- Securing waivers to ensure timely fuel deliveries.

- Developing and disseminating fuel information and protective actions to the public and news media.
- Fuel allocation to emergency and essential services providers when supplies are limited.
- Designating distribution sites for receiving emergency fuel supplies.
- Coordinating and implementing regional response measures with western states if event conditions warrant joint state actions.

In the event of a CSZ earthquake, ODOE actions include working with federal agencies and the petroleum industry to create new temporary fuel supply chains into Oregon until the region's petroleum infrastructure is restored. ODOE would continue to collaborate with federal partners to identify new delivery systems into the affected communities following a Cascadia earthquake. This would include bringing fuel into staging areas in central Oregon, expected to be located at the Redmond and Klamath Falls airports, before moving the product into communities along the I-5 corridor when possible. Small amounts of fuel could also be transported by air, but these missions would be limited. To support coastal communities, fuel supplies could be delivered by tanker ships, as it is anticipated that roads and bridges will be severely damaged and coastal communities may be inaccessible via road.



The Oregon Fuel Action Plan was developed in coordination with federal, state, local, tribal, and petroleum industry partners. Each strategy and procedure identified by the plan can be scaled up or down as needed to address different levels of supply disruption severity.

Oregon Emergency Response Structure and ODOE Responsibilities for Fuel

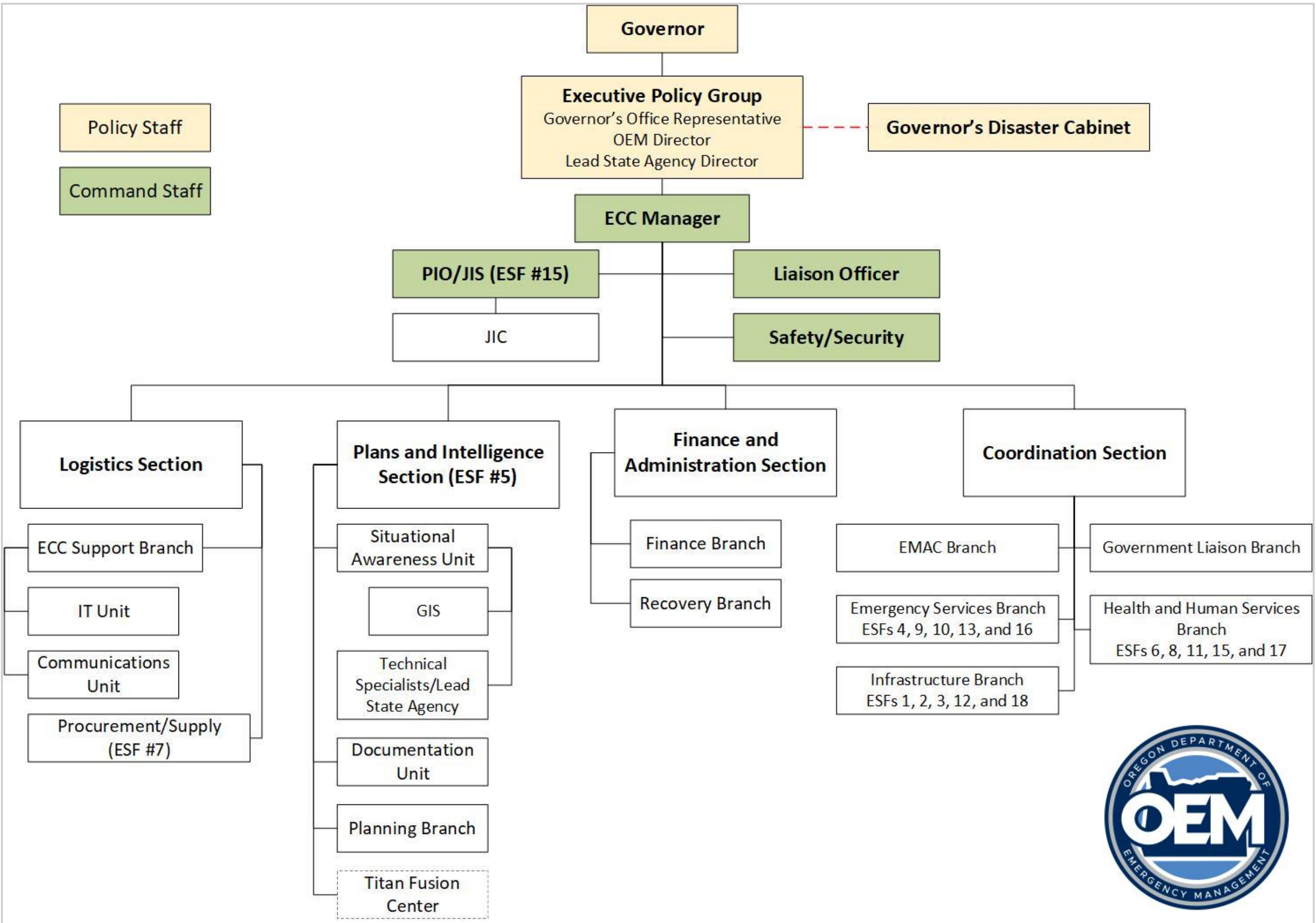
During state-declared emergencies, OEM may activate the State Emergency Coordination Center to direct and coordinate the state's overall response to an event. During State Emergency Coordination Center activations, ODOE and other state agencies with emergency response duties report to the State ECC virtually[i] or in person to support the state's overall response and recovery effort.

- ODOE's Director guides and advises state leadership on policy issues and concerns surrounding fuel disruptions. ODOE's Director reports to the Governor's Disaster Cabinet.[11]
- ODOE emergency preparedness staff works with petroleum industry partners to assess the severity of supply disruptions, determine risks to public health and safety, and identify solutions to mitigate supply and distribution concerns. ODOE emergency preparedness staff report to the ECC to coordinate with other ESF agencies to ensure interdependencies are addressed among all critical lifeline services.[12]

[i] The current plan has been updated with OEM to include virtual reporting since the onset of the COVID pandemic, but this is not currently reflected in the online plan.

- ODOE's Public Information Officers develop and disseminate emergency fuel information and protective action instructions and provides support to the state's Joint Information Center (JIC).[13]

Figure 3: Oregon State Emergency Response Structure



ODOE Response to Events

The Oregon Department of Energy has activated the Oregon Fuel Action Plan when the Governor issued state emergency declarations in response to events that affected the fuel supply and distribution system. Following are some recent examples:

2020 Wildland Fires. The Labor Day 2020 windstorm resulted in five simultaneous "megafires"– fires greater than 100,000 acres in size – in Oregon. These fires started September 7 - 8, 2020, and in a matter of days burned more than 1 million acres. While Oregon's fuel supply and distribution system was not directly impacted, there were limiting factors affecting fuel access. Fire suppression and utility crews responding to affected areas lacked fueling capabilities for their trucks within the response area. ODOE coordinated with fuel cardlock facilities to secure fuel cards for fire fighters and utility crews. Without ODOE's support, these first responders would have had to drive more than an hour away to fill their tanks before returning to continue critical life safety work. ODOE also coordinated a mission to reprogram fuel pumps in a fire-impacted area to ensure first responders could access fuel.

2021 Wildland Fires. Starting in June 2021, a sudden increase in commercial air travel as the COVID pandemic waned, coupled with an early wildfire season in late spring, resulted in jet fuel supply and distribution problems for smaller airports in southern and northeast Oregon to support wildland firefighting missions. While there was no shortage of jet fuel in Oregon, there were logistical challenges connecting available supplies with fuel haul trucks and drivers to get the much-needed fuel to those local airports where the demand for jet fuel exceeded local supplies. ODOE worked with state, local, and federal partners, as well as with the private sector, to ensure firefighters had the fuel they needed to continue to fight wildfires. This included establishing procedures in coordination with the Oregon Department of Forestry and the Oregon Department of Aviation for requesting and meeting fuel needs in future wildfire seasons.

2021 Winter Storm. In February 2021, the Governor declared a state of emergency after freezing rain and snow blanketed nine Oregon counties, causing treacherous conditions. Because roundtrip fuel deliveries from Portland to central Oregon and to some coastal communities average ten hours under normal conditions, ODOE coordinated with the Oregon Department of Transportation to secure an Hours-of-Service (HOS) waiver to allow fuel truck drivers to exceed the 11-hour limitation, if needed, to make timely deliveries without penalties. Oregon HOS laws limits drivers to 11 hours of drive time within a 14-hour window after 10 consecutive hours off-duty. ODOE also worked with suppliers and distributors to coordinate fuel deliveries to first responders and critical infrastructure facilities like water and wastewater treatment facilities for powering backup generators.

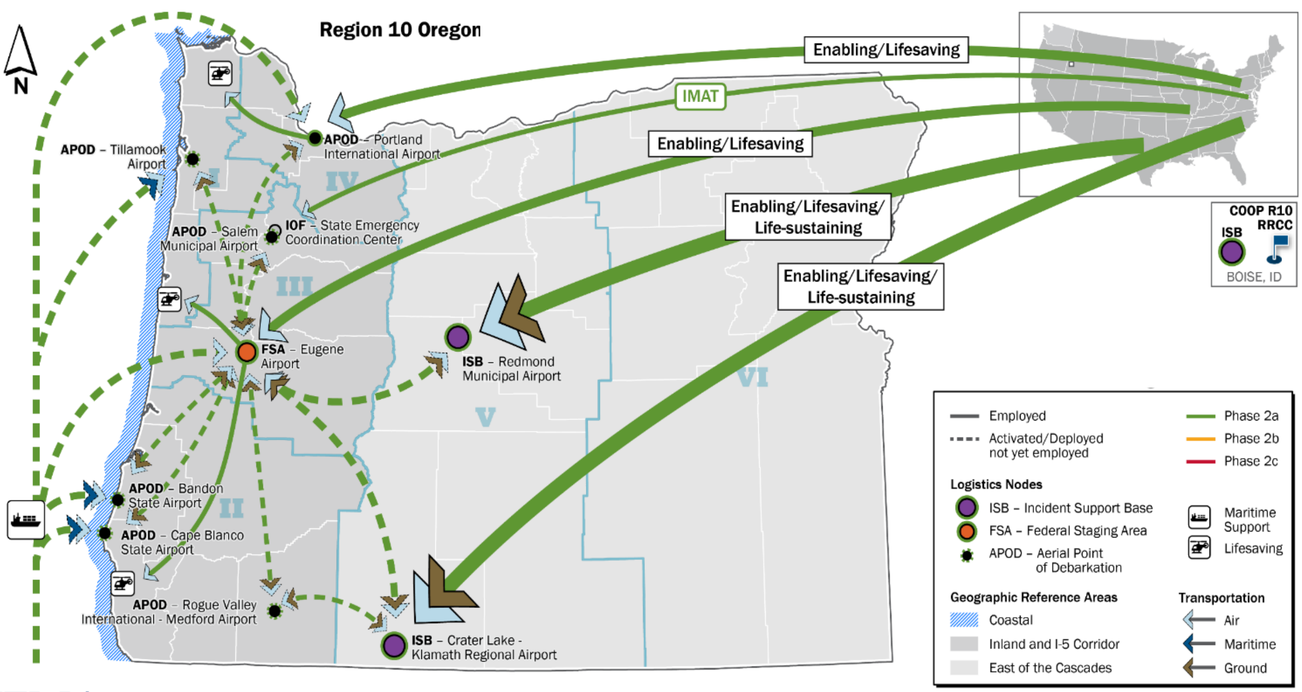
COVID-19 Pandemic. ODOE worked with the petroleum industry to assess personal protective equipment needs and was able to secure 14,000 masks and other PPE requests from FEMA for fuel terminal operators and gas station attendants. The reduction of travel caused by COVID resulted in a surplus of winter grade gasoline and diesel fuels, making it difficult for industry to meet the annual May 1 deadline to transition to summer grade fuels. At the request of industry, ODOE facilitated discussions with the Department of Environmental Quality, Department of Agriculture, and the City of Portland to lift the regulation that requires fuel distributors to change their blends of gasoline and diesel by that May 1 date. This allowed fuel companies more time to sell their remaining winter grade fuels before transitioning to summer grade fuels without penalty. ODOE also supported the Joint Information Center by developing public messaging about the temporary suspension of the self-serve gas ban to allow gas station owners the option to let customers pump their own gas. This allowed gas stations to continue operations with fewer staff. The Oregon Fuels Association reported that COVID caused a temporary 50 percent reduction in the state's gas station workforce due to illness, childcare issues, and safety concerns.

Ensuring Program Readiness

ODOE routinely participates in national, regional, state, and local level exercises to ensure program readiness. These training opportunities provide ODOE staff the ability to validate the Oregon Fuel Action Plan to ensure that strategies and procedures established remain current and relevant to address present threats to the petroleum sector. Exercises and tabletop drills also allow ODOE staff to maintain their response capabilities by working through the complexities involved in the establishment and coordination of an emergency fuel management system with key federal, state, local, and petroleum industry partners following a CSZ earthquake and tsunami.

In February 2022, for example, ODOE staff participated in FEMA's CSZ Supply Chain Logistics Management Tabletop.[14] In the three-day discussion-based exercise, ODOE staff increased its understanding of protocols for road clearing and reopening to support fuel movement into the affected communities, security measures needed to protect and support fuel distribution, and logistical requirements to establish fuel storage and distribution points. ODOE staff also discussed leveraging surviving private sector capabilities to support fuel missions. Figure 4 below demonstrates the proposed routes that would be used by FEMA to bring resources, including fuel, into Oregon in the event of a CSZ earthquake.

Figure 4: FEMA-Proposed Concept of Operations for Oregon – Cascadia Event



FEMA

As another example, ODOE staff took part in USDOE's Clear Path IX Fuels Tabletop in September 2021.[15] The purpose of the exercise was to improve the overall understanding of the federal resources and capabilities available to support fuel operations in Oregon and Washington in the aftermath of a CSZ event. ODOE staff validated federal protocols for states requesting fuel assets, identified lead federal agencies tasked to carry out specific fuel missions, and confirmed logistics coordination requirements for receiving fuel resources in Oregon post CSZ. The exercise also provided federal agencies an opportunity to understand ODOE expectations concerning fuel priorities and strategies in a major disaster.

ODOE staff also regularly participate in private sector training and emergency exercises. In October 2022, Kinder Morgan invited ODOE staff to join the company's Worst Case Disaster Exercise. The scenario involved a pipeline failure resulting in a spill of nearly 60,000 gallons of jet fuel into the Willamette River. As a result, the pipeline from the Kinder Morgan terminal to the Portland International Airport (PDX) would have been shut down for months. During the Exercise, ODOE worked with the company, PDX, Port of Portland, City of Portland, and the Oregon Department of Environmental Quality to address jet fuel supply disruptions that would have occurred at the airport.

All lessons learned from responding to actual emergencies, exercises, and training will be incorporated as appropriate in a forthcoming revision of the Oregon Fuel Action Plan.

Regional Coordination

With the increase in cyberattacks, extreme weather events, and the threat of a CSZ event and associated risks to the fuel infrastructure, regional coordination is increasingly important since fuel emergencies often have regional impacts crossing state lines. Oregon also relies exclusively on importing the finished petroleum product from refineries in other states.

Western States Petroleum Collaborative. In March 2020, the WSPC[ii] was created to facilitate the coordination and development of a regional fuel response framework with 11 state energy offices and emergency management agencies.[16] The western states recognized the need to work together and share resources to address regional petroleum shortage preparedness and response needs. This effort was built off the existing network of State Energy Emergency Assurance Coordinators originally established in 1996 to encourage information sharing in energy disruptions. The WSPC expands the coordination beyond information sharing to include coordinated response actions.

[ii] This group was originally named the Western Petroleum Shortage Response Collaborative, or WPSRC. The 11 participating states agreed to shorten the name and acronym to Western States Petroleum Collaborative, or WSPC.

Staff from ODOE and the Oregon Department of Emergency Management co-chaired the 18-month effort sponsored by the USDOE's Office of Cybersecurity, Energy Security, and Emergency Response (CESER), the National Association of State Energy Officials (NASEO), and the National Emergency Management Association (NEMA) to establish the framework for the WSPC beginning in March 2020. As co-chairs, ODOE and Oregon Emergency Management[iii] staff provided guidance and worked to ensure project goals and objectives reflected the need for regional coordination to manage fuel disruptions affecting multiple states.

The WSPC Framework was finalized in September 2021, with ODOE hosting and facilitating the initial WSPC quarterly meetings in 2021, Washington hosting the 2022 meetings, and California hosting in 2023. The meetings allow the 11 western states to collaborate on fuel planning, preparedness, response, and resilience efforts during non-emergency conditions. During emergencies, any state could activate the WSPC to share information, provide situational awareness, or to discuss implementation of regional measures if needed in response to the fuel situation in two or more states. USDOE, NASEO, and NEMA participate and support the WSPC as needed.

NASEO Energy Security Committee. ODOE staff also participates in NASEO's monthly Energy Security Committee virtual meetings to discuss, learn, and collaborate in the areas of energy data and analysis, intra-state and inter-state communications and training, and public-private sector coordination. The committee collaborates with relevant federal partners and industry stakeholders to promote the roles, responsibilities, and capabilities of State Energy Offices to manage comprehensive energy sector security.

Energy Security Planning

In November 2021, the Infrastructure Investment and Jobs Act was enacted, authorizing USDOE to provide financial and technical assistance for state energy offices to develop what is now called a State Energy Security Plan. State Energy Security Plans must include an assessment of potential hazards to all energy sectors and cross-sector interdependencies as well as proposed methods to strengthen the state's ability to have reliable, secure, and resilient energy infrastructure.[17] The federal law also requires states to engage in regional coordination and provide an annual letter of certification from the Governor to USDOE to ensure a state's State Energy Security Plan complies with federal requirements. ODOE staff will lead and coordinate the development of Oregon's Energy Security Plan.

Likewise, Oregon legislators passed a bill in the 2022 session with similar energy security provisions.[18] SB 1567 directs ODOE to develop an Energy Security Plan that evaluates the state's ability to recover quickly from natural disasters and intentional acts, including cyber risks, to Oregon's energy systems overall. This includes assessments of the state's electricity network, natural gas system, and liquid fuels. SB 1567 also directs ODOE to evaluate strategies to increase fuel storage capacity throughout the state to provide a safety net for local communities following major disasters. ODOE's ongoing planning with federal agencies shows that the greatest challenge following a CSZ event will be the widespread damage to the state's transportation systems, which will limit the ability to deliver fuel to

[iii] On July 1, 2022, the Oregon Office of Emergency Management became the Oregon Department of Emergency Management.

affected communities in western Oregon. It could take weeks to deliver fuel to some communities due to the lack of access, and will likely take longer in the more remote areas of the state.

Developing the plan will be a major effort for ODOE and require close coordination with key state agencies, local governments, tribal governments, Environmental Justice Council, and the public. ODOE will also consult with private-sector partners in the petroleum industry, electric and natural gas utilities, and other qualified technical experts in disaster resilience. ODOE expects that developing the Energy Security Plan will take about 18 months. SB 1567 requires ODOE to complete the plan by June 2024.

REFERENCES

[1] U.S. Department of Energy, Office of Management, Office of the Executive Secretariat, and Office of History and Heritage Resources. *"The Federal Energy Administration".* (November 1980) https://www.energy.gov/sites/prod/files/FEA%20History.pdf (Page 1)

[2] Oregon Department of Energy. *"Oregon Fuel Action Plan".* (2017). Accessed March 11, 2022 from Oregon-Fuel-Action-Plan.pdf

[3] Oregon Department of Energy. *"Oregon Fuel Action Plan".* (2017). Accessed March 11, 2022 from Oregon-Fuel-Action-Plan.pdf (Page 9-10)

[4] Oregon Department of Energy. *"Oregon Fuel Action Plan".* (2017). Accessed March 11, 2022 from Oregon-Fuel-Action-Plan.pdf (Page 9)

[5] Oregon Seismic Safety Policy Advisory Commission. "CEI Hub Mitigation Strategies: Increasing Fuel Resilience to Survive Cascadia (2019) https://www.oregon.gov/oem/Documents/OSSPAC_CEI-Hub_report_122019.pdf (Page 5)

[6] Oregon Seismic Safety Policy Advisory Commission. "CEI Hub Mitigation Strategies: Increasing Fuel Resilience to Survive Cascadia (2019) https://www.oregon.gov/oem/Documents/OSSPAC_CEI-Hub_report_122019.pdf (Page 5)

[7] Oregon Emergency Management. *"State of Oregon Emergency Management Plan".* (2017). Accessed March 11, 2022 from https://www.oregon.gov/oem/Documents/OR_EOP_Basic_Plan.pdf (Page 44)

[8] Oregon Revised Statutes. "ORS 401.188 Management of Resources During Emergency Rules". Accessed March 11, 20222 from https://oregon.public.law/statutes/ors_401.188

[9] Oregon Emergency Management. "Oregon State Emergency Support Function (ESF) Quicksheets". Accessed March 11, 2022 from https://www.oregon.gov/OEM/Documents/Oregon_ESF_Descriptions_One_Page_Job_Aid.pdf

[10] Oregon Emergency Management. "Oregon State Emergency Support Function (ESF) Quicksheets". Accessed March 11, 2022 from https://www.oregon.gov/OEM/Documents/Oregon_ESF_Descriptions_One_Page_Job_Aid.pdf

[11] Office of the Governor. "State of Oregon Continuity of Government Executive Branch". (June 2022) Document for Officials Use Only on file at ODOE.

[12] Oregon Emergency Management. "ESF 12 – Energy". (2016) Accessed June 16, 2022 from https://www.oregon.gov/oem/Documents/2015_OR_EOP_ESF_12_energy.pdf (Page 5 and 10)

[13] Oregon Emergency Management. "ESF 12 – Energy". (2016) Accessed June 16, 2022 from https://www.oregon.gov/oem/Documents/2015_OR_EOP_ESF_12_energy.pdf (Page 5 and 10)

[14] Federal Emergency Management Agency. "LMD/Region X Cascadia Subduction Zone Earthquake and Tsunami Tabletop Situation Manual". (February 2022) Situation Manual on file at ODOE.

[15] U.S. Department of Energy. "Clear Path IX Exercise Series After Action Report". (June-September 2021). Accessed March 11, 2022 from https://www.energy.gov/sites/default/files/2022-01/Clear%20Path%20IX%20Series%20AAR%20%282021-12-14%29%20Public_508.pdf

[16] National Association of State Energy Officials. "Regional Petroleum Shortage Response Collaborative Regional Framework" for Western States. (2021). Accessed March 11, 2022 from https://www.naseo.org/data/sites/1/documents/publications/Western%20Petroleum%20Shortage%20Response%20Collaborative%20Regional%20Framework_FINAL_09302021.pdf

[17] 117th Congress. *"Enhancing State Energy Security Planning and Emergency Preparedness Act of 2021".* Accessed March 11, 2022 from Text - H.R.3684 - 117th Congress (2021-2022): Infrastructure Investment and Jobs Act | Congress.gov | Library of Congress

[18] Oregon State Legislature. *"Enrolled Senate Bill 1567"*. (2022) Accessed March 11, 2022 from https://olis.oregonlegislature.gov/liz/2022R1/Downloads/MeasureDocument/SB1567/Enrolled

Energy 101: Backup Power

Backup power systems provide emergency onsite energy generation in the event of a power outage. These systems use generators or battery storage to provide emergency backup power. Fossil fuel generators have traditionally been used for industrial or institutional uses, such as at hospitals, as well as for residences. These systems may use diesel, gasoline, propane, or natural gas to generate onsite electricity. Recently, however, technology advancements and price reductions have increased the use of solar energy systems paired with battery storage to provide backup power in residential and small commercial applications. Solar plus storage systems may also be installed with conventional fossil fuel generators to extend run times and improve system performance. Regardless of the type of system used for backup power, energy efficiency measures and careful operations are necessary to reduce loads and ensure maximum system benefits.

The Oregon Department of Energy office in Salem has a 300-gallon diesel backup generator that can provide power to critical agency equipment for about 24 hours in the event of an outage or emergency.

Most of the backup power systems serving commercial and industrial loads are diesel-fueled generators. There are no recent studies analyzing backup generators in Oregon, but a 2021 study conducted in California found that nearly 90 percent of existing commercial and industrial backup generators are fueled with diesel, 6 percent from natural gas, and the remainder from other fuels, such as propane.[1] Permits for new backup generators also indicate a strong preference for diesel-fueled systems. In Crook County, Oregon, the Apple and Facebook data centers together hold permits to operate 222 diesel generators totaling more than 600 MW of capacity.[2] The 2021 California study found that 84 percent of backup power generators permitted since April 2020 are diesel-fueled.

Battery storage paired with onsite renewable energy systems is an emerging backup power technology in Oregon. These systems typically use rooftop solar to charge wall-mounted battery storage packs. Solar plus storage systems can be continuously recharged without the need to store or procure fuel during a natural disaster but must be sized appropriately and rely on variable solar resources for recharging. In Oregon, battery storage systems are becoming more commonly used in residential applications; on a larger scale, solar plus storage systems may be used to power microgrids, providing power to critical infrastructure and making Oregon communities more resilient. However, there are limitations to the amount of power that can be generated and stored with onsite solar-plus-battery storage systems. For providing backup power to larger systems, and

This residential battery storage system stores energy generated by rooftop solar panels.

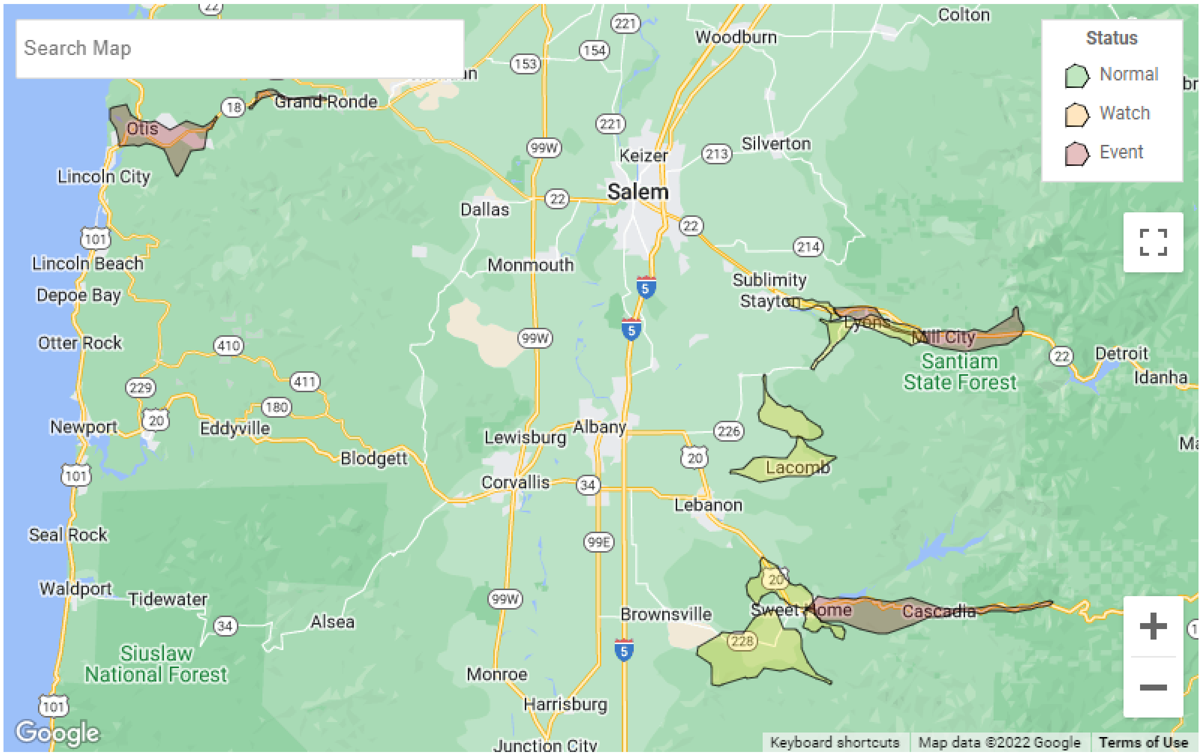
for many other applications, solar plus storage systems are still more expensive than fossil fuel-based generators and may be seen as cost prohibitive for some consumers.

Function and Importance

Escalating frequency and severity of extreme weather events may increase interest in backup power systems. For example, the catastrophic Oregon wildfires of 2020 and their corresponding widespread power outages showed how changes in the climate may increase the need for backup power. Wildfire risk to grid infrastructure may result in utilities implementing proactive Public Safety Power Shutoffs, or other protective measures to ensure public safety. In California, these shutoffs have increased demand for backup power — the 2021 California study found that total capacity of backup generators increased by 34 percent from December 2018 to 2021.[1]

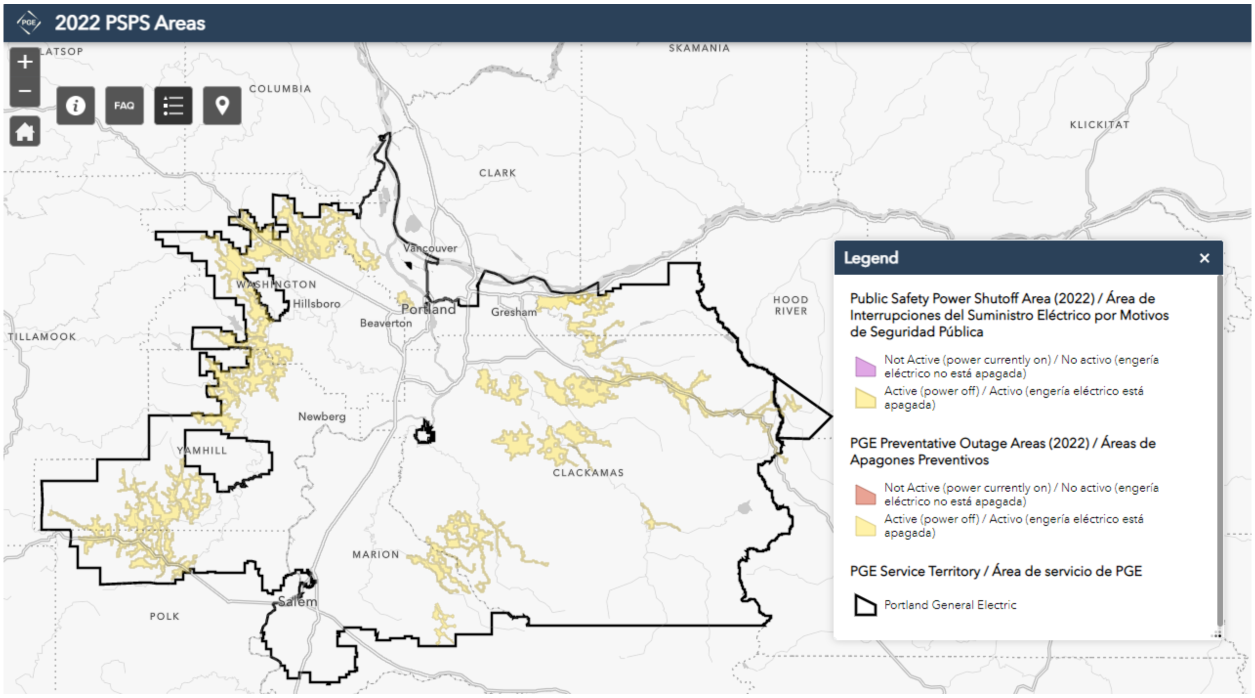
In May 2022, the Oregon Public Utility Commission adopted rules establishing protocols for Public Safety Power Shutoffs (PSPS) for Oregon utilities.[3] Pacific Power and Portland General Electric maintain web pages where customers can get up-to-date information regarding potential power shutoffs. On September 9, 2022, Portland General Electric and Pacific Power initiated Public Safety Power Shutoffs to mitigate the risk of wildfire during an extreme fire hazard weather event. The shutoffs affected over 40,000 customers.[4] Figures 3 and 4 below indicate some of areas affected by the shutoffs. The maps published by PGE and Pacific Power are updated throughout the wildfire season.

Figure 3: Areas affected by the Public Safety Power Shutoff implemented by Pacific Power to mitigate wildfire risk during an extreme fire hazard weather event on September 9, 2022.[5]



Power was cut off to the areas tinted red.

Figure 4: Areas affected by the Public Safety Power Shutoff implemented by Portland General Electric to mitigate wildfire risk during an extreme fire hazard weather event on September 9, 2022.[6]



Power was cut off to the areas tinted yellow.

Critical Facilities

Some facilities and building systems are required by Oregon Building Codes to have backup power to ensure public safety. For example, facilities where interruption of the primary power could result in loss of human life or serious injuries, such as hospitals, are required to have emergency backup generators. Facilities that are not required to have backup generators may still be required to have emergency power systems on some building systems, such as exit lighting and smoke detectors. The 2019 Oregon Structural Specialty code defines emergency power systems as "a source of automatic electric power of a required capacity and duration to operate required life safety, fire alarm, detection and ventilation systems in the event of a failure of the primary power."[7]

Limitations

Limitations of Diesel Generators

Fuel Storage. During a natural disaster, fossil fuel generators are likely to be limited by the amount of fuel that is stored on site. A Cascadia subduction zone earthquake is expected to devastate Oregon petroleum supplies and distribution.[8] As a result, many facilities across the state may be limited to the fuel stored on site with refueling postponed weeks or months following a natural disaster.

Backup fuel storage requirements are set forth in Oregon Building Codes for critical facilities. The Oregon Structural Specialty Code references NFPA Standard 110 published by the National Fire Protection Association.[9] Fuel storage requirements vary depending on facility type and local seismic classifications. For example, a hospital in a high seismic risk area may be required to store fuel for up to 96 hours of generator operation with storage tanks sized at 133 percent of expected full load fuel consumption.

The fuel consumption rate of fossil fuel generators depends on the generator size and to a lesser extent the electrical load being served. For example, a 400-kW diesel generator operating at 25 percent load will consume about 7.9 gallons of fuel per hour and operate at a fuel conversion efficiency of 31 percent. The same generator operating at 100 percent load will consume 24.2 gallons per hour and operate at a fuel conversion efficiency of 41 percent.[10] Under full load conditions, the 400 kW generator would need about 3,000 gallons of on-site fuel to meet the 96-hour run time requirement in Oregon Code.

Diesel generators and fuel storage tanks. Photo: Portland General Electric

Maintenance. NFPA-110 also describes requirements for maintenance and operations of fossil fuel generators.[9] Facility operators are required to do weekly inspections of the generators and conduct monthly operational testing. Operation tests must be conducted under full load for a period of at least 30 minutes. Liquid fuels that are stored on site must remain within manufacturers specifications. For example, NFPA 110 requires that diesel fuel must undergo regular testing if stored for more than 12 months.

Even with routine maintenance and inspections, diesel generators are prone to mechanical failures during an emergency. During Hurricane Sandy in 2012, generators failed at several hospitals in New York and New Jersey.[11] More recently, in 2021, a backup generator at Thibodaux Hospital in New Orleans failed during Hurricane Ida, requiring Intensive Care Unit patients to be moved.[12] The causes of diesel generator failures have included equipment flooded in basements, failed switchgear, overheating, and fuel shortages.[11]

Limitations of Solar Plus Storage

Size. Solar plus storage systems have significant limitations for use as stand-alone backup power systems —especially in facilities with high electrical loads like hospitals. For example, the 400-kW diesel generator described above was assumed to run for 96 hours at full load and consume 3,000 gallons of fuel. This run-time represents 38.4 MWh of electricity provided to the site over four days, or 9.6 MWh of energy per day. If this system were located in Portland, and the backup power were required in December, it would take about 8 MW of solar PV to provide a similar amount of daily energy. Eight MW of solar with battery storage would require about 50 acres of space and be cost prohibitive as a backup power system. Solar plus storage systems may be used to supplement large facility backup operations as described for large hybrid systems below.

Opportunities

Residential and Small Commercial

While solar plus storage systems may not be viable for large facilities with limited space, there is an opportunity to use them in residential and small commercial applications. Systems may be configured to power limited essential loads or, in off-grid applications, serve as the sole power source in a home. Many systems are designed to operate indefinitely during a power outage, utilizing daytime solar to recharge the battery packs. Discharge rates will depend upon the loads being served in the home (additional information regarding battery storage systems can be found in the *Electricity Storage* Energy Resource and Technologies Review section of this report). Rooftop solar tied to wall-mounted battery packs are now in use in hundreds of homes in Oregon. The Oregon Solar Plus Storage Rebate program has supported installation of these systems in more than 200 Oregon homes including 23 systems for low- and moderate-income residents.

Table 1: Oregon Solar + Storage Rebate Program – Storage Overview as of September 2022

Number of battery storage systems installed	217
Average cost of batteries	$20,853
Average size	11.2 kWh
Number of projects in low-income homes	23
Number of projects for low-income service providers	0

Critical Facilities with Moderate Loads

On-site solar and storage systems can be used to power critical facilities to increase the energy resilience of Oregon communities. There are now several examples in Oregon of local on-site solar and battery storage systems that can power critical community services such as emergency shelters, potable water delivery and first responder communications, in the event of a prolonged power outage. The Beaverton Public Safety Center uses battery storage to ensure emergency services are available in the community in the event of a natural disaster.[13] Similarly, the Eugene Water & Electric Board developed the Grid Edge Demonstration project, which uses solar and battery storage to power a microgrid, including a potable water fill station and emergency shelter.[14]

Large Hybrid Systems

There are also opportunities to use solar plus storage systems in conjunction with diesel generators to improve system performance. These hybrid systems use solar and/or batteries to improve system performance and extend fuel supplies. Consider the 400-kW diesel generator described in the limitations section above. The generator has an efficiency (kWh per gallon of fuel) of only 31 percent when operated at one-quarter load compared to 41 percent at full load. Lower load ratios would result in even lower operational efficiencies (taking more fuel to create a kWh of electricity). Building systems do not operate at a steady state; building systems cycle on and off, resulting in changing electrical loads. Batteries have the advantage of being able to track building loads instantaneously with no reduction in efficiency. In a hybrid system, the batteries can be configured to serve building loads to minimize run time of the fossil fuel generator. If the generator is needed, it can be run at full capacity, and therefore maximum efficiency, for as long as necessary to charge the batteries. These systems can be further optimized by ensuring energy efficiency measures are in place to reduce loads to extend backup power capabilities.

Additional Benefits

Backup power systems can provide value to Oregon utilities during day-to-day utility operations. For example, Portland General Electric operates a Dispatchable Standby Generation program that enables utility operation of customer-owned generators during emergency conditions, such as unplanned loss of generation.[15] In this program, output from the generators is used to provide emergency support to the electric grid. The owners of the generators receive maintenance, fuel, and equipment upgrades from PGE in exchange for the option to call upon the resources should the grid need them. PGE and ratepayers benefit from 135 MW of dispatchable generation, deferring the need to build new generation resources to deliver replacement power when critical grid issues arise.

Solar and battery storage systems can also support utility operations. In addition to supporting the community in the event of a natural disaster, the Beaverton Public Safety Center's solar and storage system also supports day-to-day grid operations.[13] Similarly, Portland General Electric and Pacific Power are both piloting battery storage programs where distributed batteries can be aggregated and operated by the utility.[16] [17] These distributed storage systems will reduce the need to run fossil fuel power plants and will support Oregon's clean energy transition.

Electric Vehicles and Backup Power

Electric vehicles are an emerging potential source of residential backup power. In 2022, Ford released the F-150 Lighting, an electric pickup truck that provides automatic backup power in the event of a power outage. The base model includes a 98 kWh battery pack, and the extended range model a 131 kWh battery.[18] Ford estimates that the extended range option could provide up to 10 days of backup power to a residence, and touts this benefit in one of its TV commercials. Ford has partnered with the solar company SunRun to provide integrated solar charging systems for the Lightning and is developing a home integration system.[19]

Ford F-150 Lighting Pro.[20]

Electric vehicles are unique in that they may serve as a standalone backup power system at a residence or serve as mobile power units in the event of an emergency. In 2018, Nissan launched the Blue Switch program in Japan. The program creates partnerships between Nissan and local government or commercial partners to leverage fleets of Nissan LEAFs as mobile power units.[21] In the event of an earthquake or other natural disaster, the fleets of vehicles are deployed as versatile power packs to assist recovery efforts. Nissan reports that the 62 kWh battery in a Nissan LEAF can power an average Japanese home for four days, charge more than 6,000 phones, or provide power to an elevator to conduct 100 round trips in a 43-story apartment building.[22] Closer to home, Snohomish County Public Utility District in Washington has completed the Arlington Microgrid Project, which includes an electric vehicle fleet that can be used to power the facilities in the event of a power outage.[23]

While some electric vehicles can provide backup power during a natural disaster, they also represent a potential source of emergency transportation during periods of constrained liquid fuel resources. It is expected that a Cascadia Subduction Zone earthquake would devastate Oregon petroleum supplies and distribution, as well as Oregon's power grid. Even if some roads and bridges are damaged, electric vehicles tied to solar charging systems could provide critical local transportation options during disaster recovery. The table below demonstrates the potential for a 10-kWdc solar PV system to charge an electric vehicle in three climate zones: Astoria, Portland, and Bend. A 10-kW solar PV system would require about 600 square feet of roof space.

Table 2: A 10-kWdc Solar PV System Charging an Electric Vehicle in Three Oregon Location

Oregon Location	Avg Daily PV Output December (kWh)[1]	EV Miles[2]	Avg Daily PV Output July (kWh)	EV Miles
Astoria	13	42	43	144
Portland	12	39	50	165
Bend	22	73	55	183

As seen in Table 2, an electric vehicle in Portland could be expected to get about 39 miles of range from an average single day of charging with a 10 kWdc PV system in December. The 10 kWdc system size is arbitrary and values can be scaled up or down for larger or smaller PV system sizes. In a disaster recovery scenario, an electric vehicle fleet would likely need to alternate days of operation and days of solar charging to ensure that some vehicles are always available for use.

