City of Seattle Office of Economic Development

Fossil Fuel Workforce Transition Study

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Prepared by:

Prepared for:

Community Attributes Inc. tells data-rich stories about communities that are important to decision makers.

Chris Mefford, President & CEO

Madalina Calen
Spencer Cohen
Michaela Jellicoe
Zack Tarhouni

With contributions from

Heather Rhoads-Weaver
eFormative Options LLC

Community Attributes Inc.
500 Union Street, Suite 200
Seattle, Washington 98101

www.communityattributes.com

EXECUTIVE SUMMARY

Fossil fuels cause local pollution where they are being produced and used, and the ongoing use of fossil fuels is causing lasting harm to the climate of the entire planet. King County and the Seattle region are already experiencing the impacts of climate change with fundamental and far-reaching consequences for the environment, the regional economy, and public health. To achieve the necessary significant reductions in carbon pollution and build a comprehensive response to climate change, the City of Seattle is exploring policies and programs that would support a transition away from fossil fuels to a clean energy economy.

The COVID-19 crisis has driven a series of political, economic, and social changes with potential to influence sustainable energy transitions. Social practices around mobility, work and public health can accelerate the digitization of the workforce and increase the value of investments in automation.[1] The pandemic has had a disproportionate impact on communities of color, women in the workforce, and individuals with a high school education or less as they are more highly represented within jobs most at risk to experience reduced hours or layoffs. This emphasizes the need to address diversity, equity, and inclusion.

While the transition presents many challenges and opportunities, this study focuses on the workforce side of the transition. **This project assesses the size and breadth of fossil fuel and clean energy industries in King County and provides an overview of the nature of work and occupations within each industry. It includes a discussion of job growth and industry outlook for clean energy based on data analysis and interviews with key stakeholders. It also serves as a baseline to identify those occupations that are most dependent on the fossil fuels industry.**

Lastly, it makes recommendations, reflecting data analysis, research and stakeholder feedback, that the City and its partners can implement to: (a) ensure a just transition[2] for workers, with a particular focus on how to equip workers with the necessary skills to move from jobs reliant on fossil fuels to jobs in the clean energy sector; (b) accelerate and expand job growth in the clean energy sector, if necessary; and (c) ensure that jobs created are family-wage jobs.

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[1] Seattle Jobs Initiative and Seattle Office of Economic Development, "COVID-19 and the Future of Work", (July, 2020), Link.

[2] A just transition would ensure a fair and inclusive energy transition that leaves no one behind, provides economic security and opportunities for all workers and considers communities that will bear the worst impact from decarbonization.

Fossil Fuel Industry Employment and Occupations in King County

This study estimates that in 2019 the fossil fuel sector employed an estimated 7,700 workers in King County, which represents roughly 0.5% of the County's total employment. The largest subsector was "Automotive Mechanical and Electrical Repair and Maintenance", with more than 2,500 workers. Most common occupations within this subsector include automotive service technicians and mechanics and automotive body and related repairers.

Racial and gender inequity remains a stubborn issue in this sector. Most fossil fuel occupations have a low share of female workers, except office clerks. All leading fossil fuel occupations with the exception of laborers and freight, stock, and material movers and construction laborers have a smaller share of non-white workers than the County's average population (34%). Most leading fossil fuel occupations have a median wage below the County's median wage of $69,000 in 2019[3].

Clean Energy Industry Employment and Occupations in King County

In 2019, there were 12,400 jobs in the clean energy industry in King County. Specialty trade contractors, electric power distribution, and other electronic component manufacturing are the biggest sectors in the clean energy industry, which together represent roughly half of the County's total employment in clean energy.

Construction related occupations such as construction laborers, operating engineers and other construction equipment operators, and first-line supervisors of construction trades and extraction workers are among the most commonly found in the clean energy industry, mostly due to the prevalence of jobs in the specialty trade contractors sector. This sector within the clean energy industry requires skilled workers with knowledge of green construction, energy efficiency and pollution reduction techniques, such as builders with knowledge of advanced framing techniques to reduce heating and cooling costs, painters using low volatile organic compound paints, and roofing, flooring, and paving workers using similar environmentally friendly products.

Most leading clean energy occupations have a low share of female workers, except customer service representatives and business operations specialists.

[3] Washington State Employment Security Department Median and hourly wages, 2018.

Laborers and freight, stock, and material movers, construction laborers, and customer service representatives are the lowest paid occupations in the County's clean energy industry, comprising 14% of the sector's jobs.

Workforce Transition Impacts

Using data analysis, existing research and stakeholder inputs and feedback, this study finds that:

- Businesses in the fossil fuel and clean energy industries both rely on similar professional support activities for various administrative, legal, financial, and businesses services. If displaced from fossil fuels, these workers could secure employment in other industries without much additional training, provided those jobs are available. However, workers who rely on skills specific to fossil fuels such as pipefitters or other construction workers building and maintaining fossil fuel infrastructure are expected to require more resources in such a transition.
- The electrification of the transportation system will impact fossil fuel workers differently depending on the transferability of knowledge and skills. For example, automotive glass installers and repairers and body and related repairers working in internal combustion engine vehicles (ICEs) manufacturing have knowledge and skills applicable to EV manufacturing. On the other hand, automotive service technicians and mechanics will likely require some level of retraining to transition.
- All-electric new construction of buildings could reduce the need for plumbers and pipefitters to extend new natural gas lines and connections, and reduced sales of gas could decrease the number of utility workers for those utilities with a high share of natural gas in their energy mix. However, these negative impacts could be offset by the increase in building retrofit work, which will require electrical, HVAC, and plumbing work. Also, increased demand for district energy systems, such as those in Seattle's Central Business District, hospital district and First Hill neighborhood, can create new jobs for displaced gas workers, plumbers, and pipefitters.
- While the occupations expected to be more in demand in Seattle's emerging clean energy economy may not directly match those declining in fossil fuel industry, a variety of pathways for positions such as pipefitters and fusers can be explored to map effective transitions. The up skilling of workers through stackable micro credentials and specialized trainings can ensure a robust local labor market and continued employment. Further research is needed to map these career pathways and identify training opportunities.

Recommendations

The recommendations identified by this study are informed by data analysis, secondary research and stakeholder outreach and are grouped into three categories:

- **Policies to prioritize demand-side clean energy strategies:**
  - Invest in decarbonized district energy.
  - Pursue aggregated community-scale decarbonization.
  - Offer incentives and accelerated permitting/interconnection for projects that meet clean energy workforce criteria.
  - Pre-qualify contractors and enforce certification/licenses.
  - Extend efforts to reach underrepresented workers.
- **Affected workforce and stakeholder engagement:**
  - Create conditions to build skilled workforce from local talent pools.
  - Plan an orderly transition.
  - Develop a fund for fossil fuel worker retention and transition assistance.
- **Business expansion support targeting clean energy supply-side strategies:**
  - Support the up skilling of workers through stackable micro credentials.
  - Create opportunities for disadvantaged workers[4].

[4] Disadvantaged workers could include at-risk youth, women, workers living in depressed areas, or other workers with difficulties entering the labor market. Additional research is recommended to understand who makes up the disadvantaged workforce in King County in order to implement recommendations and develop solutions.

Table of Contents

Exhibits

Abbreviations

INTRODUCTION

Background and Purpose

The worsening impacts of human-caused climate change and a carbon-based economy are prompting cities to take actions to reduce the burning of fossil fuels and use of other carbon-emitting energy sources. King County and the region have been experiencing the impacts of climate change through record temperatures, increased wildfire threats and poor air quality, increased flooding and landslide hazards, a decline in snow and ice in the Cascades and Olympic mountains, and harmful changes in ocean chemistry for marine wildlife. Additionally, climate change harms people and communities differently across the County based on race, age, gender, health, where they live, and what they do for work. The transition away from fossil fuels, one of the main sources of greenhouse gases, to clean energy sources presents opportunities as well as challenges and risks for Seattle businesses and workers, all of which need to be understood to inform policy decision-making.

Seattle is a national leader in the fight against climate change and has made a commitment to be carbon neutral by 2050.[5] However, Seattle's Greenhouse Gas (GHG) Inventory (2018) shows that city-wide emissions are beginning to increase. Under these trends, the City will not be able to make significant further progress towards emissions reduction without decarbonizing its energy supply in the buildings and transportation sectors and reducing end-use consumption of fossil fuels in favor of cleaner fuel types. The two major electric utilities that serve the city presently have substantially different power mixes, deeply connected to the region's historical policy and regulatory context. Seattle City Light (SCL) sources more than 90% of its power from renewable sources, while Puget Sound Energy (PSE) receives roughly 40% of its power from renewable sources and the remaining 60% from coal and natural gas.[6]

The COVID-19 pandemic has implications for climate policy and the transition to clean energy that present both challenges and opportunities. The pandemic is changing the workforce landscape, eliminating roughly 70,000 jobs in King County between February and December 2020.[7] Impacts are felt across all industries and occupations but have disproportionate impacts on communities of color, women in the workforce, and individuals with a high school education or less. In King County, Black/African American

[5] Finn-Coven, Jessica and Smith, Debra J,, Aug 2020, "RE: City of Seattle & Seattle City Light Joint Proposal to Electrify America for Cycle 3 Investments"
[6] Cadmus, "King County Renewable Electricity Transition Pathways" (July 2018), Link
[7] Washington State Employment Security Department, Total Nonfarm Employment, Accessed in January 2021.

claimants have 2.6% higher representation in the new unemployment insurance (UI) claimant pool than in the labor force, compared to 6.3% less for white claimants. Approximately 60% of new filers in the County between March and November 2020 held an Associates' degree or less.[8]

While job losses caused by the pandemic are not long-term and some jobs have already been recovered since February 2020, the pandemic has led to structural changes in the labor force. The need for maintaining physical distance for an extended period has created a very strong incentive for businesses to invest in automation. Workers that are most likely to be impacted include those working in jobs with routine tasks, that are customer facing[9].

New recovery programs and stimulus measures that governments are putting in place have the potential to create a recovery that is both green and inclusive. The current pandemic has only increased the urgency of investments in careers that offer equitable wages, promote transferable skills, and pose lower formal educational barriers to entry. Linking infrastructure job creation to climate action can stimulate the economy after COVID-19 and lead to a just transition to a clean energy economy.

The City of Seattle is exploring policies and programs that would transition us away from fossil fuels to zero-emissions energy in our homes, cars, trucks, buses, and buildings. The City's Office of Economic Development (OED) requested an analysis to: (1) understand the potential impact to workers as the City acts to reduce reliance on fossil fuels; (2) analyze where job growth is anticipated in clean energy and related industries; and (3) identify strategies for supporting businesses and their workers as the City transitions away from fossil fuels.

Methods

This report makes use of both qualitative and quantitative sources. To estimate the number of jobs and occupations associated with both the clean energy and fossil fuel industries in the region, existing reports and studies were consulted to derive industry definitions. We worked with OED staff to run King County data queries using the EMSI data tool[10] for each industry. Additional data were included through use of the Quarterly Census of Employment and Wages data series for King County, employment-occupational matrices published by the Washington State Employment

[8] https://www.seakingwdc.org/covid-19-employment-impact
[9] Seattle Jobs Initiative, "COVID-Recession & Recovery" (May 2020), http://www.seattle.gov/Documents/Departments/economicDevelopment/workforce/COVID-19-Recession-and-Recovery-Brief%20(1).pdf.
[10] https://www.economicmodeling.com/

Security Department, and data from Puget Sound Regional Council. The employment and occupations estimates were continuously improved through stakeholder feedback and secondary research.

Businesses, unions, and organizations involved in the fossil fuels and clean energy industries were contacted for input and perspective through both interviews (interview questions in Appendix E) and an electronic survey (survey questions in Appendix F). Stakeholders were asked questions regarding their activities related to the two industries, workforce needs, risks and opportunities associated with a shift away from fossil fuels, industry outlook, and recommendations and concerns for the City Council to consider. The survey requested additional information on fossil fuel and clean energy activities and potential impact of policies that transition Seattle away from fossil fuels.

We received 49 responses to the survey and interviewed 18 stakeholders, together including 15 Minority/Women Business Enterprises (MWBE) and Black, Indigenous and people of color (BIPOC) and women-led firms and organizations.[11] The interviews and survey provided information and data to inform the industry employment, outlook and workforce analysis for this study and supported the development of final recommendations.

Additionally, a study Advisory Committee with diverse backgrounds met throughout the project to offer insights, support interview introductions, and report considerations. Four virtual meetings were held on definitions, stakeholder engagement, themes heard during interviews, and suggestions on prioritizing recommendations.

Organization of Report

The remainder of this report is organized as follows:

- **Fossil Fuel Industry Employment and Occupations in King County.** An analysis of employment and occupations in the fossil fuel industry in King County, including a summary of the definition of fossil fuel industry used in this study and a discussion of businesses and activities that depend on fossil fuels.
- **Clean Energy Employment and Occupations in King County.** An analysis of employment and occupations in the clean energy industry in King County, including a summary of the definition of clean energy industry used in this study.

[11] The study team contacted more than 330 Seattle-area stakeholders including approximately 50 WMBEs and BIPOCs, representing 20-30% response rates.

- **Clean Energy Industry and Occupational Outlook.** An overview of the future of clean energy in Washington and King County, including projected future jobs based on occupations.
- **Wages, Knowledge and Skills Analysis.** Analysis of the types of education, experience and skills associated with the occupations identified.
- **Workforce Transition Impacts.** A summary of key findings on local workforce transition impacts and other concerns expressed by stakeholders in the Seattle-area clean energy and fossil fuel industries.
- **Summary and Recommendations.** A review of key findings, including recommendations for strategies and policies the City and its partners can implement.

FOSSIL FUEL INDUSTRY EMPLOYMENT AND OCCUPATIONS IN KING COUNTY

The fossil fuel industry encompasses three broad sets of businesses. First, it includes activities that produce carbon-based fuel, such as burning coal, oil, natural gas, corn ethanol, biodiesels, and wood fuel. Second, it includes activities related to the manufacture, maintenance, and repair of equipment that relies on carbon-based fuel, including the transportation sector and its supply chains. Third, it includes businesses, workers, and organizations engaged in the distribution and sale of oil, as well as supporting services associated with the handling and delivery of fossil fuels.

Fossil Fuel Industry Definition

Existing research and literature on fossil fuels includes a variety of possible definitions for this industry. A July 2020 white paper published by MIT professors Saul Griffith and Sam Calisch, and Rewiring America's Alex Laskey[12] defines the fossil fuel industry using the 6-digit North American Industry Classification System (NAICS) codes and sectors outlined in Exhibit **1**. This study employs the MIT paper definition but due to employment data suppression at the 6-digit NAICS, it applies the corresponding 4-digit NAICS for each sector as shown in Exhibit 1.

The MIT paper distinguishes between gasoline stations with convenience stores and other gasoline stations, such as those engaged in retailing automotive fuels, oils, replacement parts and accessories and/or providing repair or food services. Only other gasoline stations are included in the MIT paper's definition of the fossil fuel industry. This study does not include either types of gasoline stations as part of the fossil fuel industry. According

[12] Saul Griffith & Sam Calisch, "Mobilizing for a zero carbon America," *Rewriting America* (July 29, 2020), Link.

to data from the Washington State Employment Security Department on the distribution of occupations by industry, most workers in gas stations are cashiers. Cashiers do not require fossil fuel specific skills and could secure employment in other industries such as retail, provided those jobs are available.

