KEY FINDINGS

Workforce Analysis

Net-Zero Northwest: Technical and Economic Pathways to 2050 **is an economy-wide deep decarbonization pathways analysis to guide actions that will put Idaho, Montana, Oregon, and Washington on the path to achieving net-zero emissions by 2050.**

Northwest Stands to Gain Jobs with Clean Energy Transition

How would existing and future jobs change if the Northwest were on the path to net-zero emissions?

The *Net-Zero Northwest (NZNW) Workforce Analysis* examined the jobs that would be created or displaced if the Northwest were on the path to achieving net-zero emissions,[1] as modeled in the *NZNW Energy Pathways* analysis,[2] by industry and occupation in the electricity, fuels, buildings, and transportation sectors. The following key themes emerged:

- Electricity sector jobs grow by 43% (nearly 44,400 jobs) between 2021 and 2030, driven by increases in Land-based Wind, Transmission, Distribution, and Solar.
- Despite job displacement in fossil fuel subsectors, the Fuels sector as a whole sees a net increase of nearly 7,400 jobs between 2021 and 2030. Hydrogen drives this growth, adding more than 11,000 jobs, while Biofuels adds more than 1,400.
- Between 2021 and 2030, Buildings sector employment increases by 22%, driven largely by Commercial HVAC and Residential Shell jobs. In fact, all Buildings subsectors are projected to grow as energy efficiency and building electrification and decarbonization efforts ramp up.
- Employment in the Transportation sector increases by about 1% (approximately 2,000 net jobs) between 2021 and 2030, reflecting decreases in employment in Conventional Fueling Stations and, to a lesser extent, Vehicle Manufacturing, along with net growth in Vehicle Maintenance, Wholesale Trade Parts, and Charging Stations.
- In all sectors, it will be important to promote strategies such as labor union pathways, prevailing wage requirements, apprenticeships, and project labor agreements to ensure job quality is a priority in the transition to a clean energy economy.

Historical Trends in Clean Energy Employment in the Northwest

Clean energy jobs in the United States are growing at a faster rate than jobs in the rest of the economy,[3] a growth rate likely spurred by geopolitical factors,[4] state and local climate policies, and federal funding—notably the CHIPS and Science Act,[5] the Bipartisan Infrastructure Law (BIL),[6] and the Inflation Reduction Act (IRA),[7] which are making clean energy technologies more economically feasible.

Based on U.S. Energy & Employment Jobs Report (USEER) data for 2022, the Northwest region employed nearly 158,000 clean energy workers across renewable electric power generation, grid and storage, energy efficiency, clean fuels, and alternative technology transportation, a 2.8% increase from the previous year.[8] Of these, energy efficiency comprised the majority of clean energy jobs (73%), followed by renewable electric power generation (13%). Alternative transportation and grid and storage each account for another 6% of the region's clean energy workforce, with clean fuels responsible for the remaining 2%.

Above: Electrician installing cable lines and electrical system. Photo credit: Prapat

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In terms of geographical distribution, Washington state accounted for half of all clean energy workers in 2022 in the Northwest, with Oregon employing 35%, and Montana and Idaho supporting the remaining 15%.

From 2017 through 2019, clean energy employment in the region increased by 4%. In 2020, during the COVID-19 pandemic, clean energy jobs suffered a 9% decline, most of which was due to decreased employment in energy efficiency. Since 2020, the Northwest's clean energy workforce has increased by 6%, back to 2017 levels. While there is more employment now than before the pandemic in alternative transportation and grid and storage, employment in energy efficiency has yet to make a full recovery.

Through the following figures, this *NZNW Workforce Analysis* offers insights into Northwest clean energy employment as the region aims to achieve net-zero emissions by 2050, with a focus on the next seven years through 2030.[9]

Table 1 lays out the energy sectors, subsectors, and job areas examined in this analysis. Then, Figure 1 shows how employment in each of these subsectors changes from the baseline year (2021) to 2030. Figure 2 reports the change in overall energy employment from 2021 to 2030, broken out by direct, indirect, and induced job impacts.

Direct jobs are those associated with the initial economic activity of a given investment or activity, and indirect jobs are those associated with the supply chain connected to that initial economic activity. Induced jobs refer to employment based on the additional household spending resulting from the direct and indirect employment generated.

Figure 3 and Figure 4 provide high-level views of how employment changes in each sector between 2021-2030. Figure 3 examines this change by industry category (construction, manufacturing, other supply chain, and professional services), showing the economic impact of energy investments made on the path to net-zero emissions. Figure 4 provides an occupational analysis, looking at the change in installation/repair, management/professional, production/manufacturing, sales, administrative, and other occupations in each energy sector.

Finally, Figure 5 presents a wage analysis for 2030 that shows the distribution of jobs by wage tier for each energy sector. Together, these figures and the accompanying analysis offer direction for Northwest decision-makers to understand how energy employment is projected to change as the region attempts to achieve net-zero emissions by 2050.

