Inclusive Sustainability:

Workforce and Community Impacts of Environmental Initiatives at the Port of Seattle

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Port of Seattle

2024

SJI SEATTLE JOBS INITIATIVE

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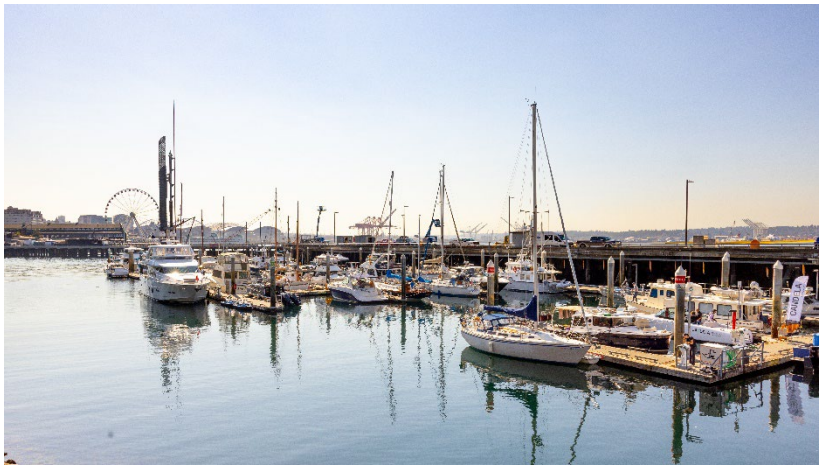
List of Abbreviations

Abbreviations	Definition
BOEM	Bureau of Ocean Energy Management
CETA	Clean Energy Transformation Act
CH_3OH	Methanol
CH_4	Methane
CO_2	Carbon Dioxide
CREST	Center for Responsible Travel
DOE	Department of Energy
ESD	Employment Security Department
FLOWIN	Floating Offshore Wind Readiness Prize
FOSW	Floating Offshore Wind
GHG	Greenhouse Gases
GW	Gigawatt
GWh	Gigawatt Hour
H_2	Hydrogen molecule
HVAC	Heating, Ventilation, and Air Conditioning
ICE	Internal Combustion Engine
IIJA	Infrastructure Investment and Jobs Act of 2021 or Bipartisan Infrastructure Law
IRA	Inflation Reduction Act
MSW	Municipal Solid Waste
NAICS	North American Industry Classification System
NH_3	Ammonia
NWPCAS	Northwest Ports Clean Air Strategy
ODEO	Oregon Department of Energy
OSW	Offshore Wind Energy
PNWH2	Pacific Northwest Hydrogen Association
RNG	Renewable Natural Gas
ROTS	Responsible Outdoor Travel Summit
SAF	Sustainable Aviation Fuel
SOC	Standard Occupation Code

Introduction

In 2022, the Port of Seattle contracted Seattle Jobs Initiative to conduct labor market analysis and research to determine the impact of COVID-19 on Port-related industries and identify the in-demand career pathways in Port-related industries. The Port sought this analysis to inform strategic investments that improve access to living-wage careers in Port-impacted communities. This work identified key maritime and green job pathways. However, it raised the question of the workforce development potential of the Port's environmental initiatives.

These initiatives were not undertaken for their workforce development impact, and workforce impact is not a criterion for their success. However, there is a recognition that the success of these initiatives depends on having an adequately prepared workforce. In addition, equity demands that those most impacted by climate change and environmental degradation have access to living-wage careers working on efforts to mitigate and improve environmental conditions.



Thus, the Port of Seattle asked Seattle Jobs Initiative to undertake a second phase of research focusing on the workforce impact of the Port's environmental initiative, addressing the following questions:

- What workforce impact can be expected from each environmental initiative?
- Which environmental initiative will have the largest employment impact?
- What occupations and skills are needed to support these environmental initiatives?
- What would be the expected impacts on frontline communities?

Port's Commitment

The Port of Seattle recognizes its impact and the region's dependence on a healthy environment. Consequently, it has committed to making investments and targeting programs toward reducing the Port's impact on the environment, particularly the environment of near-Port communities. Building on numerous federal and state policies as well as international efforts (see Appendix A), the Port has adopted several environmental initiatives. The Port workforce development team identified six initiatives to explore to determine what workforce programming and investments are needed:

See Appendix A for overview of federal and state policies driving the decarbonization of the economy

- **Offshore Wind Energy (OSW)**
- **Aviation Decarbonization**
- **Responsible Tourism**
- **Maritime Decarbonization**
- **Hydrogen Fuel**
- **Habitat Restoration, including the Seattle Aquarium-Port of Seattle Kelp Research Partnership**

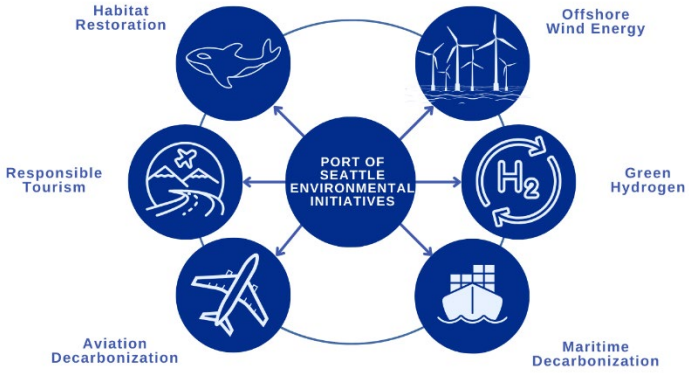


FIGURE 1 - PORT OF SEATTLE ENVIRONMENTAL INITIATIVES

These six initiatives overlap and interact with each other. Progress and success in one initiative may spark a virtuous cycle in others as technological advancements, capacity, and infrastructure created in one may spill over to enhance the work in another initiative.

However, because these initiatives overlap, they also involve many of the same occupations. If progress leads to demand for labor outstripping supply, progress could be constrained in any or all these initiatives. As noted above, these initiatives were undertaken by the Port for their environmental impact, not for their workforce potential. But this potential dynamic raised questions for the Port:

- What is the workforce that is needed to accomplish this work?
- What workforce development potential do these initiatives have?
- What are the potential impacts on near-port communities, specifically the workforce impacts?

Criteria for Selecting Initiatives for Deep-Dive

Due to the scale and scope of some of the environmental initiatives considered in this report, it appeared necessary to focus efforts. The criteria for narrowing the focus were:

- Initiatives predicted to have the largest impact on the workforce
- Initiatives with predict impacts on entry-level and middle-wage[*1] occupations
- Initiatives most likely to materialize.

The selection process involved a first round of ten interviews with Port staff and representatives of industry, labor, and community organizations to discuss the state of the initiatives, the Port's role in advancing and implementing them, and the expected workforce needs.

The selected projects are Offshore Wind Energy, Green Hydrogen, Maritime Decarbonization, and Responsible Tourism.

Offshore Wind Energy

Washington State's Clean Energy Transformation Act (CETA) requires the state's utilities to be carbon-free by 2045. Washington is starting from a strong position because a significant portion of the state's electricity comes from hydroelectricity. However, climate change threatens that source: changes in snowpack, early snowmelt, and more extreme high- and low-runoff events means less consistent water flow through the region's dams.[2] In addition, the impact of the dams on the region's ecosystems has long been a source of contention.[3]

[*] The Brookings Institute defines middle wage as occupations with a median annual earning of at least 80% of the metropolitan area's median annual earnings and requires less than a four-year degree to enter. We adapted this to the state's annual earnings. We use this as opposed to a living wage or self-sustaining wage because a living wage depends on the household composition of workers.

Wind energy is a critical component of de-carbonizing the electrical grid and energy market, but onshore wind does not supply a consistent, reliable flow of electricity. In contrast, offshore wind energy (OSW) is promising due to stronger and more consistent wind flow, allowing for more capacity than onshore wind.[4,5] There are some concerns about OSW's impact on marine and bird life around the installations and between installations and servicing ports.[6] However, proponents maintain that careful siting will minimize the adverse effects and may result in net positive by creating habitats around installations.[7]

The East Coast has developed OSW more rapidly, primarily due to geological challenges on the West Coast. The continental shelf is much closer to the West Coast shore than the East Coast. The quick drop off to very deep waters means that typical fixed-bottom (the base is secured in the sea floor) turbines cannot be used, requiring the development of floating platforms. This technology has not been widely developed, and very few OSW farms use this technology.[8]

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Federal Policy Incentives

Federal and state policy are the major drivers in realizing OSW on the West Coast. In addition to Washington and California's rigorous emission goals, federal policy under the Biden-Harris Administration has been fundamental in driving the OSW industry. Shortly after entering office, the administration set a goal for 30 gigawatts (GW) of OSW by 2030.[9] In September 2022, they announced additional investment in floating OSW. It set a goal of 15 GW of offshore floating wind by 2035 and

announced the Floating Offshore Wind Shot program intended to promote industry and lower costs by 70%.[9]

This program, part of the Infrastructure Investment and Jobs Act of 2021 (IIJA or Bipartisan Infrastructure Law), funds research and development competitions such as the Floating Offshore Wind Readiness (FLOWIN) Prize for developing floating platforms and plans for manufacturing and deployment. One of the nine teams to advance to phase two of the competition is Seattle-based PelaStar. PelaStar has committed to drawing on the resources and skills of Washington and the Puget Sound region in their design and plan.[10,11]

In addition to these specific incentives, the 2022 Inflation Reduction Act (IRA) provides additional resources to drive industry.[12] There are development and production tax credits for clean energy initiatives, including wind and energy storage, money for grid upgrades, resiliency projects, transmission projects, and smart-grid[13] technology. There are also $30 billion in tax credits for wind, solar, battery manufacturing, and offshore wind installation vessels.[14]

State Policy

California has taken the lead on the West Coast. The state began exploring the potential early on, auctioning off five leases at two sites in December 2022. The State has set impressive goals of achieving 25 GW of offshore wind energy by 2045.[15–17†] The current leased projects encompass 373,268 total acres and have a capacity estimated at 4.5-4.6 GW, which could power 1.5 million homes.[18]

> ***Where offshore wind has really started to take off in the United States have been places where the state has stepped up and provided direction, resources, policy actions, or executive orders, whatever it is that's needed in order to really push the alignment needs from the various industries that will support offshore wind to get them together, to get them coordinated.***
>
> - Vy Nguyen

† Gigawatt hours (GWh) is the power source's nameplate capacity multiplied by the number of hours per year (8,760) multiplied by the source's capacity factor, which is how much of nameplate capacity it produces accounting for inefficiencies and time offline. For example, natural gas-fired power plants and photovoltaic power stations have an estimated 50% and 20% capacity, respectively. Regarding wind energy, modern offshore wind large turbines have a capacity factor of 60% compared to 50% for onshore farms. A conservative estimate for California's 2045 target, using the present-day capacity factor for offshore wind installations is: $25GW \times 8{,}760\ hours \times 60\% = 131{,}400GWh$. Similarly, Oregon's 2030 target is $3GW \times 8{,}760\ hours \times 60\% = 15{,}768GWh$

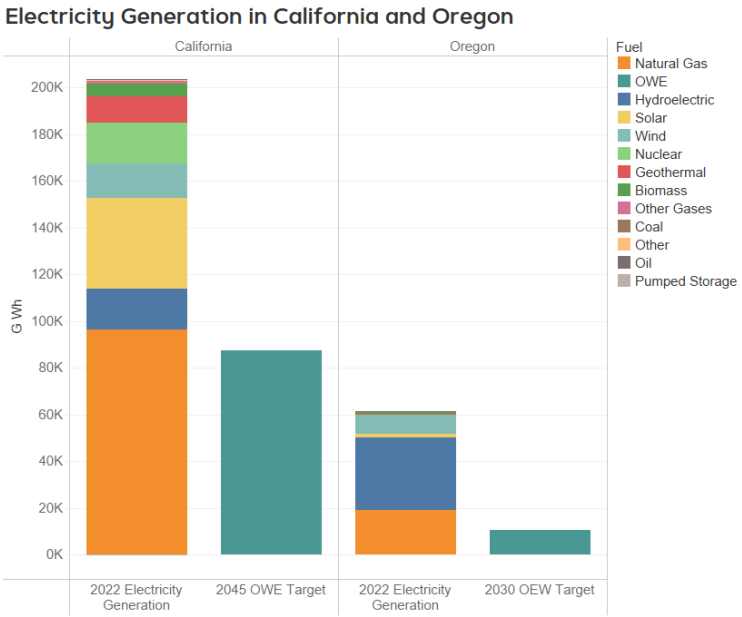

FIGURE 2 - ELECTRICITY GENERATION IN CALIFORNIA AND OREGON

Oregon is following suit. As of August 8, 2023, they have two draft Wind Energy Areas open to public review through the Bureau of Ocean Energy Management (BOEM), the government entity tasked with developing the United States development of offshore energy.[19] The state anticipates auctioning these areas in 2024. Oregon's goal is to have 3GW of OSW by 2030.[20]

Though discussions have started, there are no current plans to deploy OSW off Washington's coast. There are many considerations for the state. Of utmost importance are tribes' sovereign rights over the water in Washington coast's best wind fields. The interests, desires, and buy-in of tribes into OSW must drive decisions. If Washington does move forward with OSW farms, deployment could be at least a decade out, according to interviews and estimates based on BOEM's timelines.[5,21]

> ***Tribes have retained their sovereignty, and we need to engage with them in a way that like recognizes their sovereignty. On the Pacific Northwest West coast, there has to be, there absolutely has to be engagement and buy in from the tribes***
>
> - Cassidy Fisher

Project Summary

Most of the attention for Washington is focused on participating in the "deep and broad"[5] supply change needed for current and proposed projects on the West Coast. As Port of Seattle Commissioner Calkins stated at a study session for OSW, "California's goals are astronomical. They are huge… They will need the support of ports up and down the coast."

Moreover, the Oregon Department of Energy (ODEO) reported to the Oregon legislature that Puget Sound ports require fewer upgrades to support floating offshore wind energy (FOSW) than the best port option in Oregon. The ODEO suggested that "regional collaboration could help optimize the number and locations of ports to minimize costs involved with port upgrades and costs of transporting FOSW components to a deployment port."[22] The magnitude of Washington's opportunity to contribute to projects along the West Coast will depend on state policies in California and Oregon. Washington's role may be limited if the states set goals or requirements for in-state supply of components or vessels. However, if the states set domestic procurement requirements or in-region goals, possibly linked to an interstate compact, Washington is situated to have a substantial role in the supply chain.

> ***It's somewhere between five and ten times the sort of programmatic infrastructure that we have collectively that we need to scale.***
>
> - Jake Beattie

Supply Chain Opportunities

Interviews with experts and study sessions regarding FOSW highlighted the strength of Washington's manufacturing and maritime industries, specifically Puget Sound. FOSW requires substantial investment in manufacturing, shipbuilding, and infrastructure, especially at ports.