Exhibit 1. MIT Paper and Current Study Fossil Fuel Industry Sectors

6-digit NAICS	Sector	Current Study Sector	NAICS
213112	Support activities for oil and gas operations	Support Activities for Mining	2131
211130	Oil and gas extraction	Oil and Gas Extraction	2111
237120	Oil and gas pipeline construction	Utility System Construction	2371
221210	Natural gas distribution	Natural Gas Distribution	2212
211120	Petroleum	Oil and Gas Extraction	2111
447190	Other gasoline stations	Not Included	NA
221112	Fossil fuel electric power generation	Electric Power Generation, Transmission and Distribution	2211
333132	Mining and oil and gas field machinery	Agriculture, Construction, and Mining Machinery Manufacturing	3331
324110	Petroleum refineries	Petroleum and Coal Products Manufacturing	3241
486110	Pipeline transportation	Pipeline Transportation of Crude Oil	4861
212112	Bituminous coal underground mining and anthracite mining	Coal Mining	2121
212111	Bituminous coal and lignite surface mining	Coal Mining	2121

Source: Saul Griffith & Sam Calisch, "Mobilizing for a zero carbon America," Rewriting America, 2020; Community Attributes, 2020.Employment and Occupations

The MIT paper definition does not capture fossil fuel related activities and businesses, like internal combustion engine vehicles (ICEs) manufacturing and its supply chain. A report completed by Seattle Jobs Initiative on the workforce implications of the electrification of transportation[13] was employed to identify the ICE-relevant NAICS codes and to estimate employment. The MIT paper definition was supplemented with the following NAICS codes:

- 3361: Motor Vehicle Manufacturing
- 3362: Motor Vehicle Body and Trailer Manufacturing
- 3363: Motor Vehicle Parts Manufacturing

[13] Seattle Jobs Initiative, "Amping up Electric Vehicle Manufacturing in the PNW. Opportunities for Business, Workforce, and Education", https://webuildgreencities.com/wp-content/uploads/2020/05/READ-THE-EV-REPORT-HERE.pdf

- 3344: Semiconductor and Other Electronic Component Manufacturing
- 335312: Motor and Generator Manufacturing

Lastly, as it relates to the transition from ICE vehicles to electric vehicles, the following NAICS were also included to capture fuel distribution and repair and maintenance of ICE vehicles:

- 4247: Petroleum and Petroleum Products Merchant Wholesalers
- 81111: Automotive Mechanical and Electrical Repair and Maintenance

King County Estimates

In King County, based on the definition above, an estimated 7,660 workers were employed in 2019 in the fossil fuel sector.[14] This represents approximately 18% of Washington state employment in this industry.

Exhibit 2. Fossil Fuel Industry Jobs in King County, 2019

Subsector	Jobs	% of WA Jobs	Average Wage
Automotive Mechanical and Electrical Repair and Maintenance	2,510	30%	$56,500
Utility System Construction	2,050	36%	$81,000
Motor Vehicle Manufacturing	1,240	NA	NA
Semiconductor and Other Electronic Component Manufacturing	620	16%	$78,400
Motor Vehicle Parts Manufacturing	380	27%	$52,100
Petroleum and Petroleum Products Merchant Wholesalers	360	18%	$82,000
Agriculture, Construction, and Mining Machinery Manufacturing	210	16%	$74,200
Motor and Generator Manufacturing	80	89%	$89,100
Motor Vehicle Body and Trailer Manufacturing	90	10%	$57,800
Petroleum and Coal Products Manufacturing	70	2%	$117,000
Electric Power Generation, Transmission and Distribution	50	0%	$177,800
Gasoline stations	*2,530*	*19%*	*$31,100*
Total	*10,190*		
Total Fossil Fuel Jobs	**7,660**	**18%**	**$58,800**

Sources: Washington State Employment Security Department, 2020; Griffith, Calisch, & Laskey, 2020.
Note: The Utility System Construction sector was adjusted to exclude water and sewer system construction and to include custom estimates for pipefitters as indicated through stakeholder

[14] Most current jobs in renewable natural gas (RNG) are not included. King County's RNG facilities, Cedar Hills Landfill and South Treatment Plant, are not captured in this NAICS list. More information about RNG in Washington state can be found at this link.

interviews. There are a total of 2,840 jobs in the Utility System Construction sector, which includes water and sewer system construction, in addition to oil and gas pipeline construction and power and communication system construction. Due to data suppression, a breakout of which jobs are in the water and sewer system and oil and gas pipeline construction subsectors was not available for King County. Statewide, oil and gas pipeline construction and power and communication system construction jobs represent 58% of total employment in the utility system construction sector.

The largest subsector was "Automotive Mechanical and Electrical Repair and Maintenance", with more than 2,500 workers, followed by "Utility System Construction" with 2,050 workers. Average county wages among fossil fuel workers are highest in the electric power generation, transmission and distribution sector, followed closely by the petroleum and coal products manufacturing sector (**Exhibit 2)**.

Exhibit 3. Fossil Fuel Industry Jobs by Occupational Group, King County, 2019

Occupational Group	Fossil Fuel Jobs, 2019	% of King County All Jobs, 2019
Production	1,840	3.2%
Installation, Maintenance, and Repair	1,550	3.7%
Construction and Extraction	1,430	2.5%
Transportation and Material Moving	800	0.9%
Office and Administrative Support	680	0.5%
Business and Financial Operations	380	0.3%
Management	380	0.4%
Sales and Related	250	0.2%
Architecture and Engineering	180	0.5%
Jobs in Other Occupational Groups	170	
	7,660	**0.5%**

Sources: EMSI, 2020; Washington State Employment Security Department, 2020; Griffith, Calisch, & Laskey, 2020; Community Attributes Inc., 2020.

Roughly two thirds of workers in the fossil fuel industry in King County are employed in production, installation, maintenance and repair, and construction and extraction occupations. Installation, maintenance, and repair workers in the fossil fuel industry represent 3.7% of total workers in this occupational group in the County. (**Exhibit 3**)

The leading fossil fuel occupations illustrated in **Exhibit 4** represent 53% of King County's total jobs in the fossil fuel industry. The full list of occupations in the County's fossil fuel industry are shown in **Exhibit 16** in Appendix C. Miscellaneous assemblers and fabricators are the most commonly found occupation in the fossil fuel industry in King County, most of them working

in motor vehicle manufacturing and semiconductor and electronic component manufacturing. Some of the fossil fuel occupations most commonly found among fossil fuel subsectors in the County are ubiquitous and do not require specific fossil fuel related skills, such as office clerks, laborers, and freight, stock, and material movers, or general and operations managers.

Most fossil fuel occupations have a low share of female workers, except office clerks. Laborers and freight, stock, and material movers and construction laborers have the highest share of non-white workers at 39% and 36%, while all other leading fossil fuel occupations have a lower portion of white workers than the County's average population.[15] Most leading fossil fuel occupations, except general and operations managers and plumbers, pipefitters and steamfitters, have a smaller median wage than the County's median wage of $69,000 in 2019[16]. **(Exhibit 4)**

[15] https://www.census.gov/quickfacts/kingcountywashington
[16] Washington State Employment Security Department Median and hourly wages, 2018.

Exhibit 4. Leading Fossil Occupations and Worker Demographics, King County, 2019

Occupational Group	Occupation	Jobs	Median Annual Wage	Share Age 55 and Above	% Female	Share Non-White
Production	Miscellaneous Assemblers and Fabricators	730	$37,669	NA	NA	NA
Construction and Extraction	Construction Laborers	470	$37,336	16%	6%	36%
Installation, Maintenance, and Repair	Automotive Service Technicians and Mechanics	450	$37,708	17%	2%	31%
Construction and Extraction	Plumbers, Pipefitters, and Steamfitters	440	$81,453	NA	NA	NA
Installation, Maintenance, and Repair	Automotive Body and Related Repairers	440	$35,663	20%	2%	28%
Construction and Extraction	Operating Engineers and Other Construction Equipment Operators	230	$60,281	26%	3%	18%
Office and Administrative Support	Office Clerks, General	220	$31,817	26%	83%	33%
Transportation and Material Moving	Laborers and Freight, Stock, and Material Movers, Hand	220	$27,487	15%	19%	39%
Transportation and Material Moving	Heavy and Tractor-Trailer Truck Drivers	210	$39,506	29%	6%	33%
Production	Welders, Cutters, Solderers, and Brazers	180	$42,354	18%	6%	30%
Management	General and Operations Managers	170	$92,185	20%	30%	23%
Transportation and Material Moving	Automotive and Watercraft Service Attendants	160	$28,097	15%	13%	32%
Production	First-Line Supervisors of Production and Operating Workers	160	$55,810	27%	21%	28%
	Jobs in Other Occupations	*4,460*				
	Total Fossil Fuel Jobs	**7,660**				

Sources: EMSI, 2020; Washington State Employment Security Department, 2020; Griffith, Calisch, & Laskey, 2020; Community Attributes Inc., 2020.
Note: Plumbers and pipefitters jobs estimate based on interview feedback and findings.

Businesses and Activities that Depend on Fossil Fuels

Beyond the traditional fossil fuel industry sectors, additional industries in King County depend heavily on fossil fuels for their business activities. The transportation sector uses about 80% of petroleum consumed in Washington state, and the industrial sector uses most of the rest.[17]

Large facilities such as universities and hospitals are also energy intensive as they require fossil fuels for temperature regulation and air flow. Most of these facilities still rely on the electrical grid to power their activities, so are implicitly reliant on fossil fuels and would require a high initial investment to set up the infrastructure needed for transitioning. They also consume more energy per square foot than other buildings in the commercial sector, such as offices and retail stores, and need a reliable source that can meet their high demand.

Other examples of industries that depend on fossil fuels include the automotive repair industries which have many jobs that are trained in the combustion engine and the systems that produce the food supply for powering irrigation pumps, petroleum based pesticides and herbicides, mechanization for both crop production and food processing, fertilizer production and others.

Transportation

Transportation is the largest contributor of greenhouse gas emissions in Washington state and the Seattle region. Transportation activities include on-road gasoline and diesel vehicles, marine vessels, jet fuel and aviation gasoline, railroads, and natural gas used in transportation. In 2017, these activities produced 43.5 million metric tons of carbon dioxide equivalent (CO_2e) in Washington, a measurement which takes into account heat trapping and other impacts of greenhouse gases. That year, transportation activities contributed 44.6% of total state emissions[18] and accounted for nearly one third of end-use energy consumption.[19]

Ground transportation businesses include trucking services, which transfer cargo from businesses to businesses and between other modes of transportation. Trucking companies, as well as individual consumers, purchase fuel at nearly 1,900 gas stations in Washington state. Motor

[17] U.S. Energy Information Agency, "Washington State Profile and Energy Estimates," Link.
[18] Washington State Department of Ecology, "2017 greenhouse gas data," Link.
[19] U.S. Energy Information Agency, "Washington State Profile and Energy Estimates," Link.

gasoline accounts for about 40% of the state's refined petroleum product consumption, and diesel fuel accounts for almost 20%.[20]

Other transportation activities include those related to marine, air, and rail use. In King County, airlines at Seattle-Tacoma International Airport used about 700 million gallons of jet fuel in 2017.[21] Statewide, several large U.S. military installations contribute to the high amount of jet fuel consumption. Washington is also a leader in aircraft manufacturing and other transportation equipment. Across its facilities in Auburn, Kent, Renton, and Seattle, in recent years The Boeing Company has been the third largest contributor of CO_2e emissions in King County, behind Ash Grove Cement Company and Nucor Corporation.[22]

Commercial Buildings

Large indoor spaces are major energy consumers, using electricity and fuels for lighting, refrigeration, ventilation, cooling, space heating, and a variety of equipment uses. Shopping malls, retail stores, car dealerships, and other mercantile and service-providing businesses consume 15% of total energy used nationwide by commercial buildings. This segment is followed by office buildings (which in recent years has consumed 14% of total energy used by commercial buildings), education (10%), healthcare (8%), and lodging (6%).[23]

In King County, the fourth largest contributor of greenhouse gas emissions is the University of Washington. Its main campus in Seattle produces more than 92,000 tons of CO_2e per year.[24] However, the university purchases electricity from Seattle City Light, which sources 84% of its electricity from hydroelectric power,[25] and has undertaken ambitious actions to reduce emission 36% below 2005 levels by 2035.[26] In general, hospitals are also energy-intensive because they are open 24 hours a day with sophisticated heating and ventilation systems to control temperatures and air flow.[27]

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[20] Ibid.
[21] Port of Seattle, "Port of Seattle Announces Partnership for Sustainable Aviation Fuels at Sea-Tac Airport" (May 1, 2018), Link.
[22] Washington State Department of Ecology, "GHG Reporting Program Publication" (Dec. 5, 2019), Link.
[23] U.S. Energy Information Agency, "Use of energy explained: Energy use in commercial buildings" (Sept. 28, 2018), Link.
[24] Washington State Department of Ecology, "GHG Reporting Program Publication" (Dec. 5, 2019), Link.
[25] Seattle City Light, "Power Mix" (2019), Link.
[26] https://green.uw.edu/inform/uw-climate-action-plan
[27] U.S. Energy Information Agency, "Large hospitals tend to be energy-intensive" (Aug. 23, 2012), Link.

Clean Energy Employment and Occupations in King County

The terms clean energy, carbon-free, and zero-carbon are often used interchangeably. Clean energy resources generally have no net greenhouse gas emissions associated with their generation, while some renewable energy resources such as biofuels and large hydroelectric generation[28] are associated with emissions factors. Clean, renewable energy resources can be defined as those that are "not depleted when used," such as solar, wind, and geothermal.[29]

The clean energy industry is comprised primarily of activities that contribute to reducing greenhouse gas emissions by increasing renewable energy production, improving energy efficiency, reducing waste, and conserving natural resources.[30] These activities are broader than traditional energy sectors. As defined by Mark Muro, Adie Tomer, Ranjitha Shivaram, and Joseph Kane of the Brookings Institute, in addition to procurers of clean energy, the clean energy industry covers jobs and firms that manufacture energy-saving products, construct and operate energy-efficient buildings, and provide services that reduce energy consumption, such as by modernizing heating, ventilation, and air conditioning (HVAC) systems.[31]

Decarbonization of buildings and transportation is a major goal of many environmental organizations and states. This process primarily affects equipment and vehicle manufacturing, renewable energy construction, electricity generation and distribution, building electrification, natural gas and petroleum distribution, energy efficiency, and other transportation-related industries. Employment is expected to increase in construction and building trades due to increased demand for electrification, efficiency improvements, building modifications, and equipment installation. Manufacturing, renewable energy, grid infrastructure, and utilities are also expected to experience job growth to support increased electricity sales.

All-electric new construction of buildings could reduce the need for plumbers and pipefitters to extend natural gas lines and connections, and reduced sales of natural gas could decrease the number of utility workers needed to

[28] http://blogs.edf.org/energyexchange/2019/11/15/long-considered-a-clean-energy-source-hydropower-can-actually-be-bad-for-climate/
[29] UCLA Luskin Center for Innovation, *Progress Toward 100% Clean Energy* (Nov. 2019), Link.
[30] The Pew Charitable Trusts, *The Clean Energy Economy* (June 2009), Link.
[31] Mark Muro et al., *Advancing inclusion through Clean Energy Jobs*, The Brookings Institution (April 2019), Link.

install gas lines and support gas distribution.[32] However, the overall impact on the local demand for plumbers could be positive due to the increase in building retrofit work and increasing interest in district energy systems.

