MASSACHUSETTS CLEAN ENERGY CENTER®

Powering the Future:

A Massachusetts Clean Energy Workforce Needs Assessment

July 2023

[bw] RESEARCH PARTNERSHIP

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Letter from MassCEC's CEO Jennifer Daloisio

For Massachusetts to meet its ambitious decarbonization targets, we will need to significantly ramp up clean energy activity, including accelerating the deployment of solar and offshore wind facilities, decarbonizing buildings and electrifying the transportation sector. To achieve these targets, *Powering the Future: A Massachusetts Clean Energy Workforce Needs Assessment* details the clean energy workforce needed by 2030 as seen through regional, occupational and equity lenses. Based on expansive research across a wide range of stakeholders, the report also highlights existing training, awareness and coordination gaps, and offers key recommendations to overcome barriers and support the expansion of a robust and diverse clean energy workforce.

The transition needed is daunting in scale. To meet our 2030 greenhouse gas emission reduction targets, the Massachusetts clean energy workforce will need to grow by an additional 29,700 full-time equivalent workers, which will require **38,100** workers to be trained and ready to deploy some or all of their time on climate-critical work. The Offshore Wind industry, in which Massachusetts' is a national leader, is projected to grow 724% by 2030, with the growth trajectory continuing well beyond 2030. Across all clean energy sectors, over 140 occupations will see job increases, while 20 of these occupations will account for 65% of jobs added. These added clean energy jobs will not only help us meet our climate goals but also create increased economic opportunity, adding living-wage jobs with a median wage of over $36 dollars per hour, using today's dollars.

By 2030, 38,100 more workers must be trained and ready to deploy some or all of their time on climate-critical work.

Historic investments at the state and federal levels provide an opportunity for Massachusetts to continue to lead the way toward net zero. Since taking office, Governor Maura Healey has made fighting climate change a priority of her Administration, advocating for climate-focused policies, expanding public funding of critical programs and creating a cabinet-level Climate Chief position to coordinate a whole-of-government approach to climate.

These commitments carve a path for a cleaner future that will be built upon a just transition. The clean energy industry must grow by nearly 30% by 2030 and 74% by 2050 amid an incredibly tight labor market, and our future clean energy workforce must expand through inclusive practices that recognize that a diverse workforce is a robust and resilient workforce. This report finds that attracting, training and supporting diverse candidates is essential to meeting demand, driving equitable growth and expanding opportunities for residents of Environmental Justice neighborhoods and other underrepresented populations. Additionally, although the impact of the clean energy transition on current fossil fuel workers will largely occur after 2030, careful planning and coordination are needed to ensure their role in this transition.

Our future clean energy workforce must expand through inclusive practices that recognize that a diverse workforce is a robust and resilient workforce.

The Massachusetts Clean Energy Center is uniquely positioned to leverage collaborations with state partners and other key stakeholders to deploy effective workforce development strategies that expand pipelines for new workers and promote retention, upskilling and advancement for current workers. Since its launch in 2011, the Massachusetts Clean Energy Internship Program has placed over 5,400 interns at over 600 unique clean energy companies — connecting employers to a diverse next generation of workers. Additionally, MassCEC is deploying over $12 million in funding annually for Equity Workforce Development programming to support training and business development opportunities for underrepresented populations. These programs not only address the need to grow Massachusetts' clean energy workforce but also prioritize Diversity, Equity and Inclusion (DEI) efforts across the full spectrum of economic opportunity, yielding both an increasingly diverse bench of highly trained new workers and a wider array of thriving minority- and women-owned business enterprises to help lead climate-critical work.

The results and recommendations from this report will drive smart program design within MassCEC, but they can also be used as a guiding resource for state and regional partners, training providers, employers and other stakeholders to drive informed planning and decision making to build the workforce needed to reach our decarbonization goals.

MassCEC is uniquely positioned to deploy workforce strategies to expand pipelines for new workers and promote retention, upskilling and advancement for current workers.

Sincerely,

Jennifer Daloisio

CEO, Massachusetts Clean Energy Center

Acknowledgments

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State, City and Utilities

- Executive Office of Education
- Executive Office of Labor and Workforce Development
- Massachusetts Department of Elementary and Secondary Education
- City of Boston
- Mass Save Utility Program Administrators

Labor Unions and Training Centers

- Ironworkers Local 37
- IBEW 223 Electricians
- IBEW 103 Electricians
- Massachusetts Building Trades Council
- Greater Boston Joint Apprentice Training Center
- Greater Boston Labor Council
- North Atlantic Carpenters Training Fund
- North Atlantic States Regional Council of Carpenters

Educational Institutions, Private Training Providers and Community-Based Organizations

- Bristol Community College
- Building Pathways
- Emerald Cities
- Greater Boston Joint Apprentice Training Center
- Greater Boston Labor Council
- Greater Lawrence Technical School
- Greenfield Community College
- Local Initiatives Support Corporation (LISC)
- Martha's Vineyard Center for Education and Training
- Massachusetts Association of Community Colleges
- Massachusetts Maritime Academy
- North Atlantic Carpenters Training Fund
- PSD Consulting
- UMass Clean Energy Extension
- YouthBuild
- Action 4 Equity
- Building Pathways
- Codman Square Neighborhood Development Corporation
- Emerald Cities

- International Family Services Institute
- Jewish Vocational Services (JVS)
- Job Training Alliance
- Just-A-Start
- Old Bedford Village Development Corporation
- Urban League
- UTEC
- Worcester Community Action Council

Employers

- ACE Solar
- Building Evolution Corporation
- Codman Square Neighborhood Development Corporation
- Curbhub
- Ekotrope
- Elevated Design Inc.
- Entegra + Architectural Health
- Greater Springfield Habitat for Humanity
- HomeWorks Energy
- My Generation Energy
- NECEC
- NEO Virtus Engineering, Inc.
- Nexamp
- Renew Energy Partners, LLC
- Rogers Insulation
- SolarKal
- Solect Energy
- Solstice Power Technologies
- Xodus Group

Executive Summary

Massachusetts is a global leader in clean energy. Both the first U.S. port for offshore wind deployment and the first commercial-scale offshore wind farm construction project are located in Massachusetts. Additionally, Massachusetts ranks second in energy efficiency by ACEEE and is home to the highest-earning clean energy workers in the country.

There are over 104,000 clean energy workers in Massachusetts today, all of whom play a crucial role in Massachusetts' current economy and future prosperity. Since 2010, the clean energy industry has grown by 73%, which accounted for more than 14% of all net jobs created in the state during that time.[1] Massachusetts has committed to reducing greenhouse gas emissions: first cutting emissions by 50% by 2030, then achieving net zero greenhouse gas emissions by 2050 — policies that will further cement the state's leadership in decarbonization and drive clean energy job growth at a rapid pace for decades to come.

Based on modeling conducted for the Massachusetts Clean Energy and Climate Plan for 2025 and 2030[2] and bolstered by extensive research with a wide range of stakeholders, this report provides detailed data and analysis of the clean energy workforce needed to meet the Commonwealth's 2030 climate goals and forge the path toward a net zero future. The state's decarbonization plan will require the clean energy workforce to expand by a likely conservative projection of **29,700 full-time equivalent** (FTE) workers by 2030, or the **equivalent of 38,100 workers spending some or all of their time on clean energy projects**. These will be new jobs added to the sector and state economy, growth that is expected to occur during a period of general economic expansion in Massachusetts, further pinching the already tight supply of workers statewide. While the passing of federal legislation such as the Bipartisan Infrastructure Law and the Inflation Reduction Act does not alter Massachusetts' already ambitious commitments to climate change, the additional associated federal funding opportunities are likely to accelerate the adoption of clean energy technologies and further increase demand for workers who manufacture, install and repair them.

Clean energy firms already report high levels of hiring difficulty, with 88% of employers surveyed as part of the 2022 Massachusetts Clean Energy Industry Report facing challenges in securing talent for clean energy positions.[1] The rapid expansion that needs to occur across all sectors of the clean energy economy will further

[1] "2022 Massachusetts Clean Energy Industry Report," page 13, https://www.masscec.com/resources/2022-massachusetts-clean-energy-industry-report.

[2] "Massachusetts Clean Energy and Climate Plan for 2025 and 2030," https://www.mass.gov/doc/clean-energy-and-climate-plan-for-2025-and-2030/download

exacerbate labor shortages and hiring difficulties. Without significant and purposeful intervention, there will simply not be enough interested and qualified job seekers for the number of additional positions needed, as many of the highest-growth clean energy positions will also be in high demand by other industries in the economy. This competitive labor market will necessitate strategies that not only expand pipelines of clean energy workers, but also increase awareness, access and engagement within communities and populations who have been historically disadvantaged, excluded, and over-burdened by climate change, pollution and rising energy costs to enter these pipelines. An all-hands approach will be needed to fully meet the growing labor needs of the clean energy industry and to ensure that the tremendous economic opportunities born out of statewide decarbonization are accessible to all.

Seven Key Findings and Recommendations

Number One

The clean energy workforce in Massachusetts must grow by nearly 37% by 2030, with growth required across all clean energy sectors and MassCEC's four focus areas.

Massachusetts needs to increase its clean energy workforce by 29,700 full-time equivalent jobs by 2030 to achieve its decarbonization goals, which will require 38,100 additional trained workers to spend some or all their time on clean energy-related work, a growth rate of nearly 37% over the span of eight years. Workforce supply will need to scale across all clean energy sectors and all of MassCEC's four focus areas. High-Performance Buildings, which has a current workforce that is almost five times greater than all three other MassCEC focus areas combined, needs to add nearly 13,000 workers — the largest absolute number of jobs, with a growth rate of 17%. Offshore Wind has the largest projected growth rate of 724%, followed by Clean Transportation (111%) and Net Zero Grid (70%). The high growth rate projected for Offshore Wind could accelerate even more if a greater share of the manufacturing associated with Offshore Wind takes place in the state.

Number Two

Although the predicted displacement of fossil fuel workers is minimal through 2030, workforce programming can help to reskill workers and increase transitions to equivalent opportunities in the clean energy workforce, which will need this steady infusion of talent.

By 2030, it is expected that fossil fuel jobs will decrease slightly from 58,000 to 56,000, or a net decrease of 3.4%. Decreased demand for gas station attendants represents the greatest potential loss of fossil fuel-related jobs through 2030, accounting for more than half of the projected job losses. Nine out of the ten occupations projected to see the largest displacements in fossil fuel jobs will also see changes in the types of demand for their services. For example, many Plant Operators, Distributors and Dispatchers may transition towards supporting a larger, more modernized grid, while Auto Mechanics will increasingly repair electric vehicles (EVs) alongside traditional combustion engine-powered cars.

Proactive planning and investment in reskilling can ensure that fossil fuel workers transition successfully to clean energy roles. For example, occupations such as Pipefitters Pipelayers, Plumbers, Pipefitters, and Steamfitters are projected to see an increase in demand through 2030, but may see fossil fuel-related decline in later decades. With proper workforce planning, this decline could be offset by the rise of green hydrogen applications that are aligned with the state's climate objectives, which is on a similar time horizon and could present opportunities to transition these workers into clean energy roles. MassCEC's Equity Workforce programs also include current and former fossil fuel workers as a priority population and provide opportunities to fund reskilling and upskilling.

Number Three

Expanded clean energy career awareness is a crucial first step to growing and diversifying the pipeline for tomorrow's climate-critical workforce.

Lack of information about clean energy careers early in education is a top barrier to clean energy careers, with 39% of clean energy workers surveyed indicating this as a challenge. However, nearly half of all women and Black or African American respondents cited this challenge, showing that lack of information in early education is an even greater barrier among workers underrepresented in the industry. Providing accurate, comprehensive information about clean energy careers is an essential component of driving career awareness. Web-based resources like MassCEC's **www.cleanenergyeducation.org** can offer broad access to needed information, but by itself is not sufficient. To have an even greater impact, career awareness efforts must customize the messaging to resonate with different demographics and communities and build strong partnerships with workforce development organizations and Community-Based Organizations (CBOs) that are on the frontlines of working with job seekers. The Massachusetts Department of Elementary and Secondary Education (DESE) has existing initiatives focused on early career awareness and exploration, which provide strong avenues for increasing awareness. A well-integrated, sustainable and scalable approach can ensure that youth statewide have the information needed to explore the many clean energy occupations that are projected to be in high demand.

Number Four

Scaling clean energy workforce training capacity to meet the 2030 workforce needs will require leveraging existing systems and programs, prioritizing quality and effectiveness, and funding new or enhanced programs to address gaps and barriers.

Additional funding, coordination and support are needed to deliver a clean energy workforce robust enough to meet the state's climate goals. Leveraging state and regional workforce systems, expanding existing programs, launching new programs to target known gaps, and enhancing the curricula, equipment, support services and employer engagement across all programs are critical steps in adding capacity to the clean energy workforce development ecosystem. The analysis for this report identified 900 training programs that are relevant to clean energy occupations. Just under half of these programs are foundational training programs that provide entry into priority climate-critical occupations. Those programs span vocational and technical high school training programs, post-secondary institutions, union-sponsored apprenticeship programs, pre-apprenticeship programs, private training organizations and CBOs. The state's vocational and technical schools currently receive far more applicants than they can seat, providing offers to just 61% of applicants in 2022. Many union apprenticeship programs also reported having more interested candidates than apprenticeship opportunities. Conversely, post-secondary institutions, especially community colleges, are struggling with a lack of enrollment and need stronger connections to recruitment partners. Across all program types, expanded employer partnerships and support services are critical levers for expanding program capacity and quality.

Number Five

Efforts to expand the clean energy workforce must also ensure a just transition – one that maintains job quality for workers, provides economic opportunity and advancement to communities that have been historically marginalized and disproportionality impacted by pollution and climate change, and eliminates employment barriers based on identity. In light of a competitive labor market, a just transition is critical to meeting the demand for clean energy workers by 2030.

MassCEC administers $12 million in funding annually for Equity Workforce Development programming to support minority- and women-owned business enterprises (MWBEs) and expand clean energy occupational training opportunities for priority populations, including fossil fuel workers, Environmental Justice populations (defined in statute by the criteria of race, income and language), members of federally recognized- and state-acknowledged tribes, low-income and other underrepresented populations.[3] These resources are foundational to prioritizing a just, equitable and inclusive clean energy transition. While one in three clean energy workers in Massachusetts are people of color, representation in many of the highest-paying positions is not equitable across race, ethnicity or gender. Women are especially underrepresented among many of the occupations projected to see the highest total job growth, such as Electricians, of which only 2% are currently women. Populations that are underrepresented in the clean energy workforce face a series of barriers that span from early awareness of the industry to unequal access to training opportunities, to additional barriers to job entry and career advancement. The maps included in this report reveal substantial gaps in access between training locations and the location of many Environmental Justice populations. "Finding training opportunities near where I live" was a top barrier to career entry among all survey respondents. Still, much greater shares of Hispanic and Black respondents highlighted this challenge, with 72% and 56% noting the barrier, respectively. Disproportionate rates of barriers persist in the hiring process and in work experiences. Many clean energy

[3] Priority populations are defined within Section 13.(a) of the 2022 climate legislation titled 'An Act Driving Clean Energy and Offshore Wind.' Although referenced separately in the legislation, Environmental Justice populations overlap substantially with the share of Native American residents within census block groups. Additionally, although income is one of the three criteria that defines Environmental Justice populations, the legislation references low-income populations separately, which enables MassCEC Equity Workforce-funded programs to support low-income individuals who may not physically reside in an Environmental Justice neighborhood.

employers prioritized hiring practices that emphasize relational and network-based methods for finding new workers that are likely to engage smaller and less diverse pools of potential candidates. Black, Hispanic and Asian workers were also more likely to experience bias in the workplace early in their career that persisted when seeking career advancement.

Additional training capacity investments must eliminate inequitable access to training opportunities and prioritize enhanced outreach and support services to help address barriers to entry. These efforts must also include changing employer practices. From more inclusive and welcoming hiring practices to work environments with stronger support for new hires and clearer pathways to advancement, employers can maximize the impact of public investments in workforce development through practices that ensure that qualified individuals completing training programs can thrive and advance as part of the growing clean energy workforce.

Number Six

With 65% of clean energy job growth projected across just 20 occupations, certain occupations will require considerable additional support to prevent shortages in trained workers from undermining the state's ambitious decarbonization goals.

Clean energy jobs abound economywide, and decarbonization efforts will lead to additional jobs across 144 occupations. Job seekers with a wide range of interests and skill sets can find career opportunities across the clean energy industry. Still, almost two-thirds of all employment growth is projected to occur across 20 occupations, many of which will require additional workforce development intervention to ensure that Massachusetts has the clean energy workers needed to reach its climate goals. Occupations that are projected to be high-growth or are at a higher risk of causing workforce bottlenecks can present unique challenges, requiring thoughtful, targeted solutions.

For example, keeping pace with the demand for Electricians, a career that requires between four to five years of training, will necessitate concurrently expanding existing training programs and establishing additional programs, including pre-apprenticeship opportunities. Leveraging the training pipelines of unions and their existing waitlist of interested workers could rapidly address some of the projected workforce gaps, but doing so requires increased coordination of state construction and clean energy projects overseen by organized labor and measures to expand the amount and ways in which Master Electricians support a rising generation of workers. Alternatively, Insulation Workers can often complete training in just a few weeks or can be trained on the job to ensure that buildings and homes are as weather tight and efficient as possible. This vital job requires physically intensive work in space-constrained areas and is coupled with relatively low median wages, yielding high turnover rates. Successful workforce programs must include clear avenues to advancement, such as the Mass Save Weatherization Crew Chief certification and other pathways to next-step clean energy roles, including energy auditors and quality control inspectors. Addressing the unique challenges of these high-demand occupations will require specific workforce development strategies that can be integrated alongside more broad-based strategies, such as expanding efforts to increase awareness of clean energy career opportunities.

Number Seven

As the Commonwealth works to decarbonize, regions of the state will follow different decarbonization pathways, leading to distinct clean energy projects and infrastructure, obstacles, challenges and even types of workers needed. To be effective, workforce development strategies must be tailored to these regional considerations.

Substantial growth in clean energy jobs is projected across each of the seven Workforce Skills Cabinet (WSC) regions,[4] with regions seeing between 26%–33% growth. While 42% of jobs will be created in the Greater Boston region, five of the seven regions will see at least 2,300 new jobs created. Electricians, Heating, Ventilation, Air Conditioning and Refrigeration (HVAC-R) Mechanics and Installers and Construction Laborers are high-growth occupations across all regions, whereas the highest demand for Electric Power-Line Installers will be in the Pioneer Valley region. When comparing regional training opportunities for high-growth occupations, the report highlights where relevant local training programs may be insufficient to meet future demand. Training centers are also not distributed evenly, which can represent an impediment to access, especially for Environmental Justice populations. In the Berkshire region, there is only one community college program and eight vocational and technical high school programs relevant to a subset of clean energy occupations, while Environmental Justice populations in the north of the region lack nearby training options entirely. These challenges persist even in the Greater Boston region, where training programs tend to be centered around downtown and surrounding areas. While public transit can make these trainings more accessible to those further outside the city, the challenges of "last-mile" travel should not be underestimated, especially for communities that already face additional barriers. Many of the region's Environmental Justice populations, like those located in Everett, Malden, Roslindale and Dorchester, lack robust training offerings. Meeting many of these workers closer to where they live, and reducing transportation barriers for workers once placed in a clean energy role will be important in ensuring that clean energy opportunities are available to Massachusetts residents of all backgrounds.

[4] https://www.mass.gov/orgs/workforce-skills-cabinet

Chapter 1: Introduction

What is Clean Energy?

Clean energy jobs play a crucial role in the Massachusetts economy, but the terms “clean energy” and “clean energy worker” can have many meanings. In this report, a clean energy worker is a person who spends some or all their time working in renewable energy, energy efficiency, alternative transportation or other carbon management technologies that either reduce or eliminate greenhouse gas emissions from the generation, distribution and consumption of electricity and fuel.

Clean energy workers make our homes and offices more energy efficient and comfortable, create the infrastructure and technology that expands our use of clean transportation, and install and maintain clean energy systems and grid infrastructure that power our homes and businesses with renewable energy with increased reliability and resilience. Since 2010, clean energy jobs in Massachusetts have grown by 73% and account for nearly 104,300 jobs, or about 3% of all jobs in the state.[5]

What Does it Mean to Work in Clean Energy?

Clean energy jobs frequently fall under various names, including “green jobs” or “climate critical jobs.” Despite differences in titles, all clean energy jobs include activities that reduce the amount of greenhouse gases in the atmosphere.

Most clean energy workers are in occupations that are active in other industries. For example, an Electrician who counts as a clean energy worker may work on installing an EV charging station one day, updating an electrical panel the next day and installing new wiring in a commercial building the day after. As many of these occupations become increasingly focused on decarbonizing efforts, the same skills are still foundational to the work. While there are some occupations that are exclusively involved in clean energy activities, such as wind turbine service technicians, these clean energy-specific occupations make up a small portion of the overall clean energy workforce. While clean energy jobs often only require training that is foundational to their occupation, new and seasoned workers entering the clean energy workforce may require additional clean energy-specific training and upskilling. For example, many HVAC-R Mechanics and Installers are entering training to learn to install and maintain air-source heat pumps.

[5] 2022 Massachusetts Clean Energy Industry Report, https://www.masscec.com/resources/2022-massachusetts-clean-energy-industry-report.

Clean energy jobs drive the reduction of greenhouse gas emissions and also offer strong wages. A 2020 report by E2 found that Massachusetts is home to the highest-earning clean energy workers in the country.[6] Eighty-two percent of the clean energy jobs created between 2022 and 2030 will have wages that are greater than the current statewide median wage of $27.22, with a median wage for all clean energy jobs created by 2030 of $36.58, based on today's dollars.[7]

Eighty-two percent of the clean energy jobs created between 2022 and 2030 will have wages that are greater than the current statewide median wage of $27.22, with a median wage for all clean energy jobs created of $36.58.

About this Report

Massachusetts' ambitious decarbonization goals will require a significant expansion from the existing clean energy activity in the state, however, up until this research, the granularity of workforce demands was unknown. To better understand the additional detailed workforce demands, this report builds off of the MassCEC *2022 Massachusetts Clean Energy Industry Report,* which provides updated information about the workers and businesses that comprise the clean energy economy, as well as the Massachusetts Executive Office of Energy and Environmental Affairs' *Massachusetts Clean Energy and Climate Plan for 2025 and 2030* (2025 & 2030 CECP),[8] a comprehensive planning document that includes specific strategies, policies and implementation benchmarks for the state's goals of economywide emissions limit of a 50% reduction from 1990 level in 2030 on the path to the ultimate goal of net zero by 2050.