Maintenance in a high-voltage electrical substation. Photo credit: Paulo Esteves

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Table 1. Energy Subsector Descriptions and Example Jobs

	Subsector	Description	Example Jobs (Direct)[1]
ELECTRICITY	Distribution	*Local power lines, smart grid*	Lineworker, groundperson, cable splicer, service technician, drone pilot, product specialist, software developer, safety manager
	Solar	*Rooftop solar, utility photovoltaic (PV), concentrated solar power (CSP)*	Solar site assessor, sales representative, PV system designer, installation contractor, structural engineer, power systems engineer, materials scientist
	Transmission	*Regional transmission*	Substation engineer, power systems engineer, power scheduler (see also: Distribution job areas)
	Land-based Wind	*Existing and new land-based wind farms*	Survey technician, assembler/fabricator, machinist, blade testing engineer, crane/tower operator, rigger, wind technician, construction manager, plant manager, meteorologist
	Storage	*Batteries, flywheel, thermal energy, pumped hydro*	Electro-mechanical technician, high voltage reliability specialist, energy storage engineer, production worker, site acquisition specialist, site surveyor, construction manager
	Hydropower	*Large-scale and run-of-river hydroelectric power generation*	Plant manager, hydropower biologist, earth scientist, mechanical engineer, compliance specialist
	Other Renewable Generation	*Biomass, hydrogen combustion generators, hydrogen fuel cells*	Power marketer, logistician, industrial engineer, project developer, economist, plant manager, farmers, harvest equipment mechanic
	Nuclear	*High-temperature gas-cooled reactors, small module reactors*	Electrician, welder, radiation protection apprentice, power reactor operator, nuclear engineer
	Natural Gas Generation	*Natural gas peaker plants, combustion turbine plants, combined cycle plants*	Power plant operator, electrician, electrical and electronics repairer, industrial machinery mechanic
	Other Fossil Generation	*Coal, oil, other fossil fuel burning plants*	Welder, foreman, pipefitter, floorhand, plant operator, petroleum engineer, industrial electrician, landman
	Offshore Wind	*New offshore wind farms*	Commercial diver, water vessel captains and mates, marine scientist (see also: Land-based Wind job areas)
FUELS	Other Fossil Fuels	*Oil and gas, coal, kerosene*	Welder, driller, foreman, underground miner, pipefitter, floorhand, plant operator, petroleum engineer, landman
	Natural Gas Distribution	*Natural gas pipelines, liquefied natural gas (LNG) trucks and tankers*	Pipeline operators, truck drivers, barge operators, pipefitter, other general natural gas jobs (see also: Natural Gas job areas)
	Biofuels	*Ethanol, bio-gasification, biomass fast pyrolysis*	Biochemist, farmer, industrial machinery mechanic, chemical and industrial engineers, storage facility operators, construction laborer
	Natural Gas	*Natural gas production and transportation*	Driller, above and below ground technician, gas operator, geologist, natural gas scheduler
	Hydrogen	*Hydrogen electrolysis and transportation*	Chemical and mechanical engineer, materials scientist, advanced manufacturing technician, lab technician, machinist, plant operator
BUILDINGS	Residential HVAC	*Sheet metal, heating, air conditioning*	Residential installer (heat pumps, ventilation, air conditioning, etc.), service technician, residential building code inspector, residential energy auditor
	Residential Other	*Laundry, refrigerators, lighting, water heating, cooking, freezing, clothes washing and drying, dishwashing, etc.*	Sales representative and estimator, energy efficiency program assistant, residential energy auditor
	Commercial HVAC	*Pipes, sheet metal, heating, air conditioning, refrigeration, power boilers, heat exchangers*	Commercial installer (heat pumps, ventilation, air conditioning, etc.), construction supervisor, refrigeration technician, facilities manager, stationary engineer, commercial energy auditor, building automation systems engineer
	Commercial Other	*Commercial lighting, cooking, refrigeration, water heating, etc.*	Commercial kitchen service technician, commercial energy auditor, lighting designer
	Residential Shell[2]	*Paintings, coatings, insulation, windows and doors*	Weatherization technician, sales representative and estimator
TRANSPORTATION[3]	Conventional Fueling Stations	*Fossil fueling stations (to the extent these stations are closed rather than converted to EV charging)*	Cashiers, retail managers, service station attendants
	Vehicle Maintenance	*Vehicle repair and maintenance activities*	Tow truck driver, mechanic, tire technician, service technician, detailer, vehicle inspector
	Wholesale Trade Parts	*Wholesale of vehicle components*	Parts specialist, product developer, quality testing engineer, process engineer, service manager
	Vehicle Manufacturing	*Electric vehicles, conventional vehicles, dual-use technologies (i.e., parts used in both ICE and ZEVs)*	Machinist, equipment assembler, materials scientist, electrical and industrial engineers, mechanical drafter, software engineer, salesperson, quality testing engineer, designer
	Charging Stations	*Manufacturing, installation, maintenance*	Electrician, electric power-line installer, urban and regional planner, software engineer, electronics engineer, operations manager, retail salesperson

1 The list of jobs is not comprehensive nor ranked in order of importance. See ***Net-Zero Northwest Workforce Analysis Resources*** for resources consulted.
2 Commercial shell subsector not included due to lack of input data from Evolved Energy Research's *Energy Pathways* modeling.
3 This analysis focuses on on-road transportation and does not include aviation and maritime shipping.

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Northwest Energy Employment Experiences Net Growth from 2021 to 2030

Figure 1 shows employment across all energy subsectors in this analysis from the baseline year (2021) and the net change by 2030.