Advanced Manufacturing

While the East Coast has already begun manufacturing for OSW, the rapid ramp-up will require additional manufacturing capacity. The more likely alternative is shipping components from Asia. However, shipping components long distance increases the life cycle carbon emission of the project. Building a West Coast supply chain would reduce the carbon emissions of the supply chain by 40% over shipping from Asia.[23]

> ***West Coast supply chain has 40% lower emissions than supply from Asia.***

In addition, transportation costs and resiliency concerns may drive up demand for manufacturers on the West Coast. For example, there has been concern over transit time through the Panama Canal due to low water levels, affecting the cost and feasibility of shipping parts from the East Coast.[24]

FIGURE 3 – OFFSHORE WIND MANUFACTURING TIERS

The largest potential for Washington manufacturers is in Tier 2, subcomponents, and Tier 3, subassemblies, rather than assembling primary parts (Tier 1) as that work should be done as close to installation as possible.[25] One of the potential platform contractors is local and looking to build components in the region. A representative saw tendon cable, tendon connector, and hull module manufacture as potentials for the region.[11]

Turbine blades were a question with differing opinions among sources interviewed. The size of the blades makes transporting them from a manufacturing facility to a port challenging. Western Washington's significant advanced manufacturing infrastructure, particularly the closely related aerospace manufacturing, is near several sizable ports, offering some advantages to the region. However, while aerospace manufacturing is a strength in this region, the materials used for blades differ substantially from airplane wings. So, while the workforce skillsets are likely transferrable, the supply chain and manufacturing facilities are not.

> ***I cannot underscore the amount of skilled, labored needs that this industry is going to need in terms of every single part of like, production, assembly, manufacturing, and the supply chain.***
>
> - Vy Nguyen

Shipbuilding

In contrast, there was far more consensus about Washington's competitive advantage in shipbuilding, maintenance, and repair. Vessels were highlighted as a great need. As of a 2023 analysis, there were only seven suitable vessels in compliance with the Jones Act, which requires good ships between US port be done with US-built, -owned, and -documented vessels.[26,27] Sources indicated that at least 20 more were needed. In addition, to maximize the carbon reduction potential of OSW, these vessels would ideally use Alternative Fuels and ports will be equipped with Shore Power and carbon capture infrastructure.

> ***A number of our shipyards are already actively engaged in building vessels to support offshore wind, both in the US and overseas like Washington shipyards specifically.***
>
> - Cassidy Fisher

Shipbuilding is noted as a particular strength of the Puget Sound region, with the potential to build everything from the additional vessels needed to ferry workers and supplies for installation and maintenance to the large, specialized vessels that transport the platforms, turbines, and blades.

In response to these opportunities, on October 10, 2023, Washington Maritime Blue, at an event hosted by the Northwest Seaport Alliance and with the support of the Port of Seattle, among others, announced the Blue Wind collaboration. This collaboration will develop strategies to promote and mobilize Washington State's strong manufacturing and maritime industries to a leadership position in the OSW supply chain.[28]

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Port Infrastructure

Finally, as noted above, though Washington's ports are some of the best suited for supporting OSW, they will still require significant investments to accommodate the increased and new sort of traffic. The final assembly and launch of FOSW platforms will require dedicated facilities and will be close to installation (e.g., in California and Oregon). However, participating in the supply chain and shipbuilding, maintenance, and repair, particularly with reduced emissions, will require additional port capacity. This does have an ongoing impact on port operations and workers. However, most of the workforce impact of this is in the installation and upgrading of port infrastructure.

Labor Market Analysis

Despite offshore wind energy being in the exploratory phase in Washington state, the potential for workforce impacts is the most significant of the selected environmental initiatives. This is because this industry's supply chain is the widest among the selected initiatives. It ranges from OSW farm-level project development, manufacturing the wind tower components, transporting and installing platforms, to connecting and distributing the electricity produced from wind energy to end-users.[29] Each phase involves different industries and relies on various skill sets. Specifically, the supply chain of offshore energy can be broken down as follows (detailed phases can be found in Appendix C):

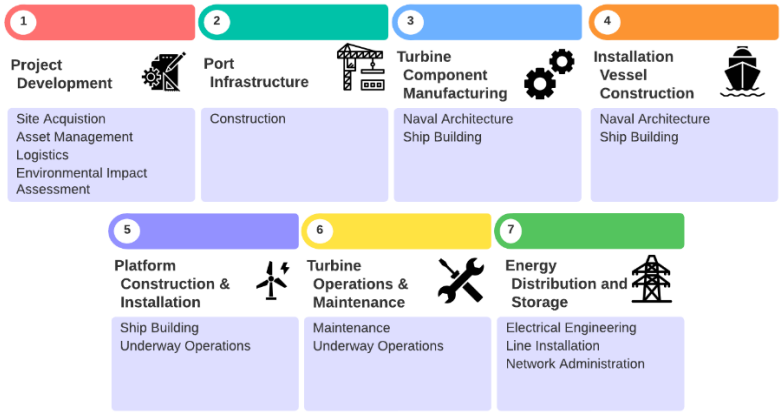


FIGURE 4 - OFFSHORE WIND PHASES

See Appendix C for a detailed description of OWS phases

Entry-Level and Middle-Wage Jobs

The analysis was restricted to entry-level and middle-wage jobs to identify offshore wind energy jobs for further workforce development investment (a detailed list of occupations can be found in Appendix B). These are defined in this report as occupations that require less than a four-year degree and less than five years of work experience to enter the profession. For example, apprentices are not distinct from journey-level workers in occupational categories. Thus, occupations requiring an apprenticeship are included, even those requiring apprenticeships four years or longer, as only a high school diploma is required to enter the apprenticeship and thus the occupation.

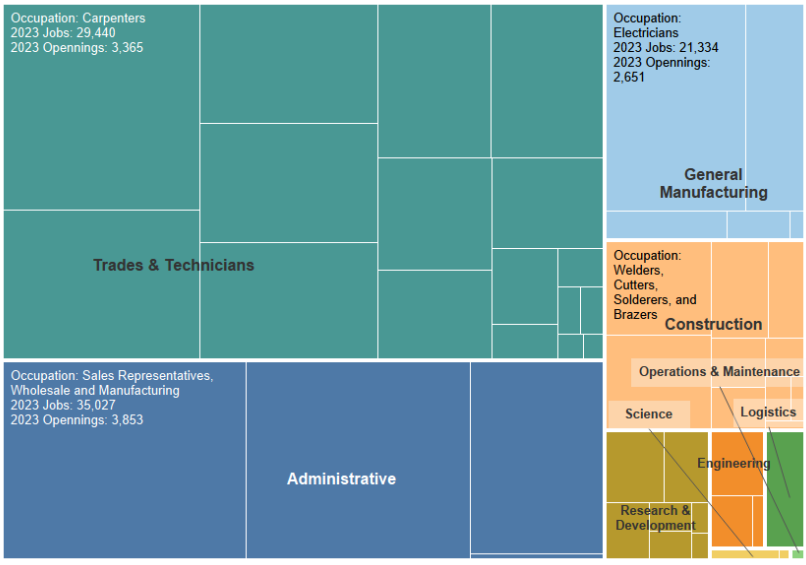


FIGURE 5 - ENTRY-LEVEL AND MIDDLE-WAGE OSW LABOR POOL

See Appendix B for a detailed list of occupations

In addition, given the large number of potential jobs found along the OSW supply chain, supervisors and managers, jobs with fewer than 100 workers, and occupations with fewer than 100 annual openings in 2023 were removed from this analysis.

The exploratory analysis shows that occupations in the Shipbuilding and Platform Construction phase, specifically carpenters and electricians, have the largest pool of workers in Washington state in 2023 (29,440 and 21,334, respectively). Entry-level administrative shipbuilding support occupations, such as sales representatives and production, planning, and expediting clerks, also have significant employment pools.

These occupations also have the most job openings in 2023 in absolute value. These are defined as the number of new positions created by economic growth and replacement positions due to worker attrition. However, wind turbine service technicians have the more significant number of job openings relative to the occupational labor pool, 19%, with 25 openings to 131 workers showing high labor needs.

Occupation Demographics

Looking at occupational demographics, general manufacturing entry-level occupations are, on average, the most diverse, with the percentage of workers of color ranging between 20% for engine and other machine assemblers and 41% for aircraft structure, surfaces, rigging, and systems assemblers. Overall, operating engineers, other construction equipment operators, and sales representatives are the least diverse occupations, with 18% of workers of color (see Appendix B for detailed demographics).

See Appendix B for detailed demographics

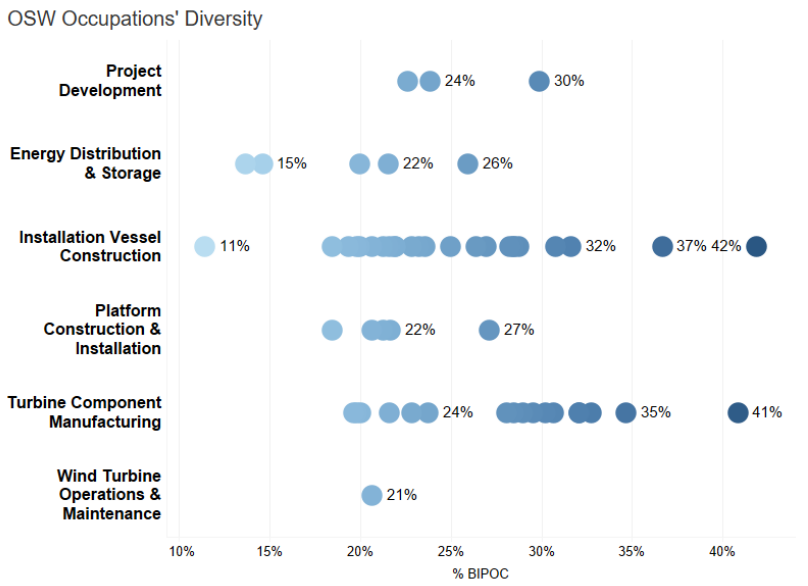


FIGURE 6 - OSW PERCENT OF WORKFORCE BLACK, INDIGENOUS, OR OTHE R PEOPLE OF COLOR (BIPOC)

Similarly, the percentage of women workers is largest among administrative support occupations (clerks) as well as during the manufacturing of blades, turbines, and towers phase, reaching 52% for life, physical, and social science technicians and 33% for aircraft structures, surfaces, rigging, and systems assemblers.

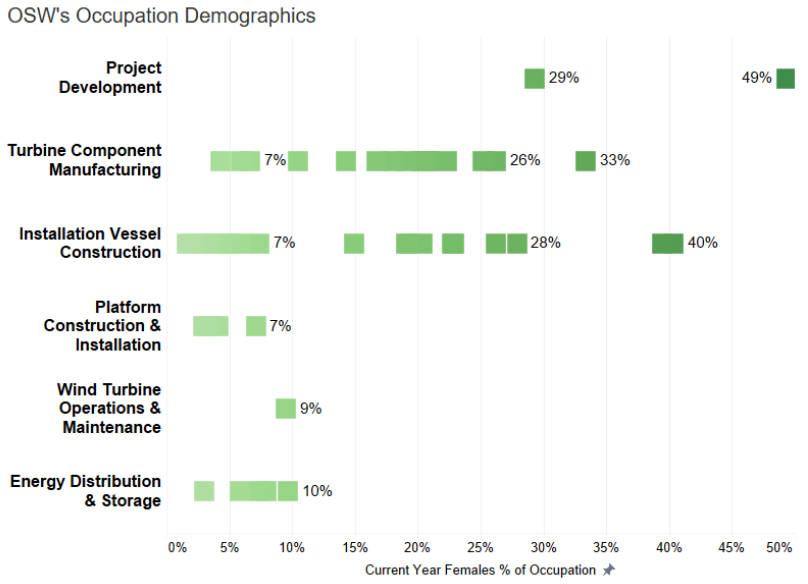


FIGURE 7 - OSW PERCENT OF WORKFORCE FEMALE

Finally, machinists are the occupation with the highest retirement risk as 33% of workers are aged 55 years old or above.

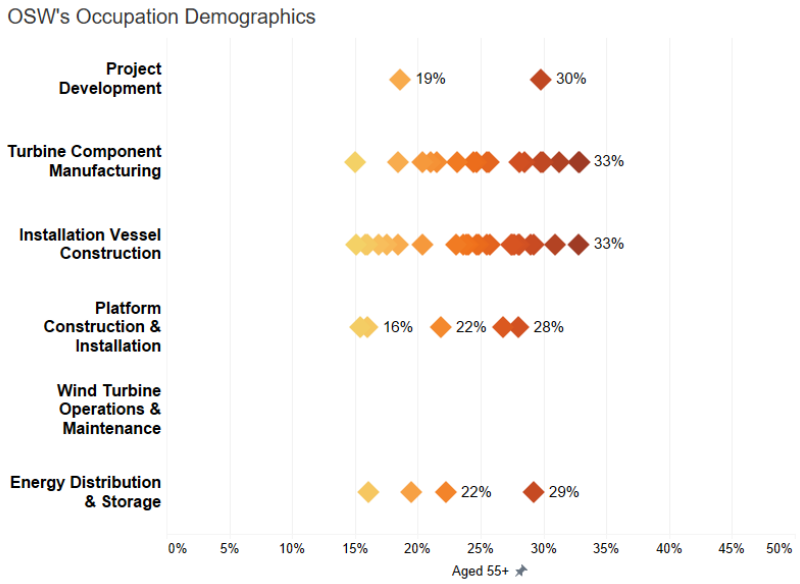


FIGURE 8 - OSW PERCENT OF WORKFORCE AGE 55+

Wages

Looking at hourly wage percentiles also provides insights into earning potential and career advancement opportunities for incoming workers (see Appendix B for detailed wages). In OSW, commercial divers provide crucial support to installing and monitoring substations. Despite not requiring an advanced college degree, these workers still command the highest wages among the OSW entry-level jobs due to their small labor supply, long-term job training, and high occupational risk. They are followed by power distributors and dispatchers supporting electricity distribution and storage, electricians, sheet metal workers, plumbers, pipefitters, and steamfitters for the trades, and sales representatives for administrative occupations.

See Appendix B for a detailed wages

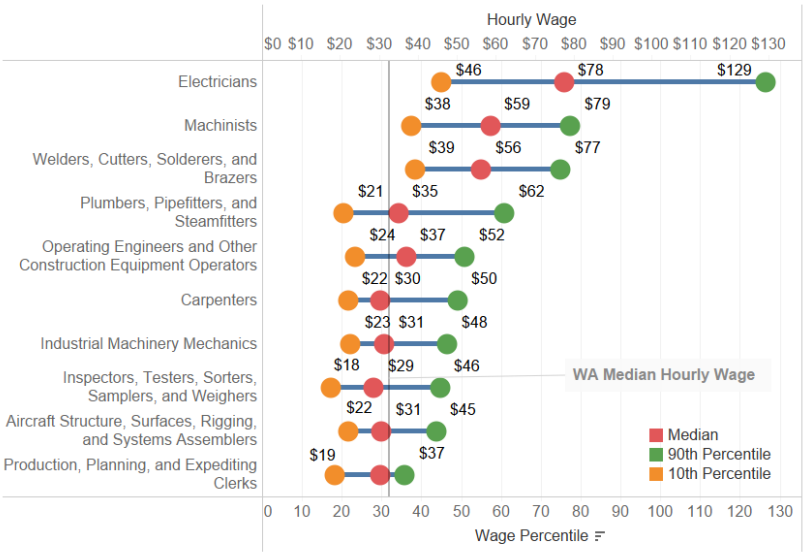


FIGURE 9 – OSW ENTRY-LEVEL AND MIDDLE-WAGE OCCUPATIONS EARNINGS

Openings

The following charts compare the average annual job openings between 2021 and 2026 to the median hourly earnings to identify entry-level occupations with the most employment opportunities for new workers in the near future that offer living wages. As the median hourly wage in Washington state was $30.50 in 2021 (WA ESD, 2023), the median wage for middle-wage jobs is 80% of this number, or $24.40.