Innovative policy approaches can help grow jobs while mitigating and adapting to the climate crisis, such as new building code measures requiring additional piping for water recycling and water reuse for residential, commercial, and public buildings.[33] Updating Seattle's water system overall could provide another avenue for job growth for plumbers and pipefitters, as could renewable-powered district energy systems, also called thermal microgrids, where hot water moving through a network of underground pipes is used to heat and cool buildings, such as Enwave's systems in Seattle.

Clean Energy Industry Definition

The 2019 Brookings report cited above establishes a list of 81 industries that make up the clean energy economy, drawing on the Department of Energy's 2017 U.S. Energy and Employment Report, the UCLA Luskin Center's report on 'Understanding the Green Economy in California,' and the BLS Green Jobs survey. The full list of industries by sector is shown in Appendix A **(Exhibit 14)**.

In defining clean energy jobs, the Brookings report widens the definition of clean energy beyond the traditional energy sector of production, transmission, distribution, and storage by including activities related to environmental management, conservation, and regulation, manufacturing of energy efficient-products, grid component manufacturing and construction, and construction of energy efficient buildings.

For the purposes of this study in differentiating and contrasting fossil fuel and clean energy jobs in King County, this definition is overly broad. Environmental management and regulation are important in meeting environmental goals, but jobs related to these activities would not be directly affected by a citywide transition away from fossil fuels. Additionally, a limited scope of energy-efficient manufacturing is appropriate, considering that several manufacturing industries are not concentrated in Seattle and King County.

In this fossil fuel workforce transition study, the NAICS codes listed below were drawn from the Brookings list of industries to represent core industries

[32] Betony Jones et al., *California Building Decarbonization*, UCLA Luskin Center for Innovation (November 2019), Link.
[33] https://www.sierraclub.org/articles/2019/11/new-study-job-impacts-electrifying-california-s-buildings

in the "clean energy" economy. These industries are primarily engaged in clean energy and are included in the employment estimate in their entirety.

Clean Energy Generation

- 221111: Hydroelectric Power Generation
- 221114: Solar Electric Power Generation
- 221115: Wind Electric Power Generation
- 221116: Geothermal Electric Power Generation
- 221117: Biomass Electric Power Generation
- 221118: Other Electric Power Generation
- 221121: Electric Bulk Power Transmission and Control
- 221122: Electric Power Distribution

Limited Manufacturing and Construction

- 238990: All other specialty trade contractors
- 333413: Industrial and commercial fan and blower and air purification equipment manufacturing
- 333414: Heating equipment (except warm air furnaces) manufacturing
- 333415: Air-conditioning and warm air heating equipment and commercial and industrial
- 334413: Semiconductor and related device manufacturing
- 334512: Automatic environmental control manufacturing for residential, commercial, and appliance
- 334513: Instruments and related products manufacturing for measuring, displaying, and controlling
- 334515: Instrument manufacturing for measuring and testing electricity and electrical signals
- 335311: Power, distribution, and specialty transformer manufacturing
- 335312: Motor and generator manufacturing
- 335911: Storage battery manufacturing
- 335931: Current-carrying wiring device manufacturing
- 335999: All other miscellaneous electrical equipment and component manufacturing
- 336111: Automobile manufacturing
- 336112: Light truck and utility vehicle manufacturing
- 336120: Heavy duty truck manufacturing
- 336211: Motor vehicle body manufacturing
- 336310: Motor vehicle gasoline engine and engine parts manufacturing
- 336320: Motor vehicle electrical and electronic equipment manufacturing
- 336330: Motor vehicle steering and suspension components (except spring) manufacturing
- 336340: Motor vehicle brake system manufacturing

- 336350: Motor vehicle transmission and power train parts manufacturing
- 336360: Motor vehicle seating and interior trim manufacturing
- 336370: Motor vehicle metal stamping
- 336390: Other motor vehicle parts manufacturing.

Additional research was undertaken to identify businesses that are not part of a core industry of the clean energy sector but whose activities are partly clean energy related. A total of 111 businesses were added to the total count of clean energy jobs, based on a custom data request to the Puget Sound Regional Council (included as "Other industries and businesses" in **Exhibit 5** below). Some of these businesses are classified under the NAICS codes listed below that are part of the Brookings report definition, while others were outside the Brookings list of industries (as shown in **Appendix B**).

- 236115: New single-family housing construction (except for-sale builders)
- 236118: Residential remodelers
- 236220: Commercial and institutional building construction
- 237130: Power and communication line and related structures construction
- 238160: Roofing contractors
- 238210: Electrical contractors and other wiring installation contractors
- 238220: Plumbing, heating, and air-conditioning contractors
- 541310: Architectural services
- 541320: Landscape architectural services
- 541620: Environmental consulting services

Employment and Occupations

King County Estimates

In 2019, the clean energy sector in King County employed an estimated 12,400 workers as shown in **Exhibit 5**. The largest subsector was "Specialty Trade Contractors", including firms such as McKinstry that provide building energy efficiency improvement services. This estimate is based on industries determined to be entirely or near entirely engaged in clean energy, such as storage battery manufacturing. It also includes other businesses identified through research that are primarily involved in clean energy-related activities, although the overall industry they are part of is not a core sector of the clean energy economy. Examples include construction firms that fall outside "Specialty Trade Contractors" that provide building energy efficiency services.

Exhibit 5. Clean Energy Jobs by Major Subsector, King County, 2019

Industry	Jobs
Specialty Trade Contractors	3,270
Electric Power Distribution	1,530
Other Electronic Component Manufacturing	1,090
Motor Vehicle and Parts Manufacturing	580
All Other Miscellaneous Electrical Equipment and Component Manufacturing	370
Instruments and Related Products Manufacturing for Measuring, Displaying, and Controlling Industrial Process Variables	350
Electric Bulk Power Transmission and Control	150
Automatic Environmental Control Manufacturing for Residential, Commercial, and Appliance Use	140
Hydroelectric Power Generation	120
Instrument Manufacturing for Measuring and Testing Electricity and Electrical Signals	110
Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing	80
Heating Equipment (except Warm Air Furnaces) Manufacturing	60
Storage Battery Manufacturing	30
Current-Carrying Wiring Device Manufacturing	30
Industrial and Commercial Fan and Blower and Air Purification Equipment Manufacturing	30
Motor and Generator Manufacturing	20
Other industries and businesses	*4,400*
Total	**12,400**

Source: Washington State Employment Security Department, 2020; EMSI, 2020; Community Attributes Inc., 2020.

Just over half of clean energy jobs are in construction and extraction, production, and office and administrative support occupations. Clean energy construction and extraction occupations represent roughly 6% of total jobs in this occupational group in King County (**Exhibit 6**).

The leading clean energy occupations illustrated in **Exhibit 7** represent 44% of King County's total jobs in this industry. The full list of occupations in the County's clean energy industry is shown in Appendix B (**Exhibit 17)**. Construction related occupations such as construction laborers, operating engineers and other construction equipment operators, and first-line supervisors of construction trades and extraction workers are among the most commonly found in the clean energy industry, mostly due to the prevalence of jobs in the specialty trade contractors sector.

Exhibit 6. Occupational Groups within the Clean Energy Industry, King County, 2019

Occupational Group	Clean Energy Jobs, 2019	% of King County All Jobs, 2019
Construction and Extraction	3,310	5.9%
Production	1,920	3.3%
Office and Administrative Support	1,430	1.0%
Business and Financial Operations	1,190	0.9%
Transportation and Material Moving	880	1.0%
Architecture and Engineering	840	2.5%
Management	820	0.9%
Computer and Mathematical	640	0.4%
Installation, Maintenance, and Repair	490	1.2%
Sales and Related	460	0.4%
Jobs in Other Occupational Groups	420	
Total	**12,400**	**0.9%**

Source: Washington State Employment Security Department, 2020; Bureau of Labor Statistics, 2020; Community Attributes Inc., 2020.

Most leading clean energy occupations have a low share of female workers, except customer service representatives (64%), business operations specialists (57%), and management analysts (44%). Laborers and freight, stock, and material movers (40%), electrical engineers (37%), construction laborers (36%), and customer service representatives (36%) have the highest share of non-white workers, while all other clean energy occupations have a lower portion of non-white workers than the County's average population (34%). These occupations, with the exception of electrical engineers, are the lowest paid among the County's leading clean energy industry occupations, comprising roughly 14% of the sector's jobs.

Exhibit 7. Leading Occupations within the Clean Energy Industry, King County, 2019

Occupational Group	Occupation	Jobs, 2019	Median Annual Wage	Share Age 55 and Above	% Female	Share Non-White
Construction and Extraction	Construction Laborers	1,080	$37,336	16%	6%	36%
Production	Miscellaneous Assemblers and Fabricators	770	$37,669	NA	NA	NA
Office and Administrative Support	Customer Service Representatives	490	$30,997	13%	64%	36%
Construction and Extraction	Operating Engineers and Other Construction Equipment Operators	460	$60,281	26%	3%	18%
Construction and Extraction	First-Line Supervisors of Construction Trades and Extraction Workers	360	$71,354	28%	6%	16%
Business and Financial Operations	Business Operations Specialists, All Other	330	$60,786	22%	57%	34%
Construction and Extraction	Paving, Surfacing, and Tamping Equipment Operators	260	$56,633	25%	4%	17%
Transportation and Material Moving	Crane and Tower Operators	260	$61,387	28%	3%	21%
Construction and Extraction	Carpenters	250	$48,348	19%	3%	29%
Computer and Mathematical	Software Developers	230	$140,234	NA	NA	NA
Transportation and Material Moving	Laborers and Freight, Stock, and Material Movers, Hand	210	$27,487	15%	20%	40%
Management	Construction Managers	210	$75,552	28%	12%	14%
Management	General and Operations Managers	210	$92,185	20%	30%	23%
Architecture and Engineering	Electrical Engineers	190	$88,763	28%	9%	37%
Business and Financial Operations	Management Analysts	180	$76,941	28%	44%	29%
	Jobs in Other Occupations	*6,910*				
	Total	**12,400**				

Source: Washington State Employment Security Department, 2020; EMSI, 2020; Community Attributes Inc., 2020.

Support Activities

Businesses in the fossil fuel and clean energy industries both rely on similar professional support activities for various administrative, legal, financial, and businesses services. These occupations are not unique to any one sector, and it is reasonable to assume that workers in these occupations could secure employment in other industries, including the clean energy sector, if displaced from fossil fuels. However, workers who rely on skills specific to fossil fuels such as pipefitters or other construction workers building and maintaining fossil fuel infrastructure are expected to require more resources in such a transition. Transitioning to clean energy jobs, particularly in clean energy production and energy efficiency, requires more knowledge in content areas with a clear scientific component and more technical skills than the average job.[34]

Clean Energy Industry and Occupational Outlook

Clean energy employment has strong potential to increase significantly nationwide as well as in Seattle. The American Council for an Energy-Efficient Economy (ACEEE) estimates that implementing its proposed set of government energy efficiency investments, many using existing federal programs, would create 200,000 U.S. jobs per year from 2021 to 2025, then 60,000 per year through 2030. These investments include expanded tax incentives and increased funding for state and local energy efficiency measures, among others. Investment in green buildings has the highest employment potential, with $35.4 billion in federal incentives for energy upgrades in existing homes and energy efficient new construction expected to create 377,000 jobs nationwide over the next three years. Similarly, $37.3 billion in tax credits for electric vehicles, charging stations, and trucks, as well as incentives for mass transportation projects, could result in 129,000 new jobs in the same timeframe. These investments in labor-intensive projects could boost employment and create energy savings exceeding initial costs, in addition to slowing climate change.[35]

In Washington state, the clean energy industry has experienced rapid growth over recent years. Currently, 55% of the state's clean energy jobs are in the

[34] Mark Muro et al., page 22.[35] American Council for an Energy-Efficient Economy (ACEEE), "Job and Climate Impacts from Energy Efficiency Investments" (August 2020), Link.
[35] American Council for an Energy-Efficient Economy (ACEEE), "Job and Climate Impacts from Energy Efficiency Investments" (August 2020), Link.

Seattle metropolitan area, while Washington's rural areas together rank second in the state for clean energy workers.[36]

The 2019 Clean Energy Transformation Act commits the state to 100% clean energy standards by 2045. The law will phase out coal electricity production by 2025, implement emission reduction targets in 2030, and increase investments in renewable energy sources.[37] These policies are likely to further grow employment in the local clean energy industry primarily in residential and large commercial building retrofits and solar PV construction.

In 2020, however, the COVID-19 pandemic has had a substantial impact on the clean energy industry's workforce. Through October 2020, more than 17,000 clean energy workers remained unemployed, which represents 19% of the sector's total workforce[38]. Most clean energy workers in Washington are employed by firms with fewer than 20 employees. These small businesses are less resistant to financial shocks than larger counterparts and have been disproportionately impacted by the economic slowdown and declining incentives.

Despite these setbacks, federal, state and local clean energy initiatives have the potential to create thousands of jobs. Every $1 million invested in the "Resilient Recovery Portfolio," a group of 14 programs analyzed by Climate Xchange and the Low Carbon Prosperity Institute, would support 10 jobs in Washington state. Jobs in the portfolio have an average wage of $51,400 per year, slightly higher than in the state economy overall.[39]

Other studies also support an optimistic outlook for clean energy in Washington state. Robert Pollin et al. [40] found that clean energy investment in the state can materialize in two ways: expanding the supply of renewable energy; and improving energy efficiency standards of buildings, transportation, and industrial production. A projected $6.6 billion invested in these areas per year over the next 15 years could result in 36,000 to 41,000 annual new jobs in Washington state. These jobs would include occupations in construction, sales, production, engineering, and administrative support, with average annual compensation ranging from $52,000 to $90,000.

Fossil fuel employment would decline by 3.5% per year in this scenario, but that effect would be less than the number of fossil fuel workers already

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[36] *Clean Jobs Washington*, E2 (2019), Link.
[37] Washington Clean Energy Transformation Act (RCW 19.405).
[38] https://e2.org/wp-content/uploads/2020/11/E2-Clean-Jobs-Washington-2020.pdf.
[39] Jonah Kurman-Faber, Kevin Tempest, Ruby Wincele, "Building Back Better" (August 2020), Link.
[40] Robert Pollin, Heidi Garret-Peltier, and Jeannette Wicks-Lim, "A Green New Deal For Washington State" (December 2017), Link.

expected to retire voluntarily. An average of 170 fossil fuel workers are projected to turn 65 in Washington state every year through 2035. All workers in the sector would benefit from $30–$40 million per year in retraining and relocation support[41]. While additional demographics analysis would be needed to project retirement rates of King County's fossil fuel and convenience store workers, this type of investment could provide for a just transition for all of the area's fossil fuel workers.

Outlook by Occupations

Clean energy occupations include the most commonly held positions in identified clean energy firms, along with additional jobs identified as clean energy occupations, e.g., solar photovoltaic installers. **Exhibit 8** details leading clean energy occupations representing at least 1.5% of total workers in clean energy in King County in 2019. Occupational projections are based on the countywide outlook across all sectors published by the Washington State Employment Security Department.

According to this analysis, the most common occupation, construction laborers, are expected to increase by 4.6% by 2028 in King County. Management analysts are expected to increase the most, by 27.8%. Customer service representatives, business operations specialists, electrical engineers, management analysts, and general and operations managers are projected to see local double-digit increases.

While the occupations expected to be more in demand in Seattle's emerging clean energy economy may not directly match those declining in fossil fuel industry, a variety of pathways for positions such as pipefitters and fusers can be explored to map effective transitions. The up skilling of workers through stackable micro credentials[42] and specialized trainings for electricians, sheet metal and HVAC workers, and plumbers and pipefitters can ensure a robust local labor market and continued employment.