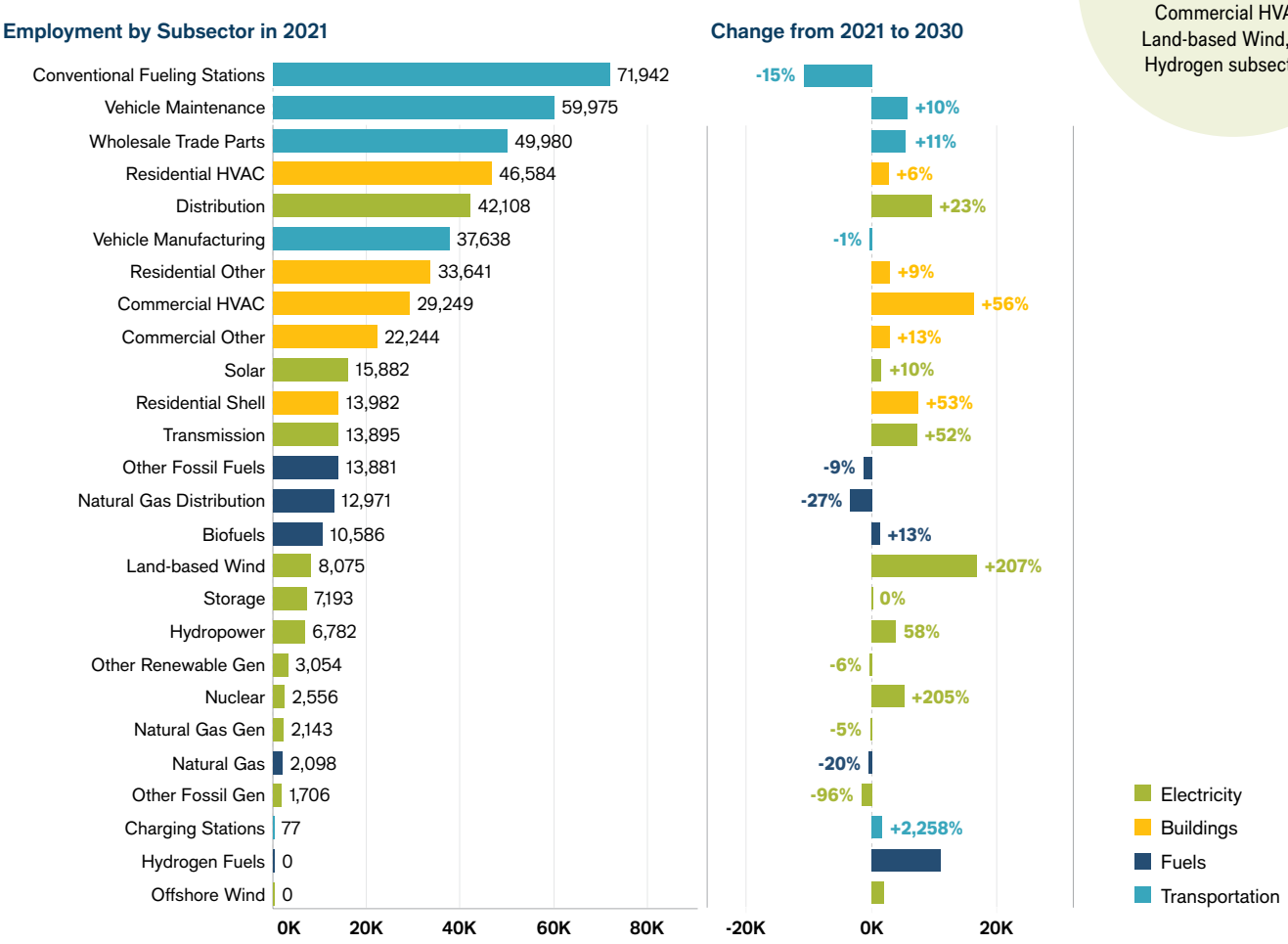
In 2021, the top three employing subsectors are from the Transportation sector. The top subsector overall, Conventional Fueling Stations, drops by 15% in 2030 as electric vehicles (EVs) and supporting infrastructure replace gas-powered internal combustion engine (ICE) vehicles and conventional fueling stations.

While Conventional Fueling Station employment declines, Charging Station employment rises by more than twenty-fold (from a baseline of 77 jobs) to roughly 1,800 jobs as EVs and other alternative vehicle stocks outpace ICE vehicle stocks.

These forecasts are based on model assumptions about the number of charging devices, expected charging station maintenance needs, and impacts to fueling stations both with and without convenience stores.[10] In reality, there are many questions about what this transition will look like for conventional fueling stations and associated workers.[11]

Overall Northwest energy employment grows by 17% from 2021 to 2030, especially in Distribution, Commercial HVAC, Land-based Wind, and Hydrogen subsectors.

Figure 1. Northwest Energy Employment by Subsector in 2021 and 2030



Source: BW Research Partnership. *Net-Zero Northwest Workforce Analysis Technical Report*, November 2023.

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The next two top employing subsectors, Vehicle Maintenance and Wholesale Trade Parts, both experience net gains in 2030, although Vehicle Maintenance jobs peak in 2025 when there is significant overlap between ICE vehicles and EVs (not shown in Figure 1).