Much of the analysis is set at the occupational level, providing projections of which specific occupations and which focus areas and technological sectors are anticipated to see the greatest growth by 2030.

The 2025 & 2030 CECP outlines several decarbonization scenarios, with the "Phased" decarbonization scenario identified as the most likely scenario. This scenario entails rapid adoption of both partial- and whole-home heat pump systems through 2030, including installing electric heat pump technologies into buildings with fossil fuel systems, and then transitions to largely whole-home retrofits thereafter.[9] This scenario is the foundation of this report and was developed before the passage of the Infrastructure Investment and Jobs Act and the Inflation

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[6] "Clean Jobs, Better Jobs," E2, October 22, 2020, https://e2.org/reports/clean-jobs-better-jobs/.

[7] State median wage based on Bureau of Labor Statistics QCEW 2022Q3, Preliminary. Percent of 2030 workforce and $36.58 median wage based on analysis of median wages of projected 2030 clean energy jobs by occupation. Please see the Massachusetts Clean Energy Workforce Needs Assessment Workbook – Detailed Clean Energy Occupations and Clean Energy Occupation Demographics sections for underlying data. LINK

[8] Chapter nine of the 2025 & 2030 CECP focuses on the employment and macroeconomic impacts of decarbonization, projecting the net change in employment and economic activity throughout the state. This is referred to as the '2050 Decarbonization Report' in several places in this Needs Assessment. The underlying model and assumptions included in the Clean Energy and Climate Plan were used to develop the employment estimates found throughout this report. Additionally, it should be noted that while the modeling used in this workforce needs assessment is the same as that used in the 2025 and 2030 Clean Energy and Climate Plan, the definitions and baseline starting years for the two reports are different. For more information comparing the methodology of these two reports, please see Appendix A on page 117.

[9] This "phased" approach means that decarbonization activities have a longer "ramp-up process" in which households are slower to fully electrify in the immediate future, but rapid electrification occurs robustly in later years after 2030.

Reduction Act , which are likely to accelerate and spur additional economic activity, meaning the projected job numbers in this report are a conservative forecast. The 2025 & 2030 CECP also includes economic impact models based on this phased decarbonization scenario to determine net job gains and losses and other direct and indirect impacts on the Massachusetts economy. This report goes further, evaluating the characteristics of the current clean energy workforce and training systems and identifying potential workforce gaps that may slow down or inhibit the state's decarbonization efforts. Much of the analysis is set at the occupational level, providing projections of which specific occupations and which focus areas and technological sectors are anticipated to see the greatest growth by 2030. This level of detailed information arms government agencies, schools, Community-Based Organizations (CBOs), job seekers, employers and other stakeholders with the data to make informed and strategic plans to build the workforce needed to reach our decarbonization goals.

In addition to including a detailed modeling of the occupational growth needed to meet the state's decarbonization goals, the report includes information gathered through more than 400 survey responses from Massachusetts clean energy employers and employees and individual interviews and stakeholder sessions with more than 50 employers, training providers, organized labor representatives, CBOs and state organizations. Additional secondary research informed many of the recommendations offered throughout and resulted in a comprehensive inventory and analysis of almost 900 different training programs and certifications relevant to climate-critical occupations.[10]

This report is organized to provide data and analysis around specific themes that build off one another. Starting with a detailed review of the current and future demands for clean energy workers, the report then offers data, analysis and recommendations for expanding the number of clean energy workers by scaling training capacity, building a more inclusive workforce, supporting an effective transition for fossil fuel workers, helping employers attract and advance workers and enacting strategic occupational and regional plans. Each chapter offers key points, recommended strategies and questions for further examination, and the final chapter offers a thorough review of these strategies and provides key stakeholders with next steps crucial to expanding the clean energy workforce equitably and in step with the state's climate goals. The report also frequently refers to a list of MassCEC's 'workforce priority occupations,' which are specific occupations that received greater attention and analysis given their importance in the energy transition.

In addition to the workforce priority occupations, which in many cases will need systematic interventions to achieve the needed scale of new workers, employees who contribute to clean energy innovation, inclusive of clean tech start-ups and researchers developing new clean energy technologies and solutions, are a critical force that directly supports the Commonwealth's aggressive greenhouse gas emission reduction targets, while also acting as a key driver of growth and economic development. Centering Massachusetts as a hub for clean energy innovation is at the core of MassCEC's mission, which acts as a convenor and provides funding across a range of programs to the industry. MassCEC supports clean energy incubators and accelerators, offers technology to market grants and direct investments in clean energy start-up companies, and provides access to new talent through the Clean Energy Internship program. Of the over 600 unique employers who have participated in the Clean Energy Internship program, 65% had 10 employees or less, many of which were clean energy start-ups or active in the clean energy innovation sector. As part of these ongoing efforts, MassCEC will filter recommendations from this report through the lens of innovation stakeholders to better support workforce needs and challenges that may be unique to this sector.

[10] For more information about this report's methodology, please see "Appendix A: Report Methodology" on page 117.

Accompanying Report Resources

Even though this report is extensive, it does not capture the full detail of the data and research conducted as part of this report. For those who are interested, there are additional resources that provide greater granularity and insight into specific occupations, regions and stakeholder groups. These resources include a full inventory of training programs relevant to the workforce priority occupations, demographic and wage data around these occupations, and more. These resources can be found within the appendices of the report and as part of the MA Clean Energy Workforce Needs Assessment Workbook[11] that can be used for strategic planning.

Workforce Landscape in 2022: Challenges and Opportunities

The pandemic drastically reshaped labor markets and brought about new challenges that complicate expanding the clean energy workforce to meet the state's 2030 greenhouse gases (GHG) reduction target. Like the rest of the economy, clean energy jobs in Massachusetts declined over the course of the pandemic. Between 2020 and 2021, an estimated 12,800 clean energy jobs were lost — more than one in every six clean energy jobs before the pandemic.[12] By September 2022, 45% of those jobs had returned but the clean energy workforce was still 7,000 workers less than pre-pandemic levels — about the size of the clean energy industry in 2017. This setback in clean energy employment means that an even greater number of workers will be needed to meet the anticipated demand for clean energy workers by 2030.

Finding clean energy workers will be more challenging because the pandemic also exacerbated Massachusetts' already shrinking labor supply.

Finding clean energy workers will be more challenging because the pandemic also exacerbated Massachusetts' already shrinking labor supply. The labor force participation rate — the number of both employed and unemployed people actively looking for work relative to the working-age population — fell to 65.5% in October 2022 from 66.8% in October 2019.[13] This decline of roughly 84,000 fewer Massachusetts residents looking for work is a continuation of a pre-pandemic trend driven largely by an aging population,[14] though the pandemic accelerated rates of retirement among older workers.[15] Even with the pandemic largely in the review mirror, shedding workers due to retirement will remain a challenge for the clean energy industry

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[11] https://www.masscec.com/resources/massachusetts-clean-energy-workforce-needs-assessment

[12] 2021 Massachusetts Clean Energy Industry Report, https://www.masscec.com/resources/2021-massachusetts-clean-energy-industry-report.

[13] U.S Bureau of Labor Statistics, Series ID: LASST250000000000006. The labor force participation rate tends to be slightly higher in Massachusetts than the national average.

[14] David Howard, "Aging Boomers Solve a Labor Market Puzzle," U.S. Census Bureau, June 21, 2021, https://www.census.gov/library/stories/2021/06/why-did-labor-force-participation-rate-decline-when-economy-was-good.html.

[15] Joshua Montes, Christopher Smith, and Julia Dajon, "The Great Retirement Boom: The Pandemic-Era Surge in Retirements and Implications for Future Labor Force Participation," 2022, Washington D.C., Federal Reserve Board, www.federalreserve.gov/econres/feds/files/2022081pap.pdf.

in Massachusetts, which has a disproportionately older workforce compared to the economywide workforce. Among 32 occupations projected to require high growth by 2030, 10 have a higher proportion of workers who are 55 or older than the overall Massachusetts workforce. Additionally, nearly 85% of these 32 occupations, many of which are largely physical in nature, have a higher proportion of workers who are 35 to 54. Without intervention, the challenges of an aging workforce are likely to only worsen as we approach 2030.

Through more inclusive training and hiring practices, the clean energy industry can help mitigate unemployment rate disparities and provide access to well-paying clean energy jobs, which can also offer a path to closing racial and ethnic wealth gaps.

Aging workers and pandemic fallout are not the whole story, however. Nationwide, prime-aged (25-54) men are working at rates nearly one percentage-point lower than they were 10 years ago. Furthermore, labor force participation rates among White (-3.0%), Black or African American (-0.5%), Hispanic or Latino/a/x (-1.0%) and all other groups (-0.1%) declined between 2011 and 2021.[16] These data suggest that workforce development strategies must expand the number of working-age people who are interested and able to work in addition to supporting currently unemployed or underemployed individuals. Additionally, while unemployment rates are at historic lows, statistics still differ drastically across racial and ethnic lines. In Q2 of 2022, unemployment for White Massachusetts residents was 3.3%, compared to 4.8% for Black residents, 3.9% for Asian and Pacific American residents and 6.6% for Hispanic residents, which is twice as high as those of White residents.[17] Through more inclusive training and hiring practices, the clean energy industry can diminish these unemployment rate disparities and, given that these jobs are higher paying than industry-wide jobs, clean energy jobs also offer a path to diminishing racial and ethnic wealth gaps.[18] [19]

Over the past five years, the Massachusetts Clean Energy Industry Report has documented longstanding employer hiring challenges, and the 2022 report revealed that 88% employers have difficulty hiring both entry-level and more experienced talent — the highest rate in the history of the report. Employers struggling to hire point to small talent pools and a lack of experience among candidates, while current employees count proximity to jobs and training, access to career education and guidance and transportation issues among the largest barriers. These details and the myriad of data collected for this report offer roadmaps to needed interventions — signs of how key stakeholders can carve a path toward engaging a clean energy workforce scaled to meet the state’s decarbonization goals.

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[16] Civilian Labor Force Participation Rate by Age, Sex, Race, and Ethnicity, Bureau of Labor Statistics, https://www.bls.gov/emp/tables/civilian-labor-force-participation-rate.htm.

[17] “State unemployment by race and ethnicity,” Economic Policy Institute, Updated December 2022, https://www.epi.org/indicators/state-unemployment-race-ethnicity/.

[18] https://www.bls.gov/emp/tables/civilian-labor-force-participation-rate.htm

[19] The median household income of a White householder is $96,869 compared to $66,792 for Black or African American householders and $54,226 for Hispanic or Latino/a/x householders. U.S. Census Bureau 2021 ACS 1-Year Estimates, Tables B19013 A, B and I.

Chapter 2: Projecting the Future Demand for Clean Energy Workers

Quantifying the Current and Future Clean Energy Workforce

In order to meet the state's 2030 greenhouse gas emission reduction targets, by 2030 the Massachusetts clean energy workforce will need to grow by 29,700 full-time equivalent (FTE) jobs, which is equivalent to 38,100 workers as measured by headcount, or those spending either some or all of their time on clean energy projects.[20] As Figure 1 illustrates, these two rates of growth equate to a 29% increase in FTE jobs and a 37% increase in the headcount of clean energy workers. FTE job estimates are used throughout the report to remain conservative and be consistent with the 2025 & 2030 CECP. While the scope of this report is focused exclusively on strategies to support the growth of a robust and diverse workforce through 2030, job growth estimates show that the need for additional clean energy workers is projected to continue to grow over the coming decades, with 77,000 additional FTE clean energy workers needed between today and 2050, a 74% growth rate.[21]

The job forecasting model incorporates ongoing fossil fuel and clean energy activity, and while some of today's existing fossil fuel workforce will transition to clean energy roles, the scale of new clean energy workers needed will require many new entrants to fill this gap. Additionally, many of the fastest-growing jobs in the clean energy industry — from Electricians to HVAC-R Mechanics and Installers to General Managers — are also growing with the broader economy and have existing supply gaps. For Massachusetts to achieve its decarbonization goals, the clean energy industry will need workforce development strategies that effectively

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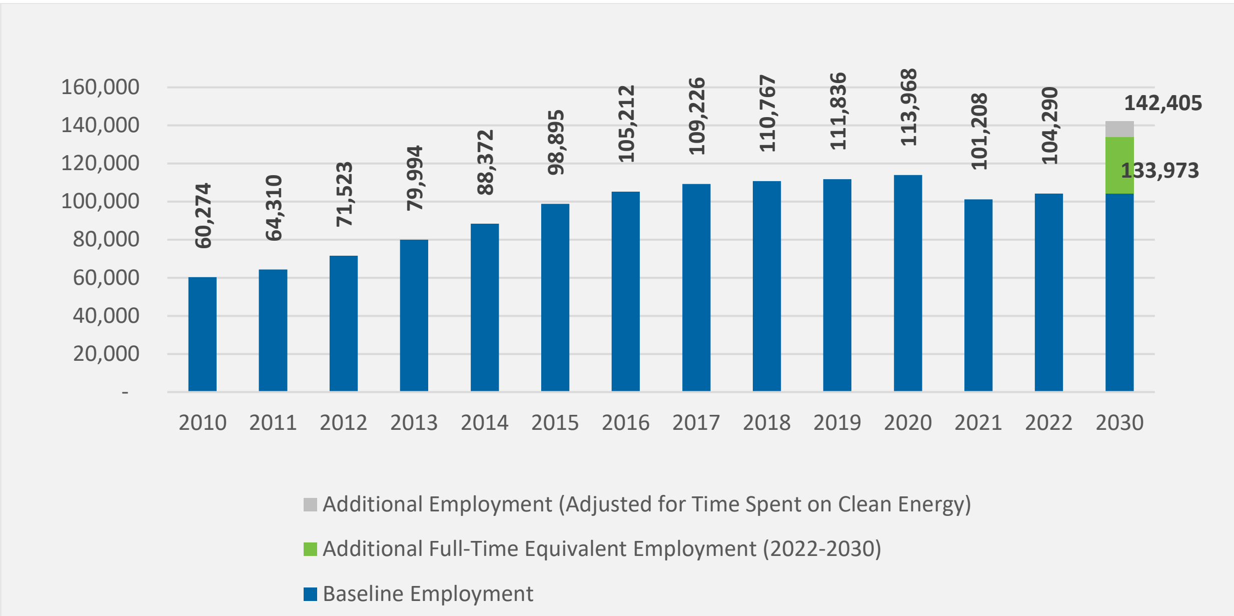
[20] There are two different methods of counting clean energy jobs. First, as is done through the Massachusetts Clean Energy Industry Report (MACEIR), is a "headcount" number that includes workers that spend any amount of time on clean energy activities. The other method is by counting clean energy jobs as "full-time equivalent" (FTEs), which would represent a worker spending all of their time on clean energy activities. To develop a "headcount" intensity-adjusted figure, the analysis adjusted for the typical amount of time clean energy workers across different sectors and technologies spend on clean energy activities. Once adjusting for this difference, we see that the intensity-adjusted "headcount" employment number would result in 8,400 additional clean energy workers beyond the FTE estimate. This is important from a workforce development perspective as it is likely that the amount of work required to meet the state 2030 interim greenhouse gas emissions targets will be spread out among more workers than the FTE headcount. It is important to note that both bars below include the same 104,290 from the 2022 Massachusetts Clean Energy Industry Report, and that the difference is the jobs added on top of that 2022 employment baseline.

[21] Projected clean energy employment modeled through 2050 using the 2025 & 2030 CECP "phased" scenario modeled can be found in the MA Clean Energy Needs Assessment Workbook. https://www.masscec.com/resources/massachusetts-clean-energy-workforce-needs-assessment

expand the pipelines for new workers and promote retention, upskilling and advancement for current workers.

There are several factors that may make these figures an underestimation of the total number of workers needed. The Infrastructure Investment and Jobs Act and Inflation Reduction Act offer strong incentives for businesses and homeowners alike to increase their adoption of clean energy technologies, likely accelerating the timeline of adoption. Furthermore, the incentives in both the Infrastructure Investment and Jobs Act and Inflation Reduction Act offer larger incentives for domestic labor and domestic production, which may boost demand for supply chain development in Massachusetts, creating more demand for workers.

FIGURE 1. TOTAL CLEAN ENERGY EMPLOYMENT, 2010-2030[22] [23]



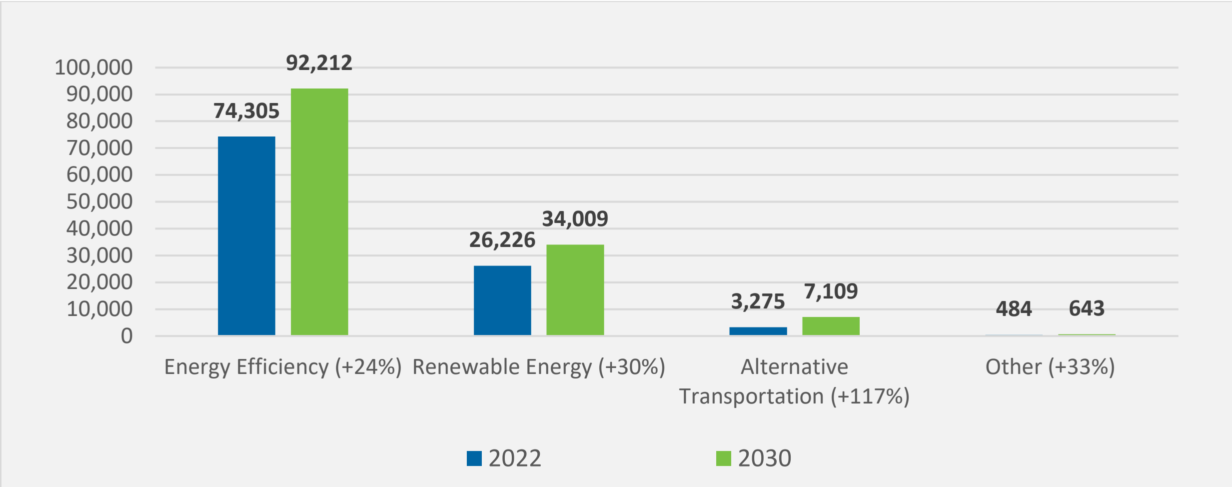
Clean Energy Technology Sector Analysis

Additional workers will be needed across all clean energy technology sectors. The Energy Efficiency, Demand Management and Clean Heating and Cooling sector (Energy Efficiency) is projected to add the greatest number of clean energy workers by 2030, creating and sustaining an additional 17,900 jobs. This accounts for 60% of all new clean energy jobs. Renewable Energy (+7,800) and Alternative Transportation (+3,800) are also projected to add a notable number of jobs, accounting for 26.5% and 13% of new clean energy jobs, respectively. Alternative Transportation is projected to grow at the greatest rate (117%), though growth in Renewable Energy (30%) and Energy Efficiency (24%) is substantial as well (Figure 2).

[22] In 2018, the underlying dataset used for employment was switched to the United States Energy and Employment Report (USEER). Because of this shift, the employment growth from 2017 through 2018 in Figure 1 represents a six-month time frame due to the differences in the data collection periods between the MassCEC and USEER data collection efforts. All subsequent years represent the 12-month change from data collected in the last quarter of the prior calendar year. For example, the 2020 data was collected in the last quarter of 2019 and thus shows employment growth from the last quarter of 2018 through the last quarter of 2019.

[23] Jobs added beyond 2022 are full-time clean energy equivalents, which likely undercounts the true "number" of workers, as many clean energy workers are likely to spend less than 100% of their time on clean energy.

FIGURE 2. CURRENT AND FORECASTED EMPLOYMENT BY TECHNOLOGY SECTOR [24] [25]



Several sub-sectors are projected to more than double in clean energy employment between 2022 and 2030.[26] These include Offshore Wind (growing 724%), Transmission and Distribution (growing 137%), Utility-Scale Solar (growing 130%) and Electric Motor Vehicles (growing 117%). Single Family Residential Energy Efficiency (+9,300 jobs) and Commercial Energy Efficiency (+2,890) are the first- and second-largest job additions (Figure 3). Employment in three sub-sectors is projected to remain static or see slight declines. By 2030, Offshore Wind and Land-Based and General Wind are estimated to have similar levels of employment, but as seen in Figure 4, Offshore Wind is projected to add an additional 2,000 jobs by 2035, while Land-Based and General Wind is projected to see modest declines.[27]

Distributed Solar will remain the renewable energy sub-sector with the largest share of jobs, but will see slight declines between 2022 and 2030, as demand is projected to peak in 2025 as more solar developers shift to installing Utility Scale Solar — which can be installed for a lower per-unit cost. Despite these shifts, Distributed Solar will make up roughly 65% of all solar-related jobs. Overall spending in Energy Storage projects remain flat after increases through 2025 but is expected to ramp up after 2030.[28]

[24] Jobs added beyond 2022 are full-time clean energy equivalents, which likely undercounts the true "number" of workers as many clean energy workers are likely to spend less than 100% of their time on clean energy.