As mentioned above, commercial divers command the highest wages of the entry-level offshore wind energy occupations but have few workers and job openings. Hence, these are not shown in this graph. On the other hand, construction laborers, office clerks, and laborers who support the construction of wind substations have the three largest employment pools among the entry-level offshore wind energy occupations but also have many annual job openings between 2021 and 2026. This signals a high churn rate, and they do not offer a middle wage as their median earnings are $24, $22, and $19 per hour, respectively.

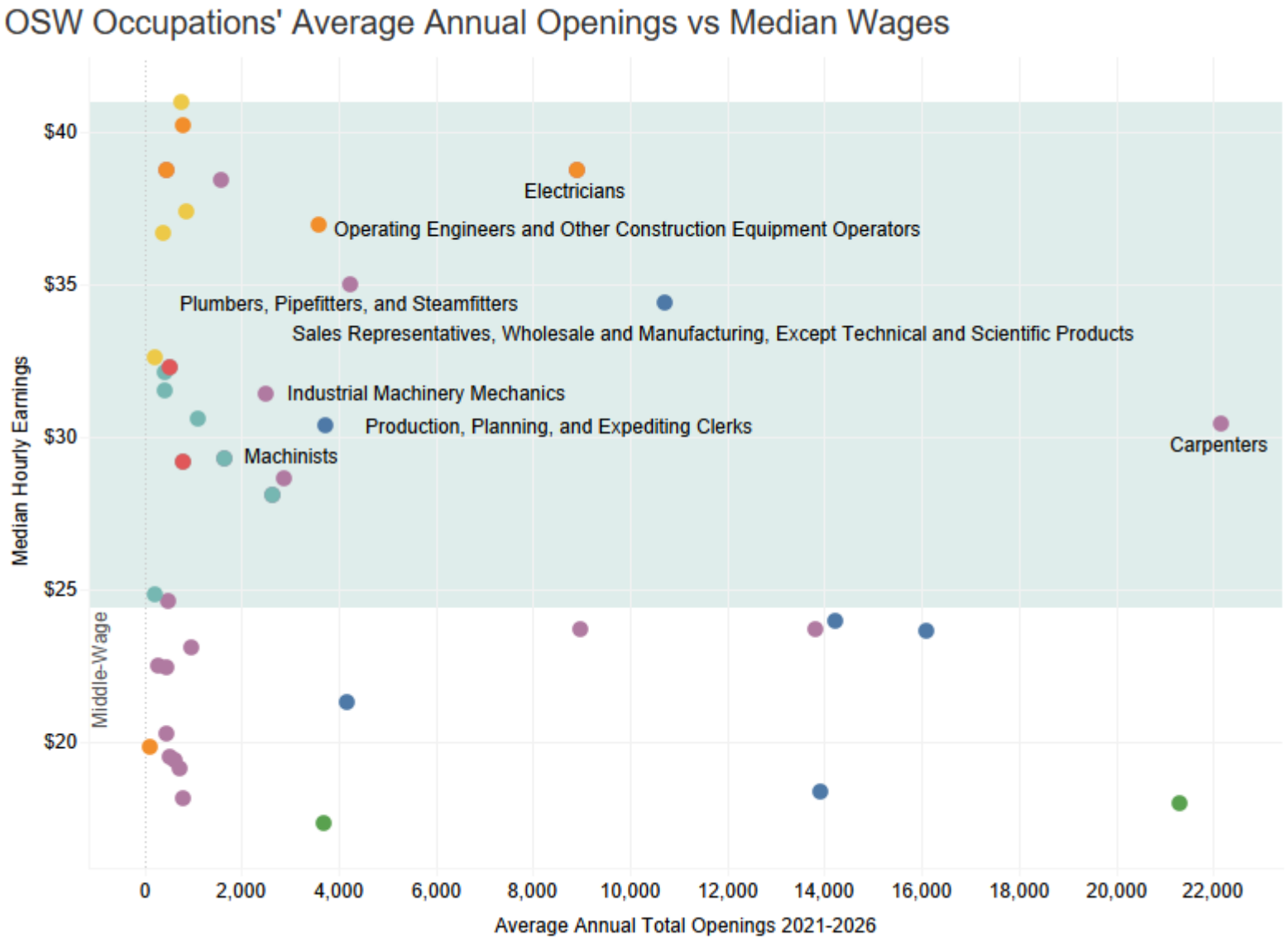


FIGURE 10 - OSW ENTRY-LEVEL AND MIDDLE-WAGE OCCUPATIONS JOB OPENINGS AND MEDIAN HOURLY EARNINGS

Overall, carpenters offer strong employment prospects, with an expected 22,152 annual job openings between 2021 and 2026 and an estimated 29,440 workers in 2023. This occupation also provides a living wage with median hourly earnings of $30, roughly the state median of $30.50

Workforce Development

Many of the jobs related to OSW are middle-wage jobs. But several of these jobs, particularly in construction and the trades, are disproportionately white and male compared to Washington's workforce, even more so compared to the Puget Sound workforce.

The Port has well-established programs and policies for diversifying the construction trades and strong partnerships for growing and diversifying the maritime sector. Continued investment in these efforts is key to ensure that Washington and Seattle have the capacity to participate in OSW supply chain and eventual implementation in Washington.

CREDIT: PORT OF SEATTLE

> ***From engineers to electricians, technicians, line workers, you name it. There are many things that folks can do and transition a career into the space.***
>
> - Gus Williams

Shipbuilding is closely related to construction and maritime and often competes for the same workers with construction (e.g., electricians, plumbers, pipefitters). Shipbuilders can struggle to retain these workers when there is high demand from construction projects nearby. Vigor, the largest provider of ship repair and conversion services in the Pacific Northwest & Alaska, offers an onramp program for welding in partnership with local community colleges in the Swan Island facility in Portland, Harbor Island Training Center in Seattle, and shipyards Ketchikan, Alaska. These programs

can serve as a model to improve the pathways to other middle-wage occupations so that Washington can leverage its history and strength in this sector.

Advanced manufacturing is outside of the Port's workforce development scope, but onramp programs can be key in supporting Washington's role in OSW supply chain. The advanced manufacturing sector has limited success diversifying the workforce and is rapidly aging with one-third of machinists nearing retirement age. This sector needs improved onramps for under-invested communities and improved outreach to youth to communicate the opportunities in and reality of modern advanced manufacturing. Work is also likely needed in making the workplace more welcoming to a more diverse workforce.

OSW offers an opportunity to fundamentally shift the demographics of these occupations and improve diversity and equity of the workforce. However, providing training programs and pathways alone will not achieve this. There are structural barriers to improving access for underinvested communities. For example, limited availability of transportation to and from work, or meeting basic needs while in training and newly employed. The cost and lack of child and other dependent care is also a barrier. This is particularly difficult for shift workers, as a sick child or closed daycare can cost them a job. Wrap-around support services and flexible work conditions will be important factors to facilitate access to OSW occupations to under-invested communities and youth.

> ***When there have been these big industrial shifts of the past o, oftentimes, there were a lot of communities that were excluded from either the jobs or the benefits… So just trying to be thoughtful about not replicating what has been done in the past in terms of the harm and the exclusion and making choices that maintain the harm in communities of color that have experienced those harms for generations.***
>
> - Vy Nguyen

Potential Community Impacts

Supply Chain

There are significant workforce opportunities in the Puget Sound region in OSW. Washington's geographical advantages and existing strengths in advanced manufacturing and shipbuilding create a high potential for middle-wage jobs in advanced manufacturing and shipbuilding. However, there is inadequate access to these career pathways, especially for Port-impacted communities.

New manufacturing facilities or increased production at existing facilities may expose near-Port communities to additional pollution and environmental degradation. Increased traffic, both maritime and land-based, will expose near-Port communities to additional pollution not coupled with aggressive Maritime Decarbonization efforts.

OWS off Washington Coast

OSW deployment in the waters off the coast of Washington is at least a decade away. A key piece cited by experts is tribal sovereignty and fishing rights in these waters. They emphasized that tribes must not only be consulted but also approve and benefit from projects. To do this, their concerns must be addressed, and they must benefit from the projects.

CREDIT: PORT OF SEATTLE

It is essential to adequately assess and account for how installation and operation will affect marine and bird life. The evidence for the impact on OSW farm's local ecology is currently mixed, and there is the potential that OSW has a positive effect beyond providing a source of clean energy. Engaging tribes, coastal communities, and the fishing

industry needs to be a priority for a comprehensive analysis of environmental impacts.

Onshore Power Distribution

The introduction of OSW will require significant upgrades to the onshore grids. While such upgrades are needed regardless of the source of renewables, OSW will drive specific infrastructure, particularly in coastal communities. These upgrades, including the smart grid, will require many middle-wage workers in trades and information technology. It is essential that coastal communities that are often skipped over benefit from infrastructure improvements and workforce opportunities.

Future of the Project

The state has significant momentum to pursue roles in the supply chain for OSW off the coast of California and Oregon. However, Washington could be left out of the supply chain if there is not adequate engagement and commitment of resources.

There is much optimism for deployment in Washington waters but wide recognition that it is not a foregone conclusion. Deciding whether the benefits outweigh the costs will take significant time, collaboration, and community engagement. Finally, OSW overlaps significantly with green Green Hydrogenproduction and Maritime Decarbonization in Washington. Hydrogen production, specifically, may require electricity generated from OSW to be fully realized as the demand for electricity increases and fossil fuel sources go offline.

Green Hydrogen

Project Summary

The Port of Seattle is part of a study using an award from the U.S. Department of Energy in collaboration with Seattle City Light and Pacific Northwest National Laboratory exploring the possibility of using hydrogen for various operations. Hydrogen as fuel could power medium-sized and heavy port equipment such as forklifts and cranes and some smaller vessels like tugboats.

Other options include small-scale hydrogen generation at the Port. This includes using the stored energy in the

electrolysis process.‡ This hydrogen would operate as a large battery and maintain the electrical grid's stability. When excess power flows from renewables like wind, rather than take them offline to avoid overloading the grid as is typical, this power would be used to generate hydrogen. This stored energy could then be released to meet peaks in demand, replacing natural gas peaker plants.[31] A peak in demand may be generated by a cargo or cruise ship connecting to shore power rather than running their diesel engines to power ships while docked.

Support for hydrogen research and production in the region also has implications for developing alternative fuels for applications that are difficult to decarbonize through battery or hydrogen fuel cell use. This has immense potential for the Port because of complications and lack of technology for other long-distance aviation and maritime vessel solutions.

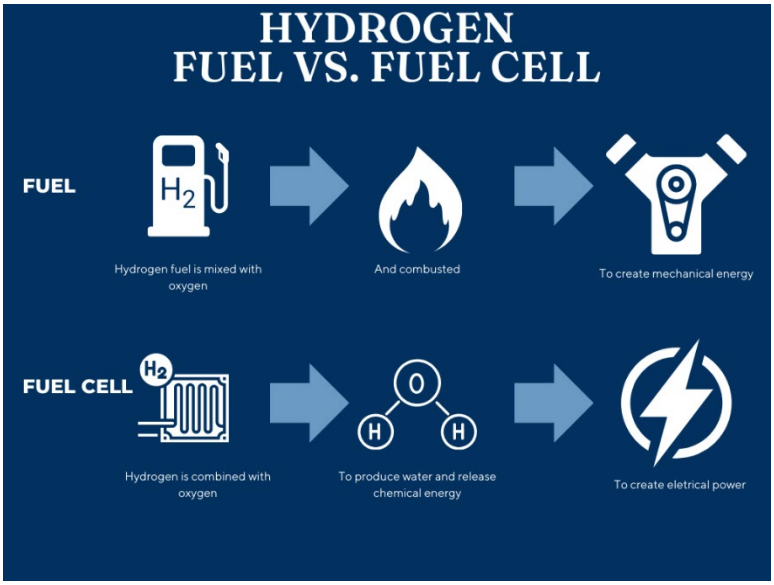


FIGURE 11 - HYDROGEN FUEL VS. FUEL CELL

Hydrogen Uses and Applications

The study at the Port touches on many of the current hydrogen applications. Hydrogen produced through electrolysis can itself be used as a fuel. It can be combusted to produce mechanical energy and heat. It can also be used in a fuel cell where oxygen is mixed with hydrogen to

‡ Electrolysis uses electricity split the hydrogen atoms from the oxygen atoms in water molecules. When this process is “green” renewable energy such as wind, hydro, or solar is used. See CETI illustration as a helpful reference[30]

produce electricity. Fuel cells are often used in transportation applications.

Because hydrogen, H_2, is a gas, it is often transported through pipelines but can also be moved in trucks or vessels in containers as a pressurized gas or as a liquid. However, compressing H_2 gas to liquid or compressed gas for transportation is costly and energy intensive. In addition, liquid hydrogen requires extremely low temperatures—lower than liquid natural gas.[32–34]

To make transportation easier, hydrogen can also be transported via "chemical carriers," creating alternative fuels.[32] H2 produced through electrolysis can produce clean versions of ammonia and methanol, potential maritime fuels. It can also be incorporated in drop-in liquid hydrocarbon fuels that are interchangeable with liquid fossil fuels, giving them potential in aviation and other uses where electricity or hydrogen is challenging.[30] Liquid hydrocarbon fuels and methanol require carbon from either carbon capture of atmospheric CO_2 or biogas and renewable natural gas (RNG) produced from biomass. The two most viable sources of biomass as feedstock in Washington state are Municipal Solid Waste (MSW) and forest waste.[35] Carbon capture could be further developed with IRA incentives.

Policy and Incentivization Landscape

The IRA provides significant incentives for hydrogen production through clean energy tax credits and hydrogen-specific incentives. Notable examples include tax credits for green hydrogen infrastructure, clean hydrogen production, and carbon capture and sequestration. [36]

The requirements of CETA in Washington have also had some effect. For example, the state's last coal-fired power plant will close in 2025. Fortescue Future Industries, which produces green hydrogen is exploring establishing a green hydrogen production facility adjacent to this site and repurposing some of the original plant's infrastructure. While some original plant's workers have already moved away as the plant has closed in phases,[37] there is a need to retrain and reskill plant workers and build a viable pathway for new workers from that community.