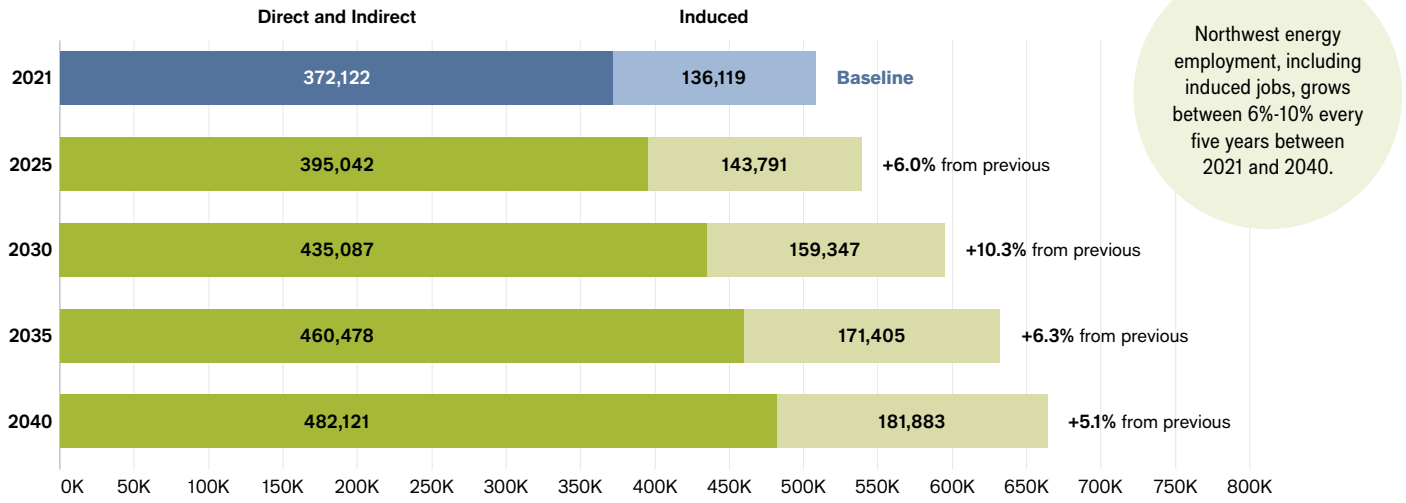
As seen in Figure 1 on the previous page, the subsectors that experience the most net growth by 2030 include the following Electricity subsectors: Land-based Wind (207%), Nuclear (205%), Hydropower (58%), Transmission (52%), and Distribution (already a large employer, Distribution adds roughly 9,700 jobs for a 23% increase).

Buildings subsectors also see substantial growth by 2030 as energy efficiency and building electrification and decarbonization efforts ramp up, notably Commercial Heating, Ventilation, and Air-Conditioning (HVAC), which grows by 56%, and Residential Shell, which grows by 53%. Within the Fuels sector, Hydrogen grows the most, from a baseline of zero jobs to around 11,000 jobs in 2030.

As seen in Figure 2, induced jobs comprise approximately 27% of the total energy employment in each year. While not energy jobs per se, induced jobs point to the broader effects of energy investment on the local economy.

Heat pump technician installing new device. Photo credit: Tomasz Zajda

Figure 2. Northwest Energy Employment (Direct, Indirect, and Induced Jobs), 2021-2040



Northwest energy employment, including induced jobs, grows between 6%-10% every five years between 2021 and 2040.

Source: BW Research Partnership. *Net-Zero Northwest Workforce Analysis Technical Report*, November 2023.

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Change in Employment by Industry and Occupation: 2021-2030

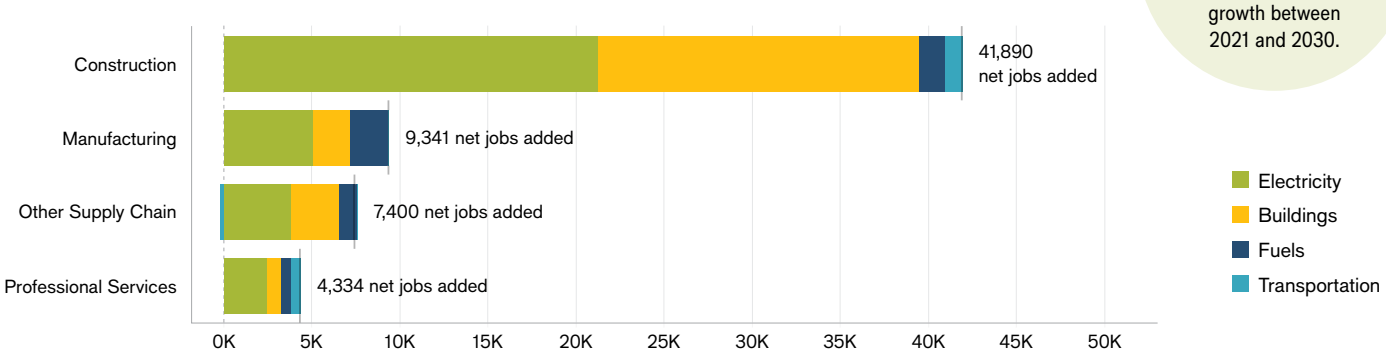
Figure 3 and Figure 4 show the change in direct and indirect jobs in each of the four Northwest energy sectors from 2021 to 2030, by Industry and Occupation respectively.