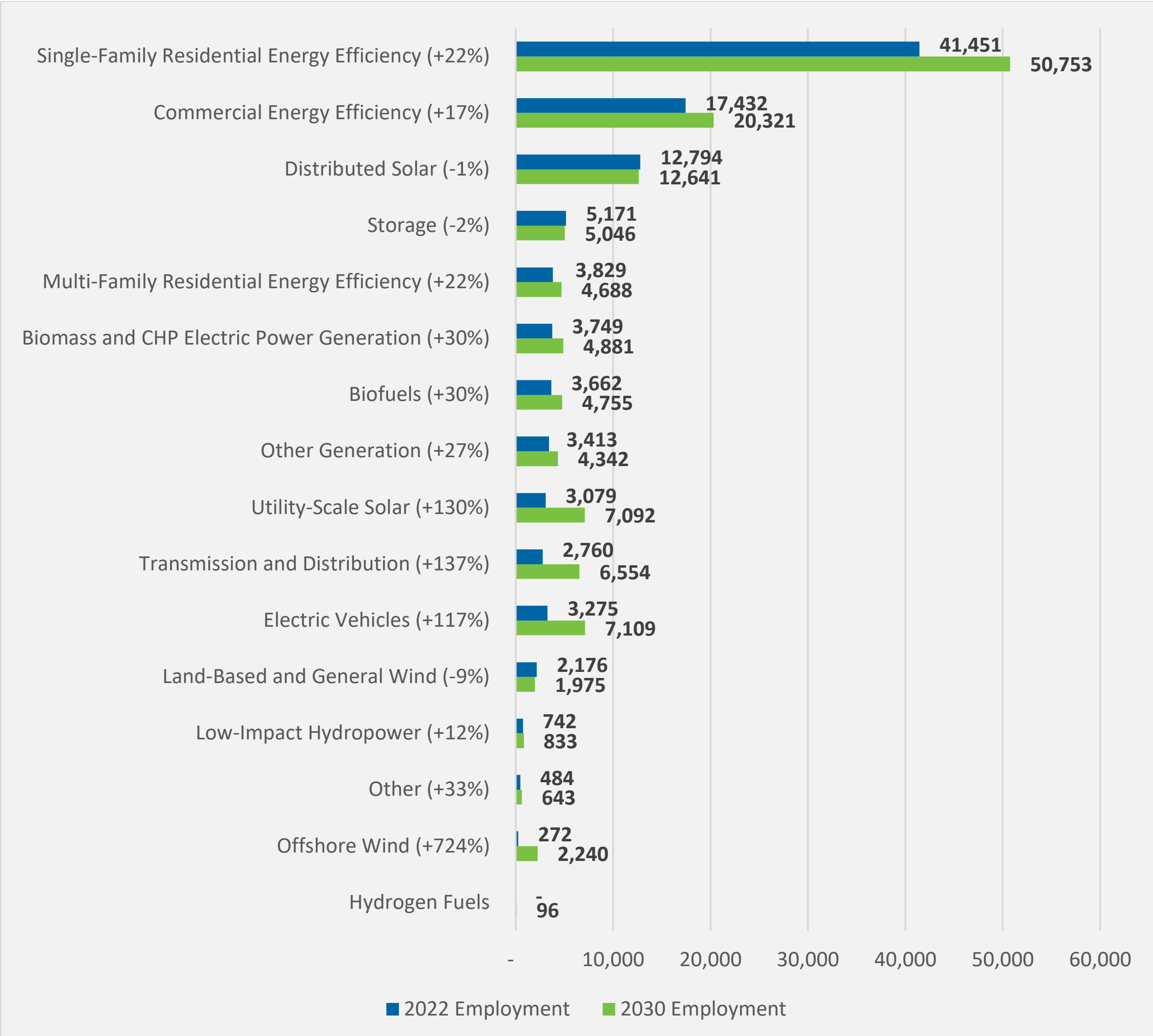
[25] The "Other" category consists of all jobs that can't be classified into one specific clean energy technology sector because the work overlaps across multiple categories. An example of this is greenhouse gas management or accounting.

[26] Sub-sectors in the Workforce Needs Assessment were developed through the modeling conducted as part of the 2025 & 2030 CECP and will not align with MA Clean Energy Industry Report categories. Please see the Methodology section of this report for additional information regarding the 2025 & 2030 CECP.

[27] Jobs in "Land-based and General Wind" are distributed across the following value chains: Construction & Maintenance, Professional Services, Manufacturing, and Other Supply Chain. Although jobs in Construction & Maintenance are largely focused on the ongoing operations of land-based wind projects in the state, jobs across other value chains, such as Professional Services, may additionally support wind projects and technology innovations at a regional, national, or international level.

[28] Based on demand projections in the 2025 & 2030 CECP, new long-duration storage is projected to spike in 2025 before plateauing between 2030-2035 and then ramping up significantly starting in 2040. For distributed solar, new installations are projected to peak in 2025 and decline somewhat from that peak through 2030. For land-based and general wind, the installation of new projects is projected to remain slow to non-existent, resulting in less spending and a small reduction in jobs in this sub-sector.

FIGURE 3. CHANGE IN CLEAN ENERGY EMPLOYMENT BY SUB-SECTOR 2022-2030[29] [30] [31]



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[29] Jobs added beyond 2022 are full-time clean energy equivalent jobs, which likely undercounts the true "number" of workers, as many clean energy workers are likely to spend less than 100% of their time on clean energy.

[30] "Biofuels" includes both woody biomass and other biofuels. "Other Generation" includes Geothermal, Marine and Tidal Power and more, while "Other" consists of all jobs that can't be classified into one specific clean energy technology sector because the work overlaps with multiple categories. An example of this could be greenhouse gas management or accounting. "Biomass and CHP Electric Power Generation" combines two technology sub-sectors into one category.

[31] In August 2022, An Act Driving Clean Energy and Offshore Wind removed woody biomass as an eligible fuel as part of the Massachusetts Clean Energy and Renewable Energy Portfolio Standards. While still eligible for the Alternative Portfolio Standard, this law brings into question whether jobs associated with woody biomass should be considered clean energy jobs. While woody biomass, biofuels and biomass electric power generation fall outside of MassCEC's four Focus Areas and associated programming, MassCEC is maintaining these jobs within the Workforce Needs Assessment to maintain alignment with the 2025 & 2030 CECP, which includes these jobs within the broader analysis, for purposes of cross-comparison.

MASSCEC FOCUS AREA ANALYSIS

Just as job growth is projected across all clean energy technology sectors, additional workers are required across all four of MassCEC's programmatic focus areas. MassCEC programming primarily targets four key focus areas: High-Performance Buildings,[32] Offshore Wind, Clean Transportation[33] and Net Zero Grid.[34] These four focus areas combined encompass about 87% of all clean energy jobs in the state for both 2022 and 2030. Employment in High-Performance Buildings is roughly five times greater than all three other focus areas combined in 2022 and will see the largest absolute number of jobs added. Offshore Wind has the largest projected growth rate (724%), followed by Clean Transportation (111%) and Net Zero Grid (70%), as compared to High-Performance Buildings (17%). Both High-Performance Buildings and Net Zero Grid focus areas include jobs in Renewable Energy and Energy Efficiency,[35] while Offshore Wind and Clean Transportation focus areas include jobs that fall entirely within Renewable Energy and Alternative Transportation, respectively.

High-Performance Buildings

Workers in this focus area construct new and retrofit existing homes and businesses with energy-efficient fixtures and appliances and improved insulation and air sealing.[36] The scale of work needed to retrofit existing residential and commercial properties will require a significant number of workers. Given the current tightness of the labor market as well as the federal 2021 Infrastructure Investment and Jobs Act — which will likely divert worker resources to other projects throughout the state — the demand for construction-related workers will likely accelerate. The scale of workers needed means that awareness and career-entry initiatives are paramount to ensure an adequate number of workers to complete retrofit activities and the construction of new high-efficiency buildings.

With nearly 13,000 additional workers needed by 2030, demand will be high across many occupations, particularly those involved in building new energy efficient buildings and retrofits, including Construction Laborers, Insulation Workers, and Building Inspectors, since energy efficiency will be the core focus of the state's building decarbonization efforts. Additionally, 430 HVAC-R Mechanics and Installers and 330 Electricians will be needed for High-Performance Buildings activities. While this is a significant number, demand for these professions is expected to continue to increase in the following decades as the pace of electrification of buildings accelerates beyond 2030.

[32] The High-Performance Buildings focus area includes all energy efficiency sub-technologies as well as distributed solar.

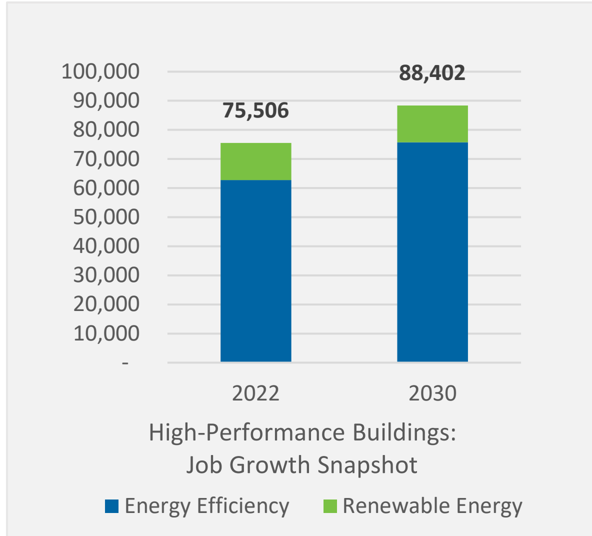
[33] The Alternative Transportation focus area does not include "Other" vehicles as counted in the Massachusetts Clean Energy Industry Report.

[34] The Net-Zero Grid Focus Area contains transmission and distribution, energy storage and utility-scale solar.

[35] For purposes of this report, the Energy Efficiency, Demand Management and Clean Heating and Cooling sector will be referenced as simply 'Energy Efficiency.'

[36] Under the 2025 & 2030 CECP 'phased' scenario, decarbonization efforts between 2022 and 2030 will focus heavily on insulation, air sealing and enhancing building envelopes, allowing for a ramp-up process with deeper electrification efforts occurring after 2030.

The Inflation Reduction Act includes substantial cost savings opportunities for residential decarbonization retrofits, including tax credits of 30% of cost (up to $2,000 per year) for heat pumps and heat pump water heaters and 30% of cost of insulation materials, among other offerings.[37] There are also significant incentives for retrofitting commercial and multifamily units. In fact, many of these credits can be stacked on top of one another and combined with state-level incentives.[38] These incentives will help push property owners to decarbonize their homes and buildings and, since the credits expire in 2032, most of this activity will be condensed into the next seven years, thereby accelerating demand for these workers.



High-Growth Occupations in the High-Performance Buildings Focus Area

Construction Laborers	(+1,420 additional workers by 2030) will construct new energy-efficient buildings and participate in construction duties in more extensive retrofits.
Insulation Workers	(+970) will spray and install additional insulation.
General Operations Managers	(+600) will manage construction and retrofit activities.
Construction and Building Inspectors (including HERS Raters and Energy Auditors)	(+530) is an occupation where some workers will work for private companies to evaluate the energy efficiency of homes while other workers will ensure buildings meet relevant building code standards.
Heating, Ventilation, Air Conditioning and Refrigeration Mechanics and Installers	(+430) will install and repair high efficiency HVAC-R systems (including heat pumps) and other energy-efficient technologies.

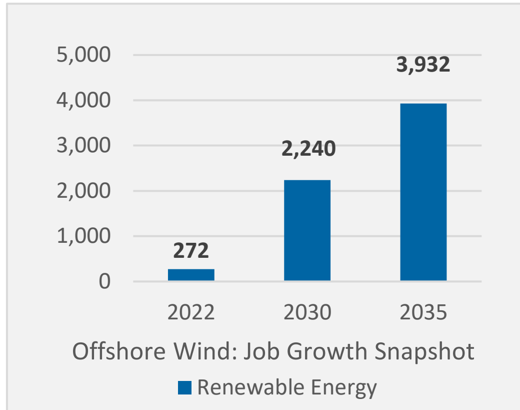
[37] https://www.energy.gov/energysaver/articles/inflation-reduction-act-2022-what-it-means-you

[38] https://www.homeinnovation.com/about/blog/20221129-mf-inflation-reduction-act

Offshore Wind

Offshore Wind (OSW) is a nascent industry in Massachusetts and the United States, but many of the roles that will see the largest increase in demand are construction and manufacturing roles that will assemble components and install turbines and supporting infrastructure. A recent report by Vineyard Wind, the company responsible for constructing the nation's first commercial-scale OSW project, highlights the number and types of jobs created and sustained through the development and construction phases of the Vineyard Wind project.[39]

While some of the high-growth OSW occupations, such as Electricians, have existing shortages of workers, other occupations, such as Miscellaneous Assemblers and Fabricators and Laborers and Material Movers, are in surplus in the overall economy. Demand within OSW represents an opportunity for these workers to transition into with some training and Global Wind Organization[40] certification. Inspectors, Testers, Sorters, Samplers and Weighers are also projected to decline throughout the overall state economy and could likely transition to OSW activities with little additional training.



High-Growth Occupations in the Offshore Wind Focus Area

Electricians	(+120 additional workers by 2030) will work on a range of activities, including connecting turbines to transmission cables.
Miscellaneous Assemblers and Fabricators	(+120) will assemble parts of turbines.
Structural Metal Fabricators and Fitters	(+100) will assemble larger structural pieces of turbines and jackets.
Miscellaneous Metal and Plastic Workers	(+80) will be involved in the manufacturing of turbine components.
Miscellaneous Installation, Maintenance, and Repair Workers	(+110) will ensure facilities and machinery are operational. Some of these roles may include maintenance on or around turbines, which may require completion of several Global Wind Organization (GWO) courses.

[39] "Vineyard Wind 1 Impact on Jobs and Economic Output," November 2022, Prepared by UMass Dartmouth, https://static1.squarespace.com/static/5a2eae32be42d64ed467f9d1/t/63ed4fea5d36ec3e4dcef2f3/1676496874921/VW1+2022+Jobs+Report.pdf.

[40] Global Wind Organization (GWO) training is required for most workers who will be on or near the water.

Understanding Offshore Wind Modeling and the Potential for Greater Impact

This research estimates that roughly 2,000 OSW jobs will be created and sustained within the state by the year 2030, in addition to the over 250 OSW jobs in 2022. The "phased" scenario used in the 2025 & 2030 CECP as well as this report projects 3.2 GW of installed capacity by 2030, with a new RFP to procure up to 3.6 GW scheduled to be released later in 2023. Installed capacity is expected to continue to grow well beyond 3.2 GW, with the 2050 CECP showing the need for as much as 23 GW of installed capacity by 2050. These additional capacity deployments could spur more OSW job growth by 2030 and will certainly result in further job growth beyond 2030.

Along with the capacity of installations, the number of jobs created is greatly dependent on the projected share of "local content," or materials, goods and services that are used from in-state sources to complete the project. To address this variable, as part of the analysis underlying the 2025 & 2030 CECP, BW Research engaged Xodus Group, an international firm with expertise in OSW development and supply chains, to develop several realistic local content assumptions based on existing and projected OSW manufacturing capabilities. Three scenarios were developed, each of which builds upon the previous scenario(s):

- A "Business as Usual" scenario has the development of the industry at a pace similar to what has been observed historically. In this scenario, Tier 1 manufacturing in Massachusetts is limited to the announced Prysmian subsea cable facility expected to provide partial supply of export cables. This is the scenario used in this report, as well as the 2025 & 2030 CECP. This scenario supports 2,200 jobs by 2030 and 9,500 jobs by 2050.
- A "Plausible but Optimistic" scenario includes the establishment of facilities to manufacture towers, transition pieces and blades in MA as well as an expansion of the capabilities of the expected export cable facility to also produce array cables. This scenario supports 3,000 jobs by 2030 and 11,400 jobs by 2050.
- A "Long Shot" local content scenario includes the establishment of a turbine nacelle assembly facility and a facility to manufacture electrical subcomponents for the offshore substation transmission infrastructure. This scenario supports 3,500 jobs by 2030 and 12,100 jobs by 2050.

The local content scenarios matter. The "Plausible but Optimistic" scenario will create 33% more jobs by 2030 than the "Business as Usual" scenario. The "Long Shot" scenario creates 51% more jobs. The timing of these scenarios is another important factor. The "Long Shot" scenario would support 2,600 more full-time direct and indirect jobs by 2050 than the to the "Business as Usual" scenario. Additionally, while these three scenarios focus on additional manufacturing opportunities for Tier 1 components like nacelles and blades, an offshore wind supply chain study compiled by NREL[41] reports that there is a higher potential for jobs and economic benefits in the indirect supply chain (which encompasses Tier 2 and 3 suppliers) than in the direct supply chain (the Tier 1 manufacturing facilities). The indirect supply chain represents a space for producing subassemblies, parts and materials for the major manufacturing facilities.

[41] "A Supply Chain Road Map for Offshore Wind Energy in the United States," Matt Shields, et al, National Renewable Energy Laboratory, January 2023, https://www.nrel.gov/docs/fy23osti/84710.pdf.

FIGURE 4. FORECASTED OFFSHORE WIND EMPLOYMENT BY SCENARIO

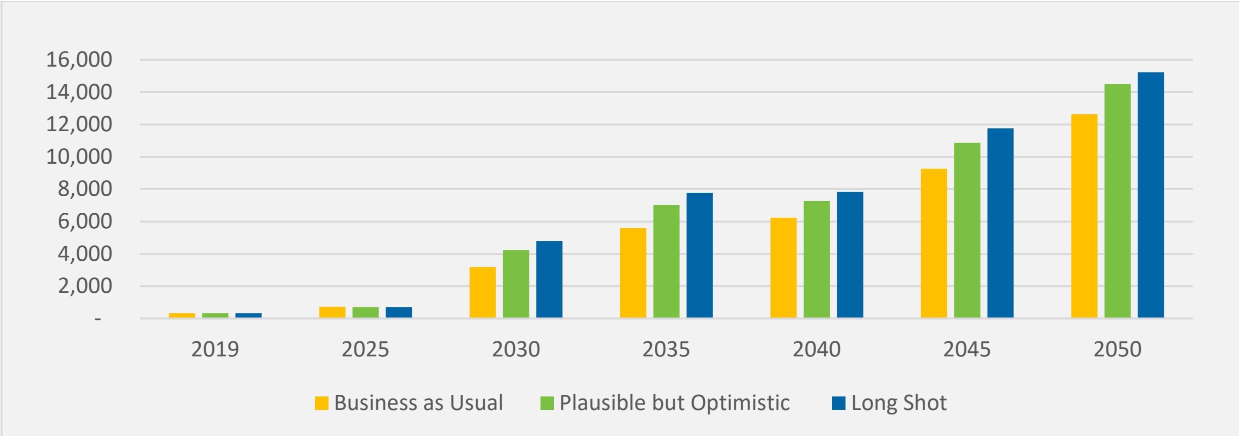
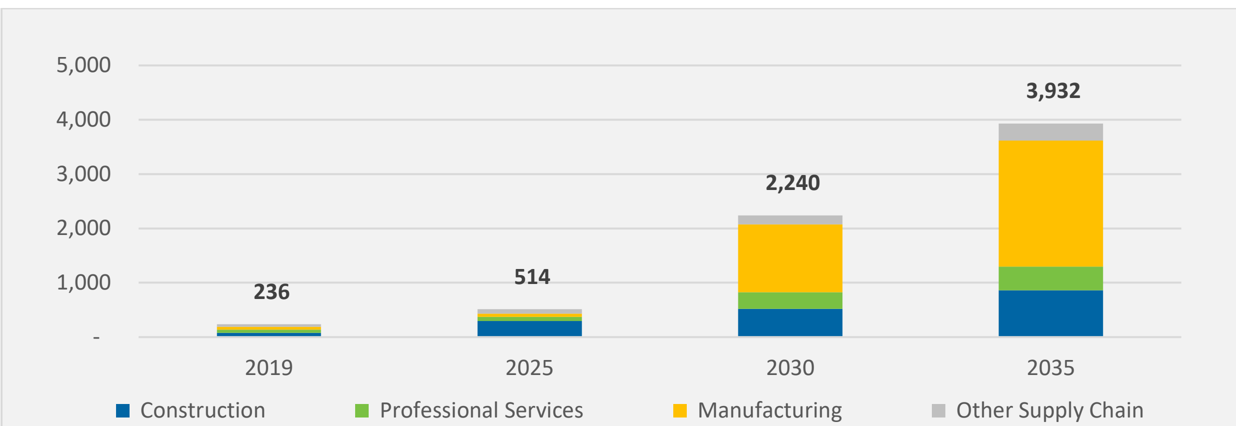


Figure 5 highlights a few important aspects of the development of OSW in Massachusetts. First, the ramp up in employment is rapid, growing from a little over 200 jobs in 2019 to over 2,200 by 2030 and 4,000 five years later in 2035. As seen in Figure 5, most of the jobs created and sustained during this time are in the manufacturing industry, as workers produce and assemble various components of the offshore wind turbines. If additional manufacturing activities are sited within the state, this number will continue to grow.

FIGURE 5. OFFSHORE WIND EMPLOYMENT (BUSINESS-AS-USUAL SCENARIO) BY VALUE CHAIN



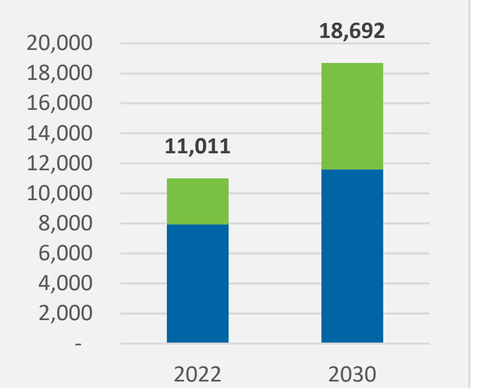
In recent years, several reports have quantified the anticipated jobs created through OSW. These reports vary in many ways, including local content assumptions, employment metrics used, and time and capacity of construction. A national report[42] produced by National Renewable Energy Laboratory (NREL) found that nearly 45,000 workers may be involved in the national OSW economy by 2030. The NREL report uses very similar methodologies as the ones utilized in this report, and the findings align with the numbers provided in this

[42] "Power Sector, Supply Chain, Jobs, and Emissions Implications of 30 Gigawatts of Offshore Wind Power by 2030," Eric Lantz, et al, National Renewable Energy Laboratory, August 2021, https://www.nrel.gov/docs/fy21osti/80031.pdf.

report.[43] A 2018 OSW Workforce Assessment previously developed for MassCEC provides numbers in job-years (a way to measure the total amount of labor-hours needed that is agnostic of time) for a smaller 1.6 GW of capacity.[44] Once accounting for the estimated duration of this project, these numbers are also relatively in line with what is forecasted in this report. For more information about how the OSW employment numbers were forecasted, please see Offshore Wind Local Content Scenarios on page 132.

Net-Zero Grid

The electrification of much of the Massachusetts economy will require efforts to upgrade and expand the grid and make it more resilient. Net Zero Grid-related jobs are likely to be found throughout the state. Much of this work will include bolstering transmission and distribution lines and installing utility-scale solar and energy storage, and many of the occupations projected to see the greatest demand require extensive electrical safety training. The duration of these trainings means that ramping up the capacity for these programs is essential long before the full demand is needed. This creates a balancing act that will require cooperation between interested parties, including utilities, utility-scale project developers, unions and regulators. If these parties work together to produce forward-looking forecasts that they are confident in, they can be sure to have the appropriately skilled and certified talent as it is needed.



Net Zero Grid: Job Growth Snapshot

Funding is a common impediment in the development of new transmission, distribution and interconnection. To help combat this barrier, in November 2022, the Biden Administration announced $13 billion in financing for the Grid Resilience Partnership (GRIP) Program and Transmission Facilitation Program.[45] These financing tools are available for grid resiliency and weatherization efforts, new grid interconnection and transmission and facilitation of innovative approaches to grid infrastructure. Greater availability of lower-cost funding will help streamline project development and financing, likely increasing the rate that these projects go from the planning stage to shovels in the dirt.