Other hydrogen-centered projects are underway. The Port of Chehalis in Lewis County leased land to Twin Transit to build a hydrogen fueling station. The Douglas County Public Utility District's hydrogen project, slated to go online in the

> ***We need folks, you know, maybe in storage and then your basic technicians, you know, your basic technicians will come from maybe some of those pipefitters and skinfitters' unions who understand moving, you know chemicals through, you know, underground pipelines and all these different things as well.***
>
> - Gus Williams

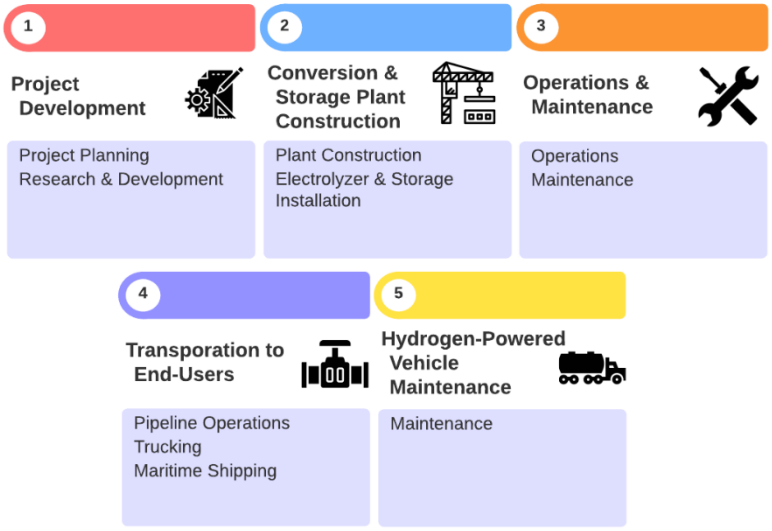
spring of 2024, will generate hydrogen from excess hydropower capacity they currently cannot use.

The most significant hydrogen production in the state of Washington on the horizon is the newly announced award of $1 billion to the Pacific Northwest Hydrogen Association (PNWH2) through the Federal Regional Clean Hydrogen Hubs grant from the Department of Energy (DOE) funded by the IIJA. PNWH2 is a coalition spanning Washington, Oregon, and Montana with private and public entities that will create a hydrogen production and use network, providing tremendous resources to the industry.[38,39] The proposed production facility sites are along interstates, with the Washington sites in Bellingham, Centralia, and East Wenatchee.

[The hub will span a wide range of operations from small] distributed generation where a small hydrogen electrolyzer… operations [to] very large facilities that are going to be producing hundreds of tons of hydrogen per day used for a variety of different large-scale transportation operations... where you would be using it to produce SAF or green methanol.

Labor Market Analysis

Albeit further along than OSW and building on the state's clean hydropower, the production of green hydrogen in Washington state is still in its infancy. Also similar to OSW, the supply chain of green hydrogen production is expected to encompass various activities and occupations as outlined below (see Appendix D for more detail).[40,41]



See Appendix D for detailed H_2 phases

Entry-Level and Middle Wage Jobs

The hydrogen jobs analysis is again restricted to entry-level and middle-wage jobs. These are defined in this report as occupations that require less than a four-year degree and less than five years of work experience. These jobs fall mainly in the plant and electrical grid construction,

operations, and maintenance, and transporting hydrogen phases.

Electricians participate in plant construction and electric grid connections like offshore wind energy. They also have a role in fuel cell research. Electricians are the second largest number of workers in Washington State in 2023 (21,334). Along with electricians, the breadth of the construction trades will also be involved in the plant construction phase.

During the operations and maintenance phase, electrical and electronic engineering technologists and technicians are the entry-level and middle-wage workers with the second most annual openings compared to the number of jobs.

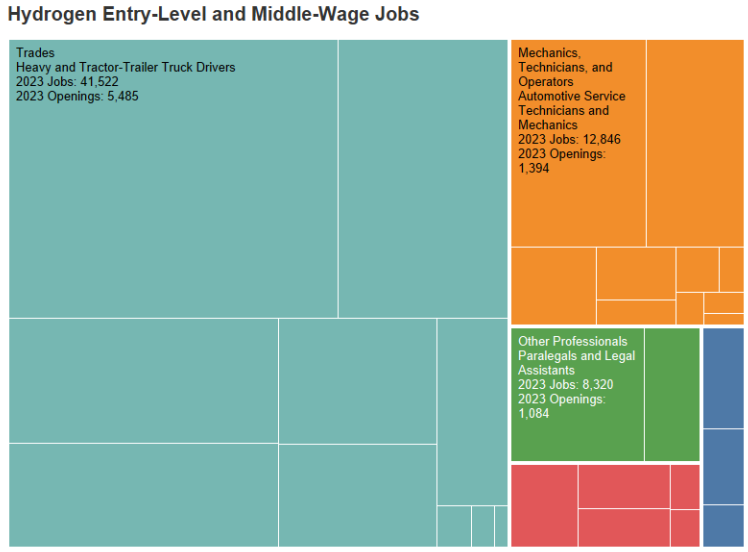


FIGURE 12 - H_2 ENTRY-LEVEL AND MIDDLE-WAGE GREEN LABOR POOL

When transporting hydrogen to end users, heavy and tractor-trailer drivers and plumbers, pipefitters, and steamfitters also have significant employment pools and will be crucial to enable hydrogen transportation by road or pipelines. These occupations also have the most job openings in 2023 in absolute value. Openings include the number of new positions created by endogenous economic growth and replacement positions due to worker attrition.

Finally, among all the occupations impacted by hydrogen production, automotive service technicians and mechanics have the largest number of openings due to growth compared to the number of current workers. However, hydrogen fuel cell vehicles require less maintenance than

See Appendix B for a detailed list of occupations

It's a really exciting opportunity from a job standpoint because it's, really diverse. There's a, there's a lot of your traditional union jobs and manufacturing positions that are going have to be filled. There's a lot of electrical work, there's a lot of piping, welding, construction. This is going be, this is a major infrastructure investment

- Aaron Feaver

internal combustion engines, resulting in lower per-vehicle demand for labor. These professionals would be required to expand their skill sets and complete safety training to handle hydrogen fuel cells.

Occupation Demographics

Looking at occupational demographics, the cement masons and concrete finishers that will operate during the production plant construction phase are by the most diverse entry-level occupation, with a percentage of workers of color reaching 42%, followed by welders and welding, soldering, and brazing machine setters, operators, and tenders (see Appendix B for detailed demographics).

Overall, power plant operators are the least diverse occupation, with 17% of workers of color. They are followed by operating engineers and other construction equipment operators, with 18% of both.

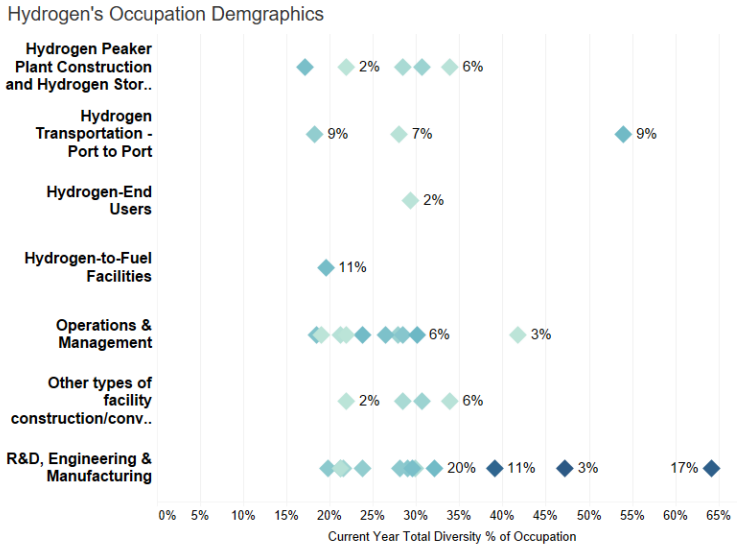


FIGURE 13 – H_2 PERCENT OF WORKFORCE BLACK, INDIGENOUS, OR OTHER PEOPLE OF COLOR (BIPOC)

See Appendix B for a detailed demographics

Also, women are primarily found in hydrogen fuel operations and management phase occupations. The percentage of women workers is by far the largest for paralegals and legal assistants (84%), followed by property, real estate, and community association managers (59%).

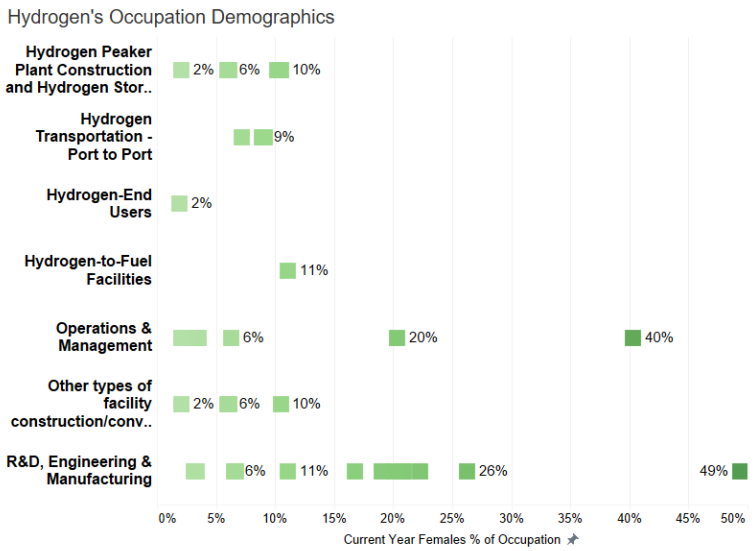


FIGURE 14 - H_2 PERCENT OF WORKFORCE FEMALE

Finally, mechanics, technicians, and operators in research and development are the most at risk of retirement as most of these occupations have a percentage of workers who are 55 years old or more. That is close to 30% for these professionals and even reaches 31% for industrial machinery mechanics.

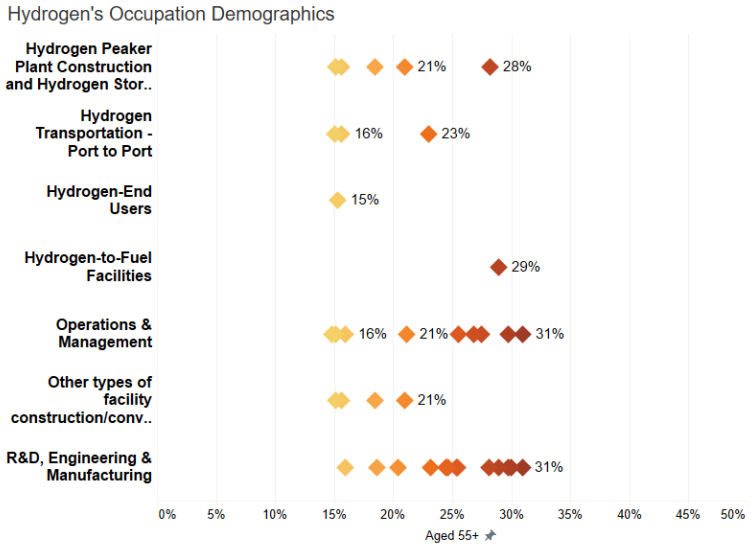


FIGURE 15 - H_2 PERCENT OF WORKFORCE AGE 55+

Wages

In hydrogen production, property, real estate, and community association managers appear to have the greatest potential for earnings advancement among entry-

level and middle-wage occupations. The hourly earnings range from $30 for the 10th percentile to $73 for the 90th percentile. This is well above the state median hourly earnings of $30.50. The earnings spread is also significant for electricians and plumbers, pipefitters, and steamfitters.

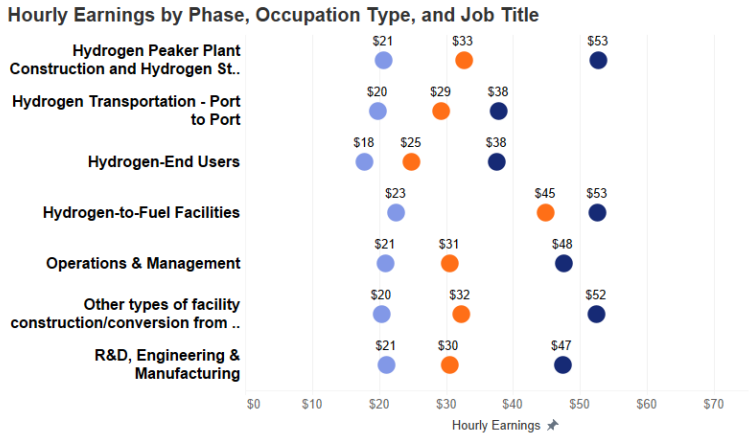


FIGURE 16 – H_2 ENTRY-LEVEL AND MIDDLE-WAGE OCCUPATIONS EARNINGS

See Appendix B for a detailed wages

Openings

The following chart compares the average annual job openings between 2021 and 2026 to the median hourly earnings to identify entry-level occupations with the most employment opportunities for new workers that are also middle-wage jobs. As the median hourly wage in Washington state was $30.50 in 2021,[42] the median wage for middle-wage jobs is 80% of this number, or $24.40.

First, construction laborers participate in facility and pipeline construction. They will have the largest estimated number of job openings between 2021 and 2026 (23,629) but tend to have a high churn rate and a median earning below living wage. On the other hand, power plant operators who will operate hydrogen production facilities have the largest median earnings of the hydrogen-related entry-level and middle-wage occupations but one of the smallest numbers of annual job openings by 2026.