Figure 3 shows Construction job growth dominating, largely in the Electricity and Buildings sectors.

In Figure 4, Installation/Repair and Management/Professional occupations grow the most, again driven by growth in Electricity and Buildings jobs.

The Construction industry, particularly in Electricity and Buildings, dominates Northwest energy employment growth between 2021 and 2030.

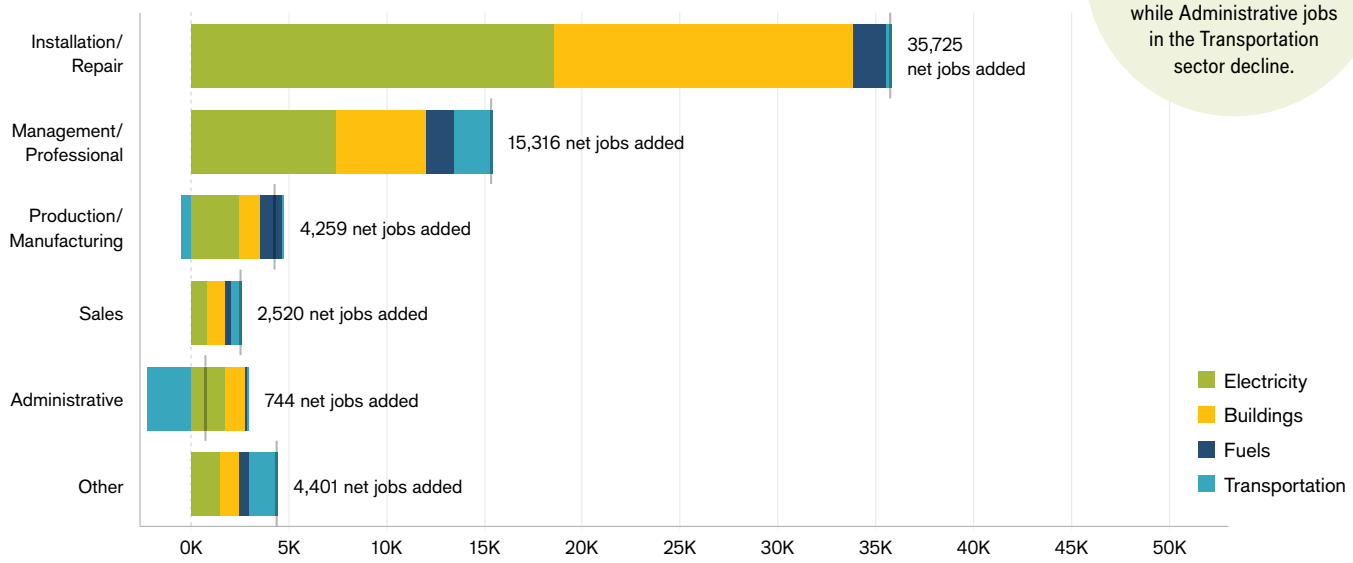
Figure 3. Northwest Employment Change by Industry, 2021-2030



Source: BW Research Partnership. *Net-Zero Northwest Workforce Analysis Technical Report*, November 2023.

Installation/Repair occupations—especially in Electricity and Buildings—drive Northwest employment growth, while Administrative jobs in the Transportation sector decline.

Figure 4. Northwest Employment Change by Occupation, 2021-2030



Source: BW Research Partnership. *Net-Zero Northwest Workforce Analysis Technical Report*, November 2023.

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Training Workers to Meet Growing Clean Energy Demand

Across the four energy jobs sectors, similar industrial and occupational employment demands arise. The Northwest region will see a dramatic increase in demand for construction and manufacturing workers with new installed generating capacity, buildings electrification work, new hydrogen and biofuel production, and installation of electric vehicle charging stations. Installation/Repair occupations and, to a slightly lesser extent, Management/Professional occupations, also increase dramatically, particularly in the Electricity and Buildings subsectors.

While these overall trends are consistent across sectors, each sector requires slightly different workforce development strategies. For instance, residential building work will require smaller, retail-based electricians, HVAC technicians, and other specialty trade contractors that have specific knowledge of energy-efficient technologies found in residential buildings and homes, while utility solar and wind projects will require electricians and technicians with specialized knowledge of larger generation systems.

As seen in Figure 3 on the previous page, most new jobs created will be within the construction trades. It will be important to leverage apprenticeship programs, which are paid positions with on-the-job training and additional instruction, that already exist for many construction trade occupations to help train new and legacy workers quickly and effectively.

Pre-apprenticeship programs are designed to prepare workers for entry into apprenticeship programs and usually target underrepresented demographics. They also can help move people off the economic sidelines and into apprenticeships.

Increasing access to community colleges and vocational programs is another important step for making training resources more widely available and bringing workers into clean energy roles. The growth in jobs and decarbonization investments presents an opportunity to focus efforts on underserved communities as a strategy to capture the entirety of the region's talent and spread economic benefits to populations who have been marginalized and under-resourced.