[43] This is a comparison for illustrative purposes only. Because the NREL report focuses nationally, it captures the nation's entire manufacturing base, which is different from the manufacturing industry in Massachusetts, meaning that money flows through these economies differently and a true "apples to apples" comparison is impossible.

[44] "2018 Massachusetts Offshore Wind Workforce Assessment," for the Massachusetts Clean Energy Center, Authored by Bristol Community College, UMass Dartmouth and the Massachusetts Maritime Academy.

[45] https://www.energy.gov/articles/biden-harris-administration-announces-13-billion-modernize-and-expand-americas-power-grid

High-Growth Occupations in the Net Zero Grid Focus Area

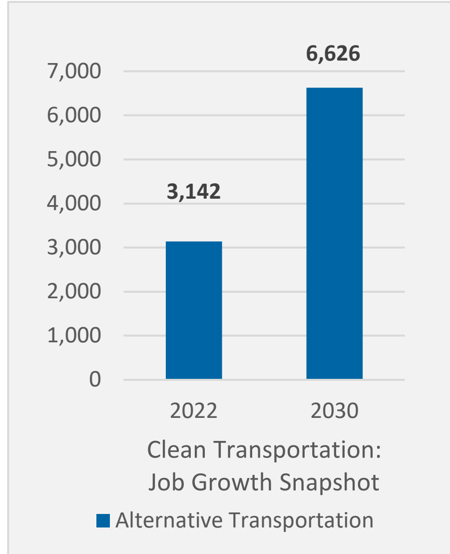
Electricians	(+1,440 additional workers by 2030) will conduct an array of work, from wiring substations to connecting utility scale solar to the grid.
Solar Photovoltaic Installers	(+800) will install utility scale solar panels and connect them to the grid. These workers are required to be licensed Electricians in the state of Massachusetts, further straining the Electrician training network.[1]
Line Installers and Repairers	(+600) install and replace transmission and distribution lines.
Construction Laborers	(+550) will assist in the construction of infrastructure that supports solar generation sites and installation of transmission and distribution lines
General and Operations Managers	(+540) will oversee operations.

Clean Transportation

The electrification of transportation will also require substantial electrical expertise. Much of the employment growth within Clean Transportation is among Electricians, who are needed to install commercial and residential charging stations throughout the state. The licensing process for Electricians takes time, so if the demand for charging infrastructure spikes suddenly — an outcome that is likely if EV adoption follows trends observed elsewhere — the supply of Electricians will not be able to keep pace. Publicly funded charging stations grants could offer an avenue to increased collaboration and data sharing, resulting in opportunities for project labor agreements, aligned workforce development funding and clearer metrics about the anticipated the number of workers required according to the duration and scale of the projects — all of which could support stronger alignment of workforce supply.

Beyond a strong demand for Electricians, there will also be increased need for professionals who understand the logistics and operations of electric fleets. Clean Transportation jobs are likely to be available throughout the state, though logistics-related opportunities will tend to cluster near transportation hubs.

There are several recent federal policies that are likely to accelerate the adoption of EVs and therefore accelerate the demand for these clean energy workers. The Inflation Reduction Act offers up to $7,500 in tax credits for eligible EVs that are below MSRP thresholds and meet critical material and battery component requirements. BloombergNEF[46] estimates that EVs could make up more than 40% of passenger vehicles sales by 2030, driven by the Inflation Reduction Act incentive and existing market trends. In addition to this significant "carrot," the EPA recently released proposed vehicle emissions standards that would provide a significant "stick" to encourage automakers to cut emissions from their product lines. The Environmental Protection Agency (EPA) projects that, depending on the path that manufacturers choose to comply with these standards, EVs could account for 67% of light-duty vehicle sales by 2032.[47] These two policies are likely to drastically accelerate EV adoption, which will similarly accelerate the demand for EV infrastructure and the workers who can develop it.



High-Growth Occupations in the Clean Transportation Focus Area

Electricians	(+2,100 additional workers by 2030) will install EV charging infrastructure.
Automotive Technicians and Repairers	(+240) will be responsible for maintaining private and commercial EVs.
General and Operations Managers	(+210) will oversee the buildout of charging infrastructure.
Logisticians and Project Manager Specialists	(+80) will manage electric fleets to ensure maximum operational capacity.
Electric Power-Line Installers and Repairers	(+70) will support the installation of additional distribution as necessary.
Construction Laborers	(+60) will build necessary structures for EV charging infrastructure.

[46] https://www.bloomberg.com/news/articles/2022-09-20/more-than-half-of-us-car-sales-will-be-electric-by-2030#xj4y7vzkg

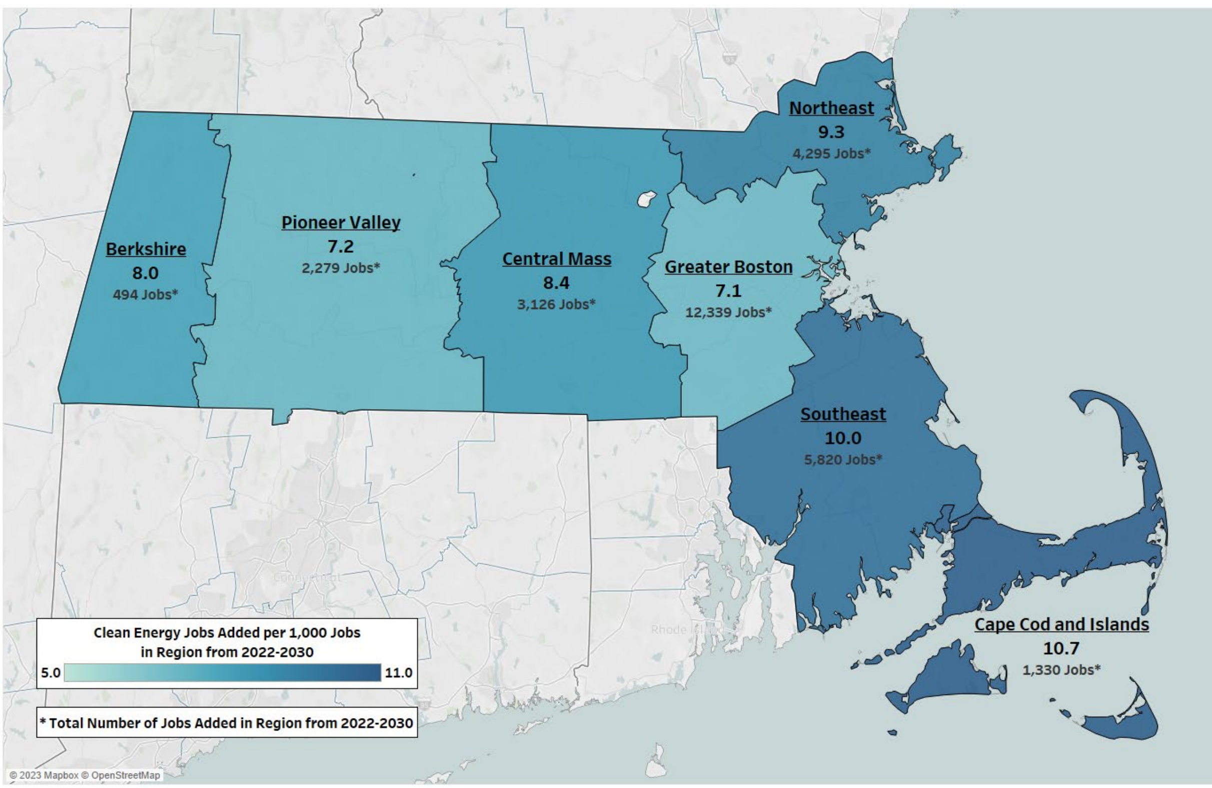
[47] https://www.epa.gov/newsreleases/biden-harris-administration-proposes-strongest-ever-pollution-standards-cars-and

GEOGRAPHIC DISTRIBUTION OF EMPLOYMENT

The Massachusetts Workforce Skills Cabinet (WSC)[48] breaks down Massachusetts into seven workforce regions: The Berkshire, Cape Cod and Islands, Central Mass, Greater Boston, Northeast, Pioneer Valley and Southeast regions. The Greater Boston region is projected to see the greatest increase in total number of clean energy jobs by 2030, adding nearly 12,300 jobs, which is 42% of all jobs created. The Southeast, Northeast and Central Mass regions are each projected to add 3,100 or more jobs during this time (Figure 6). When considered in the context of the underlying economy, the Cape Cod and Islands and Southeast regions will see the greatest proportional benefit, adding 10.7 and 10.0 clean energy jobs per 1,000 jobs economywide[49] within the region.

While the Greater Boston WSC region is projected to add the greatest number of jobs, 61% of the clean energy jobs created will be outside of Highway 128, which surrounds the city of Boston. Additionally, the broader state is projected to see a much greater proportional increase in clean energy employment than the region inside of Highway 128.

FIGURE 6. GROWTH IN CLEAN ENERGY EMPLOYMENT, TOTAL AND PER 1,000 WORKERS IN WSC REGIONS (2022-2030)



[48] The Workforce Skills Cabinet includes the Executive Office of Labor and Workforce Development (EOLWD), the Executive Office of Education (EOE) and the Executive Office of Housing and Economic Development (EOHED). For more information, see: https://www.mass.gov/regional-workforce-skills-planning-initiative

[49] "Economywide" refers to the entire economy within a region or in Massachusetts, including energy and non-energy related employment.

TABLE 1. CLEAN ENERGY EMPLOYMENT BY WSC REGION

	2022 Clean Energy Employment	2030 Clean Energy Employment	Change in Clean Energy Employment (2022-2030)						
			Percent Growth	Number of Jobs Added					
				Energy Efficiency	Renewable Energy	Alternative Transportation	Other	Total
Berkshire	1,581	2,075	31.3%	312	109	71	3	494
Pioneer Valley	6,768	9,048	33.7%	1,481	497	289	14	2,280
Central Mass	11,083	14,210	28.2%	1,810	956	345	16	3,127
Northeast	15,036	19,332	28.6%	2,499	1,254	523	20	4,296
Greater Boston	46,906	59,246	26.3%	7,588	3,117	1,560	76	12,341
Southeast	18,676	24,497	31.2%	3,306	1,579	911	25	5,821
Cape Cod and Islands	4,234	5,564	31.4%	912	271	142	5	1,330

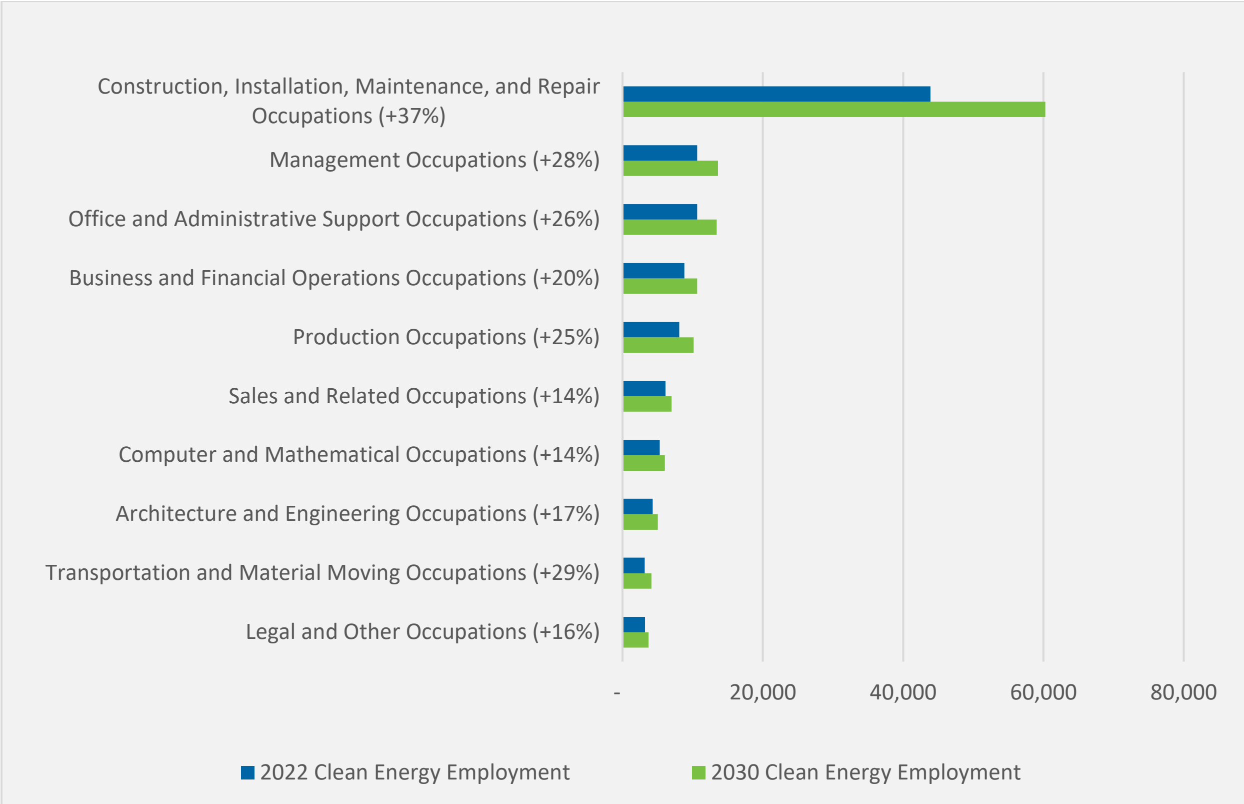
OCCUPATION-LEVEL FINDINGS

Breaking out the anticipated demand for additional workers by major occupational role reveals that Construction, Installation, Maintenance and Repair Occupations will see the greatest total increase in jobs, adding roughly 16,360 full-time jobs between 2022 and 2030 (Figure 7).[50] While this category accounts for 45% of all clean energy jobs in 2030, a wide range of other jobs will be created as result of Massachusetts pursuing its decarbonization goals. Management Occupations, Office and Administrative Support Occupations and Production Occupations are each anticipated to grow by 2,000 or more full-time jobs, which translates to hundreds of additional job openings for occupations like Architectural and Engineer Managers, Administrative Assistants and Accountants.

This report intentionally focuses on roles that have occupation-specific training or certification requirements that will require ongoing and, in many cases, expanded workforce development support to avoid jeopardizing the progress of decarbonization activities. As such, the report often presents Construction, Installation and Production-related roles in greater detail. However, there will be an array of opportunities available for prospective workers of any interest.

[50] Because of similarities in tasks of workers, this is a category of the combined "Construction Occupations" and "Installation, Maintenance and Repair Occupations" used by the Bureau of Labor Statistics.

FIGURE 7. CURRENT AND PROJECTED CLEAN ENERGY EMPLOYMENT BY OCCUPATIONAL ROLE[51] [52]



Clean energy jobs abound across our whole economy. The analysis projected job increases across 144 occupations. While the modeling encompasses a broad range of occupations, 36% of all employment growth is projected to occur within only five occupations and 65% of the growth occurs within 20 occupations. Figure 8 details the ten clean energy occupations that are projected to gain the largest number of jobs. Eight out of ten of these occupations do not require a four-year degree. Adding these additional clean energy workers will require dramatic growth rates, such as a 69% increase of Electricians and almost a full doubling of Electric Power-Line Installers and Repairers by 2030. These are increases in clean energy workers and don't include additional increases in demand for these occupations in non-clean energy industries.

> Thirty-six percent of all employment growth is projected to occur within only five occupations, and 65% of the growth occurs within 20 occupations.

[51] Jobs added beyond 2022 are full-time clean energy equivalents, which likely undercounts the true "number" of workers, as many clean energy workers are likely to spend less than 100% of their time on clean energy.

[52] These categories are based on U.S. Bureau of Labor Statistics (BLS) Occupational groups and descriptions of each group and associated occupations can be found at https://www.bls.gov/ooh/. Construction, Installation, Maintenance and Repair Occupations is the combination of "Construction Occupations" and "Installation, Maintenance and Repair Occupations." These categories were combined due to the similarity in their skills and work tasks. See Appendix I: Occupational Categories on page 123 for definitions and example occupations for these occupational groups.

FIGURE 8. TEN HIGHEST-GROWTH CLEAN ENERGY JOBS BY OCCUPATION (2022-2030)[53] [54]

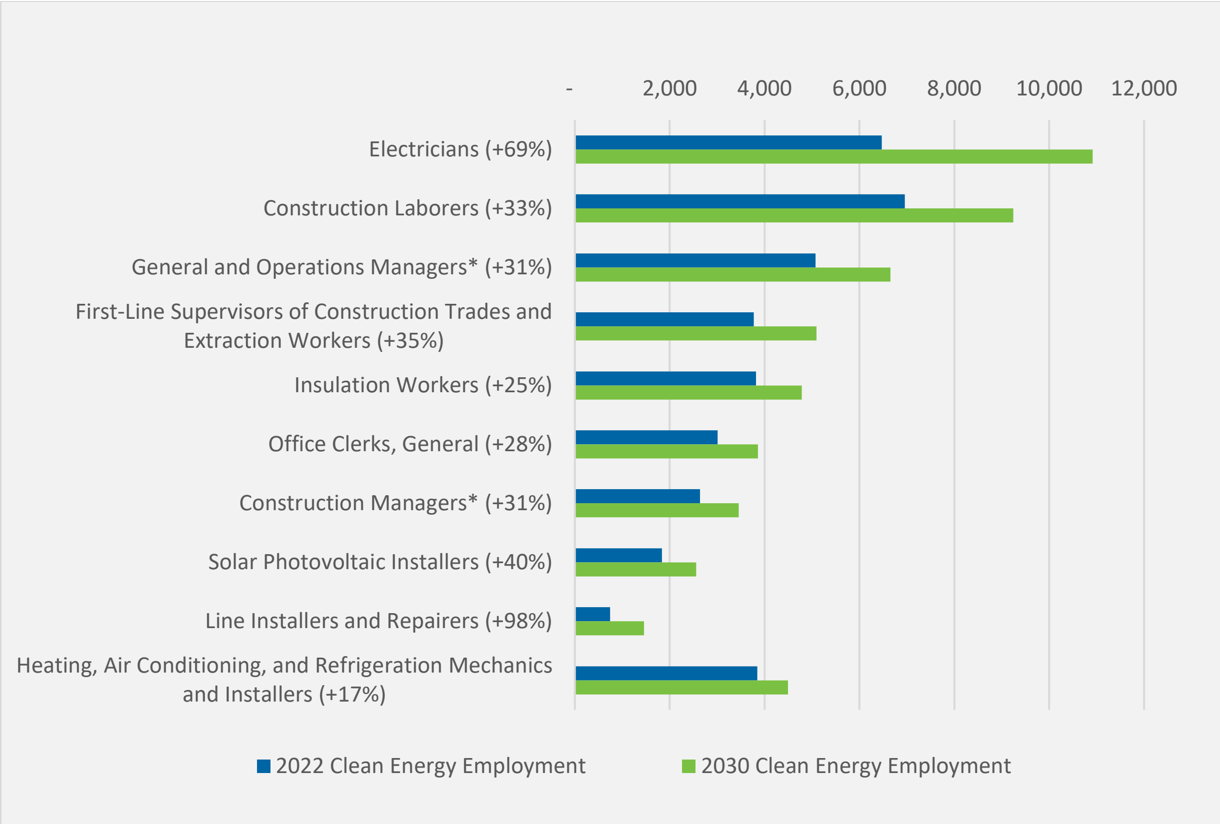


TABLE 2. MEDIAN HOURLY EARNINGS OF HIGHEST-GROWTH OCCUPATIONS [55]

Occupation	Hourly Median Wage
Electricians	$37.02
Construction Laborers	$27.90
General and Operations Managers	$60.62
First-Line Supervisors of Construction Trades and Extraction Workers	$47.19
Insulation Workers	$24.75
Office Clerks, General	$22.53
Construction Managers	$57.00
Solar Photovoltaic Installers	$30.53
Line Installers and Repairers	$48.02
Heating, Ventilation, Air Conditioning and Refrigeration Mechanics and Installers	$31.26

[53] Solar Photovoltaic Installers are required to be licensed Electricians in Massachusetts

[54] *Designates occupations that typically require a four-year degree.

[55] JobsEQ all covered employment, Massachusetts. 2022Q3.

MASSCEC WORKFORCE PRIORITY OCCUPATIONS

This report conducted an expanded analysis across 32 occupations projected to see clean energy job growth between 2022 and 2030. MassCEC selected occupations where job growth was projected in one or more of MassCEC's four focus areas and met at least one of the following criteria:

1. Occupations that are projected to see high job growth by 2030 or occupations where constraints to job growth would result in a clear bottleneck to decarbonization efforts;
2. Occupations with shorter entry-level education requirements that offer higher employee benefits and compensation upon hiring or clear advancement opportunities;
3. Occupations where new and current workers within the occupation will require upskilling or a stackable credential for their skillset to more directly support the Commonwealth's 2030 GHG emission reduction targets.

These occupations are referenced as Workforce Priority Occupations throughout this report and are a priority to MassCEC because many have occupation-specific training or certification requirements that will require ongoing and, in many cases, expanded workforce development support to avoid jeopardizing the progress of decarbonization efforts.

TABLE 3. WORKFORCE PRIORITY OCCUPATIONS BY OCCUPATIONAL CATEGORY[56] [57]

Occupation Title	2017 EOLWD Star Ranking	Median Wage	Additional Clean Energy Jobs by 2030	% Growth of Clean Energy Jobs by 2030
BUSINESS & FINANCIAL OPERATIONS OCCUPATIONS				
Cost Estimators	3.9	$ 46.87	331	35%
Logistician and Project Management Specialists (Fleet Managers)	3.6	$ 48.86	113	183%
Management Analysts	4.9	$ 52.02	252	15%
COMPUTER & MATHEMATICAL OCCUPATIONS				
Software and Web Developers, Programmers and Testers	4.8	$ 60.56	455	13%
CONSTRUCTION, INSTALLATION, MAINTENANCE AND REPAIR OCCUPATIONS				
Automotive Technicians and Repairers*	3.2	$ 25.06	103	92%
Carpenters	4.1	$ 30.47	398	29%
Construction and Building Inspectors (including Energy Analysts)	3.2	$ 36.58	532	25%
Construction Laborers	4.1	$ 27.90	2,288	33%
Electricians	4.4	$ 37.02	4,444	69%
Hazardous Waste Removal Workers	2.7	$ 22.71	41	22%

[56] *Designates occupations where clean energy job growth partially offsets projected occupation job losses economywide.

[57] The occupation star ranking was developed by the Massachusetts Executive Office of Labor and Workforce Development in 2017 and is based on a five-star ranking system in which higher-demand, higher-wage jobs are ranked higher, based on short-term hiring projections (2017), long-term hiring projections (2024) and occupation median wage.