Policy Considerations

The increased frequency and severity of natural hazards (e.g., wildfires, flooding, ice storms, etc.) and society's reliance on reliable and resilient electric service have resulted in public policies supporting community energy resilience. Federal, state, and local governments are likely to implement policies to support backup power systems to improve community energy resilience and deliver critical services during and following disruptive events. The Oregon Department of Energy will continue to work with

[1] Average kWh per day values are from the PVWatts Calculator developed by the National Renewable Energy Laboratory.[24] Output is based on a 10kWdc system, facing south, at a fixed 30-degree slope. The table also assumes 14 percent system losses, which is the default value in PV watts for a PV system utilizing a DC to AC inverter. Electric vehicle charging systems may be configured with direct DC charging that could improve system efficiency.

[2] EV miles are calculated at 3.3 miles per kWh of battery use in an electric vehicle. This value is typical of the Nissan LEAF and Chevrolet Bolt, which are both used in the State of Oregon motor pool.[25]

the Oregon Legislature and regional stakeholders to support adoption of backup power systems and statewide energy resilience planning.

In March 2022, ODOE launched the $50 million Community Renewable Energy Grant program to provide funding for community renewable energy resilience projects across the state. Grants of up to $100,000 are available for planning projects and up to $1,000,000 for construction projects. Priority is given to projects that support community energy resilience and that serve rural and traditionally underserved communities. Grants are available outside a city with a population of 500,000 or more (Portland), regardless of utility service territory.[26] Thirty-five applications for energy resilience projects, representing communities across Oregon, were successfully submitted in the first round of funding, which closed on July 10. Additional rounds of funding will follow in the fall of 2022 and in 2023.

REFERENCES

1. M3. (2021). Diesel Back-Up Generator Population Grows Rapidly in the Bay Area and Southern California. https://www.bloomenergy.com/wp-content/uploads/diesel-back-up-generator-population-grows-rapidly.pdf
2. Oregon DEQ. (2022, July 1). Oregon Department of Environmental Quality Diesel Generator Permit Data [Personal communication].
3. State of Oregon: Public Utility Commission of Oregon Docket AR 638. (n.d.). Retrieved June 13, 2022, from https://apps.puc.state.or.us/edockets/DocketNoLayout.asp?DocketID=22341
4. Oregonian/OregonLive, D. P. | T. (2022, September 9). PGE, Pacific Power begin shutting off power in Oregon communities as winds worsen fire danger. Oregonlive. https://www.oregonlive.com/wildfires/2022/09/pge-pacific-power-begin-shutting-off-power-in-oregon-communities-as-winds-worsen-fire-danger.html
5. Public Safety Power Shutoff. (n.d.). Retrieved June 13, 2022, from https://www.pacificpower.net/outages-safety/wildfire-safety/public-safety-power-shutoff.html
6. PGE Wildfire Outages & PSPS (Public Safety Power Shutoffs) | PGE. (n.d.). Retrieved July 7, 2022, from https://portlandgeneral.com/outages-safety/wildfire-outages
7. 2019 Oregon Structural Specialty Code Chapter 4. (n.d.). UpCodes. Retrieved June 13, 2022, from https://up.codes/viewer/oregon/ibc-2018
8. Oregon Department of Energy. (2017). Oregon Fuel Action Plan. https://www.oregon.gov/energy/safety-resiliency/Documents/Oregon-Fuel-Action-Plan.pdf
9. NFPA 110: Standard for Emergency and Standby Power Systems, Chapter 8. (n.d.). Retrieved June 13, 2022, from https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=110
10. Cummins Power Generation Inc. (2022). Cummins C400D6 Data Sheet. https://www.tgcgeneratorwarehouse.com/wp-content/uploads/2015/12/C400D6-60Hz-June-2019.pdf
11. Ornstein, C. (n.d.). Why Do Hospital Generators Keep Failing? ProPublica. Retrieved June 13, 2022, from https://www.propublica.org/article/why-do-hospitals-generators-keep-failing
12. writers, E. W. A. A. G. | S. (n.d.). Generator failure during Hurricane Ida at Thibodaux hospital prompts scramble to move ICU patients. NOLA.Com. Retrieved June 13, 2022, from https://www.nola.com/news/hurricane/article_5f268aaa-0912-11ec-a8fb-d3a108e9db9f.html

13. City of Beaverton and PGE announce community-resiliency collaboration at new Public Safety Center. (n.d.). Retrieved June 13, 2022, from https://portlandgeneral.com/news/2019-09-11-city-of-beaverton-and-pge-announce-community-resiliency
14. NEC finishes microgrid project in Eugene, Oregon. (2019, May 14). POWERGRID International. https://www.power-grid.com/der-grid-edge/nec-finishes-microgrid-project-in-eugene-oregon/
15. Dispatchable Standby Generators. (n.d.). Retrieved June 13, 2022, from https://portlandgeneral.com/save-money/save-money-business/dispatchable-standby-generators
16. Smart Battery Pilot. (n.d.). Retrieved June 13, 2022, from https://portlandgeneral.com/about/who-we-are/innovative-energy/smart-battery-pilot
17. Community resiliency programs. (n.d.). Retrieved June 13, 2022, from https://www.pacificpower.net/community/community-resiliency.html
18. F150 Lightning Livestream (12/16) – Q&A, Specs & Infographics. (n.d.). ⚡ F-150 Lightning Forum For Owners, News, Discussions. Retrieved June 13, 2022, from https://www.f150lightningforum.com/forum/threads/f150-lightning-livestream-12-16-%E2%80%93-q-a-specs-infographics.7503/
19. 2022 Ford F-150 Lightning™ | Onboard Generator with Intelligent Backup Power. (n.d.). Ford Motor Company. Retrieved June 13, 2022, from https://www.ford.com/trucks/f150/f150-lightning/2022/features/intelligent-backup-power/
20. 2022 Ford F-150® Lightning™ Pro Electric Truck | Model Details & Specs. (n.d.). Ford Motor Company. Retrieved August 23, 2022, from https://www.ford.com/trucks/f150/f150-lightning/2022/models/f150-pro/
21. Nissan and 4R Energy win award for efforts to boost resilience with EVs. (n.d.). Retrieved June 13, 2022, from https://global.nissannews.com/en/releases/release-a665e4ef396b6f8166dc5bb2ca01c1a3-200317-00-e
22. How electric vehicles can help communities bounce back after a disaster. (2019, September 20). How Electric Vehicles Can Help Communities Bounce Back after a Disaster. https://global.nissanstories.com/en/releases/how-electric-vehicles-can-help-communities-bounce-back-after-a-disaster
23. Arlington Microgrid Project. (n.d.). Snohomish County PUD. Retrieved August 23, 2022, from https://www.snopud.com/community-environment/our-energy-future/projects/arlington-microgrid-project/
24. PVWatts Calculator. (n.d.). Retrieved June 13, 2022, from https://pvwatts.nrel.gov/
25. Compare Side-by-Side. (n.d.). Retrieved June 13, 2022, from https://www.fueleconomy.gov/feg/Find.do?action=sbs&id=43665&id=43663
26. State of Oregon: INCENTIVES - Community Renewable Energy Grant Program. (n.d.). Retrieved July 7, 2022, from https://www.oregon.gov/energy/Incentives/Pages/CREP.aspx

Energy 101: Radioactive Waste in Oregon

Oregon has contended with radioactive waste as part of its history since World War II. In the 1970s, Oregon first developed laws, rules, and programs to prohibit the disposal of radioactive waste within the state. Oregon has long had a presence in the cleanup of former uranium mining residuals in Southern Oregon and of radioactive and chemically hazardous waste at the Hanford Nuclear Site. Located along the Columbia River in southeast Washington, Hanford is one of the largest nuclear waste cleanup sites in the world.[1]

Radioactive waste includes more than spent nuclear fuel (non-useful remnants of nuclear power plant fuel[2]) or other waste products from nuclear power plants. Virtually all materials contain some radioactivity, so it is necessary to define the level of radioactivity in waste that constitutes an unacceptable health risk to the public or the environment.

Naturally occurring radioactive materials (NORM) are everywhere, for example: fertilizer material production facility,[3] waste material from natural gas fracking,[4] pipe scale buildup,[4] and bananas, bricks, and granite countertops can all have low levels of radioactive materials. [5] [6]

The Oregon Department of Energy's Nuclear Safety and Emergency Preparedness Division, serving as staff to the Energy Facility Siting Council, is responsible for determining whether a waste material meets the state-specific definition of "radioactive waste" consistent with the rules contained in OAR 345-050. These rules are intended to help identify materials that could be disposed of or are exempt from the rule, such as slightly radioactive materials that present minimal health hazards.

This section describes the history of radioactive waste management in Oregon, the present-day challenges associated with managing radioactive waste and Oregon's role, and a look ahead to potential future management challenges.

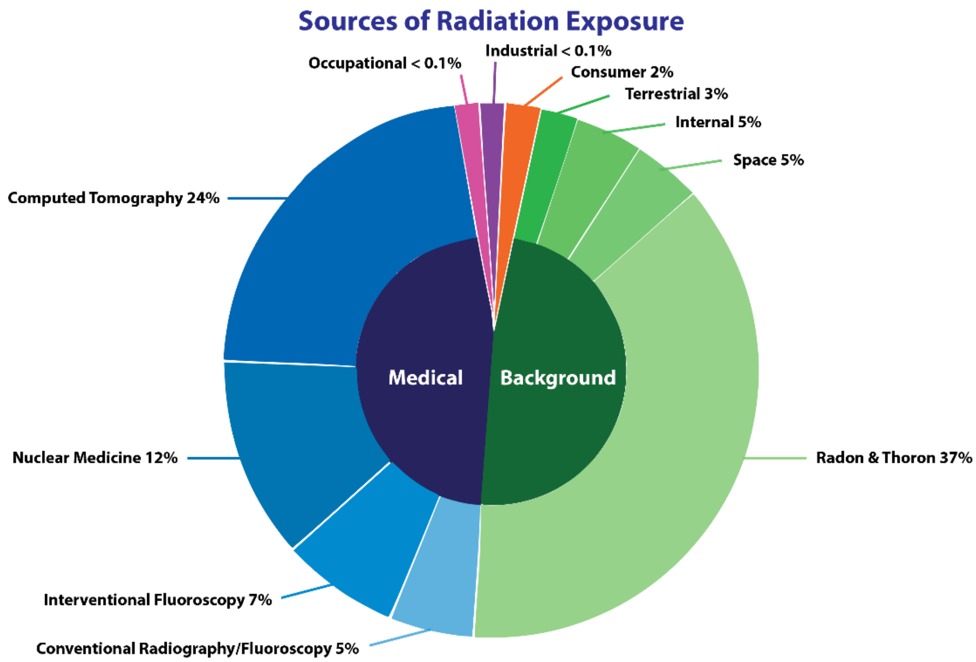
Management Challenges of Radioactive Waste

Many forms of radioactive waste remain unsafe for very long periods of time and require additional safety protocols to ensure safe storage for the duration of time the waste remains hazardous. The decay half-life of radioactive materials can range from just a few minutes to thousands of years, depending on the *radionuclide* in question. This means that permanent waste disposal sites must have safeguards in place that will stand the test of time – some longer than the span of human history to date.

Half-life is the time taken for the radioactivity of a specified isotope to fall to half its original value. It takes about 10 half-lives before a radioactive substance will fully decay.

Radioactive waste is a human and environmental health concern. While high dose exposure to radioactivity can present acute health risks, such exposures are not expected outside of nuclear emergency events. More likely scenarios involve chronic lower dose exposures to waste handlers or other members of the public who might frequently come into contact with material. This type of exposure can present long-term cancer risks for exposed individuals. As is shown in Figure 1, most radiation exposure to most people comes from either radon gas, which occurs naturally in soil in some parts of the world and can accumulate in building basements if not properly managed, or from medical diagnostics or treatments.

Figure 1: Sources of Radiation Exposure[7]



Average Annual Radiation Dose

Sources	Radon & Thoron	Computed Tomography	Nuclear Medicine	Interventional Fluoroscopy	Space	Conventional Radiography/ Fluoroscopy	Internal	Terrestrial	Consumer	Occupational	Industrial
Units mrem (United States) mSv (International)	228 mrem 2.28 mSv	147 mrem 1.47 mSv	77 mrem 0.77 mSv	43 mrem 0.43 mSv	33 mrem 0.33 mSv	33 mrem 0.33mSv	29 mrem 0.29 mSv	21 mrem 0.21 mSv	13 mrem 0.13 mSv	0.5 mrem 0.005 mSv	0.3 mrem 0.003 mSv

(Source: National Council on Radiation Protection & Measurements, Report No. 160)

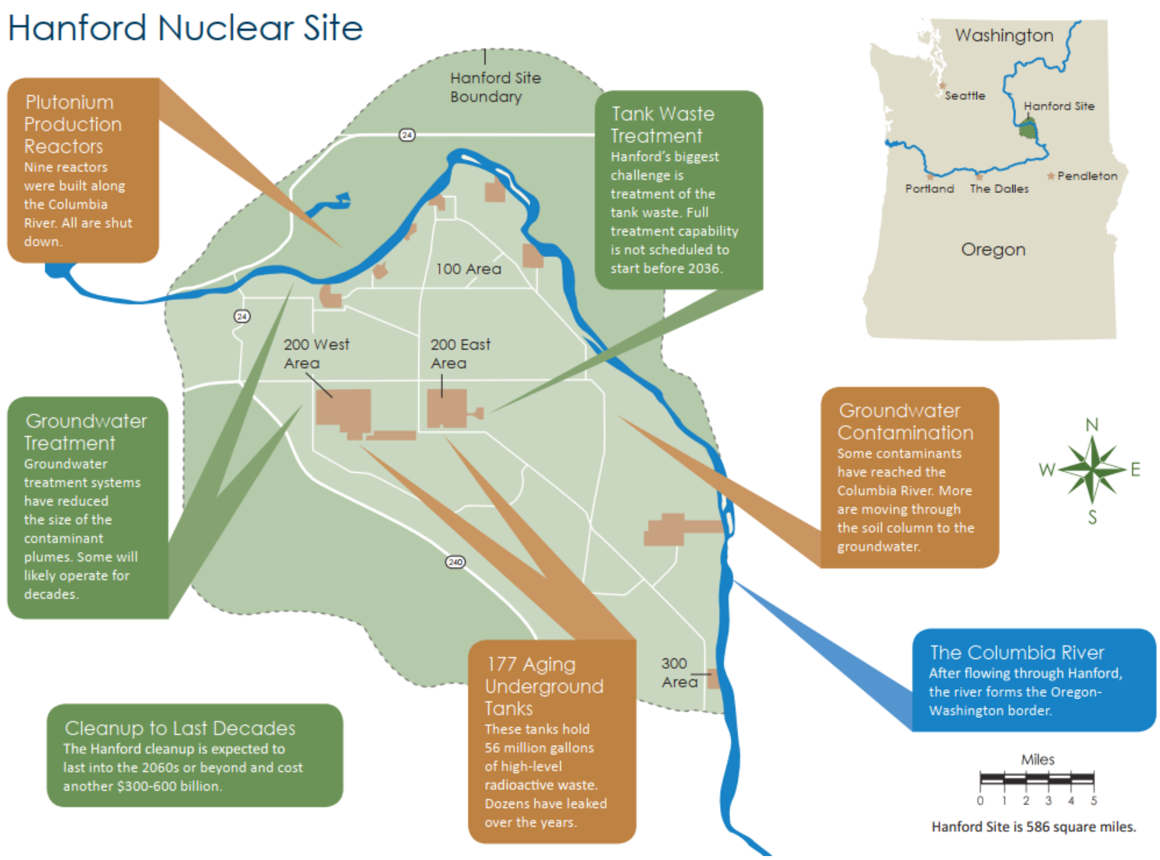
Public perception of radioactive waste and its management includes considerations for the environment and the economy of local communities. Even when potentially radioactive materials have been disposed of safely in a landfill, people may be concerned about the stigma of associating their community with radioactive waste. For example, online search results for towns near waste disposal sites may leave a negative impression on potential visitors or developers. Residents and businesses may fear this will have a detrimental effect on property values and the attractiveness of that community to visitors or new residents. Perceived risk also has the potential to affect natural resource value, such as the water that supplies agricultural products or fish and wildlife from affected environments, even if the products or water are safe to consume.

History of Radioactive Waste Management in Oregon

Hanford

Oregon's – and the nation's – nuclear waste legacy starts in Washington State, at the Hanford Site. Hanford was a foundation of the Manhattan Project, operating from 1943 to 1989 and ultimately producing 65 percent of the plutonium for America's nuclear weapons.[8 9] During Hanford's operation, large amounts of radioactive materials were discharged into the air and soil at the site and, for a period of time early in site operations, directly into the Columbia River. Radioactive isotopes from this waste were later found in coastal shellfish, river fish, and even whales offshore.[10] Plutonium production at Hanford ended in 1989, and the focus has shifted to waste cleanup.

Figure 2: Sources of Radioactive Waste at the Hanford Nuclear Site[11]



Oregon has a tremendous stake in the safe and timely cleanup of Hanford. The Hanford site is located just 35 miles upstream of Oregon's border. From Hanford, the Columbia River flows through prime Oregon farmlands and fisheries, and unchecked radioactive and chemical contamination would pose a potential long-term threat to these important resources. Accordingly, the Oregon Department of Energy's primary role in representing Oregon in the ongoing cleanup is to advocate for cleanup decisions that are protective of the river and surrounding resources.

Today, the legacy contamination at Hanford does not enter the river at levels that would negatively affect Oregonians, but many risks still remain.[12] Fifty-six million gallons of high-level radioactive waste currently reside at the site in degrading underground storage tanks. Large volumes of waste still exist in the soil at Hanford due to past leaks, spills, or because of intentional disposal in purpose-built burial sites. Hundreds of contaminated buildings remain, and groundwater that flows to the Columbia River still has plumes of chemical and radiological contamination.[13] [14]

While Oregon has no regulatory authority at Hanford, the federal government recognizes ODOE as a critical, objective voice in technical reviews and policy discussions related to the cleanup. The U.S. Department of Energy owns and operates the Hanford site and has made significant progress on several Oregon cleanup priorities. Because the extent of the contamination is so widespread, and some of the challenges so difficult, the USDOE expects cleanup to continue for another 40 years or more. [15] ODOE's engagement advocates for cleanup actions that are protective of Oregon's interest in the safety and value of the Columbia River, today and in the future.

Oregon Legislature Bans Radioactive Waste Disposal

Through the 1970s and 80s, as the nation was searching for a location to site a permanent deep geologic repository for spent nuclear fuel and high-level radioactive waste. Oregon passed a law that would prohibit such a site within the state. The 1977 legislature instituted a strict ban: "Notwithstanding any other provision of this chapter, no waste disposal facility for any radioactive material shall be established, operated or licensed within this state."[16] Responsibility for enforcing the ban on disposal was charged to the Nuclear and Thermal Energy Council, which became the Energy Facility Siting Council and the Oregon Department of Energy.[17]

Implementation of the new law proved to be challenging because while it had the intended effect of restricting the disposal of radioactive waste from nuclear weapons and nuclear power, it also had the unintended effect of banning waste from some established industries in Oregon. Industries such as metals processing and fire-resistant brickmaking produce naturally occurring radioactive materials, often referred to as NORM, as byproducts of their operations. If these materials were defined as "radioactive waste" under the law, then these industries would face a lack of disposal options for their waste.

Many wastes contain **Naturally Occurring Radioactive Materials (NORM) or Technologically Enhanced NORM (TENORM)** – and may qualify as radioactive waste that cannot be disposed of in Oregon

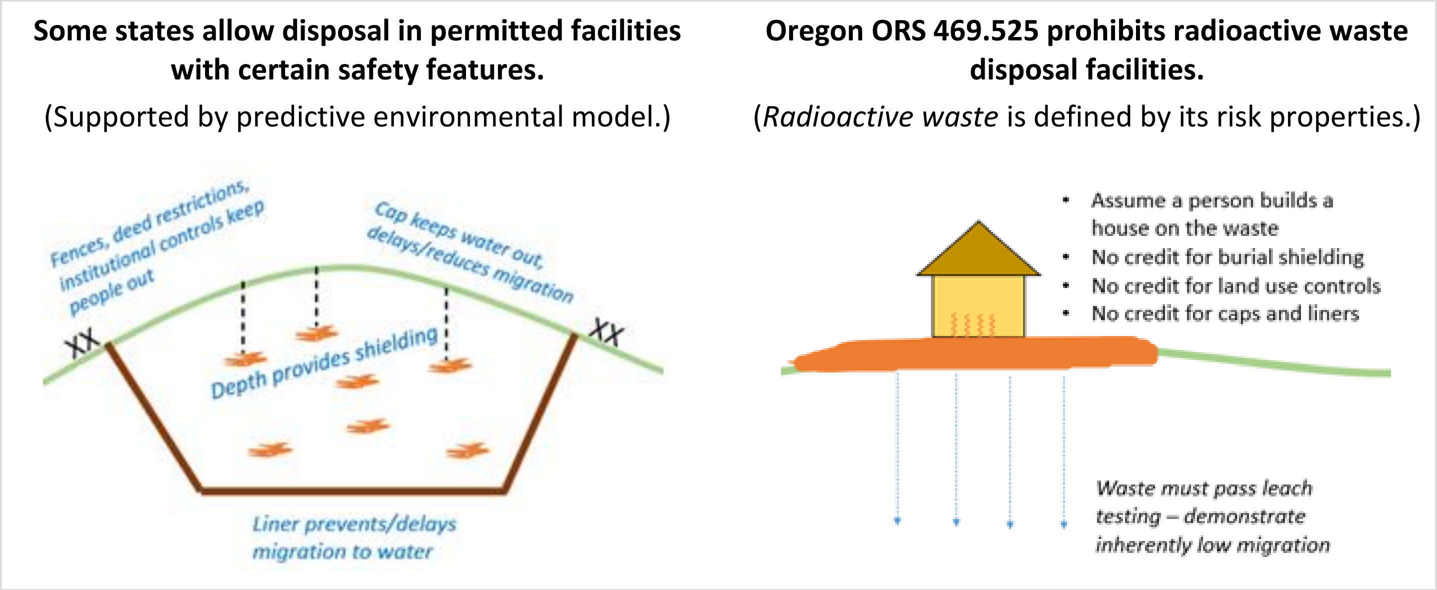
Natural radioactivity is present in trace amounts in the earth's crust and waters. Many industrial processes that use or come in contact with natural raw materials, such as water, soils, rock, or sand, may generate TENORM. In high enough concentrations, the resulting wastes that contain NORM or TENORM can present health and safety hazards to humans and the environment if they are not handled and disposed of properly. [29]

In 1978, in coordination with the legislature, the Nuclear and Thermal Energy Council and ODOE initiated a rulemaking to define radioactive waste based on a material's threat to public health and the environment.[18] Adopted on December 12, 1978, the rules defined exemptions based on quantities, concentrations, type of material, and human exposure pathways for waste materials containing NORM.

Most of the exemptions developed were based on U.S. Nuclear Regulatory Commission regulations, but because the NRC claimed no authority over NORM, additional exemptions were needed for these materials. NORM occurs in many different chemical forms, and depending on the physical and chemical characteristics, a given concentration or quantity may or may not pose a disposal risk. Human exposure pathway tests were created in part to account for these different characteristics and provide certain exemption pathways for NORM. [19]

Oregon's radioactive waste disposal law is unique compared to some other states. The state's risk-based definition of radioactive waste does not allow a petitioner to "take credit" for the natural radioactive shielding and other protections that normal landfill disposal would provide. The waste itself must be benign enough that if it were spread on the ground and a house built on top, it would be able to meet protectiveness standards. Figure 3 illustrates the Oregon rules compared to some states that allow for licensed waste facilities.

Figure 3: Oregon Radioactive Waste Disposal Comparison



Oregon has a limited part to play in the future of spent fuel and high-level waste disposal in the United States. The statewide ban on radioactive waste disposal—coupled with the moratorium on new nuclear power development (until a final repository exists and Oregon voters agree to allow construction of the power facility)—means that Oregon is not a likely location of a future waste repository.[20] However, because the Hanford Site was once considered a top candidate location for a nationwide repository,[21] the Oregon legislature established the Oregon Hanford Cleanup Board and empowered them in statute to act as the lead point of contact between the Federal Government and the State of Oregon regarding the establishment of a high-level waste repository, either at Hanford or in Oregon.[22] ODOE provides staff support to the Oregon Hanford Cleanup Board. Today, the OHCB and ODOE regularly work with the U.S. Department of Energy and its regulators to represent Oregon's interests at Hanford, as well as represent Oregon's interests in establishing a national permanent spent nuclear fuel and nuclear waste repository.

Trojan – Oregon's Former Commercial Nuclear Power Plant

Developed and built prior to the 1978 statutes on nuclear power generation, the Trojan Nuclear Power Plant was Oregon's only commercial nuclear power plant, located in Columbia County about 40 miles northwest of Portland along the Columbia River.[23] Trojan began generating power on May 20, 1976, with a capacity of 1,130 megawatts. From the outset, the plant was plagued by design flaws and other problems that led to temporary closures and expensive repairs. During this time, several failed legislative efforts to close the plant were presented by anti-nuclear groups.

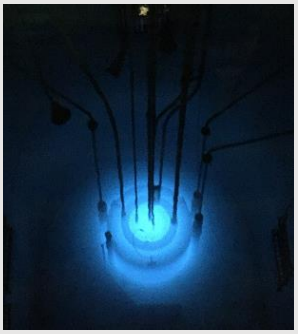
Trojan's cooling tower was imploded in 2006.

The Trojan nuclear power plant ceased operations in 1993, requiring the safe and proper decommissioning of the entire plant and the storage of the spent nuclear waste – a process that took 10 years to complete.[23] The containment building was demolished and the cooling tower imploded. Most of the radioactive waste was hauled to the U.S. Ecology landfill located on the Hanford Site for burial, and the reactor vessel and steam generators were shipped by barge up the Columbia River to the Hanford site. Today, Trojan's spent nuclear fuel is stored in 34 passive-cooled containment vessels on a concrete pad at the former plant site. The spent fuel will remain there until the federal government establishes a national spent fuel repository or interim consolidated storage facility. The site is managed by Portland General Electric with oversight by the Nuclear Regulatory Commission and engagement by ODOE staff. In this regard, the Trojan site is not unique; across the nation, nearly all spent nuclear fuel from operating and legacy nuclear power plants is stored at the site where it is generated.[24] Despite repeated efforts, the federal government has not been able to establish a deep geologic repository for the nation's spent nuclear fuel or high-level nuclear waste. The nation is far from operating such a centralized repository.

Trojan's spent nuclear fuel is now stored in 34 passive-cooled containment vessels at the former plant site.

Oregon Research Reactors

Two small-capacity nuclear reactors currently operate at Reed College (photo at right) and Oregon State University. Built in the late 1960s, these reactors are used to support education and research activities. The very limited wastes from these reactors, including the small quantities of spent fuel produced by their operation, are stored at the Hanford Site pending final disposal in a permanent spent fuel repository. [25] [26]



Uranium Mining and Milling Residuals

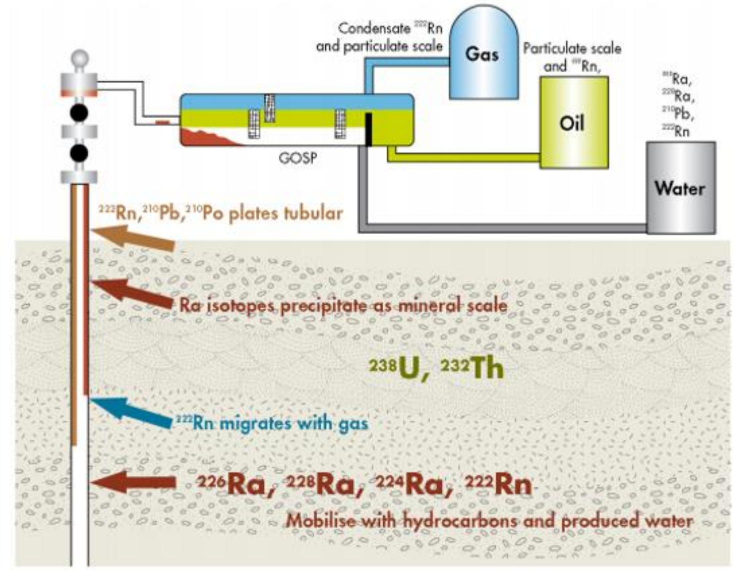
Oregon had two uranium mining sites in operation during the late 1950s and early 1960s.[27] Uranium was discovered outside of Lakeview, Oregon in 1955, which resulted in uranium production at the White King and the Lucky Lass mines. A uranium processing mill was constructed on the northern edge of Lakeview to process the mined ore and operated from late 1958 until 1961.[28] Located about 17 miles northwest of Lakeview and about a mile apart, the open pit mines produced a low grade of ore, which was used in the nation's nuclear weapons program – meaning Lakeview uranium likely was used in the Hanford reactors to produce plutonium. Mining at White King and Lucky Lass stopped around 1965.

In 1976, areas of elevated radioactivity were discovered in the uranium tailings pile (residue from ore) next to the mill, which was subsequently covered with about two feet of dirt.[28] Between 1968-1988, the mill tailings and contaminated soil were excavated and moved to a disposal cell about seven miles outside of Lakeview. A compacted soil layer was added to limit the escape of radon – a byproduct of uranium radioactive decay – and to restrict water percolation into the tailings. A rock cover was added to protect the soil from erosion. Today, ODOE conducts annual inspection visits to ensure that the site mitigation work remains protective, that the cover over the mill tailings does not erode, and that periodic water sampling from the mill site does not indicate the presence of unanticipated radiation.

The mines sat for several decades – the pits filling with acidic water and containing elevated levels of radioactive materials. Contamination threatened nearby Augur Creek. In 1995, the U.S. Environmental Protection Agency added the two mines to its cleanup priorities list. Cleanup occurred through 2005, with an ODOE resident site inspector to oversee the cleanup. The U.S. EPA, Oregon Department of Environmental Quality, ODOE, and the U.S. Forest Service work collaboratively to monitor the mine sites and ensure that the remediation continues to be protective.

2020 Notice of Violation

In 2019, ODOE was alerted to waste that was being illegally disposed in Oregon. The waste was primarily associated with oil and gas extraction, which generates technologically enhanced naturally occurring radioactive material, or TENORM. As shown in this figure, TENORM is NORM that has been "concentrated or exposed to the accessible environment as a result of human activities such as manufacturing, mineral extraction, or water processing."[29] The agency issued a Notice of Violation in 2020, followed by a risk assessment to ensure that there was no risk to workers or the surrounding environment.[30] In the 2021 legislative session, the Oregon legislature passed Senate Bill 246 granting ODOE and EFSC additional investigative and punitive authority to evaluate compliance with state rules.[31]



Origins of TENORM and Where It May Accumulate

Source: International Assoc. of Oil & Gas Producers, Report No. 412 (2008)

Since 2019, ODOE has been evaluating waste streams from waste disposal companies and from industries that commonly dispose of NORM or TENORM in the state. No other waste streams which meet the definition of "radioactive waste" have been identified during this ongoing evaluation, which includes review of pathway exemption reports for suspect waste streams from more than 15 facilities. ODOE continues to work with its partners at the Oregon Health Authority's Radiation Protection Services and the Oregon Department of Environmental Quality to develop robust programs to minimize the chance of future illegal disposal of radioactive waste.

Present-Day Management Challenges for Radioactive Waste

Oregon's prohibition on the disposal of radioactive waste created a challenging regulatory environment because virtually everything contains some amount of radioactivity. Subsequent state rules created strict definitions and exemptions for materials the state will accept, but new technologies, raw material productions, and pathways for new economic development may knowingly or unknowingly lead to potential radioactive material waste production in Oregon. Because sources of radioactive waste are so diverse, ODOE is expanding its efforts to work with industry partners, landfills, transportation companies, trade groups, and other state and local government agencies to provide both awareness of Oregon's rules and technical support to maintain compliance.

Landfills around the state periodically encounter radioactive materials during normal operations. Often the material is medical waste from therapies or diagnostic procedures that contain radioactive elements and are usually safe for disposal after they have been isolated for a week or two to allow for radioactive decay. Other commonly encountered items include older scrap metals that contain higher proportions of certain radioactive metals, heat exchangers or pipes that have accumulated naturally-occurring radioactive build-up over years of use, the occasional consumer item, or family heirloom that contains a small amount of radioactive material.[29] In these cases, the common solution is to separate the waste for disposal outside Oregon at licensed low-level radioactive waste disposal facilities. Guidance on radioactive material disposal is provided by the Oregon Health Authority's Radiation Protection Services division. On some occasions, these items may qualify for disposal in Oregon based on a determination of low public hazard due to their total quantity or concentration of material, or via a specific risk-based exemption in consultation with ODOE. Some landfills around the state have installed radiation portal detectors, which screen incoming waste loads for radiation. If radiation is detected, the portal will alert landfill staff to further investigate the waste and contact state partners at ODOE and Oregon Health Authority.

In 2021, the Chemical Waste Management facility near Arlington, OR installed a radiation detection portal system, which screens all incoming hazardous waste loads to check for potential radiation.

NORM and TENORM represent a class of radioactive material that has long been a management challenge in Oregon and across the nation.[29] These materials can occur as a byproduct of several types of industrial processes, including oil and gas production, metals refinement and metal casting, fertilizer production, activities where refractory bricks are used, scrap metal recycling, geothermal power production, or even simply residues from water and sewer pipe cleaning. One industrial process that is gaining increased national attention is the management of water associated with hydraulic fracturing for oil and gas, and some oil and gas producing states have recently implemented regulations to safely manage disposal of TENORM waste.

The system of waste transportation, transfer, and disposal involves many different places and players around the state. Radiation portal detectors are used in key locations where potential radioactive waste may occur, typically at certain landfills, recycling facilities, and waste transfer stations. Awareness of the Oregon laws concerning radioactive waste has also grown in recent years. ODOE and its stakeholders are working to make sure the people who are a part of this system know about and are equipped to comply with state law.

Looking Ahead: What is Oregon Doing to Address the Challenges of Radioactive Waste?

The establishment of regulations for radioactive waste in other states and at the federal level has implications for the future of radioactive waste management in the state. Historically, Oregon was a leader in promulgating standards for radioactive waste disposal, including NORM and TENORM, while most states and the federal government had no regulations in place for these waste products. Since 2015, at least five states (Montana, Pennsylvania, North Dakota, Texas, Colorado) have conducted rulemaking efforts to set disposal standards for TENORM.[32] [33] [34] [35] [36] As other states begin to establish their own definitions of acceptable waste, it is important for Oregon to review and potentially update its rules to ensure the state keeps in step with advancing science around radiation safety.

The State of Oregon will continue working to assess the risks and rules associated with radioactive waste and protect Oregon interests and values. The state has already strengthened its enforcement capabilities and is currently engaged with stakeholders to update Oregon's radioactive waste definition rules. ODOE is also engaging in a statewide effort to grow and strengthen its radioactive waste disposal prevention program. The Trojan spent fuel continues to be safely stored in Oregon until a national repository becomes available and ODOE is ready to engage with the federal government if the high-level waste repository conversation returns to the Pacific Northwest. Finally, Oregon will remain a strong voice for the cleanup of the Hanford site and the protection of the Columbia River for many decades to come.

REFERENCES

1. Office, U. S. G. A. (2022, July 29). *Nuclear Waste Cleanup: Hanford Site Cleanup Costs Continue to Rise, but Opportunities Exist to Save Tens of Billions of Dollars*. https://www.gao.gov/products/gao-22-105809

2. U.S. Nuclear Regulatory Commission. (2020, March 19). *What is Spent Nuclear Fuel?* NRC Web. https://www.nrc.gov/reading-rm/basic-ref/students/science-101/what-is-an-spent-fuel.html

3. US Environmental Protection Agency. (2018, November 28). *Radioactive Material From Fertilizer Production* [Overviews and Factsheets]. https://www.epa.gov/radtown/radioactive-material-fertilizer-production

4. US Environmental Protection Agency. (2018, November 30). *Radioactive Waste Material From Oil and Gas Drilling* [Overviews and Factsheets]. https://www.epa.gov/radtown/radioactive-waste-material-oil-and-gas-drilling

5. Forbes. (2016, October 18). *Yes, Bananas Are Radioactive, And Yes, You Should Keep Eating Them Anyway*. Forbes. https://www.forbes.com/sites/quora/2016/10/18/yes-bananas-are-radioactive-and-yes-you-should-keep-eating-them-anyway/

6. CDC. (2015, December 7). *Radiation from Building Materials*. Centers for Disease Control and Prevention. https://www.cdc.gov/nceh/radiation/building.html

7. US Environmental Protection Agency. (2015, April 15). *Radiation Sources and Doses* [Overviews and Factsheets]. https://www.epa.gov/radiation/radiation-sources-and-doses

8. Gephart, R. E. (2002). *A Short History of Hanford* (PNNL-13605 Rev. 3, 897390; pp. 2–3). https://doi.org/10.2172/897390

9. Gephart, R. E. (2002). *A Short History of Hanford* (PNNL-13605 Rev. 3, 897390; p. 5). https://doi.org/10.2172/897390

10. New York Times. (1964, December 11). A Radioactive Whale Is Killed Off Oregon. *The New York Times*. https://www.nytimes.com/1964/12/11/archives/a-radioactive-whale-is-killed-off-oregon.html

11. Oregon Department of Energy. (n.d.). *About Hanford*. Retrieved September 27, 2022, from https://www.oregon.gov/energy/safety-resiliency/Pages/About-Hanford.aspx

12. U.S. Department of Energy. (2010). *River Corridor Baseline Assessment Volume II: Human Health Risk Assessment* (DOE/RL-2007-21; p. Forward-1 through-8). https://www.hanford.gov/files.cfm/cal_vol_ii_draft_c_part-1.pdf

13. U.S. Department of Energy. (n.d.). *About Hanford Cleanup—Hanford Site*. Retrieved September 14, 2022, from https://www.hanford.gov/page.cfm/AboutHanfordCleanup

14. U.S. Department of Energy. (2022). *Hanford Site RCRA Groundwater Monitoring Report for 2021* (DOE/RL-2021-50, REV. 0). https://www.hanford.gov/files.cfm/DOE_RL-2021-50_R0_Clean.pdf

15. U.S. Department of Energy. (2022). *2022 Hanford Lifecycle Scope, Schedule and Cost Report* (DOE/RL-2021-47, Rev. 0; p. ES-2). https://www.hanford.gov/files.cfm/2022_LCR_DOE-RL-2021-47_12-27.pdf

16. Oregon 59th Legislative Assembly, 469.525 Oregon Regulatory Statute (1977), Formerly ORS 459.630. https://oregon.public.law/statutes/ors_469.525

17. *State of Oregon: Facilities—About the Council*. (n.d.). Retrieved September 14, 2022, from https://www.oregon.gov/energy/facilities-safety/facilities/Pages/About-the-Council.aspx

18. *Oregon Secretary of State Administrative Rules*. (n.d.). Oregon Secretary of State Administrative Rules. Retrieved September 15, 2022, from https://secure.sos.state.or.us/oard/displayDivisionRules.action;JSESSIONID_OARD=cEvl4-_1cwJkYFPai2eKxcwHAUj20YEiO_RiPf4ZhVo_kY-DY712!1243901809?selectedDivision=1588

19. *Oregon Secretary of State Administrative Rules*. (n.d.). Oregon Secretary of State Administrative Rules. Retrieved September 15, 2022, from https://secure.sos.state.or.us/oard/displayDivisionRules.action;JSESSIONID_OARD=cEvl4-_1cwJkYFPai2eKxcwHAUj20YEiO_RiPf4ZhVo_kY-DY712!1243901809?selectedDivision=1588

20. Oregon Secretary of State. (n.d.). *Oregon Blue Book Almanac & Fact Book*. Retrieved September 15, 2022, from https://sos.oregon.gov/blue-book/Documents/elections/initiative.pdf

21. Washington Public Interest Research Group. (1985). *Hanford A National Nuclear Waste Repository? A Citizens Guide to Key Issues*. 11. https://www.nrc.gov/docs/ML0406/ML040650262.pdf

22. Oregon 59th Legislative Assembly, 469.573 Oregon Regulatory Statute. Retrieved September 15, 2022, from https://oregon.public.law/statutes/ors_469.573

23. Oregon Department of Energy. (n.d.). *State of Oregon: Safety & Resilience—Trojan Nuclear Site Spent Fuel Storage*. Retrieved September 15, 2022, from https://www.oregon.gov/energy/safety-resiliency/Pages/Trojan-Site.aspx

24. U.S. Department of Energy Office of Nuclear Energy. (2019, July 30). *INFOGRAPHIC: 5 Fast Facts about Spent Nuclear Fuel*. Energy.Gov. https://www.energy.gov/ne/downloads/infographic-5-fast-facts-about-spent-nuclear-fuel

25. Oregon Department of Energy. (n.d.). *State of Oregon: Facilities—Reed Nuclear Research Reactor*. Retrieved September 15, 2022, from https://www.oregon.gov/energy/facilities-safety/facilities/Pages/REED.aspx

26. Oregon Department of Energy. (n.d.). *State of Oregon: Facilities—OSU Nuclear Research Reactor*. Retrieved September 15, 2022, from https://www.oregon.gov/energy/facilities-safety/facilities/Pages/OSU.aspx

27. EPA Region 10 Office of Environmental Cleanup. (2001). *White King/Lucky Lass Superfund Site Record of Decision* (p. iii). https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev3_061758.pdf

28. Oregon Department of Energy. (n.d.). *State of Oregon: Safety & Resilience—Lakeview Uranium Sites*. Retrieved September 15, 2022, from https://www.oregon.gov/energy/safety-resiliency/Pages/Uranium.aspx

29. US Environmental Protection Agency. (2014, November 12). *Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM)* [Overviews and Factsheets]. https://www.epa.gov/radiation/technologically-enhanced-naturally-occurring-radioactive-materials-tenorm

30. Oregon Department of Energy. (2021). *Notice of Violation: Chemical Waste Management*. https://www.oregon.gov/energy/safety-resiliency/Documents/CWM-NOV-History.pdf#:~:text=Notice%20of%20Violation%3A%20Chemical%20Waste%20Management%20On%20February,%12hemical%20Waste%20Management%20hazardous%20waste%20landfill%20near%20Arlington.