Engineer in front of hydrogen facility. Photo credit: scharfsinn86

Transitioning Workers for the Clean Energy Economy

In addition to training new workers, displaced workers will need retraining to transition into emerging employment areas. Early, intentional planning that develops prevailing wage jobs in emerging clean energy fields and involves workers impacted by the transition away from fossil fuels is critical to avoid otherwise devastating effects of fossil fuel layoffs.

These themes show up consistently in recent studies about transitioning fossil fuel workers. A 2023 report from the public policy organization True Transition surveyed over 1,500 oil and gas workers in the United States and found that the top three issues of importance in considering moving to a new job outside of the oil and gas industry were: pay, health and safety conditions, and a similar work schedule.[12] The same report also emphasized the importance of listening to oil and gas workers (and more broadly, workers in any declining sectors) because workers know what they need, and should have a seat at the table deciding the future of energy jobs in the U.S.[13]

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According to another 2023 study from the University of California, Berkeley Labor Center,[14] in the aftermath of the shutdown of an oil refinery in California, 74% of former workers had found new jobs, but the median hourly wage of these new jobs was $38 an hour compared to $50 an hour at the refinery. Findings from that study point to four types of assistance that workers need most: 1) Third-party skill certification to ensure efficient and accurate skill-matching for jobs in new markets; 2) Targeted job search assistance; 3) An economic development strategy that ensures that the new jobs created are of comparable quality to those in the declining industry; and 4) Financial support for workers and their families.

This *NZNW Workforce Analysis* illuminates several areas for further consideration in terms of transitioning from fossil fuel to clean energy jobs in the Northwest.

In the Electricity sector, Natural Gas Generation and Other Fossil Generation (coal, oil, and other fossil fuel burning plants) experience net decreases in employment as renewables take over as sources of electricity generation. After 2035, the *NZNW Energy Pathways* modeling assumes[15] that new gas generating capacity will use biomass methane gas, which could open transition opportunities for current natural gas generation workers, as the facilities themselves could remain in place but the fuel would switch from natural gas to biomass methane gas. This may require retraining workers on new processes and day-to-day operating, but there would likely be many transferable skills.

The Fuels sector also offers opportunities to make best use of available skilled labor and to mitigate negative impacts to workers in the transition. Resources should be allocated specifically toward training and transitioning displaced Natural Gas, Natural Gas Distribution, and Other Fossil Fuel workers into new opportunities, such as the production, distribution, and storage of Hydrogen and Biofuels—two Fuels subsectors that grow by more than 11,000 jobs and more than 1,400, respectively, by 2030.

A complicating factor to this transition could be location: the *NZNW Energy Pathways-Clean Fuels*[16] analysis found that it would be economic to co-locate production of hydrogen and subsequent clean fuels with high-quality renewable resources, which may not exist in the same locations as workers from existing natural gas and fossil fuel jobs, according to a 2023 article published in *Nature Communications*.[17]

In the Buildings sector, all subsectors experience net job growth, so there is less of a concern about transitioning displaced workers. However, there is still a significant need for educating and potentially re-training existing workers to install lower-carbon versions of HVAC technology and appliances (heat pumps, high-efficiency building shells, etc.).

The Transportation sector's decarbonization transition must take into account the uncertainty surrounding conventional fueling station workers as demand for conventional fuel drops and new charging station technologies expand. There are also concerns from autoworkers about the impact of the electric vehicle transition on high-quality union jobs in the automotive sector.

Solar energy technical and vocational training program at the Northwest Indian College, Lummi Nation. Photo credit: Jessica Plumb

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Wage Tier Analysis

Figure 5 shows the wage tier distribution of jobs in each sector in 2030 (less than $30 an hour, $30-$44 an hour, or more than $44 an hour).[18]

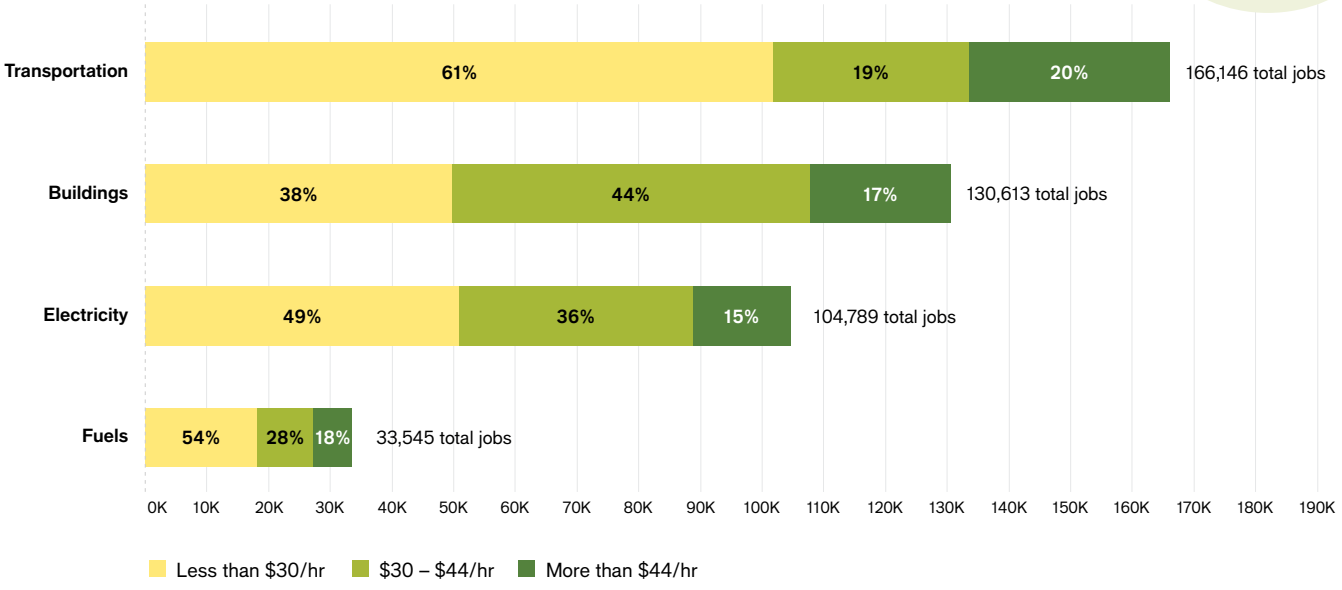
The Transportation sector has the largest share (61%) of jobs in the lowest wage tier (under $30 an hour), while the Buildings sector has the largest percentage of workers (61%) earning over $30 an hour. The Electricity sector has just under half (49%) of workers earning less than $30 an hour, with the remaining 51% earning either $30-$44 an hour or over $44 an hour. The Fuels sector has the lowest number of jobs overall, with over half (54%) earning less than $30 an hour.