Heating, Ventilation, Air Conditioning and Refrigeration Mechanics and Installers	4	$	31.26	650	17%
Insulation Workers	2	$	24.75	965	25%
Line Installers and Repairers	3.3	$	48.02	722	98%
Maintenance Workers and Repairers, General (including building operators)	4.1	$	24.62	161	57%
Operating Engineers and Other Construction Equipment Operators	4	$	31.69	321	29%
Pile Driver Operators	4	$	47.86	14	482%
Pipelayers, Plumbers, Pipefitters and Steamfitters	3.6	$	37.91	397	11%
Roofers	3.2	$	30.46	154	25%
Sheet Metal Workers	3.2	$	35.55	281	28%
Surface Mining Machine Operators and Earth Drillers	N/A	$	30.48	16	43%
Wind Turbine Service Technicians	N/A	$	32.38	33	33%
MANAGEMENT OCCUPATIONS					
General and Operations Managers	5	$	60.62	1,579	31%
OFFICE AND ADMINISTRATIVE SUPPORT OCCUPATIONS					
Customer Service Representatives*	4	$	22.72	404	27%
PRODUCTION OCCUPATIONS					
Engine and Other Machine Assemblers	3	$	19.46	52	697%
Miscellaneous Assemblers and Fabricators*	2.5	$	18.94	358	23%
Miscellaneous Metal Workers and Plastic Workers*	1.6	$	21.61	75	1851%
Power Plant Operators, Distributors and Dispatchers	3.8	$	44.11	116	85%
Structural Metal Fabricators and Fitters*	2.4	$	25.43	140	57%
Welding, Soldering, and Brazing Workers	2.5	$	26.31	139	28%
SALES REPRESENTATIVES OF SERVICES OCCUPATIONS					
Miscellaneous Sales Representatives, Services	4.5	$	38.13	333	22%
TRANSPORTATION AND MATERIAL MOVING OCCUPATIONS					
Crane and Tower Operators	2	$	32.47	51	331%
Ship and Boat Captains and Operators	2.5	$	30.81	40	136%

An analysis of the 32 Priority Occupations determined what training, licenses and certifications are required, preferred by clean energy employers or supplementary for each occupation. Additionally, clean energy employers were queried via survey and interview to further understand the occupations most difficult to hire for and associated hiring projections. The report then conducted an inventory of training programs and apprenticeships that were applicable to the 32 occupations and compared availability of trainings that result in entry into the occupation, or foundational training programs, to projected clean energy and economywide job growth of the occupations. Chapter 4 of this report is a culmination of this combined work, in which a gap analysis highlights 10 of the 32 Priority Occupations as being at the highest risk of becoming a bottleneck to the state meeting its 2030 GHG reduction targets.

FOSSIL FUEL EMPLOYMENT, WORKER DISPLACEMENT AND TRANSITION OPPORTUNITIES

Under the decarbonization scenario outlined in the 2025 & 2030 CECP, much of the activity through 2030 is focused on expanding electric generation capacity. It is not until after 2030 that this additional electric generation begins to drastically erode the need for fossil fuels throughout the economy. Between 2022 and 2030, there are some modest declines as electricity generation via natural gas and other fossil fuels see mild declines in demand (Figure 9 & Table 4). During this time, fossil fuel jobs will decrease slightly from 58,090 to 56,121 jobs, or a net decrease of 3.4%.

FIGURE 9. EMPLOYMENT IN FOSSIL FUEL SUB SECTORS

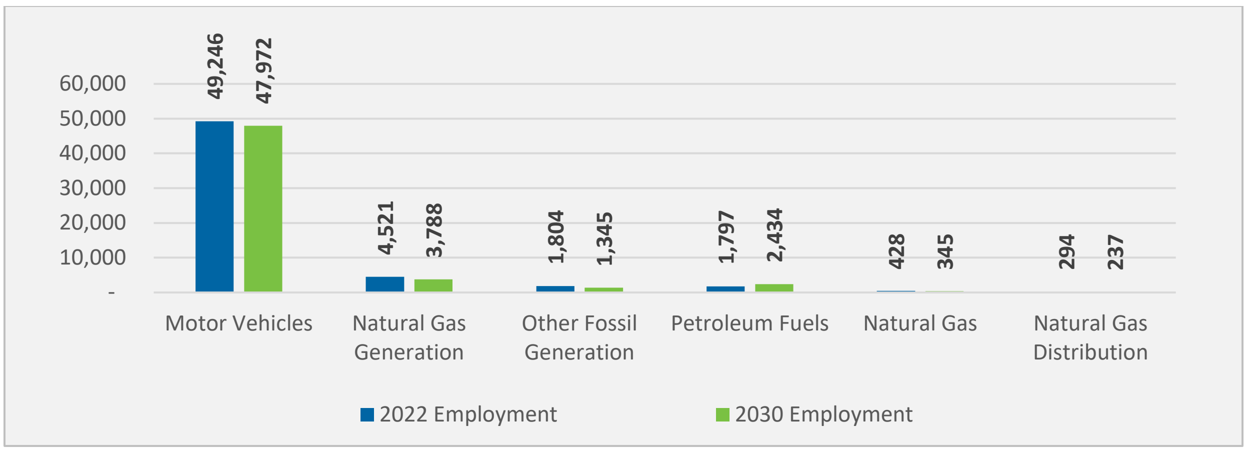


TABLE 4. DISPLACEMENT AMONG FOSSIL FUELS SUB SECTORS (2022-2030)[58]

	2022 Employment	2030 Employment	Total Job Gain/Loss	Percent Change (2022-2030)
Fossil Fuel Motor Vehicles	49,246	47,972	(1,274)	-3%
Natural Gas Generation	4,521	3,788	(733)	-16%
Other Fossil Fuel Generation	1,804	1,345	(458)	-25%
Petroleum Fuels	1,797	2,434	637	35%
Natural Gas	428	345	(84)	-19%
Natural Gas Distribution	294	237	(57)	-19%
TOTAL	**58,090**	**56,121**	**(1,969)**	**-3.4%**

Between 2022 and 2030, most of the employment losses in Fossil Fuel Motor Vehicles are due to decreased demand for gas station attendants, in which Cashiers may shed over 1,000 jobs. This decline in gas station attendants assumes that adoption of EVs will drive a decline in the demand for gas station retailers. However, if gas station retailers can pivot their businesses model to accommodate the shift in consumer behavior, including providing or expanding services as convenience stores, making accommodations for a longer-duration "rest-stop" model for EV fast charging, or if fast charging technology approaches similar times to fill up a gasoline tank,[59] then this displacement of gas station retail workers will not occur at the same scale. It will be important to monitor how gas station business models respond to the shift to EVs to determine the need to help cashiers transition to other roles, especially as this occupation has already shed jobs economywide due to increased job automation. There are also mild employment losses in motor vehicle maintenance because EVs tend to require less maintenance than their internal combustion engine counterparts.[60] Although Natural Gas Electricity Generation sees a 16% decline in employment, most of these jobs are in support and office roles, which may easily transition to high demand clean energy roles that are in the same occupation.

As seen in Table 5, nine out of 10 fossil fuel occupations projected to see the largest displacements will in actuality see changes in the types of demand for their services, rather than significant declines of their services overall. This means that these workers may reduce or stop their fossil-fuel related activity and instead have work that is captured as clean energy activity. For example, many Plant Operators, Distributors and Dispatchers may transition towards supporting a larger and more modernized grid, and auto mechanics will increasingly repair EVs alongside traditional combustion engine-powered cars. For both occupations, the increase in clean energy jobs largely offsets the anticipated declines while, across the remainder of occupations, additional clean energy jobs not only offset fossil fuel job losses but also strengthen occupational demand.

[58] Employment in Petroleum Fuels increases as investment continues to rise through 2025. This occurs as homes continue to replace or upgrade their home heating systems with fossil-fuel systems in the short-term.

[59] According to the U.S. Department of Transportation, fast charging can now provide 80% battery in 20–60 minutes.

[60] Per U.S. Department of Energy Alternative Fuels Data Center: https://afdc.energy.gov/vehicles/electric_maintenance.html#:~:text=All%2Delectric%20vehicles%20typically%20require,oil%2C%20that%20require%20regular%20maintenance

TABLE 5. NET DISPLACEMENT AMONG FOSSIL WORKERS BY OCCUPATION (2022-2030)

Occupation	Change in Fossil Fuel Jobs (2022-2030)	Clean Energy Job Additions (2022-2030)	Net Economy Additions (2022 -2030)
Cashiers	(1,028)	-	(1,028)
Power Plant Operators, Distributors and Dispatchers	(149)	116	(34)
Line Installers and Repairers	(60)	722	662
Automotive Technicians and Repairers	(289)	103	(186)
Software and Web Developers, Programmers and Testers	(51)	455	404
Management Analysts	(50)	252	203
General and Operations Managers	(49)	1,579	1,530
Electrical and Electronics Engineers	(47)	280	234
Customer Service Representatives	(42)	404	362
Accountants and Auditors	(38)	222	184
Total	**(1,803)**	**4,133**	**2,331**

The natural gas sub-sector is a key component of the current Massachusetts' economy — accounting for more than two-thirds of electricity generation in 2021[61] and serving as the primary source of heat for over half of homes.[62] The models show that the role of natural gas will not disappear overnight and certainly not by 2030. Based on modeling of the Phased Scenario as part of the 2025 & 2030 CECP analysis, losses in Petroleum Fuels and Non-Natural Gas Generation decline more rapidly after 2030 as these fuel sources are phased out, while Natural Gas Fuels and Generation continue to be used in a diminished capacity throughout the state. By 2040, an estimated 32% and 22% of workers in Natural Gas Fuels and Natural Gas Generation are displaced, respectively, from 2019 levels. State agencies and stakeholders need to develop thoughtful solutions to support larger scale transitions beyond the 2030 window.

Occupations such as Pipefitters are projected to see an increase in demand during the 2022-2030 window, both within clean energy and fossil fuels. Although these jobs may begin to decline in later decades, this window provides time for additional planning and strategy development. This includes determining ways to leverage the Federal Trade Adjustment Assistance for Workers Act (TAA), which is currently up for reauthorization. The rise of green hydrogen applications that are aligned with the state's climate objectives, which are on a similarly longer time horizon, are also an opportunity to transition these workers into a clean energy role.[63] In the immediate term through 2030, the additional demand for electricity generation and replacement of inefficient systems means that almost all occupations will see increases in demand.

In addition to fossil fuel-related transitions, the jobs created through decarbonization activities will present opportunities for a number of other occupations throughout the economy, including some occupations that

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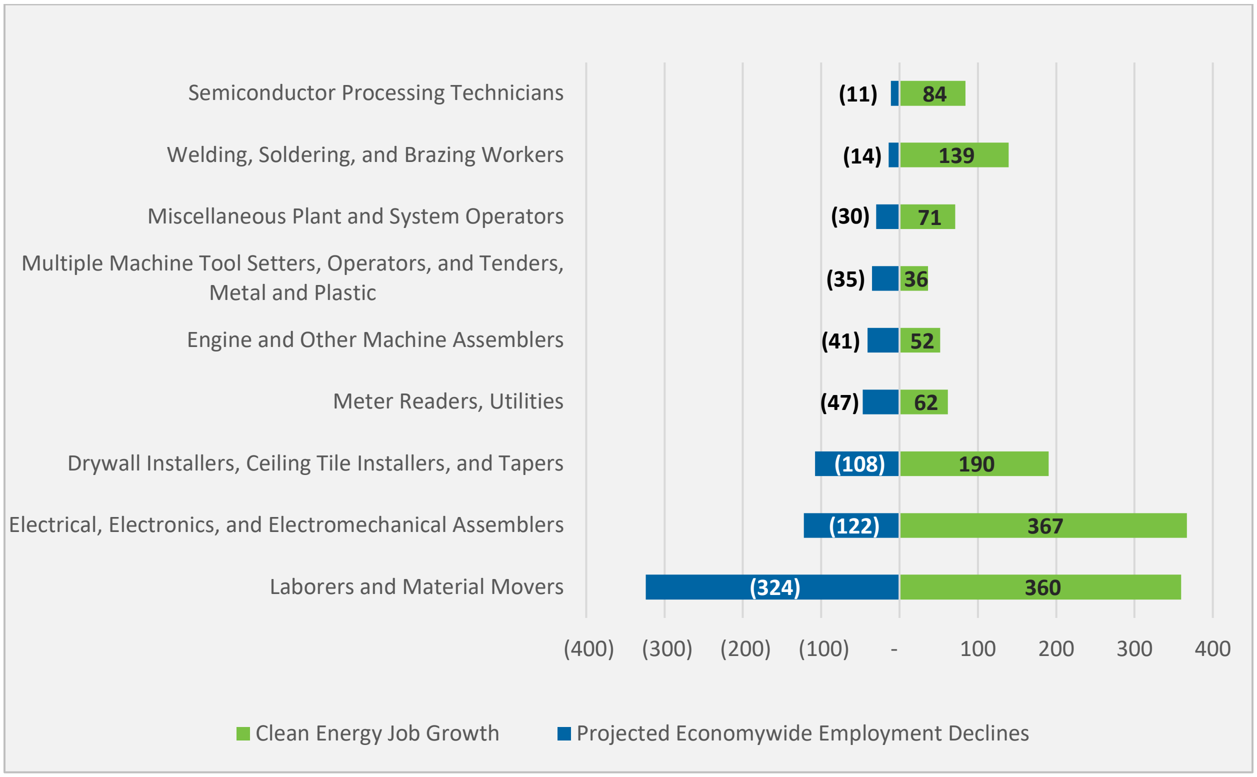
[61] https://www.eia.gov/state/analysis.php?sid=MA#:~:text=22-,Electricity,largest%20share%20in%20the%20region

[62] U.S. Census Bureau, Massachusetts, Table B25040, House Heating Fuel, 2021 ACS 1-Year Estimates Detailed Tables.

[63] Green hydrogen applications aligned with the state's climate objectives and that represent opportunities for fossil fuel workers include utility-scale hydrogen production via electrolyzers and related storage and transport via trucks and limited, targeted new pipe networks.

are projected to decline. The Massachusetts Department of Unemployment Assistance and Economic Research Department created long-term occupational outlooks that aim to predict the occupation-level growth in jobs between 2018-2028.[64] Thirty-two occupations are projected to see economywide declines but are projected to see job growth via the state's decarbonization goals. In fact, of these 32 occupations that are projected to decline economywide, nine are estimated to have clean energy growth that exceeds the corresponding projected economywide job loss. Many of these occupations are manufacturing roles, which are likely to see even greater growth through the tax credits and other financial incentives offered through the Inflation Reduction Act. This presents an enormous opportunity for these workers as these workers can transition to the clean energy economy instead of facing declining economywide demand for their skills.

FIGURE 10. CHANGE IN CLEAN ENERGY AND ECONOMYWIDE OCCUPATIONS



[64] Estimates for 2020-2030 were recently released, though, because of pandemic-related fluctuations in 2020 employment and coupled with updated data being released near the publishing of this report, 2018-2028 estimates are used.

Chapter 3: Building a More Robust and Diverse Clean Energy Workforce

Massachusetts' substantial investment in decarbonization efforts can create economic opportunity for residents of all backgrounds, including those who face more barriers to entry and those who have been historically underrepresented within the clean energy workforce. Increasing equitable access to gainful employment in the clean energy industry is not only important in securing greater economic justice, but greater inclusion is also necessary to achieve the number of workers needed. The current tightness of the labor market and lower rates of labor force participation require an expansion of the beginning stage of the workforce "funnel" into clean energy if the state is to meet its decarbonization goals. This means increasing the number of graduating students, career changers, first-time workers, new Massachusetts residents and historically underrepresented populations who are aware of, interested in and qualified for clean energy jobs. Bolstering industry awareness, scaling up workforce and education programs, increasing stakeholder collaboration and system coordination and improving alignment with employers' and participants' needs are all essential to ensuring that Massachusetts has the workforce to meet its climate goals.

> Bolstering industry awareness, scaling up workforce and education programs, increasing stakeholder collaboration and system coordination and improving alignment with employers' and participants' needs are all essential

To better understand the strengths, gaps and opportunities of the clean energy industry workforce, the research process for this report included surveys of both employers and employees, as well as focus groups and interviews with training providers, CBOs, employers and organized labor. Beyond expansive secondary research on relevant training programs, the information gathered from these stakeholders provides a more nuanced understanding of the current state of clean energy workforce programming across the Commonwealth. This chapter of the report explores the current programming and practices that shape clean energy career awareness, training and advancement alongside strategies to meet the expanding workforce needs of the clean energy industry. These strategies for improvement form a framework of changes and investments that can ensure Massachusetts is well equipped with a workforce ready to meet both the immediate and future human capital needs to decarbonize our state.

Expanding Clean Energy Career Awareness

Increasing the awareness of clean energy opportunities is a crucial first step in expanding the clean energy talent pipeline. The clean energy workers surveyed for this report indicated that a "lack of basic information about energy careers early in [their]education" was the second-most common barrier to entry into their careers, with 39% indicating that this lack of awareness was a challenge.[65] [66] Similarly, roughly 35% cited lack of career guidance or mentorship as a barrier. Training providers and CBOs often echoed this need for more information, and one of them explained the situation by stating, "One of the gaps to fill is knowledge and the intervention of education will help more people flow into clean energy. It's not deficit-based because people can do this work already. It's a lack of information." Additionally, greater shares of Black or African American, Hispanic or Latino/a/x and female respondents indicated lack of basic information and career guidance as barriers, suggesting that disparities in access to clean energy jobs are present from the start and require increased intervention in the form of strategic career awareness and navigation programming (Figure 11 & Figure 12).

FIGURE 11. CAREER AWARENESS BARRIERS TO ENTRY BY RACE/ETHNICITY

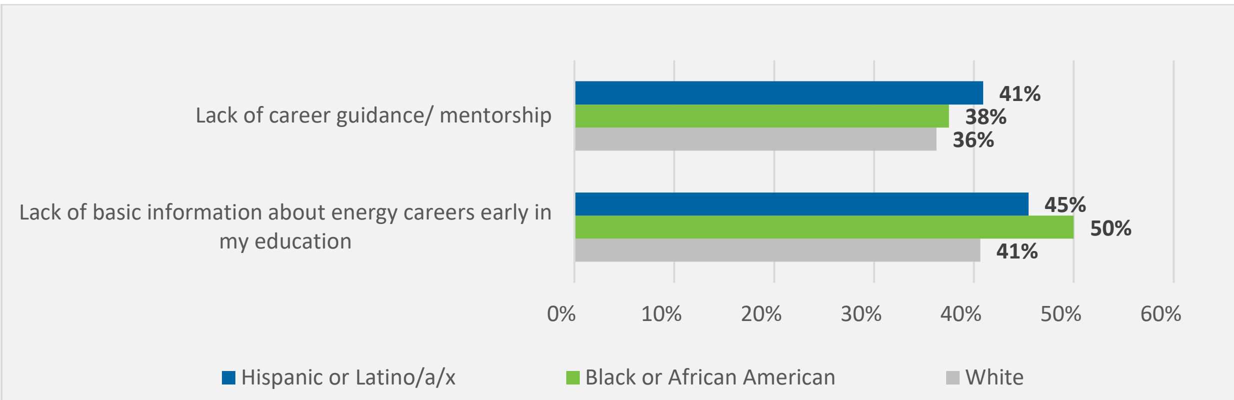
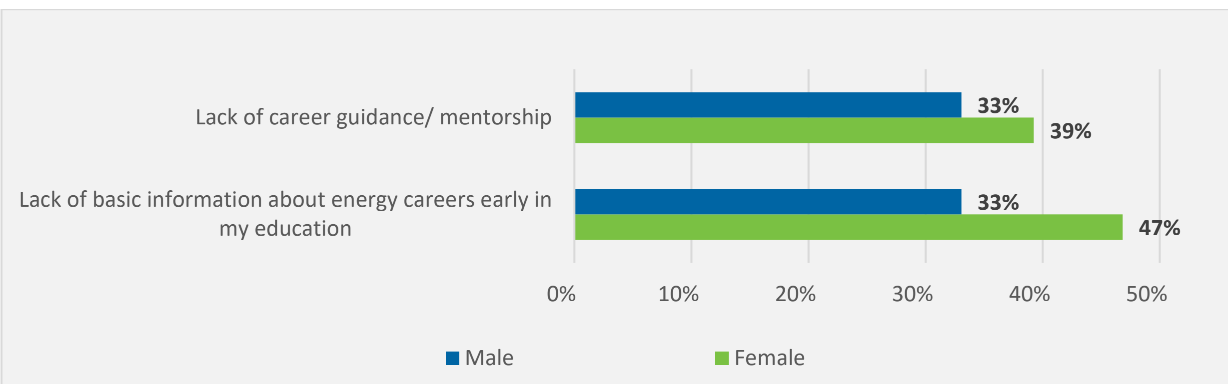


FIGURE 12. BARRIERS TO ENTRY BY GENDER



[65] The largest barrier to entry was "finding employment opportunities that are near where I live or am willing to live." See '10. Clean Energy Worker Survey Topline Responses' found in the MA Clean Energy Workforce Needs Assessment Workbook. https://www.masscec.com/resources/massachusetts-clean-energy-workforce-needs-assessment

[66] It is worth noting that these are barriers identified by workers who successfully entered the clean energy space, therefore, the results contain a "survivorship bias." The barriers and intensity of those barriers may differ for populations who are, or could be, interested in clean energy careers but did not enter the industry.

Providing accurate, engaging and comprehensive information about clean energy careers is an essential component to driving career awareness. MassCEC's CleanEnergyEducation.org includes information about what different clean energy jobs entail: the knowledge, skills, abilities and education required, entry-level and experienced-level wages, typical career progressions in the form of career pathways and relevant training providers across the state.

Even the best web-based informational offerings require companion marketing and outreach efforts to engage people's initial attention. These campaigns face daunting dual challenges of broadening people's perceptions about longstanding trades occupations like Electricians, Carpenters and Pipefitters and generating interest in newly emerging positions most people have never heard of, such as Cryogenic Technicians, Mechano-Electrical Engineers, Energy Justice Outreach Specialists and Blade Test Engineers.[67] Innovative clean energy career awareness approaches offer solutions to these challenges. For example, the Interstate Renewable Energy Council (IREC) additionally offers interactive career maps[68] and seeks to brand clean energy workers as "climate or energy heroes."[69] MassCEC has funded Bristol Community College's National Offshore Wind Institute - Wind Works campaign,[70] and additionally funded Franklin Cummings Institute of Technology and VinciVR to deploy virtual reality simulations for Offshore Wind career exploration as well as safety and technical training.[71] Both of these examples offer ways to overcome broad-based awareness obstacles, but more solutions are needed and those that show the greatest effect will need support to be scaled statewide.