31. Senate Bill 246, 81st Oregon Legislative Assembly, 2021, Chapter 38 (2021). https://olis.oregonlegislature.gov/liz/2021R1/Downloads/MeasureDocument/SB246/Enrolled

32. Tetra Tech. (2016). *Development of TENORM Rules for the State of Montana*. https://deq.mt.gov/files/Land/SolidWaste/Documents/docs/TENORMReportFinal.pdf

33. Perma-Fix Environmental Services. (2016). *Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM) Study Report*. http://www.depgreenport.state.pa.us/elibrary/GetDocument?docId=5815&DocName=01%20PENNSYLVANIA%20DEPARTMENT%20OF%20ENVIRONMENTAL%20PROTECTION%20TENORM%20STUDY%20REPORT%20REV%201.PDF%20

34. North Dakota Department of Health. (2014). *Notice of Intent to Adopt and Amend Administrative Rules*. https://deq.nd.gov/Tenorm/Rules/Public%20Notice%20of%20Intent%20to%20Adopt%20and%20Amend%20Administrative%20Rules%20related%20to%20TENORM.pdf?v=2

35. Texas Commission on Environmental Quality. (n.d.). *Naturally Occurring Radioactive Material (NORM) Disposal*. Retrieved September 15, 2022, from https://www.tceq.texas.gov/permitting/radmat/uranium/norm.html

36. Colorado Department of Public Health & Environment. (n.d.). *TENORM Guidance Development*. Retrieved September 15, 2022, from https://cdphe.colorado.gov/part-20-tenorm-guidance-development

Energy 101: Public Utility Regulatory Policies Act of 1978 (PURPA)

The Public Utility Regulatory Policies Act of 1978 (PURPA) has played an important role shaping energy markets and encouraging renewable energy nationally—and in Oregon—for more than 40 years.[1] This section is designed to provide Oregonians a better understanding of current perspectives on the policy and the potential effects of PURPA reform on Oregon's evolving electric sector, and includes a summary of key aspects of PURPA, its role in renewable energy development, and a high-level overview of current discussions about potential policy reform.

History of PURPA

In 1978, Congress passed PURPA as a legislative response to the energy crises of that decade. In its passage, Congress aimed to reduce dependence on imported fossil fuels and increase diversity in energy resources by encouraging development of alternative energy resources. At the same time, the legislation encouraged conservation of electric energy and increased efficiency in the use of generation facilities and resources by electric utilities while ensuring equitable retail rates for electric consumers.[2]

One of the ways that PURPA was designed to accomplish its goals was through the creation of a new class of generating facilities known as "non-utility generators," or as they are now more commonly known: qualifying facilities. Qualifying facilities are often called "QFs" and fall into two groups:[1]

1. **Small power production facilities.** Generating facilities of 80 MW or less whose primary energy source is renewable (hydropower, wind, solar, biomass, or geothermal); and
2. **Cogeneration facilities.** Generating facilities that produce both electricity and another form of useful thermal energy (such as heat or steam) in a way that is more efficient than the separate production of both forms of energy.

To encourage the development of QFs by independent power producers, PURPA authorized the Federal Energy Regulatory Commission to adopt rules to determine the eligibility of QFs for special rates and exemption from certain regulatory requirements.[4] According to FERC, small power producers seeking to connect to the utility grid before PURPA was enacted often faced three "major obstacles."[4] First, utilities were not required to purchase the output from power projects owned by IPPs. Second, some utilities charged high rates to IPPs for back-up grid service for their projects. And third, in many cases, an IPP exporting wholesale electricity to the utility grid could actually be considered an electric utility itself, and therefore would be subject to considerable federal and state regulation.[4] To overcome these three barriers, PURPA created certain rights for QF projects that fall into three categories:[5]

Independent Power Producer or IPP: A corporation, person, agency, authority, or other legal entity or instrumentality that owns or operates facilities for the generation of electricity for use primarily by the public, and that is not an electric utility.[3]

1. **The right to sell electricity or capacity to a utility at the utility's avoided cost rate.** PURPA imposes a mandatory purchase obligation on utilities, requiring utilities to purchase electricity from QFs at either an avoided cost rate or a negotiated rate. The avoided cost rate is intended to represent the incremental cost to the electric utility of electric energy or capacity which, but for the purchase from the QF, the utility would have to generate itself or purchase from another source. An avoided cost rate is somewhat analogous to the marginal wholesale price for a utility to acquire another kilowatt-hour of energy.
2. **The right to purchase certain services from utilities.** PURPA gives QFs the right to interconnect to a utility's transmission or distribution system by paying a fair price for upgrade costs on a non-discriminatory basis. PURPA also gives QFs the right to purchase supplementary power, back-up power, maintenance power, and interruptible power from utilities as needed at rates which are just and reasonable.
3. **Relief from certain regulatory requirements.** Federal and state laws define an electric utility and subject entities falling within such definitions to significant regulation and oversight. PURPA exempts QFs from obligations under the Public Utility Holding Company Act of 1935 and provides an exemption from certain state laws and regulations regarding the rates and financial organizational aspects of electric utilities.

Since its inception in 1978, PURPA has undergone several changes as energy markets have evolved in the United States. During the 1990s and into the early 2000s, federal legislation, combined with regulatory action at FERC aimed at increasing competition, led to substantial restructuring of wholesale electricity markets across the country.[i] In particular, these actions led to the development of competitive, centralized markets for buying and selling wholesale electricity in much of the country. These markets were and remain administered by independent system operators or regional transmission organizations.[ii] As a result of these changes, there were several efforts to modify or repeal PURPA. Elements of the original legislation were increasingly viewed by some stakeholders as being unnecessary, particularly given the development of competitive, centralized markets where QFs could sell power.

Energy Policy Act of 2005

In 2005, Congress amended PURPA through the Energy Policy Act of 2005 (EPAct 2005) to account for changes in wholesale electricity markets, such as the development of organized wholesale dispatch markets, among other changes in the industry.[6] Significantly, EPAct 2005 created a procedure to relieve utilities of their must-purchase obligation from certain renewable QFs, provided the utility seeks such a waiver from FERC, and that the Commission finds that such QF projects in the utility's service territory have non-discriminatory access to competitive electricity markets. In implementing this provision through Order 688, FERC found that some organized markets (but, notably, not CAISO at the time as it had not yet launched its Day-Ahead Market) offered sufficient, non-discriminatory access to renewable QFs between 20 MW and 80 MW in size and thus utilities operating in those

[i] For example, see: the Energy Policy Act of 1992 and FERC Orders 888 (creating the Open Access Transmission Tariff), 889 (creating the Open Access Same-time Information System), and 2000 (encouraging the formation of Regional Transmission Organizations).
[ii] For more on Regional Transmission Organizations, see ODOE's 2021 report on RTOs: www.oregon.gov/energy/energy-oregon/Pages/RTO.aspx

markets were relieved of their must-purchase obligations for those projects pursuant to PURPA.[7] In 2011, FERC found that California's three large investor-owned utilities also qualified for this waiver.[8] Notably, in Order 688, the Commission also established a rebuttable presumption that projects equal to or smaller than 20 MW do *not* have non-discriminatory access and thus the must-purchase obligations of utilities remained unchanged. This change for renewable projects larger than 20 MW lessened the effect of PURPA in some states, while the core elements of PURPA remained essentially unchanged in Oregon and the Pacific Northwest.

FERC Order 872

In 2020, FERC further revised its regulations implementing PURPA. In Order 872,[5] FERC reduced the minimum size of a renewable QF that is presumed to have non-discriminatory access to power markets from 20 MW to 5 MW for projects located within certain ISO or RTO markets. This provision essentially relieves utilities operating within these markets of their must-purchase obligations for renewable QFs sized between 5 MW and 80 MW (the maximum size of a renewable QF pursuant to PURPA). The order also granted additional flexibility to state regulatory authorities to establish avoided cost rates for QF projects. This change affected state regulatory authority regardless of whether the QF was located inside an ISO or RTO market.

Role of the State

Though FERC has broad authority to prescribe rules for PURPA implementation throughout the nation in many instances, Congress reserved discretion to state regulators (public utility commissions in the case of investor-owned utilities, and governing boards in the case of consumer-owned utilities) to determine implementation in others. This allows states to tailor elements of PURPA implementation to the specific market and industry conditions in their state, which can vary significantly in terms of existing resource mix, prevailing power rates, and interconnection considerations. The following are core elements of PURPA implementation over which states exercise significant authority, including some indication of the range in how different states exercise this authority:[9]

- **Avoided Cost Pricing**. States have wide discretion to define what is reasonable and non-discriminatory when establishing avoided cost rates that utilities must pay for the energy and the capacity delivered from QF projects. The intention of PURPA is that utilities should pay QFs for the power output of their projects at a rate that represents the "avoided cost" to that utility of having to otherwise procure or purchase that amount of energy and capacity elsewhere, in the absence of the QF project existing.

  Historically, many states have developed avoided cost pricing based on market prices for purchasing a marginal MWh of power, which in recent decades would often be set by a natural gas plant. Other states, meanwhile, have looked to market pricing for renewables, specifically, to set the avoided cost rates paid to renewable QFs. There is significant diversity in how states develop avoided cost pricing. Nationally, avoided cost pricing for QFs varies widely with some states offering higher or lower rates for output during different times of the year.

  For a summary of PURPA implementation by state, including avoided cost pricing, the National Regulatory Research Institute maintains the following online database: https://www.naruc.org/nrri/nrri-activities/purpa-tracker/

- **Fixed vs. Variable Energy Rates**. Pursuant to FERC Order 872, states acquired the authority to offer either fixed-price energy contracts or to offer variable-price energy contracts to QFs based on the time the energy is delivered. To determine a fair variable price, the purchasing utility can rely upon market pricing from an ISO or RTO market, where one exists, or from another wholesale bilateral market trading hub (such as the Mid-Columbia, or Mid-C, in the Pacific Northwest) in areas that operate without an ISO or RTO. In either case, QF projects retain the ability to opt for fixed-price capacity payments.
- **Contract Terms and Conditions**. State regulators have authority to adopt standard terms and conditions for QF contracts, or to require bilateral negotiations between individual QF projects and the utility obligated to purchase the output.
- **Contract Duration**. The duration of contracts offered to QF projects varies widely across the country. Most states offer contract durations in the 10- to 20-year range, with some exceptions as short as 2-year and as long as 25-year contract terms.
- **Interconnection Agreements.** States also exercise authority over the type of interconnection agreements required for QF projects in their state and the associated fees that utilities can charge for interconnection.

PURPA Implementation in Oregon

Since the inception of PURPA, Oregon has taken numerous actions to implement the legislation, including enacting its own complementary legislation in ORS 758.505-555.[10] Oregon's PURPA implementation legislation was designed to fulfill the state's goal of promoting "the development of a diverse array of permanently sustainable energy resources" while ensuring that the rates paid to PURPA QFs are "just and reasonable."[9] For the state's consumer-owned utilities, each governing board has adopted its own rules for administering its PURPA obligations, including the establishment of pricing and contract durations.[9]

Meanwhile, for the state's IOUs, the Oregon Public Utility Commission is responsible for regulatory oversight of PURPA.[9] The OPUC aims to implement the legislation such that it encourages the economically efficient development of QFs, while protecting ratepayers by ensuring that utilities pay rates equal to what they would have incurred in lieu of purchasing power from a QF project.[11] While there have been numerous regulatory proceedings at the OPUC related to PURPA implementation, there are three groups of decisions that shape how PURPA is implemented today:

- **Order No. 05-584 (2005)**:[12]
    - Established standard contracts for QFs smaller than 10 MW with uniform terms and conditions, 20-year contract duration, and 15-year fixed prices.
    - Established a process for calculating avoided cost pricing and required utilities to develop several pricing options.

    - QFs larger than 10 MW would receive avoided cost rates via negotiated contracts rather than standard offers.[iii]
- **Order No. 14-058 (2014)**:[12]
    - Reconsidered the provisions adopted in Order No. 05-584.
    - Reaffirmed decision to maintain 10 MW eligibility cap for standard contracts with a 20-year contract duration and 15-year fixed prices, in addition to provisions intended to reduce transaction costs for QF development.
    - Modified avoided cost method to: (1) account for the capacity contribution of different QFs, and (2) to incorporate wind integration costs.
    - Committed to revisit solar integration costs in the future after more solar QF development occurs.
- **Orders No. 16-129 (2016),[13] No. 16-130 (2016),[14] and No. 19-016 (2019):[15]**
    - Reaffirmed its decision to maintain 20-year contract durations with 15-year fixed prices.
    - Identified that some solar developers were able to circumvent the 10 MW threshold to qualify for standard contracts by developing multiple, smaller projects.
    - Reduced the size threshold for standard contracts, as adopted in Order No. 05-584, for solar QFs (but *not* for non-solar QFs) from 10 MW to 3 MW for Idaho Power (Order No. 16-129), PacifiCorp (Order No. 16-130), and PGE (Order No. 19-016).

Effects of PURPA on Renewable Development in Oregon

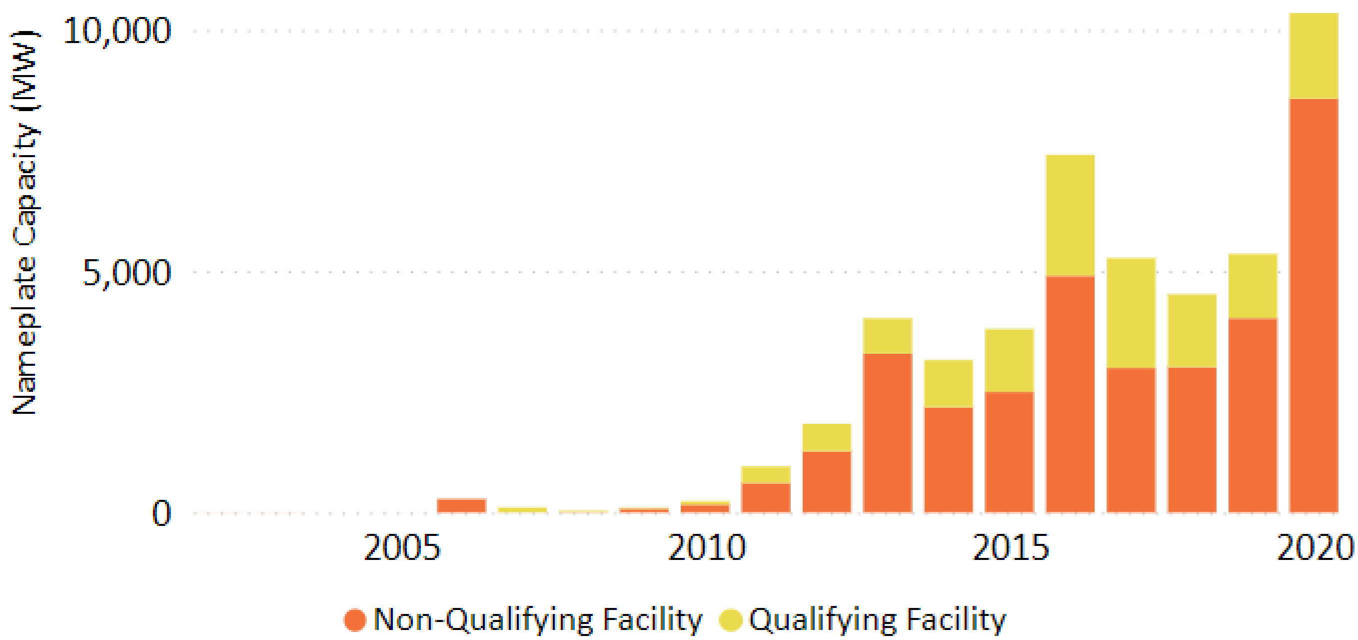
According to data from the U.S. Energy Information Administration, more than 169 gigawatts (GW) of renewable generating capacity became operational in the United States between 2000 and 2020. Of that total, PURPA QF projects account for 21 GW (or approximately 12 percent). Solar PV projects account for nearly two-thirds of those QF projects (approximately 13.5 GW of capacity), driven by significant reductions in solar technology costs in recent years. By contrast, wind energy projects account for less than one-quarter of those QF projects (approximately 5 GW of capacity).[16]

More than 169 GW of renewable generating capacity became operational in the U.S. between 2000 and 2020. Of that total, PURPA projects account for 21 GW (about 12%).

Figure 1 shows the national growth in solar capacity since 2000, with QFs continuing to account for a significant share of total projects through 2020.

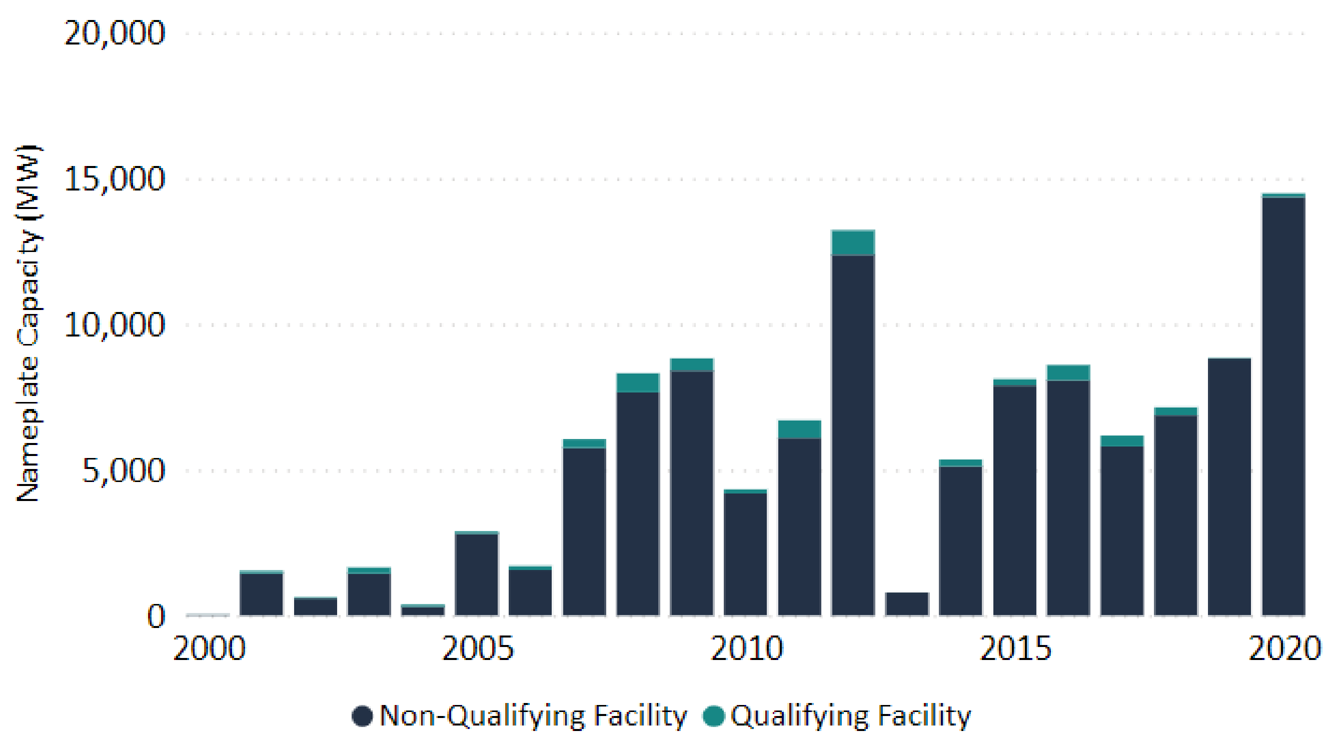
[iii] OPUC Order No. 07-360 established guidelines for determining negotiated rates for large QFs consistent with 18 CFR 292.304(e). For more information: https://apps.puc.state.or.us/orders/2007ords/07-360.pdf

Figure 1: U.S. Solar Nameplate Capacity (MW) by Year and QF Status[16]



Meanwhile, Figure 2 illustrates the deployment of wind energy capacity since 2000, which tells a different story. Major deployments occurred earlier (by the mid-2000s) and the contribution of QF projects is noticeably smaller than with solar.

Figure 2: U.S. Wind Nameplate Capacity (MW) by Year and QF Status[16]



Between 2000 and 2020 in Oregon, approximately 4.5 GW of renewable generating capacity became operational, of which PURPA QFs accounted for approximately 650 MW (or approximately 14 percent of all renewable projects). Solar QF projects account for 420 MW of that capacity (or roughly two-thirds of all QFs in Oregon). By contrast, wind QFs account for 143 MW of that capacity (or less than one-quarter of all QFs in Oregon).

Figure 3: Oregon Solar Nameplate Capacity (MW) by Year and QF Status[16]

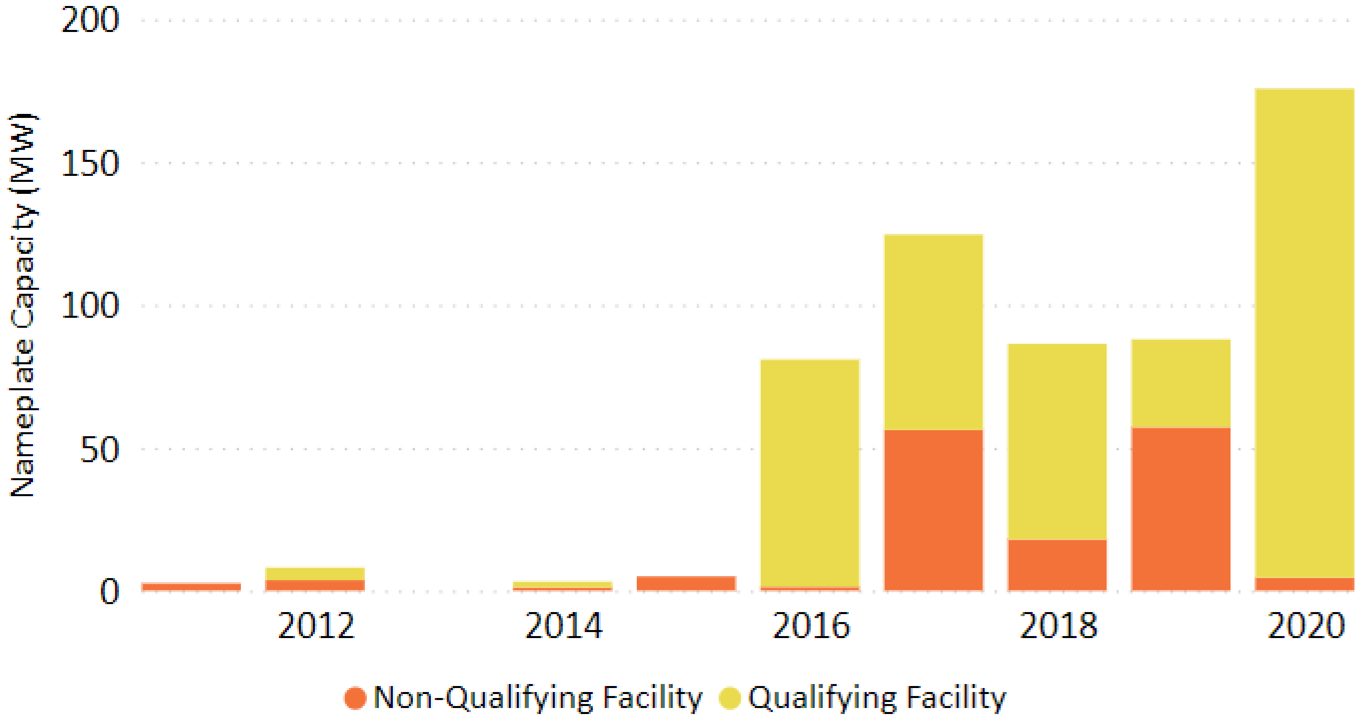
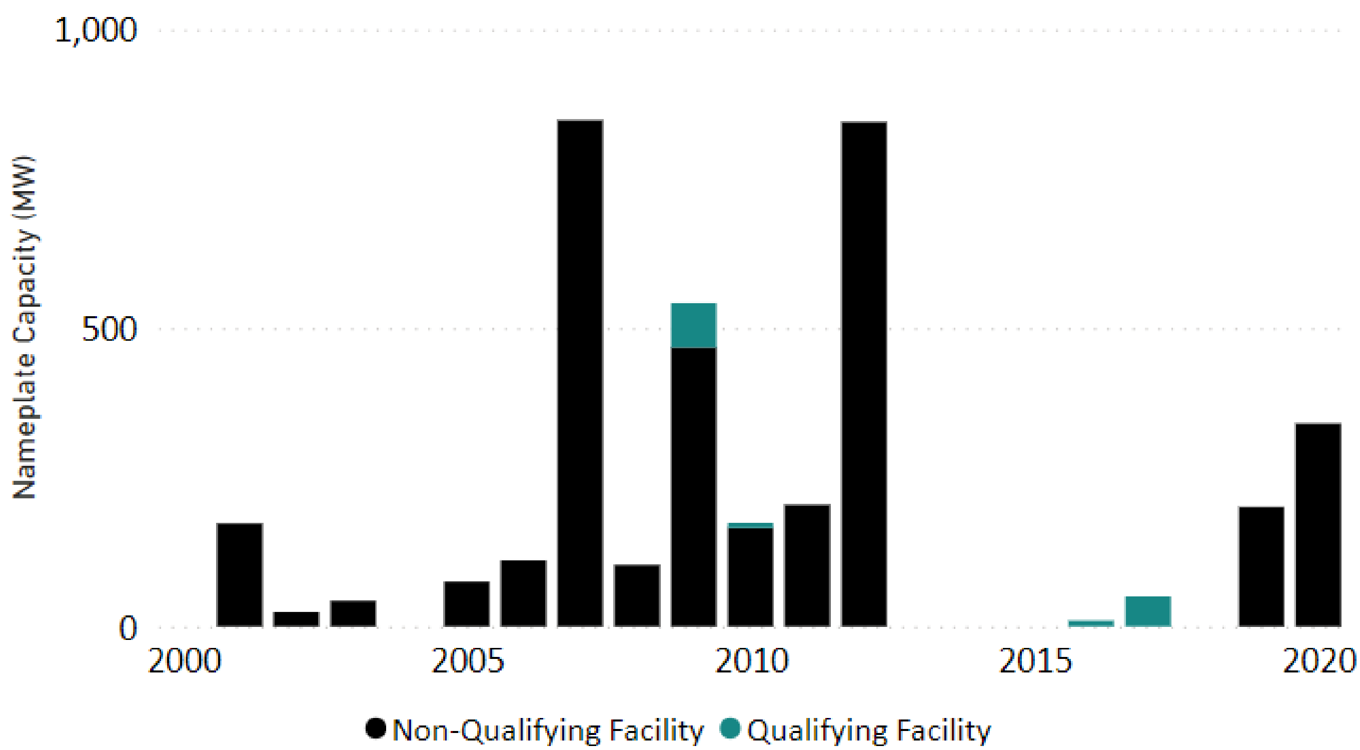


Figure 4: Oregon Wind Nameplate Capacity (MW) by Year and QF Status[16]



Next Steps: The Future of PURPA

The electric utility sector has changed dramatically since the adoption of PURPA in 1978. As shown above, the deployment of utility-scale renewables has grown significantly in the last two decades. This has been driven by state policies responding to an increased awareness of the threat posed by climate change combined with technology advancements and cost reductions. As of 2022, renewable projects of all sizes are increasingly cost-effective in the power sector. And recent actions taken by FERC in Order 872—such as reducing the must-purchase obligation for utilities from renewable QFs larger than 20 MW to those renewable QFs larger than 5 MW in certain RTO markets, and giving authority to states to adopt variable-priced avoided costs at the time of delivery—reflect these fundamental changes to the competitiveness of renewables in the marketplace. While PURPA has driven meaningful development of renewable projects in the past, there are divergent perspectives about the continued role of PURPA in helping Oregon to meet its clean energy goals in the decades ahead.

As of 2022, renewable projects of all sizes are increasingly cost-effective in the power sector.

REFERENCES

1. Public Utility Regulatory Policies Act (PURPA), Pub. L. No. 95–617, 16 USC (1978). https://www.congress.gov/95/statute/STATUTE-92/STATUTE-92-Pg3117.pdf

2. Abel, A. (1992, July 30). *Public Utility Regulatory Policies Act (PURPA) of 1978: A Fact Sheet*. https://energyhistory.yale.edu/library-item/public-utility-regulatory-policies-act-purpa-1978-fact-sheet

3. U.S. Energy Information Administration (EIA). (n.d.). *Glossary*. Retrieved June 14, 2022, from https://www.eia.gov/tools/glossary/index.php

4. Federal Energy Regulatory Commission (FERC). (1980). *Order No 69 (Federal Energy Regulatory Commission)*. https://www.ferc.gov/sites/default/files/2020-04/order-69-and-erratum.pdf

5. Federal Energy Regulatory Commission (FERC). (2020). *Order No 872-A*. https://www.ferc.gov/media/order-no-872

6. Federal Energy Regulatory Commission (FERC). (2006). *Fact Sheet: Energy Policy Act of 2005*. https://www.ferc.gov/sites/default/files/2020-04/epact-fact-sheet.pdf

7. Federal Energy Regulatory Commission (FERC). (2006). *Order No 688*. https://www.ferc.gov/sites/default/files/2020-05/E-2_104.pdf

8. Federal Energy Regulatory Commission (FERC). (2011). *135 FERC ¶ 61,234*.

9. National Regulatory Research Institute (NRRI). (n.d.). *PURPA Tracker*. PURPA Tracker. Retrieved May 24, 2022, from https://www.naruc.org/nrri/nrri-activities/purpa-tracker/

10. Chapter 758—Cogeneration and Small Power Production Facilities, Oregon Revised Statute (ORS) § 758.505-555 (2021). https://www.oregonlegislature.gov/bills_laws/ors/ors758.html

11. Oregon Public Utility Commission (OPUC). (n.d.). *What is PURPA?* PURPA. Retrieved May 24, 2022, from https://www.oregon.gov/puc/utilities/Pages/Energy-PURPA.aspx

12. Oregon Public Utility Commission (OPUC). (2005). *Order No. 05-584*. https://apps.puc.state.or.us/orders/2005ords/05-584.pdf

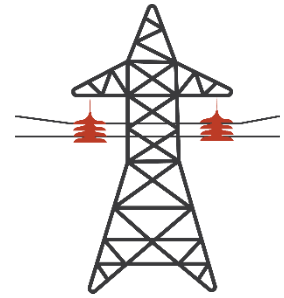
13. Oregon Public Utility Commission (OPUC). (2016). *Order No. 16-129*. https://apps.puc.state.or.us/orders/2016ords/16-129.pdf

14. Oregon Public Utility Commission (OPUC). (2016). *Order No. 16-130*. https://apps.puc.state.or.us/orders/2016ords/16-130.pdf

15. Oregon Public Utility Commission (OPUC). (2019). *Order No. 19-016*. https://apps.puc.state.or.us/orders/2019ords/19-016.pdf

16. Oregon Department of Energy. (n.d.). *Internal Analysis. Data on file at the Oregon Department of Energy.*

Energy 101: Electric Sector Resource Planning and Acquisition



The electric utility sector lacks significant capability to store its generated electricity.[i] As a result, electric utilities must ensure that they have sufficient electricity available to serve the demands of their customers in real-time, all the time. But not all resources need to be electric generating resources (e.g., power plants), as utilities can also meet these demands by investing in energy efficiency measures or developing incentives to shift customer demand patterns from times of higher to lower demand. To do this, utilities must continually evaluate what types of resources are available to them now and in the future, and correspondingly what they expect their customer demand to look like in the future, and then acquire the least-cost, least-risk portfolio of resources to meet demand.

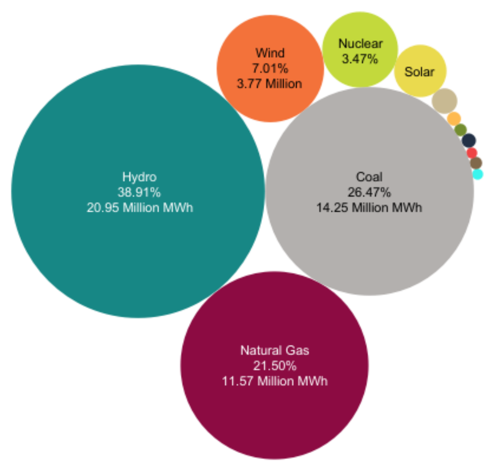
This section provides foundational information on:

Resource Planning. How do electric utilities in Oregon identify a need to develop or acquire new generating resources to serve customer demand in the future?

- *Investor-Owned Utilities:* How do investor-owned utilities (Portland General Electric, PacifiCorp, and Idaho Power) engage in this type of planning? What role does the state play?
- *Consumer-Owned Utilities:* How do consumer-owned utilities (e.g., rural electric cooperatives, municipal utilities, and People's Utility Districts) engage in this type of planning? What role does the Bonneville Power Administration play? What role does the state play?

Resource Acquisition: Once an electric utility has identified a need to acquire a new resource to meet customer demand in the future, it has several different mechanisms available to procure the additional necessary resources, including:

- *Spot market purchases:* Historically, electric utilities in Oregon have looked to engage with neighboring utilities in bilateral transactions to acquire resources to meet customer needs over short-term time intervals.
- *Long-term contracts:* In other instances, a utility might project a persistent future deficit that warrants signing a long-term contract (typically ranging from several years to 20 years) to purchase a resource from a third-party on an ongoing basis.
- *Utility-owned projects:* And the final major mechanism involves a utility developing and owning its own resource(s) to meet projected future long-term needs.



Learn about Oregon's electricity resource mix: **www.tinyurl.com/OregonERM**

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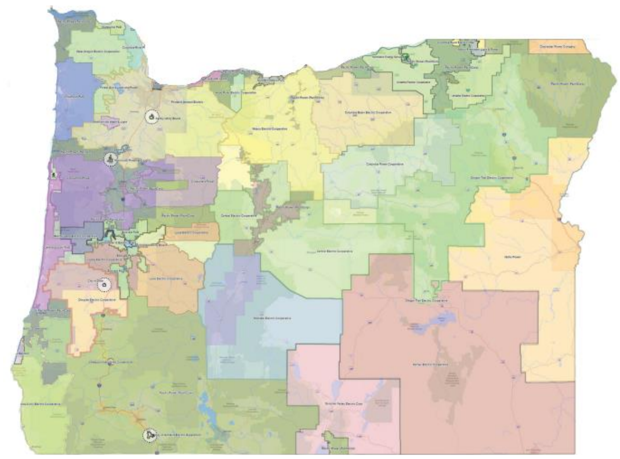
[i] While limited amounts of battery storage are beginning to deploy onto the power grid, this foundational reality of the electric sector has not changed.

Electric Resource Planning



An interactive map of Oregon utilities is available online:
www.tinyurl.com/FindYourUtility

Two types of electric utilities serve Oregon customers: private investor-owned utilities (IOUs) and not-for-profit, consumer-owned utilities (COUs). The regulatory construct is significantly different between IOUs and COUs, including around utility resource planning and the involvement of the state in that process.

The primary mechanism for IOUs to engage in resource planning occurs through the development of integrated resource plans (IRPs) with oversight from the Oregon Public Utility Commission (OPUC). Meanwhile, the 38 COUs serving Oregonians are governed by local boards, with significant variations in how each COU engages in resource planning.

Investor-Owned Utilities: Integrated Resource Planning

In the 1980s, Oregon became one of the first states in the country to require state-regulated electric utilities—Portland General Electric, PacifiCorp, and Idaho Power—to develop least-cost plans, later called integrated resource plans (IRPs).[1] An IRP is designed to identify a utility's need for resources in the future. Development of a plan is typically led by specialists that deploy sophisticated computer modeling tools to evaluate a range of possible future scenarios. Important inputs to this process include a forecast of future customer demand based on expected population and economic growth, the adoption of new electric technologies (such as electric vehicles), and variable weather conditions. The state's three IOUs develop IRPs for submission to the OPUC about every two to three years. According to the OPUC:[1]

> *The IRP presents a utility's current plan to meet the future energy and capacity needs of its customers through a **'least-cost, least-risk'** combination of energy generation and demand reduction. The plan includes estimates of those future energy needs, analysis of the resources available to meet those needs, and the activities required to secure those resources.*

Public Participation

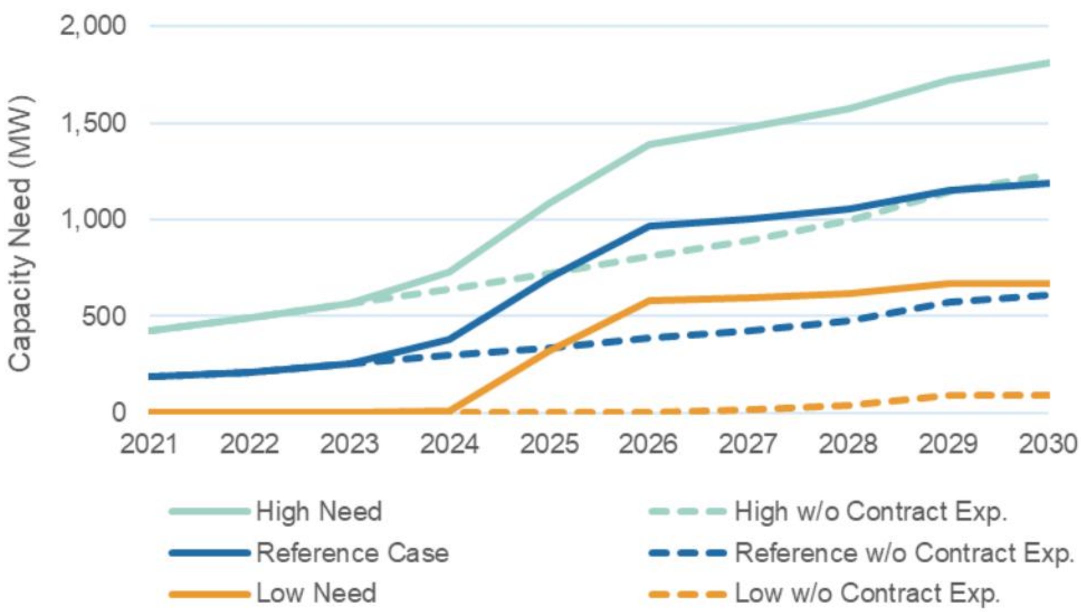
The development of IRPs is an ongoing, iterative process that presents opportunities for stakeholder engagement and feedback. Public meetings are held by the utilities several times a year, as often as monthly, where stakeholders are encouraged to provide information, feedback, and input that can influence how the IRP is shaped. These meetings are also often used as opportunities for the IOUs to share new modeling and forecast information with stakeholders as it becomes available. Public participation can also occur at the OPUC after the utility submits its IRP to the Commission for acknowledgement. ODOE recognizes, however, that the time required to engage in, and the technical nature of, these processes can be a substantial barrier to the meaningful participation of many stakeholders.

Identifying Resource Needs

As a utility engages in the development of its IRP, it is common for the utility to identify a projected future resource deficit—that is, a point of time perhaps several years into the future when it expects to have insufficient generating resources available to meet what it expects its customer demand for electricity to be. This might occur when the utility makes the decision to retire an existing power plant (e.g., such was the case when PGE retired the Boardman coal plant), or due to the expiration of an existing long-term contract to purchase power from a third-party, or simply due to a projected increase in customer demand for electricity.

As an example, the following graph from PGE's 2019 IRP shows how this type of a deficit can be illustrated as part of a utility IRP. The graph forecasts PGE's anticipated future capacity need under a reference case scenario, and across both a low need and a high need scenario. In addition, PGE has also reflected here how that deficit would change if it assumes that its existing contracts for power delivery do *not* expire but were renewed (the dotted lines).[2]

Figure 1: PGE Future Capacity Needs Under Various Scenarios[2]



These types of deficits appear frequently as a routine part of the IRP process. When they occur, the utility will develop an action plan to acquire resources to lower the risk of that future projected deficit materializing. The following section addresses how utilities can acquire resources once a projected future deficit has been identified.

State Role

In addition to the OPUC requiring IOUs to develop and file IRPs on a regular schedule, state agency staff from several agencies (including the Oregon Department of Environmental Quality, OPUC, and the Oregon Department of Energy) engage directly with IOU staff throughout the IRP development cycle. After a utility submits its IRP with the OPUC, the OPUC Commissioners will vote on whether to "acknowledge" the plan. Acknowledgment of the actions in an IRP does not constitute pre-approval by the OPUC of an investment for which the utility may later seek to recover the costs via rates charged to its customers.[1] Instead, the OPUC reviews the prudency of utility investments through a rate case proceeding after investments have been made.