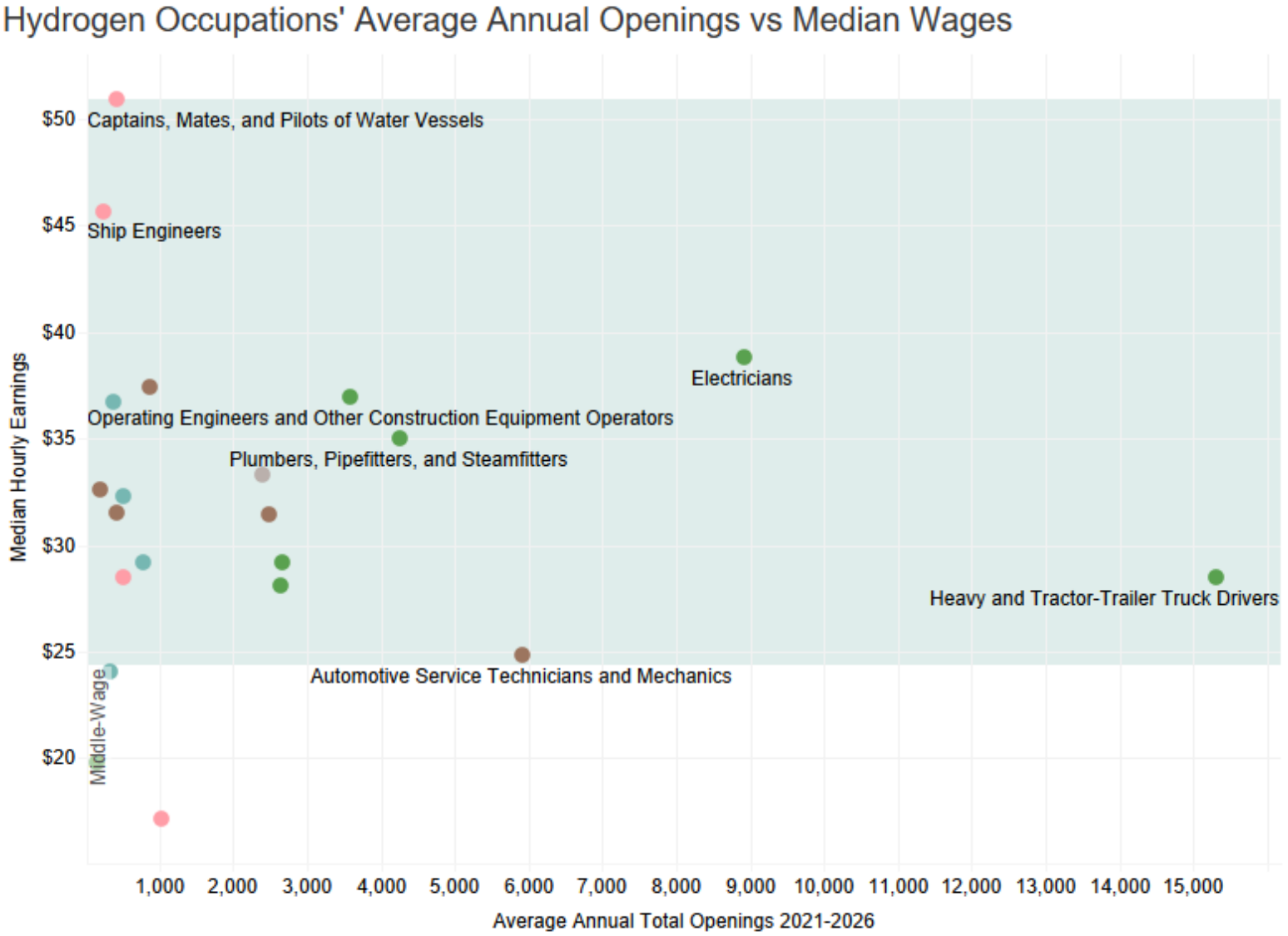


FIGURE 17 - H_2 ENTRY-LEVEL AND MIDDLE-WAGE OCCUPATIONS JOB OPENINGS AND MEDIAN HOURLY EARNINGS

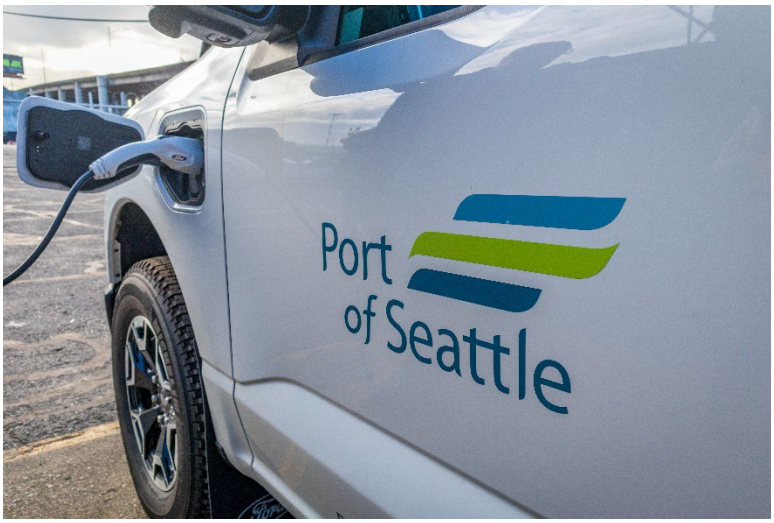
Overall, Operating Engineers and Other Construction Operators offers a good combination of high median earnings ($37, above the state median) and strong employment prospects with an expected 3,574 annual job openings between 2021 and 2026. Plumbers, Pipefitters, and Steamfitters are expected to have 4,251 annual openings with median hourly earnings of $35.

Workforce Development

Green Hydrogen does offer significant potential for middle-wage occupations falling well within the Port's scope. First, of course, are the construction trades involved in building out the infrastructure. In particular, electricians, pipelayers, and pipefitters will play critical roles in this phase and have ongoing roles in maintenance.

> ***Hydrogen technicians will require a combination of electrical and mechanical knowledge […] combined with a little bit of electric chemistry***

In hydrogen hub production, multiple hydrogen electrolyzers would be installed along the electric grid, stimulating the demand for workers who can install, maintain, and service these electrolyzers. These occupations are still new; thus, little information is available on their training.



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Emerging occupations offer an opportunity to build a diverse workforce from the start. The Port can play a role in developing the pathways and onramps to ensure that near-Port and other underinvested communities can access these jobs.

The push for hydrogen production is expected to drive up the production of hydrogen fuel cell cars. Like electric battery cars, fuel-cell vehicles run on electricity, do not produce greenhouse gas emissions, and have fewer

moving parts than traditional internal combustion engine (ICE) cars, reducing maintenance costs and needs, shrinking the demand for automotive technicians and mechanics. However, due to hydrogen flammability, existing automotive mechanics and technicians must receive training on safely handling fuel storage systems and fuel cells. Repair facilities will also need to have proper ventilation to prevent hydrogen buildup, which will have some impact on construction trades and heating, ventilation, and air conditioning (HVAC) professional.

The Port also has a role supporting the development of training and best practices as the Port itself adopts hydrogen-fuel and hydrogen fuel cell equipment.

As with OSW, offering training alone is not enough to ensure there will be a workforce adequate to meet the demands for green hydrogen workers. Individuals pursuing these jobs still face the challenges of meeting basic needs, inadequate transportation, and lack of dependent care options that frequently derail trainees and the newly employed from their career path. Wrap-around services and creative solutions to meeting workers' needs are required to ensure that this new sector's workforce is equitable and diverse.

Potential Community Impacts

Safety

Hydrogen has great potential to improve air quality around ports and in near-Port communities. It could reduce particulate emissions and the health concerns related to burning fossil fuels at ports. However, there are still issues to consider. The first is on the safety and impact of hydrogen itself. Due to its well-known explosive potential, there will need to be communication around safety to allay concerns

and general fear of hydrogen. In addition, one expert discussed concerns related to nitrogen oxide emissions. Nitrogen oxides are smog-forming gases that still form when hydrogen is combusted. He noted that this can be controlled but will be an essential public and community relations issue. Clear communication of how it will be controlled will be necessary.

Water Usage

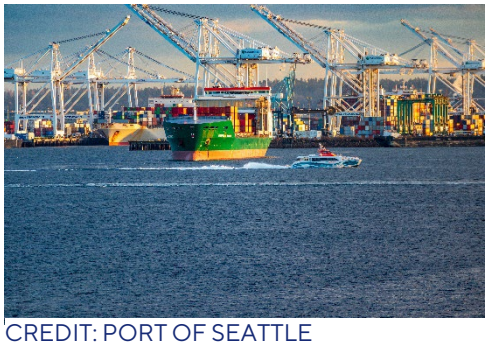
The production of hydrogen also has some implications for water usage and water rights. Hydropower is a crucial source of clean energy in Washington state and is thus a vital part of the state's ability to produce clean hydrogen. As a result, discussions will continue around the benefits and drawbacks of hydro dams and their environmental effects, especially on salmon populations and the communities who depend on them. Water is also a concern because hydrogen production through electrolysis also uses and consumes water to produce free H_2 gas. These issues will require intentional community engagement so that concerns can be heard and addressed appropriately.

> ***As we're looking at these different fuels what is, what information is important for them to know, to feel maybe like comfortable or knowledgeable about what these fuels are that might be going past their neighborhood or the vessels are being fueled up, you know, not that far away. Are you talking, do you have an outreach plan? You know, how are you planning to talk to communities about this fuel transition?***
>
> - Melissa Parks

Maritime Decarbonization

Project Summary

The Port of Seattle has ambitious decarbonization goals and is making great strides at achieving them. As part of the Northwest Sea Port Alliance, they are committed to phasing out emissions from seaport-related activities by 2050, as outlined in the Northwest Ports Clean Air Strategy (NWPCAS).[43] In conjunction with this strategy, the Port of Seattle released in 2021 "Charting the Course to Zero: Port of Seattle's Maritime Climate and Air Action Plan," where they outlined a strategy for reaching net zero for all controlled and indirect emissions by 2040, which is an accelerated goal. Moreover, they aim to reduce emissions that they do not directly control but can influence to 50% below 2007 levels by 2030 and *at least* carbon neutral by 2050.[44]



CREDIT: PORT OF SEATTLE

To do this, the plan lays out strategies for reducing emissions from Port's maritime administration. Reductions occur through efforts such as the electrification of fleet vehicles and light-duty vehicles, equipment, and building systems and the use of renewable fuels when electrification is not possible.

While the Port controls its administration activities, it does not control maritime and landside activity. These activities, which include the operations of ships, harbor vessels, trains, and equipment, produce "94% of the Port's maritime emissions." However, the Port can influence these activities.[44] The Port seeks to improve and support efficiency and make intentional investments so that the infrastructure and technologies that support decarbonization are available at the Port for use. Lease requirements for tenants that ensure the use of this infrastructure and technology could also produce results. Another vital way to support the development, affordability, and scaling of technologies is through a commitment to "demonstrate and adopt" technologies, supporting and implementing pilot projects, which prove demand and viability.[42]

> ***As the Port of Seattle really becomes fully electrified, they could easily become like a mini utility, they also could be potentially generating, they could be deciding to invest in [renewables]. So, they're going to need human beings, power engineers, electrical engineers, people who understand how to manage electricity.***
>
> - Eileen Quigley

Shore Power

Installing and maintaining shore power infrastructure is one of the most important ways to reduce emissions. Rather than vessels running diesel engines to power essential systems while docked, ships can plug in and use electricity provided through the Port. Two of the three cruise births are already equipped with shore power, and the third, Pier 66, is scheduled to be completed by the 2024 cruise season.[45,46] The Port is also planning shore power at shipping terminals[46] and is already providing it at commercial and recreational marinas.[42]

Hydrogen Technology

Additional emissions-reducing plans, like shore power, "has a pretty heavy focus on electrification." But as mentioned earlier, the Port could support adopting hydrogen technologies, especially for heavy-duty equipment and

trucks.[43] This will require significant investments in electrical infrastructure and careful consideration in partnership with Seattle City Light to manage the increased demand this will most certainly create.

Alternative Fuels

Another major component of decarbonization strategies is developing and using alternative fuels in vessels. Some smaller vessels and vessels that run for short trips (e.g., ferries) can use batteries, but this is not currently possible for long-distance vessels such as cruise and cargo ships. The Port included advocating for and supporting the development and production of alternative fuels and vessels that can use them in its strategy.[44]

CREDIT: PORT OF SEATTLE

Alternative Fuels

There is increasing support for developing alternative maritime fuels that would help reduce maritime transportation GHG emissions. As mentioned earlier, vessel electrification (full or hybrid) is already being adopted where it is currently feasible. However, this option is only feasible for shorter trips and lighter vessels. As a result, it is mainly used in ferry-based transportation. No existing battery or fuel cell technology can power large vessels like passenger cruise and cargo ships, especially not for the long trips they are designed for. Green alternative fuels can power large ships for long voyages and would still reduce vessel emissions. In addition, it may be feasible to retrofit existing ships to use new fuels, reducing the cost and time to transition.

The three primary alternative fuels currently in research are hydrogen (H_2), ammonia, and methanol. A fourth, less likely option is nuclear power. Each of these fuels has advantages and disadvantages, and there is no clearly optimal fuel. This has prevented maritime companies from adopting a universal fuel of choice that would drive investment in production and distribution infrastructure. The variety and current scattered use of alternative fuels hamper the establishment of a solid supply chain that would allow rapid economies of scale.

H_2 Fuel

First, H_2 is cumbersome to transport. It has lower energy density than alternatives, as such it requires a large amount of space, which makes it impractical for long-distance ships. To transport it via ship, hydrogen must be kept at extremely cold temperatures, which requires an immense amount of energy. Hydrogen in its gaseous form is also highly flammable and presents significant explosion risks, requiring stringent ventilation and handling standards, while the hazards of liquified hydrogen are still poorly understood.

Ammonia

Perhaps due to these concerns, ammonia (NH_3) and methanol (CH_3OH) seem to be the current zero-emission fuels of choice for the shipping industry. However, these preferences are still shifting and haven't stabilized yet. Ammonia is making inroads into shipping as it is projected to account for 45% of its global energy demand by 2050.[35]

One of its particularities is its dual usage as a fuel to generate electricity or as a chemical storage for hydrogen in a fuel cell. However, ammonia is highly toxic and corrosive and presents significant flammability risks. These characteristics would require adequate safety measures during bunkering, storage, and use and would be a more

viable option for the shipping industry than the cruise industry.

Methanol

Methanol is another hydrogen-derived zero-emission fuel and could also involve collecting methane (CH_4) from various sources, including municipal solid waste. This fuel poses a lower risk of explosion and is less flammable and toxic than H_2 and ammonia, making it a safer alternative for the cruise industry.

Modular Nuclear Reactor

Finally, nuclear propulsion via a modular reactor is a topic that resurges and is receiving increased attention. For example, in September 2023, the marine and energy solutions company Crowley signed a memorandum of understanding to explore and develop microreactor ships. Despite its cost-efficiency advantage due to long operation intervals between refueling, the widespread use of nuclear-powered civilian ships will not happen in the foreseeable future.

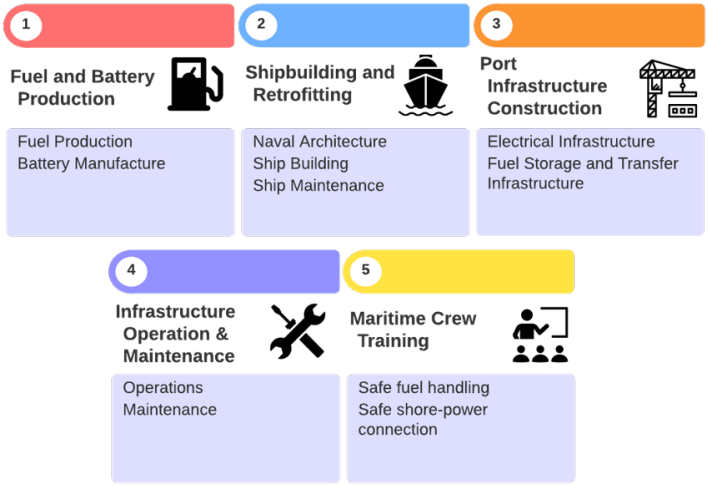
However, this final technology poses the most drastic training and certification impacts, requiring hiring cybersecurity professionals and securing this critical infrastructure. Still, the Inflation Reduction Act introduced new tax credits to support the production of zero-emission nuclear power, including small modular nuclear reactors. Notably, nuclear battery manufacturing would require significant community outreach efforts due to concerns about nuclear options and how and where to discard radioactive waste.

Labor Market Analysis

Strategies to decrease greenhouse gas emissions from shipping and other maritime industries currently rely on three main avenues: installing shore power, electrifying vessels for short trips, and using green fuels for longer

sailing. These two areas involve building electric batteries and producing clean marine fuels, transporting them to ports and shipyards, building or retrofitting ships to run with the new battery or fuel, and maintaining the new propulsion systems. The phases are outlined below (detailed phases can be found in Appendix E):

See Appendix E for a detailed Maritime Decarbonization phases



Entry-Level and Middle-Wage Jobs

Like the other initiatives, the maritime decarbonization labor market analysis was restricted to entry-level and middle-wage jobs, defined as occupations that require less than a four-year degree and less than five years of experience.