Effective career awareness campaigns will additionally need to integrate input from members of target audiences to increase impact because the factors that hold the greatest appeal and the messaging that will resonate most often vary across demographics and communities. For example, the current worker survey conducted for this report found wages and benefits were important in attracting many workers to clean energy. However, prioritization of attraction factors varied across racial and ethnic groups (Figure 13).

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[67] Sample job titles were pulled from MassCEC's job boards at the time of the report. Although many clean energy jobs are not different enough to require a whole new occupational title and SOC code, they often are framed in different ways and may require niche skills or experience.

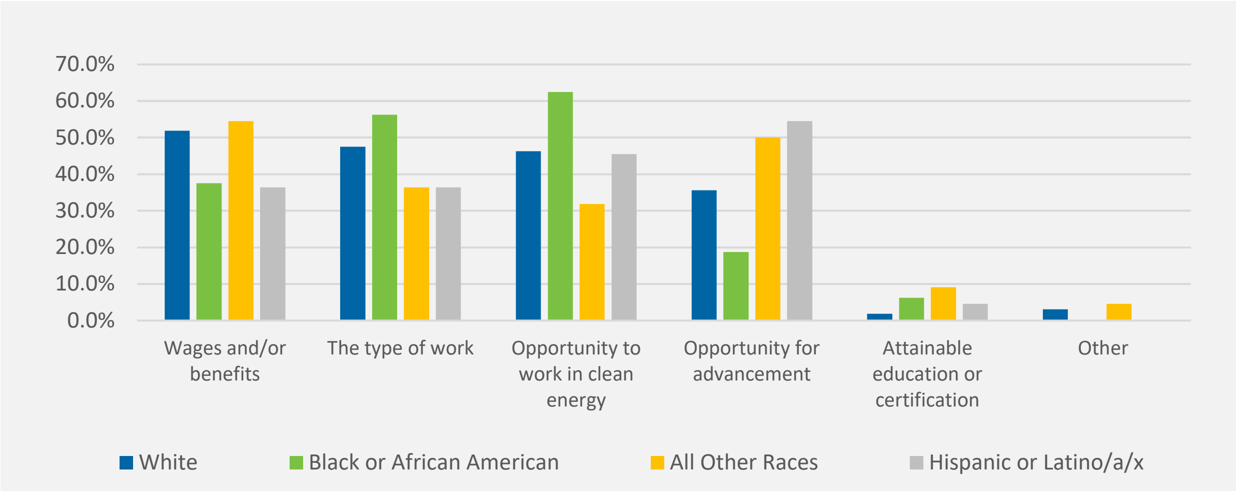
[68] https://www.irecusa.org/career-maps/

[69] https://irecusa.org/wp-content/uploads/2023/02/Alliance-Report-2.23-Interactive-compressed.pdf

[70] https://windworksforyou.com/

[71] https://www.masscec.com/program/offshore-wind-workforce-grants

FIGURE 13. TWO MOST IMPORTANT FACTORS IN ATTRACTION TO CLEAN ENERGY JOB BY RACE AND ETHNICITY[72]



The differences in attraction factors for survey respondents reinforce the reality that a range of promotional messages are required to attract different job seekers, and the need to include stakeholder input in the design process. Representation in informational campaigns is also important. In discussions with CBO leaders and staff, many emphasized the importance of potential job seekers to see people "like them" who are within these careers to foster an advanced sense of belonging and feasibility. This includes representation across all facets of the clean energy ecosystem, including the Commonwealth's start-up and clean-tech innovation sector, small and medium-scale installation contractors, and municipal light plant and investor-owned utilities.

Increasing career awareness can be maximized through strong partnerships with organizations that are on the frontlines of career and workforce development. MassHire Workforce Boards and Career Centers, Training Providers, Post-Secondary Institutions, CBOs and the K-12 educational system are all well-positioned to help address informational barriers to attracting more people into the clean energy workforce. Ensuring that these organizations have access to and the ability to navigate clean energy career and training information can amplify outreach to the populations they engage with and support.

Reaching net zero by 2050 will depend on a growing clean energy workforce for decades to come, which means youth statewide need the information to explore high-demand clean energy occupations.

While this report is scoped to identify needs through 2030, Massachusetts' commitment to reaching net zero by 2050 will depend on a growing clean energy workforce for decades to come, underscoring the importance of a well-integrated, sustainable and scalable approach to ensure that youth statewide have the information to explore the many clean energy occupations projected to be in high demand across near- and future-term models. The Massachusetts Department of Elementary and Secondary Education (DESE) has a range of existing initiatives focused on early career awareness and exploration that provide strong avenues for increasing awareness if MassCEC and industry partners collaborate with educators to establish curriculum, partnerships and work-based learning opportunities. The DESE Connecting Activities

[72] For statistical reasons, Asian, Hawaiian and Pacific Islander, Native American and Alaskan, Two or More Races and Other Race respondents were aggregated into an "All Other Races" category.

(CA) program, coordinated through the 16 MassHire Workforce Boards, annually provides students from over 200 public high schools with career development opportunities. Clean energy employers and industry associations can partner with local school districts and MassHire Workforce Boards to ensure clean energy career opportunities are well-represented. Additionally, with further coordination across education, workforce and energy, DESE's Early College and Innovation Pathways programs, which prioritize career exploration and planning, could offer ways to increase student awareness of the clean energy sector careers and programs.[73]

Recently, the 2022 Climate Act required DESE to work with the Executive Office of Labor and Workforce Development (EOLWD) to develop an Offshore Wind career training pilot program, and the findings from this effort alongside those from previous MassCEC programs like Learn and Earn and Clean Energy Activity Day can inform how best to expand broader clean energy career awareness into the K-12 curriculum.[74]

In Massachusetts, efforts to increase clean energy career awareness do not need to be limited to in-school programming. The state has a robust set of opportunities in the out-of-school-time space that can be leveraged to provide young people with valuable career exploration and work experience. For example, YouthWorks, a statewide youth employment program, could provide young people increased exposure to the clean energy industry while helping them build valuable skills and explore potential high-demand career paths. Additionally, Massachusetts has a rich network of CBOs that focus on career exploration and creating bridges to post-secondary programming and careers. These organizations provide young people with a range of resources, from mentoring and coaching to internships and informal apprenticeships, all of which can help them to explore their interests and build the skills they need to succeed in the clean energy industry and beyond.

Building Training Capacity and Effectiveness

While generating sufficient awareness and interest in clean energy roles is in many ways a prerequisite and ongoing component of scaling the workforce, the most significant investments and efforts must tie directly to adding capacity to effectively train and retain additional clean energy workers.

The substantial scale of projected worker increases across key clean energy occupations is challenging and likely to place additional strain on the existing workforce system. Of the ten highest-growth occupations, projected growth in clean energy jobs through 2030 ranges from 17% for HVAC-R Mechanics and Installers to Electricians at 69%, while Line Installers and Repairers will essentially need to double the size of their workforce focused on clean energy, with a 98% projected increase. Other high-growth occupations are projected to need to increase their clean energy workforce by 25% to 40% by 2030, with most occupations projected to need additional workers for jobs across other industries as well. Efforts to scale the capacity of training programs must align with the anticipated needs — both in terms of projected demand intensity and the specific barriers to entry — and support a just transition by addressing current inequities of Environmental Justice populations and other historically underrepresented populations, and by supporting current and former fuel workers' attainment of comparable clean energy roles.

[73] "Massachusetts Innovation Pathway & Early College Pathway Program Evaluation Impact Report," Massachusetts Department of Elementary and Secondary Education, June 2020, https://www.doe.mass.edu/research/reports/2020/06impact-evaluation.docx.

[74] An Act Driving Clean Energy and Offshore Wind, H.5060, 2022, https://malegislature.gov/Bills/192/H5060.

Feedback across the fifty interviews and three focus groups conducted for this report revealed a complex set of challenges likely to require an equally complex set of solutions.

Adding capacity will require a range of investments, coordination and support because, in most cases, just opening additional training programs or more seats within existing programs will not achieve the desired results. Feedback across the fifty interviews and three focus groups conducted for this report revealed a complex set of challenges likely to require an equally complex set of solutions. Since clean energy jobs span a wide range of occupational categories and have different types of preparation paths, the clean energy workforce development ecosystems involve a complex and often disjointed web of stakeholders.

This analysis identified just under 900 training programs that are relevant to clean energy occupations and 756 that are relevant to the 32 workforce priority occupations captured in this analysis.[75] Of these, there were 406 training programs that were foundational to providing entry into at least one of the workforce priority occupation fields, while an additional 396 training programs were identified as either preferred but not required by employers, or opportunities for specialization, upskilling or continuing education.[76]

Across the 756 training programs that are relevant to workforce priority occupations, some have a clear clean energy focus. Table 6 provides some examples of these offerings.

TABLE 6. SAMPLE CLEAN ENERGY TRAINING PROGRAMS BY CONTENT SPECIALIZATION

Content Specialization	Example Programs
High-Performance Buildings	• BPI Energy Auditing Course at Zack Academy • HERS Training Certification Prep at Roxbury Community College • Energy Systems Technology at Springfield Technical Community College • Mechanical Engineering Green Engineering Concentration at Western New England University
Net Zero Grid	• Electric Power Utility Program at Bunker Hill Community College • Energy Utility Technology Program at National Grid • Renewable Energy Technology Associates Degree at Franklin Cummings Tech

[75] Workforce priority occupations were a set of occupations identified to have particular significance in the transition to a decarbonized economy. These 32 occupations are listed in Appendix I: Occupational Categories on page 123.

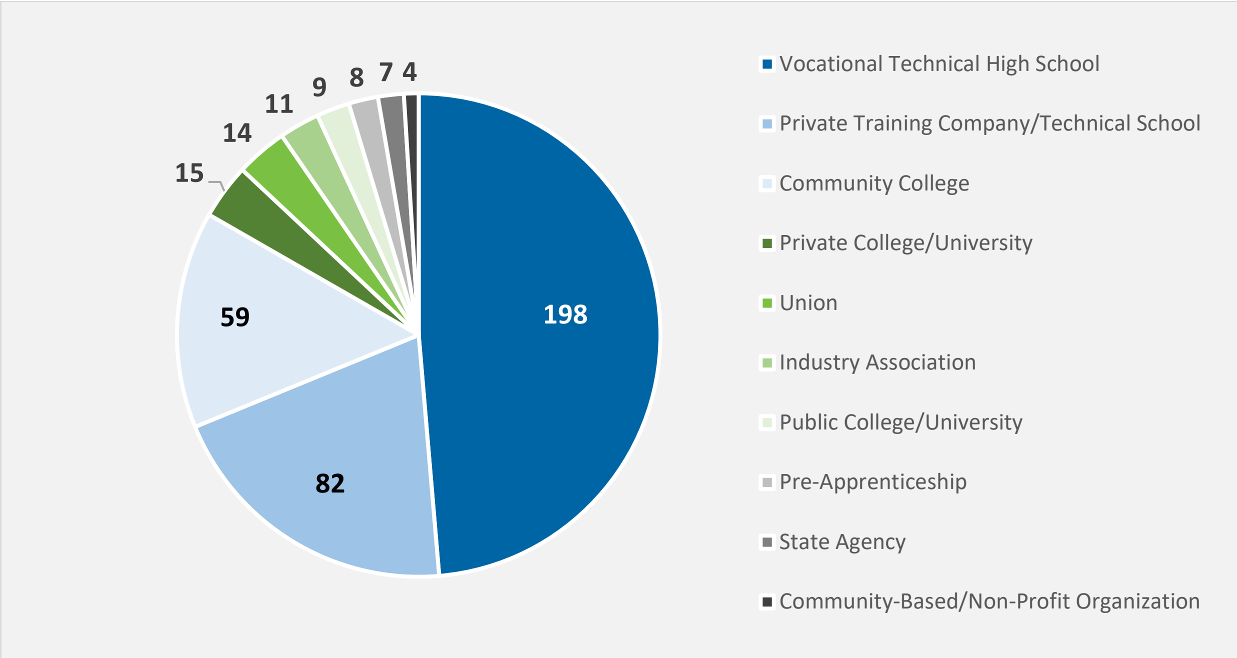
[76] A training program may be captured as foundational for some Workforce Priority Occupations, and as preferred or as an upskilling opportunity for others. Therefore the combined number of foundational and preferred and upskilling trainings is higher than the total number of trainings. Please see the training inventory in the MA Clean Energy Workforce Needs Assessment Workbook for more information. https://www.masscec.com/resources/massachusetts-clean-energy-workforce-needs-assessment

Offshore Wind	• GWO Basic Safety Training for Offshore Wind at Massachusetts Maritime Academy • Wind Energy Engineering Certificate at UMass Lowell • Offshore Wind Power Technician Certificate and GWO Basic Safety and Technical Training at Bristol Community College's National Offshore Wind Institute
Transportation	• Electric Vehicle Technology at UMass Lowell • Alternative Fuels and Emissions Certificate at Massasoit Community College
Solar Photovoltaics and Clean Heating and Cooling Technologies	• Solar Energy Certificate at Bristol Community College • Selling the Sun: Listing, Marketing and Establishing Value for Solar PV Homes at Keep Me Certified Real Estate School • Heat Pumps for Engineers and Energy Auditors at UMass Amherst
Sustainable Design and Construction	• Geothermal Energy Certificate at Holyoke Community College • Strategic Sustainability Leadership at UMass Dartmouth • LEED Green Associate Credential Prep at Roxbury Community College
Energy Planning and Policy	• Certified Green Supply Chain Professional at Springfield Technical Community College • Undergraduate Certificate in Clean Energy and Sustainability at UMass Boston • Sustainability Certificate Program at Babson College

Many other training programs are not explicitly framed as clean energy trainings, but they are relevant to many climate-critical occupations, which rely heavily on the same foundational training as their economywide counterparts that are active in other industries. For example, the foundational training and certification required for Electricians does not change simply because they are working on clean energy projects. Existing training programs can scale to support many of the roles projected to have the highest demand, but for these programs to be most effective, many will need a range of additional capacity and resources, such as updated clean energy equipment, additional training for instructors, new curricula and stronger connections with clean energy employers.

Figure 14 below provides a breakout of the 407 foundational training programs. This includes 198 vocational and technical high school training programs, 59 programs at community colleges, 14 union-sponsored apprenticeship programs, 8 pre-apprenticeship programs, 82 programs sponsored by private training organizations and 24 programs at private and public colleges and universities.

FIGURE 14. CLEAN ENERGY TRAINING ORGANIZATIONS



Analysis of the quantity and location of these training programs reveals that while there are many relevant programs throughout the state, additional and scaled training programs for specific occupations and within specific regions are likely needed to meet the workforce needs of the decarbonization economy. The subsequent chapters of this report explore these training needs more directly through an occupational and geographic lens.

While meeting the workforce development needs of the growing clean energy industry will require expanded programming and resources, Massachusetts' strong set of existing workforce systems and resources presents a firm foundation from which to build. The Executive Office of Labor and Workforce Development provides a range of relevant funding opportunities through the Department of Career Services, The Division of Apprenticeship Standards and Commonwealth Corporation.[77] The MassHire Workforce Boards and Careers Centers are regionally and locally focused agencies that specialize in meeting the needs of both employers and job seekers. The Workforce Skills Cabinet structure has fostered increased collaboration between the MassHire system, educational systems and regional planning authorities, laying a strong foundation for clean energy employers, industry associations and training providers to increase collaboration to scale pipeline of clean energy workers.

Supporting training providers to meet expanding need for clean energy workers will require additional funding for both physical capital and infrastructure, such as expanded training centers, and funding for staffing of additional training instructors and administrative workers. Training providers of all types noted that finding qualified and interested instructors was challenging, particularly as budgets are tightened and a hot labor

[77] MassHire Department of Career Services, https://www.mass.gov/orgs/masshire-department-of-career-services; Division of Apprenticeship Standards, https://www.mass.gov/orgs/division-of-apprentice-standards; Commonwealth Corporation, https://commcorp.org/

market makes remaining in the field an attractive option. Still, there is an opportunity to engage with aging workers who are recently retired or considering retirement to head to the classroom instead. Training providers and workforce development professionals can find additional sources of support and funding through leveraging the existing state workforce systems. Although collaboration with vocational and technical schools, community colleges and union training centers is increasing, with some examples highlighted in the section below, MassCEC can act as a convenor to facilitate and accelerate opportunities for enhanced coordination and collaboration.

Vocational and Technical High Schools and Programs

Vocational and technical high schools offered 48% of the identified foundational training programs in the state for workforce priority occupations. Expanding capacity of vocational and technical schools, in the form of adding seats seats at current schools, and in the long run, standing up new programs, is vital to addressing many of the greatest training-related challenges, including supplying workers for occupations most likely to present workforce bottlenecks. Interviews with training providers and employers revealed that vocational and technical high schools play a crucial role in introducing students to technical roles, fostering their interests and skill sets and preparing them for further education if necessary.

Vocational and technical schools provide an important point of access to expand diversity and representation among Environmental Justice populations in high-demand clean energy occupations. Of applications submitted in 2022 by eligible 9th grade students for entry into vocational and technical schools statewide, 42% of completed applications were submitted by students of color and 47% of completed applications were submitted by students categorized as low-income.[78] However, the state's vocational and technical schools currently receive far more applicants than they can seat. In 2022, of the 71,463 eligible 9th grade students, 22,071 completed applications but only 13,557 (61%) were provided with offers, which means the acceptance rate across vocational high schools statewide is lower than that of the University of Massachusetts, Amherst. Furthermore, the demand for some schools is even higher, such as Worcester Technical High School, which is located in an Environmental Justice neighborhood and was only able to extend offers to 43% of its 1,069 applicants.

> In 2022, statewide, 42% of completed applications to vocational and technical schools were submitted by students of color and 47% of completed applications were submitted by students categorized as low-income.

As part of a focus group conducted for this report, union leaders and staff noted the importance of the vocational system, explaining, "A lot of us advise vocational schools and we often miss that that is the starting point. These schools are grossly underfunded and safety equipment eats up a lot of the overall [equipment] budget. Trade schools are where we get a majority of workers and we have to increase investments." A 2019 policy brief examining the unmet demand for vocational education highlighted that 95% of oversubscribed schools identified building capacity as a constraint on seat expansion and another 45% identified teachers as a source of constraint.[79]

[78] CTE Chapter 74 Admissions & Waitlist Analysis, https://app.powerbigov.us/view?r=eyJrIjoiYjMzODhkZWYtYzY5Ny00Y2VlLWJkNTAtNGIxMGM0MTEwODVhIiwidCI6IjNlODYxZDE2LTQ4YjctNGEwZS05ODA2LThjMDRkODFiN2IyYSJ9.

[79] "Policy Brief: Understanding Excess Demand for High-Quality Career and Technical Education in Massachusetts," Prepared for the Massachusetts Department of Elementary and Secondary Education, Shaun M. Dougherty and Isabel

Expanding resources to vocational and technical high schools and Career Technical Education (CTE) programs is an existing priority in Massachusetts. In December 2021, the state devoted over $200 million to capital grants and skills training for vocational high schools and CTE programs, and the 2022 awards included plans to modernize and add capacity in carpentry, HVAC-R, electrical and advanced manufacturing programs, all of which are relevant to an expanded clean energy workforce.[80] The opportunity to increase capacity extends beyond the regular school day, as more vocational programs add second-shift offerings through the Chapter 74 Partnership "After Dark" program, which allows comprehensive high schools students to attend vocational programming after their regular school day, and third-shift offerings through the Career Technical Initiative (CTI), which links support from MassHire Career Centers to provide additional services, career readiness and job placement support to adults.[81] [82]

Given the crucial role these programs play in fostering interest in many occupations that are critical to the state's decarbonization efforts and building skills and career readiness, additional support for these programs is necessary. Ensuring that the curriculum includes clean energy career information and materials is an additional step that can ensure these schools continue to serve as gateways to clean energy careers for students of all backgrounds. Additionally, vocational schools and associated training programs that align with clean energy occupations are not equally distributed throughout the state. The regional analysis on page 102 of this report provides additional context about where training programs by vocational schools and other centers for training are constrained.

Providing existing students with enhanced career guidance, professional and job readiness training, and matchmaking with employers can all facilitate successful transitions to careers in students' fields of training, leading to an expanded pipeline of workers to fill jobs in climate-critical occupations. As part of a Career Vocational Technical Education Graduate Follow-up Survey extended to graduates 3 to 6 months after graduation, the percentage of program completers who went on to be employed in a field relevant to their training was roughly 33%, though rates varied significantly across programs.[83] The survey showed that 50% of vocational and technical school graduates went on to pursue additional education in the form of 2- and 4-year higher education programs, apprenticeships and private technical programs, while other graduates went on to pursue direct employment, both inside and outside of their field of training. To facilitate graduate career readiness and maximize the number of graduates entering their field of training, vocational and technical schools additionally need funding for adequate career services staffing, including specific roles such as Co-Op Coordinators, who are critical to facilitating student-employer relationships and placement into Co-Ops that provide on-the-job training opportunities, which can lead to apprenticeships and jobs post-graduation.

Post-Secondary Institutions and Programs

Post-secondary institutions, including four-year colleges and universities, community colleges, private technical colleges and training companies offered over 40% of the identified training programs in the state that offer required training services across MassCEC's workforce priority occupations. There are relevant clean

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Harbaugh, July 2019. https://www.doe.mass.edu/ccte/cvte/programs/2019-07policy-brief.pdf#search=%22Understanding%20Excess%20Demand%20for%20High-quality%20Career%20Technical%22

[80] https://www.mass.gov/service-details/2022-skills-capital-grant-program-awards

[81] https://www.doe.mass.edu/ccte/cvte/afterdark/

[82] The CTI program is relatively new and additional information can be gleaned from the first annual report, Commonwealth Corporation, *2021 Annual Report: Career Technical Initiative*, https://commcorp.org/wp-content/uploads/2022/08/CTI-2021-Annual-Report.pdf.

[83] All Ch74 completions in 2020-2021.

energy programs across all post-secondary institution types. The MassCEC Clean Energy Internship Program provides an avenue to connect students in post-secondary programs with clean energy employers. Community colleges and private technical colleges and training companies play an especially important role in cultivating the clean energy worker pipeline, as most of the workforce priority occupations do not require a four-year degree and rely more heavily on certifications and 2-year degrees.