More Information

More information on current Integrated Resource Planning efforts underway in Oregon, including information to track and sign-up for information on public meetings:

PGE: https://portlandgeneral.com/about/who-we-are/resource-planning

PacifiCorp: https://www.pacificorp.com/energy/integrated-resource-plan.html

Idaho Power: https://www.idahopower.com/energy-environment/energy/planning-and-electrical-projects/our-twenty-year-plan/

Track the regulatory dockets at the Oregon PUC related to IOU IRPs: https://www.oregon.gov/puc/filing-center/Pages/Key-Cases.aspx.

The NW Power & Conservation Council: Regional Power Plan

Individual electric utilities engage in their own resource planning, identify their own needs, and develop their own action plan to acquire resources when necessary. Meanwhile, the Northwest Power and Conservation Council, pursuant to the 1980 Northwest Power Act,[ii] develops a regional power plan every five years "to ensure an adequate, efficient, economical, and reliable power supply for the region."[3]

The regional power plan includes several key provisions, including:[4]

- a regional electricity demand forecast;
- electricity and natural gas price forecasts;
- an assessment of cost-effective energy efficiency potential;
- identification of a least-cost portfolio of generating resources.

While the regional power plan guides resource decision-making by the Bonneville Power Administration, it has no regulatory effect on the electric utilities that serve retail customers in Oregon. Instead, the regional power plan is relied upon by Oregon utilities mostly as an informational resource that helps them better understand the regional landscape when engaging in their own planning efforts.

The most recent five-year regional power plan, the 2021 Northwest Power Plan, was published in February 2022: **https://www.nwcouncil.org/2021-northwest-power-plan/**

[ii] Passage of the Northwest Power Act was in part a reaction to the lack of an accurate plan and electricity forecast, which led to an overbuilding of resources known as WPPSS (see the History Timeline section of this report). The Act created the Northwest Power and Conservation Council and directed the Council to give priority 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" (NWPCC 7th Power Plan Summary Brochure). The Northwest continues to see benefits from this approach, as energy efficiency is the region's second largest resource behind hydropower.

Consumer-Owned Utilities: Resource Planning

As noted above, COUs are self-governed by local elected boards and not subject to OPUC oversight when it comes to resource planning activities. Some of the state's larger COUs, such as the Eugene Water & Electric Board,[5] engage in integrated resource planning to consider potential future need for resources. Resource planning for most of the state's smaller COUs, however, looks quite a bit different for the reasons described below.

Role of BPA

In all cases, Oregon's COUs have a long history of contracting with the Bonneville Power Administration (BPA) for significant amounts of the power supply necessary to serve their retail customers. COUs are currently engaged in 20-year Regional Dialogue Contracts with BPA that are due to expire in 2028.[6] BPA recently initiated a series of public workshops to address the development of the policies and contracts that it will offer to its customers to meet their evolving needs post-2028.[7]

Under the current contracts, some of the state's COUs receive a ***fixed amount*** of BPA's power output, while that utility supplements the electricity delivery from BPA with output from its own generating resources or from other power contracts. The majority of the COUs that serve Oregonians, however, are ***full requirements*** customers of BPA, meaning that they "generate no power, relying instead on BPA for all of the power needed to meet their total load requirements."[8]

In the case of these full requirements customers, while they could elect to secure and apply non-federal resources to meet their current and future customer needs, their full power needs are currently handled by BPA. If BPA's existing federal resources are insufficient to meet these customer loads, it will procure additional resources (typically through market purchases) to deliver adequate supply to these customers. An important step in this process occurs through the establishment of each utility's Rate Period High Water Mark every two years, which allows for a recurring feedback loop between BPA and the utilities to account for changes to customer demand for electricity.[9]

These utilities were served 100% by BPA in 2021:

- City of Bandon
- Canby Utility
- City of Cascade Locks
- Clearwater Power Company
- Columbia Basin Electric Cooperative
- Columbia Power Cooperative
- Columbia River PUD
- Coos-Curry Electric Cooperative
- Douglas Electric Cooperative
- City of Drain
- Harney Electric Cooperative
- Hermiston Energy Services
- Hood River Electric Cooperative
- Midstate Electric Cooperative
- Monmouth Power & Light
- Oregon Trail Electric Cooperative
- Salem Electric Cooperative
- Springfield Utility Board
- Surprise Valley Electrification Corp.
- Umpqua Indian Utility Cooperative
- Wasco Electric Cooperative
- West Oregon Electric Cooperative

State Role

Resource planning by COUs is not regulated or overseen by the state, but instead by locally elected boards. Staff from the Oregon Department of Energy, however, engages on an informational and regular basis with BPA, and with individual and groups of COU General Managers and other representatives on a wide range of issues.

More Information

Bonneville Power Administration – Resource Planning: https://www.bpa.gov/energy-and-services/power/resource-planning
Bonneville Power Administration – Regional Dialogue (Post-2006) Contracts: https://www.bpa.gov/energy-and-services/power/regional-dialogue
Bonneville Power Administration – Provider of Choice (Post-2028) Contracts: https://www.bpa.gov/energy-and-services/power/provider-of-choice
Eugene Water & Electric Board – Integrated Resource Plan: https://www.eweb.org/about-us/power-supply/integrated-resource-plan

"Prediction is difficult—particularly when it involves the future."
— Mark Twain

It is important to recognize that electric utilities are required to forecast the future when they engage in resource planning. Because of the need to generate power in real-time to meet customer demand at all times, there is little margin for error in the power system. As a result, there is a long history of the utility sector working to proactively identify potential future resource deficits several years in advance to allow for resource acquisition to occur before a significant deficit ever materializes.

Of course, this type of future-looking planning involves a significant amount of uncertainty. Utilities must try to answer questions to inform their planning, such as:

- **Demand growth:** Will the population increase or decrease? Will the economy grow, and by how much? How rapidly will consumers adopt electric vehicles? Are there expected to be large new industrial customers moving to the area? What type of weather extremes should be anticipated?
- **Supply availability:** Are any existing power plants expected to retire or need maintenance? How much power will be available to import from other utilities and other regions at different times of the year? What new resources are planned and when will they become available? Will extreme weather (e.g., drought) affect power generation from resources like hydropower? How much can demand be reduced through investments in energy efficiency measures?

Answering any one of these questions introduces variables into the resource planning process for an electric utility. If the output of the answers to these questions results in having too few resources available, the risk becomes that the utility cannot keep the lights on. To avoid this downside, utilities often err on the side of staying ahead of projected future deficits to maintain some level of surplus resource availability or reserves. While this minimizes risk, it also comes at a cost to ratepayers. How much risk is too much risk to accept? And at what cost? These questions are central considerations when utilities engage in resource planning based on uncertain future conditions.

Electric Resource Acquisition

As noted above, both IOUs and COUs engage in resource planning to identify potential deficits and the need to acquire new resources to meet future customer demand. There are several mechanisms commonly used by utilities to acquire new resources to meet these needs.

Long-term Resource Acquisition

If a utility's resource planning identifies a persistent future need for more resources to meet customer demand, the utility generally has two primary options to acquire such a resource: to develop the resource itself or to enter a contract to purchase output from a resource owned by a third party. And in some cases, if the utility believes sufficient market supply will be available, a utility may opt to meet this type of future need through ongoing spot-market purchases.

Supply-side and Demand-side

It is important to note that these long-term resources are not limited to electricity generating resources (i.e., power plants). Utilities may also find that acquisition of demand-side resources, such as energy efficiency or load flexibility[iii] measures, could more cost-effectively address the need. In the context of an IOU IRP, utilities will evaluate a range of different resource portfolios, including both supply-side and demand-side actions, under different future scenarios to identify an optimal least-cost pathway forward on resource acquisition.

Energy Storage

As noted above, there is a historic lack of storage capabilities in the power system. But this is beginning to change. In some circumstances, utilities may identify energy storage as the optimal resource to meeting a specific future need. For example, this could occur in a circumstance where more solar or wind power is available for generation than what is needed to meet current demand. With conventional resources, like a gas plant, the utility could simply turn off the plant, stop physically burning more gas, and then turn the plant back on later and resume burning that gas physically stored on-site. The solar and wind resource, by its nature, requires the utility to use it when it is available or lose it. Energy storage systems can capture this otherwise wasted (or curtailed) energy for use later. This is one example of the type of scenario that is expected to drive more energy storage onto the power grid to help meet utility needs in the years ahead. See the Energy Storage Technology Review for more.

Risk

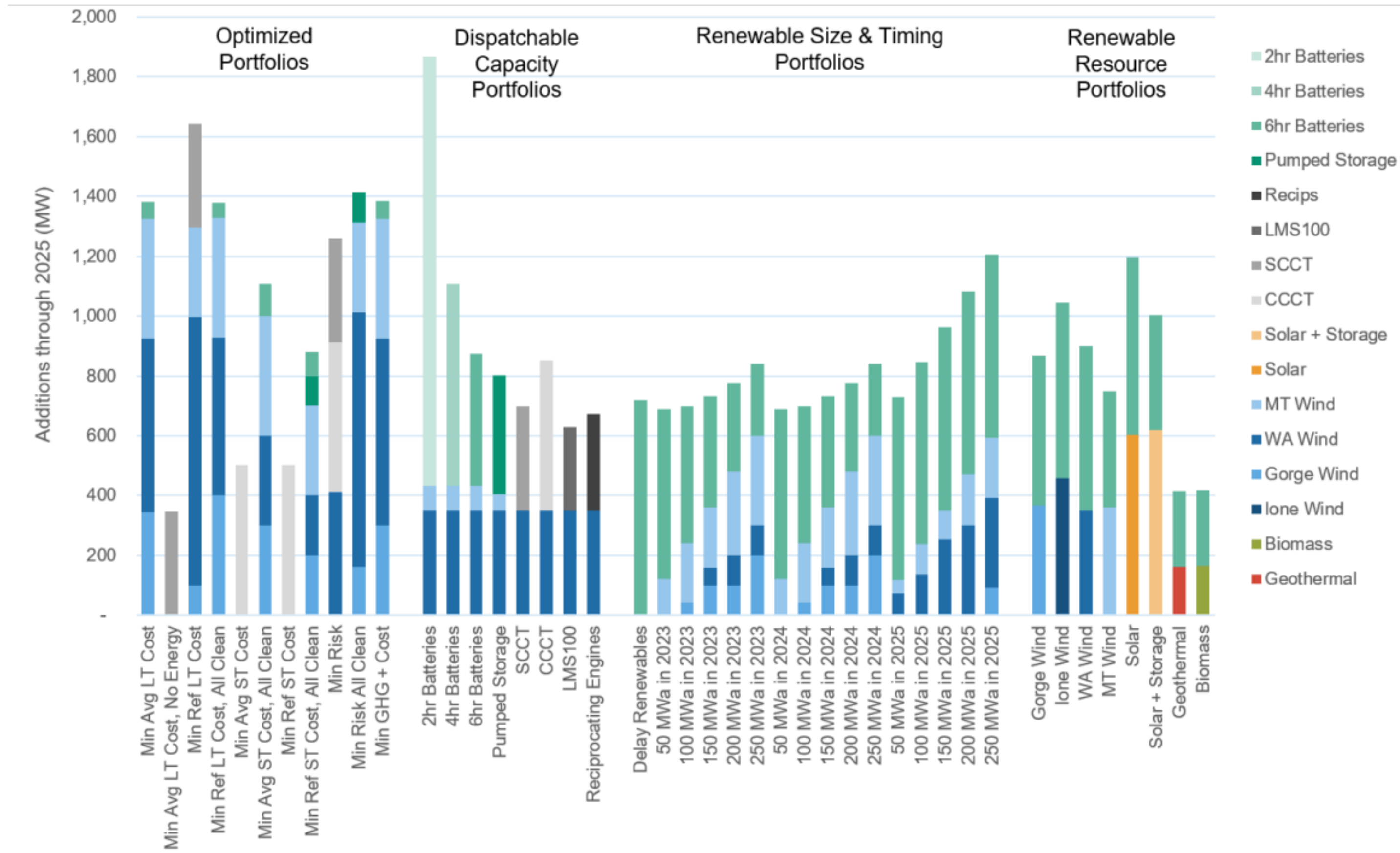
Utilities and their regulators will consider not only the cost of various resource portfolio pathways, but also the risk of choosing one pathway over another. For example, are there particular risks associated with future costs for a certain technology increasing? Or are there risks of a specific type of resource

[iii] Load flexibility, or demand response, refers to the ability of a utility to incentivize customers to shift their demand patterns to better align with the needs of the power system. For example, offering a rebate to customers who voluntarily reduce demand (e.g., a residential customer turning up their thermostat, or an industrial customer shifting into standby mode) on hot summer afternoons. The reduction in power demand that can result serves the same purpose for the utility as acquiring a power generating resource.

failing to perform? Are there risks associated with developing a new power plant with an operational life expected to last for several decades versus relying on contracts to purchase power from a third party? Utilities will also use sophisticated modeling to test how different resource portfolios perform under a variety of scenarios that capture a range of potential future conditions.

The following visual from PGE's 2019 IRP illustrates the types of resource portfolios that utilities will evaluate as part of their planning. This graph displays different types of resource additions through 2025 across the different resource portfolios evaluated.[2]

Figure 2: PGE Resource Additions Through 2025 Across the Portfolios



Resource Strategy

Once a strategy for long-term resource acquisition has been selected, the utility may take direct action itself (e.g., to invest in energy efficiency or develop load flexibility programs for its customers), enter directly into negotiations to purchase a targeted resource, or develop a Request for Proposals to solicit bids from third parties for the amount and type of resources it seeks. Depending on the type of resource the utility identifies as being necessary, the lead-time required to acquire the resource could be several years (or more) in the case of a large-scale power plant.

Utility-Scale Power Plants: Project Development Process

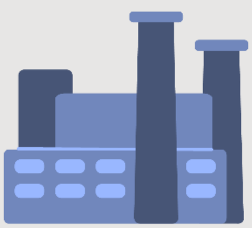
Significant resource planning and work to identify an optimal resource strategy will occur before a utility reaches a decision to either move forward with building a new power plant or signing a long-term contract to buy the output from a new plant developed by a third-party. Planning activities can take several years.

Because both the planning process and the project development process for a specific power plant take several years, often projects begin the development process long before the utility finalizes its resource planning and acquisition strategy.

What are the key steps involved in the project development process?

- Assembly of a capable project team
- Identification of suitable project site
- Acquisition and/or control of the site
- Identification of target project size and technology selection
- Siting and permitting
- Interconnection study process
- Secure a power offtake arrangement (e.g., Power Purchase Agreement or PPA)

Learn more about Oregon's energy facility siting and permitting process in the 2020 Biennial Energy Report: **www.tinyurl.com/SitingPermitting**



Often, once a utility makes the decision to acquire a project it will issue a Request for Proposals (RFP) and solicit bids. In certain circumstances, IOUs may need to comply with OPUC competitive bidding requirements for the RFP. Many projects that have achieved some or all of the project development milestones identified above may submit bids, even though only one or a few of the projects may ultimately be selected to execute a PPA, proceed to development, and become operational.

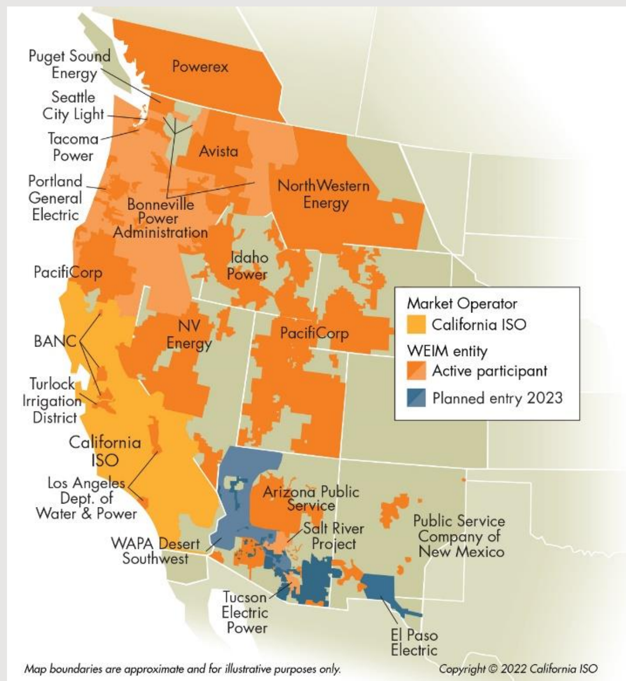
Short-term Resource Acquisition

Resource planning is an ongoing, iterative process designed to identify medium- to longer-term needs (typically three to five years or more in the future) so that utilities have ample time to take action to acquire resources before a resource deficit materializes. That said, short-term resource deficits still occur for a variety of reasons. For example, this might occur if extreme temperatures drive customer demand higher than what was planned for, or if a power plant goes offline for an unplanned reason. Sometimes the utility may need to acquire additional resources for a season, for several weeks, or even several hours.

When these types of short-term needs arise, utilities can buy and sell power directly with other utilities through negotiated deals, generally referred to as bilateral transactions. In most parts of the country, utilities participate in centralized markets administered by a Regional Transmission Organization (RTO) or Independent System Operator (ISO). Where these types of centralized markets exist, utilities are often able to meet short-term needs through the market. This is the type of structure that exists, for example, in California through the markets administered by the California Independent System Operator (CAISO). Because Oregon utilities are not currently members of an RTO or ISO, the Oregon Department of Energy published the *Regional Transmission Organization Study: Oregon Perspectives* in December 2021 that identifies current stakeholder perspectives on the benefits, challenges, and risks of Oregon entities participating in an RTO or ISO. The full report is available online: https://www.oregon.gov/energy/energy-oregon/Pages/RTO.aspx.

What role does the Energy Imbalance Market (EIM) play?

In recent years, all three IOUs operating in Oregon have joined the Western EIM, and BPA joined earlier in 2022. The EIM is an extension of the real-time centralized market platform used by the California Independent System Operator to entities across the west outside of California.



The EIM has been designed to minimize costs to utilities by optimizing the dispatch of participating resources. However, the EIM has been designed specifically to preclude participants from relying on that market to meet short-term resource deficits. This is accomplished by imposing strict resource sufficiency tests on market participants every hour before they are able to participate in the EIM. If a utility has insufficient resources available, then its participation in the EIM will be restricted.

For more information on the impact of the EIM on Oregon entities, see the Policy Briefs section of this report.

What's Next

The electric utility sector continues to undergo transition as the economy moves from a reliance on fossil fuels to clean energy. Following the passage of HB 2021 in 2021, Oregon's IOUs will need to transition to 100 percent clean energy by 2040.[10] This will require a transition away from fossil-fuel resources and the development of a significant amount of new clean energy resources—notably wind and solar.[iv] This is occurring at a time when overall demand for electricity is also likely to increase due to expanded electrification, such as through the adoption of electric vehicles. At the same time, COUs are entering a potential period of transition as their existing long-term contracts with BPA expire in 2028. This is also occurring against a backdrop of large-scale retirements of coal power plants across the western United States, and a changing climate that is increasing pressures on hydropower resources.

As a result of these changes, it is likely that utility resource planning efforts will become even more dynamic, complex, and consequential in the years ahead. Utilities will need to balance the costs and risks associated with different pathways to decarbonize the power system. The scale of fossil fuel retirements will be large, but the scale of clean energy development will be even larger, especially as demand for electricity rises due to increased electrification. Continued momentum toward increased regionalization of energy markets combined with changes in technology—from new types of generation, like floating offshore wind, to new opportunities for incentivizing load flexibility—will create new opportunities and challenges for electric sector resource planning and acquisition.

REFERENCES

1. Oregon Public Utility Commission. (n.d.). *Integrated Resource Planning*. Utility Regulation. Retrieved May 24, 2022, from https://www.oregon.gov/puc/utilities/Pages/Energy-Planning.aspx

2. Portland General Electric. (2019). *2019 Integrated Resource Plan—Executive Summary*. https://assets.ctfassets.net/416ywc1laqmd/RjjS2ZSbLlaxfc7v1LYJp/948c2b32e706c6775e23b4df7e297cc0/2019_Integrated_Resource_Plan_Executive_Summary.pdf

3. Northwest Power and Conservation Council. (n.d.). *Power Planning*. Retrieved May 24, 2022, from https://www.nwcouncil.org/power-planning/

4. Walker, M. (2019, April 11). *The Northwest's Regional Power Plan: Its Role in Securing Our Power Supply*. https://www.nwcouncil.org/news/northwest-s-regional-power-plan/

5. Eugene Water & Electric Board. (n.d.). *Integrated Resource Plan | EWEB*. Retrieved May 24, 2022, from http://www.eweb.org/about-us/power-supply/integrated-resource-plan

6. Bonneville Power Administration. (n.d.). *Regional Dialogue*. Retrieved May 24, 2022, from https://www.bpa.gov/energy-and-services/power/regional-dialogue

7. Bonneville Power Administration. (2022). *Provider of Choice*. https://www.bpa.gov/energy-and-services/power/provider-of-choice

8. Public Power Council. (n.d.). *Glossary of Northwest Electric Industry Terms*. Retrieved May 24, 2022, from https://www.ppcpdx.org/industry-info/glossary/#F

9. Bonneville Power Administration. (n.d.). *Rate Period High Water Mark Process*. Retrieved May 24, 2022, from https://www.bpa.gov/energy-and-services/rate-and-tariff-proceedings/rate-period-high-water-mark-process

10. Oregon State Legislature. (2021). *House Bill 2021*. https://olis.oregonlegislature.gov/liz/2021R1/Downloads/MeasureDocument/HB2021/Enrolled

[iv] A key element of this implementation will occur through the development of Clean Energy Plans submitted to the Public Utility Commission. For more information, see: https://www.oregon.gov/puc/Documents/HB2021-Summary.pdf

Energy 101: Long-Duration Energy Storage

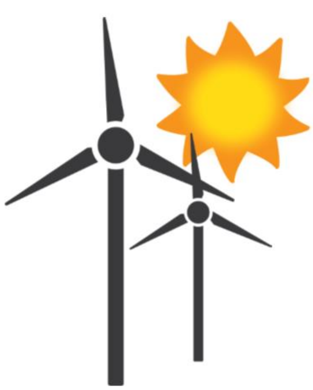
Technical studies in the power sector increasingly identify the need for significant volumes of energy storage to achieve deep decarbonization policy objectives. Most storage systems deployed in recent years have been lithium-ion batteries designed to completely discharge their stored energy to the grid over timescales ranging from two to four hours, which could be referred to as **short-duration energy storage**. These types of battery storage systems can provide significant benefits to consumers and to grid reliability.

Some grid planners and utilities, however, have started to identify a need for storage resources that can discharge energy to the grid for longer durations. These types of storage assets are increasingly referred to as **long-duration energy storage** or **LDES**. For example, the California Public Utilities Commission, which develops a statewide reference system plan as part of its integrated resource planning proceeding, recently identified a statewide need for 973 MW of long-duration energy storage by 2026.[1] However, there is a lack of clarity around what long-duration energy storage in the power sector really means—how to define it, what technologies can deliver it, what the capabilities are or could be, and how much will be needed to cost-effectively decarbonize the power sector.

Renewable Energy and Storage

Consumer demand for electricity is variable throughout the course of a day, over different days of the week, and across different months of the year, and the electric power system has been developed over the last century to accommodate this variability. This has been achieved primarily through the development of large dispatchable power plants – such as those powered by coal or natural gas – that can modulate their power output to correspond to variability in demand.

Wind and solar generation projects, on the other hand, have variable output dependent on the natural availability of the winds and the rising and setting of the sun, respectively. Hydropower resources similarly have variable output based on the availability of water flows driven by precipitation patterns, seasonal runoff from snowmelt, and other factors. While the variability of hydropower tends to be most pronounced over months, seasons, and years, the variability of wind and solar power occurs on daily and hourly timescales while also displaying seasonal variability. This presents a new challenge for grid planners tasked with matching supply availability with consumer demand in real-time. The challenge is one characterized by a mismatch in timing, for which energy storage presents a solution.



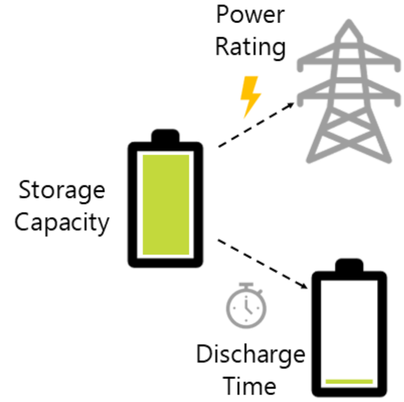
As a result of the anticipated large-scale deployment of wind and solar in the years and decades ahead, the power system's need for energy storage is expected to increase. In some respects, this might result in the power system more closely resembling other sectors, for which large volumes of centralized and distributed storage are ubiquitous. The gasoline and natural gas sectors, for example, have the equivalent of two to three weeks' worth of end-use fuel in storage at any given time. The electric sector by contrast currently has less than three hours' worth of electricity in storage (the vast majority of which is stored in pumped-storage hydro projects).[2] It is highly unlikely that the electric sector would ever approach the volume of storage that exists in the gasoline and natural gas sectors, but given the need for a decarbonized power sector to rely on large amounts of variable output resources, like wind and solar power, it is highly likely that more grid-connected storage will be valuable in the years and decades ahead.

Defining Long-Duration Energy Storage

The Basics of Measuring Energy Storage

In recent years, lithium-ion batteries have become the most common new type of energy storage technology deployed on the power grid. These batteries are flexible power resources that can serve a multitude of grid needs, but they need to be charged with power from the grid. The contribution that these storage assets can make to the grid is largely dependent upon the total capacity of the battery to store energy, how much energy can flow out of that battery back onto the power grid, and for what duration. Those projects are typically reported with the following metrics: [3] [4]

- **Storage Capacity or Energy Rating:** A measurement of the maximum volume of stored energy, in megawatt-hours (MWh) or kilowatt-hours (kWh), within a given storage technology.
- **Power or Power Rating:** A measurement of how much energy, in megawatts (MW) or kilowatts (kW), can flow out of a battery device and onto the power grid in a given instant.
- **Discharge Time or Duration (Hours):** A measurement of the energy-to-power ratio of the storage technology expressed as the amount of time that the technology can discharge at its maximum power rating until it has exhausted its energy supply (typically measured in one-, two-, four-, or six-hour increments).

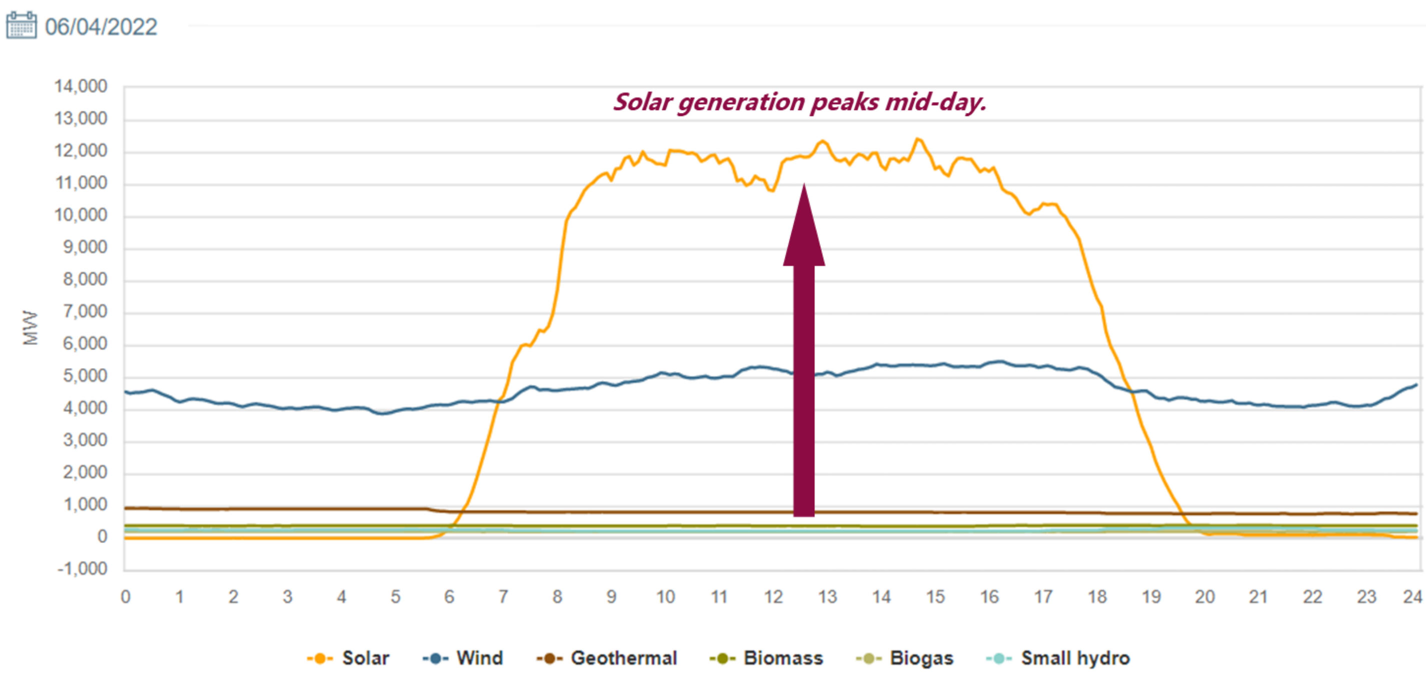


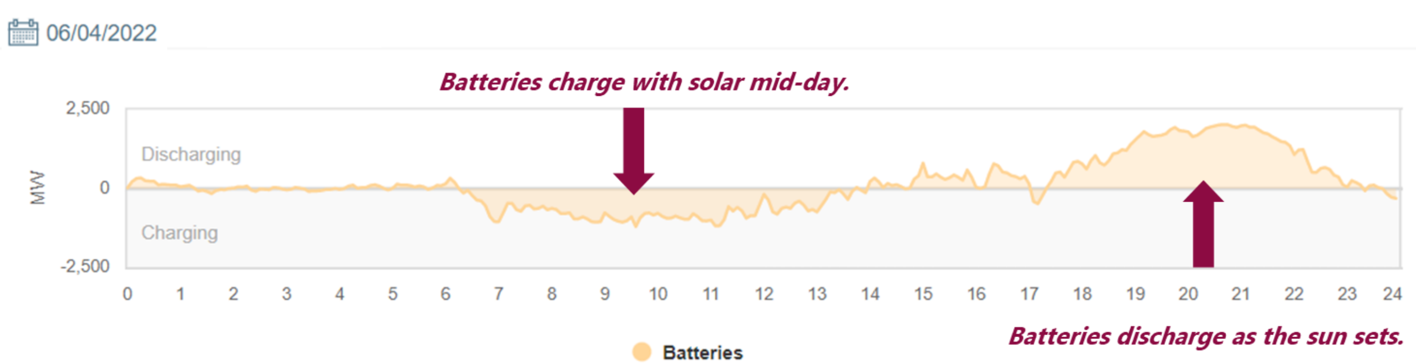
According to the National Renewable Energy Laboratory, battery storage systems with a duration of two to six hours are currently sufficient to provide reliable peaking capacity in most parts of the country until renewable penetrations exceed 25 percent.[5] For this reason, it is common to see grid-connected battery systems reported as having a duration in this range. NREL anticipates future phases of storage deployments greater than eight-hour durations as renewable penetration levels exceed 50 percent.[5] Note, however, that a battery with a fixed power rating and battery capacity can theoretically operate for different durations, while the economics of doing so may vary across different use cases. Consider the following hypothetical 10 MW / 40 MWh battery system:

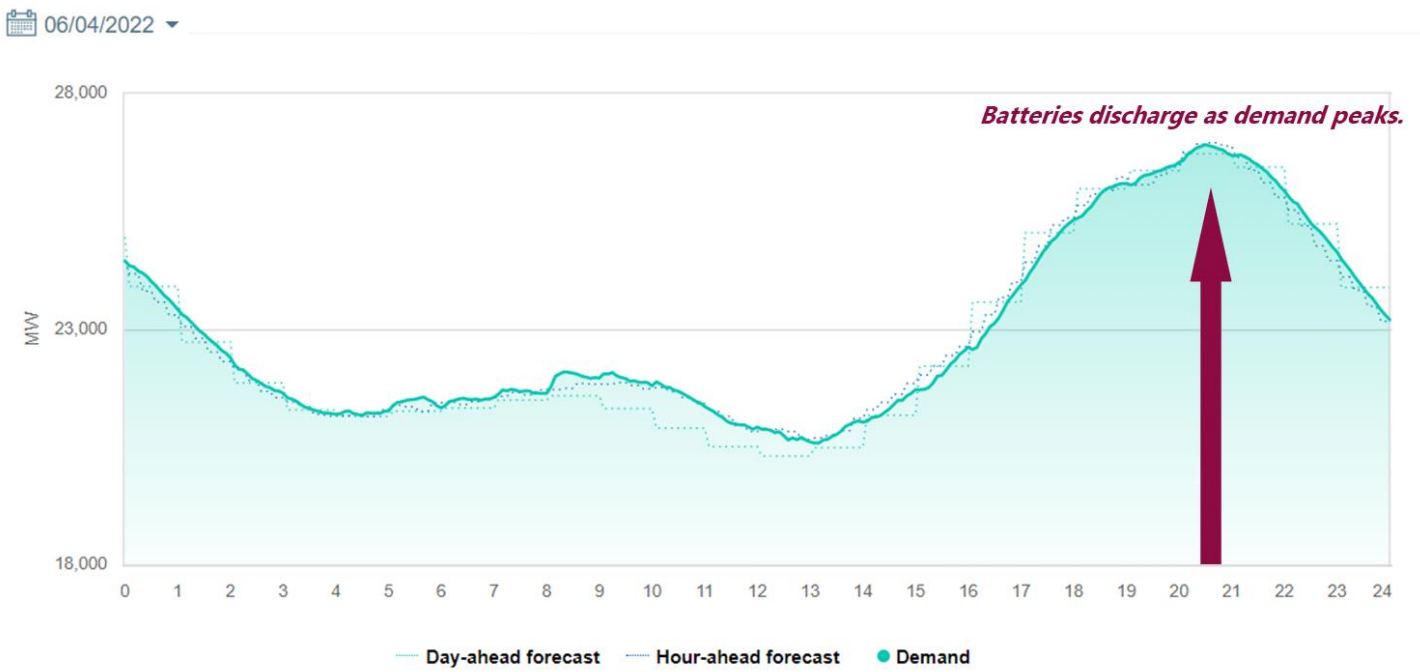
Power Rating	Battery Capacity	Power Output	Duration
10 MW	40 MWh	100% of max	4-hour
		50% of max	8-hour
		25% of max	16-hour

Depending on the use case and the corresponding economics of operating a battery a particular way, a utility may choose to dispatch a storage device in a variety of ways. The following visuals from the California Independent System Operator illustrate one potential use case for grid-connected batteries – storing excess solar generation during mid-day hours and shifting that output to later in the evening as the sun sets and power demand increases: [6] [7]

Figures 1-3: Solar Generation and Battery Charging and Discharging Data from California ISO on June 4, 2022







These figures show that the bulk of the battery discharge currently occurs over a 4-hour time interval, from about 6 to 10 p.m. As the cost of lithium-ion batteries continues to fall, it may become more economical to operate batteries at lower power output to achieve longer durations, or to "stack" 4-hour duration batteries at max power output to achieve effective, longer durations. For example, one scenario could have two 10 MW / 40 MWh batteries operating at max output for four hours, with the first discharging from 4 p.m. to 8 p.m., and the second one discharging from 8 p.m. to midnight.

Defining Long-Duration Energy Storage

Utilities across the country are beginning to procure long-duration energy storage (LDES) projects. As noted above, the California PUC identified a need for 973 MW of long-duration energy storage by 2026.[1] Meanwhile, a coalition of community choice aggregators in California recently issued a request for proposals to solicit bids for long-duration energy storage projects, requiring the projects to be 50 MW or larger, able to discharge at that power output for eight hours or more, and able to become operational by 2026.[8] An electric utility in Minnesota has signed a contract with an LDES project developed by Form Energy that promises to deliver 1 MW of power output for 150 hours by 2023.[8]

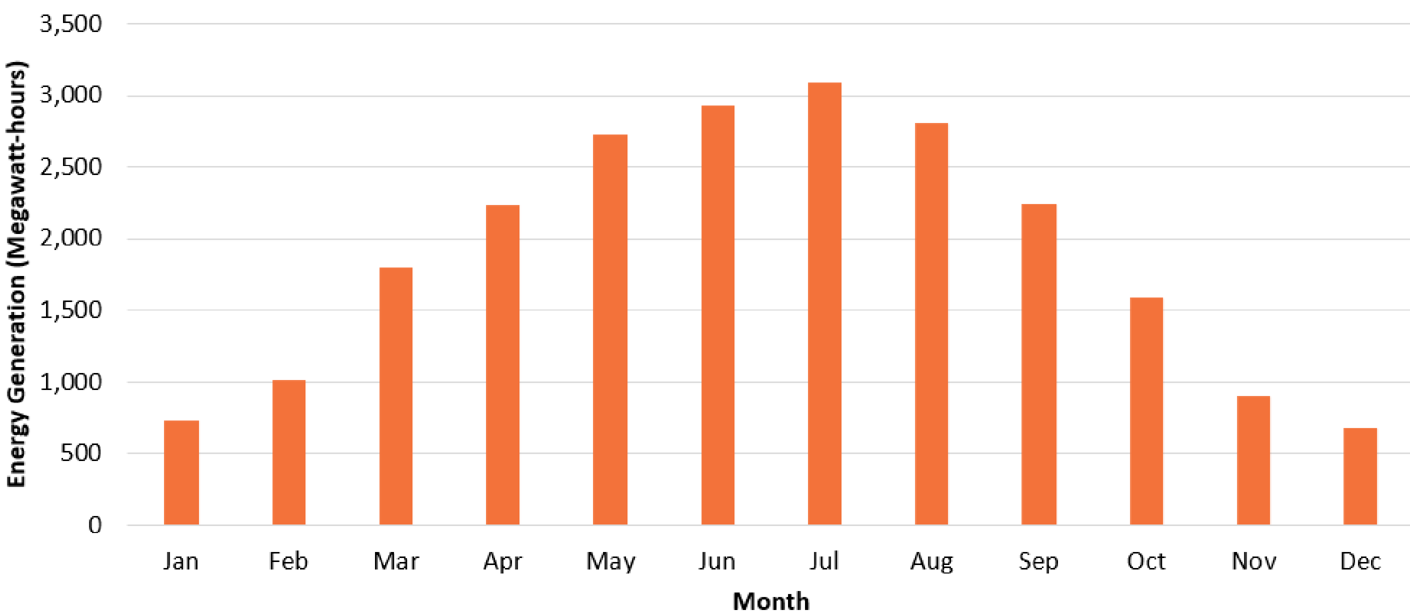
How then does the industry define long-duration energy storage? Despite these emerging efforts to procure LDES resources, no definitive technical definition of LDES exists, as found by the National Renewable Energy Laboratory in a paper published in November 2021 titled, *Storage Futures Study: The Challenge of Defining Long-Duration Energy Storage*.[9] In that study, NREL reviewed recent literature to survey the range of definitions used across the industry. According to NREL, despite the "large range in definitions, there appears to be at least some justification for considering ≥10 hours as a consensus duration" required for a storage device to qualify as LDES.[9] They settled on this threshold for two primary reasons: (1) it was the most often cited number in the literature reviewed, and (2) it is consistent with the definition adopted by the Advanced Research Projects Agency-Energy (ARPA-E) of 10-to-100 hours, which was also referenced by the U.S. Department of Energy's Long-Duration Storage Shot initiative described below.[9]

Table 1: Storage Technologies and Economical Durations of Max Output

Storage Type	Primary Technology	Economical Duration of Max Output
Standard storage	Lithium-ion batteries	2-hour, 4-hour, 6-hour
Long-duration energy storage	Pumped-storage hydro, hydrogen, flow batteries, gravity storage, compressed air, derated lithium-ion batteries, etc.	10- to 100-hour
Seasonal storage	TBD – hydrogen a likely candidate	More than 100-hour

That said, NREL also pointed out that while the literature does identify a lower-end threshold (10 hours), there is very little discussion of the upper-bound number (100 hours) included in the ARPA-E definition.[9] This point may be relevant to the extent it allows us to distinguish long-duration energy storage (10-to-100 hours) from an even longer-duration form of energy storage which might better be conceptualized as "seasonal energy storage" (which might be measured across weeks or even months). For power systems with up to 80 percent penetration of variable output wind and solar, however, NREL contends that 10- to 100-hour LDES systems should be sufficient, and that in the near-term, four-hour storage systems will be sufficient in most regions of the country for most applications.[9] In the long term, consider the visual in Figure 4, which shows modeled power generation output from a hypothetical 10 MW solar project located in Lakeview, Oregon. As this visual illustrates, solar systems in Oregon generate significantly more power during the summer months than the winter months. As the state moves to higher levels of renewable energy, and approaches 100 percent, it may become necessary to consider solutions to effectively store solar energy generated during the spring and summer months to be able to use during other seasons.[10]

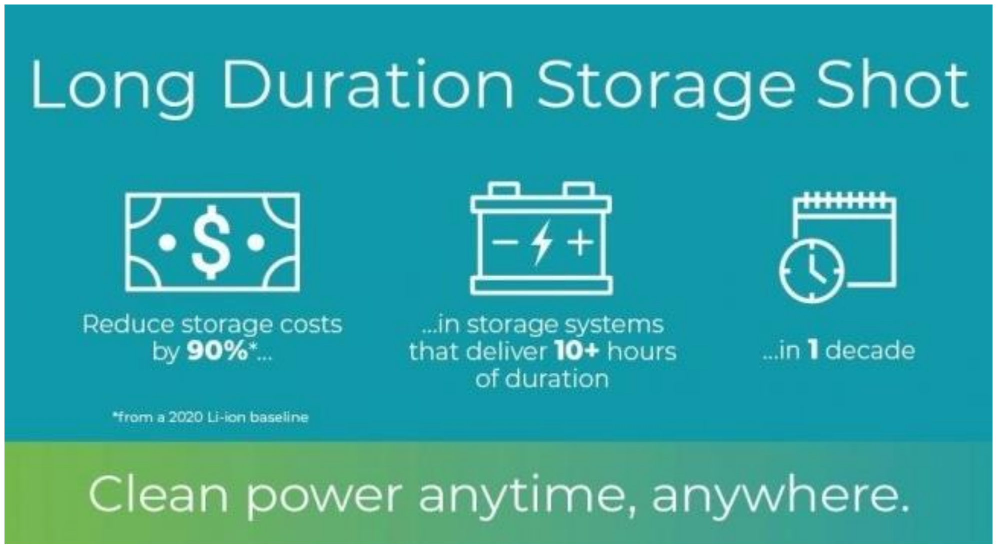
Figure 4: Modeled Power Generation Output from Hypothetical 10 MW Solar Facility in Lakeview, OR



Potential Technology Solutions

Two technologies have dominated energy storage deployments in the power sector to date: pumped-storage hydropower and lithium-ion batteries. Pumped-storage hydropower projects have been in operation for several decades, while the commercial deployment of lithium-ion batteries for energy storage is a recent development over the last several years. Both technologies deliver energy storage to the grid, but both have limitations. Pumped-storage hydropower projects can only be developed in locations with highly specific site characteristics, while lithium-ion batteries may not be cost-effective in delivering the capabilities sought from long-duration energy storage.