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[41] This figure is based on assumptions on the annual costs of providing pension guarantee for workers aged 65 and older, glide path to retirement for workers aged 60 to 64, retraining and 100% wage replacement (2 years), wage insurance after reemployment, capped at $10,000 (4 years) or unemployment benefits with no reemployment for workers under 60. It also assumes that the pattern of employment contraction due to the transition from fossil fuels will entail periods of steady annual job losses which alternate with sporadic periods of larger annual losses.

[42] Micro-credentials are defined as short, competency-based recognition that allows a worker to demonstrate mastery in a particular area. They differ from traditional degrees and certificates in that they are generally offered in shorter or more flexible timespans and tend to be more narrowly focused. Micro-credentials can be offered online, in the classroom, or via a hybrid of both.

Exhibit 8. Leading Clean Energy Industry Occupations by Employment and Projections, King County, 2019-2028

Occupation	2019 Jobs	Growth rate, '19-'28
Construction Laborers	1,080	4.6%
Miscellaneous Assemblers and Fabricators	770	0.0%
Customer Service Representatives	490	14.3%
Operating Engineers and Other Construction Equipment Operators	460	4.3%
First-Line Supervisors of Construction Trades and Extraction Workers	360	5.6%
Business Operations Specialists, All Other	330	12.1%
Paving, Surfacing, and Tamping Equipment Operators	260	3.8%
Crane and Tower Operators	260	3.8%
Carpenters	250	4.0%
Software Developers	230	4.3%
Laborers and Freight, Stock, and Material Movers, Hand	210	9.5%
Construction Managers	210	9.5%
General and Operations Managers	210	19.0%
Electrical Engineers	190	10.5%
Management Analysts	180	27.8%
Jobs in Other Occupations	*6,910*	
Total	**12,400**	

Sources: Washington State Employment Security Department, 2020; Community Attributes Inc., 2020.
Note: The growth rate projections from the Washington State Employment Security Department are based on historical data that was released prior to the production of projections, Therefore, projections will not be affected or include impacts by the COVID-19 pandemic and response efforts. Furthermore, projections mostly likely do not account for potential future policy decisions that may drive the transition from fossil fuels or incentivize clean energy economy growth.

Stakeholder Engagement Findings

This section summarizes the findings from stakeholder interviews regarding prospects and challenges for the future of clean energy industry in King County.

- Stakeholders indicated that state restrictions under COVID-19 have greatly affected the local clean energy industry as well as disadvantaged communities with access to facilities and sites difficult, business postponed, and temporary employee layoffs. Six months into the pandemic the sector was opening back up and recovering, with sales inquiries growing but customers remaining less willing to commit.

- Seattle's clean energy sector is seeing growing interest in solar, energy efficiency, fuel shifting, electrification, energy eco-districts, electric vehicle (EV) charging stations, and battery storage, as well as corporate climate and diversity commitments. Overall Seattle clean energy industry leaders see a strong outlook for job growth even with continued COVID-19 impacts and federal policy uncertainty. If not extended by Congress, federal solar tax credits scheduled to ramp down 12/31/2020 and sunset 12/31/22 could undercut the young industry. The potential for new clean energy friendly recovery programs and policies at federal, state, and local levels in the coming years, such as stimulus funding tied to living wage job creation and funding for basic health care for small businesses, could further strengthen and stabilize the industry.
- Clean energy companies are generally bullish on continued growth in business and employment. Employers cited competitive current renewable prices and the likelihood of future reductions as growth drivers for the industry.
- Non-union clean energy companies have had a hard time hiring electrical engineers due to Seattle's construction boom. The current economic downturn may ease this shortage somewhat, but Washington's relatively strict labor guidelines are likely to extend the demand for licensed electricians.
- Clean energy sector demographics are reported to be changing from older white males to a younger, more diverse workforce. Employers are recognizing the need for different perspectives and acknowledging workers "can't all come from the same mindset" to solve problems effectively. Clean energy employers are becoming more interested in recruiting youth with diverse backgrounds and hiring workers with vocational training rather than 4-year degrees, following Google's lead – those with the right skills don't need full undergraduate degrees.
- Stakeholders note that Seattle utility infrastructure is growing and decentralizing, leading to more successful installations of distributed generation. However, increasing competition from larger California solar installers is seen as a growing threat to local clean energy business owners.
- While COVID-19 is increasing ventilation needs—more fresh air is required which expends more energy—the future of office space needs is a major unknown. Solar installers point out with facility upgrades and conversions underway, placement of HVAC and other equipment on roofs can be consolidated to improve spacing for solar arrays.
- Greening of the transportation sector is another major growth opportunity in the form of quality job creation for marginalized

communities, both with EV charging and biofuel retrofits for large diesel fleets. [43]

WAGES, KNOWLEDGE AND SKILLS ANALYSIS

Broadly, both fossil fuel and clean energy jobs have low entry barriers, with relatively higher educational requirements for clean energy jobs. Most leading occupations in these industries require little to no higher education and few years of on-the-job experience for entry. Additionally, some occupations have direct crossover potential between fossil fuels and clean energy.

Required Education Levels

Exhibit 9 shows the leading clean energy occupations in King County and respective required levels of education. Construction laborers make up the largest clean energy occupation, of which 93% require a high school education or less. Other occupations in the clean energy industry that mostly require a high school diploma or less include laborers and freight, stock, and material movers, paving, surfacing, and tamping equipment operators, and operating engineers and other construction equipment operators.

Roughly 55% of total jobs within leading clean energy occupations require a high school education or less, and 24% require a bachelor's degree or higher. Several clean energy occupations require specialized certificates, including electricians, construction managers, plumbers, HVAC mechanics, and wind turbine service technicians.

An estimated 65% of fossil fuel occupations require a high school education or less, and fewer fossil fuel sector jobs tend to require post-secondary certificates as shown in **Exhibit 10**. Overall, only 3% of jobs within leading fossil fuel occupations require a bachelor's degree or higher.

Required Work Experience

Clean energy and fossil fuel jobs can also be compared by required work experience. While 43% of jobs in leading clean energy occupations require none to less than a year of on-the-job experience, that percentage is higher (53%) for fossil fuel leading occupations. Among leading occupations, there is a greater share of clean energy jobs that require more than four years of work experience. These include construction managers, management analysts, general and operations managers and software developers (**Exhibit 11** and **Exhibit 12**).

[43] Witt, Hays December 2019. "Connecting Disadvantaged Communities to Quality Jobs in the Transportation Electrification Sector: An Initial Assessment." Prepared for the Drive Clean Seattle Program.

Exhibit 9. Leading Clean Energy Occupations by Required Level of Education, King County, 2020

Occupation	Less than a High School Diploma	High School Diploma	Post-Secondary Certificate	Some College Courses	Associate's Degree	Bachelor's Degree or Higher
Construction Laborers	23%	70%	6%	0%	0%	1%
Miscellaneous Assemblers and Fabricators	30%	48%	7%	11%	3%	0%
Customer Service Representatives	3%	34%	2%	7%	6%	48%
Operating Engineers and Other Construction Equipment Operators	13%	67%	18%	2%	0%	0%
First-Line Supervisors of Construction Trades and Extraction Workers	7%	25%	29%	26%	8%	5%
Business Operations Specialists, All Other	1%	17%	12%	6%	7%	57%
Paving, Surfacing, and Tamping Equipment Operators	37%	43%	18%	1%	0%	0%
Crane and Tower Operators	8%	32%	61%	0%	0%	0%
Carpenters	17%	47%	23%	5%	6%	2%
Software Developers	0%	0%	1%	0%	3%	95%
Laborers and Freight, Stock, and Material Movers, Hand	19%	70%	0%	5%	5%	0%
Construction Managers	0%	0%	4%	12%	4%	80%
General and Operations Managers	0%	15%	9%	19%	9%	48%
Electrical Engineers	0%	3%	0%	0%	2%	95%
Management Analysts	0%	0%	0%	0%	0%	100%

Exhibit 10. Leading Fossil Fuel Occupations by Required Level of Education, King County, 2020

Occupation	Less than a High School Diploma	High School Diploma	Post-Secondary Certificate	Some College Courses	Associate's Degree	Bachelor's Degree or Higher
Miscellaneous Assemblers and Fabricators	30%	48%	7%	11%	3%	0%
Construction Laborers	23%	70%	6%	0%	0%	1%
Automotive Service Technicians and Mechanics	7%	35%	51%	4%	4%	0%
Plumbers, Pipefitters, and Steamfitters	10%	34%	52%	2%	2%	0%
Automotive Body and Related Repairers	23%	42%	35%	0%	0%	0%
Operating Engineers and Other Construction Equipment Operators	13%	67%	18%	2%	0%	0%
Office Clerks, General	2%	41%	7%	15%	36%	0%
Laborers and Freight, Stock, and Material Movers, Hand	19%	70%	0%	5%	5%	0%
Heavy and Tractor-Trailer Truck Drivers	19%	56%	15%	5%	1%	5%
Welders, Cutters, Solderers, and Brazers	22%	42%	26%	7%	3%	0%
General and Operations Managers	0%	15%	9%	19%	9%	48%
Automotive and Watercraft Service Attendants	16%	59%	23%	2%	0%	0%
First-Line Supervisors of Production and Operating Workers	3%	44%	9%	14%	6%	24%

*Sources: Washington State Employment Security Department, 2020; O*NET, 2020.*

Exhibit 11. Leading Clean Energy Occupations by Required Work Experience, King County, 2020

Occupation	None	1 year or less	1-4 years	4-10 years	Over 10 years
Construction Laborers	17%	54%	26%	2%	0%
Miscellaneous Assemblers and Fabricators	36%	42%	12%	10%	1%
Customer Service Representatives	3%	27%	51%	18%	0%
Operating Engineers and Other Construction Equipment Operators	6%	20%	54%	12%	9%
First-Line Supervisors of Construction Trades and Extraction Workers	3%	14%	33%	41%	9%
Business Operations Specialists, All Other	9%	10%	46%	28%	7%
Paving, Surfacing, and Tamping Equipment Operators	15%	43%	21%	22%	0%
Crane and Tower Operators	20%	33%	31%	15%	1%
Carpenters	8%	27%	41%	19%	5%
Software Developers	15%	0%	22%	51%	12%
Laborers and Freight, Stock, and Material Movers, Hand	35%	44%	16%	2%	3%
Construction Managers	0%	0%	8%	64%	28%
General and Operations Managers	1%	5%	33%	46%	14%
Electrical Engineers	3%	8%	53%	18%	19%
Management Analysts	0%	0%	35%	54%	12%

Exhibit 12. Leading Fossil Fuel Occupations by Required Work Experience, King County, 2020

Occupation	None	1 year or less	1-4 years	4-10 years	Over 10 years
Miscellaneous Assemblers and Fabricators	36%	42%	12%	10%	1%
Construction Laborers	17%	54%	26%	2%	0%
Automotive Service Technicians and Mechanics	5%	24%	45%	26%	1%
Plumbers, Pipefitters, and Steamfitters	20%	16%	39%	22%	3%
Automotive Body and Related Repairers	41%	29%	12%	13%	5%
Operating Engineers and Other Construction Equipment Operators	6%	20%	54%	12%	9%
Office Clerks, General	8%	39%	50%	3%	0%
Laborers and Freight, Stock, and Material Movers, Hand	35%	44%	16%	2%	3%
Heavy and Tractor-Trailer Truck Drivers	4%	53%	38%	5%	0%
Welders, Cutters, Solderers, and Brazers	13%	31%	35%	15%	5%
General and Operations Managers	1%	5%	33%	46%	14%
Automotive and Watercraft Service Attendants	52%	10%	36%	2%	0%
First-Line Supervisors of Production and Operating Workers	9%	5%	15%	23%	48%

*Sources: Washington State Employment Security Department, 2020; O*NET, 2020.*

Knowledge and Skills Analysis

Fossil fuel jobs likely to be disproportionately affected by the transition to clean energy have significant shares of workers in the fossil fuel industry specifically. **Exhibit 13** shows fossil fuel occupations: 1) with more than 100 fossil fuel jobs, and 2) with a fossil fuel industry dependency of 5% or more. The fossil fuel industry dependency by occupation is expressed as the share of fossil fuel jobs of total King County jobs within an occupation. For example, an estimated 42% of automotive glass installers and repairers in King County work in the fossil fuel industry.

Occupations in **Exhibit 13** are grouped by the fossil fuel subsector with the highest concentration of workers in that occupation. For example, all operating engineers and other construction equipment operators that work in the fossil fuel industry are concentrated in the utility system construction. An estimated 29% of welders, cutters, solders, and brazers in the fossil fuel industry work in utility system construction, while the rest work in several other subsectors including agriculture, construction, and mining machinery manufacturing (24%) and motor vehicle body and trailer manufacturing (17%).

The transition from fossil fuels will impact these occupations differently depending on the transferability of knowledge and skills. Automotive glass installers and repairers and body and related repairers within the automotive mechanical and electrical repair and maintenance subsector, as well as painters of transportation equipment in motor vehicle manufacturing subsector have skills and knowledge that are presumably transferable from ICE vehicles to EVs.

The other occupations in the automotive mechanical and electrical repair and maintenance subsector from **Exhibit 13** such as mechanics and service attendants will require some EV related skills training to transition from working on ICE vehicles to EVs. Automotive service technicians and mechanics have been identified in SJI's study on the electrification of transportation system in Washington state as part of the occupational infrastructure for EV supply chains. According to their study, automotive service technicians and mechanics are expected to grow by 4% between 2019 and 2025.

The fossil fuel and clean energy industries have four leading occupations in common: Construction Laborers; Miscellaneous Assemblers and Fabricators; Operating Engineers and Other Construction Equipment Operators; and General and Operations Managers. These four occupations have direct crossover and transferability, with similar educational and work experience requirements, but still may require deeper investigation to identify any skills specific to each industry.

The analysis of knowledge, skills, and abilities elements between occupations provides a preliminary analysis of the clean energy occupations that may be options for displaced fossil fuels workers. However, this preliminary analysis does not contain the detailed skills and abilities that may be unique to each of these occupations. Additional research and stakeholder feedback are needed to determine a more detailed list of skills required for fossil fuel industry occupations and transferability to the clean energy industry.

O*NET OnLine provides data on knowledge, abilities, and skills required for each occupation, as defined by the Bureau of Labor Statistics Standard Occupational Classification (SOC) code. Each knowledge, ability, and skill element is ranked by both importance and level for each occupation. An analysis of these elements provides a preliminary assessment of transferable occupations based on skills. The knowledge, ability, and skills elements are broad and therefore do not identify some of the detailed and specific skills required for each occupation. Additionally, occupations defined by SOC codes, while allowing for data analysis, are also broad categories often crossing between industries. Stakeholder and interview feedback are important to distinguish the specific attributes of jobs that are unique to a specific industry such as fossil fuels and clean energy, as well as skills that are most transferable between industries.

O*NET also provides a Career Changers matrix to identify related occupations – occupations that make use of similar skills and experience. Workers from one occupation may transfer to a job in a related occupation with minimal additional preparation. This matrix uses an algorithm to identify jobs that would require little additional training for transfer, these are related occupations. According to the Career Changers Matrix Heavy and Tractor-Trailer Truck Drivers, a fossil fuel occupation, is related to the Paving, Surfacing, and Tamping Equipment Operators occupation in the clean energy industry. Additionally, Operating Engineers and Other Construction Equipment Operators has transferability to Crane and Tower Operators, a clean energy occupation.