While only 2030 is shown in this figure, the percentage of workers in each wage tier does not change significantly between 2021 and 2030.

Inspecting a test wind turbine blade. Photo credit: Dennis Schroeder / NREL

51% of all clean energy jobs in 2030 are in the lowest wage tier, pointing to the importance of intentional planning for job quality in this transition.

Figure 5. Northwest Employment by Wage Tier, 2030



Note: Proportional employment by wage tier is presented for the 2030 scenario using constant 2021 U.S. dollars.

Source: BW Research Partnership. *Net-Zero Northwest Workforce Analysis Technical Report*, November 2023.

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Ensuring Job Quality

There are various strategies—including labor union pathways, prevailing wage requirements, registered apprenticeships, and project labor agreements (PLAs)—that could promote good-paying, fair jobs in emerging clean energy sectors and bring economic development to a wide range of communities that have historically been left out.[19]

Through the IRA, the federal government has taken significant steps to ensure that clean energy investment creates quality, good-paying jobs. One mechanism in the IRA is a bonus tax credit that links prevailing wage and registered apprenticeship requirements to the level of clean energy tax incentive available.[20] Prevailing wage (a minimum wage rate typically the average or market wage for a type of work in a specific area) has historically been established for public works or federal construction projects. Since prevailing wage is now tied to certain federal IRA incentives, there may be more market demand for union involvement since unions guarantee those requirements are met, although prevailing wage rates can also be met without union involvement.

Registered apprenticeships (paid positions with on-the-job training and additional instruction) are another key workforce development strategy that can be sponsored by unions, employers, or collaboration between the two. Registered apprenticeships have proven to bring higher earnings to participating workers, help employers reduce the cost of hiring, and improve company culture and employee loyalty.[21]

PLAs (agreements negotiated in advance of a project to specify wages, benefits, working conditions, and more) can be another helpful tool to ensure job quality. President Biden signed an Executive Order in February 2022 clarifying that "it is the policy of the Federal Government for agencies to use project labor agreements in connection with large-scale construction projects to promote economy and efficiency in Federal procurement."[22] Community Workforce Agreements (CWAs) and Community Benefit Agreements (CBAs) often go beyond the scope of PLAs and can also be beneficial tools to maximize benefits for local communities.[23]

Worker assembling charging station. Photo credit: Oregon Department of Transportation

Labor unions are a valuable part of the energy workforce ecosystem in the Northwest and nationwide. As of 2022, 11% of the energy workforce was represented by a union or covered under either a PLA or a collective bargaining agreement, which is over 1.5 times the private sector average of unionization (7%).[24]

In the Northwest, Washington has the country's third highest unionization rate: nearly one in five workers belonged to a union in 2022. Oregon ranked 7th, with an approximately 15% unionization rate. Montana came in at 19th, with 11% unionization, followed by Idaho at 41st, with nearly 5% unionization rate.[25]

Unions can help promote more inclusive and diverse workforces. According to the 2023 USEER, for example, union employers were more than twice as likely than non-union employers to offer or require a diversity and/or inclusion training program and were more likely to report specific strategies, policies, or programs to increase the number of women, ethnic and racial minorities, and LGBTQ+ hires.[26]

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Conclusion

The *NZNW Workforce Analysis* offers regional policymakers direction for how employment is projected shift over time as the region moves toward attaining a net-zero emissions goal by 2050. While fossil fuel-related jobs will decline, on balance net energy jobs in the Northwest will grow by 17% between 2021 and 2030. The question for the region's stakeholders is how to manage the transition to clean energy in such a way that as many people as possible benefit, either by having access to jobs that were previously foreclosed or by receiving training that would enable them to learn new skills and maintain a good standard of living.