In 2021, the US Department of Energy launched the "Long Duration Storage Shot" initiative. The initiative is open to any storage technology, or combination of technologies, that can achieve the following three objectives: (1) reduce costs by 90 percent from a 2020 baseline for lithium-ion batteries, (2) deliver 10+ hours of duration, and (3) can achieve these objectives within 10 years.[11]



There is a range of technologies that might compete in this initiative, including:[12] [13] [14] [4]

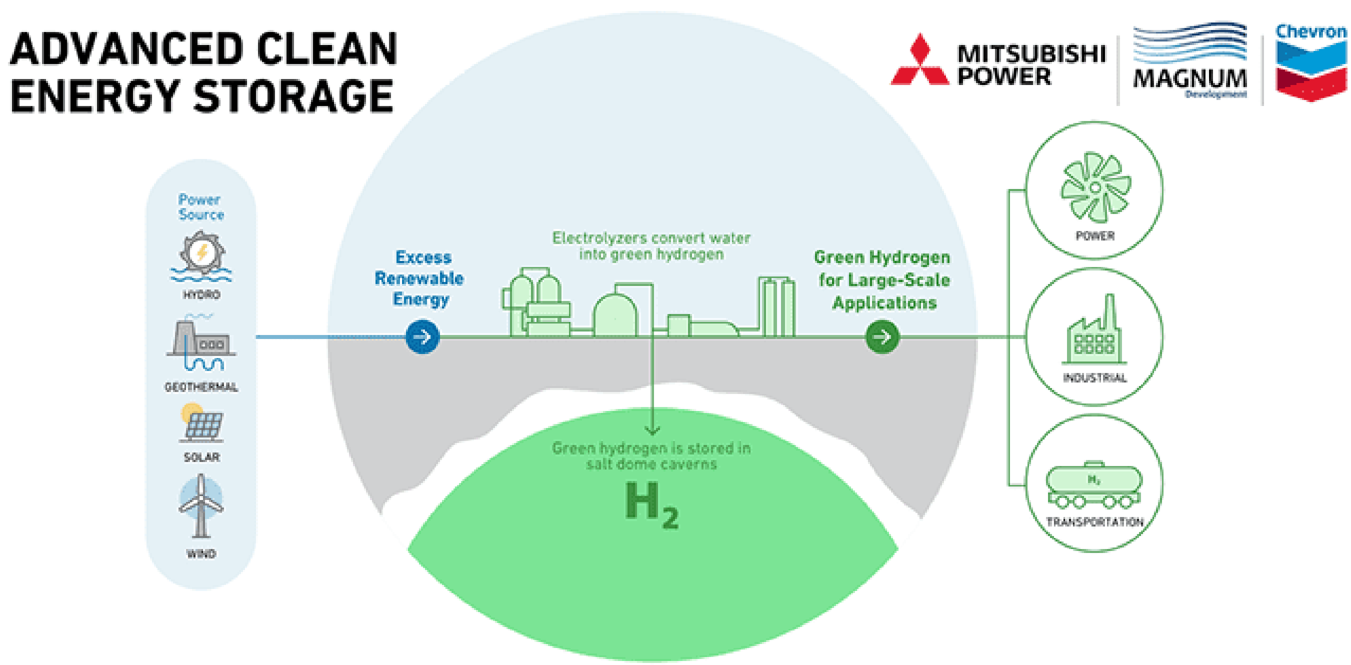
- **Pumped-storage hydropower:** Using low-cost electricity to pump water to a reservoir at elevation, before leveraging gravity to let the water descend from the reservoir to generate electricity at a time of higher need.
- **Mechanical gravity storage:** Similar to the concept of leveraging gravity with pumped-storage hydropower, but instead using cables or other mechanical systems to elevate large masses (e.g., large concrete blocks) using low-cost electricity before letting the masses descend at a later time to generate electricity.
- **Electro-thermal storage:** Converting electricity into thermal energy that can be stored as heat (e.g., in molten salt) or cold (e.g., in a chilled liquid), before using a heat engine powered by a temperature differential to convert back into electricity for the grid.
- **Liquefied air:** Using low-cost electricity to supercool and liquefy air in pressurized above-ground tanks that can be dispatched to power a generator and generate electricity when needed.
- **Underground compressed air:** Injecting large volumes of compressed air into underground geologic formations, then releasing the pressurized air to generate electricity when needed.
- **Flow batteries:** A type of battery technology that uses electricity to circulate liquid electrolytes that can charge or discharge electrons.

- **Virtual storage:** Aggregating many distributed resources (e.g., rooftop solar systems, or residential batteries) across a wide area to provide virtual storage capabilities that can either absorb (by increasing demand for power from flexible loads) or generate (by dispatching distributed batteries or rooftop solar systems) power like a large-scale storage system.
- **Hydrogen:** Using an electrolyzer powered by excess renewable energy to separate hydrogen from water that can be stored as a gaseous or liquid fuel, and then either used in a fuel cell or combustion engine to generate electricity when needed.

These technologies each exist at different levels of commercial readiness, with numerous companies actively working on research and development. For example, trade press reports that significant investment funds have recently flowed to companies working on long-duration energy storage systems based on gravity-based energy storage, nickel-hydrogen batteries, an electro-thermal pumped heat energy system, and an iron-air battery.[14] Given the range of different technologies that may be suitable for long duration energy storage, and their varying levels of technological readiness, it is difficult at this point to characterize a single cost of long duration energy storage.

Meanwhile, a consortium of companies is actively developing a long-duration energy storage project—the Advanced Clean Energy Storage Project—at the site of a retiring coal plant in Utah. The project intends to use a 220 MW electrolyzer to convert renewable power into hydrogen, which can be stored in large volumes in salt caverns (each one approximately the size of the Empire State Building) located beneath the site of the power plant. The retiring coal plant will be repowered as an 840 MW gas plant with turbines capable of combusting the renewable hydrogen stored on site. Project sponsors expect that the caverns can store enough renewable hydrogen (labeled "green hydrogen" in the graphic below) to generate 150 GWh of clean energy.[i]

Figure 5: Illustration of Underground Hydrogen Storage Design for Advanced Clean Energy Storage Project[15]



[i] Note that 150 GWh (150,000 MWh) is equivalent to the 840 MW gas plant operating at its theoretical maximum output consecutively for seven days.

While many technologies are expected to compete, it is not yet certain which technology, or combination of technologies, might prove most cost-effective to deliver the kind of long-duration energy storage at-scale that the power sector may require in the decades ahead.

Oregon-Based ESS, Inc. Forging a Path for Long-Duration Energy Storage

ESS Inc. is ready to bring more long-duration energy storage to the market – and further accelerate the clean energy transition. The Wilsonville-based company's mission is to provide clean and sustainable long-duration energy storage options through its environmentally friendly iron flow batteries that use earth-abundant iron, salt, and water to store energy.

The chemistry also means the batteries are safer and non-toxic – which means they are easier to permit and site and significantly reduce the need for fire suppression or containment preparations. At the end of a battery's 25-year life, it can also be recycled to keep materials out of landfills.

ESS has storage solutions for different customer types, including utilities, commercial businesses, and industries. The company's *Energy Warehouse* product is designed to store up to 400 kilowatt-hours of electricity, providing storage durations of four to 12 hours. ESS's *Energy Center* model is designed for utility-scale needs, providing megawatts of power with a duration of six to 12 hours. Energy Center capacity varies depending upon site design and customer needs, but a one-acre footprint can support approximately 8 megawatts, and 64 megawatt-hours.

As Oregon and other states work toward clean energy goals, including 100 percent clean electricity by 2040, long-duration energy storage solutions like these can support variable renewable energy resources, like wind and solar, to strengthen overall grid reliability and provide power when Oregonians need it.

Learn more about ESS online: https://essinc.com/

In August 2022, Oregon Department of Energy Director Janine Benner joined U.S. Department of Energy Secretary Jennifer Granholm, Oregon Senators Ron Wyden and Jeff Merkley, Oregon Governor Kate Brown, and others on a tour of ESS, Inc.'s Wilsonville campus.

Long-Duration Energy Storage as a Tool for Decarbonization

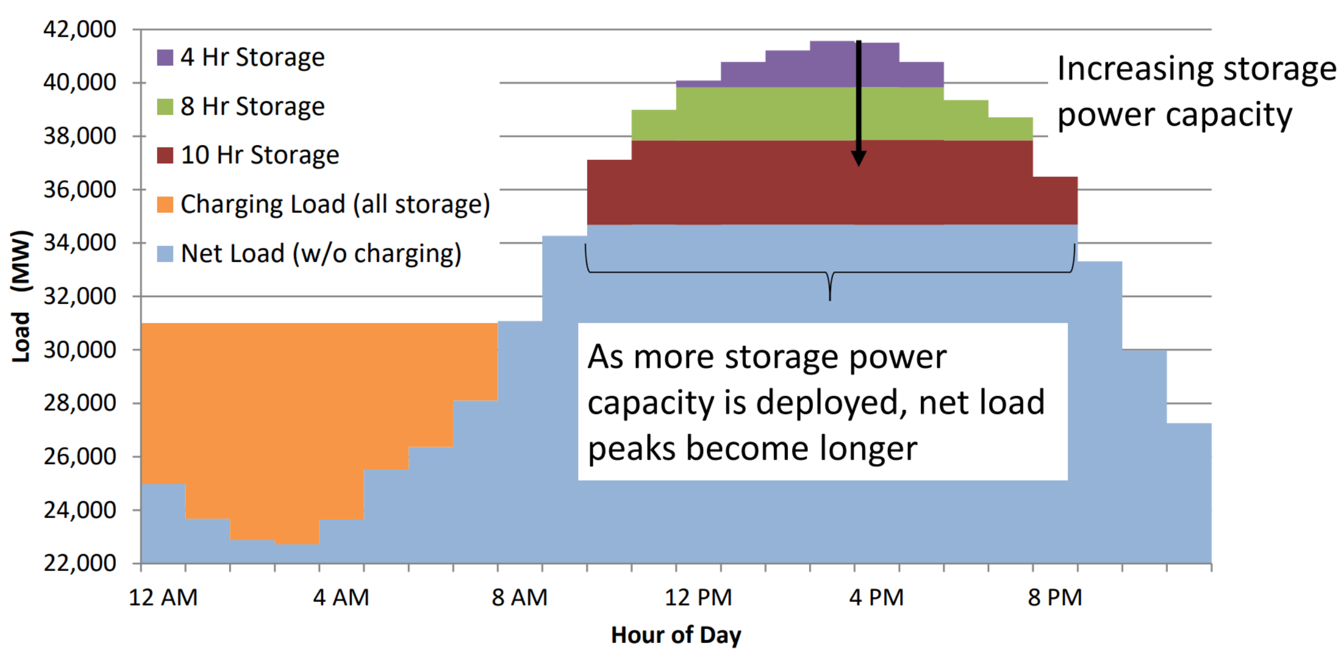
The potential need for LDES solutions to support a deeply decarbonized power system in Oregon and the Pacific Northwest is not yet certain. To reach extremely high levels of decarbonization in the economy, the power system will require some combination of the following solutions to manage the variability in the output of wind and solar generation:[4]

- Dispatchable electricity that can be powered by zero- or low-carbon resources (hydropower, nuclear, fossil fuels with carbon capture, bioenergy, geothermal, or renewable hydrogen);
- Negative emissions technologies that can offset the GHG emissions of fossil fuel resources;
- Significant transmission expansion to facilitate transfers of variable wind and solar across large geographic areas; and/or
- Energy storage systems that can mitigate the imbalances that occur between variability in consumer demand for power and the availability of wind and solar output.

To a large extent, these types of solutions (and others, such as flexible loads that can respond to grid conditions) will be in competition with one another in the decades ahead. It is too soon to know which specific technology pathway will prove the most cost-effective in helping our state and region to achieve our climate objectives. LDES may play a role in supporting a cleaner electricity grid, but recent technical studies do not provide a consistent picture of a definitive need for LDES to support a future grid with large amounts of variable, clean energy generation resources. This means that the power system's need for long-duration energy storage is challenging to define today. The following examples illustrate the diversity of results on the need for LDES provided in two recent studies.

A 2021 study by the National Renewable Energy Laboratory indicates that larger deployments of standard storage (two- to six-hour storage devices) on the grid will affect the potential need for LDES systems.[9]

Figure 6: Effect of Storage Deployment on Duration Needed[9]



As illustrated in Figure 6, four-hour storage systems can offset the apex of peak load where the peak is less than the four-hour output of the battery. Below the apex, the duration of peak load need exceeds four hours, necessitating a longer-term solution to meet this portion of peak demand. The NREL paper indicates this 'longer-duration' need is not unique and could be met by appropriately de-rating a four-hour storage system.[9] For example, in Figure 6, a system manager could operate a four-hour storage system at 50 percent of maximum output to achieve eight hours of duration, or at 25 percent of maximum output to achieve 16 hours, etc. NREL summarizes this dynamic (emphasis added): [9]

> *…the need for durations of more than 4 hours is lessened by the increased deployment of solar PV and the ability to derate shorter-duration storage (if sufficiently cost-effective),* ***making the need for technologies with specific durations as much of an economic issue as a technical one****. Therefore, the need for storage with durations of 10 or more hours largely hinges on a future grid with a specific set of conditions including regional load patterns, renewable energy deployment, previous storage deployments, and the economics of competing storage options.*

Alternatively, a study published in November 2021 by McKinsey finds that, while technically feasible to use derated lithium-ion batteries to sustain output for longer durations, it will not be economical to do so at-scale. The study suggests that long-duration energy storage will become "the lowest-cost flexibility solution" for power systems once the penetration of wind and solar reaches 60 to 70 percent, which may occur in some countries as soon as 2025 to 2035.[16] As a result, McKinsey expects 1,500 to 2,500 GW of LDES to be deployed globally on the power grid by 2040.[16] [4] The study notes, however, that as costs continue to decline for lithium-ion batteries and as grid-connected battery installations increase, LDES systems may be less cost-effective.

Next Steps

As explored in this report's *Charting the Course for Oregon's Energy Future* Policy Brief, the scale of solar and wind energy development necessary in the decades ahead to achieve mid-century policy objectives is substantial. There is also consensus in the literature that a significant deployment of grid-connected energy storage technologies will add value in helping to mitigate supply and demand imbalances that result from this buildout of variable wind and solar generation. That said, grid planners and utilities do not yet have certainty about the extent to which dedicated ***long-duration*** energy storage solutions (as opposed to ***short-duration*** energy storage solutions, such as the two-hour and four-hour batteries that are beginning to proliferate in the power sector) may be required to cost-effectively decarbonize the power system in Oregon and the region. And to the extent that grid planners and utilities do identify a clear need for long-duration energy storage, it is not yet certain what technology, or suite of technologies, will be best positioned to meet that need in the decades ahead.

REFERENCES

1. California Public Utilities Commission. (2020). *2019-2020 Electric Resource Portfolios to Inform Integrated Resource Plans and Transmission Planning (D.20-03-028)*. https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M331/K772/331772681.PDF
2. Oregon Department of Energy. (2020). *Energy 101—Resource Adequacy*. https://www.oregon.gov/energy/Data-and-Reports/Documents/2020-BER-Energy-101.pdf
3. McLaren, J. (n.d.). *Batteries 101 Series: How to Talk About Batteries and Power-To-Energy Ratios*. Retrieved May 24, 2022, from https://www.nrel.gov/state-local-tribal/blog/posts/batteries-101-series-how-to-talk-about-batteries-and-power-to-energy-ratios.html
4. Sepulveda, N. A., Jenkins, J. D., Edington, A., Mallapragada, D. S., & Lester, R. K. (2021). The design space for long-duration energy storage in decarbonized power systems. *Nature Energy*, *6*(5), 506–516. https://doi.org/10.1038/s41560-021-00796-8
5. Denholm, P., Cole, W., Frazier, A. W., Podkaminer, K., & Blair, N. (2021). *The Four Phases of Storage Deployment: A Framework for the Expanding Role of Storage in the U.S. Power System*. National Renewable Energy Laboratory (NREL). https://www.nrel.gov/docs/fy21osti/77480.pdf
6. California Independent System Operator (CAISO). (2022). *Supply, Today's Outlook—June 4, 2022*. https://www.caiso.com/todaysoutlook/Pages/index.html
7. California Independent System Operator (CAISO). (2022). *Demand, Today's Outlook—June 4, 2022*. https://www.caiso.com/todaysoutlook/Pages/index.html
8. Spector, J. (2020, October 26). *So, What Exactly Is Long-Duration Energy Storage?* GreenTechMedia. https://www.greentechmedia.com/articles/read/so-what-exactly-is-long-duration-storage-explained
9. Denholm, P., Cole, W., Frazier, A. W., Podkaminer, K., & Blair, N. (2021). *The Challenge of Defining Long-Duration Energy Storage*. National Renewable Energy Laboratory (NREL). https://www.nrel.gov/docs/fy22osti/80583.pdf
10. National Renewable Energy Laboratory (NREL). (n.d.). *PVWatts Calculator—Solar Resource Data*. https://pvwatts.nrel.gov/pvwatts.php
11. U.S. Department of Energy (USDOE). (n.d.). *Long Duration Storage Shot*. Retrieved May 24, 2022, from https://www.energy.gov/eere/long-duration-storage-shot
12. U.S. Department of Energy (USDOE). (n.d.). *Solar Integration: Solar Energy and Storage Basics*. Retrieved May 24, 2022, from https://www.energy.gov/eere/solar/solar-integration-solar-energy-and-storage-basics
13. Spector, J. (2020, March 31). *The 5 Most Promising Long-Duration Storage Technologies Left Standing*. GreenTechMedia. https://www.greentechmedia.com/articles/read/most-promising-long-duration-storage-technologies-left-standing
14. Golden, S. (2021, September 17). *Big money flows into long-duration energy storage*. GreenBiz. https://www.greenbiz.com/article/big-money-flows-long-duration-energy-storage
15. Larson, A. (2021, December 1). Want Long-Term Energy Storage? Look to Hydrogen. *POWER Magazine*. https://www.powermag.com/want-long-term-energy-storage-look-to-hydrogen/
16. Bettoli, A., Linder, M., Naucler, T., Noffsinger, J., Sengupta, S., Tai, H., & van Gendt, G. (2021, November 22). *Net-zero power: Long-duration energy storage for a renewable grid*. McKinsey Sustainability. https://www.mckinsey.com/business-functions/sustainability/our-insights/net-zero-power-long-duration-energy-storage-for-a-renewable-grid

Energy 101: Electrification Options in the Agricultural Sector

Electrifying equipment and vehicles in the agricultural sector can reduce pollution and greenhouse gas emissions from fossil fuels and save energy costs for farmers and ranchers.[1] [2] Oregon farmers and ranchers are already taking advantage of options to reduce fossil fuel use by making their buildings and equipment more energy efficient, practicing reduced-till and no-till farming, and installing renewable energy generation.[3] Increasingly, agricultural producers will also have options to electrify the tools and equipment they use on their farm or ranch.

Oregon agricultural producers rely more heavily on electricity as an energy source than those in other regions of the U.S.[4] Oregon farms, like farms in many other western states, are more likely to irrigate and more likely to power their irrigation pumps with electricity compared to farmers in other regions.[5] According to ODOE analysis for the 2020 Biennial Energy Report, Oregon agriculture gets about 60 percent of its power from electricity with the remaining 40 percent coming from a variety of fossil fuels, while the U.S. agricultural sector as a whole gets about 24 percent of its power from electricity.[6] [4] Oregon agriculture uses about 8,900 billion Btu of energy yearly, which is about 3.5 percent of the total energy used by the Oregon industrial sector.[6]

While electric tractors have so far received the most legislative discussion in Oregon, there are several other important on-farm fossil fuel uses that could be electrified now and in the near future.[7] In some cases, electric equipment is already available, like electric heat pumps for space heating, electric forklifts, and robotic dairy feeders. Electric vehicles like pickup trucks, utility vehicles, and small tractors are new to the market with long waiting lists of potential customers despite higher upfront costs than gas- or diesel-powered versions. Electric and hybrid versions of heavier farm vehicles are still in the research phase and not yet commercially available, while researchers are also exploring options for post-harvest crop processing using electricity. The pace of technological innovation and development in the sector has accelerated in recent years, with researchers developing precision agricultural techniques and autonomous equipment incorporating sensors, wireless communications, and in some cases battery-powered devices such as robots and drones.

This Energy 101 will explore the possible benefits and challenges of electrification for farmers and ranchers, as well as the factors that are likely to affect whether and when agricultural operators will adopt electric equipment. Next, this piece will describe the status of technological and commercial development for different types of electric farm equipment and consider lessons from an innovative Oregon electric tractor demonstration project. Finally, this Energy 101 will consider existing incentives that could promote agricultural electrification and issues that on-farm electrification will raise for rural electric systems.

Electrification of farm and ranch operations, like the electrification of other aspects of our economy such as transportation, and cooking and heating for homes and commercial businesses, is complex and raises several issues relating to sustainability and social impacts. The mining of materials and manufacturing of equipment, as well as the practical and economic challenges of recycling at the end-of-life for batteries, will be important topics for research and innovation. (See the Policy Briefs section of this report for more information)

Current Uses of Fossil Fuels on Oregon Farms and Ranches

Oregon farmers and ranchers increasingly have electric options for many types of equipment and vehicles to support the many different tasks they perform in their agricultural operations. Oregon's diverse mix of landscapes and climates supports a similarly diverse mix of agricultural products. Not surprisingly, Oregon farmers and ranchers use a wide array of production methods and equipment, while relying upon a variety of energy resources including electricity, diesel, gasoline, natural gas, LP gas/propane, biomass, and biofuels.[3] Table 1 lists types of agricultural equipment that currently use fossil fuels and could be candidates for electrification.

Table 1: Current Agricultural Fossil Fuel Uses That Are Candidates for Electrification[8] [9] [10]

Equipment	Agricultural Uses	Fuels Used	Commercialization And Adoption Status of Electric Options
Water pumps	Irrigation, wells, stock watering	Diesel, electricity, solar	Available; irrigation pumps largely already electrified; solar increasingly used for stock watering pumps and small-scale irrigation
Water heating	Process heat, sanitation	Natural gas, propane, electricity	Available; early/low adoption
Small mobile specialty equipment: forklifts, dairy barn equipment, pruning and harvesting platforms	Moving feed, hay, and other materials in farmyards and enclosed or semi-enclosed buildings; dairy feed mixers, alley scrapers for dairy barns	Diesel, propane, electricity	Available; early but growing adoption of electric forklifts and dairy barn equipment
Hand tools and small-scale motorized tools: pruning saws, loppers, trimmers, chainsaws	Pruning orchards, vineyards; trimming weeds; removing downed trees	Diesel, propane, electricity	Available; growing adoption
Space heating (heat pumps, heat exchangers, radiant heating)	Heating greenhouses, workshops, offices, livestock barns	Natural gas, propane, electricity	Heat pumps available, early/low adoption; Heat exchangers under development, limited availability and adoption; Radiant heaters available for small-scale applications, both plug-in and hardwired common in some service territories

Equipment	Agricultural Uses	Fuels Used	Commercialization And Adoption Status of Electric Options
Construction equipment: skid steers, excavators, backhoes	Earth moving, trenching, and digging	Diesel	New to market: limited availability
Small tractors (under 100 horsepower)	Mowing, rototilling, moving fruit bins, tending orchards and vineyards; indoor agricultural operations such as greenhouses and livestock barns	Diesel	New to market: limited availability
Pickup and medium-duty trucks	On-road and off-road transportation; hauling hay, fertilizer, other materials	Gasoline, diesel	New to market: limited availability, wait lists for purchase
Utility vehicles, all-terrain vehicles	Off-road transportation, moving tools and small goods	Gasoline, diesel	New to market: limited availability, wait lists for purchase
Mobile power sources (generators)	Wind machines for crop protection, mobile chilling units, mobile irrigation pump stations	Diesel, gasoline, propane, electricity	New to market: limited availability; field equipment such as wind machines are already plugged into electric service where available
On-farm processing equipment	Drying (thermal/forced air, radio wave), distilling; specialized equipment tailored for individual crops	Natural gas, propane, diesel, biomass	Research phase; early commercial models available for drying grains, alfalfa; low adoption
Medium and large tractors, combines, harvesters: fully electric, hybrid diesel-electric	Field operations including tilling, planting, spraying, harvesting	Diesel	Research phase: not commercially available

Potential Benefits and Challenges for Agricultural Electrification at the Farm/Ranch Level

One of the primary benefits of electrification for farmers and ranchers is reduced energy use. Taking tractors as an example, agricultural tractors in the U.S. consumed 4.3 billion gallons of diesel fuel in 2020, producing 44 million metric tons of CO2 emissions. Only 20 percent of the diesel consumed by tractors is translated into useful work, with most of the energy content wasted either by idling or in the form of heat. On average, electric tractors use 50 percent less energy to do the same amount of work due to the increased efficiency of electric motors.[1]

In addition to more efficient use of energy, **potential co-benefits** at the farm or ranch level include:

- Reducing fuel costs and lowering total costs of equipment ownership over time.[2 11 12]
- Avoiding exposure to fossil fuel price volatility.[13 14]
- Reducing costs and labor time to maintain vehicles (for example, eliminate the need to change oil and coolant or clean the engine compartment for electric tractors and other vehicles).[15 8]
- Reducing or eliminating on-site exhaust fumes and overall greenhouse gas emissions from equipment operations.[2 12]
- Reducing need for engine lubricants and coolants that can pollute water and crops, and reducing or eliminating need to transport and store fossil fuels on-site.[8 16]
- Improving operator safety from reduced exposure to: moving parts within the engine compartment, exhaust, vibration, and noise that can cause hearing loss.[16 2 8]
- Increasing functionality of electrical equipment: precision, remote control and communications capability, interoperability with other precision agriculture technologies, possibilities for autonomous operation, such as self-driving tractors, field and dairy barn robots, and drones.[16 17 14]
- Increasing ability to meet energy needs using on-farm electricity generation from solar, wind, hydropower, and/or biodigesters with battery backup.[16 14]
- Specific to electric tractors: no idling required to operate auxiliaries and implements; maximum torque available starting at zero RPM; regenerative braking adds to battery run-time; for smaller tractors the additional weight of batteries aids with traction and eliminates or reduces the need to attach metal or concrete weights for this purpose.[18 12 8]

Converting from equipment powered by fossil fuels to electric equipment will present **potential challenges** at the farm/ranch level, including:

- Higher upfront cost for electric equipment compared to fossil fuel powered equipment, varying by type of equipment.[2 11 14]
- Limited initial availability of electric versions of some equipment, especially for specialty crops and large field equipment.[10 2]
- Performance concerns for early adopters due to uncertainty about battery life, downtime for charging, and durability and operational capabilities under farm conditions like extreme temperatures, dust, and mud.[9 8 14 19]

- Maintenance and troubleshooting learning curve for owners; concerns about availability of spare parts and trained repair and maintenance professionals in the early phases of adoption.[2]
- Limited knowledge about and trust in the startup companies that manufacture many early models of electric equipment, compared to farmers' long experience with established brands and associated distributors.[2] [19]
- Upfront costs to upgrade on-farm electrical service and/or install a charging station for some types of equipment.[16]
- Lack of electrical service or inconvenient location of existing electrical service to charge electrical equipment in remote fields and pastures.[8] (See *Issues for Further Study* below for additional information about utility service in rural areas and issues raised by agricultural electrification).
- Uncertainty about ability to install on-farm generation, mainly solar, due to lack of a suitable on-site location, lack of experience with permitting requirements, or limitations under land use laws.[8]
- Limitations on stockpiling electric power in the event of grid disruptions, compared to the ability to store diesel and propane on-farm.[9]

Oregon Agrivoltaics Continue to Show Promise

Oregon State University researchers and students have been studying Oregon farming approaches that can blend solar energy (photovoltaics) and agriculture into *agrivoltaics* for mutual benefit. According to OSU's research, agrivoltaics are showing promise, with potential co-benefits for farmers and the environment — including more food, better food, less water use, and more energy.

Plants need light to grow — but it turns out, they don't always need that light from the direct sun, and in certain cases can actually thrive in low-light conditions. OSU's research shows that some plants are less stressed when they have partial shade and produce higher quality crops with less water. And it's not just about crops – an OSU study published in April 2021 showed that partial shading by solar panels allows flowers to delay blooming, giving pollinators more options later in the season.

A 2020 study by the university team showed that co-developing just 1 percent of American farmland with solar energy and agriculture could have a significant economic effect, providing about 20 percent of the total electricity generation in the country with an investment of less than 1 percent of the U.S. budget. The cost would be paid for in energy savings within 14 years. Agrivoltaics could also reduce greenhouse gas emissions by 330,000 tons and create more than 100,000 jobs in rural communities.

Learn more about OSU's agrivoltaics research and five-acre sustainable farming system model: https://agsci.oregonstate.edu/newsroom/sustainable-farm-agrivoltaic

Factors Influencing Rate of Adoption for Electric Agricultural Equipment

Researchers and industry experts expect that many factors will influence the rate at which farmers and ranchers adopt electric equipment, and that the transition from fossil fuels to electric farm equipment will take place over a generation. Electrification of equipment will happen more quickly when it clearly simplifies farmers' work and saves time and money;[1] in these cases electrical equipment will become the industry standard as has already occurred with irrigation pumps in Oregon. The level of investment required to purchase different types of equipment, as well as the risks associated with a transition to unfamiliar equipment with new fueling and maintenance requirements, will also affect decisions about electrification on the farm. Electrification in agriculture is likely to follow similar patterns as electrification in other sectors, although adoption on the farm may be slower than adoption in the transportation and construction sectors. This section will consider the factors that affect whether and when electrification is an attractive option for various agricultural uses, while the next section will discuss the state of technological and commercial readiness for various types of electrical farm equipment.

Electrification of equipment will happen more quickly when it clearly simplifies farmers' work and saves time and money.

Table 2. Characteristics Affecting Rate of Adoption for Different Types of Electric Farm Equipment

Strong Candidates for Early Electrification	Equipment Likely to Be Electrified Later
• Used indoors or near farm buildings with electrical service • Small size • Charges on 110V or 220V outlet • Low differential in upfront cost compared to internal combustion version • Large fuel savings/short payback time • Used daily for routine tasks • Saves time and/or labor • For electric tractors: equipment needed for three to four hours per day; farm operations with light-duty tasks	• Used in remote fields/pastures • Large and mobile, requiring heavy batteries • Requires special charging infrastructure and/or electrical system upgrades • Large differential in upfront cost compared to internal combustion version • Long payback time based on fuel cost savings • Used in time-sensitive farm operations such as planting and harvesting

Characteristics Affecting the Timing of Electrification for Different Types of Equipment

The strongest candidates for early electrification will be relatively small equipment that farmers and ranchers use daily "in the farmyard" or close to the geographical center of the operation, where electric service for charging is already available and the equipment has short payback times due to fuel cost savings.[16 1 8 9] Oregon examples of equipment used in the shop or barn that are likely to be adopted early include electric forklifts and dairy barn equipment (which save time, labor, and fuel) and heat pumps for space and water heating.

The strongest candidates for early electrification will be relatively small equipment that farmers and ranchers use daily.

The next tier of electric equipment for early adoption includes equipment that farmers use in the field or pasture that returns to the barn or shop every night, especially equipment that can be charged using existing 220V plugs. Examples in Oregon include utility vehicles, small tractors, and pickup trucks. As discussed below under the sections on the E-Tractor Demonstration Program and current incentives for electrification, several Oregon organizations are finding creative ways to make these electric vehicles available for trials in the field as they start to come on the market.

In agricultural settings, it is common to use a diesel generator or idle a diesel truck or tractor out in the field to provide power for a variety of purposes, such as unloading grain or running cooling units to extend the shelf life for just-picked fruit. Electrification of those field tasks could occur in parallel with adoption of electric farm vehicles. Electric tractors and pickup trucks can be used as a mobile power source for welders, drills, chainsaws, and other hand tools out in the field or pasture, while larger tools and implements can be powered by electrically charged mobile power stations. Mobile power stations could also run wind machines to provide frost protection in orchards where electrical service is not available,[20 21] charge small tractors or utility vehicles to keep them running all day out in the field during critical times,[22] or provide backup power for farm operations during outages.[9]

Electric and hybrid versions of high-horsepower tractors, combines, and harvesters are likely to be adopted later than other electrical farm equipment.[8 2] This category of equipment includes some of the most expensive equipment used by farmers and ranchers, meaning that replacing internal combustion versions with electric versions will involve significant investments. Large field equipment is used for many time-sensitive operations like planting and harvesting, leaving little down time for recharging, and with large financial risks for delays due to machine breakdowns or missing components.

Another limiting factor for electrification for large farm equipment is the need to develop suitable charging infrastructure near where the machinery is used, since this equipment is generally not returned to the shop or barn each night. Large agricultural operations that farm scattered parcels are most likely to own such equipment. The owners frequently store large field machinery away from the shop or barn rather than bringing it in from the fields every night, as these vehicles travel at low speeds and use agricultural tires that break down rapidly when driven on hard road surfaces. Farmers may have concerns that remotely stored electric equipment like large tractors and harvesters would be vulnerable to weather and theft, particularly to being stripped of wiring and electronic components depending upon market value.[8]

Electric space heating for large agricultural buildings and electric-powered crop drying are also likely to be adopted later than other on-farm uses, if at all, due to cost considerations. Greenhouses in Oregon are mainly heated with propane or natural gas where it is available; the efficiency of natural gas heating for greenhouses has improved over recent decades, and natural gas is likely to remain the most cost-effective method for greenhouse heating for the foreseeable future.[23 9]

Crop drying and other processing commonly occurs on-farm after harvest. As discussed below in the section on technological development and commercial availability, researchers are investigating methods to substitute electricity for fossil fuels in commodity-scale crop drying, but electric drying methods are not currently cost-competitive. Oregon farms produce several niche crops requiring a variety of specialized processing equipment, such as hops, mint, and meadowfoam. An east coast example suggests that at least some agricultural processing in Oregon could be electrified where suitable and cost-competitive technologies are available: the Vermont Electric Co-op has run a successful incentive program to encourage its members to electrify their maple syrup evaporators, with electric evaporators using 22 times less energy than oil-fired evaporators.[1]

Oregon hops growers use specialized processing equipment.

Sector-Wide Factors Affecting Timing and Rate of Agricultural Electrification

Given the capital-intensive nature and seasonal timeframe of agriculture, producers are typically able to make only a limited number of capital improvements each year between the harvest and next season's planting. Electrification of equipment is one among many potential capital improvements that farmers could make in the off-season and will compete with other potential cost-saving investments.[16] Farmers tend to make large capital investments after a profitable harvest for tax reasons, which means that a few strong economic years for the sector could bring a large wave of investment in electrification if suitable equipment, installers, and supporting infrastructure are available at the right time.[2] However, as noted below, Oregon farmers report net cash incomes below national averages, which could be a barrier to electrification.[24]

Experts studying agricultural and environmental sustainability expect that food manufacturers will increasingly seek to bolster their sustainability credentials and will in turn put pressure on commodity growers to implement practices that reduce greenhouse gas emissions and other negative environmental impacts. This pressure from commodity buyers, along with public and utility incentives to reduce fossil fuel use and farmers' own interests in sustainability, will also figure into farmers' and ranchers' investment decisions about whether to adopt electric equipment and/or undertake other improvements offering verifiable and quantifiable environmental benefits.[16]

Overlap with Other Economic Sectors

Electrification of agriculture is likely to follow similar patterns as the electrification of on-road vehicles and off-road construction vehicles, with earliest adoption occurring for: smaller vehicles; vehicles that operate within a limited range of electrical service for charging; and applications with high potential to reduce pollution, vibration, and noise. For example, terminal tractors or "yard trucks" are easier for freight companies to electrify than tractor-trailers that operate primarily on highways.[25] [18] For large highway vehicles, diesel-electric hybrid solutions, including conversion kits for existing tractor-trailers, are likely to be market ready before fully electric trucks;[26 27] this dynamic could apply to large field tractors as well.[28 29] The adoption of electric landscaping equipment is following a similar pattern as industry experts' expectations for agriculture: homeowners and commercial landscapers have been relatively quick to adopt smaller and handheld tools and equipment, which now dominate retail shop floors, while larger equipment like electric riding mowers with sufficient battery life for commercial landscapers currently have high upfront costs that are not made up by fuel savings.[9 30]

Agricultural electrification proponents expect that many general challenges for electrification will be ironed out as markets for electric equipment expand and mature in other sectors. Agriculture will benefit from advances in battery technologies and equipment design in the transportation and construction sectors, as battery prices decline and farmers and ranchers become more accustomed to using electric tools and vehicles.[16 9] On the other hand, as more farm operations adopt electric equipment, prices for used diesel- or gasoline-powered farm equipment could fall, prolonging the life of older fossil-fueled equipment. This dynamic has been seen in the diesel heavy-duty truck market when some states adopt stricter emissions regulations than neighboring states.[31] In response, recent diesel emissions reduction programs require that older engines be disabled in order for recipients to receive an incentive for newly-purchased diesel equipment.[32 33]

Electrification of other economic sectors is often a higher priority for policy makers than electrification of agriculture, given the greater volume of fuel used and the noise and pollution associated with diesel-powered equipment used on and near ports, highways, and construction sites in urban environments.[32] For a sense of scale, Oregonians consumed 76.12 trillion Btu of diesel fuel for transportation in 2018 while Oregon agriculture consumed approximately 1.34 trillion Btu of diesel, making agricultural diesel consumption about 1.75 percent of consumption by the transportation sector.[34] Considering these various factors, electrification of agricultural vehicles could take off slowly in the near term, but the sector could ultimately electrify quickly after electric options mature and reach greater market share for automobiles and diesel equipment in other sectors.[16]

Technological development and commercial availability

Commercially Available Electric Equipment

Electric equipment options to meet on-farm needs are in several phases of development, commercialization, and adoption. In some cases, electric technology has been commercially available for some time. For example, farmers and ranchers in Oregon have largely switched from diesel **irrigation pumps** to electric versions, with USDA surveys indicating that 96 percent of agricultural irrigation pumps in Oregon are powered by electricity.[5] Many of the remaining irrigation pumps are located in areas where extending utility infrastructure is expensive, and where irrigation upgrades are economically feasible only as part of larger water projects receiving conservation funding.[9] Farmers and ranchers continue

About 96 percent of agricultural irrigation pumps in Oregon are electric. Photo: Wy'East RC&D

to make additional irrigation improvements using utility incentives to install variable frequency drives and water- and energy-saving irrigation hardware upgrades.[35] Many irrigation districts in Oregon are implementing and/or planning irrigation modernization projects, replacing open canal/ditch systems with piped, pressurized water delivery to farms. Irrigation modernization projects have allowed farmers receiving pressurized water to reduce the size of their pumps or forego pumps altogether, saving energy and associated expenses for pumping, while allowing irrigation districts and some farms to generate hydroelectricity.[36]

Electric heat pump technology has improved in recent years, and their improved cold weather performance now makes heat pumps a better fit for space and water heating in colder environments like central and eastern Oregon in wintertime.[37] [38] While not yet common on farms and ranches, heat pumps could provide cost-effective and efficient heating and cooling for rural residences, farm workshops, and horse barns, especially if combined with weatherization improvements.[9] Other electric heating technologies, such as radiant heating and heat exchangers, show promise for large scale poultry and hog operations, which are most common in the midwestern and southeastern U.S.[1]

Agricultural and industrial users are adopting electric **forklifts**[18] for multiple work tasks, while many Oregon dairy operations are adopting specialized electric **dairy barn equipment**, including equipment like alley scrapers, hay pushers, and robotic feeders to replace small diesel tractors and skid steers.[39] [40] [41] [42] Forklifts and dairy barn equipment mostly operate in enclosed and semi-enclosed environments, making electric equipment beneficial for indoor air quality.[43] [44] [45]

Agricultural and industrial users are embracing electric forklifts.
Photo: Toyota (CC BY-NC-ND 2.0)

Electric Equipment New to Market

Electric versions of several types of vehicles commonly used on farms and ranches are coming online and sparking interest, with utility terrain vehicles, tractors, and pickup trucks the most high-profile examples. Early offerings in the **electric tractor** market are in the under-40 horsepower and 40-100 horsepower categories — a size suitable for small acreages, orchards and vineyards, and light tasks such as mowing on larger operations.[2] (See "Oregon E-Tractor Demonstration Program" section below for more information about the market status for electric tractors).