Community colleges make up eight of the state's twelve postsecondary Minority Serving Institutions (MSIs).[84] There is an existing density of 15 community colleges distributed relatively evenly across the Commonwealth. Many offer foundational trainings and associates degree programs that support a range of MassCEC workforce priority occupations while also offering workforce stackable credentials, some of which are directly applicable to clean energy. For example, Bristol Community College offers an Offshore Wind Power Technician certificate with GWO certification, a Green Building Technology Certificate and a Solar Energy Technology certificate, among others.

The challenges facing community colleges both reflect and contrast with vocational and technical schools. Similar to vocational and technical schools, community college programs can benefit from capital and equipment grants and funding to incorporate clean energy technologies into curriculum and training labs. Clean Energy externships for current trainers, expanded efforts to engage new trainers with expertise in clean energy technologies and enhanced funding and coordination to support professional development and placement of graduates into industry positions can also have an important impact. Unlike vocational and technical schools, enrollment at community colleges is facing longstanding declines, exacerbated by the COVID-19 pandemic. In Massachusetts, community college enrollment of students pursuing degrees fell 37% between Fall 2012 and Fall 2022, a decline that has left just over 63,000 students enrolled.[85] Between Fall 2019 and Fall 2022, community colleges lost almost 13,000 students working towards degrees. Administrators highlight the increasing cost of living as an important factor impacting student decisions to continue with degrees or to enroll at all. As part of a stakeholder session, administrators clarified that in addition to facing reduced enrollment levels, many programs additionally faced elevated levels of student attrition. For students, this dynamic impacted overall morale and opportunities for networking and industry connection, while for trainers, impacts ranged from ability to apply for additional grant funding, reduced revenue streams and in some instances, concerns about the viability of continuing some training programs.

In Massachusetts, community college enrollment of students pursuing degrees fell 37% between Fall 2012 and Fall 2022, a decline that has left just over 63,000 students enrolled.

The state has been taking steps to disrupt this dynamic. The Community College SUCCESS Fund provides grants to community colleges to provide or expand wraparound support services to improve outcomes of

[84] Postsecondary MSIs are accredited academic institutions whose enrollment of a single minority or a combination of minorities exceeds 50% of the total enrollment, including graduate and undergraduate and full- and part-time students. Massachusetts-based MSIs include Benjamin Franklin Cummings Institute of Technology, Bunker Hill Community College, Cambridge College, Holyoke Community College, Middlesex Community College, North Essex Community College, North Shore Community College, Roxbury Community College, University of Massachusetts – Boston, University of Massachusetts – Lowell, Springfield Technical Community College, and the Urban College of Boston.

[85] https://www.bostonglobe.com/2022/12/27/metro/inflation-covid-continue-hurt-community-college-enrollment/

vulnerable populations, including low-income, minority, LGBTQ and disabled student populations.[86] Support services can include expanding opportunities for peer mentorship, academic skills workshops and comprehensive advising services. The initiative was funded in the state fiscal year 2021 and 2022 budgets at $7.0 and $10.5 million, respectively. Additionally, the Healey Administration has proposed to set aside funding in the 2024 state budget to pay for tuition, books and wraparound services for residents older than 25.[87] Both of these efforts directly support community college students who are older or who may be facing a range of barriers to success.

MassCEC has an additional role to play in increasing awareness and outreach efforts to support expanded recruitment into community college and other post-secondary institution training programs, whether by broad-based or targeted outreach methods. MassCEC can additionally act as a convenor between key stakeholders, including community college administrators and employers to facilitate opportunities for collaboration and placement.

Union Training Centers, Apprenticeship and Pre-Apprenticeship Programs

While union training programs make up just under 2% of the identified number of foundational training programs for clean energy workforce priority occupations statewide, they play a far greater role in supplying new candidates to these fields. In contrast to programs at individual vocational high schools or CBOs that often have relatively small annual cohorts, many union training centers serve much larger numbers of new entrants to these climate-critical fields. For example, International Brotherhood of Electrical Workers (IBEW) 103, the Boston-based Electrician union, graduates between 250–300 from their apprenticeship program each year. Additionally, for climate-critical occupations that require extensive training and licensing, students who complete a vocational high school or community college technical program will still need to secure an apprenticeship to meet state licensing requirements and progress in their career path.

Just as the current demand for seats in vocational high school programs greatly outpaces availability, many union staff noted long waiting lists for apprenticeships. One representative explained, "There is certainly no shortage of applicants for the [union apprenticeship] program. We have way more people applying than we can take on. We're dealing with strategies on how to retain people from certain communities and exploring ways to provide transportation and daycare."

Scaling capacity through union training programs will be a critical component of growing the workforce needed to meet the state's climate goals. Still, the type of capacity that needs to be added is different than other training pathways. Additional public workforce funding can help ensure unions have the training equipment and curricula to keep current with clean energy advances. For example, MassCEC's Offshore Wind Works program provided a grant to support members of the International Association of Bridge, Structural, Ornamental and Reinforcing Iron Workers Local 7 to acquire GWO Basic Safety Training certification and their Hytorc tool certification. The same program also awarded IBEW Local 223 a grant to establish a high voltage and fiber optic

Scaling capacity through union training programs will be a critical component of growing the workforce needed to meet the state's climate goals.

[86] https://budget.digital.mass.gov/summary/fy22/enacted/education/higher-education/71004002

[87] https://www.boston.com/news/politics/2023/03/01/massachusetts-free-community-college-maura-healey-massreconnect/

training program for skilled Electricians in partnership with a Vineyard Wind 1 project cable supplier. However, public workforce grants generally will not change the number of apprentices that unions enroll in their programs. Unions calibrate class sizes based on demand for work. In professions like Electricians, which take four to five years of training to reach the fully licensed status needed to work independently on jobs, the timeline for scaling is long. Increased utilization of union labor for publicly funded decarbonization projects would lead to expanded incoming apprentice cohorts in relevant unions and aligns with the current federal priority of engaging organized labor and ensuring high-quality jobs.

As climate-critical unions scale incoming classes to meet the decarbonization workforce needs, there is an additional opportunity to prioritize inclusivity and build a more expansive profile of trades workers. Many unions have already started prioritizing DEI. In 2021, the North American Building Trades Union (NABTU) commissioned the Institute for Construction Employment Research (ICERES) to conduct a study of female and minority participation in the U.S. construction industry as part of a larger effort to advance inclusivity in the trades. While women and minorities remain underrepresented across many trades, a comparison of union versus non-union apprenticeship programs found that “female, Black, Hispanic and ‘other race’ apprentices account for a greater proportion of [union] apprentices than their non-[union] counterparts, both historically (1999- 2019) and in the most recent year of the data (2019).”

The increased commitment to diversity on the part of many unions is encouraging. It underscores the importance of expanding the current practices that show the most promise in terms of engaging and preparing a broader range of candidates to enroll in union training programs. Pre-apprenticeship programs, which offer younger job seekers an opportunity to learn about careers through hands-on and paid instruction, were also identified as a key mechanism to increase the number and diversity of prepared job seekers. For example, Building Pathways in Boston has a decade-plus track record of working with trainees groups comprised of 90% people of color and over 40% women. In interviews and focus group sessions, union representatives noted the importance of pre-apprenticeship and vocational and technical school programs in preparing applicants for entry into unions and the day-to-day of what the occupations entail. One staff representative explained, “Outreach to vocational and CTE programs and pre-apprenticeships is a good measure to know that those folks have the greatest chance of success for retention.”

“Outreach to vocational and CTE programs and pre-apprenticeships is a good measure to know that those folks have the greatest chance of success for retention.”
- Union Staff Member

Interviews with a range of training providers and employers identified that some job seekers, particularly those who were young and in their first professional experience, struggled with simple work preparedness tasks, such as showing up on time and refraining from using their cellphone during instruction or working hours. These same employers and training providers praised the success of work-preparedness programs, including pre-apprenticeship programs and vocational and technical education. Employers and training providers also identified a shortage of work-preparedness programs, noting that some candidates who do not complete these programs are ill-prepared for the intensity or day-to-day requirements of the occupations for which they are training. One union staff member noted the importance: “The biggest challenge with apprenticeships is understanding the lifestyle, and pre-apprenticeships help people understand if that is a path they want to take. Students live the lifestyle and get exposure to the kind of work while they go through the program.”

Pre-apprenticeship programs promote career awareness and interest, build foundational technical skill sets and foster work readiness while offering stipends or financial compensation. These programs have also successfully reached disadvantaged populations and provided support services to reduce barriers and bolster success. The experience that pre-apprenticeships and vocational schools offer job seekers can also help alleviate the concerns of 50% of employers who stated they had enough applicants but those applicants lacked experience.[88] Given the success of these programs in preparing talent of all backgrounds for clean energy career success, scaling existing programs and providing the resources for new programs in regions that currently lack these supports can offer expanded on-ramps for future generations of clean energy workers.

The Role of Community-Based Organizations

CBOs are critical to building a robust and equitable clean energy workforce. CBOs often have the strongest connections to populations that are historically disadvantaged and often hardest to reach. Massachusetts has a vast network of CBOs but very few have existing clean energy workforce development programs. Interviews for this report included some of those currently involved in clean energy workforce development and those that have workforce development programs but have yet to get deeply involved in clean energy workforce activities. Staff from CBOs in this latter category offered insights into what resources would be needed for their organizations to directly offer or strategically support clean energy workforce development.

Many interviewees were aware of recent state and federal legislation to address climate change and an awareness that expanded job opportunities were on the horizon. Interviewees indicated a willingness to explore helping their communities pursue clean energy workforce opportunities, but most lacked direct knowledge about clean energy careers. One staff member from a CBO highlighted that, **"**We have developed relationships in tech, biotech and were asked to do work with skills acquisition and certification, and we built a whole set of processes for what explorations mean and how to align that to employer needs. We are putting together all these pieces and we are trying to figure out how to apply it to the green industry." CBOs frequently indicated an interest in partnering with clean energy firms to understand industry needs and specific training requirements. Additionally, CBO interviewees emphasized the importance of positioning participants for tangible positions with good pay and a pathway to a sustainable career, rather than abstract offerings of opportunities. Commenting on this crucial program element, a CBO staff member explained, "I would never start a program without specific figures and ties to employers who are willing to take on people at the end of the program. If the outlook is 20 people, I wouldn't start that training because that's not sustainable. You need more demand because it is time- and resource-intensive."

"I would never start a program without specific figures and ties to employers who are willing to take on people at the end of the program. If the outlook is 20 people, I wouldn't start that training because that's not sustainable. You need more demand because it is time- and resource-intensive."

- Community-Based Organization

Bringing more CBOs into the Clean Energy Workforce development ecosystem — both as training providers and partners in offering wrap around support services — is essential to reaching more potential clean energy workers across disadvantage communities throughout the Commonwealth. Additionally, given the current federal prioritization on community benefit plans as a key

[88] For more information about hiring difficulty among clean energy employers, please see "Placing, Retaining and Advancing Workers" on page 68.

component of proposals for funding through the Department of Energy, strong partnerships with CBOs can also help bring more resources to fund decarbonization efforts across the state. Interviews with CBOs yielded a common set of requests for support that need to be prioritized to effectively engage more CBOs to support clean energy workforce and training offerings (Table 7).

TABLE 7. FIVE PROMINENT REQUESTS FROM CBOS CONSIDERING EXPANDING INTO CLEAN ENERGY WORKFORCE DEVELOPMENT

Requests	Needs Addressed
Clear, Accessible and Customizable information about Clean Energy Careers	• Gaps in clean energy career awareness among participants • Limited staff capacity within CBOs to research and create career exploration collateral • A starting point from which to modify for specific populations
Reliable Data about Job Demands and Timing	• Information for scoping program size and targeted employer outreach efforts
Support Building Relationships with Clean Energy Employers	• Insights about what skills and experiences to emphasize in the training design • Placement partners for completing participants • Ongoing feedback about how best to adjust the programming to prepare job seekers to meet employer needs
Robust and Reliable Funding for Comprehensive Training Programs and Support Services	• Resources for training equipment, infrastructure and staffing, including capacity to bolster community outreach and engagement efforts • Funding to devote to comprehensive support services that address transportation needs, adult education, childcare, housing insecurity, benefits cliffs and more[89] • Multi-year resources that cover the full per-participant costs and allow time for organizations to identify ways to blend and braid funding sources
An Asset-Based Approach to Engaging the Communities and Participants	• Acknowledge the wealth of experience and knowledge that participants can bring to their workplaces • As relevant, recognize prior experience from outside the U.S. and transferable skills from other industries to cast a broader net on which roles participants can be competitive for clean energy role

The MassCEC is well positioned to provide support to interested CBOs. Alongside industry organizations, MassCEC can serve as a connective tissue helping CBOs and employer partners and communicate directly about respective needs. Improving and expanding existing resources, such as MassCEC's CleanEnergyEducation.org, could provide career awareness information alongside timely information on regional and statewide occupational demands across the clean energy industry. Finally, MassCEC's Equity

[89] Benefits cliffs are where additional income that families earn make folks ineligible for benefits in an amount that exceeds the gain in income, resulting in a net loss of effective income. For example, a single mother of three children may lose the entirety of their Head Start benefits if their annual income goes from $22,000 to $24,000 per year. The loss of benefits (more than $10,000 in this case) greatly exceeds the additional income. UMass Boston researcher Susan Crandall has a large body of research on benefits cliffs, some of which can be found here: https://scholarworks.umb.edu/csp_pubs/88/.

Workforce Working Group provides a standing space for community stakeholders to provide input into the program designs that will best address the barriers and build on the strengths of their participants.

Improving Program Quality: The Role of Support Services and Increased Coordination

To meet the needs of an expanding clean energy workforce, workforce development efforts must be scaled and improved. The following list of best practices was developed through conducting online research, interviewing experts in the field and facilitated conversations with program managers of workforce programs. These practices were explicitly mentioned by experts with vast expertise in clean energy workforce development and by literature reviews on the topic.

The best practices listed below in Table 8 contribute to overall program quality and participant success, but they are especially important to increase equity and access for populations that have been historically marginalized, including Environmental Justice populations, Black, Indigenous and people of color (BIPOC) communities, women, and people who were previously incarcerated.

TABLE 8. BEST PRACTICES FOR CLEAN ENERGY WORKFORCE DEVELOPMENT PROGRAMS

Phase	Best Practices
Program Design	Engage employers in training design to ensure that the skills and experience prioritized in the training program meet the market needs. Revisit program design, outcomes and opportunities for improvement regularly with employers as market needs continually evolve.
	Evaluate participation requirements and remove unnecessary requirements that may act as a barrier to participation among populations with limited resources and support. For requirements that are necessary, offer support services and referrals to help interested individuals overcome barriers and access training.
	Review training materials and methods to improve learner accessibility for participants. Include instructional modifications to address barriers and determine what additional academic supports will be offered prior and alongside programming. Consider how partner organizations can provide services beyond those included in the training program.
	Prioritize collaboration over competition. Workforce development programs should collaborate to avoid “reinventing the wheel” and developing a new program from scratch when examples of successful programs exist in other communities. Ongoing collaboration among different programs benefits all parties and leads to increased opportunities to share curricular resources and insights gathered from employer partners.
Outreach and Recruitment	Design outreach and recruitment with input from members of the target populations and communities. Be mindful that exposure and awareness of clean energy jobs vary and messaging may resonate differently from one community to the next. Consider engaging community advocates and recent program participants as part of the outreach plan.

	Provide clear information and opportunities to explore the target occupation, possible work environments and career pathway options as part of the recruitment strategy. Helping potential participants understand the challenges and opportunities of the occupation positions programs to have participants who are more invested in the training and employment opportunities.
	Provide staff who are working on outreach and recruitment with referral information for alternate programs in the area to give staff options for helping individuals who need access to workforce development programming but do not indicate strong interest or fit for the program's occupational focus.
	Participate in early awareness efforts in the communities that the program seeks to serve, even if youth and young adults are not part of the target population. Early awareness and exposure to clean energy careers can address existing disparities in career access and be part of an intentional two-generation programmatic strategy.
Training and Support	Build multiple methods for skills assessment into the training program and share progress evaluations with participants regularly. Align assessment tools directly to relevant industry certification tests and partner employers' expectations. Provide relevant soft or work-readiness skills alongside technical skills and include time for participants to reflect on and debrief about progress.
	Leverage hands-on training opportunities and, whenever possible, work-based learning components to provide participants with practical knowledge and application of skills through authentic work and projects that closely mirror current work of prospective employers.
	Prioritize funding models that allow participants who would not otherwise be able to access training to receive robust support services, wages and benefits during training. Build robust partnerships with CBOs and local workforce agencies to maximize participant access to support services. Ensure that program support staff directly understand public benefits and cliff effects or partner to provide support through referrals.
	Continue the career exploration process throughout the programming to help participants increase their understanding of not only immediate target occupations but also longer-term career path opportunities. Engage current workers as mentors and help participants develop a clean energy professional network prior to completing the program. Disparities in social capital must be addressed intentionally to drive quality, long-term outcomes for all participants.
Placement and Advancement	Establish pathways for job placements for trainees and provide support for participants in the job search process, both during and after the training. Greater shares of BIPOC and female respondents indicated that resume development was a barrier to employment and advancement, so programs must support these essential career acquisition assets. It also helpful to continually debrief with participants about the job search process. Workforce development programs can help address issues of bias in employer hiring processes, but only if staff ask these questions and understand the challenges.

	Work with employer partners to understand the key components of their hiring processes, including drug testing and background checks. Strong partnerships with employers can lead to a more nuanced understanding of non-negotiable hiring standards and those that have more room for discussion or advocacy. Programs need to prepare participants for these components well in advance of the job search timeline. Formerly court-involved participants may be eligible to seal some or all criminal records, but the process takes time and support.
	Prioritize funding models that are robust enough to include short-term, subsidized employment to lower the initial hiring risk for employers. Given the high demand for many clean energy occupations, this option often does not need to be applied in a universal fashion, but being able to include short-term, subsidized employment is a valuable tool for employer engagement and participant support.
	Support services should not stop with program completion. Ongoing support services, such as mentorship or financial assistance, are essential to helping participants acclimate to new work environments, address instances of workplace bias, strengthen workplace skills and mitigate cliff effects associated with transitioning to full-time employment. Additionally, programs must work with participants to re-evaluate how transportation, childcare and other support service needs are likely to change during the initial transition to employment.

While all the above best practices are essential, the importance of robust support services routinely rose to the top of recommendations that stakeholders identified in individual interviews and focus group sessions. Training providers and employers alike shared many instances of how job seekers needed increased support for themselves and their families while completing training programs or when beginning a new job. Whether it be finding affordable childcare while participating in training or helping newly hired workers secure reliable transportation to and from work, support services ensure that job seekers are not disadvantaged simply because they lack initial resources. Mentorship, living wage stipends, placement support and ongoing professional development and check-ins are among the other resources that can support job seeker success.

Increased support services can remove barriers that would otherwise hinder the economic participation of some Environmental Justice populations as well as workers who are currently underrepresented and may face additional barriers. Training providers, employers and CBOs all understand that the challenges that job seekers face are substantial. High costs of childcare, expensive, unreliable or indirect transit, housing costs, rising cost of living and potential benefits cliffs are all obstacles that can seriously impair a job seeker’s ability to succeed in starting a new career. These challenges are often interrelated and rarely occur in isolation. The breadth of these challenges that job seekers face means that different government agencies — from housing to workforce training to transportation — can coordinate to develop comprehensive programs that can address the needs of job seekers while minimizing administrative redundancies or programmatic inefficiencies. This “whole-of-government” approach is particularly important when considering the role that

> High costs of childcare, expensive, unreliable or indirect transit, housing costs, rising cost of living and potential benefits cliffs are all obstacles that can seriously impair a job seekers ability to succeed in starting a new career.

support services, which can include state assistance programs, will need to play in helping increase equity in access to clean energy careers. Without these additional supports and increased coordination, the base of the future clean energy workforce supply will continue to be constrained for a range of reasons, from training programs being too expensive, inaccessible by public transit or having prerequisites that present barriers for job seekers.

Powering a Just Transition

As Massachusetts works to decarbonize and expand the capacity to train additional clean energy workers, it is crucial that this transition is just and equitable for all, which requires extending the economic benefits of these additional clean energy jobs to all communities. Ensuring that those communities that have been historically marginalized and disproportionately impacted by environmental pollution and climate change are able to benefit from the growing clean energy jobs will require dedicated financial resources and consistent engagement with community stakeholders.

Supporting minority- and women-owned small business enterprises (MWBEs) essential to an equitable workforce strategy because it recognizes that increasing the diversity of the clean energy workforce must extend beyond the role of employee to that of employers. Business ownership is often a vehicle for wealth generation, while MWBEs are also more likely to be employers of diverse talent. A 2022 survey by Mckinsey & Company found that MWBE employers were 67% more likely to hire diverse talent than the average for US companies, and to hire more minorities at the highest levels.[90] The $12 million in annual funding provided to MassCEC for Equity Workforce Development programming provides a baseline of funding to both provide clean energy occupational training for priority populations and support MWBEs.[91] In 2022, MassCEC provided implementation and planning grants, and ongoing technical assistance to nine MWBE support organizations, including Emerald Cities Collaborative, Browning the Green Space, and Greater New England Minority Supplier Development Council.[92] As clean energy business opportunities increase while private companies, municipalities and state agencies evaluate and change

> By prioritizing a just, equitable and inclusive energy transition, Massachusetts can build a more resilient and sustainable future for all its residents. Strategies to train new workers and upskill existing ones must include fossil fuel workers who need to transition to different work as the state moves towards renewable energy.

[90] McKinsey & Company, "Expand Diversity among your Suppliers – and Add Value to Your Organization," https://www.mckinsey.com/capabilities/operations/our-insights/expand-diversity-among-your-suppliers-and-add-value-to-your-organization#/

[91] Priority populations identified in the legislation include small business enterprises that are minority and women-owned, other businesses or communities underrepresented in the clean energy workforce or clean energy industry, Environmental Justice populations, current and former workers from the fossil fuel industry, federally recognized and state-acknowledged tribes within the Commonwealth, and low-income populations.

[92] In September 2022, the Baker-Polito administration announced $3.6 million in Minority- and Women-Owned Business Enterprises Support Implementation and Planning Grants and Equity Workforce Training Grants administered through MassCEC. "Baker-Polito Administration Announces $3.6M in Funding to Equity Workforce Training and Minority- and Women-Owned Business Enterprises in Climate-Critical Fields," Massachusetts Clean Energy Center, https://www.masscec.com/press/baker-polito-administration-announces-36m-funding-equity-workforce-training-and-minority-and#.

how they source their suppliers with a lens toward supporting more MWBE’s, support organizations can facilitate networking, match-making, access to capital, and enhance strategic planning and back-office support to help MWBE’s secure business and grow their companies. Expanding employer awareness and engagement in business opportunities in clean energy and offering support to new and expanding MWBEs will ensure that these businesses are able to grow and benefit from private, state and federal decarbonization investments.