Next steps coming out of this analysis could include a comprehensive workforce needs assessment (WNA), which could provide data and analysis of the clean energy workforce needed in each sector and subsector to meet net-zero emissions goals in the Northwest. The Massachusetts 2023 Clean Energy WNA,[27] for example, was a follow-up study that built upon research for the Massachusetts Clean Energy and Climate Plan for 2025 and 2030.[28] This WNA provided a more granular level of analysis, such as forecasts of electricians needed for different subsectors (e.g., utility-scale solar, land-based wind).

The WNA also determined which occupations present the greatest workforce challenge to achieving decarbonization goals, and involved collaboration with education and training institutions, unions, employers, and community-based organizations to identify opportunities to better support the development of a diverse and equitable workforce among these highest priority occupations.

While a WNA for the Northwest region and each constituent state would differ from this Massachusetts example due to differences in timelines, technologies, stakeholders, policies, and available labor supply, the assessment would uncover key insights and areas of greatest need to guide targeted workforce development strategies. The *NZNW Workforce Analysis* provides the starting point for all in the region who are invested in ensuring an equitable clean energy transition in the Northwest.

Electrical lineworkers preparing to replace damaged high-voltage insulator. Photo credit: 3asy60lf

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Glossary

For a full list of Net-Zero Northwest terms and definitions, please see: www.nznw.org/glossary

Apprenticeship programs: Paid positions with on-the-job training and additional classroom instruction.

Direct employment: Employment associated with the initial economic impact of a given investment or activity (e.g., changes in wages, production, or jobs).

Indirect employment: Employment associated with the supply chain connected to the initial economic impact of the original investment or activity (e.g., purchases of goods and services or business tax impacts).

Induced employment: Employment based on the additional household spending resulting from the direct and indirect employment that is generated from the initial economic impact of the original investment or activity (e.g., wages paid, household purchases, or household tax impacts).

Labor union: A labor union or trade union is an organized group or association of workers who unite to make decisions about conditions affecting their work, including pay, benefits, working conditions, and more. Labor unions negotiate contracts with employers and engage in collective bargaining on behalf of their members to increase wages and benefits and improve workplace conditions.

Pre-apprenticeship programs: Programs designed to prepare workers with the skills needed for successful entry into apprenticeship programs, usually targeting certain underrepresented populations or demographics.

Prevailing wage: The basic hourly rate of wages and benefits paid to a number of similarly employed workers in a given geography.

Project labor agreements: Pre-hire collective bargaining agreements negotiated between construction unions and construction contractors that establish the terms and conditions of employment for construction projects.

Registered apprenticeships: An apprenticeship program that is approved and validated by the U.S. Department of Labor or a State Apprenticeship Agency.

Endnotes

1 The emissions target used in this study—net-zero emissions by 2050—is in line with meeting the Intergovernmental Panel on Climate Change (IPCC) guidance on maintaining a 1.5°C temperature rise. IPCC, 2022: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926. https://www.ipcc.ch/report/sixth-assessment-report-working-group-3/

2 See the following *Net-Zero Northwest Energy Pathways* results by sector: https://www.nznw.org/energy/electricity; https://www.nznw.org/energy/clean-fuels; https://www.nznw.org/energy/buildings; https://www.nznw.org/energy/transportation.

3 The number of U.S. clean energy jobs grew 3.9% from 2021 to 2022, while overall U.S. employment increased by 3.1% in the same time period. United States Department of Energy. "United States Energy & Employment Report 2023." June 2023. https://www.energy.gov/sites/default/files/2023-06/2023%20USEER%20REPORT-v2.pdf

4 World Economic Forum. "How does the war in Ukraine affect oil prices?" March 4, 2022. https://www.weforum.org/agenda/2022/03/how-does-the-war-in-ukraine-affect-oil-prices/

5 The White House. "Fact Sheet: CHIPS and Science Act Will Lower Costs, Create Jobs, Strengthen Supply Chains, and Counter China." August 9, 2022. https://www.whitehouse.gov/briefing-room/statements-releases/2022/08/09/fact-sheet-chips-and-science-act-will-lower-costs-create-jobs-strengthen-supply-chains-and-counter-china/

6 The White House. "Fact Sheet: The Bipartisan Infrastructure Deal." November 6, 2021. https://www.whitehouse.gov/briefing-room/statements-releases/2021/11/06/fact-sheet-the-bipartisan-infrastructure-deal/

7 The White House. "Building a Clean Energy Economy: A Guidebook to the Inflation Reduction Act's Investments in Clean Energy and Climate Action." January 2023. https://www.whitehouse.gov/wp-content/uploads/2022/12/Inflation-Reduction-Act-Guidebook.pdf

8 United States Department of Energy, "United States Energy & Employment Report 2023." Note: Alternative technology transportation refers to vehicles that use a fuel source other than gasoline or diesel (including hybrid electric, plug-in hybrid, battery electric, hydrogen fuel-cell, and others).

9 The *NZNW Workforce Analysis* examines traditional energy jobs in addition to the clean energy jobs included in the USEER.

10 BW Research Partnership. "Net-Zero Northwest Jobs Study Assumptions Overview." June 5, 2023. https://www.nznw.org/files/workforce-assumptions

11 Gearino, Dan. "What's the Future of Gas Stations in an EV World?" Inside Climate News. March 30, 2023. https://insideclimatenews.org/news/30032023/inside-clean-energy-gas-stations-electric-vehicle-charging/

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Endnotes (continued)

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Solar installers on roof. Photo credit: A&R Solar

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