At the time of publication, wait lists for **electric pickup trucks** are long and these vehicles are just starting to make their way into consumers' hands.[46] [47] [48] [49] Meanwhile, both established companies and startups are announcing progress on **electric utility terrain vehicles**, with initial sales of a Polaris utility terrain vehicle (UTV) announced for 2022, and UTV prototypes by other startup companies in the works.[50] [51] As industry observers note, the early models for electric UTVs are following a similar pattern as for electric cars, with higher-priced premium versions coming to market first, while lowerpriced, mid-market, and entry-level versions — which may be most attractive to many farm operations — are to be released later.[51]

Established companies are developing electric versions of construction equipment that create zero exhaust and low amounts of noise and vibration, largely to meet concerns in urban environments.[52] [53] [54] Construction equipment such as **backhoes, excavators, and skid steers** are commonly used on farms and ranches as well, and agricultural producers may find electric versions increasingly attractive as costs come down and farmers and ranchers gain experience and comfort with incorporating electric equipment into their operations.[9] **Mobile power stations** that carry large portable battery packs charged using grid electricity are new to the market, and mainly marketed for their emergency response capabilities, such as running heavy equipment for debris cleanup.[22]

Electric Agricultural Equipment in Research and Development

Established farm equipment companies are researching non-fossil fuel powered and hybrid diesel-electric alternatives for **large, high-horsepower field machinery**, and have presented concept vehicles and prototypes at farm shows over the past two decades.[55] [56] [57] [58] As noted above, some researchers expect that hybrid diesel-electric tractor-trailers for highway use will be adopted more quickly than fully-electric versions, a dynamic that could also carry through for large diesel-powered field equipment in the agricultural sector.[26] However, companies developing diesel-electric hybrid tractors have not yet started producing these vehicles for the commercial market.[58] Electric powered options for this class of tractors also remain largely in the research stage of development with very few units sold,[59] and many experts anticipate that additional advances in battery technologies will be needed for large electric tractors to succeed commercially.[60] Manufacturers of heavy duty trucks, tractors and construction equipment are also researching and testing hydrogen-powered versions.[61] [62] [63]

Diesel-electric hybrid tractor technologies promise to reduce fuel consumption while preserving the power and efficiency benefits of diesel. One approach is to boost a tractor's diesel engine with an electric motor when additional power is needed to negotiate hills or rough ground, allowing the diesel engine to run more efficiently at a constant speed and avoiding wear and tear on the engine.[8] Other approaches include using a diesel-powered generator to power electric motors that drive the front axle,[64] or pairing a diesel engine for propulsion of the tractor with electric motors to run implements and/or auxiliaries such as fans and conditioning of the occupant cab. Decoupling the diesel engine from implements and auxiliaries allows each component to run at the most efficient speed for the task at hand and means that a diesel-electric hybrid could use a smaller diesel motor. This approach could allow implements such as unloading augurs to run for some time on battery capacity without requiring the diesel engine to idle, while also taking advantage of electric motors' ability to operate at precisely controlled speeds ranging from zero to 100 percent capacity.[16] [65] [66]

Researchers are also exploring alternatives to reduce or replace fossil fuel use for **grain drying**. Farmers in Manitoba, for example, are interested in switching from fossil fuels to electricity to dry corn after harvest. Switching to electricity for grain drying as much as possible will help farmers minimize the impact of carbon pricing because, like many parts of rural Oregon, electricity in Manitoba is almost entirely generated from renewable sources, mainly hydroelectric.[67] Current crop-drying approaches combine electric fans and conveyors with propane or natural gas as a thermal source. Studies in Canada and Europe indicate that heat pumps could provide thermal energy for drying, as well as cooling the grain at the back end of the process; however, heat pump grain drying equipment is more expensive than current crop-drying equipment and may require farmers to make electrical service upgrades.[68] Similar analysis would be needed to assess how feasible and cost-effective electric crop drying would be in Oregon, taking into account Oregon-specific fuel and electricity prices, utility tariff structures, crops, and drying methods.[69] (See *Issues for Further Study* below for more discussion about possible needs to upgrade electrical service to incorporate electric equipment.)

Another potential electric-powered approach would use radio waves to evaporate the water from grain kernels.[68] [70] This technology could also be used to dry nuts, fruits, alfalfa, biomass like wood chips, and manure, according to a midwestern company offering commercial radio wave drying equipment.[71] [72] [69] Radio frequency crop drying may prove to be a more cost effective option in the long run, but is still in very early commercial development and only likely to be available in the near-term for a subset of Oregon's commodity crops.

Electricity-fueled technologies are better able to take advantage of precision agriculture approaches that incorporate remote sensing and communications technologies to more efficiently and effectively manage field and orchard crops.[16] Researchers are developing and testing autonomous farm equipment, including **small autonomous and remote-controlled devices**, such as drones and robot "swarms," for agricultural operations like weeding; monitoring crops, livestock, and fencing; deterring birds from eating fruit in orchards and vineyards; and distributing beneficial insects to control pests.[73] [8] [74] [75] [76] [14] [77] Their usefulness will increase as battery longevity improves and battery weight decreases. Electric tractor manufacturers, including the company that makes Monarch tractors, are testing **self-driving tractors**.[17] Finally, researchers and early adopters are testing **electrostatic weeding machines** in Europe and locally in Oregon[78] [79]

Oregon E-Tractor Demonstration Program

Oregon is home to a pioneering "tractor share" program, giving farmers and ranchers around the state an opportunity to try out an electric tractor on their property. The program is a joint effort by four local organizations: Sustainable Northwest, Forth, Bonneville Environmental Foundation, and Wy'East Resource Conservation and Development Area Council, and has received funding from USDA as well as other private donors. To date, the program has five tractors on hand with plans to acquire an additional five or six electric tractors, as well as electric pickup trucks and UTVs and possibly a small excavator or skid steer. The initial tractors purchased under the program are equivalent to diesel tractors in the 30-40 HP range, suitable for mowing and other light duty

An electric Soletrac tractor in use in Oregon. Photo: Wy'East RC&D

tasks; the program also has 70 HP units on order. [80] [81] [19]

Before sending them out into the field, project partners are outfitting the electric tractors with sensors to record operational data and allow researchers to compare field performance and fuel costs with that of diesel-powered tractors. An Oregon State University study using data collected by sensors during the program's first season compared the estimated total cost of ownership of a 30 HP Solectrac tractor with the cost to own and operate a 32 HP John Deere diesel tractor. Researchers commonly calculate the "total cost of ownership" when comparing electric vehicles with internal combustion engine vehicles to account for differences between the initial purchase price and other costs over the life of the vehicle, including financing, fuel, and maintenance costs. Like EVs, electric tractors are currently more expensive to purchase but have lower expected fuel and maintenance costs over the life of the vehicle.

The electric tractor model in the OSU study costs approximately $3,000 more to purchase than an equivalent, similarly equipped diesel model ($28,398 for the electric model versus $25,345 for the diesel model). Taking into account fuel and maintenance costs over an assumed tractor life of seven years, the OSU study found the electric and diesel tractors close to parity on total cost of ownership when assuming that each machine is operated for 250 hours annually. According to the study authors, a more realistic assumption is that a farm would use a tractor in this size category for about 750 hours per year. Assuming 750 hours annual use, the electric version would save between $4,400 and $18,000 in total cost of ownership, with greater savings associated with heavier, more energy-intensive use under the study's "workhorse scenario." Solectrac estimates that its 25 horsepower electric tractor costs $0.78 per hour to run, while an equivalent diesel version would cost around $5.00 per hour to run, depending on fuel prices.[12] The OSU analysis used a diesel price of $3.20 per gallon, meaning that fuel savings would be higher when diesel prices are higher than assumed in the study; the study author notes that the lifetime savings associated with an increase in diesel prices are compounded as annual operating hours of an electric tractor increase. Additionally, the OSU analysis used conservative assumptions that likely overestimated maintenance costs for electric tractors, while also assuming four percent financing for the electric tractor compared to zero percent financing for the diesel model. [11]

Project partners also commissioned a report by the Cadeo Group studying barriers to adoption of electric tractors in the Pacific Northwest. Significant challenges to initial adoption include higher up-front costs and the current sales and financing structure — electric tractor manufacturers are still building their distribution networks to sell their wares directly to farmers, while most diesel tractors and associated implements are sold by local distributors who have longstanding relationships with producers and can offer zero percent financing.[2] [82]


Wy'East RC&D

Despite these challenges, Oregon is one of the states that researchers have identified as most promising for electric tractor adoption.[1] The Cadeo Group study authors suggest several factors that could make electric tractors a good fit for agricultural operations in the region: the preponderance of small acreages and specialty crops, including orchards and vineyards; higher-than-average diesel prices versus lower-than-average electricity prices; and higher-than-average age of existing tractor stock.[2] Oregon farms are smaller than farms in the rest of the region on average — two-thirds of Oregon farms are under 50 acres in size, with less than 10 percent over 500 acres. There are nearly 5,000 farms in Oregon growing fruit, tree nuts, and berries — some of the operations that researchers expect will find small electric tractors most attractive.[83] Many of the specialty crops in Oregon are also grown in Europe, where companies are leaning heavily into electric and hybrid diesel-electric tractor development; for example, the Landini brand from Italy, which is popular in specialty orchard applications in Oregon, has announced a new diesel-electric hybrid model.[64] The study authors note that electric tractor companies are targeting the growers of high value crops and hobby farmers as being the most likely early adopters of the technology.[2] However, as noted above, Oregon farm incomes are lower than the national average, with many small farms making no or low profits, which may outweigh the otherwise attractive fit between electric tractor's characteristics and Oregon's topography and mix of crops.[24]

Current Incentives for Agricultural Electrification

Electrification of internal combustion equipment used in agriculture is one of many actions that policy makers could promote to reduce fuel use, pollution, and greenhouse gas emissions in the sector. Incentives may be effective to promote purchases for various types of electric agricultural equipment as that equipment becomes more widely available over the next few years and as farmers need to replace existing equipment. For example, the OSU study of early Oregon E-Tractor Demonstration Program results, described above, finds that relatively small incentives could help overcome the higher upfront purchase and financing costs for small electric tractors compared to diesel alternatives, and provide a boost to purchases.[11]

While there are no federal or state programs available in Oregon that are explicitly designed to electrify the agricultural sector, investments in several types of electrical equipment used on farms are eligible to receive funding assistance under existing programs. USDA assistance includes grants and low-interest rate loans that can be applied toward purchases of stationary electric equipment in some cases, while owners of mobile electric equipment can generate credits for electric charging under the Oregon Clean Fuels Program. Pickup truck purchases may be eligible for state rebates and/or federal electric vehicle tax credits, although tax credits will be of limited use for operations with little profits.[84] [85] On the other hand, mobile power sources are not eligible for energy storage incentives[9] and agricultural vehicles and equipment are not eligible for state diesel emission reduction incentives. Such programs offer incentives to replace or repower diesel engines in school buses, construction

The Oregon Rural and Agricultural Energy Audit program, funded by USDA and administered by ODOE, can help agricultural producers identify investments that are REAP-eligible and provide documentation of potential energy savings needed for a successful REAP application.

equipment, delivery trucks and tractor-trailers, and equipment operating in and near ports, like barges.[33]

Several USDA programs offer assistance that could support electrification of agricultural equipment. The USDA Rural Energy for America Program offers competitive grants and loan guarantees to agricultural producers for renewable energy and energy efficiency projects. Electric farm vehicle purchases are not eligible for REAP funds, but other stationary electrical equipment that achieves energy efficiency gains compared to internal combustion equipment could qualify.[86] The Oregon Rural and Agricultural Energy Audit program, funded by USDA and administered by ODOE, can help agricultural producers identify investments that are REAP-eligible and provide documentation of potential energy savings needed for a successful REAP application.[87] Under the Rural Energy Savings Program (RESP), rural electric cooperatives are eligible to apply for zero percent loans from the USDA that cooperatives can in turn loan to their customers at below market rates for energy efficiency projects, which could include electrical equipment that achieves energy savings.[88] Few Oregon utilities have participated in the RESP program to date, however, due to the administrative burden or perceived lack of need.[69] The USDA Natural Resource Conservation Service also offers financial assistance for projects that conserve resources, including energy; two electric tractor projects in Oregon have received USDA NRCS Conservation Innovation Grant awards: the E-Tractor Demonstration project and an autonomous electric tractor demonstration project on an Oregon blueberry farm.[89]

Owners of charging stations in Oregon can generate Clean Fuels Program credits for the electricity used to charge farm vehicles, including tractors, utility vehicles, pickup trucks, forklifts, excavators, backhoes, and skid steers. Medium- and heavy-duty diesel-electric hybrid tractors would qualify, similarly to plug-in hybrid electric vehicles, as would agricultural vehicles like small tractors and utility vehicles that are charged on a 220V outlet. Vehicle owners will need to be able to document the charging activities by using a directly metered outlet or by providing charging information generated by the vehicle itself.[90] [91]

Utilities that aggregate Clean Fuels Program credits could use proceeds from credit sales to fund electric tractor adoption. For example, Pacific Power has distributed grants using Oregon Clean Fuels Program funds to the Crook County Fairgrounds for an electric tractor demonstration and to the Oregon Environmental Council for a rural EV pilot project. The OEC project put electric utility terrain vehicles into the hands of field staff and installed electric chargers at three Oregon irrigation districts where they are proving to be nimble and useful for maintenance and other tasks.[92] [93]

An electric utility terrain vehicle in use in Oregon. Photo: Oregon Environmental Council

A few other states are offering incentives for electric agricultural equipment. For example, California is dedicating part of the revenues from its cap-and-trade program to the Funding Agricultural Replacement Measures for Emission Reductions or FARMER Program, offering funding through local air districts to replace high emission agricultural equipment with low- or no-emitting versions, including electric equipment. Local air districts can choose to fund replacements for agricultural trucks, irrigation pump engines, tractors, harvesters, and/or agricultural UTVs.[94] The Colorado Clean Diesel Program offers grants to assist with purchases of electric or hybrid electric equipment to replace certain diesel equipment, including agricultural tractors as well as terminal tractors, construction equipment, transportation refrigeration units, airport ground support equipment, and snow groomers. The Colorado program requires that the diesel equipment be rendered inoperable and gives priority to the northern Colorado non-attainment zone.[95] [96]

Issues for Further Study: Rural Electric Service and Utility Planning

One study estimates that agricultural electrification will increase electric cooperative sales by 12 to 15 percent at the national level.

The degree to which agricultural electrification will affect electrical loads and infrastructure needs for rural Oregon utilities is uncertain and will differ by utility given the diversity among Oregon's rural electricity providers and their service territories. A 2018 study sponsored by the National Rural Electric Cooperative Association estimated that electrification of agricultural equipment currently powered by fossil fuels would increase electric sales in the U.S. by 55,000 to 67,000 GWh annually, with half of the increase due to adoption of electric tractors. The study estimated that agricultural electrification would increase electric cooperative sales by 12 to 15 percent at the national level.[1]

For investor-owned and large consumer-owned utilities with substantial industrial and commercial loads, agricultural electrification will likely have minimal effect on their overall customer demand. Smaller utilities with loads dominated by agricultural users could experience more substantial increases in demand as a percentage of their current loads, as well as significant changes in timing of loads, which in the long term may require acquisition of additional generation resources and/or investments in infrastructure. Further study is needed to quantify the potential for load growth due to agricultural electrification and the impacts for rural utilities, including the timing of potential new agricultural loads in relation to the seasonal peaks in generation by existing and expected resources like hydroelectric, solar, and wind.

Planning for increased loads due to electrification of vehicles, appliances, and other equipment is part of the regular planning that Oregon electric utilities undertake to reliably serve their residential, commercial, industrial, and agricultural customers. Utilities consider likely demand growth, including beneficial electrification, when sizing transformers and substations as they build out and update their distribution systems. In early stages of adoption, existing generation resources and distribution infrastructure will likely be capable of meeting any increased demand due to agricultural electrification with some limited and localized need for infrastructure investments. Future infrastructure investment needs will depend on how much new load is added, the extent to which new loads are staggered or overlap with the timing of existing agricultural loads, and the age, condition, and capacity of a utility's existing distribution infrastructure.[69] Some rural utilities will need to increase their load management capacity to handle the increasingly complicated daily and seasonal patterns of demand for electricity as their customers adopt new electrical equipment that is used at times and in volumes that differ from current demand patterns. On the other hand, increased electrical use on farms and ranches could help some rural utilities to even out their loads on a daily and/or seasonal basis.[69]

At the farm level, most agricultural operators will be able to accommodate the equipment most likely to be adopted first using existing service and outlets. Most farm and ranch properties have at least one 220V outlet to power a welder or other tools; these outlets can also charge small electric tractors, electric pickup trucks, and electric UTVs.[9] Central Electric Cooperative, for example, indicates that the utility's existing distribution systems can absorb the addition of 220V outlets into many existing customer accounts to charge these smaller vehicles without any need for a utility equipment upgrade.[69] Additionally, electric service is already available in dispersed locations in fields and pastures to power electric irrigation pumps; farmers and ranchers may be able to add charging infrastructure at these dispersed sites for electric farm vehicles used in the field.[69]

Some electric agricultural equipment, including large processing equipment currently and in the future fast chargers for electric farm vehicles, may require three-phase power service while many farms and ranches currently receive single-phase power service (See call-out box for an explanation of three-phase versus single-phase power and the significance for agricultural producers).[68 16] Depending on how far the farm or ranch is from the nearest three-phase power connection point and the type of equipment that the farm or ranch wishes to install, an onsite phase converter may be a cost-effective and workable option rather than extending three-phase power to the shop or barn.[97 98] Given that many farms are now using more powerful equipment than they did when rural areas were first electrified last century, several companies design and sell high-powered equipment like irrigation pumps that is specially designed to operate on single-phase power.[97] However, specialty equipment for on-site processing, which in Oregon could include larger scale wine-making, crop drying, malting, and sawmill equipment, will likely require three-phase power.[99 100]

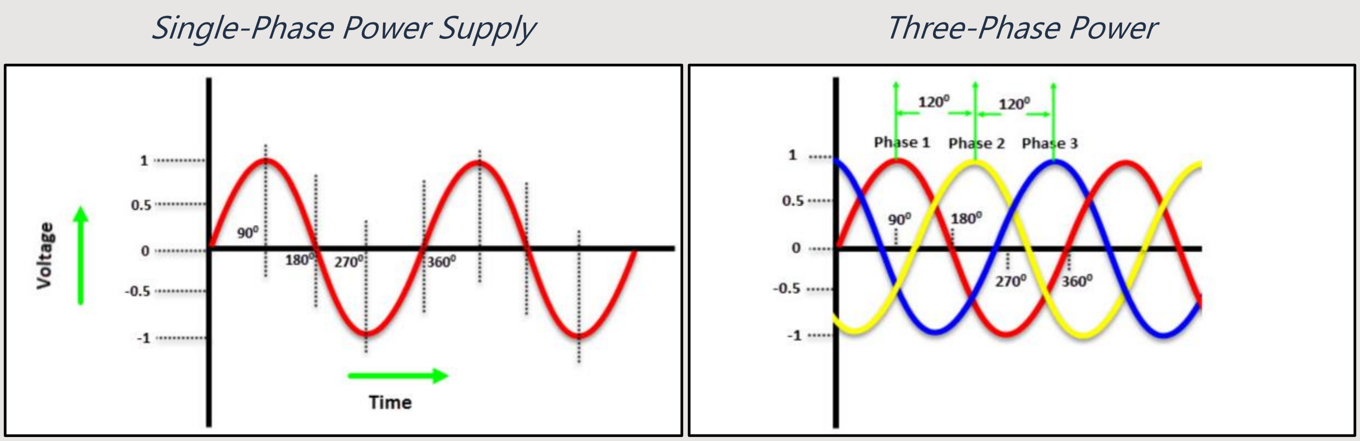
Farms and ranches may also consider installing renewable energy generation onsite to meet all or part of their electricity needs, as well as implementing energy efficiency measures to offset a portion of any increase in electrical use due to electrification. Some examples of cost-effective energy efficiency measures on Oregon farms include installing LED lighting, insulating agricultural buildings, installing variable frequency drives for the motors powering pumps and other equipment, and implementing water-saving irrigation upgrades.[101] Agricultural producers interested in increasing energy efficiency in their operations are eligible to receive an energy audit with 75 percent of the cost covered by a USDA grant administered by ODOE under the ORAEA program; rural electric utilities and the Energy Trust of Oregon also offer energy assessments and energy efficiency incentives for agricultural operations.[87 101 102]

Agricultural producers may be able to shift their electrical use to different times of day to lower their electric bills; irrigators in particular are already experienced with timing their electricity use to balance costs and potential productivity gains, taking advantage of cheaper rates at certain times of day or avoiding demand charges where applicable.[69] Utility representatives stress that they are eager to work with their customers who are considering electrification to provide information about the best times to charge and to make sure that conversions to electric equipment occur smoothly,[69] while researchers also emphasize the need for utilities to gain in-depth understanding of the potential value and the practical considerations of electrification for farmers and ranchers.[1]

Single-Phase Vs. Three-Phase Power

In a single-phase alternating current (AC) power supply, power is distributed using two wires, one that carries the electric current and one that is neutral. AC power takes the form of a wave, meaning that power supplied oscillates and is equal to zero at some point with each oscillation of the wave, between 50-60 times per second. While single-phase power supply is suitable for most residential and small business applications and for small motors up to about five horsepower, single-phase power supplies are less efficient in transfer of power than three-phase. In single-phase circuits some motors may require specialized start up equipment.[103] [104]

Figure 1: Pattern of Alternating Currents for Single-Phase Versus Three-Phase Power Supply[103]



In a three-phase AC power supply using three wires, the power takes the form of three waves staggered by 120 degrees, which means the peak level of power never drops to zero. Three-phase power supplies can deliver more power and are more efficient at transferring power compared to single-phase power supplies. Larger motors, including those used in many types of agricultural processing equipment and fast chargers for electric vehicles, require three-phase electrical power to ensure consistency of power supply.[103]

Implications for Agricultural Electrification

Some agricultural producers wishing to electrify additional equipment may be able to meet their needs using phase converters tailored to the specific size and type of equipment that requires three-phase power. Such equipment, including static, rotary, and digital phase converters, is commercially available and useful for equipment that operates at a constant frequency.[105] [97] [98] Variable frequency drives or VFDs are also able to convert single-phase power supply to three-phase power, and are a better option for small motor applications where it's beneficial to vary the frequency and motor speed. VFDs change single-phase power into direct current, and then invert the direct current to three-phase power.[98]

Agricultural producers who perform large-scale processing on-farm may need to upgrade the utility infrastructure serving their operations. Extending three-phase power to a shop or barn can be costly depending upon the distance for new wiring, and customers who upgrade to three-phase power or install digital three-phase converters on site may incur demand charges on their electric bills that they did not incur previously. Some Oregon rural utilities charge demand charges for three-phase power service (with no demand charges for single-phase) due to the increased demands that the inductive motors cause for utility infrastructure,[68] while other utilities charge demand charges for all irrigation loads regardless of whether those loads are powered by single-phase or three phase service.[69]

REFERENCES

1. Clark, K. (2018). *Farm beneficial electrification: Opportunities and strategies for rural electric cooperatives* (Business & Technology Surveillance). EnSave, Inc. for National Rural Electric Cooperative Association. https://www.cooperative.com/programs-services/bts/Documents/TechSurveillance/Surveillance-Article-Farm-Beneficial-Electrification-October-2018.pdf
2. Cadeo Group. (2022). *Pacific Northwest electric tractor barriers study*. https://www.cadeogroup.com/wp-content/uploads/2022/04/PNW-Tractor-Electrification-Study.pdf
3. Oregon Department of Energy. (2020). *Oregon Department of Energy, 2020 Biennial energy report, policy brief: Agricultural energy use and associated greenhouse gas emissions in Oregon* (p. 56). https://www.oregon.gov/energy/Data-and-Reports/Documents/2020-BER-Policy-Briefs.pdf#page=56
4. Hitaj, C. (2017, February 6). *Energy consumption and production in agriculture*. USDA Economic Research Service: Amber Waves. https://www.ers.usda.gov/amber-waves/2017/januaryfebruary/energy-consumption-and-production-in-agriculture/
5. USDA National Agricultural Statistics Service. (2018). *U.S. farm and ranch irrigation study 2018: Table 13. Energy expense for all well pumps and other irrigation pumps by type of energy used* (U.S. Farm and Ranch Irrigation Study). https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/Farm_and_Ranch_Irrigation_Survey/fris_1_0013_0013.pdf
6. Oregon Department of Energy. (2020). *2020 Biennial energy report: Energy by the numbers, sector profiles: Agriculture* (p. 57). https://www.oregon.gov/energy/Data-and-Reports/Documents/2020-BER-Energy-by-the-Numbers.pdf#page=51
7. Oregon House of Representatives. (2021, May 5). *Oregon Legislative Assembly, House Committee on Energy and Environment, Informational meeting on Electric Tractors*. Oregon Legislative Video. https://olis.oregonlegislature.gov/liz/mediaplayer/?clientID=4879615486&eventID=2021051035
8. Sandau, J. & Oregon Department of Agriculture. (2022, April 18). [Personal communication].
9. Wallace, R. & Wy'East Resource Conservation and Development Council. (2022, April 14). [Personal communication].

10. Environmental and Energy Study Institute. (n.d.). *Beneficial electrification toolkit: Agriculture*. Beneficial Electrification Toolkit. https://www.betoolkit.org/applications/agriculture-1
11. Proctor, K. W. (n.d.). *Total cost of ownership of a compact battery electric agricultural tractor*. 22. https://static1.squarespace.com/static/5eab584a296dca09a66e85a6/t/627946f6c12c786debe434c7/1652115191705/TCO_report_May+2022.pdf
12. Heckeroth, S., Martinez, M., & David, D. (2022, August 16). *Creating a sustainable agricultural strategy*. https://subscribe.act-news.com/SolectracWebinarAugust2022Registration
13. Plaven, G. (2022, May 20). Growing electric—Farmers, nonprofit groups experiment with eTractors. *Capital Press (Salem, OR)*, 001. America's News. http://infoweb.newsbank.com/apps/news/openurl?ctx_ver=z39.88-2004&rft_id=info%3Asid/infoweb.newsbank.com&svc_dat=NewsBank&req_dat=2B140E9C150141AA8396633C0FEEC0E2&rft_val_format=info%3Aofi/fmt%3Akev%3Amtx%3Actx&rft_dat=document_id%3Anews%252F18A196D5943FBB28
14. Navigant Consulting. (2019). *Electrified agriculture: Best practice guide for farmers*. National Electrical Manufacturers Association. https://www.nema.org/docs/default-source/nema-documents-libraries/nema-best-practice-guide-for-farmers.pdf?sfvrsn=306702c7_1
15. Yekikian, N. (2021, June 21). *The government confirms obvious: EVs cheaper to maintain than internal combustion vehicles*. MotorTrend. https://www.motortrend.com/news/government-ev-ice-maintenance-cost-comparison/
16. Dooley, K., Dennis, Keith, Hutchings, Doug, Whitaker, Jim, Heiser, Tony, Slattery, Drew, & Saltzberg, Edward. (2021, November 4). *Beneficial electrification: The future of farming*. https://ssfworld.org/electrify-everything-the-future-of-farming/
17. McClain, S. D. (2021, July 30). Blueberry grower tests self-driving electric tractor. *Capital Press (Salem, OR)*, 005. America's News. http://infoweb.newsbank.com/apps/news/openurl?ctx_ver=z39.88-2004&rft_id=info%3Asid/infoweb.newsbank.com&svc_dat=NewsBank&req_dat=2B140E9C150141AA8396633C0FEEC0E2&rft_val_format=info%3Aofi/fmt%3Akev%3Amtx%3Actx&rft_dat=document_id%3Anews%252F1840B00FFA923B70
18. Wallace, R., Wham, B., Heckeroth, S., & Walkington, A. (2022, May 10). *Electric-powered equipment*.
19. Weisbrod, K. (2022, July 13). A new project in rural Oregon is letting farmers test drive electric tractors in the name of science. *Inside Climate News*. https://insideclimatenews.org/news/13072022/a-new-project-in-rural-oregon-is-letting-farmers-test-drive-electric-tractors-in-the-name-of-science/
20. Orchard-Rite. (n.d.). *Wind machines*. https://orchard-rite.com/wind-machines#overview
21. HF Hauff Company. (n.d.). *Chinook Wind Machines*. https://www.hfhauff.com/engines.php
22. DD DANNAR LLC. (n.d.). *DD DANNAR LLC, "Battery on Wheels."* DD DANNAR LLC. https://www.dannar.us.com/platforms/battery-on-wheels/
23. Stone, J. & Oregon Association of Nurseries. (2020, July 31). *Personal communication* [Personal communication].
24. USDA National Agricultural Statistics Service. (2018). *U.S. agricultural census 2017: Net cash income of producers and operators 2017 and 2012* (U.S. Agricultural Census). https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_1_State_Level/Oregon/st41_1_0005_0006.pdf
25. Brooks, J. (2022, June 1). Orange EV Unveils the e-TRIEVER™, the 3rd Generation of its Industry-Leading Electric Yard Trucks. *Pure Electric Terminal Trucks | Orange EV*. https://orangeev.com/orange-ev-news/orange-ev-unveils-etriever/

26. Hyliion. (n.d.). *Hyliion Hybrid*. Hyliion. https://www.hyliion.com/hybrid/
27. Fox 12 Staff. (2022, June 10). *New hybrid semi-trucks unveiled in N. Portland*. https://www.kptv.com/2022/06/10/new-hybrid-semi-trucks-unveiled-n-portland/?outputType=amp
28. Anderson, B. (2021, January 18). *Steyr konzept is a hybrid tractor with five electric motors—And a drone*. Carscoops. https://www.carscoops.com/2021/01/steyr-konzept-is-a-hybrid-tractor-with-five-electric-motors-and-a-drone/
29. Karsten, B. (2021, December 13). *Steyr develops hybrid tractor*. Future Farming. https://www.futurefarming.com/tech-in-focus/steyr-develops-hybrid-tractor/
30. Schuerman, M. (2022, July 30). Professional landscapers are reluctant to plug into electric mowers due to cost. *National Public Radio*. https://www.npr.org/2022/07/30/1114406216/professional-landscapers-are-reluctant-to-plug-into-electric-mowers-due-to-cost
31. Davis, O. (2015, January 23). *Oregon becomes dumping ground for California's old, polluting diesel big rigs*. Oregonlive. https://www.oregonlive.com/environment/2015/01/oregon_becomes_dumping_ground.html
32. Oregon Department of Environmental Quality. (n.d.). *Department of Environmental Quality: Diesel Emissions Mitigation Grants: Air Quality Programs: State of Oregon*. Oregon DEQ Clean Vehicles. https://www.oregon.gov/deq/aq/programs/Pages/Diesel-Grants.aspx
33. Oregon Department of Environmental Quality. (2022). *Fact sheet: Diesel Emissions Mitigation Fund*. https://www.oregon.gov/deq/aq/Documents/DieselGrants-FS.pdf
34. Oregon Department of Energy. (2020). *2020 Biennial energy report: Energy by the numbers*. Oregon Department of Energy. https://www.oregon.gov/energy/Data-and-Reports/Documents/2020-BER-Energy-by-the-Numbers.pdf
35. Energy Trust of Oregon. (n.d.). *Agriculture: Irrigation pump variable frequency drive*. Energy Trust of Oregon. https://www.energytrust.org/incentives/agriculture-irrigation-pump-variable-frequency-drive/
36. Farmers Conservation Alliance. (2019). *District of the future* (p. 5). http://2pw3hv1eaczqwfliy22eqqvb-wpengine.netdna-ssl.com/wp-content/uploads/2019/08/2-IM-Case-Studies-Packet-2019-July.pdf
37. Osaka, S. (2022, May 9). *Heat pumps do work in the cold—Americans just don't know it yet*. Grist. https://grist.org/housing/heat-pumps-do-work-in-the-cold-americans-just-dont-know-it-yet/
38. Matson, J. (2022, July 12). *Clean Energy 101: Heat Pumps*. RMI. https://rmi.org/clean-energy-101-heat-pumps/
39. Blum, M. (2021, December 8). *Robotic feeders provide consistent feed mix daily to dairy cows – AgriNews*. AgriNews. https://www.agrinews-pubs.com/livestock/2021/12/09/robotic-feeders-provide-consistent-feed-mix-daily-to-dairy-cows/
40. Lely. (n.d.). *Feeding robot—Automatic feeding—Vector—Lely*. Lely Vector. https://www.lely.com/us/solutions/feeding/vector/
41. AMX Galaxy USA. (n.d.). *HETWIN - Robotic feed pusher*. https://www.agriexpo.online/prod/ams-galaxy-usa/product-176496-68416.html
42. Plaven, G. (2022, April 8). Tillamook farmer adopts robotic milking, feeding systems—Tillamook farmer adopts robotic milking, feeding systems. *Capital Press (Salem, OR)*, 008. America's News. http://infoweb.newsbank.com/apps/news/openurl?ctx_ver=z39.88-2004&rft_id=info%3Asid/infoweb.newsbank.com&svc_dat=NewsBank&req_dat=2B140E9C150141AA8396633C0FEEC0E2&rft_val_format=info%3Aofi/fmt%3Akev%3Amtx%3Actx&rft_dat=document_id%3Anews%252F1893BF8D6BD62718

43. Forklift Center. (2022). *Electric forklifts—The pros and cons*. The Forklift Center: Guides. http://www.theforkliftcenter.com/guide/advantages-of-electric-forklifts.php

44. Toyota Forklifts. (n.d.). *Toyota electric forklifts | Assembled in the U.S.A.* Toyota Forklifts. https://www.toyotaforklift.com/lifts/electric-motor-rider-forklifts

45. CAT. (n.d.). *Environmentally Friendly Electric Forklifts*. Cat® Lift Trucks EAME. https://www.catlifttruck.com/products/counterbalance-forklift-trucks/electric-powered-forklift-trucks

46. Davies, C. (2022, April 27). *Why Ford is done selling the 2022 F-150 Lightning*. SlashGear. https://www.msn.com/en-us/autos/news/why-ford-is-done-selling-the-2022-f-150-lightning/ar-AAWEEwn?ocid=entnewsntp&cvid=aa6172c0c8594e83b957d42d87e26d33

47. Falkenberg-Hull, E. (2022, January 5). *2024 Chevrolet Silverado EV brings the thunder to Ford's F-150 Lightning*. Newsweek. https://www.newsweek.com/2024-chevrolet-silverado-ev-brings-thunder-fords-f-150-lightning-1665970

48. Olinga, L. (2022, May 1). *Ram has a product that Ford, GM, Rivian and Tesla won't like*. https://www.thestreet.com/technology/ram-has-a-product-that-ford-gm-rivian-and-tesla-wont-like

49. Mehta, T. (2022, April 27). *More Rivian R1T delays coming as EV truck-maker teases fresh features*. SlashGear.Com. https://www.slashgear.com/845884/more-rivian-r1t-delays-coming-as-ev-truck-maker-teases-fresh-features/

50. Toll, M. (2021, October 19). Volcon's US-built electric UTV gets manufacturing boost ahead of 2022 production. *Electrek*. https://electrek.co/2021/10/19/volcons-us-built-electric-utv-gets-manufacturing-boost-ahead-of-2022-production/

51. Toll, M. (2021, December 1). Polaris launches 110 hp electric RANGER XP Kinetic, "most powerful" UTV on the market. *Electrek*. https://electrek.co/2021/12/01/polaris-launches110-hp-electric-ranger-xp-kinetic-most-powerful-utv-on-the-market/

52. Lambert, F. (2020, March 16). Case unveils all-electric backhoe with 90% lower cost of operation. *Electrek*. https://electrek.co/2020/03/16/case-electric-backhoe/

53. Chang, B. (2020, March 29). *The first fully electric construction backhoe "Project Zeus" was just unveiled and its maker says it's just as powerful as a diesel-powered one*. Business Insider. https://www.businessinsider.com/case-fully-electric-backhoe-loader-project-zeus-2020-3

54. Volvo CE. (2021, October 11). Electric construction reviews by early adopters. *The Scoop*. https://volvoceblog.com/benefits-of-early-electric-construction-equipment-adopters/

55. Lambert, F. (2016, December 5). John Deere unveils latest all-electric tractor prototype for zero-emission agriculture. *Electrek*. https://electrek.co/2016/12/05/john-deere-electric-tractor-prototype/

56. New Holland. (2011). *New Holland presents the first NH2™ hydrogen powered tractor ready to go into service on a farm*. https://agriculture.newholland.com/eu/en-uk/about-us/whats-on/news-events/2011/nh2

57. Breen, J. (2018, December 18). An all-electric John Deere that needs no big battery; just a clever "extension cord." *Agriland.Ie*. https://www.agriland.ie/farming-news/an-all-electric-john-deere-that-needs-no-big-battery-just-a-clever-extension-cord/

58. St. Valentin. (2022, January 13). *Steyr hybrid drivetrain konzept shortlisted for major award*. STEYR Tractoren. https://www.steyr-traktoren.com/en-distributor/agriculture/News-Site/Pages/steyr-hybrid-drivetrain-konzept-shortlisted-for-major-award.aspx

59. FuelCellsWorks. (n.d.). *First 100% hydrogen EOX electric tractor sold by H2trac*. Retrieved April 25, 2022, from https://fuelcellsworks.com/news/first-100-hydrogen-eox-electric-tractor-sold-by-h2trac/

60. Scott, J. (2017, March 29). *Improving tractors, implements with electrification*. Successful Farming. https://www.agriculture.com/machinery/tractors/improving-tractors-implements-with-electrification

61. Bamford, Lord. (2020, July 1). *JCB's first hydrogen powered excavator*. https://www.jcb.com/en-gb/news/2020/07/jcb-leads-the-way-with-first-hydrogen-fuelled-excavator

62. Leo, J. (2021, June 8). *Kubota to roll out hydrogen-powered fuel cell tractors in 2025*. https://www.senecaesg.com/insights/kubota-to-roll-out-hydrogen-powered-fuel-cell-tractors-in-2025/

63. *Volvo Trucks showcases new zero-emissions truck*. (2022, June 20). https://www.volvotrucks.com/en-en/news-stories/press-releases/2022/jun/volvo-trucks-showcases-new-zero-emissions-truck.html

64. Powertrain Diesel International. (2021, November 19). *REX4 Electra—Evolving hybrid, the Landini special unveiled at EIMA 2021*. Powertrain - Diesel International. https://www.diesel-international.com/off-highway/landini-hybrid/

65. Heiser, T. (2019, October 22). *The electrification of agricultural equipment – tractor auxiliaries*. KEB. https://www.kebamerica.com/blog/electrification-of-agricultural-equipment-tractor-auxiliaries/

66. Heiser, T. (2019, October 22). *The electrification of agricultural equipment – tractor and implements*. KEB. https://www.kebamerica.com/blog/electrified-farming-implements-for-agriculture-industry/

67. Province of Manitoba. (n.d.). *Support Manitoba's renewable electricity generation*. Manitoba Measuring Progress. https://mbmeasuringprogress.ca/quality-of-life/support-manitoba-renewable-electricity-generation/

68. Prairie Agricultural Machinery Institute. (2021). *Electrification of grain drying to reduce the impact of carbon pricing—Preliminary investigation*. https://pami.ca/wp-content/uploads/2021/05/Carbon_Reduced_Grain_Drying_Final_Mar-17-21.pdf

69. Elzinga, T. & Central Electric Cooperative. (2022, May 13). [Personal communication].

70. PSC Heating & Drying. (2020, May 27). *Radio frequency basics*. https://www.pscrfheat.com/radio-frequency-basics/

71. DryMax. (n.d.). *Grain Drying Systems*. DryMax Products. https://drymaxsolutions.com/products/

72. Dunn, C. (2020, September 8). *Start-up spotlight: DryMAX Solutions*. Successful Farming. https://www.agriculture.com/technology/crop-management/start-up-spotlight-drymax-solutions

73. Benjamin, C. (2020, August 28). Drone-mounted weed sensor sets scene for cost-efficient spot spraying. *Grain Central*. https://www.graincentral.com/cropping/drone-mounted-weed-sensor-sets-scene-for-cost-efficient-spot-spraying/

74. AgriExpo. (n.d.). *Weeding robots*. https://www.agriexpo.online/agricultural-manufacturer/weeding-robot-2390.html

75. Farmer Georgie. (2020, July 7). Tiny weed-killing robots could make pesticides obsolete. *OneZero*. https://onezero.medium.com/tiny-weed-killing-robots-could-make-pesticides-obsolete-99b3a6359c39

76. Claver, H. (2022, June 9). *Automated drones scare birds off agricultural fields*. Future Farming. https://www.futurefarming.com/tech-in-focus/drones/automated-drones-scare-birds-off-agricultural-fields/

77. Plaven, G. (2022, July 22). Oregon Hop Field Day highlights new facilities, technology. *Capital Press (Salem, OR)*, 007. America's News. http://infoweb.newsbank.com/apps/news/openurl?ctx_ver=z39.88-2004&rft_id=info%3Asid/infoweb.newsbank.com&svc_dat=NewsBank&req_dat=2B140E9C150141AA8396633C0FEEC0E2&rft_val_format=info%3Aofi/fmt%3Akev%3Amtx%3Actx&rft_dat=document_id%3Anews%252F18B65B1E4F9C23B8

78. New Holland. (2021). *New Holland & AGXTEND present the XPower XPN concept, an electric weeding solution for narrow vineyards.* https://agriculture.newholland.com/eu/en-uk/about-us/whats-on/news-events/2021/new-holland-and-agxtend-present-the-xpower-xpn-concept

79. McClain, S. D. (2021, March 19). Electric weed control research in Oregon will zap weeds to death—Oregon researcher explores electric weed control to combat herbicide resistance. *Capital Press (Salem, OR)*, 007. America's News. http://infoweb.newsbank.com/apps/news/openurl?ctx_ver=z39.88-2004&rft_id=info%3Asid/infoweb.newsbank.com&svc_dat=NewsBank&req_dat=2B140E9C150141AA8396633C0FEEC0E2&rft_val_format=info%3Aofi/fmt%3Akev%3Amtx%3Actx&rft_dat=document_id%3Anews%252F1814DABF5F448058

80. Wasco Electric Cooperative. (2021, December 1). *Quiet roar of change*. https://www.wascoelectric.com/quiet-roar-of-change/

81. Callahan, B. & Sustainable Northwest. (2022, April 14). [Personal communication].

82. *Solectrac Adds More Dealerships and Offers Customers a New Tool to Estimate Savings*. (n.d.). Solectrac. Retrieved September 22, 2022, from https://solectrac.com/news/solectrac-adds-seven-new-dealerships-across-the-united-states

83. USDA National Agricultural Statistics Service. (2018). *U.S. agricultural census 2017: Table 71 Summary by size of farm* (U.S. Agricultural Census). https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_1_State_Level/Oregon/st41_1_0071_0071.pdf

84. Normile, B. (2022, June 16). *Which electric cars are still eligible for the $7,500 federal tax credit?* Cars.Com. https://www.cars.com/articles/which-electric-cars-are-still-eligible-for-the-7500-federal-tax-credit-429824/

85. Oregon Department of Environmental Quality. (2022). *EV Charge Ahead Rebate vehicles*. https://www.oregon.gov/deq/FilterDocs/EV-ChargeAheadRebatevehicles.pdf

86. USDA Rural Development. (n.d.). *Rural Energy for America Program renewable energy systems & energy efficiency improvement guaranteed loans & grants*. Rural Development. https://www.rd.usda.gov/programs-services/energy-programs/rural-energy-america-program-renewable-energy-systems-energy-efficiency-improvement-guaranteed-loans

87. Oregon Department of Energy. (n.d.). *State of Oregon: Save energy—Rural & agricultural energy audit program*. Rural & Agricultural Energy Audit Program. https://www.oregon.gov/energy/save-energy/Pages/Rural-Energy-Audit-Program.aspx

88. USDA Rural Development. (n.d.). *Rural Energy Savings Program*. USDA Rural Development. https://www.rd.usda.gov/programs-services/electric-programs/rural-energy-savings-program

89. Davis, A. (2021, July 22). USDA grant supports deployment of Monarch electric tractor. *Highways Today*. https://highways.today/2021/07/22/usda-monarch-electric-tractor/

90. Oregon Department of Environmental Quality. (2017). *Oregon Clean Fuels Program: Electric utilities and the Clean Fuels Program*. https://www.oregon.gov/deq/FilterDocs/guidanceUtilities.pdf

91. Wind, C.-A. (2022, April 28). *Clean Fuels Program: Eligibility of agricultural equipment charging to generate credits* [Personal communication].