Exhibit 13. Leading Fossil Fuel Occupations by Share of Jobs in Industry, King County, 2019

Subsector	Occupation	Jobs	Fossil Fuel Industry Dependency	Subsector Job Concentration
Automotive Mechanical and Electrical Repair and Maintenance	Automotive Glass Installers and Repairers	110	42%	100%
	Automotive Body and Related Repairers	440	39%	100%
	Automotive and Watercraft Service Attendants	160	31%	100%
	Automotive Service Technicians and Mechanics	450	13%	99%
	Helpers--Production Workers	110	11%	87%
	Bus and Truck Mechanics and Diesel Engine Specialists	130	6%	96%
	Cost Estimators	130	6%	84%
	% of Jobs in Subsector	*61%*		
Utility system construction	Operating Engineers and Other Construction Equipment Operators	230	10%	100%
	Welders, Cutters, Solderers, and Brazers	180	9%	29%
	Construction Laborers	470	5%	100%
	Plumbers, Pipefitters, and Steamfitters	440	NA	NA
	% of Jobs in Subsector	*64%*		
Motor Vehicle Manufacturing	Painters, Transportation Equipment	140	39%	100%
	Miscellaneous Assemblers and Fabricators	730	8%	57%
	% of Jobs in Subsector	*70%*		
Motor Vehicle Parts Manufacturing	Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic	120	20%	97%
	% of Jobs in Subsector	*32%*		

*Sources: Washington State Employment Security Department, 2020; O*NET, 2020.*

The most common[44] knowledge, abilities, and skills elements identified across the fossil fuel industry (ranked by applicability to both fossil fuel and clean energy occupations) include:

Knowledge Elements

- Customer and Personal Service
- English Language
- Mechanical
- Mathematics
- Public Safety and Security
- Administration and Management
- Building and Construction

Skill Elements

- Active Listening
- Speaking
- Coordination

Abilities Elements

- Information Ordering
- Near Vision
- Oral Comprehension
- Oral Expression
- Problem Sensitivity
- Speech Clarity
- Deductive Reasoning
- Speech Recognition
- Selective Attention
- Written Comprehension

A detailed comparison of knowledge, skills, and abilities between occupations can provide insight into the potential transferability of an occupation. Comparing the unique set of knowledge, skills, and abilities[45] for the three most fossil fuel industry dependent occupations identifies the most likely matches for transfer to clean energy occupations.

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[44] Common indicates more than half of leading fossil fuel occupations receive an importance of 3 or greater out of 5 for knowledge elements and more than 75% receive a score of 3 or greater for skill and abilities elements.

[45] An analysis compares the top 5 ranked elements for each knowledge, skill, and abilities areas between two occupations to identify the percentage match between the two occupations. For example, the Pipefitters occupation has 13 total elements that are in the top 5 for each element area with the Carpenter occupation. Overall, the pipefitter occupation has 5 top knowledge elements, 9 top skills elements, and 6 top abilities elements, for a total of 20 potential elements for comparison. With 13 elements in common, the Carpenter occupation has a 65% match to the Pipefitters occupation.

Below are the three of the most fossil fuel dependent occupations and the clean energy occupations having at least a 50% match in knowledge, skills, and abilities, with the portion of overlap between occupations in each sector shown. Details on the broad knowledge, skill, and abilities elements that match between these occupations can be found in **Appendix D**.

Plumbers, Pipefitters and Steamfitters

- Carpenters (65%)
- Laborers and Freight, Stock, and Material Movers, Hand (60%)
- Construction Laborers (55%)

Welders, Cutters, Solderers, and Brazers

- Miscellaneous Assemblers and Fabricators (88%)
- Carpenters (56%)
- Laborers and Freight, Stock, and Material Movers, Hand (56%)

Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic

- Miscellaneous Assemblers and Fabricators (69%)
- Paving, Surfacing, and Tamping Equipment Operators (56%)
- Laborers and Freight, Stock, and Material Movers, Hand (56%)

WORKFORCE TRANSITION IMPACTS

This chapter of the study includes a summary of feedback and key findings from stakeholder outreach on potential workforce impacts of a transition away from fossil fuels.

Fossil Fuel Industry

Background on Fossil Fuel Stakeholders

Companies, unions, and organizations tied to fossil fuels come from a variety of backgrounds. Some, such as the UA Local 32 Plumbers and Pipefitters, have members who directly work for the region's largest investor-owned utility Puget Sound Energy (PSE) and could be adversely impacted by an end to new natural gas pipelines in Seattle. Others, such as IBEW 46 (electrical workers) are agnostic as to the power and fuel source and may likely see an increase in demand for work associated with electrification and solar installations.

As part of this study, 6 stakeholders were interviewed, and 11 responded to the survey from the fossil fuel industry. Interviewees and survey respondents included Pacific Northwest Carpenters Union, Teamsters, independent truck drivers, Laborers Local Union 242 (10-15% of whose members are involved in building and maintenance of fossil fuel infrastructure), International Union of Operating Engineers, Local 302, Seattle Building Trades Labor Council, as well as businesses such as BP America, Ballard Oil Co., BNSF, Christensen Fuels (a distributor of gasoline and other fuels), Innio (a manufacturer of gas

and renewable fuel engines), heating and oil providers, and representatives of the building trades.

Among the 11 organizations that responded to the online survey conducted for this study, six reported employment in the region of less than 30 workers. Five respondents self-identified as union members, speaking from their own positions and perspectives or on behalf of the local union; two were employees and the remaining four were business owners.

Fossil Fuels Workforce Impacts

Feedback on **workforce impacts** of Seattle's shift away from fossil fuels varied based on the kinds of work each stakeholder is engaged in. Among unions, training to become a journey worker is a long and intensive process, requiring significant monetary and time investment. Workers in some occupations such as the 260 fusers who work on PSE natural gas pipelines and 180 additional workers employed on PSE projects through Infrasource would likely require several years of retraining and might experience a decline in wages as similarly compensated opportunities in the local clean energy industry may not yet exist. Representatives of Laborers Local Union 242 indicated that the elimination of fossil fuel infrastructure in the Seattle region could affect the careers of 500 to 750 members. Their members install the shared gas distribution infrastructure for buildings and install and maintain the main lines of gas and oil coming from the source.

Other occupations, such as electricians represented by IBEW 46, do not anticipate dislocations due to a transition to clean energy—and foresee an increase in local work opportunities—but did share concerns about negative impacts that may be seen by other unionized workers whose skills are not as easily transferable to clean energy work, such as pipefitters or other construction workers building and maintaining the natural gas infrastructure. Similarly, sectors such as rail transport of fossil fuels, do not anticipate a local occupational change since the supply and demand for these products exists in locations distant from the Seattle regional market.

For other firms such as fuel and lubricant distributors, the actual workforce requirements for their operations are not heavily skewed or specific to the production, handling, distribution, or infrastructure tied to fossil fuels. For example, some firms indicated that the majority of their workers are involved in various office tasks and have related skills, such as accounting and administration. These positions require some subject matter understanding of the industry, but the technical skills for these positions are not specific to fossil fuels. Truck drivers transporting flammable materials receive certifications and training and are likely paid a higher wage, but this is viewed as supplemental to their primary skill sets.

The **demand for skills** varies widely across the sector, a reflection of the diverse set of activities captured under "fossil fuels." For example, BP America, which owns and operates a fuel pipeline hub in Renton, Washington, employs workers whose primary tasks involve maintaining key pieces of equipment for the Olympic Pipeline, along with construction coordinators, control center staff, mechanical and civil engineers, administrative staff, and health and safety workers.

Other illustrative fossil fuel occupations include local fuel delivery truck drivers, service technical, sales staff, and installers. At least one family-owned fossil fuel sector firm reported multiple customer service agents and equipment managers.

The opportunity for fossil fuel workers to transition into the clean energy industry, especially into "high-road" jobs[46] that require and appropriately compensate a skilled and trained workforce, will require deliberate policy intervention to support what may otherwise become a stranded subset of the labor market. Job training and transition support for specific occupations may not necessarily be lowest upfront cost for growing the clean energy economy but should help ensure quality work is performed resulting in satisfied customers, accelerated market transformation, and availability of a robust and diverse local skilled workforce.

Recommendations and Other Concerns Expressed

Most of the concerns raised among fossil fuel stakeholders focused on the disruption to existing work and the need for a more thorough understanding of the economic costs borne by these workers. Specific comments included:

- *We need to have a plan that helps transition the work force that will see their fossil fuel jobs disappear. We need to make sure that all workers are placed in an appropriate union, based on the work that they associate with. This also means making sure that the work force gets proper evaluations that will place them at an appropriate wage rate no less than the wage rate they are currently working under.*
- *To transition away completely from fossil fuels would be reckless without a complete study of the impact and costs to the region. We know that the technology around the use of fossil fuels has allowed the consumption and emissions numbers to decline per person. Things to consider include the strain on our electrical infrastructure and the cost to upgrade that; the reliance on one form of energy to power our grid;*

[46] High-road jobs are defined as jobs in sectors in which firms compete on the basis of skill, experience, and qualifications and worker pay tends to increase with training and experience.

the retraining of the employees whose careers are affected to give them a just transition.

- *Need to balance CAPEX, reliability, OPEX, and have a reasonable timeline to accommodate cost effective solutions. Conservation with existing infrastructure and resources should be the first step as it is always the most cost effective.*
- *A lot more discussion and analysis are required before engaging in legislation. Also, mindfulness that your laws affect only those within your jurisdiction and a macro/statewide level analysis is more appropriate than a regional change that folks can simply cross the city line to avoid.*

Clean Energy Industry

Background on Clean Energy Stakeholders

Seattle's clean energy sector has strong representation in clean buildings, solar, electric vehicles, and related renewable energy and energy efficiency technologies. Key stakeholders interviewed or surveyed for this study include A&R Solar, Ameresco, Artisan Electric, DNV GL, Cascadia Consulting Group, E8, FlexCharging, Green Project Solutions Group, Janicki Industries, Johnson Controls, MacDonald Miller, McKinstry, OneEnergy Renewables, Puget Sound Solar, Sazan Environmental Services, Spark Northwest, Sphere Solar, Sun Path Electric, Sustainable Seattle, Sweek Consulting Engineers, Verde Energy, and several additional clean energy consultants.

Half of the survey respondents that self-identified with the clean energy sector have less than 10 employees, and another four have between 10 and 50 employees. Roughly 47% of survey respondents categorized themselves as business owners and 38% as employees.

Clean Energy Workforce Impacts

Clean energy firms are facing aggressive **competition for diverse talent** due to a "people war" in Seattle area, with shortages especially network/IT-centric and certified electricians. Some have even been offering signing bonuses to attract qualified employees. Retaining good workers and key management professionals is also challenging as the tech industry can pay 40% higher salaries than the clean energy industry.

Other **in-demand jobs** are for electrical engineers and clean energy specialists such as heat pump technicians and efficiency upgrades experts. Firms also expressed a desire for more policy experts for navigating local regulations, and consultants want more expertise in econometrics, carbon accounting, and lifecycle cost assessments.

Local clean energy businesses also face a **growing need** for electricians as well as plumbers and pipefitters – with water-related systems in high

demand – in addition to service mechanics, design and commissioning engineers, data analysts, and technical sales representatives.

Many clean energy business leaders expressed a desire to interest high school students in non-college career pathways in trades. With many openings and an aging workforce retiring, clean energy construction and operations related jobs provide good compensation and benefits and are an appealing career choice with long-term potential for advancement.

With the region's relatively low energy costs, clean energy requires long term investment commitments which take time to secure. While many workforce issues faced by Seattle's clean energy sector will need to be solved at the state and federal levels, stakeholders urged the City to leverage its green image and provide greater leadership to advance broad solutions.

Recommendations and Other Concerns Expressed

Seattle's clean energy leaders cited high regulatory uncertainty, including local zoning/permitting delays, inspections and interconnection challenges, and rollbacks of incentives, as well as unknowns related to grid capacity and control equipment costs (such as zero export relays) as **ongoing business challenges**. Customer acquisition costs and increasing costs to convert inquiries plus worsening revenue and debt challenges, as well as operational pressures with decreasing budgets are impacting profitability. Ensuring a stable, responsible pace of business growth has also been difficult with the area's volatile boom and bust market related both to changing incentives as well as shifts in the local economy.

Seattle clean energy business leaders also stressed the importance of increasing public-private partnerships (P3) to finance infrastructure projects. The SODO area, for example, has an ideal commercial/industrial/residential mix ripe for district energy development. Clean energy sector firms are also seeking pro-decarbonization tax and regulatory policies at the city level.

Specific feedback from clean energy stakeholders included:

- *Clean energy is becoming more and more affordable relative to other energy sources, and when the true costs to the environment are considered, are likely more affordable. This makes the decision to move to renewables that much easier.*
- *Education matters. Get current professionals into schools to familiarize students with options in the skilled trades. We are _really_ short on clean energy technicians who are fully trained to install and operate clean energy.*
- *To achieve transition away from fossil fuels in Seattle will require huge focus on decarbonizing single family residential sector. This will need*

incentives. Legal changes are needed to eliminate barriers to Seattle City Light funding of electrification – or the City of Seattle can fund it directly and recoup some revenue with carbon reduction fees on electrical bills. Training opportunities for heat pump installers with focus on under-represented groups in the trades.

- *Grid level transition efforts on the whole, make it easier for companies to transition, rather than requiring separate, individual incorporation by individual companies at the per meter level. Tax incentives might also make it easier for companies to institute internal efficiency upgrades and investments.*

SUMMARY AND RECOMMENDATIONS

Local policy support for a just energy transition should aim to expand opportunities that offer family-sustaining wages, benefits, and job security for workers. Utilities and local government exert the most influence on the clean energy labor market in procuring services through demand-side strategies. By establishing procurement priorities and workforce standards, agencies set the bar for costs, compensation, and the level of skill and training of workers, particularly in emerging industries such as clean energy.

With deliberate effort the City of Seattle, King County, and Washington State can support "high-road" workforce development, or else run the risk of inadvertently driving a low-wage workforce and gig economy and furthering the urban/rural divide. For example, concerns about project costs often lead to decision makers seeking ways to reduce soft costs, especially for labor and "high" labor rates in cities such as through off-site pre-fabrication or financing large solar farms in distant rural areas. Driving down costs by reducing labor costs has direct negative consequences for skilled workers in the local construction market and may actually slow market adoption. And reducing compensation for labor has high costs for society, for individual workers, and for businesses that train and employ skilled workers.[47]

Recommendations

The recommendations identified by this study are informed by data analysis, secondary research, and stakeholder engagement. They are grouped into three categories: (1) policies to prioritize demand-side clean energy strategies; (2) affected workforce and stakeholder engagement; and (3) business expansion support targeting clean energy supply-side strategies. Investments to decarbonize Seattle's buildings and transportation sector will need to target both building construction activity to install new circuits,

[47] Jacobs, K, I. E. Perry, and J. MacGillvary. (2015). The High Public Cost of Low Wages. UC Berkeley Labor Center. http://laborcenter.berkeley. edu/the-high-public-cost-of-low-wages/

charging stations, plumbing and pressurized pipes for district energy, ductwork, and appliances as well as construction work to expand clean electricity generation capacity to meet new electric demands. Seattle City Light and City Council are well positioned to model innovative, high-road programs and serve as local leaders for the state and nation.