The exploratory analysis shows that the entry-level occupations in maritime decarbonization with the largest employment pools are heavy and tractor-trailer truck drivers (41,522 workers in 2023 and 5,485 in annual job openings in 2023) who transport clean fuels by road.

Other main occupations include trades professionals participating in the shipbuilding and retrofitting phase (welders and structural fabricators) as well as those participating in the fuel production and distribution (plant operators, as well as plumbers, pipefitters, and steamfitters), infrastructure installation (high-voltage electricians, power distributors), and underway crew members who must upskill.

Finally, the security requirements of modular nuclear reactors would increase the demand for cybersecurity professionals. Computer user support specialist is the entry-level occupation with the largest number of workers as these positions typically require less than an associate degree.

While heavy truck and tractor-trailer drivers have the most job openings in 2023 in absolute value (5,485), petroleum pump system operators, refinery operators, and gaugers have the larger number of job openings as a percentage of total workforce, 15% or 36 of 240 workers in 2023 showing high labor needs.

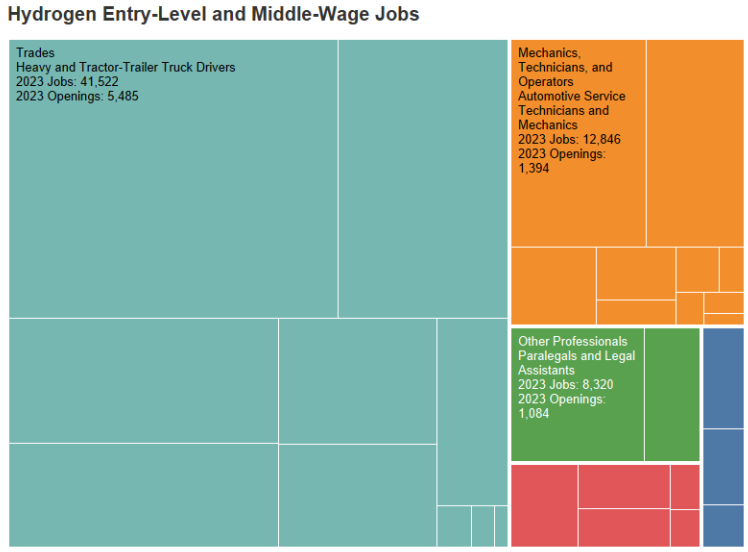


FIGURE 18 - MARITIME DECARBONIZATION ENTRY-LEVEL AND MIDDLE-WAGE LABOR POOL

Occupation Demographics

Regarding occupational demographics, all middle-wage and entry-level maritime decarbonization occupations have a lower diversity rate than the general state workforce (34%), except for cybersecurity workers. Thirty-six percent of computer user support specialists and 36% of computer network support specialists are persons of color (see Appendix B for detailed demographics).

See Appendix B for detailed occupation list

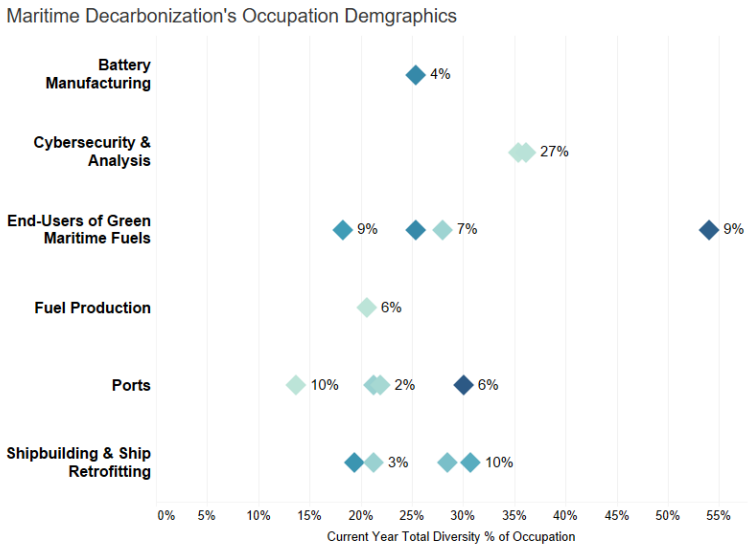


FIGURE 19 - MARITIME DECARBONIZATION PERCENT OF WORKFORCE BLACK, INDIGENOUS, OR OTHER PEOPLE OR COLOR (BIPOC)

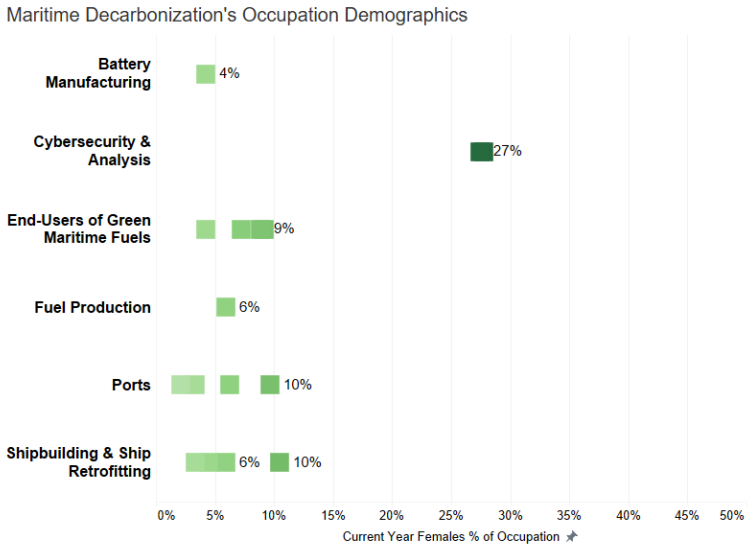


FIGURE 20 - MARITIME DECARBONIZATION PERCENT OF WORKFORCE FEMALE

Entry-level and middle-wage shipbuilding and retrofitting and underway crewing occupations have the next highest percentage of workers of color, ranging from 18% for captains, mates, and pilots to 31% for welding, soldering, and brazing machine setters, operators, and tenders. Power distributors and dispatchers are the least diverse occupations, with 14% of workers of color.

See Appendix B for detailed demographics

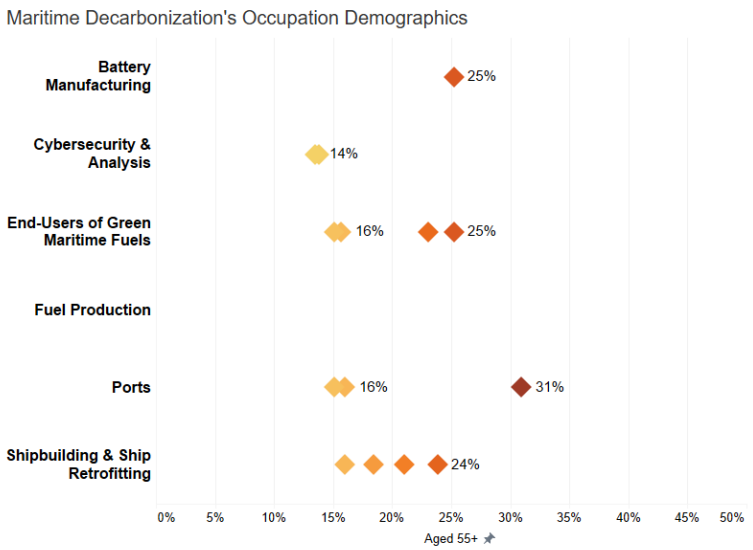


FIGURE 21 - MARITIME DECARBONIZATION PERCENT OF WORKFORCE AGE 55+

Similarly, the percentage of women workers is also lower than the state workforce (48%). Still, it is the largest among welding, soldering, and brazing machine setters, operators, tenders, and power distributors and dispatchers (10% each). Finally, heavy and tractor-trailer truck drivers have the highest retirement risk as 31% of workers are 55 years old or above compared to 22% for the state workforce.

Wages

Of the entry-level and middle-wage maritime decarbonization occupations, the increase in earnings along the career ladder is highest for power distributors and dispatchers as their hourly earnings go from $52 for incoming workers (10th percentile) to $81 for the most experienced workers (90th percentile). Even though these positions do not require a four-year college degree, professionals still need to complete long-term on-the-job training. Additionally, there were only 44 job openings in 2023 and 134 hires, including internal and external hiring.

Captains, mates, and pilots and petroleum pump system operators, refinery operators, and gaugers have the second and third highest hourly earnings for upcoming workers with a tenth percentile of $29 and $34, respectively. Like power distributors and dispatchers, these positions do not require a long-term college degree but do require extensive on-the-job training and are currently experiencing a labor shortage, especially captains, mates, and pilots.

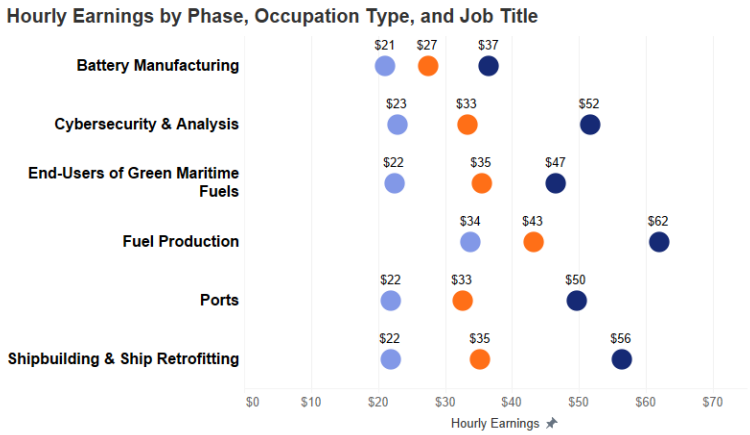


FIGURE 22 - MARITIME DECARBONIZATION ENTRY-LEVEL AND MIDDLE-WAGE OCCUPATIONS EARNINGS

See Appendix B for detailed wages

Openings

We compare job openings to earnings to identify occupations in the maritime decarbonization space that would most benefit from workforce development investments. As described earlier in this report, the following chart shows the expected average annual job openings between 2021 and 2026 on the horizontal axis and the median hourly earnings on the vertical axis for each entry-level occupation supporting maritime decarbonization. Workforce development programs should target occupations offering good hiring prospects and a living wage (80% of the state median hourly earnings, $30.50 in 2021, or $24.40).[42]

As discussed above, power distributors and dispatchers have the highest earning potential of entry-level maritime decarbonization occupations but have a small labor pool. On the other hand, heavy and tractor-trailer truck drivers have the largest labor pool of entry-level maritime decarbonization occupations and still offer a middle wage as the median hourly earnings is $28.

Electricians, plumbers, pipefitters, and steamfitters, and computer user support specialists offer similar prospects with relatively large labor pools and good hourly earnings above the middle-wage threshold ($39, $35, and $32 median hourly earnings, respectively).

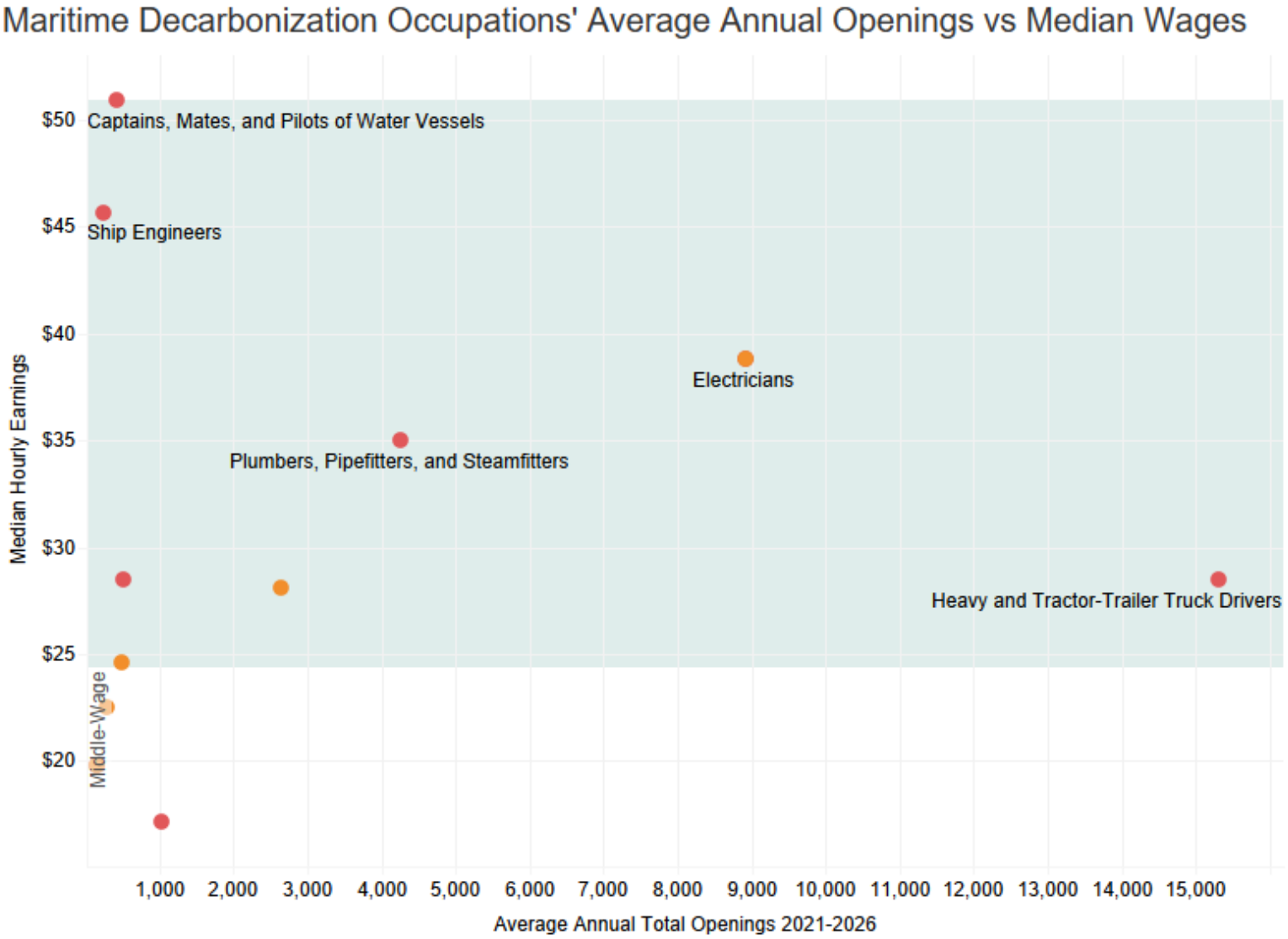


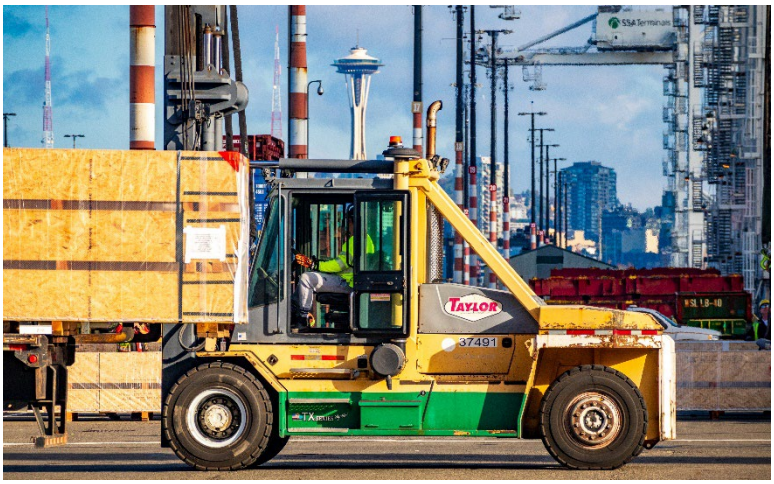
FIGURE 23 - MARITIME DECARBONIZATION ENTRY-LEVEL AND MIDDLE-WAGE OCCUPATIONS JOB OPENINGS AND MEDIAN HOURLY EARNINGS

Overall, automotive and watercraft service attendants who will handle clean fuels on the docks have low expected annual job openings between 2021 and 2026 (1,015) and earn well below ($17 per hour) the state median of $30.50 and below the middle-wage threshold of $24.40.