92. Pacific Power. (2020, December 18). *Electric tractors, buses and e-bikes: Pacific Power grants are helping Oregon communities jump-start electric mobility*. Pacific Power Newsroom. https://www.pacificpower.net/about/newsroom/news-releases/oregon-electric-mobility-grants-tractors-buses-ebikes.html

93. Schoening, J. (2022, April 15). *EVs are not just for urban commuters*. Oregon Environmental Council. http://oeconline.org/evs-are-not-just-for-urban-commuters/

94. California Air Resources Board. (n.d.). *FARMER Program*. https://ww2.arb.ca.gov/our-work/programs/farmer-program/about

95. Krebs, C. (2021, November 22). *Colorado program encourages e-tractor adoption*. https://news.yahoo.com/colorado-program-encourages-e-tractor-150032238.html

96. Clean Energy Economy for the Region. (n.d.). *Colorado Clean Diesel Program—Powered by CLEER*. Colorado Clean Diesel Program. http://cocleandiesel.org/

97. Morris, B. (2021, April 6). Single phase power solutions partners with Cornell Pumps. *Single Phase Power Solutions*. https://singlephasepowersolutions.com/2021/04/06/single-phase-power-solutions-partners-with-cornell-pumps/

98. U.S. AID. (n.d.). *Powering three-phase electrical devices from a single-phase source: Technical brief #1*. https://www.agrilinks.org/sites/default/files/resources/e4as_brief_1_powering_three_phase_with_single_phase_final_2.pdf

99. GENTEC American Rotary. (2016, November 21). *How to Get Affordable Three-Phase Power on Your Farm*. American Rotary. https://www.americanrotary.com/blog/get-affordable-three-phase-power-farm/

100. Ghrist, G. & RHT Energy. (2022, April 25). *Personal communication* [Personal communication].

101. Energy Trust of Oregon. (n.d.). *Agriculture*. Energy Trust of Oregon. https://energytrust.org/programs/agriculture/

102. Bonneville Power Administration. (n.d.). *BPA agricultural sector energy efficiency program offerings*. https://www.bpa.gov/energy-and-services/efficiency/agricultural

103. Teja, R. (2021, April 3). Difference between single phase and three phase power supplies. *Electronics Hub*. https://www.electronicshub.org/difference-between-single-phase-and-three-phase/

104. Expert Electric. (2016, November 22). Single-phase vs. Three-phase electrical circuits. *Expert Electric Blog*. https://www.expertelectric.ca/blog/what-is-the-difference-between-single-phase-and-three-phase-circuits/

105. Morris, B. (2019, September 27). Single-phase power source for electric vehicle charging stations. *Single Phase Power Solutions*. https://singlephasepowersolutions.com/2019/09/27/single-phase-power-source-for-electric-vehicle-charging-stations/

Energy 101: Oregon State Climate Programs and Actions

In March 2020, Governor Kate Brown issued Executive Order 20-04 directing Oregon state agencies to take a series of significant actions to reduce emissions of greenhouse gases and help prepare for the effects of climate change in Oregon. EO 20-04 further advanced the State's GHG reduction goals by setting targets of at least 45 percent below 1990 levels by 2035, and at least 80 percent by 2050.[1] While some of the directives in EO 20-04 were explicit, many were broadly defined.

To promote understanding of what work is underway and help identify gaps to advance climate policy, the Oregon Department of Energy and the Oregon Global Warming Commission took stock of major ongoing climate change-related programs and projects led by various state entities (agencies, boards, and commissions). The following tables summarize entities' major initiatives related to four main categories:

- **Greenhouse Gas Emissions Reductions and Sequestration**: Programs or policies *directly* resulting in GHG emissions reductions or carbon sequestration (the capturing and storage of carbon dioxide).
- **Assessment of Climate Risks and Vulnerabilities**: Assessment projects and ongoing monitoring of climate change-related risks and associated vulnerabilities emerging in a variety of contexts/sectors in Oregon.
- **Preparing for Climate Change**: Policies and programs facilitating measures to increase resilience to climate change-related risks, as well as policies and programs to transition to a cleaner (low-carbon) economy. This can include *indirect* efforts to reduce GHG emissions and efforts to increase the sustainable use of resources.
- **Educating Oregonians About Climate Change**: Publications, resources, and outreach directed toward educating Oregonians about climate change (including schools and the general public).

Many initiatives are collaborative among several agencies; these initiatives are cross-referenced and are colored in **orange text** below. For mitigation programs/policies, where estimated, the expected GHG emissions reductions resulting from a project/program are noted. Emissions reduction estimates for many programs in this topic will be available in the Oregon Global Warming Commission's forthcoming Roadmap to 2035 report. Such information is helpful to monitor and advance progress toward reaching our state goals.

Business Oregon (Oregon Business Development Department)

Greenhouse Gas Emissions Reductions and Sequestration	Assessment of Climate Risks and Vulnerabilities	Preparing for Climate Change	Educating Oregonians About Climate Change
Rural Renewable Energy Development Zone Program • Provides businesses tax abatement from local property taxes (for 3-5 years) for generating renewable electricity or producing, distributing, or storing biofuels[2] **Solar Development Incentive Program** • Provides businesses incentives for developing qualified solar projects ($0.005/kWh for up to 150 MW of capacity; sunsets Jan 2023)[3]	*No activities in this category*	**Oregon Renewable Energy Siting Assessment (ORESA) – See ODOE** **Oregon's Climate Change Adaptation Framework – See DLCD** **Climate Equity Blueprint – See OHA**	*No activities in this category*

Department of Administrative Services

Greenhouse Gas Emissions Reductions and Sequestration	Assessment of Climate Risks and Vulnerabilities	Preparing for Climate Change	Educating Oregonians About Climate Change
Sustainable Procurement Services Program • Integrates consideration of sustainability and GHG reduction in procurement[4] **Conversion of state fleet to zero-emission vehicles** • 100% of new light-duty vehicles by 2025[5] • Installation of new electric vehicle charging infrastructure **Agency Climate Action Toolkit - Lead** • Provides tool and guidance for agencies to reduce GHGs in their operations **Zero Emission Vehicle Interagency Working Group - See ODOT** **Built Environment Efficiency Working Group - See ODOE**	**Assessment of climate hazards to inform leases, construction, and land purchases** • Inclusion of mid- and long-term climate risk (e.g., from floods and fires) and resilience benefits in decision-making processes[6]	**Building design/retrofit (in progress)** • Incorporates climate change projections and hazard analysis into building design and retrofit plans and statewide policy[7] **Oregon's Climate Change Adaptation Framework – See DLCD** **Climate Equity Blueprint – See OHA**	*No activities in this category*

Department of Consumer and Business Services (Building Codes Division, Division of Financial Regulation, and Oregon Occupational Safety and Health)

Greenhouse Gas Emissions Reductions and Sequestration	Assessment of Climate Risks and Vulnerabilities	Preparing for Climate Change	Educating Oregonians About Climate Change
Oregon Energy Efficiency Specialty Code • Improves Oregon's energy efficiency requirements for new buildings and renovations to achieve 60 percent decrease in energy use by 2030 (relative to 2006)[8] **Oregon Reach Code** • Optional energy efficiency construction standard for builders, consumers, and contractors beyond the state building code[9] **Built Environment Efficiency Working Group - See ODOE**	**Assessment of insurance & climate risk** • Analysis of climate risks (e.g., damage from wildfires), insurance premiums, and mitigation costs to engage insurance industry and account for climate risks in financial risk assessment[10]	**Fire Hardening Grant Program** • Grant for fire hardening in repair or replacement of structures damaged or destroyed in 2020 wildfires[11] **New heat and smoke exposure rulemaking** • Updated existing OSHA rules to better reflect changing hazard conditions and ensure protection for vulnerable workers[12] **Building Codes:** • New residential: fire hardening for construction in high wildfire risk areas by 4-1-23[13] • New residential: Zero energy ready by 10-1-23 • Commercial: irrigation via water recapture by 10-1-25 **Oregon's Climate Change Adaptation Framework – See DLCD**	**Mandatory training for new heat and smoke exposure rules** • Oregon OSHA implementation of risk-mitigation training requirements for exposed/vulnerable workers[14] • Audience: employers/ employees **Public communication campaign about heat and smoke hazards** • Ongoing education outreach on climate-related work hazards in English and Spanish[15] • Audience: general

Department of Land Conservation and Development (DLCD)

Greenhouse Gas Emissions Reductions and Sequestration	Assessment of Climate Risks and Vulnerabilities	Preparing for Climate Change	Educating Oregonians About Climate Change
Climate-Friendly and Equitable Communities • Program to meet climate goals though improved transportation options, more walkable neighborhoods and services in urban areas (with pop. of 50k+)[16] • Requires Eugene-Springfield and Salem-Keizer to develop regional strategy to meet GHG targets **Transportation and Growth Management Program** • Coordinates land and transportation planning to improve transportation efficiency[17] • Supports development of walking/biking opportunities **Every Mile Counts – See ODOT**	**Natural Hazards Mitigation Planning** • Supports state, local, and tribal governments in assessing how climate change will affect natural hazards; identifying vulnerable assets and populations; and assessing overall risk to natural hazard events[18] • Develops Oregon's Natural Hazard Mitigation Plan • Leads the Hazard Mitigation Team for the Office of Emergency Management **Oregon Coastal Management Program** • Supports coastal communities in assessing natural hazards and vulnerabilities specific to the coast[19] • Supports coastal communities in developing and implementing actions to reduce	**Coordinates implementation of FEMA's National Flood Insurance Program in Oregon** • Connects participants with federal program and resources[21] **Interagency Working Group on Climate Impacts to Impacted Communities** • Development of guidance for climate actions for impacted communities with equity focus[22] **Oregon's Climate Change Adaptation Framework – Lead** • Identification of adaptation needs and strategies across Oregon's economy[23] **Climate Equity Blueprint – See OHA** **Oregon Renewable Energy Siting Assessment (ORESA) – See ODOE**	**FEMA National Flood Insurance Program (NFIP) training** • DLCD-hosted training on a range of NFIP-related topics[24] • Audience: local gov/general **Resources on DLCD website** • Information and links for program information, toolkits, local planning, reports, etc.[25] • Audience: general

	vulnerability and risk from natural hazards **Oregon's Climate Change Vulnerability Assessment – Lead** • Assessment of how climate change is affecting the well-being, livelihoods, and cultural identify of Oregonians[20]		

Environmental Quality Commission and Department of Environmental Quality (DEQ)

Greenhouse Gas Emissions Reductions and Sequestration	Assessment of Climate Risks and Vulnerabilities	Preparing for Climate Change	Educating Oregonians About Climate Change
Climate Protection Program • January 2022 program that establishes GHG emission limits on fossil fuel providers/suppliers and large industrial sources (mitigating 25.1 MMTCO2e by 2050)[26] **Clean Fuels Program** • Reduces lifecycle GHG emissions from fuels used in transportation sector by 10% by 2025, 20% by 2030, and 37% by 2035[27] • Resulted in 6.5 MMTCO2e emissions savings through 2020[28] **Oregon Clean Vehicle Rebate Project** • Rebate program to incentivize purchase/lease of new/used zero emission vehicles[29] • Charge Ahead Rebate incentive for low- and moderate-income households to acquire an EV	**Assessment of environmental health cost of carbon-based fuel use** • Identified health outcomes and healthcare cost savings associated with pollution reduction[32] **Ongoing environmental monitoring** • Continued investment in monitoring capabilities, including effect of wildfire smoke on air quality[33] **Material Recovery Programs** **See:** Preparing for Climate Change category	**Wildfire smoke hazard resilience** • Significant investment in air quality monitoring; facilitating wildfire smoke monitoring and reporting • Support for community preparedness and response for associated public health risks[34] **Food Waste Reduction Strategy** • Identifies and funds food waste reduction and outreach[35] • Targets social benefits and lifecycle GHG savings[36] **Built Environment Strategic Plan** • Reduces lifecycle GHG impacts of built environment through voluntary programs, capacity building, grants and more • Centers equity and environmental justice	**Resources on DEQ website** • Information on climate change, DEQ programs, and other state programs and resources[37] • Audience: general **GreenState Podcast** • Explores environment and environmental quality in Oregon[38] • Audience: general **Air, Land & Water Blog** • Covers environmental quality and climate change topics[39] • Audience: general **Bad Apple Campaign** • Statewide marketing campaign educating consumers to reduce food waste and lifecycle emissions from food production • Audience: general

Zero Emission Vehicle Standards[iii] • Advanced Clean Truck Regulations, which requires medium- and heavy-duty truck manufacturers to produce and deliver increasing percentages of zero-emission vehicles[30] • ZEV standards for light-duty vehicles, requires manufacturers to produce and deliver increasing percentages of zero-emission vehicles and reduce GHG emissions from conventional vehicles. DEQ is in rulemaking to adopt California's Advanced Clean Cars II rule requiring all new light-duty vehicle sales to be zero-emission by 2035[31] **Zero Emission Vehicle Interagency Working Group - See ODOT** **Every Mile Counts – See ODOT**		**Material Recovery Programs** • Plans, regulates, and provides assistance for local recovery programs statewide • Incorporates lifecycle impacts of material recovery **Oregon's Climate Change Adaptation Framework – See DLCD** **Interagency Working Group on Climate Impacts to Impacted Communities – See DLCD** **Climate Equity Blueprint – See OHA** **Oregon Renewable Energy Siting Assessment (ORESA) – See ODOE** **Natural & Working Lands Proposal – See OGWC**	

Oregon Department of Agriculture (ODA)

Greenhouse Gas Emissions Reductions and Sequestration	Assessment of Climate Risks and Vulnerabilities	Preparing for Climate Change	Educating Oregonians About Climate Change
Research into carbon sequestration through changing land use practices • Identifying strategies to improve soil health and carbon sequestration potential[40] • Integrating expertise on soil health throughout ODA programs with new Soil Health Position	No activities in this category	**Advancing water management practices** • Improving the quality of groundwater management areas • Improving agricultural water quality rules that increase watershed resilience • Engaging in Place-Based Planning for water resources, focused on adapting to the impacts of changing water regimes across Oregon **Advancing the resilience of native species** • Changing climate conditions can favor invasive species, helping them to out-compete native species and expand their populations rapidly • Implementation of an Early Detection and Rapid Response (EDRR) strategy to protect native species habitat	No activities in this category

		Interagency Working Group on Climate Impacts to Impacted Communities – See DLCD **Oregon's Climate Change Adaptation Framework – See DLCD** **Oregon Renewable Energy Siting Assessment (ORESA) – See ODOE** **Natural & Working Lands Proposal – See OGWC**	

Oregon Department of Energy (ODOE) and Energy Facility Siting Council

Greenhouse Gas Emissions Reductions and Sequestration	Assessment of Climate Risks and Vulnerabilities	Preparing for Climate Change	Educating Oregonians About Climate Change
Solar + Storage Rebate Program • Rebate program for installation of solar panels and storage capacity[41] • 684 projects completed in 2021[42] **Energy Efficient Schools Program** • Provide technical support and connect schools with resources for energy efficiency projects[43] **Energy Efficiency Appliance Standards** • Advancement of standards from HB 2062[44] • Appliance efficiency improvements could achieve 2.5 MMTCO2e in emissions savings through 2035[45] **Energy Facility Siting Council Carbon Standards** • Monetary Offset rate for excess facility emissions raised from $2.85 to $4.27 per ton of CO2 in 2022 (the maximum increase allowed by current statute), update emissions standards, and implement HB 2021	**Energy Sector Climate Vulnerability Assessment** • Identifies and evaluates climate change related vulnerabilities and risks facing energy infrastructure and services[49] • Explores opportunities for risk mitigation and resilience, and provides a guide for others to conduct climate vulnerability studies[50] **Biennial Energy Report** • Overview of climate change risks and impacts to energy use and infrastructure[51]	**Community Renewable Energy Grant Program** • Grants for community renewable energy generation and storage projects[52] • Improves energy resilience[53] • 50% of funding dedicated to environmental justice communities[54] **Energy Efficient Wildfire Rebuilding Incentive** • Provides grant incentives for energy efficient rebuilding of destroyed structures[55] **Research into development of alternative energy resources** • Renewable Hydrogen Study (expected 2022)[56] • Floating Offshore Wind Energy Study[57] • Small-Scale and Community-Based Renewable Energy Projects Study[58]	**Biennial Energy Report** Reports in 2018, 2020, and 2022 include analysis and resources on climate change including: • Statewide GHG emission data and statistics • Goals and climate commitments • Risks and impacts • Deep decarbonization pathways • Clean energy and renewable standards • Energy efficiency and net-zero buildings • Energy sector climate vulnerability assessment • Electric vehicles and chargers • Hydrogen fuel cell vehicles • Renewable and zero-emission vehicle standards • Truck fuel efficiency • Alternative fuels assessments • Transportation fuels assessments • Carbon capture and storage

requirements.[46] [47] **Heat Pump Program**[139] • $25M provided in SB 1536 (2022) for grants and rebates to replace mainly bulk fuel based and electric resistance heating systems with heat pumps to provide both cooling and more efficient heating to residents **Built Environment Efficiency Working Group - Lead** Tasked with reducing energy consumption and emissions related to the built environment[48] **Renewable Portfolio Standards for Investor-Owned Utilities and Energy Service Suppliers – See PUC** **Zero Emission Vehicle Interagency Working Group - See ODOT** **Every Mile Counts – See ODOT** **Roadmap to 2035 – See OGWC**		**Biennial Energy Report** • Evaluation of current GHG reduction targets and projected impacts[59] • Findings used to inform future GHG reduction strategies[60] **Oregon's Climate Change Adaptation Framework – See DLCD** **Interagency Working Group on Climate Impacts to Impacted Communities – See DLCD** **Oregon Renewable Energy Siting Assessment (ORESA) – Co-Lead** • Developed a mapping tool to help inform the siting of new renewable energy resources[61] **Natural & Working Lands Proposal – See OGWC**	• Wildfire mitigation planning • Agriculture sector GHG emissions analysis • Renewable energy resource and technology reviews • Overview of effects of energy development and consumption on climate, opportunities to mitigate emissions through energy efficiency and clean energy development, and climate change risks and impacts to energy use and infrastructure[62] • Audience: general **Resources on ODOE website** • Electric Vehicle Dashboard[63] • Solar Dashboard[64] • Links to reports/publications [65] • Program information[66] • Audience: energy industry/general **Educational outreach on energy efficiency and clean energy** • Direct school engagement[67] • Activities and

			materials on ODOE website[68] • Audience: children and students **Grounded Podcast** • Exploration of energy landscape in Oregon[69] • Audience: general **Roadmap to 2035 – See OGWC**

Oregon Department of Fish & Wildlife

Greenhouse Gas Emissions Reductions and Sequestration	Assessment of Climate Risks and Vulnerabilities	Preparing for Climate Change	Educating Oregonians About Climate Change
ODFW wildlife area carbon sequestration • The approximately 200,000 acres of wildlife and recreation lands managed by ODFW sequesters 61,000 MTCO2e per year[70] **ODFW GHG Emissions Reduction Plan** • The ODFW GHG Emissions Baseline Assessment (2019-2020) estimated agency operations generate 9,280 MTCO2e per year[71] • The ODFW GHG Emissions Reduction Plan will be released by the end of 2022, identifying goals and targets for reducing agency GHG emissions	**Oregon Connectivity Assessment and Mapping Project (OCAMP)**[140] • High resolution habitat connectivity mapping effort for 60 species[72] • Data used for species and ecosystem conservation and protection[73] **Strategy Species List** • Identifies Oregon's species of greatest conservation need, highlighting species particularly vulnerable to climate change **Aquatic habitat prioritization** • Assessing climate resilience of aquatic habitat across the state • Focuses on instream water conservation and fish passage efforts **Ongoing environmental monitoring** • Re-aligned monitoring of aquatic species and	**Climate and Ocean Change Policy** • Incorporating a climate lens in programs, policies, and expenditures (as directed by OAR Chapter 635, Division 900) **Thermal Angling Sanctuaries** • Creation of protected cold-water refuges during warmest months to protect migrating species from high water temperatures[76] • Developing consistent guidelines for modifying angling regulations to protect fish during climate-driven downturns (such as warmer than average water temperatures) **Oregon Ocean Acidification and Hypoxia Report** • Identified opportunities for all state agencies to reduce ocean acidification and	**Drought Outreach Campaign via Oregon Conservation and Recreation Fund** • Large investment in targeted marketing campaign highlighting the impacts of drought on fish and wildfire, ongoing drought being driven by climate change, and opportunities for the public to help fish and wildlife persist. • Audience: General **Climate and Ocean Change Communications Plan** • Developing comprehensive communications to educate the public on the impacts of climate and ocean change on fish, wildlife, and their habitats • Audience: General **Ocean Conservation Strategy** • Oregon's State Wildlife Action Plan identifies climate change as one of the seven Key

	habitat conditions and change over time[74] **Assessment of climate vulnerability for the hatchery system** • Identification of increased risks to hatchery infrastructure from wildfire, flooding, hypoxia, drought, etc.[75]	hypoxia **Conservation Opportunity Areas** • Focusing investments and conservation efforts on locations across the state to support the highest number of species of greatest conservation need, providing intact habitats, act as climate refugia, and connect vital landscapes **Oregon's Climate Change Adaptation Framework – See DLCD** **Interagency Working Group on Climate Impacts to Impacted Communities – See DLCD** **Oregon Renewable Energy Siting Assessment (ORESA) – See ODOE**	Conservation Issues in Oregon, providing background information and identifying priority goals and actions for Oregonians • Audience: General

Oregon Department of Forestry (ODF)

Greenhouse Gas Emissions Reductions and Sequestration	Assessment of Climate Risks and Vulnerabilities	Preparing for Climate Change	Educating Oregonians About Climate Change
Adapting forest management to reduce wildfire risk • Reduces biogenic carbon emissions from fires[77] **Carbon sequestration in wildland forests** • Works to avoid net reduction in sequestered carbon (relative to 1974)[78]	**Assessment of forest health and composition in a changing climate** • Collaborative effort with U.S. National Forest Inventory Program to inventory and measure changes in tree species distribution, range, etc.[79]	**ODF Climate Change and Carbon Plan (2021)** • Identifies opportunities and goals for wildfire management, mitigation, and adaptation[80] • Explores incentives and rulemaking for appropriate stewardship of private forestland[81] • Expands resources for urban and community forests[82] **Oregon's Climate Change Adaptation Framework – See DLCD** **Interagency Working Group on Climate Impacts to Impacted Communities – See DLCD** **Climate Equity Blueprint – See OHA** **Natural & Working Lands Proposal – See OGWC**	**Resources on ODF website** • Climate Change and Carbon Plan information and webinar[83] • Blogs on wildfire and carbon sequestration in harvested wood products[84] • Audience: wood products industry/general

Oregon Department of Transportation (ODOT) and Oregon Transportation Commission (OTC)

Greenhouse Gas Emissions Reductions and Sequestration	Assessment of Climate Risks and Vulnerabilities	Preparing for Climate Change	Educating Oregonians About Climate Change
West Coast Electric Highway • West Coast regional corridor of charging stations for zero emission vehicles[85] • 1.3 million kilowatt-hours of charging to date[86] • Upgrades in 2022-2023 expanding access **Piloting road user charges, tolls, and other pricing tools** • Market incentives to reduce driving[87] • Potential for large-scale implementation later this decade[88] **Intensification of investment in no-/low-emission transportation infrastructure** • $55 million funding increase for walking and biking transportation infrastructure[89] **EV charging infrastructure plans and investments** • National EV Infrastructure (NEVI) program provides $52 million federal/$13 million non-federal match funding over 5 years to build fast	**Transportation infrastructure climate vulnerability assessment** • Evaluation of risks associated with sea level rise, coastal erosion, landslides, flooding, and wildfire hazards and impacts on transportation infrastructure, as well as condition assessment of current infrastructure assets[92]	**Active Transportation Needs Inventory** • Data collection on pedestrian/bike infrastructure deficiencies[93] • Will be used to target funding of future infrastructure development[94] **Statewide Climate Change Adaptation and Resilience Plan** • Identification of needs, goals, and strategies to contend with projected future climate conditions and hazards[95] **Net-Zero Transit Pilot Project** • Assessing options to reduce emissions from public transit through lower carbon fuel use and zero-emission vehicle adoption **Oregon's Climate Change Adaptation Framework – See DLCD**	**Resources on ODOT Climate Office website** • General information, reports, program information, climate hazard factsheets, etc.[96] • Audience: general

charging stations on corridors • Community EV Charging Rebate program (2022) for Level 2 charging investments, largely in disadvantaged communities • Section 11401 of Bipartisan Infrastructure Law (2021) establishes $2.5 billion competitive grants for fueling infrastructure in communities and corridors, over 5 years • Transportation Electrification Infrastructure Needs Analysis (TEINA) (2021; 2022 update) identifies charging gaps and needed investments in charging infrastructure in rural, underserved, and urban areas throughout Oregon, with goals and deployment strategies **Statewide Transportation Improvement Program** • Planning includes evaluating GHG emissions resulting from transportation projects • $55 million increase for walking and biking transportation infrastructure in 2024-27 cycle		**Interagency Working Group on Climate Impacts to Impacted Communities – See DLCD** **Climate Equity Blueprint – See OHA**	

Operations and Maintenance GHG Inventory • Assessment of GHG inventory for emissions associated with agency maintenance and construction operations for the development of reduction strategies **Zero Emission Vehicle Interagency Working Group - Lead convener** • Increases the rate of adoption of electric vehicle use through regulation, investment, and infrastructure development[90] **Every Mile Counts - Lead convener** • Identification, prioritization, and implementation of opportunities to reduce GHG emissions from transportation[91] **Transportation and Growth Management Program – see DLCD**			

Oregon Health Authority

Greenhouse Gas Emissions Reductions and Sequestration	Assessment of Climate Risks and Vulnerabilities	Preparing for Climate Change	Educating Oregonians About Climate Change
Healthy Homes Grant Program • Grant supporting weatherization and retrofits for reduced energy consumption and climate resilience[97]	**Climate and Health in Oregon - 2020 Report** • Assessment of current/projected health risks associated with climate hazards[98] • Exploration of cross-cutting effects of climate change (e.g., on livelihoods, housing, mental health, etc.)[99] **Climate Change and Social Resilience (2020)** • Analysis of impacts of climate change on social/community health[100] **Research on effects of climate change on youth depression** • Participatory, community-based study, with emphasis on intersectionality, especially for youth of color and Indigenous youth[101] **2021 State Modernization Investment ($37.9 million) to Local Public Health Agencies (LPHAs) and Tribes**	**Oregon Climate and Health Resilience Plan (2017)** • Identifies needs and makes recommendations to modernize and equip healthcare community to manage climate related health hazards[102] **Oregon ESSENCE (Electronic Surveillance System for the Early Notification of Community-Based Epidemics)** • Statewide public health monitoring system of incidences of climate change-related health hazards leading to visits to medical treatment centers[103] **2021 State Modernization Investment ($10 million) to Community-Based Organizations (CBOs)** • OHA awarded funds to 35-40 individual CBOs across the state to lead local climate resilience	**Climate Change Resilience Planning Toolkit** • Tools and resources to prepare for changing healthcare needs related to climate change[105] • Audience: healthcare community **Resources on OHA website** • Reports, presentations, handouts, videos, local adaptation plans, training materials, etc.[106] • Audience: healthcare community/general **Culturally Responsive Climate and Health Curricula** • OHA is funding Oregon Community Health Workers Association (ORCHWA) to develop and deliver a culturally responsive climate and health curricula, for Community Health Workers across the state. ORCHWA will also be available to

	• LPHAs are asked to protect communities from environmental health threats from climate change through public health interventions that support equitable climate adaptation. The LPHA will demonstrate strategies toward developing a local or regional climate adaptation plan or incorporate into community health assessment. • Tribes are asked to perform Environmental Health, climate change and emergency preparedness activities, technical assistance, and training	projects. **Building Resilience Against Climate Effects (BRACE)** • This federal grant supports the Climate and Health program to advance equitable climate adaptation through collaboration across all levels of government and with community partners serving priority populations **Climate Equity Blueprint - Lead** • Provides agencies with guidance on how to design and implement programs to advance equity[104] **Oregon's Climate Change Adaptation Framework – See DLCD** **Interagency Working Group on Climate Impacts to Impacted Communities – See DLCD**	consult smaller organizations planning community education interventions through Public Health Modernization Audience: community health workers

Oregon Water Resources Department (OWRD)

Greenhouse Gas Emissions Reductions and Sequestration	Assessment of Climate Risks and Vulnerabilities	Preparing for Climate Change	Educating Oregonians About Climate Change
Water conservation programs • Reduction of energy use as a co-benefit of programs to increase water efficiency[107]	**Oregon's Integrated Water Resources Strategy (2017)** • Analysis of water needs and pressures, including climate change-related impacts[108] **2015 Statewide Long-Term Water Demand Forecast** • Projection of the future water needs of the state with consideration of climate change scenarios[109]	**Use of incentives and place-based water resource planning to reduce water use** • Increased resilience to water scarcity[110] • Reduction of energy use related to efficiency improvements and the energy-water nexus[111] **Oregon's Climate Change Adaptation Framework – See DLCD** **Interagency Working Group on Climate Impacts to Impacted Communities – See DLCD** **Climate Equity Blueprint – See OHA**	**Resources on OWRD Website** • Curated resources for "Drought" and "Wildfire Recovery" topics • Audience: general[112] **See also:** publications in assessment category

Oregon Watershed Enhancement Board

Greenhouse Gas Emissions Reductions and Sequestration	Assessment of Climate Risks and Vulnerabilities	Preparing for Climate Change	Educating Oregonians About Climate Change
Riparian reforestation and wetland restoration grant programs • Sequestering 5 to 10 MTCO2e per hectare per year[113] **Grants that support prevention of land use change (preservation of forest, grassland, etc.)** • Avoiding release of 16 to 300 MTCO2e per hectare per year[114]	No activities in this category	**Climate Resolution:** • Directs the agency to integrate emissions reductions, carbon sequestration and storage, and adaptation and resilience in their budgeting, investing, and policy-making decisions **Land management strategies eligible for OWEB grant funding:** • Use of forest conservation and restoration practices designed to reduce/mitigate fire risk[115] • Riparian restoration efforts designed to mitigate effects of drought and heat on fish/wildlife[116] • Management of wetlands and floodplains for mitigation of improved filtration and storage of surface runoff[117] **Oregon's Climate Change Adaptation Framework – See DLCD**	**Climate-Related Technical Resources for OWEB Grant Applicants (2021)** • Projected climate impacts and hazards related to watersheds, water quality, native species, habitats[118] • Information on external tools/resources[119] • Audience: OWEB grant applicants/general

		Interagency Working Group on Climate Impacts to Impacted Communities – See DLCD **Natural & Working Lands Proposal – See OGWC**	

Oregon Public Utility Commission (PUC)

Greenhouse Gas Emissions Reductions and Sequestration	Assessment of Climate Risks and Vulnerabilities	Preparing for Climate Change	Educating Oregonians About Climate Change
Energy efficiency investments through Energy Trust of Oregon • Reduction of 4.3 MMTCO2e from 2016 to 2020[120] **Regulate 100% clean electricity by utilities** • Requires 80% GHG emissions reductions (below baseline emissions) by 2030, 90% by 2035, and 100% by 2040[121] • Projected reduction of 12 MMTCO2e from 2021 to 2030[122] **Oversight of 90% GHG reduction from gas utilities by 2050[iv]** • Ensure gas utilities meet targets set by DEQ in Climate Protection Program in least-cost, least-risk manner **Enforce Renewable Portfolio Standards for Investor-Owned Utilities and Energy Service Suppliers** • Requires at least 20% of electricity sold by the electric utility or electricity service supplier in 2020 be 'qualified' renewable energy	**Hosted Wildfire Dialogue of West Coast Utility Commissions** • Collaborative discussion/ assessment of wildfire hazards to utilities[123] **Established requirement for utilities to assess climate risks** • Requires utilities to include assessment of climate risks posed to generation and distribution capacity in their integrated resource plans (IRPs)[124] • Update approach to avoided costs across all technology planning and acquisition that prices in value of GHG reduction and reduces climate risk. • Require best available climate science in IRPs including weather forecasting and hydroelectric availability • All gas and electric IOUs employ the use	**Wildfire rulemaking (AR 638)[141]** • Per EO 20-04 and SB 762, rulemaking to reduce/mitigate hazard risk to utilities from wildfires and other extreme weather events (e.g., modification to vegetation management rules)[125] **Exploring resiliency to climate change events in utility planning and investing** • As part of HB 2021,[142] explore utility planning and future investing in grid resiliency • Increased direction to gas and electric IOUs to produce climate vulnerability and/or adaptation sections in their long-term planning documents	**Oregon Wildfire & Electric Collaborative - Wildfire Mitigation Workshop Series** • Workshop series to develop and share best practices to reduce wildfire risk and damage[126] • Audience: energy utilities

• Requirement increases incrementally every five years to 50% by 2040 **Enable procurement of Renewable Natural Gas by natural gas utilities** • Supports qualified renewable natural gas investments up to 5% in each calendar year 2020-2024, increasing every 5 years up to 30% for years 2045-2050 **Implement utility Transportation Electrification investment framework and updated approach to TE planning** • Per HB 2165 and EO 20-04, developed with stakeholders an enhanced approach to utility investing and planning that supports more rapid electrification of transportation **Zero Emission Vehicle Interagency Working Group - See ODOT** **Built Environment Efficiency Working Group - See ODOE** **Roadmap to 2035 – See OGWC**	of the social cost of carbon when assessing portfolios of resources to meet energy needs • Conducted Natural Gas Fact Finding to explore with stakeholders the regulatory tools that could be employed by the Commission to encourage/ support gas utilities to meet GHG reduction targets and mitigate associated customer risks.	**Oregon's Climate Change Adaptation Framework – See DLCD** **Interagency Working Group on Climate Impacts to Impacted Communities – See DLCD** **Oregon Renewable Energy Siting Assessment (ORESA) – See ODOE**	

Environmental Justice Council[i]

Greenhouse Gas Emissions Reductions and Sequestration	Assessment of Climate Risks and Vulnerabilities	Preparing for Climate Change	Educating Oregonians About Climate Change
No activities in this category	**Development of an Environmental Justice Mapping Tool as described HB 4077, passed by the Oregon Legislature in 2021** • The tool will include environmental, health, socioeconomic, and other factors and will help define EJ communities in Oregon • Uses for the tool can include informing benefits while diminishing burdens for EJ communities • Provide GIS map layers that will be compatible with other mapping tools at state agencies to enable more specific data analysis and comparisons	**Interagency Working Group on Climate Impacts to Impacted Communities – See DLCD** **Climate Equity Blueprint – See OHA**	**Environmental Justice Task Force Handbook** • Best practices guidebook for state natural resource agencies to integrate environmental justice concerns, including effects of climate change into agency programs, actions, and decisions • Audience: State natural resource agencies, boards, and commissions

[i] Formerly the Environmental Justice Task Force, which was renamed in the passage of HB 4077 in 2022.

Oregon Climate Change Research Institute (OCCRI)

<table>
<tr><th>Greenhouse Gas Emissions Reductions and Sequestration</th><th>Assessment of Climate Risks and Vulnerabilities</th><th>Preparing for Climate Change</th><th>Educating Oregonians About Climate Change</th></tr>
<tr><td>No activities in this category</td><td>Oregon Climate Assessments
• Biennial assessment of current and projected effects of climate change in Oregon[127]
Assessing Climate Risks for Oregon Counties
• Developing county-level natural hazard mitigation plans that include climate change-related hazards (in partnership with DLCD)
Oregon's Climate Change Vulnerability Assessment – See DLCD
• Producing content and graphics for visuals that will be used in 12 regional workshops</td><td>Provision of technical support for the development of policies and programs responding to effects of climate change
• Local, state, and regional levels, in partnerships with utilities and other groups[128]
Oregon's Climate Change Adaptation Framework – See DLCD</td><td>Media contributions on climate change (local-national)
• Local and national contributions to climate change-related journalism[129]
• Presentations on climate change and its effects at the invitation of diverse governmental, nongovernmental, educational, and civic groups.
• Audience: sector-based, general.
Publication of peer-reviewed papers
• Contributions to scientific literature related to climate change in Oregon[130]
• Audience: academic
See also: Oregon climate assessments in assessments category</td></tr>
</table>

Oregon Global Warming Commission

Greenhouse Gas Emissions Reductions and Sequestration	Assessment of Climate Risks and Vulnerabilities	Preparing for Climate Change	Educating Oregonians About Climate Change
Roadmap to 2035 • Develop an economy-wide, Oregon-specific model that forecasts expected emission reductions from state programs and regulations[131] • Provide decision-makers with recommendations for future actions the state should take to reduce Oregon's greenhouse gas emissions[132]	*No activities in this category*	**OGWC Biennial Report to the Legislature** • Economy-wide and sector-based recommendations for government response to mitigate emissions and increase resilience in Oregon[133] • Assessment of the efficacy and progress of current goals/ programs/policies[134] **Natural & Working Lands Proposal – Lead** • Development of carbon sequestration and storage goals for Oregon's natural and working lands[135] **Interagency Working Group on Climate Impacts to Impacted Communities – See DLCD**	**Resources on OGWC website** • Publications, reports, links to state and local government climate change resources, links to non-government resources[136] • Audience: general

Oregon Sustainability Board

Greenhouse Gas Emissions Reductions and Sequestration	Assessment of Climate Risks and Vulnerabilities	Preparing for Climate Change	Educating Oregonians About Climate Change
No activities in this category	*No activities in this category*	**Review and approval of agency sustainability plans** • Collaboration with state entities to develop plans that meet state and entity goals[137] **Interagency Working Group on Climate Impacts to Impacted Communities – See DLCD**	**Sustainability support and outreach** • Assistance for consumer/industrial product environmental impact assessment[138] • Audience: industry/general

REFERENCES

1 Oregon Exec. Order No. 20-04. (2020, March 10). https://www.oregon.gov/gov/Documents/executive_orders/eo_20-04.pdf

2 Business Oregon. (n.d.). *Rural Renewable Energy Development (RRED) Zone*. Oregon.gov. Retrieved February 23, 2022, from https://www.oregon.gov/biz/programs/RuralRenewableEnergyDevelopment%28RRED%29Zone/Pages/default.aspx

3 Solar Development Incentive Program. OAR § 123.093 (2017). https://secure.sos.state.or.us/oard/displayDivisionRules.action?selectedDivision=197

4 Oregon Department of Administrative Services. (2018, August 9). *2018 Department of Administrative Services Sustainability Plan*. https://www.oregon.gov/das/Facilities/Documents/SustPln_DAS_2018.pdf

5 Wortman, D. (2021, November 1). *DAS and Oregon Sustainability Board (OSB) efforts to address climate change* [memorandum].