1. Policies to Prioritize Demand-Side Clean Energy Strategies

Demand-side interventions to support high-road local employment, in which firms compete on the basis of skill, experience, and qualifications and worker pay tends to increase with training and experience, include aggregating smaller projects, and establishing workforce standards for programs and policies. Seattle should:

- **Invest in decarbonized district energy.** Expanding new clean district energy system infrastructure with public subsidies and financing can provide carbon-free pathways to create and sustain good jobs for Seattle's gas workers, plumbers, and pipefitters as well as a new line of business.[48] District energy systems can be powered by a wide array of renewable energy sources, reducing reliance on the electric grid, and their use could be expanded beyond current applications to new residential developments, redevelopment zones, campuses, business parks, and whole neighborhoods. Utility-owned and operated district energy systems in Seattle could provide ongoing jobs for King County's current gas utility workers already trained and qualified to work on networks of pressurized pipes.
- **Pursue aggregated community-scale decarbonization.** Requiring solar or net zero energy for all new construction and targeting electrification projects in neighborhoods in need of upgrades are smart ways to "prune" the natural gas distribution system and minimize future stranded assets. Aggregating or bundling small commercial and residential projects through policies such as virtual net metering, community subscriptions, and Solarize bulk buys can improve the economies of scale, reduce contractor marketing expenses, accelerate market adoption, and enforce skill standards to enhance both the quality of the work performed and the quality of jobs for workers. Geographic pilots and funding for underserved areas should adopt and enforce prevailing wage and targeted hire standards in order to improve job quality and access for disadvantaged workers.
- **Offer incentives and accelerated permitting/interconnection for projects that meet clean energy workforce criteria.**

[48] Like the gas system, district energy systems rely on underground networks of pipes, but instead of moving gas, they move hot water to provide heating and cooling directly to buildings. Jones et al., 2019.

Condition utility rebates and incentives on skill standards and responsible contractor criteria to retain high performing contractors, ensure work quality, and prevent low wages. HVAC and technical skill standards should be applied to decarbonization policies and programs, including building code compliance and EV infrastructure. Subsidies, low-interest loans, streamlined permitting, prompt meter installations, and simplified interconnection for customer purchases such as residential rebates for solar, heat pumps, battery backups, flexible loads, remote/automated controls, and off-peak EV chargers can leverage greater private investments to add generation and storage to the grid and smooth the transition. Ideally, this would promote North American Board of Certified Energy Practitioners (NABCEP) certified contractors and those with other validated national credentials, and eventually be coordinated at the statewide level, but Seattle can lead the way by implementing a contractor vetting process and publishing lists of experienced, qualified local companies. In addition, more effective enforcement of refrigerant handler licenses and other certifications can reduce spills and leaks of high global warming potential agents.

- **Extend efforts to reach underrepresented workers.** The clean energy sector lacks both gender and racial diversity in most occupations. This signals a continued lack of visibility and outreach among certain underserved jobseekers to these skilled trades and a need to ensure clear career pipelines and opportunities to market to all prospective workers. Efforts to reach underrepresented workers will be essential to ensure a pool of talent for the clean energy industry. This could include early involvement in STEM, apprenticeships focused on inclusivity, and local partnerships with community groups, neighborhood centers and organizations to help in recruiting diverse candidates.

2. Affected Workforce and Stakeholder Engagement

Providing opportunities for impacted communities and businesses to drive and co-lead efforts to grow good jobs and minimize job loss are essential to a just energy transition. Seattle should:

- **Create conditions to build skilled workforce from local talent pools.** The City can serve as a broker to engage local building trades councils and labor management committees to identify where goals align. Electrification of buildings and transportation is complex work requiring skilled and trained professionals across a range of occupations. Building trade unions and their signatory contractors already co-invest in the best-in-class trainings for construction professionals: apprenticeships. Working with apprenticeship coordinators to ensure training curriculums cover electrification work,

smart HVAC controls and operation, and other relevant clean energy technology topics presents a solid path to developing a skilled and trained local clean energy workforce drawing from displaced and available talent. Ensuring work opportunities for apprenticeship-trained workers ensures those skills and knowledge will be deployed in real-world environments.

- **Plan an orderly transition.** Engage labor, ratepayer advocates, utility policy leaders, and other stakeholders and experts in a committed, long-term planning process to shift Seattle from fossil fuels in a way that is safe, economical, and minimizes worker displacement. This should include determining specific career roadmaps for the most impacted occupations. Increasing paid internship and pre-apprenticeship opportunities for both youth and adults in a variety of clean energy related tasks such as customer service and district heating system construction can help open tangible pathways for continued employment and highlight the vibrant clean energy industry to grow a high-quality workforce pipeline.
- **Develop a fund for fossil fuel worker retention and transition assistance.** Worker transition assistance should include bridges to retirement for older workers and wage/benefits replacement, retraining, and job placement assistance for younger workers. A variety of career pathways for displaced fossil fuel workers to retain employment in the clean energy economy will need to be established and supported, and mechanisms for union workers to keep their ranked pensions explored. In addition, as Seattle's fossil fuel industry contracts, retaining a skilled and trained workforce to ensure safety and reliability of the remaining infrastructure is critical.

3. Business Expansion Support Targeting Clean Energy Supply-Side Strategies

Much more than a set of training programs and activities, successful workforce development requires trainings to be calibrated to market demand. Creating stand-alone training programs or over-investing in training aspects can lead to negative results, such as flooding the local labor market with more workers than there are jobs, suppressing wages, and diluting workforce skills. Thoughtfully targeted training interventions can ensure positive outcomes and more effectively support clean energy goals. Seattle should:

- **Support the up skilling of workers through stackable micro credentials.** While workforce training is needed to support quality work, specialized training should be used in addition to, not instead of, broad occupational training. Analysis and stakeholder outreach has surfaced that some of the trades most needed for Seattle's clean

energy transition are electricians, sheet metal and HVAC workers, and plumbers and pipefitters. Fossil fuel transition training will be most effective if it is targeted to workers with licenses in these trades rather than to general contractors or other market actors. Key jobs tasks for NABCEP clean energy credentials include: Energy Auditors, PV Technical Sales, PV Installation Professionals, Retrofit Installer Technicians, Quality Control Inspectors, Crew Leaders, and Small Wind Installers. Programs such as Northwest Energy Efficiency Council's Building Operator certification,[49] the Kent-based HVAC Business and Technical Institute,[50] Washington's Eligible Training Provider (ETP)-approved education providers listed in the Washington Career Bridge,[51] and stackable micro credentials advocated by the Interstate Renewable Energy Council[52] will likely be most effective. Seattle OED and City Light can play a useful role in marketing such courses and training opportunities particularly to women and underrepresented communities.

- **Create opportunities for disadvantaged workers with difficulties entering the labor market without assistance.** The City can play an important role in supporting high-road construction careers and developing high-road training partnerships for manufacturing and other skills needed for the clean energy transition to improve job access for disadvantaged workers and support their career development with strategically placed stimulus-funded projects and matching funds to grow public-private partnership opportunities, including sustainable financial support for energy audits and comprehensive weatherization upgrades. Stimulus funding tied to living wage job creation, funding for basic health care for small businesses, and recruitment efforts aimed to engage youth and other workers with diverse backgrounds can help stabilize and strengthen Seattle's clean energy sector. Community-based organizations are well-positioned to serve the specific needs of individuals in their communities. When these frontline training organizations have formal agreements with employers, agencies, and apprenticeship programs, better job training and placement outcomes are achieved. Forging stronger partnerships between different facets of the workforce

[49] Curriculum include Energy Efficient Operation of Building HVAC Systems, Measuring and Benchmarking Energy Performance, Efficient Lighting Fundamentals, HVAC Controls Fundamentals, Common Opportunities for Low-Cost Operational Improvement, Facility Electrical Systems, and Operations & Maintenance Practices for Sustainable Buildings. https://www.theboc.info/
[50] https://www.hvacinstitute.com/
[51] https://irecusa.org/2019/04/making-the-business-case-for-micro-credentials/
[52] https://irecusa.org/2019/04/making-the-business-case-for-micro-credentials/

development and support system is key to improving outcomes for disadvantaged workers.

Pursuing a high-road path to clean energy economy can help fulfill Seattle's commitment to broadly shared prosperity in a just, low-carbon future. Important issues to be investigated with further research and stakeholder engagement include how training delivery can be orchestrated and designed in ways that meet both the needs of the talent pool and the local clean energy industry's labor demand; what steps can be taken to ensure that Seattle clean energy jobs created are family-wage; and how else the City can advance opportunities toward an equitable green economy.

A valuable next step could be to develop a tailored Seattle clean energy career map covering a broad range of fossil fuel industry and clean energy-related jobs as well as sector-specific trainings to support specific pathways, such as connecting pipefitters with opportunities for new occupations. Seattle's long history of climate leadership, utility innovation and work advancing race and social justice positions the City well for rapid advancement of an equitable transition to clean energy. Investments in retraining and relocation support as well as clean energy business expansion support are critical in providing for a just transition for Seattle's fossil fuel workforce.

APPENDIX A. BROOKINGS CLEAN ENERGY INDUSTRIES

Exhibit 14. Industries in the Clean Energy Economy by Sector

Brookings Sector	NAICS	Industry Description	Included in this study
Generation utilities	221111	Hydroelectric power generation	Y
Generation utilities	221113	Nuclear electric power generation	
Generation utilities	221114	Solar electric power generation	Y
Generation utilities	221115	Wind electric power generation	Y
Generation utilities	221116	Geothermal electric power generation	Y
Generation utilities	221117	Biomass electric power generation	Y
Generation utilities	221118	Other electric power generation	Y
Generation utilities	221121	Electric bulk power transmission and control	Y
Generation utilities	221122	Electric power distribution	Y
Generation utilities	221330	Steam and air-conditioning supply	
Grid component manufacturing and construction	332410	Power boiler and heat exchanger manufacturing	
Grid component manufacturing and construction	333611	Turbine and turbine generator set units manufacturing	
Grid component manufacturing and construction	335311	Power, distribution, and specialty transformer manufacturing	Y
Grid component manufacturing and construction	335911	Storage battery manufacturing	Y
Grid component manufacturing and construction	335931	Current-carrying wiring device manufacturing	Y
Grid component manufacturing and construction	237130	Power and communication line and related structures construction	Y (Custom PSRC Request)
Grid component manufacturing and construction	237990	Other heavy and civil engineering construction	
Grid component manufacturing and construction	238210	Electrical contractors and other wiring installation contractors	Y (Custom PSRC Request)
Manufacturing of energy-efficient products	327993	Mineral wool manufacturing	
Manufacturing of energy-efficient products	332321	Metal window and door manufacturing	
Manufacturing of energy-efficient products	332322	Sheet metal work manufacturing	
Manufacturing of energy-efficient products	333415	Air-conditioning and warm air heating equipment and commercial and industrial	Y
Manufacturing of energy-efficient products	336111	Automobile manufacturing	Y
Manufacturing of energy-efficient products	336112	Light truck and utility vehicle manufacturing	Y
Manufacturing of energy-efficient products	336120	Heavy duty truck manufacturing	Y
Manufacturing of energy-efficient products	336211	Motor vehicle body manufacturing	Y
Manufacturing of energy-efficient products	336310	Motor vehicle gasoline engine and engine parts manufacturing	Y
Manufacturing of energy-efficient products	336320	Motor vehicle electrical and electronic equipment manufacturing	Y
Manufacturing of energy-efficient products	336330	Motor vehicle steering and suspension components (except spring) manufacturing	Y
Manufacturing of energy-efficient products	336340	Motor vehicle brake system manufacturing	Y
Manufacturing of energy-efficient products	336350	Motor vehicle transmission and power train parts manufacturing	Y
Manufacturing of energy-efficient products	336360	Motor vehicle seating and interior trim manufacturing	Y
Manufacturing of energy-efficient products	336370	Motor vehicle metal stamping	Y
Manufacturing of energy-efficient products	336390	Other motor vehicle parts manufacturing	Y
Manufacturing of energy-efficient products	334512	Automatic environmental control manufacturing for residential, commercial, and appliance	Y
Manufacturing of energy-efficient products	334513	Instruments and related products manufacturing for measuring, displaying, and controlling	Y
Manufacturing of energy-efficient products	334515	Instrument manufacturing for measuring and testing electricity and electrical signals	Y
Manufacturing of energy-efficient products	336510	Railroad rolling stock manufacturing	
Manufacturing of energy-efficient products	335110	Electric lamp bulb and part manufacturing	
Manufacturing of energy-efficient products	335121	Residential electric lighting fixture manufacturing	

Exhibit 14. Industries in the Clean Energy Economy by Sector continued

Brookings Sector	NAICS	Industry Description	Included in this study
Manufacturing of energy-efficient products	335122	Commercial, industrial, and institutional electric lighting fixture manufacturing	
Manufacturing of energy-efficient products	335210	Small electrical appliance manufacturing	
Manufacturing of energy-efficient products	335221	Household cooking appliance manufacturing	
Manufacturing of energy-efficient products	335222	Household refrigerator and home freezer manufacturing	
Manufacturing of energy-efficient products	333413	Industrial and commercial fan and blower and air purification equipment manufacturing	Y
Manufacturing of energy-efficient products	333414	Heating equipment (except warm air furnaces) manufacturing	Y
Manufacturing of energy-efficient products	334413	Semiconductor and related device manufacturing	Y
Manufacturing of energy-efficient products	335312	Motor and generator manufacturing	Y
Manufacturing of energy-efficient products	335999	All other miscellaneous electrical equipment and component manufacturing	Y
Construction of energy efficient buildings & provision of energy efficiency services	236115	New single-family housing construction (except for-sale builders)	Y (Custom PSRC Request)
Construction of energy efficient buildings & provision of energy efficiency services	236116	New multifamily housing construction (except for-sale builders)	
Construction of energy efficient buildings & provision of energy efficiency services	236117	New housing for-sale builders	
Construction of energy efficient buildings & provision of energy efficiency services	236118	Residential remodelers	Y (Custom PSRC Request)
Construction of energy efficient buildings & provision of energy efficiency services	236210	Industrial building construction	
Construction of energy efficient buildings & provision of energy efficiency services	236220	Commercial and institutional building construction	Y (Custom PSRC Request)
Construction of energy efficient buildings & provision of energy efficiency services	237210	Land subdivision	
Construction of energy efficient buildings & provision of energy efficiency services	238350	Finish carpentry contractors	
Construction of energy efficient buildings & provision of energy efficiency services	238220	Plumbing, heating, and air-conditioning contractors	Y (Custom PSRC Request)
Construction of energy efficient buildings & provision of energy efficiency services	238160	Roofing contractors	Y (Custom PSRC Request)
Construction of energy efficient buildings & provision of energy efficiency services	238990	All other specialty trade contractors	Y
Construction of energy efficient buildings & provision of energy efficiency services	541310	Architectural services	Y (Custom PSRC Request)
Construction of energy efficient buildings & provision of energy efficiency services	541340	Drafting services	
Construction of energy efficient buildings & provision of energy efficiency services	541320	Landscape architectural services	Y (Custom PSRC Request)
Construction of energy efficient buildings & provision of energy efficiency services	541350	Building inspection services	
Environmental management, conservation and regulation	541620	Environmental consulting services	Y (Custom PSRC Request)
Environmental management, conservation and regulation	562111	Solid waste collection	
Environmental management, conservation and regulation	562112	Hazardous waste collection	
Environmental management, conservation and regulation	562119	Other waste collection	
Environmental management, conservation and regulation	562211	Hazardous waste treatment and disposal	
Environmental management, conservation and regulation	562212	Solid waste landfill	
Environmental management, conservation and regulation	562213	Solid waste combustors and incinerators	
Environmental management, conservation and regulation	562219	Other nonhazardous waste treatment and disposal	
Environmental management, conservation and regulation	562910	Remediation services	
Environmental management, conservation and regulation	562920	Materials recovery facilities	
Environmental management, conservation and regulation	562998	All other miscellaneous waste management services	
Environmental management, conservation and regulation	813312	Environment, conservation and wildlife organizations	
Environmental management, conservation and regulation	924110	Administration of air and water resource and solid waste management programs	
Environmental management, conservation and regulation	924120	Administration of conservation programs	
Environmental management, conservation and regulation	925120	Administration of urban planning and community and rural development	
Environmental management, conservation and regulation	926120	Regulation and administration of transportation programs	
Environmental management, conservation and regulation	926130	Regulation and administration of communications, electric, gas, and other utilities	

Sources: Mark Muro et al., Advancing inclusion through Clean Energy Jobs, The Brookings Institution (April 2019).