Workforce Development

The primary areas for workforce development for maritime decarbonization overlap substantially with OSW and green hydrogen. As noted in OSW, much of this work will involve updating and maintaining new infrastructure at ports like shore power and alternative fuel storage and delivery. All three initiatives will require workers in construction and other trades, in particular, electricians. These occupations are well within the Port's scope of workforce development and in line with existing programs. Further investment and program development to ensure that near-Port and underinvested communities can access these career paths is key to the implementation of maritime decarbonization.

In addition to those needed to build out and maintain new infrastructure, many existing jobs will require some upskilling. While the job description of longshore workers and underway crew members is not expected to change from using clean maritime fuels, maritime workers will need to undergo training on how to handle alternative fuels safely, particularly ammonia and H_2, which can pose serious health risks from improper exposure.



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Additionally, as more companies adopt electric batteries and research is underway to build ships powered by fuel cells or nuclear batteries, ship engineers, captains, and mates will need additional training to understand and work

> ***There are a lot of job opportunities if you can really tap into the communities and the kind of training and meet the training needs and other things as well. So, I think there are also a lot of workforce development opportunities for our airport communities. But we really get need to get the recruitment in place to get exposure to the opportunities in the maritime sector. Like Washington Maritime Blue has these, uh, um, you know, youth maritime collaboratives focused on youth and communities of color and really building trust with the parents, and exposing the youth to ocean-based job opportunities... And, um, you know, a lot of the barriers I've heard to [these jobs] … So there are all sorts of different access issues that need to be addressed for, for workforce development to really enable our, our near-Port communities to take advantage of the jobs that are there.***
>
> - Jennifer States

with these new operational systems. In addition, mechanics will need to be upskilled in repairing and maintaining new propulsion systems. Finally, hiring professionals to secure and maintain nuclear-powered ships' digital infrastructure will also be crucial to prevent attacks.

Responsible Tourism

Overview of Responsible Tourism

The Center for Responsible Travel (CREST) has identified four threats they seek to address through changes in tourism: the effects of climate change, damage to biodiversity and cultural heritage, the strain on environments and communities from over-tourism, and wealth inequality.[47] The desire to make tourism a positive force does not come only from advocates or residents in over-trafficked areas, but there is also growing demand among travelers for more responsible travel options.[48,49]

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A holistic plan requires locally driven approaches to be effective. CREST stressed the importance of local governments, destination management organizations, travel organizations, and local businesses' involvement. Still, the most crucial element to success was engagement with communities.

However, representatives acknowledged that "responsible tourism" or "sustainable travel" can become claims and campaigns lacking substance. So, evidence and documentation of responsible travel are important to maintaining fidelity to the concept and preventing greenwashing across the sector.

> *Every single hotel that you put on your itinerary…has some sustainability strategy and some community impact. Are they paying their people a living wage? Are there… opportunities for advancement? What are you doing about waste? What are you doing about energy?... And so you have an opportunity for every one of your tours that it's going to be doing the right thing. And that goes on to meals and [attractions].*

> ***Tourism can be a force for good. Oftentimes, it is not, but it can be a force for positive economic change, for better livelihoods, and for a better quality of life. But in order to do so, the challenges being faced that are specific to that destination have to be brought to the table and have to be addressed holistically.***
>
> - Wes Espinosa

Project Summary

Responsible Tourism Handbook

Tourism Development at the Port of Seattle aims to encourage travel to Washington in an economically impactful way, emphasizing international travel. They are working in aviation to make long-haul flights more environmentally friendly and work with cruise companies to improve their footprint. They also encourage people to spend their time and money responsibly before and after their cruises. A tourism project specialist oversees a grant program rewarding $200,000 worth of grants and a free advertising program at the airport. Both can provide mechanisms for promoting specific tourism activities if incorporated into a responsible tourism framework.

Read about the Green Cruise Corridor, project at the intersection of initiatives in Appendix G

In 2022, Tourism Development sponsored and organized the Responsible Outdoor Travel Summit (ROTS). This was merged with the Washington State Tourism's annual tourism conference in 2023. As one person said, the summit was focused on "how people can visit public lands without destroying them," emphasizing "making sure that everyone's included and feels welcome to do outdoor recreation in the state."

After developing ROTS and providing a mode for its continuation at the state's annual conference in 2023, Tourism Development is funding a project partnering with two internationally recognized responsible tourism [§]

[§] There are a variety of terms and definitions. For example, the Travel Foundation uses in many materials "sustainable tourism" and Tourism Cares tends to use "meaningful travel." We have

organizations: the Travel Foundation and Tourism Cares. After a series of workshops with industry leaders and tribes and an attempt to include "representation from all our communities," they developed a Responsible Tourism Handbook. The handbook outlines how to apply responsible tourism goals and strategies so that tourism is "working for all Washingtonians."

If well implemented and recognized in responsible tourism networks as a desirable destination for travelers sharing these priorities, it could attract more tourism as demand for this grows. For example, Tourism Cares, one of the partners in this project, has an online Meaningful Travel Map, which could potentially include more destinations in Washington state. "This could literally put us on the responsible tourism map" stated one source

> ***We're working with a lot of our big companies and tour operators to push this local connection and this partnership model in collaboration with local communities to where we take this economic engine of tourism, and redirect it towards underserved communities, marginalized communities, indigenous communities, women-owned businesses.***
>
> - Paula Vlamings

Other Components

Interviewees offered ideas for achieving positive workforce community impacts in urban and near-Port areas. For example, local wage requirements and environmental standards could be prerequisites for inclusion in travel itineraries or marketing. Other strategies include intentional marketing, the development of itineraries, and curating and exploring new connections and opportunities.

This can not only work to promote better wages and more positive activities for the environment but also function to spread people out, diversify experiences, localize resources, and more fairly distribute those resources. Even in the case of short-term trips, such as cruise passengers or conference and business travelers, there are strategies for dispersal through incentivization and targeted promotion.

> ***It's a social enterprise…or it's a nonprofit… all of these community impact partners that exist… and every community has these kinds of efforts going on, but not many are tied into tourism. And so, we try to find which ones could be... sourcing out opportunities that are already in existence.***

used responsible tourism for convenience and because it – possibly along with sustainable travel – seems to be the most widely used language, though we recognize there are important reasons and points of emphasis represented in different terminologies.

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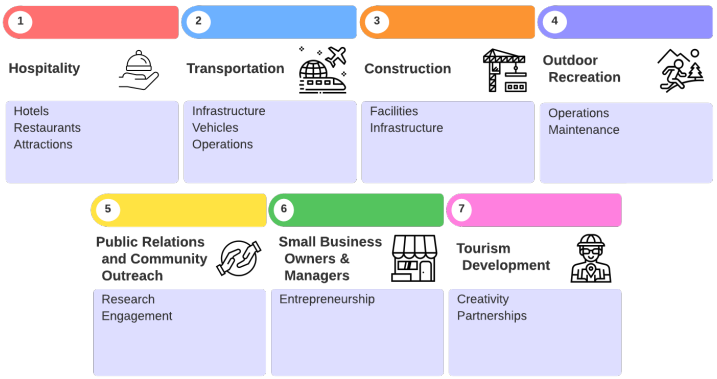
A strategy an interviewee suggested is partnering with local environmental and social nonprofits and finding ways to create tourism experiences that develop new revenue streams while offering unique and meaningful travel options. A creative example was where tourists could help replant coral or participate in habitat restoration projects through an environmental organization. Environmental and community organizations are abundant in Washington and the Puget Sound, and similar activities could be explored.

As previously mentioned, however, these strategies take dedicated work, partnering with communities to identify, coordinate, and market opportunities.

Labor Market Analysis

Responsible tourism practices may often be a redistribution of labor and workforce needs rather than a driver of job creation. Nevertheless, this remains an essential opportunity for equity and increasing access to the wealth generated through such a large industry. The demand for more responsible tourism destinations, practices, and experiences and the willingness to pay more suggests that if Seattle and Washington state develop and promote the opportunities here that meet guidelines and demand, this could be an opportunity for growth.[49]

If responsible tourism initiatives are prioritized, various industries and occupations could be impacted. The release of the handbook this fall will provide greater detail on the scope of the project recommendations and the potential for impact on implementation.



Entry-Level and Middle-Wage Jobs

The variety of opportunities for workforce impact in the tourism industry means that potentially all sectors and subsectors serving tourists could experience increased demand. For this reason, this analysis focuses on "traditional" tourism sectors that are most routinely associated with hospitality and leisure, as these industries are most likely to be impacted by responsible tourism initiatives (see Appendix F for full list of NAICS codes).

As noted above, responsible tourism may encourage tourism in new areas. To prepare for an influx of visitors, the targeted areas should either prepare their current workforce or ramp up hiring to accommodate the increase in demand for services and goods.

See Appendix F for detailed industries in Responsible Tourism

To improve relevance, the analysis focused on the main occupations employed in the key industries (at least 1,000 workers employed in these industries in the state) using staffing patterns and labor market data from Lightcast. These tourism-related occupations include those in the

restaurant industry, lodging and hotels, retail stores, travel arrangements, and other support roles.

Like the other selected initiatives, the tourism jobs analysis is restricted to entry-level and middle-wage jobs. As a reminder, these are defined in this report as occupations that require less than a four-year degree and less than five years of work experience. The analysis is restricted to jobs offering a middle wage to ensure potential job training program participants can support themselves and their families. The latter is 80% of the state's median hourly earnings ($30.50), or $24.40. Unfortunately, out of the 32 main tourism occupations, only two roles offer middle wages: Travel agents with 8,058 workers and 1,242 average annual job openings in Washington state in 2023 and sales and related workers with 5,773 workers and 830 job openings in 2023.

Both occupations have a relatively broad scope. The Travel Agents SOC code also encompasses travel consultants and coordinators (median advertised earnings from job postings at $24.49 and $24.62, respectively), who tend to earn more than travel agents ($18.40). This is also the case for other sales and related workers. While most of these workers are employed in supermarkets and other grocery stores, many also work in other sectors of the economy not related to tourism, such as corporate officers or software publishers, as this occupation code includes more technical sales roles (sales engineers, energy sales representatives, etc.) that offer higher wages. Responsible tourism initiatives should thus focus on supporting and creating good jobs for tourism workers by setting higher wage targets to ensure equitable outcomes and income distribution.

Occupation Demographics

Of these two roles, travel agents are the most diverse group, with a percentage of workers of color exceeding the state workforce (37% vs 34%). Workers in this occupation are also predominantly women 65%, exceeding the state workforce estimate by 17 percentage points. Finally, the workforce in both roles is still relatively young, with only 21% of travel agents and 28% of sales and related workers aged 55 or above.

See Appendix B for detailed occupation list

So, workforce development and tourism are super important. Why? .. You have a lot of jobs, right? It's a tenth of the global economy. But many of those jobs are low-wage jobs. They're jobs that don't provide a lot of upward mobility. They're jobs that are temporary and have a lot of turnovers. So, through these different initiatives that, we have obviously recognized, one of our threats is decreasing and ever-widening wealth gap is the idea that tourism jobs can be sustainable for economic growth. Right? It's the idea, then, rather than just having quick turnaround guide jobs that you can create a whole ecosystem if a destination wants and enables it for the preservation of cultural and natural heritage…

- West Espinosa

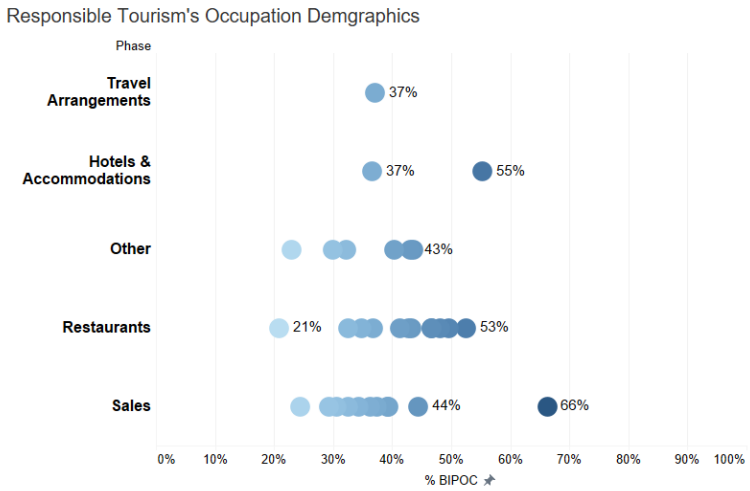


FIGURE 24 - RESPONSIBLE TOURISM PERCENT OF WORKFORCE BLACK, INDIGENOUS, OR OTHER PEOPLE OF COLOR (BIPOC)

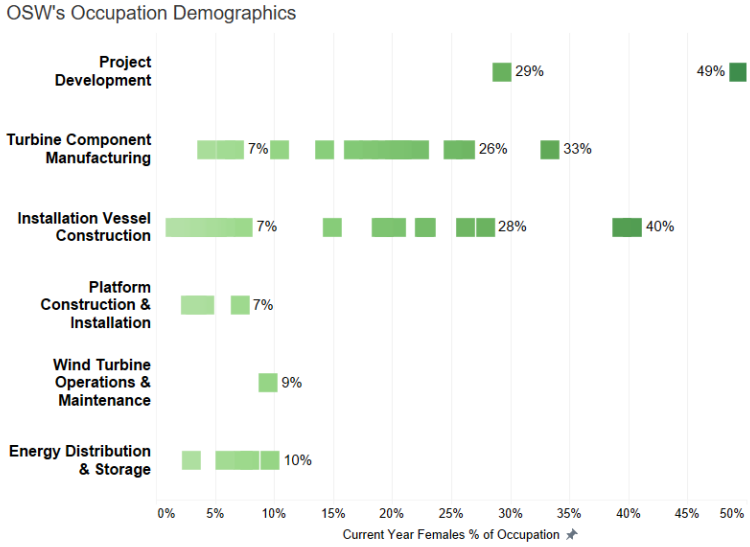


FIGURE 25 - RESPONSIBLE TOURISM PERCENT OF WORKFORCE FEMALE

See Appendix B for detailed demographics

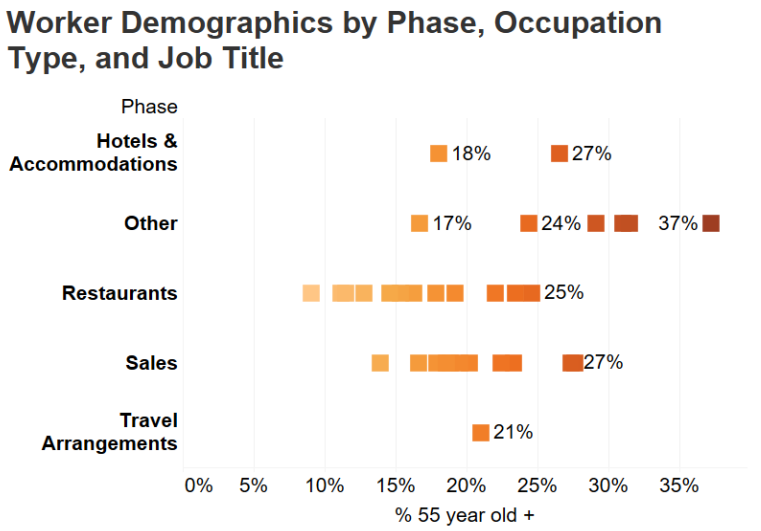


FIGURE 26 - RESPONSIBLE TOURISM PERCENT OF WORKFORCE 55+

Wages

As mentioned, travel agents and retail worker are the only roles requiring less than a 4-year degree in this sector offer a middle wage as their median hourly earnings are above 80% ($24.40) of the state median hourly earnings. Still, entry-level salaries, proxied by the 10th percentile of the earnings distribution, show incoming workers can expect to make between $19 and $20 an hour. As they gain experience, earnings increase to $28 and $32 for the median earnings and can even reach $39 for the highest-paid sales and related Workers (90th percentile).