6 Oregon Department of Administrative Services. (2020, September 15). *Integrating climate change: Operations, planning, budgeting, investing, fleet, and procurement*, Report to Governor Kate Brown. https://www.oregon.gov/gov/Documents/DAS-EO20-04-Report-915.pdf

7 Oregon Department of Administrative Services. (2020, September 15). *Integrating climate change: Operations, planning, budgeting, investing, fleet, and procurement*, Report to Governor Kate Brown. https://www.oregon.gov/gov/Documents/DAS-EO20-04-Report-915.pdf

[8] Oregon Department of Consumer and Business Services Building Codes Division. *Energy Code Program*. Retrieved October 19, 2022, from https://www.oregon.gov/bcd/codes-stand/Pages/energy-efficiency.aspx

[9] Oregon Department of Consumer and Business Services Building Codes Division. *Reach Code*. Retrieved October 19, 2022, from https://www.oregon.gov/bcd/codes-stand/Pages/reach.aspx

[10] Written Communication from the Oregon Department of Administrative Services to the Oregon Department of Energy, Nov. 1, 2021 (on file with department).

[11] Oregon Department of Consumer and Business Services, Building Code Division, *Fire Hardening Grant Program,* https://www.oregon.gov/bcd/pages/firehardening.aspx.

[12] Oregon Department of Consumer and Business Services, Oregon Occupational Safety and Health, *Rulemaking to Protect Employees from Unhealthy Levels of Wildfire Smoke,* https://osha.oregon.gov/rules/advisory/smoke/Pages/default.aspx.

[13] Written Communication from the Oregon Department of Administrative Services to the Oregon Department of Energy, Nov. 1, 2021 (on file with department).

[14] Oregon Department of Consumer and Business Services, Oregon Occupational Safety and Health, Key Requirements: Oregon OSHA's Permanent Rules for Protection from Wildfire Smoke, https://osha.oregon.gov/OSHAPubs/factsheets/fs92.pdf.

[15] Oregon Department of Consumer and Business Services, Oregon Occupational Safety and Health, *Wildfires,* https://osha.oregon.gov/Pages/topics/wildfires.aspx.

[16] Oregon Department of Land Conservation and Development. (n.d.). *Climate-Friendly and Equitable Communities rulemaking*. Oregon.gov. Retrieved February 23, 2022, from https://www.oregon.gov/lcd/LAR/Pages/CFEC.aspx

[17] Oregon Department of Land Conservation and Development. (n.d.). *About the Transportation and Growth Management Program*. Oregon.gov. Retrieved February 23, 2022, from https://www.oregon.gov/lcd/TGM/Pages/About.aspx

[18] Oregon Department of Land Conservation and Development. (n.d.). *Natural Hazards Mitigation Planning*. Oregon.gov. Retrieved February 23, 2022, from https://www.oregon.gov/lcd/NH/Pages/Mitigation-Planning.aspx

[19] Oregon Department of Land Conservation and Development. (n.d.). *Oregon Coastal Management Program: Hazard mitigation*. Oregon.gov. Retrieved February 23, 2022, from https://www.oregon.gov/lcd/OCMP/Pages/Hazard-Mitigation.aspx

[20] Oregon Department of Land Conservation and Development. (n.d.). *Climate Change Vulnerability Assessment.* Retrieved February 23, 2022, from https://www.oregon.gov/lcd/CL/Pages/Vulnerability-Assessment.aspx

[21] Oregon Department of Land Conservation and Development. (n.d.). *National Flood Insurance Program (NFIP) in Oregon*. Oregon.gov. Retrieved February 23, 2022, from https://www.oregon.gov/lcd/NH/Pages/NFIP.aspx

[22] Oregon Exec. Order No. 20-04. (2020, March 10). https://www.oregon.gov/gov/Documents/executive_orders/eo_20-04.pdf

[23] Oregon Dept. of Land Conservation and Development. (2021). *Oregon Climate Change Adaptation Framework.* https://www.oregon.gov/lcd/CL/Documents/2021_CLIMATE_CHANGE_ADAPTATION_FRAMEWORKandBlueprint.pdf

[24] Oregon Department of Land Conservation and Development. (n.d.). *State of Oregon NFIP training calendar 2021*. https://www.oregon.gov/lcd/NH/Documents/Oregon_NFIP_Training_Calendar_2021.pdf

[25] Oregon Department of Land Conservation and Development. (n.d.). *Climate Change Resources*. Oregon.gov. Retrieved February 23, 2022, from https://www.oregon.gov/lcd/CL/Pages/Climate-Change-Resources.aspx

[26] Oregon Department of Environmental Quality. (n.d.). *Greenhouse Gas Emissions Program 2021*. Oregon.gov. Retrieved February 23, 2022, from https://www.oregon.gov/deq/rulemaking/Pages/rghgcr2021.aspx

[27] Oregon Department of Environmental Quality. *Clean Fuels Program Overview*. Retrieved October 17, 2022, from https://www.oregon.gov/deq/ghgp/cfp/Pages/CFP-Overview.aspx

[28] Oregon Department of Environmental Quality. (n.d.). *2020 annual cost of the Clean Fuels Program*. https://www.oregon.gov/deq/ghgp/Documents/cfp2020AvgCost.pdf

[29] Center for Sustainable Energy. (n.d.). *Oregon Clean Vehicle Rebate Project*. Energycenter.org. Oregon.gov. Retrieved February 16, 2022, from https://energycenter.org/program/oregon-clean-vehicle-rebate-project

[30] Oregon Department of Environmental Quality, (2021, November) EQC staff report and fiscal statement. https://www.oregon.gov/deq/EQCdocs/111721_C_CleanTrucks.pdf

[31] Oregon Department of Environmental Quality. *Oregon's Clean Car Standards*. Retrieved October 17, 2022, from https://www.oregon.gov/deq/aq/programs/Pages/ORLEV.aspx

[32] See Oregon Department of Environmental Quality, Clean Fuels Program: Program Review for the 2022 Oregon Legislature 10-13 (Feb. 1, 2022), https://www.oregon.gov/deq/ghgp/Documents/CFP-ProgramReview.pdf.

[33] Oregon Department of Environmental Quality. *Air Quality Monitoring,* https://www.oregon.gov/deq/aq/Pages/Air-Quality-Monitoring.aspx.

[34] Oregon Department of Environmental Quality. *Air Quality: Resources for Community Response Plans and Smoke Management,* https://www.oregon.gov/deq/aq/Pages/Smoke-Resources.aspx.

[35] Oregon Department of Environmental Quality. *Food Strategic Planning*, https://www.oregon.gov/deq/mm/food/Pages/foodwastestrategy.aspx.

[36] Oregon Department of Environmental Quality. *Food Strategic Planning,* https://www.oregon.gov/deq/mm/food/Pages/foodwastestrategy.aspx.

[37] Oregon Department of Environmental Quality. (n.d.). *Action on Climate Change: DEQ's mission to be a leader in restoring, maintaining, and enhancing the quality of Oregon's air, land, and water*. Oregon.gov. Retrieved February 23, 2022, from https://www.oregon.gov/deq/ghgp/Pages/default.aspx

[38] Oregon Department of Environmental Quality. (n.d.). *GreenState DEQ podcast*. Soundcloud.com. Retrieved February 23, 2022, from https://soundcloud.com/greenstate-podcast

[39] Oregon Department of Environmental Quality. (n.d.). *About this blog*. DEQblog.com. Retrieved February 23, 2022, from https://deqblog.com/about-this-blog/

[40] Taylor, A. (2021, November 1). *Conference of Parties on climate change* [memorandum].

[41] Oregon Department of Energy, Oregon Solar + Storage Rebate Program: 2022 Program Report (Sept. 15, 2022), https://www.oregon.gov/energy/Data-and-Reports/Documents/2022-OSSRP-Annual-Report.pdf.

[42] Oregon Department of Energy, Oregon Solar + Storage Rebate Program: 2022 Program Report 5 (Sept. 15, 2022), https://www.oregon.gov/energy/Data-and-Reports/Documents/2022-OSSRP-Annual-Report.pdf.

[43] Oregon Department of Energy. (n.d.). *Energy Efficient Schools Program*. Oregon.gov. Retrieved February 23, 2022, from https://www.oregon.gov/energy/energy-oregon/Pages/Schools-Program.aspx.

[44] Oregon Department of Energy. (n.d.). *Energy efficiency standards: Appliances and other products*. Oregon.gov. Retrieved February 16, 2022, from https://www.oregon.gov/energy/energy-oregon/Pages/Appliance-Standards.aspx

[45] Oregon Department of Energy, Executive Order 17-20: Improved State Standards for Appliances 15 (Nov. 2018), https://www.oregon.gov/energy/Get-Involved/Documents/2018-Appliance-Standards-Report.PDF.

[46] Oregon Department of Energy. *Energy Facility Siting Council Rulemaking*. Retrieved October 17, 2022, from https://www.oregon.gov/energy/Get-Involved/Pages/Energy-Facility-Siting-Council-Rulemaking.aspx#22CSR

[47] Energy Facility Siting Council (2022, April 27). Notice of Proposed Rulemaking for Implementation of HB 2021 (2021) and Updates to Carbon Dioxide Emissions Standards. https://sos.oregon.gov/archives/Pages/oregon_administrative_rules.aspx

[48] Oregon Department of Energy. (n.d.). *Built Environment Efficiency Working Group*. Oregon.gov. Retrieved February 23, 2022, from https://www.oregon.gov/energy/Get-Involved/Pages/BEEWG.aspx

[49] Oregon Department of Energy. (2020). *2020 biennial energy report: Policy briefs*. https://www.oregon.gov/energy/Data-and-Reports/Documents/2020-BER-Policy-Briefs.pdf

[50] Oregon Department of Energy. (2020). *2020 biennial energy report: Policy briefs*. https://www.oregon.gov/energy/Data-and-Reports/Documents/2020-BER-Policy-Briefs.pdf

[51] Oregon Department of Energy, *Biennial Energy Report*, https://www.oregon.gov/energy/Data-and-Reports/Pages/Biennial-Energy-Report.aspx.

[52] Oregon Department of Energy, *Community Renewable Energy Grant Program,* https://www.oregon.gov/energy/Incentives/Pages/CREP.aspx.

[53] Oregon Department of Energy, *Community Renewable Energy Grant Program,* https://www.oregon.gov/energy/Incentives/Pages/CREP.aspx.

[54] Oregon Department of Energy, *Community Renewable Energy Grant Program,* https://www.oregon.gov/energy/Incentives/Pages/CREP.aspx.

[55] Oregon Department of Energy, *Energy Efficient Wildfire Rebuilding Incentive,* https://www.oregon.gov/energy/Incentives/Pages/EEWR.aspx.

[56] Oregon Department of Energy. *Renewable Hydrogen Study*. Retrieved October 18, 2022, from https://www.oregon.gov/energy/energy-oregon/Pages/rh2.aspx

[57] Oregon Department of Energy. *Floating Offshore Wind Study: Benefits & Challenges for Oregon*. Retrieved October 18, 2022, from https://www.oregon.gov/energy/energy-oregon/Pages/fosw.aspx

[58] Oregon Department of Energy. *Small-Scale & Community-Based Renewable Energy Projects Study*. Retrieved October 18, 2022, from https://www.oregon.gov/energy/Data-and-Reports/Pages/SSREP-Study.aspx

[59] Oregon Department of Energy. (2020). *2020 biennial energy report*. https://www.oregon.gov/energy/Data-and-Reports/Documents/2020-Biennial-Energy-Report.pdf

[60] Oregon Department of Energy. (2020). *2020 biennial energy report*. https://www.oregon.gov/energy/Data-and-Reports/Documents/2020-Biennial-Energy-Report.pdf

[61] Oregon Department of Energy. (n.d.). *Oregon Renewable Energy Siting Assessment (ORESA)*. Oregon.gov. Retrieved February 23, 2022, from https://www.oregon.gov/energy/energy-oregon/Pages/ORESA.aspx

[62] Oregon Department of Energy, *Biennial Energy Report*, https://www.oregon.gov/energy/Data-and-Reports/Pages/Biennial-Energy-Report.aspx

[63] Oregon Department of Energy. (n.d.). *Oregon electric vehicle dashboard*. Oregon.gov. Retrieved February 23, 2022, from https://www.oregon.gov/energy/Data-and-Reports/Pages/Oregon-Electric-Vehicle-Dashboard.aspx

[64] Oregon Department of Energy. (n.d.). *Oregon solar dashboard*. Oregon.gov. Retrieved February 23, 2022, from https://www.oregon.gov/energy/energy-oregon/Pages/Oregon-Solar-Dashboard.aspx

65 Oregon Department of Energy. (n.d.). *Addressing climate change*. Oregon.gov. Retrieved February 23, 2022, from https://www.oregon.gov/energy/energy-oregon/Pages/Climate-Change.aspx

66 Oregon Department of Energy. (n.d.). *Addressing climate change*. Oregon.gov. Retrieved February 23, 2022, from https://www.oregon.gov/energy/energy-oregon/Pages/Climate-Change.aspx

67 Oregon Department of Energy. (n.d.). *Energy Efficient Schools Program*. Oregon.gov. Retrieved February 23, 2022, from https://www.oregon.gov/energy/energy-oregon/Pages/Schools-Program.aspx

68 Oregon Department of Energy. (n.d.). *Activities for kids*. Oregon.gov. Retrieved February 23, 2022, from https://www.oregon.gov/energy/resources/Pages/Activities-for-Kids.aspx

69 Oregon Department of Energy. (n.d.). *Grounded: An Oregon Department of Energy podcast*. Soundcloud.com. Retrieved February 23, 2022, from https://soundcloud.com/oregonenergy

70 Oregon Department of Fish and Wildlife. (2021). *Addressing the carbon footprint of ODFW operations: Base year GHG inventory report*. https://www.dfw.state.or.us/climate_ocean_change/docs/ODFW%20Baseline%20GHG%20Inventory%20Report_Final.pdf#page=7

71 Oregon Department of Fish and Wildlife. (2021). *Addressing the carbon footprint of ODFW operations: Base year GHG inventory report*. https://www.dfw.state.or.us/climate_ocean_change/docs/ODFW%20Baseline%20GHG%20Inventory%20Report_Final.pdf#page=7

72 Oregon Department of Fish and Wildlife. (n.d.). *The Oregon Connectivity Assessment and Mapping Project (OCAMP)*. Oregonconservationstrategy.org. Retrieved February 23, 2022, from https://oregonconservationstrategy.org/success-story/the-oregon-connectivity-assessment-and-mapping-project-ocamp/

73 Oregon Department of Fish and Wildlife. (n.d.). *The Oregon Connectivity Assessment and Mapping Project (OCAMP)*. Oregonconservationstrategy.org. Retrieved February 23, 2022, from https://oregonconservationstrategy.org/success-story/the-oregon-connectivity-assessment-and-mapping-project-ocamp/

74 Oregon Department of Fish and Wildlife. (n.d.). *Monitoring*. Oregonconservationstrategy.org. Retrieved February 23, 2022, from https://oregonconservationstrategy.org/monitoring/

75 Oregon Department of Fish and Wildlife, Update on Implementation of Executive Order 20-04, https://www.oregon.gov/gov/Documents/ODFW-Update-Climate-EO-Final.pdf.

76 Or. Admin. R. § 635-023-0129.

77 Oregon Department of Forestry, *About the Fire Protection Program,* https://www.oregon.gov/odf/fire/Pages/default.aspx.

78 Oregon Department of Forestry. (2020). *Report on proposed actions for Executive Order No. 20-04*. https://www.oregon.gov/odf/Documents/forestbenefits/report-on-proposed-actions-eo-20-04.pdf

79 Oregon Department of Forestry. (2020). *Report on proposed actions for Executive Order No. 20-04*. https://www.oregon.gov/odf/Documents/forestbenefits/report-on-proposed-actions-eo-20-04.pdf

80 Oregon Department of Forestry. (2021). *The Oregon Department of Forestry climate change and carbon plan*. https://www.oregon.gov/odf/forestbenefits/Documents/odf-climate-change-and-carbon-plan-draft.pdf

81 Oregon Department of Forestry. (2021). *The Oregon Department of Forestry climate change and carbon plan*. https://www.oregon.gov/odf/forestbenefits/Documents/odf-climate-change-and-carbon-plan-draft.pdf

[82] Oregon Department of Forestry. (2021). *The Oregon Department of Forestry climate change and carbon plan*. https://www.oregon.gov/odf/forestbenefits/Documents/odf-climate-change-and-carbon-plan-draft.pdf

[83] Oregon Department of Forestry. (n.d.). *Climate Change and Carbon Plan*. Oregon.gov. Retrieved February 23, 2022, from https://www.oregon.gov/odf/forestbenefits/pages/climate-change.aspx

[84] Oregon Department of Forestry. (n.d.). [Homepage with links to resources]. Oregon.gov. Retrieved February 23, 2022, from https://www.oregon.gov/odf/Pages/index.aspx

[85] Oregon Department of Transportation, *Oregon's West Coast Electric Highway,* https://www.oregon.gov/odot/Programs/Pages/WestCoastElectricHighway.aspx.

[86] Written Communication from Oregon Department of Transportation to Oregon Department of Energy, Nov. 1, 2021 (on file with department).

[87] Oregon Department of Transportation, *OReGO: Oregon's Road Usage Charge Program*, https://www.oregon.gov/ODOT/Programs/Pages/OReGO.aspx.

[88] Oregon Department of Transportation, *Road User Fee Task Force,* https://www.oregon.gov/odot/Programs/Pages/Road-User-Fee-Task-Force.aspx.

[89] Oregon Department of Transportation, *Pedestrian and Bicycle Strategic Funding Program,* https://www.oregon.gov/odot/STIP/Pages/PBS.aspx.

[90] Oregon Department of Energy. (n.d.). *Zero Emission Vehicle Interagency Working Group*. Oregon.gov. Retrieved February 23, 2022, from State of Oregon: GET INVOLVED - Zero Emission Vehicle Interagency Working Group

[91] Oregon Department of Transportation. (n.d.). *Statewide Transportation Strategy*. Oregon.gov. Retrieved February 23, 2022, from https://www.oregon.gov/odot/Planning/Pages/STS.aspx

[92] Oregon Department of Transportation, *Climate Change Adaptation and Resilience,* https://www.oregon.gov/odot/climate/Pages/Adaptation-and-Resilience.aspx.

[93] Oregon Department of Transportation, *Statewide Active Transportation Needs Inventory,* https://www.oregon.gov/odot/RPTD/Pages/Statewide-Active-Transportation-Needs-Inventory.aspx#:~:text=In%20conjunction%20with%20ODOT%20Regions%201%2C%202%2C%203%2C,Bicycle%20and%20Pedestrian%20needs%20for%20all%20ODOT%20highways.

[94] Oregon Department of Transportation, *Statewide Active Transportation Needs Inventory,* https://www.oregon.gov/odot/RPTD/Pages/Statewide-Active-Transportation-Needs-Inventory.aspx#:~:text=In%20conjunction%20with%20ODOT%20Regions%201%2C%202%2C%203%2C,Bicycle%20and%20Pedestrian%20needs%20for%20all%20ODOT%20highways.

[95] Oregon Department of Transportation, Climate Change Vulnerability Assessment and Adaptation Options Study (Dec. 2014), https://www.oregon.gov/odot/Programs/TDD%20Documents/Climate-Change-Vulnerability-Assessment-Adaptation-Options-Study.pdf.

[96] Oregon Department of Transportation. (n.d.) *Climate Office*. Oregon.gov. Retrieved February 23, 2022, from https://www.oreg on.gov/odot/Programs/Pages/climate%20office.aspx

[97] Oregon Health Authority. (2021, November 1). *United Nations climate change conference – COP26: Oregon Heath Authority – Climate and Health Program accomplishments and future contributions* [memorandum].

[98] Oregon Health Authority Public Health Division. (2020). *Climate and health in Oregon 2020 report*. https://www.oregon.gov/oha/PH/HEALTHYENVIRONMENTS/CLIMATECHANGE/Documents/2020/Climate%20and%20Health%20in%20Oregon%202020%20-%20Full%20Report.pdf

[99] Oregon Health Authority Public Health Division. (2020). *Climate and health in Oregon 2020 report*. https://www.oregon.gov/oha/PH/HEALTHYENVIRONMENTS/CLIMATECHANGE/Documents/2020/Climate%20and%20Health%20in%20Oregon%202020%20-%20Full%20Report.pdf

[100] Oregon Health Authority. (n.d.). *Social Resilience Project*. Oregon.gov. Retrieved February 23, 2022, from https://www.oregon.gov/oha/PH/HEALTHYENVIRONMENTS/CLIMATECHANGE/Pages/social-resilience.aspx

[101] Oregon Health Authority. (2021, November 1). *United Nations climate change conference – COP26: Oregon Heath Authority – Climate and Health Program accomplishments and future contributions* [memorandum].

[102] Oregon Health Authority Public Health Division. (2017). *Oregon climate and health resilience plan*. https://sharedsystems.dhsoha.state.or.us/DHSForms/Served/le8267a.pdf

[103] Oregon Health Authority. (2021, November 1). *United Nations climate change conference – COP26: Oregon Heath Authority – Climate and Health Program accomplishments and future contributions* [memorandum].

[104] Oregon Health Authority. (2021). *State of Oregon Climate Equity Blueprint*. https://www.oregon.gov/lcd/CL/Documents/2021_Jan_Climate-Equity-Blueprint.pdf

[105] Oregon Health Authority. (n.d.). *About the toolkit*. Oregon.gov. Retrieved February 23, 2022, from https://www.oregon.gov/oha/PH/HealthyEnvironments/climatechange/Toolkit/Pages/index.aspx

[106] Oregon Health Authority. (n.d.). *Climate change and public health*. Oregon.gov. Retrieved February 23, 2022, from https://www.oregon.gov/oha/PH/HEALTHYENVIRONMENTS/CLIMATECHANGE/Pages/index.aspx

[107] Oregon Water Resources Department. (2020, May 15). *Oregon Water Resources Department May 15, 2020 Executive Order No. 20-04 report*. https://www.oregon.gov/gov/Documents/2020%20OWRD%20EO%2020-04%20Implementation%20Report.pdf

[108] Mucken, A., & Bateman, B. (Eds.). (2017). *Oregon's 2017 integrated water resources strategy*. Oregon Water Resources Department. https://www.oregon.gov/owrd/WRDPublications1/2017_IWRS_Final.pdf

[109] Oregon Water Resources Department. (2015, December). *2015 statewide long-term water demand forecast: Oregon's integrated water resources strategy*. https://www.oregon.gov/OWRD/wrdpublications1/OWRD_2015_Statewide_LongTerm_Water_Demand_Forecast.pdf

[110] Oregon Water Resources Department. (2015, February). *Draft guidelines: A tool for conducting place-based integrated water resources planning in Oregon*. https://www.oregon.gov/owrd/WRDPublications1/2015_February_Draft_Place_Based_Guidelines.pdf

[111] Oregon Water Resources Department. (2015, February). *Draft guidelines: A tool for conducting place-based integrated water resources planning in Oregon*. https://www.oregon.gov/owrd/WRDPublications1/2015_February_Draft_Place_Based_Guidelines.pdf

[112] Oregon Water Resources Department. (n.d.). *Climate*. Oregon.gov. Retrieved February 23, 2022, from https://www.oregon.gov/owrd/programs/climate/Pages/default.aspx

[113] Oregon Watershed Enhancement Board. (2020, June 19). *Report to Oregon Governor Kate Brown in response to Executive Order 20-04*. https://www.oregon.gov/gov/Documents/OWEB-report-final.pdf

[114] Oregon Watershed Enhancement Board. (2020, June 19). *Report to Oregon Governor Kate Brown in response to Executive Order 20-04*. https://www.oregon.gov/gov/Documents/OWEB-report-final.pdf

[115] Oregon Watershed Enhancement Board. (2020, June 19). *Report to Oregon Governor Kate Brown in response to Executive Order 20-04*. https://www.oregon.gov/gov/Documents/OWEB-report-final.pdf

[116] Oregon Watershed Enhancement Board. (2020, June 19). *Report to Oregon Governor Kate Brown in response to Executive Order 20-04*. https://www.oregon.gov/gov/Documents/OWEB-report-final.pdf

[117] Oregon Watershed Enhancement Board. (2020, June 19). *Report to Oregon Governor Kate Brown in response to Executive Order 20-04*. https://www.oregon.gov/gov/Documents/OWEB-report-final.pdf

[118] Oregon Watershed Enhancement Board. (2021, July 15). *Climate-related technical resources for OWEB applicants*. https://www.oregon.gov/oweb/Documents/Climate-Related-Technical-Resources.pdf

[119] Oregon Watershed Enhancement Board. (2021, July 15). *Climate-related technical resources for OWEB applicants*. https://www.oregon.gov/oweb/Documents/Climate-Related-Technical-Resources.pdf

[120] Written Communication from Oregon Public Utility Commission to Oregon Department of Energy, Nov. 1, 2021 (on file with department).

[121] Oregon Public Utility Commission, *Summary of HB 2021—Clean Energy,* https://www.oregon.gov/puc/Documents/HB2021-Summary.pdf.

[122] Written Communication from Oregon Public Utility Commission to Oregon Department of Energy, Nov. 1, 2021 (on file with department).

[123] Oregon Public Utility Commission. (2020, May 15). *Report on Executive Order 20-04.* https://www.oregon.gov/puc/utilities/Documents/EO20-04PUC-Report.docx.pdf

[124] Written Communication from Oregon Public Utility Commission to Oregon Department of Energy, Nov. 1, 2021 (on file with department).

[125] Oregon Public Utility Commission. (2022). Docket No. AR 638: Adopt Rules for Risk-Based Wildfire Protection Plans and Planned Activities Consistent with Executive Order 20-04. (Administrative Hearings Division (AHD) Report Item No. RM1; p. 47). https://edocs.puc.state.or.us/efdocs/HAH/ar638hah151428.pdf

[126] Oregon Public Utility Commission. (n.d.). *Wildfire mitigation workshop series*. Oregon.gov. Retrieved February 23, 2022, from https://www.oregon.gov/puc/Pages/EO-20-04-Wildfire-Mitigation-Workshops.aspx

[127] Dalton, M., & Fleishman, E. (Eds.). (2021). *Fifth Oregon climate assessment*. Oregon Climate Change Research Institute. https://oregonstate.app.box.com/s/7mynjzhda9vunbzqib6mn1dcpd6q5jka

[128] Oregon Climate Change Research Institute. (n.d.). *About*. Retrieved February 23, 2022, from https://blogs.oregonstate.edu/occri/about/

[129] Oregon Climate Change Research Institute. (n.d.). *Publications*. Retrieved February 23, 2022, from https://blogs.oregonstate.edu/occri/publications/

[130] Oregon Climate Change Research Institute. (n.d.). *Recent peer-reviewed publications*. Retrieved February 28, 2022, from https://blogs.oregonstate.edu/occri/recent-peer-reviewed-publications/

[131] Oregon Global Warming Commission. (n.d.). *Roadmap to 2035: A plan for Oregon to meet its greenhouse gas reduction targets.* Keeporegoncool.com. Retrieved February 16, 2022, from https://www.keeporegoncool.org/tighger

[132] Oregon Department of Energy. *Oregon Global Warming Commission Analysis Shows Oregon's Greenhouse Gas Reduction Goal is Within Reach*. July 25, 2022. https://energyinfo.oregon.gov/blog/2022/7/25/oregon-global-warming-commission-analysis-shows-oregons-greenhouse-gas-reduction-goal-is-within-reach

[133] Macdonald, C., Buchanan, M., Duncan, A., & Hanemann, M. (2020). *Biennial report to the Oregon Legislature*. Oregon Global Warming Commission. https://static1.squarespace.com/static/59c554e0f09ca40655ea6eb0/t/5fe137fac70e3835b6e8f58e/1608595458463/2020-OGWC-Biennial-Report-Legislature.pdf

[134] Macdonald, C., Buchanan, M., Duncan, A., & Hanemann, M. (2020). *Biennial report to the Oregon Legislature*. Oregon Global Warming Commission. https://static1.squarespace.com/static/59c554e0f09ca40655ea6eb0/t/5fe137fac70e3835b6e8f58e/1608595458463/2020-OGWC-Biennial-Report-Legislature.pdf

[135] Macdonald, C., Buchanan, M., Hatch, A., & Strawn, A. (2021). *Natural & working lands proposal*. Oregon Global Warming Commission. https://static1.squarespace.com/static/59c554e0f09ca40655ea6eb0/t/6148a9d36431174181e05c7c/1632152029009/2021+OGWC+Natural+and+Working+Lands+Proposal.pdf

[136] Oregon Global Warming Commission. (n.d.). [Homepage with links to resources]. Keeporegoncool.com. Retrieved February 16, 2022, from https://www.keeporegoncool.org/

[137] Oregon Sustainability Board. (n.d.). *Oregon Sustainability Board*. Oregon.gov. Retrieved February 23, 2022, from https://www.oregon.gov/das/Facilities/Pages/Sustainability.aspx

[138] Oregon Sustainability Board. (n.d.). *Oregon Sustainability Board*. Oregon.gov. Retrieved February 23, 2022, from https://www.oregon.gov/das/Facilities/Pages/Sustainability.aspx

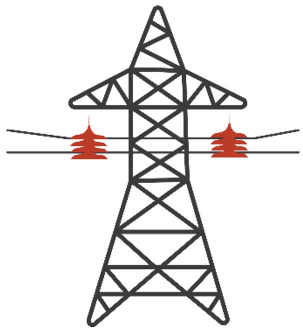
[139] Oregon Department of Energy. (n.d.). Heat Pump Incentive Program. https://www.oregon.gov/energy/Incentives/Pages/heat-pumps.aspx

[140] The Oregon Conservation Strategy. (n.d.). Barriers to Animal Movement. https://www.oregonconservationstrategy.org/key-conservation-issue/barriers-to-animal-movement/#scrollNav-6

[141] Oregon Public Utility Commission. (2022). Docket No. AR 638: Adopt Rules for Risk-Based Wildfire Protection Plans and Planned Activities Consistent with Executive Order 20-04. (Administrative Hearings Division (AHD) Report Item No. RM1; p. 47). https://edocs.puc.state.or.us/efdocs/HAH/ar638hah151428.pdf

[142] 81st Oregon Legislative Assembly (2021). *House Bill 2021*. https://olis.oregonlegislature.gov/liz/2021R1/Downloads/MeasureDocument/HB2021/Enrolled

Energy 101: Infrastructure Investment and Jobs Act of 2021



The Infrastructure Investment and Jobs Act (PL 117-58)[i] will fund the building and repairing of roads and bridges, deployment of broadband internet, strengthening of the electric grid and water systems, and much more. The initial bill was introduced by Oregon Representative Peter DeFazio on June 4, 2021. Following months of negotiations, the bill passed in Congress with bipartisan support and was signed into law by President Joe Biden on November 15, 2021. The law authorizes $1.2 trillion in infrastructure spending across more than 380 federal programs. Of that, approximately $650 billion reauthorizes existing funding, while another $550 billion adds new funding to support the nation's infrastructure needs.[1] [2]

The Biden-Harris Administration is working to implement this funding across multiple federal agencies. With such a variety of programs funded, the Infrastructure Investment and Jobs Act funds are anticipated to be dispersed from the federal government to recipients at different times, depending on the complexity of the program and the individual grantmaking and/or procurement processes associated with aspects of each program. The Biden-Harris Administration has established the following priorities across programs in administering these funds:

(a) investing public dollars efficiently, working to avoid waste, and focusing on measurable outcomes for the American people;

(b) increasing the competitiveness of the United States economy, including through implementation of the Act's Made-in-America requirements and bolstering United States manufacturing and supply chains;

(c) improving job opportunities for millions of Americans by focusing on high labor standards for these jobs, including prevailing wages and the free and fair chance to join a union;

(d) investing public dollars equitably, including through the Justice40 Initiative, which is a government-wide effort toward a goal that 40 percent of the overall benefits from federal investments in climate change and clean energy flow to disadvantaged communities;

(e) building infrastructure that is resilient and that helps combat the crisis of climate change; and

(f) effectively coordinating with state, local, Tribal, and territorial governments in implementing these critical investments.[ii]

With all these distinct programs, it is challenging to precisely identify at the time of this report's publication how this law will affect energy-related infrastructure in Oregon. However, below are highlights of anticipated funding that will support energy-related investments nationwide, including Oregon.

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[i] The Inflation Reduction Act of 2022 was passed after the drafting of this section, but prior to publication. Please see ODOE's website using the link at the end of this article to follow updates pertaining to the funding opportunities under the Inflation Reduction Act.

[ii] Exec. Order No. 14052 as of Nov. 15, 2021, 86 Fed. Reg. 64335 (Nov. 18, 2021).

State Energy Program

Purpose	National Funding Level	Oregon Agency Anticipated to Receive Funds
Provides funding to states to support electric transmission and distribution planning as well as planning activities and programs that help reduce carbon emissions in all sectors of the economy — including the transportation sector, by accelerating the use of alternative transportation fuels and vehicle electrification. This funding will also support improvements to a State Energy Security Plan as directed by Oregon SB 1567. This allocation is in addition to the existing annual state allocation of State Energy Program funding.	$500 Million	Oregon Department of Energy
	Estimated Funding Amount to Oregon	**Anticipated Subrecipients (if applicable)**
	Approximately $5.6 Million	To Be Determined

Energy Efficiency Revolving Loan Fund Capitalization Grant Program

Purpose	National Funding Level	Oregon Agency Anticipated to Receive Funds
Provides capitalization grants to states to establish a revolving loan fund under which the state shall provide loans and grants for energy efficiency audits, upgrades, and retrofits to increase energy efficiency and improve the comfort of buildings.	$250 Million	Oregon Department of Energy
	Estimated Funding Amount to Oregon	**Anticipated Subrecipients (if applicable)**
	Approximately $1.3 Million	Loans and/or grants will be made to commercial or residential property owners

Energy Efficiency and Conservation Block Grant

Purpose	National Funding Level	Oregon Agency Anticipated to Receive Funds
Assists states, local governments, and Tribes in reducing energy use, reducing fossil fuel emissions, and improving energy efficiency.	$550 Million	Oregon Department of Energy will receive the state allocation
	Estimated Funding Amount to Oregon	**Anticipated Subrecipients (if applicable)**
	Unknown	Cities and/or counties with lower populations will be eligible to apply for a portion of the state allocation

Preventing Outages and Enhancing the Resilience of the Electric Grid (IIJA Section 40101(d))

Purpose	National Funding Level	OR Agency Anticipated to Receive Funds
Provides grants to States and Tribes to prevent outages and enhance the resilience of the electric grid.	$2.3 Billion	Oregon Department of Energy will receive the state allocation
	Estimated Funding Amount to Oregon	**Anticipated Subrecipients (if applicable)**
	Approximately $50 million	Electric Grid Operators, Electricity Storage Operators, Electricity Generators, Transmission Owners and Operators, Distribution Providers, & Fuel Suppliers

Preventing Outages and Enhancing the Resilience of the Electric Grid (IIJA Section 40101(c))

Purpose	National Funding Level	OR Entities Anticipated to Receive Funds
Provides competitive grants to eligible entities to prevent outages and enhance the resilience of the electric grid.	$2.3 Billion	Electric Grid Operators, Electricity Storage Operators, Electricity Generators, Transmission Owners and Operators, Distribution Providers, and Fuel Suppliers
	Estimated Funding Amount to Oregon	**Anticipated Subrecipients (if applicable)**
	Unknown	N/A

Energy Auditor Training Grant Program

Purpose	National Funding Level	OR Agency Anticipated to Receive Funds
Provides grants to "eligible states" to train individuals to conduct energy audits or surveys of commercial and residential buildings to build the clean energy workforce, save customers money on their energy bills, and reduce pollution from building energy use.	$40 Million	Oregon Department of Energy anticipates preparing a competitive application
	Estimated Funding Amount to Oregon	**Anticipated Subrecipients (if applicable)**
	Estimated funding to Oregon unknown; Awards cannot exceed $2 million	To Be Determined

Building Codes Implementation for Efficiency and Resilience

Purpose	National Funding Level	OR Agency Anticipated to Receive Funds
Creates a competitive grant program to enable sustained, cost-effective implementation of updated building energy codes to save customers money on their energy bills.	$225 Million	To Be Determined
	Estimated Funding Amount to Oregon	**Anticipated Subrecipients (if applicable)**
	Unknown	To Be Determined

National Electric Vehicle Infrastructure Formula Program

Purpose	National Funding Level	OR Agency Anticipated to Receive Funds
Creates a five-year program to strategically deploy high-powered, fast electric vehicle charging infrastructure on federally-approved EV Alternative Fuel Corridors and establishes an interconnected charging network to facilitate access, reliability, and data collection. Sets aside 10 percent of funding for discretionary grants to state and local governments that require additional assistance to strategically deploy EV charging infrastructure. The State of Oregon will provide additional information about the deployment of funds as it becomes available on ODOT's NEVI webpage.	$5 Billion	Oregon Department of Transportation
	Estimated Funding Amount to Oregon	**Anticipated Subrecipients (if applicable)**
	Approximately $52 Million in federal funds over five years; 20 percent non-federal match required	N/A

Weatherization Assistance Program

Purpose	National Funding Level	OR Agency Anticipated to Receive Funds
To increase energy efficiency in low-income households to reduce their total residential energy costs and improve health and safety, especially for older adults, people with disabilities, and children.	$3.5 Billion	Oregon Housing and Community Services
	Estimated Funding Amount to Oregon	**Anticipated Subrecipients (if applicable)**
	$30,603,866	Will be administered by community-based organizations

Low-Income Home Energy Assistance Program

Purpose	National Funding Level	OR Agency Anticipated to Receive Funds
Additional funding for the Low-Income Home Energy Assistance Program (LIHEAP), which assists eligible low-income households with their heating and cooling energy costs, bill payment assistance, energy crisis assistance, weatherization, and energy-related home repairs.	$500 Million	Oregon Housing and Community Services
	Estimated Funding Amount to Oregon	**Anticipated Subrecipients (if applicable)**
	$1,081,558	Will be administered by community-based organizations

A complete list of programs funded through the Infrastructure Investment Act can be found at: https://www.whitehouse.gov/wp-content/uploads/2022/01/BUILDING-A-BETTER-AMERICA_FINAL.pdf.

Rural communities may also want to consult the Rural Playbook, a guide released by the White House intended to help rural communities strategize the potential uses of IIJA funds. https://www.whitehouse.gov/wp-content/uploads/2022/04/BIL-Rural-Playbook-.pdf.

The Rural Playbook highlights several energy-related investments under the Bipartisan Infrastructure Law, including $700 million to upgrade existing hydropower dams and $1 billion to improve resilience, safety, reliability, and availability of energy in rural and remote communities with a population under 10,000. The law also includes grants to invest in: electric vehicle charging networks in rural areas and low- and moderate-income neighborhoods; zero-emission school buses; cybersecurity for rural and municipal electric utilities; and weatherization assistance to improve energy efficiency for low-income families.

Other important funding opportunities for rural communities under the bill include improving high-speed internet access; cleaning up abandoned mines, Superfund sites, and brownfields; improving transportation infrastructure including bridges, roads, and transit; strengthening drinking water and wastewater systems; developing and implementing community wildfire protection plans; reducing risks to local infrastructure from disasters and natural hazards; and extending the existing Secure Rural Schools program.

Oregon Department of Energy staff have heard from stakeholders that communities with fewer resources may be disadvantaged in seeking these much-needed funds. Many environmental justice communities in Oregon lack the resources and capacity to adequately plan for, apply to, and subsequently manage these federal dollars. While solutions to this problem are likely not one-size-fits-all, the agency is exploring options to provide assistance and reduce these barriers.

The State of Oregon will provide additional information about the deployment of these funds as it becomes available. You can follow the implementation of Infrastructure Investment and Jobs Act funds across all agencies online: https://www.oregon.gov/odot/IF/Pages/default.aspx.

Specific updates from the Oregon Department of Energy are available from ODOE's website: https://www.oregon.gov/energy/energy-oregon/Pages/IIJA.aspx.

REFERENCES

[1] Curtin, T., Lukas, R., & Whitaker, A. (2021, Nov. 7) House Passes Bipartisan Infrastructure Package, Sends to President. *National Governor's Association.* House Passes Bipartisan Infrastructure Package, Sends to President - National Governors Association (nga.org)

[2] Infrastructure Investment and Jobs Act, H.R. 3684, 117th Congress. (2021). https://www.congress.gov/bill/117th-congress/house-bill/3684