APPENDIX B. CLEAN ENERGY RELATED INDUSTRIES

Exhibit 15. Companies in Clean Energy Related Industries (outside the Brookings NAICS list)

NAICS	Description	# of Firms
541330	Engineering Services	9
541110	Offices of Lawyers	5
541715	Research and Development in the Physical, Engineering, and Life Sciences (except Nanotechnology and Biotechnology)	5
541611	Administrative Management and General Management Consulting Services	4
541690	Other Scientific and Technical Consulting Services	4
541519	Other Computer Related Services	3
541990	All Other Professional, Scientific, and Technical Services	3
541511	Custom Computer Programming Services	2
813410	Civic and Social Organizations	2
237120	Oil and Gas Pipeline and Related Structures Construction	1
325611	Soap and Other Detergent Manufacturing	1
332710	Machine Shops	1
333923	Overhead Traveling Crane, Hoist, and Monorail System Manufacturing	1
336991	Motorcycle, Bicycle, and Parts Manufacturing	1
423610	Electrical Apparatus and Equipment, Wiring Supplies, and Related Equipment Merchant Wholesalers	1
423620	Household Appliances, Electric Housewares, and Consumer Electronics Merchant Wholesalers	1
423690	Other Electronic Parts and Equipment Merchant Wholesalers	1
423710	Hardware Merchant Wholesalers	1
423720	Plumbing and Heating Equipment and Supplies (Hydronics) Merchant Wholesalers	1
423730	Warm Air Heating and Air-Conditioning Equipment and Supplies Merchant Wholesalers	1
423810	Construction and Mining (except Oil Well) Machinery and Equipment Merchant Wholesalers	1
423830	Industrial Machinery and Equipment Merchant Wholesalers	1
511120	Periodical Publishers	1
511210	Software Publishers	1
522130	Credit Unions	1
523999	Miscellaneous Financial Investment Activities	1
541370	Surveying and Mapping (except Geophysical) Services	1
541380	Testing Laboratories	1
541410	Interior Design Services	1
541512	Computer Systems Design Services	1
541613	Marketing Consulting Services	1
541614	Process, Physical Distribution, and Logistics Consulting Services	1
541618	Other Management Consulting Services	1
561499	All Other Business Support Services	1
561621	Security Systems Services (except Locksmiths)	1
561990	All Other Support Services	1
611310	Colleges, Universities, and Professional Schools	1
611430	Professional and Management Development Training	1
813219	Other Grantmaking and Giving Services	1
	Total	**67**

Sources: Community Attributes Inc., 2020.

APPENDIX C. FULL LIST OF FOSSIL FUEL AND CLEAN ENERGY OCCUPATIONS

The list of fossil fuels and clean energy occupations was developed using the Washington State Employment Security Department occupation-to-industry matrix for King County, which provides the shares of occupations for each industry. The matrix is available only at the 4-digit NAICS level, while the fossil fuels and clean energy industry definitions include some subsectors at the 5- or 6-digit NAICS level. Due to this data limitation, the full list of fossil fuels and clean energy occupations may include some occupations that are outside these industries.

Exhibit 16. Fossil Fuel Occupations, King County

SOC Code	Occupation	Jobs, 2019
51-2090	Miscellaneous Assemblers and Fabricators	726
47-2061	Construction Laborers	467
49-3023	Automotive Service Technicians and Mechanics	452
47-2152	Plumbers, Pipefitters, and Steamfitters	440
49-3021	Automotive Body and Related Repairers	437
47-2073	Operating Engineers and Other Construction Equipment Operators	225
43-9061	Office Clerks, General	225
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	217
53-3032	Heavy and Tractor-Trailer Truck Drivers	215
51-4121	Welders, Cutters, Solderers, and Brazers	177
11-1021	General and Operations Managers	172
53-6031	Automotive and Watercraft Service Attendants	162
51-1011	First-Line Supervisors of Production and Operating Workers	162
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	149
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	143
51-9122	Painters, Transportation Equipment	139
53-1049	First-Line Supervisors of Transportation Workers, All Other	132
49-3031	Bus and Truck Mechanics and Diesel Engine Specialists	128
13-1051	Cost Estimators	128
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	120
51-4041	Machinists	119
51-4081	Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic	119
51-9198	Helpers--Production Workers	113
49-3022	Automotive Glass Installers and Repairers	113
41-2021	Counter and Rental Clerks	100
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	96
43-4051	Customer Service Representatives	95
49-2096	Electronic Equipment Installers and Repairers, Motor Vehicles	91
13-1199	Business Operations Specialists, All Other	86
43-3031	Bookkeeping, Accounting, and Auditing Clerks	77
43-5061	Production, Planning, and Expediting Clerks	73
43-6014	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	73
11-9021	Construction Managers	69
33-9091	Crossing Guards	66
13-2011	Accountants and Auditors	66
17-2112	Industrial Engineers	63

Exhibit 16. Fossil Fuel Occupations continued

SOC Code	Occupation	Jobs, 2019
13-1020	Buyers and Purchasing Agents	61
49-9041	Industrial Machinery Mechanics	52
47-2151	Pipelayers	49
49-9052	Telecommunications Line Installers and Repairers	45
17-2141	Mechanical Engineers	44
51-4011	Computer-Controlled Machine Tool Operators, Metal and Plastic	42
51-9141	Semiconductor Processors	40
43-1011	First-Line Supervisors of Office and Administrative Support Workers	39
53-7065	Stockers and Order Fillers	38
11-9199	Managers, All Other	36
47-2031	Carpenters	36
11-3051	Industrial Production Managers	34
43-3021	Billing and Posting Clerks	34
49-9098	Helpers--Installation, Maintenance, and Repair Workers	30
47-2111	Electricians	28
41-2011	Cashiers	27
51-2041	Structural Metal Fabricators and Fitters	26
43-5071	Shipping, Receiving, and Traffic Clerks	25
49-9071	Maintenance and Repair Workers, General	23
47-2051	Cement Masons and Concrete Finishers	23
11-3031	Financial Managers	19
49-9051	Electrical Power-Line Installers and Repairers	19
53-3033	Light Truck or Delivery Services Drivers	18
15-1232	Computer User Support Specialists	17
13-1071	Human Resources Specialists	16
17-2051	Civil Engineers	16
43-4171	Receptionists and Information Clerks	16
37-2011	Janitors and Cleaners, Except Maids and Housekeeping Cleaners	15
51-6093	Upholsterers	14
43-5032	Dispatchers, Except Police, Fire, and Ambulance	14
11-9041	Architectural and Engineering Managers	13
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	12
51-9111	Packaging and Filling Machine Operators and Tenders	12
17-3013	Mechanical Drafters	12
11-2022	Sales Managers	11
13-1161	Market Research Analysts and Marketing Specialists	11
47-5022	Excavating and Loading Machine and Dragline Operators, Surface Mining	11
17-3012	Electrical and Electronics Drafters	11
53-1044	First-Line Supervisors of Passenger Attendants	10
11-3010	Administrative Services Managers	10
11-3121	Human Resources Managers	10

Sources: EMSI, 2020; Washington State Employment Security Department, 2020; Griffith, Calisch, & Laskey, 2020; Community Attributes Inc., 2020.
Note: Plumbers and pipefitters jobs estimate based on interview feedback and findings

Exhibit 17. Clean Energy Occupations (with more than 10 jobs), King County

SOC Code	Occupation	Jobs, 2019
47-2061	Construction Laborers	1,085
51-2090	Miscellaneous Assemblers and Fabricators	768
43-4051	Customer Service Representatives	495
47-2073	Operating Engineers and Other Construction Equipment Operators	462
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	360
13-1199	Business Operations Specialists, All Other	326
47-2071	Paving, Surfacing, and Tamping Equipment Operators	264
53-7021	Crane and Tower Operators	263
47-2031	Carpenters	254
15-1252	Software Developers	227
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	209
11-9021	Construction Managers	207
11-1021	General and Operations Managers	205
17-2071	Electrical Engineers	186
13-1111	Management Analysts	180
43-9061	Office Clerks, General	176
51-4081	Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic	169
51-1011	First-Line Supervisors of Production and Operating Workers	166
53-3032	Heavy and Tractor-Trailer Truck Drivers	166
43-1011	First-Line Supervisors of Office and Administrative Support Workers	157
47-2111	Electricians	156
17-2112	Industrial Engineers	152
43-3031	Bookkeeping, Accounting, and Auditing Clerks	145
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	142
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	140
13-2011	Accountants and Auditors	134
51-4121	Welders, Cutters, Solderers, and Brazers	132
15-1211	Computer Systems Analysts	130
13-1020	Buyers and Purchasing Agents	128
47-2051	Cement Masons and Concrete Finishers	113
17-2141	Mechanical Engineers	112
47-2152	Plumbers, Pipefitters, and Steamfitters	106
43-6014	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	101
53-1049	First-Line Supervisors of Transportation Workers, All Other	99
47-4031	Fence Erectors	96
13-1161	Market Research Analysts and Marketing Specialists	96
51-4041	Machinists	94
13-1051	Cost Estimators	91
47-2141	Painters, Construction and Maintenance	91
41-3099	Sales Representatives, Services, All Other	90
49-3042	Mobile Heavy Equipment Mechanics, Except Engines	89
15-1232	Computer User Support Specialists	89
43-5061	Production, Planning, and Expediting Clerks	83
51-8013	Power Plant Operators	76
49-9051	Electrical Power-Line Installers and Repairers	75
11-3021	Computer and Information Systems Managers	70
51-9141	Semiconductor Processors	70
17-2199	Engineers, All Other	64
11-9199	Managers, All Other	57
43-5071	Shipping, Receiving, and Traffic Clerks	56
11-3031	Financial Managers	56
43-5032	Dispatchers, Except Police, Fire, and Ambulance	53
47-2211	Sheet Metal Workers	52

Exhibit 17. Clean Energy Occupations Continued

SOC Code	Occupation	Jobs, 2019
17-2051	Civil Engineers	52
13-1071	Human Resources Specialists	50
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	49
15-1299	Computer Occupations, All Other	48
23-1011	Lawyers	48
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	46
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	46
11-2022	Sales Managers	46
13-2099	Financial Specialists, All Other	45
41-3031	Securities, Commodities, and Financial Services Sales Agents	43
17-3023	Electrical and Electronics Engineering Technicians	43
49-9071	Maintenance and Repair Workers, General	40
53-7065	Stockers and Order Fillers	40
49-9041	Industrial Machinery Mechanics	38
41-3091	Sales Representatives of Services, Except Advertising, Insurance, Financial Services, and Travel	38
51-8012	Power Distributors and Dispatchers	37
17-1011	Architects, Except Landscape and Naval	37
47-2081	Drywall and Ceiling Tile Installers	34
11-2021	Marketing Managers	34
11-9041	Architectural and Engineering Managers	34
11-3051	Industrial Production Managers	33
15-1244	Network and Computer Systems Administrators	33
53-7041	Hoist and Winch Operators	32
13-1041	Compliance Officers	30
49-9096	Riggers	30
13-1081	Logisticians	30
51-5112	Printing Press Operators	30
23-2011	Paralegals and Legal Assistants	28
13-1151	Training and Development Specialists	28
47-2181	Roofers	27
51-2011	Aircraft Structure, Surfaces, Rigging, and Systems Assemblers	27
17-3026	Industrial Engineering Technicians	27
41-2031	Retail Salespersons	26
17-3029	Engineering Technicians, Except Drafters, All Other	25
43-4171	Receptionists and Information Clerks	25
49-9012	Control and Valve Installers and Repairers, Except Mechanical Door	25
19-1042	Medical Scientists, Except Epidemiologists	25
51-4011	Computer-Controlled Machine Tool Operators, Metal and Plastic	23
33-9091	Crossing Guards	22
47-4071	Septic Tank Servicers and Sewer Pipe Cleaners	22
37-2011	Janitors and Cleaners, Except Maids and Housekeeping Cleaners	21
13-1031	Claims Adjusters, Examiners, and Investigators	20
51-9199	Production Workers, All Other	20
43-3021	Billing and Posting Clerks	20
17-2061	Computer Hardware Engineers	20
53-7051	Industrial Truck and Tractor Operators	19
47-4021	Elevator Installers and Repairers	19
17-2011	Aerospace Engineers	19
47-2131	Insulation Workers, Floor, Ceiling, and Wall	19
15-1231	Computer Network Support Specialists	18
47-2151	Pipelayers	18
17-3013	Mechanical Drafters	18
19-5011	Occupational Health and Safety Specialists	18
17-2072	Electronics Engineers, Except Computer	17
15-1254	Web Developers	17

Exhibit 14. Clean Energy Occupations Continued

SOC Code	Occupation	Jobs, 2019
27-1024	Graphic Designers	17
17-3027	Mechanical Engineering Technicians	17
47-2121	Glaziers	17
47-4011	Construction and Building Inspectors	17
15-2031	Operations Research Analysts	16
43-6011	Executive Secretaries and Executive Administrative Assistants	16
47-2082	Tapers	15
15-1212	Information Security Analysts	15
43-3051	Payroll and Timekeeping Clerks	15
15-1251	Computer Programmers	14
51-8092	Gas Plant Operators	14
27-3031	Public Relations Specialists	14
41-3021	Insurance Sales Agents	14
53-7032	Excavating and Loading Machine and Dragline Operators	13
43-9021	Data Entry Keyers	13
19-2041	Environmental Scientists and Specialists, Including Health	13
53-3033	Light Truck or Delivery Services Drivers	13
11-3061	Purchasing Managers	13
47-2044	Tile and Marble Setters	13
11-3121	Human Resources Managers	13
19-4021	Biological Technicians	13
49-9098	Helpers--Installation, Maintenance, and Repair Workers	12
31-9096	Veterinary Assistants and Laboratory Animal Caretakers	12
51-8099	Plant and System Operators, All Other	12
17-3011	Architectural and Civil Drafters	12
41-2011	Cashiers	11
11-3010	Administrative Services Managers	11
51-9124	Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	11
49-2094	Electrical and Electronics Repairers, Commercial and Industrial Equipment	11
27-1025	Interior Designers	11
49-2091	Avionics Technicians	11
47-2132	Insulation Workers, Mechanical	10
51-9162	Computer Numerically Controlled Tool Programmers	10
51-9122	Painters, Transportation Equipment	10

Source: Washington State Employment Security Department, 2020; EMSI, 2020; Community Attributes Inc., 2020.

APPENDIX D. FOSSIL FUEL AND CLEAN ENERGY OCCUPATION MATCHING KNOWLEDGE, SKILL, AND ABILITY ELEMENTS

The list below provides the knowledge, skill, and abilities elements that are each among the top 5 elements between the leading fossil fuel industries and clean energy industries identified.