However, as mentioned earlier in this section, while most sales and related workers can be found in supermarkets and other grocery stores, many are working in non-tourism-related sectors that require additional education or are in niche areas (sales engineers, energy sales representatives, etc.) and receive large salaries that are pushing these earnings percentiles up. Ensuring responsible tourism initiatives offer good earnings opportunities for workers involved in these projects would help move the tourism sector towards more equitable outcomes.

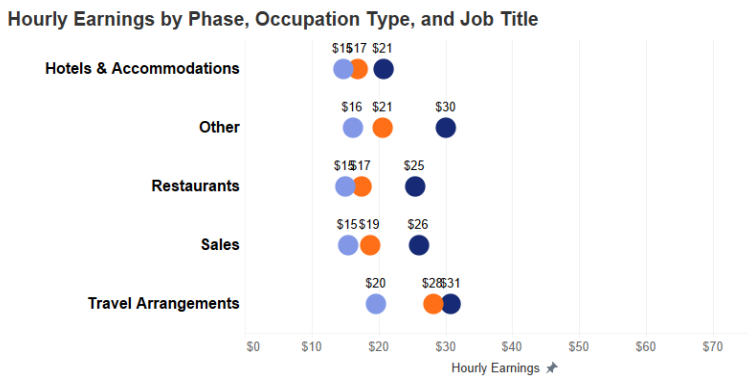


FIGURE 27 - RESPONSIBLE TOURISM ENTRY-LEVEL AND MIDDLE-WAGE OCCUPATIONS EARNINGS

Comparing the average annual job openings between 2021 and 2026 shown to the median hourly earnings helps identify which entry-level occupations are the most likely to offer both robust employment opportunities for new workers and living wages (here again defined as 80% of the state median hourly wage, $30.50 in 2021, or $24.40).[42]

The retained entry-level occupations, sales and related workers and travel agents, offer the highest median earnings but have some of the smallest employment pools. On the other end of the spectrum, fast food and counter workers and retail salespeople, have the largest number of workers of all tourism occupations (52,245 and 43,037 workers, respectively) but have some of the lowest earnings potentials with $17 median hourly earnings.

See Appendix B for detailed wages

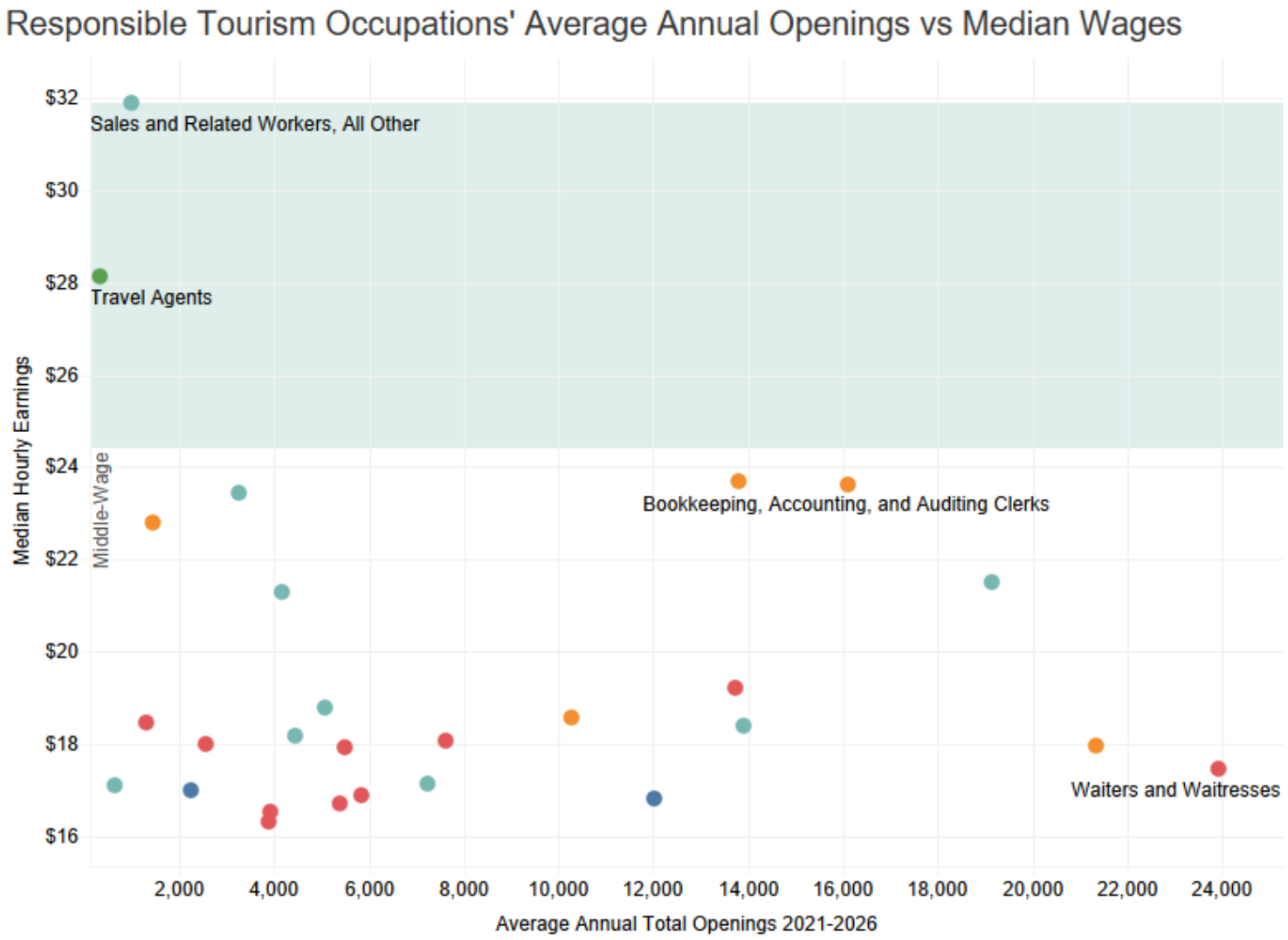


FIGURE 28 - RESPONSIBLE TOURISM ENTRY-LEVEL AND MIDDLE-WAGE OCCUPATIONS JOB OPENINGS AND MEDIAN HOURLY EARNINGS

In the middle, maintenance and repair workers, bookkeeping, accounting, and auditing clerks, and office clerks have the strongest employment potential to their largest number of expected annual job openings but are below the middle-wage earnings threshold, albeit by a slight difference as the median hourly earnings for the first two occupations reach $23.68 and $23.64, barely below the $24.40 threshold.

Workforce Development

One area of potential need is related to small business ownership. Skills in business and entrepreneurship, management, and marketing, as well as training in finance and tax codes, could support those getting started—professional development courses to assist business owners with handling the increase in business stemming from an influx of tourists. Training in any new environmental standards in the industry, food safety requirements, and labor laws would also be necessary for those seeking business ownership.

In addition to supporting entrepreneurship in underinvested communities, workforce development in this sector must focus on making existing jobs "good jobs." This is essential for this sector to produce the Port's triple bottom line.[50] This can be arrived at through several policy mechanisms. One key policy driver is incorporating labor standards into benchmarks required to obtain a "responsible tourism" designation.[51] These standards include improved pay, safe working conditions, stable work schedules, adequate time off, including sick and family leave. Australia had developed a family friendly workplace model that can be adapted and applied in this sector.[52]

Future of the Project

Responsible tourism practices and potential opportunities may take time to grow and develop. Change will not occur overnight. Continued collaborations and discussions around the handbook and how to implement it must take place with clear implementation plans.

As mentioned, one opportunity for workforce development at the Port and elsewhere suggested by this study is the potential need for small business training and workshops related to connecting with the tourism industry or implementing responsible tourism standards. Small grants could help support and promote entrepreneurs from underserved communities or near port communities looking to start businesses related to developing tourism experiences and itineraries in their communities.

Despite the sector currently depending on low-wage jobs, this is still a critical industry for the Port. First, it is a very large sector that is also labor-intensive. Second, it is the most public-facing of the Port's sectors, through which it interacts both with tourists from all over the world *and* the local communities, thus it is both important for the Port's image and its direct impact on said communities. Finally, this sector has the potential to drive and reinforce other environmental initiatives, particularly habitat restoration and maritime decarbonization.

> ***[O]ur work is…a lot of community engagement … to work with communities to connect them various resources. And, and part of that is workforce development. But the other part of it is really green jobs pathways and sort of exposing different ways opportunities for different green jobs pathways.***
>
> - Kathleen Hurley

Other Port Initiatives

The Port has several other environmental initiatives it has committed to. Two of these initiatives, aviation decarbonization and habitat restoration, were included in the initial phase of this research. While their environmental impact and value is not in question here, their direct workforce impacts are anticipated to be small, particularly as related to entry-level and middle wage jobs.

Habitat Restoration

The Port's planning for habitat restoration aims to identify opportunities for habitat enhancement and habitat restoration along the Port's shorelines. The Port also partners with various agencies and nonprofits to undertake research and development projects, such as mapping of bull kelp beds in Elliott Bay.

It was determined that despite its Port-wide application, habitat restoration program is limited in geographic scope. In addition, these projects rely on a relatively small number

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of entry-level manual labor occupations and a few positions requiring graduate degrees. In addition, there are no established pathways to move from entry-level manual labor roles to roles requiring advanced degrees.

Restoration of ecosystem functions that the Port relies on is critical work. It offers valuable opportunities to connect people to the environment and environmental work, increasing support and buy-in for other initiatives. For example, it can overlap with responsible tourism through both making the Port and Seattle a more responsible destination and offering opportunities to collaborate with environmental nonprofits in creating meaningful tourism experiences connected to these habitats and even their restoration.

In addition, in the long run, it may impact how many people across the Port do their jobs to have less impact on the environment. However, these connections are not anticipated to impact the skills or number of people employed greatly. As a result of the relatively small, anticipated impact on the workforce, habitat restoration was not selected for further research.

Aviation Decarbonization

Aviation Decarbonization is an ambitious plan with large environmental payoffs, given that air travel is the fastest-growing source of greenhouse gas (GHG) emissions. Sustainable aviation fuels (SAF) and electric aviation are two primary routes to decarbonization.

Electric aviation, including fully or hybrid electric planes and hydrogen-powered planes, like the electrification of ground transportation, would substantially curb the sector's GHG emissions. However, significant technological barriers exist, and these systems are still in research and development. An aircraft's average lifespan is approximately 30 years, so it will take decades to see this fully deployed.

Far more advanced is the manufacture and use of sustainable aviation fuels, including biofuels. These fuels offer the benefit of reduced emissions, and SAF can flow into existing infrastructure and be used in existing aircraft. There are already biofuel producers in the state, and two new SAF production facilities in Washington have recently been announced. One facility involves new technology, and potential employment is small and concentrated in occupations that require advanced postsecondary degrees.

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> ***Once the sustainable aviation fuel is, is produced, we'll be putting it into the same jet fuel pipeline system to go to the airport… There's no job creation that's new. It, goes into the same system.***
>
> - Stephanie Meyn

The other facility has not disclosed its technology, but alternative fuels can be produced from solid waste, cooking oil, and byproducts from the timber industry. A dramatic expansion in the production of biofuels may support many temporary jobs in plant construction and some jobs in feedstock preparation and bio-refinery operations, as well as provide a profitable market for forestry and agricultural byproducts in the state.

However, much of the SAF production is likely to occur in existing refineries as they incorporate a changing feedstock mix. As noted above, these refineries feed the blended fuels into existing distribution networks and would be virtually indistinguishable from conventional aviation fuel to the ground crews who fuel the planes. As a result, there is no significant change in occupations or skills from the production phase to the end-user. For this reason, aviation decarbonization was not selected for further research, even though hydrogen production detailed below could push this initiative further.

Conclusion

The Port's environmental initiatives offer some critical workforce development opportunities. In turn, having an adequate and skilled workforce is necessary for the success of these initiatives.

Offshore wind energy has the widest-reaching workforce development opportunity despite OSW deployment in the State of Washington being a decade or more away. Washington's strengths in shipbuilding and manufacturing, along with the geographical advantage of Puget Sound, have it poised to play a critical role in the supply chain for West Coast OSW projects. The occupations in these industries are skilled-middle wage jobs with an aging workforce. The career paths in both sectors could be made substantially more accessible to near-Port communities.

Hydrogen Power is much closer to implementation in the state, with a significant investment from the US Department of Energy in the region's hydrogen hubs and two other state projects coming online in the next two years. This industry-wide movement will support the implementation at the Port. This initiative also has a wide range of skilled, middle-wage occupations and offers the potential to support a just transition for workers transitioned from fossil-fuel industries. Like OSW, Hydrogen Power's labor pool lacks diversity and is aging, indicating that outreach and support for underrepresented communities are needed to ensure this new workforce is diverse and equitable.

The closely related Maritime Decarbonization initiative involves electrification and alternative fuels. It requires upgrades to the electrical infrastructure and new fuel storage and delivery infrastructure. As a result, the labor pool overlaps significantly with Green Hydrogen with the addition of underway operations occupations. While maritime decarbonization is not expected to impact the demand for underway operations occupations, the captains, mates, sailors, and engineers will require training to operate and maintain new propulsion systems.

Finally, the Responsible Tourism initiative draws on a different labor pool than the first three initiatives. It can potentially have the widest array of impacts on near-Port communities. However, the existing occupations are largely low paying. Increasing wages and improving other job quality metrics is critical to making this initiative have a positive workforce impact and ensuring that one of the impacts on near-Port communities is jobs with family-sustaining wages.

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