	Knowledge	Skills	Abilities
Plumbers, Pipefitters, and Steamfitters			
• Construction Laborers (55%)	• Building and Construction • Mechanical	• Active Listening • Speaking • Operation Monitoring	• Oral Comprehension • Problem Sensitivity • Arm-Hand Steadiness • Manual Dexterity • Multilimb Coordination • Near Vision
• Laborers and Freight, Stock, and Material Movers, Hand (60%)	• Mechanical • Mathematics • English Language	• Reading Comprehension • Active Listening • Speaking • Critical Thinking • Operation Monitoring	• Oral Comprehension • Manual Dexterity • Multilimb Coordination • Near Vision
• Carpenters (65%)	• Design • Building and Construction • Mechanical • Mathematics • English Language	• Reading Comprehension • Active Listening • Speaking • Critical Thinking • Judgment and Decision Making	• Problem Sensitivity • Manual Dexterity • Near Vision
Welders, Cutters, Solderers, and Brazers			
• Miscellaneous Assemblers and Fabricators (88%)	• Administration and Management • Production and Processing • Mechanical • Mathematics	• Active Listening • Critical Thinking • Monitoring • Operation Monitoring • Quality Control	• Problem Sensitivity • Arm-Hand Steadiness • Manual Dexterity • Finger Dexterity • Near Vision
• Carpenters (56%)	• Design • Mechanical	• Active Listening • Critical Thinking	• Problem Sensitivity

	Knowledge	Skills	Abilities
	• Mathematics	• Monitoring	• Manual Dexterity • Near Vision
• Laborers and Freight, Stock, and Material Movers, Hand (56%)	• Production and Processing • Mechanical • Mathematics	• Active Listening • Critical Thinking • Operation Monitoring	• Manual Dexterity • Control Precision • Near Vision
Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic			
• Miscellaneous Assemblers and Fabricators (69%)	• Production and Processing • Mechanical • Mathematics	• Critical Thinking • Monitoring • Operation Monitoring • Quality Control Analysis	• Problem Sensitivity • Arm-Hand Steadiness • Manual Dexterity • Near Vision
• Paving, Surfacing, and Tamping Equipment Operators (56%)	• Mechanical • Mathematics	• Critical Thinking • Monitoring • Operation Monitoring • Operation and Control • Troubleshooting	• Problem Sensitivity • Control Precision
• Laborers and Freight, Stock, and Material Movers, Hand (56%)	• Production and Processing • Mechanical • Mathematics	• Critical Thinking • Operation Monitoring • Operation and Control	• Manual Dexterity • Control Precision • Near Vision

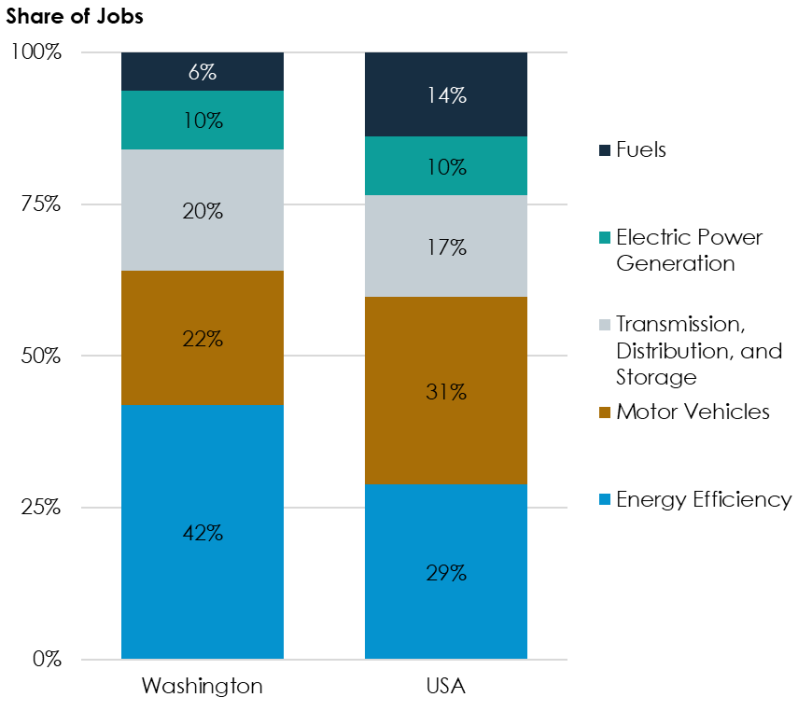
APPENDIX E. ENERGY INDUSTRY IN WASHINGTON STATE

The traditional energy industry is made up of fuels, electric power generation, transmission, distribution, and storage. Activities related to fuels include extraction of all major forms of carbon-emitting fuels, petroleum, natural gas, coal, and biomass. Electric power generation includes both clean energy and carbon-emitting energy production, in addition to energy efficiency methods and Combined Heat and Power (CHP). Related sectors are energy conservation and motor vehicles. Transmission, distribution, and battery storage, as well as the construction and maintenance of facilities, are also key industry elements.

Energy Employment in Washington State

Compared to the country overall, Washington state has higher shares of energy sector employment in Energy Efficiency (+13%) and Transmission, Distribution, and Storage (+3%), and a lower concentration of Fuels (-8%) and Motor Vehicles (-9%), shown in **Exhibit 18**.

Exhibit 18. U.S. and Washington State Energy Sector Employment Shares, 2019



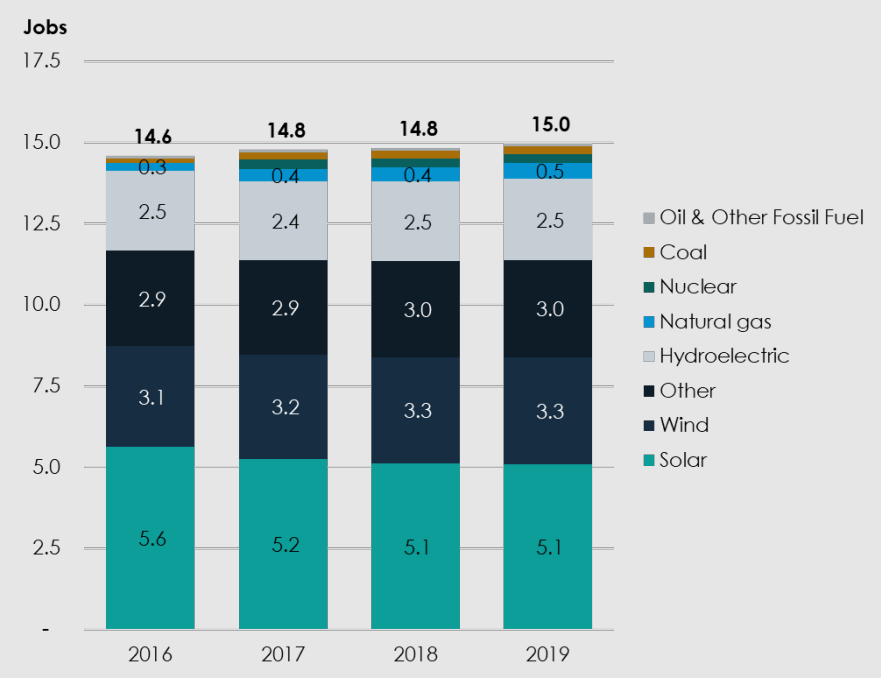
Source: USEER, 2016-2020.

Statewide, approximately 15,000 workers were in employed in energy industries in 2019, of which the largest share were in solar (5.1%) and wind energy (3.3%) as shown in **Exhibit 19**. Energy jobs statewide increased in

every category defined by USEER from 2016 to 2019, together growing 1.4% annually, compared to 2.1% annually nationwide.

Washington state fuels employment grew fastest (8.8%) during this period, though remains the smallest major energy technology application. Energy Efficiency and Motor Vehicles jobs both saw strong growth and combined make up more than half of all energy employment. Solar continues to be the largest employer in the state's Electric Power Generation but has decreased since 2016. Wind, the second largest employer, has increased 2.3% over the same period.

Exhibit 19. Washington State Electric Power Generation Employment by Source, 2016-2019



Source: USEER, 2016-2020.

APPENDIX F. STAKEHOLDER INTERVIEWS PROTOCOL

Clean Energy Industry Questions

Background Information and Activities

1. How does your business relate to clean energy, electrification, and/or grid resiliency?
2. Please describe your company or organization, including:
    a. Main line of business or mission, and types of goods and services provided.
    b. Any information you are willing to share on size overall and in the Seattle area (revenues, number of workers).
    c. Types of clients/customers and goods and services you provide.
    d. Are you based only in Seattle or elsewhere in the region and U.S.? Please explain.
3. Have you seen your business grow, contract, and stay the same in 2020?
4. What were your top three challenges as a business or organization, before Covid-19?

Workforce

5. Tell us about your workforce, e.g., unionization, types of skills and workers/occupations, wage levels, demographics, apprenticeship trainings, pensions?
6. What are some of the most common employment positions at your business?
7. What are the highest demand workers and skills you look for?
8. What are workforce challenges you face, e.g., retention, finding the right skilled workers, diversity?

Industry Outlook and Opportunities in Clean Energy

9. What types of support for recovery and growth of Seattle clean energy jobs are most needed?
10. What advantages does Seattle area offer for clean energy industry leadership compared to other U.S. regions and/or globally?
11. What are key current barriers to Seattle's clean energy industry growth, especially considering COVID-related financial and social challenges? (e.g., Local policy and enforcement timeframes including permitting, interconnection & inspection; Infrastructure/utility interconnection costs and process; Access to capital/financing; Intellectual Property; Securing customers/market volatility; State/federal regulation; Workforce shortages/skills)
    a. How can Seattle's clean energy sector aid hospitals, clinics, COVID testing centers, or other facility modifications (e.g., hotels) that might require energy engineering/design, emergency backup power, and implementation of equipment/systems?

12. To improve reliability and security, Seattle is relying more on the electric grid. How is the workforce changing to accommodate this, and where do you anticipate finding new workers?
13. What is your current outlook for Seattle clean energy sector jobs -- near-term (1-year) and mid-term (5 year)? What are some key developments, prospects, and change in the industry do you foresee in the near future?
14. How is your business preparing for and positioning to prosper in a cleaner, greener economy? (Investments, worker trainings, changing your business model, etc.?)
15. What concrete steps can be taken to ensure that all customers benefit from the transition to clean energy?
    (e.g. Specific approaches for equitable distribution of energy and nonenergy benefits and reduction of burdens to vulnerable populations and highly impacted communities; Ensuring long-term and short-term public health and environmental benefits and reduction of costs and risks in certain neighborhoods; Increasing energy security and resiliency; Helping prevent utility disconnections/shutoffs)
16. In order for Seattle's clean energy industry to grow 10-100x, what future workforce gaps need to be addressed today?

Other Concerns and Comments

17. How has your business been impacted by Covid-19?
18. Are there other comments or concerns you would like to share with the City?

Fossil Fuels Industry Questions

Background Information and Activities

1. How does your business rely on or relate to fossil fuels?
2. Please describe your company or organization, including:
    a. Main line of business or mission, and types of goods and services provided.
    b. Any information you are willing to share on size overall and in the Seattle area (revenues, number of workers).
    c. Types of clients and goods and services you provide.
    d. Are you based only in Seattle or elsewhere in the region and U.S.? Please explain.
3. Have you seen your business grow, contract, and stay the same in 2019?
4. What were your top three challenges as a business or organization, before Covid-19?

Workforce

5. Tell us about your workforce, e.g., unionization, types of skills and workers/occupations, wage levels, demographics, apprenticeship trainings, pensions?

6. What are some of the most common employment positions at your business?
7. What are the highest demand workers and skills you look for?
8. What are workforce challenges you face, e.g., retention, finding the right skilled workers, diversity?

Industry Outlook and Opportunities in the Clean Energy

9. Do you see or anticipate opportunities for your firm in the clean energy sector, including HVAC, weatherization, building electrification and/or transportation electrification? Please explain.
10. In your view, how transferable are the skills of your workers and knowledge base and capabilities of your firm to clean energy applications? (Who within your company do you think will be most adversely impacted by some of these changes? What kind of support do you think they will need?)
11. What are some key developments, prospects, and change in the industry do you foresee in the near future?
12. How is your business preparing for and positioning to prosper in a cleaner, greener economy? (Investments, worker trainings, changing your business model, etc.?)
13. What are some actions or policies you think the city should implement to support fossil fuel-related firms and workers in the transition to a cleaner economy?

Other Concerns and Comments

14. How has your business been impacted by Covid-19?
15. Are there other comments or concerns you'd like to share with the City?

APPENDIX G. STAKEHOLDER SURVEY

1. Name of company, organization, or affiliation.
2. Located in Seattle?
    a. Yes
    b. No
3. Type of role or affiliation?
    a. Business owner
    b. Employee
    c. Union member
    d. Independent contractor
    e. Building owner
    f. Other – If Other, please describe
4. Number of employees in Seattle region (including self)
    a. 1-9
    b. 10-19
    c. 20-29
    d. 30-49
    e. 50-99
    f. 100-499
    g. 500+
5. Company revenues in 2019 in the Seattle region
    a. Less than $1 million
    b. Between $1 million and $5 million
    c. Between $5 million and $10 million
    d. More than $10 million
    e. Other – If Other, please describe
6. Which of the above sectors do you primarily self-identify with?
    a. Fossil fuels and intensive users
    b. Clean energy

Fossil Fuels and Intensive Users

7. In what way are fossil fuels central to your business or employment?
    a. Supplier of fuels
    b. Marketing fuels
    c. Distribution and sales
    d. Maintenance of related equipment and support services
    e. Construction and/or installation of pipelines and other infrastructure
    f. Critical to your processes, e.g. natural gas for manufacturing
    g. Retail or wholesale of fuel-based devices, e.g., natural gas-burning fireplaces
    h. Vehicle use and shipping
    i. Other - If Other, please describe

8. Please explain and provide any data or metrics you are willing to share on the importance of fossil fuels as relates to your business or employment.
9. What are the most common types of occupations at your business or organization? Please explain with a list types of workers and numbers or percentages if available.
10. How many workers are directly involved in the production, handling, and/or use of fossil fuels in your organization?
11. What recommendations or perspectives should be considered as the City Council evaluates legislation to transition Seattle away from fossil fuels?

Clean Energy

7. In what ways do clean energy, electrification, grid resiliency, and/or energy efficiency relate to your business/organization or employment?
    a. Supplier marketing
    b. Distribution and sales
    c. Maintenance and support services
    d. Construction and/or installation
    e. Critical to your processes e.g. manufacturing
    f. Retail or wholesale of clean energy products
    g. Building design or operation
    h. Professional services
    i. Other - If Other, please describe
8. Please explain and provide any data or metrics you are willing to share on the importance of clean energy, electrification, grid resiliency, and/or energy efficiency as relates to your business/organization or employment.
9. What are the most common types of occupations at your business or organization? Please explain with a list types of workers and numbers or percentages if available.
10. As a clean energy business or organization, from your perspective, what skills are in highest demand right now? What about in the next 5 to 10 years?
11. How many workers are directly involved in the production, handling, and/or use of clean energy products and services in your organization?
12. What is your outlook for the clean energy sector over the next five years?
13. What recommendations, perspective and economic impacts, should be considered as the City Council evaluates legislation to transition Seattle away from fossil fuels and maximize job/career benefits of inclusive energy transition policies?