By prioritizing a just, equitable and inclusive energy transition, Massachusetts can build a more resilient and sustainable future for all its residents. Strategies to train new workers and upskill existing workers must include fossil fuel workers who need to transition to different work as the state moves towards renewable energy. Additionally, programs that support BIPOC individuals and members of Environmental Justice communities can ensure that the energy transition provides increased opportunities rather than perpetuating historical inequities.

Supporting Environmental Justice Populations

Environmental Justice is based on the principle that all people have the right to be protected from environmental hazards and the ability to live in and enjoy a clean and healthy environment.[93] In order to be categorized as an Environmental Justice population, or sometimes referred to in this report as an Environmental Justice neighborhood, a census block tract must meet one or more of the following criteria:

- The annual median household income is 65% or less than the statewide annual median household income;
- Minorities comprise 40% or more of the population;
- 25% or more of households identify as speaking English less than "very well"; or
- Minorities make up 25% or more of the population and the annual median household income of the municipality in which the neighborhood is located does not exceed 150% of the statewide annual median household income.

Figure 15 and Figure 16 show the different Environmental Justice neighborhoods throughout the state, as well as the clean energy training programs that are available in corresponding zip codes. These maps illustrate that Environmental Justice neighborhoods in the northern portion of the Berkshire and Pioneer Valley regions as well as Martha’s Vineyard and Nantucket tend to have fewer or no clean energy-related training programs. Figure 16 also reveals that some Environmental Justice neighborhoods on the outskirts of the Greater Boston region have little or no access to training programs unless they commute into the city, which may present transportation challenges.

[93] Environmental Justice is the equal protection and meaningful involvement of all people with respect to the development, implementation and enforcement of environmental laws, regulations and policies and the equitable distribution of environmental benefits. https://www.mass.gov/environmental-justice

FIGURE 15. CLEAN ENERGY TRAINING PROGRAMS AND ENVIRONMENTAL JUSTICE NEIGHBORHOODS

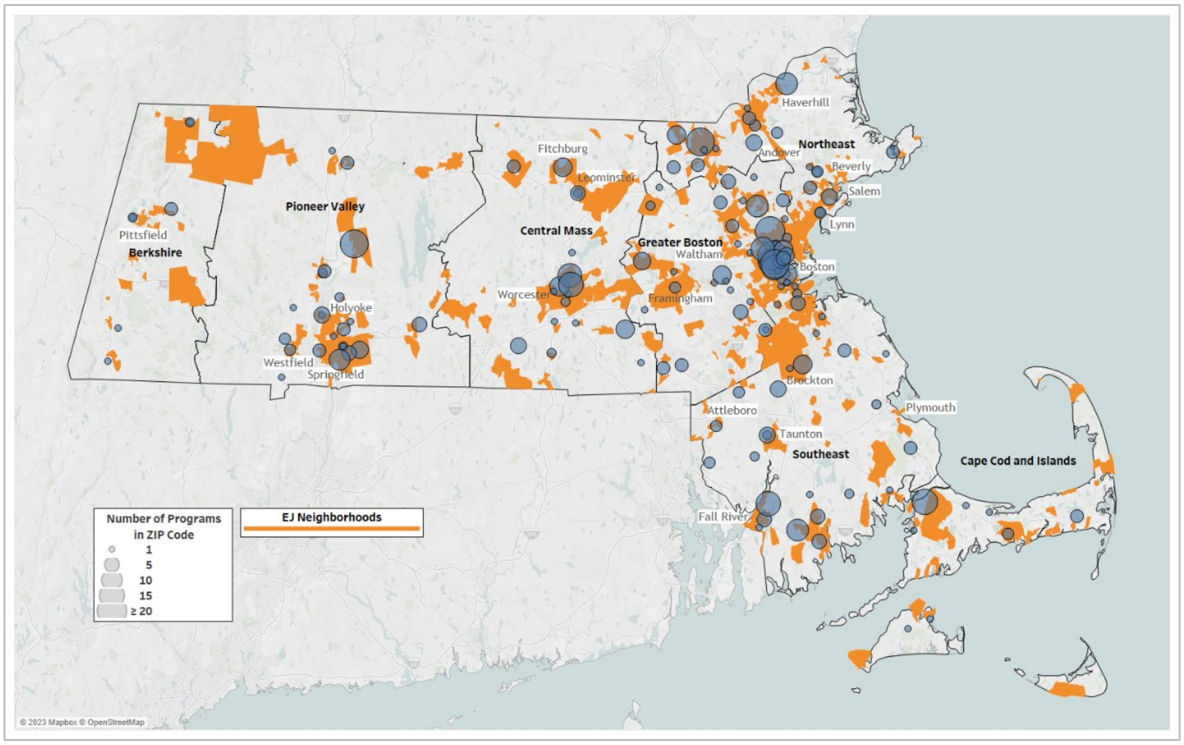
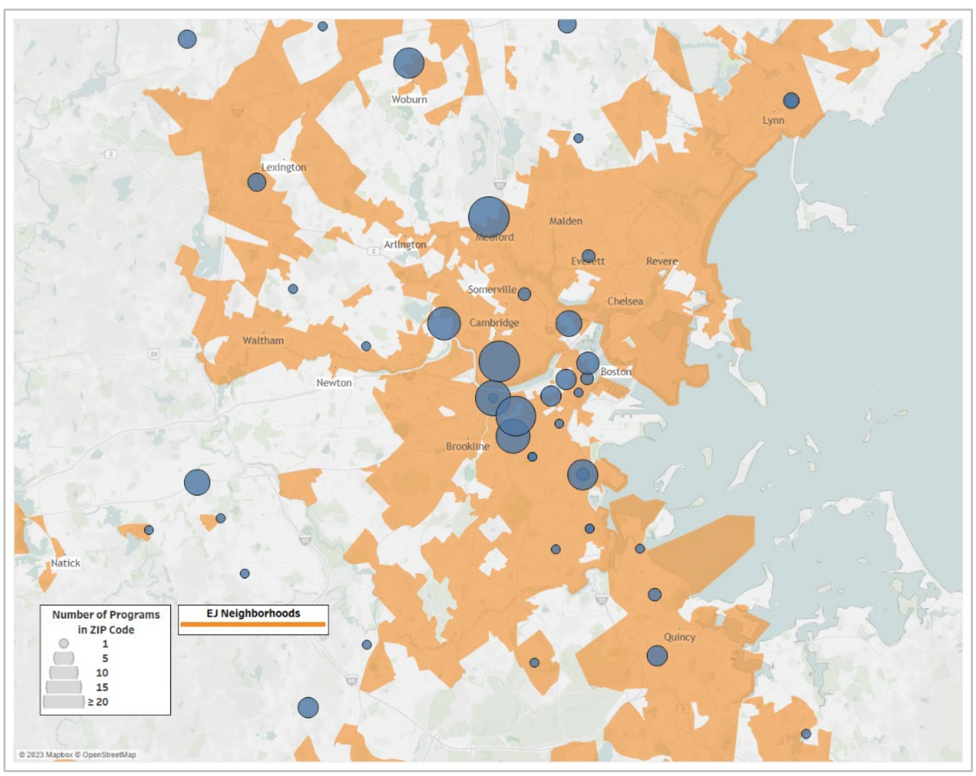


FIGURE 16. CLEAN ENERGY TRAINING PROGRAMS AND ENVIRONMENTAL JUSTICE NEIGHBORHOODS IN THE METRO AREA



One method to reduce geographic gaps in availability of training is to prioritize opening or expanding additional training programs in areas that currently lack training programs and prioritize robust transportation support services across all grant-funded workforce development programs. See Chapter 7, Regional Snapshots and Strategies, for further discussion of the Environmental Justice neighborhoods that are currently isolated from training options and recommendations that are specific to the seven Workforce Skills Cabinet Regions. Online training, when available, is also an opportunity to expand access and scheduling flexibility, and may be available in multiple languages, which can support residents where English is not their first language. but it comes with additional barriers as not all communities have equitable access to reliable high-speed Internet and modern computers, while some online training programs may lead graduates to be at a disadvantage if employers prefer or require hands-on training for job placement.

English isolation is one of the three criteria of Environmental Justice populations. English isolation is one of the main reasons immigrant communities and families are inadvertently excluded from services and programs. As part of this report, a survey of current clean energy workers found that language barriers were an impediment to some workers in both entering into and progressing within their profession.[94] Increasing language access within the current training and workforce pipeline, from providing training materials and curriculum in multiple languages to enhanced ESOL services, will be important to increase participation of this Environmental Justice population segment.

Increasing Diversity, Equity and Inclusion (DEI)

One in three current clean energy workers in Massachusetts are people of color, which is somewhat more diverse than statewide demographics of workers.[95] Still, representation in many of the highest-paying positions is not equitable, across both roles that require a bachelor's degree and those that prioritize on-the-job training and/or licensing. Disproportionately high representation among some of the most physically demanding roles contributes to the broader clean energy workforce demographics but masks other instances of inequality and lack of representation. For example, only 11% of Massachusetts' workforce is Hispanic or Latino/a/x, but 53% of Roofers and 35% of Insulation Workers are Hispanic or Latino/a/x. When considering gender, women are underrepresented industrywide. Women account for 51% of Massachusetts' overall workforce but represent just 31% of Clean Energy workers, and women are even more underrepresented among many of the occupations projected to see the highest demand, such as Electricians of which only 2% are currently women. If Massachusetts is going to grow the clean energy workforce to keep pace with the demands of its decarbonization commitments, clean energy occupations must be equally accessible and welcoming to all potential workers. The charts below highlight some of the high-demand roles that lack equitable representation across different races, ethnicities and genders.

[94] See pages 66 and 75 for further information about how language barriers impact the entry and promotion of clean energy workers within their profession.

[95] 2022 Massachusetts Clean Energy Industry Report, Page 23, https://www.masscec.com/resources/2022-massachusetts-clean-energy-industry-report.

FIGURE 17. SHARE OF OCCUPATIONS BY RACE AND ETHNICITY: BLACK OR AFRICAN AMERICAN WORKERS [96] [97]

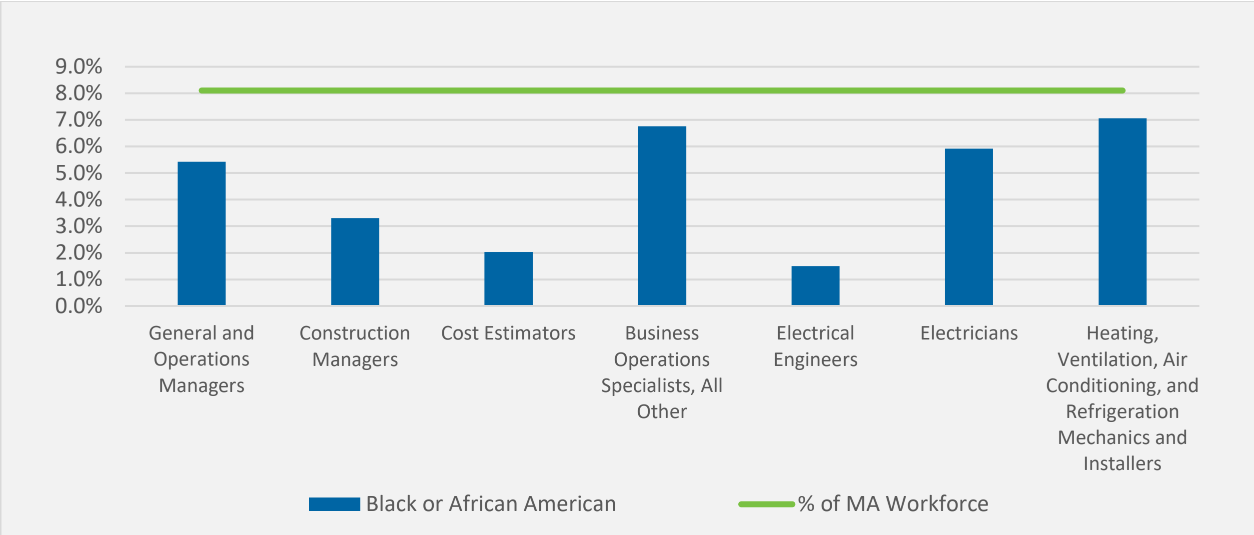
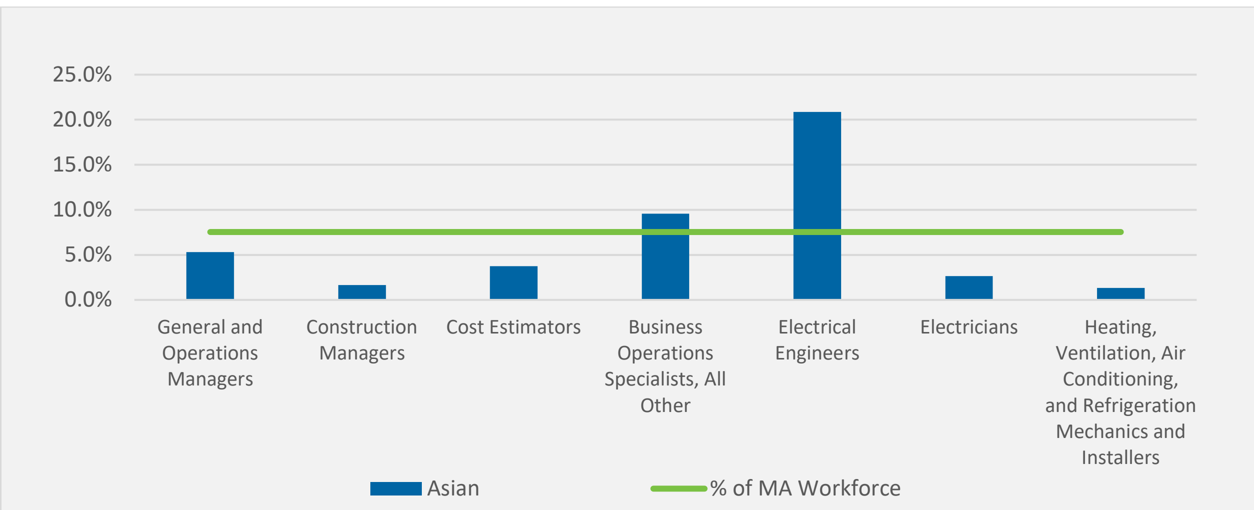


FIGURE 18. SHARE OF OCCUPATIONS BY RACE AND ETHNICITY: ASIAN WORKERS



[96] The demographics data reported is reflective of economywide employment in these occupation categories. While clean energy-specific employment may not fall exactly within these same demographic proportions, the underlying trends remain true.

[97] Data for race, ethnicity and gender is from https://www.bls.gov/lau/ptable14full2020.htm. Population percentages for Asian and occupation-specific demographic data, due to lack of BLS data, is from jobseq.com.

FIGURE 19. SHARE OF OCCUPATIONS BY RACE AND ETHNICITY: HISPANIC OR LATINO/A/X WORKERS

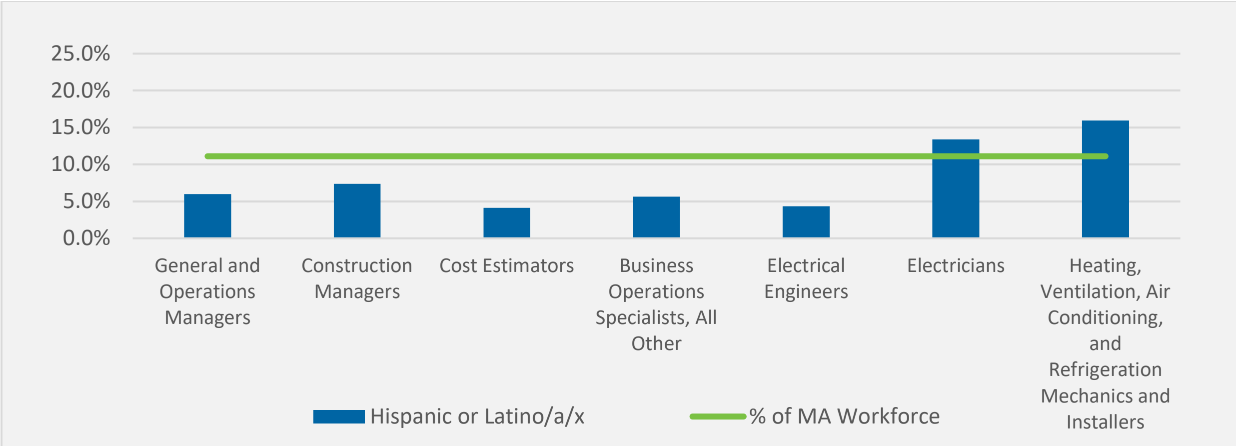


FIGURE 20. SHARE OF OCCUPATIONS THAT ARE HELD BY WOMEN[98]

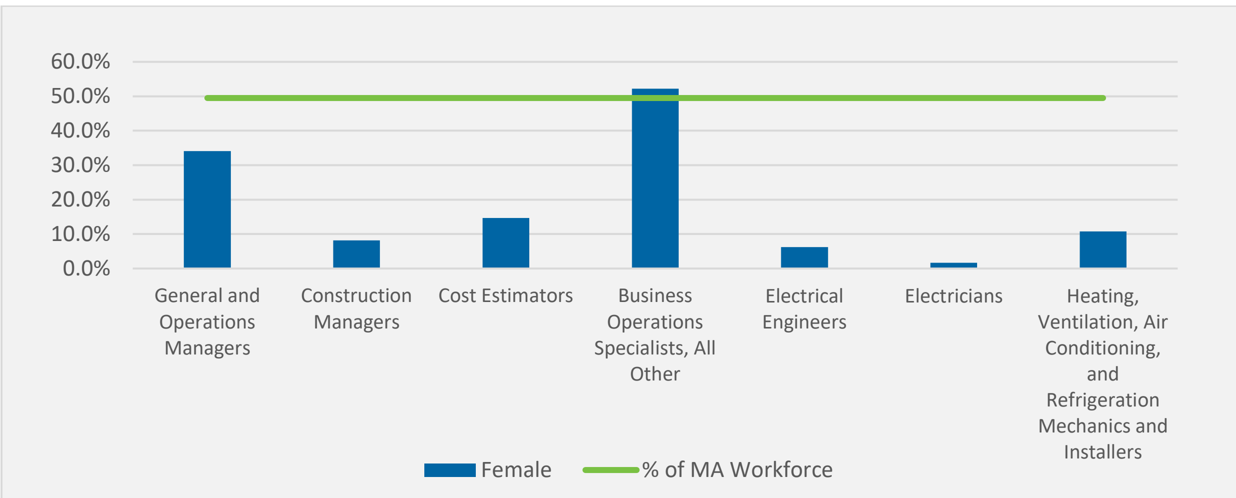


TABLE 9. MEDIAN WAGE FOR SEVEN HIGH-GROWTH OCCUPATIONS

Occupation	Hourly Median Wage	Hourly 75th Percentile Wage
General and Operations Managers	$57.00	$67.29
Construction Managers	$60.62	$95.53
Cost Estimators	$46.87	$61.30
Business Operations Specialists, All Other	$40.14	$53.81
Electrical Engineers	$59.58	$75.63
Electricians	$37.02	$48.19
Heating, Ventilation, Air Conditioning and Refrigeration Mechanics and Installers	$31.26	$38.44

[98] Data for overall gender is from https://www.bls.gov/lau/ptable14full2020.htm. Occupation-specific data is from jobseq.com.

Effectively prioritizing DEI across the clean energy workforce requires programming focused on addressing barriers to entry alongside industry commitment to inclusive recruitment and work environment practices. A survey of current clean energy workers in Massachusetts conducted as part of this report provides some initial insights into how barriers to clean energy careers vary.[99] While certain demographics reported higher incidences of specific barriers than others, female, Hispanic and non-White respondents were almost universally more likely to experience every type of barrier listed (Figure 21 and Figure 21).

Proximity to training opportunities and access to transportation were more likely to pose challenges for female, Hispanic or Latino/a/x and non-White respondents. For example, over two-thirds of Hispanic or Latino/a/x respondents flagged these barriers, which was double the rates among White respondents. This response underscores the need for careful consideration of access issues when locating additional training programs and the importance of including transportation and other support services in the funding for workforce development programming. The mapping of training programs against Environmental Justice neighborhoods reveals many instances of lack of access and proximity, confirming the disparities in the current worker survey.

Additionally, while the number of respondents identifying as Native American wasn't sufficient to report findings for this subgroup, the substantial overlap between EJ neighborhoods and census blocks with larger shares of Native American residents indicates that Native American students and prospective workers are likely also to face barriers with proximity to training opportunities. Eight of the ten census block groups where 5% or more of the population is Native American are also categorized as Environmental Justice neighborhoods. Additionally, 293 of the 347 census block groups where 1% or more of the population is Native American are also categorized as Environmental Justice neighborhoods. While students enrolled in an undergraduate degree program at a Massachusetts college or university may be eligible for tuition assistance through the Native American Tuition Credit, this credit is not applicable to shorter training programs. However, administrators who facilitate student participation in tuition assistance and other state and federal education and workforce opportunities highlighted a lack of opportunities to acquire relevant work experience through internships and on the job training as a key barrier to career exploration and job placement. While some training programs may offer services that place students with employers or offer other worked-based learning opportunities, other training providers may find partnership with CBO's, regional workforce boards, industry groups or other partners a better fit to provide more comprehensive training, professional development and placement services.

Some clean energy workers identified that English was not their native language and that this presented a barrier to entry into a clean energy occupation. Just over 11% of all respondents highlighted this as a barrier, while 41% of Hispanic or Latino/a/x and 25% Black or African American respondents reporting it as a barrier. This suggests that foundational training programs, support services and programs need to include English language support and access to language materials in the participants primary language. Additionally, over 56% of Black or African American and 54% of Hispanic or Latino/a/x respondents indicated having to overcome prejudice or bias in the workplace compared to 29% of White respondents. Nearly 40% of women indicated the same challenge. These challenges point to the need for ongoing support of candidates during the placement phases of programming and additional training for hiring managers on how to understand their own biases and improve their processes to be more inclusive and equitable.

[99] For more information about the survey methodology, please see the methodology section on page 117.

FIGURE 21. BARRIERS TO ENTRY INTO CLEAN ENERGY BY RACE AND ETHNICITY

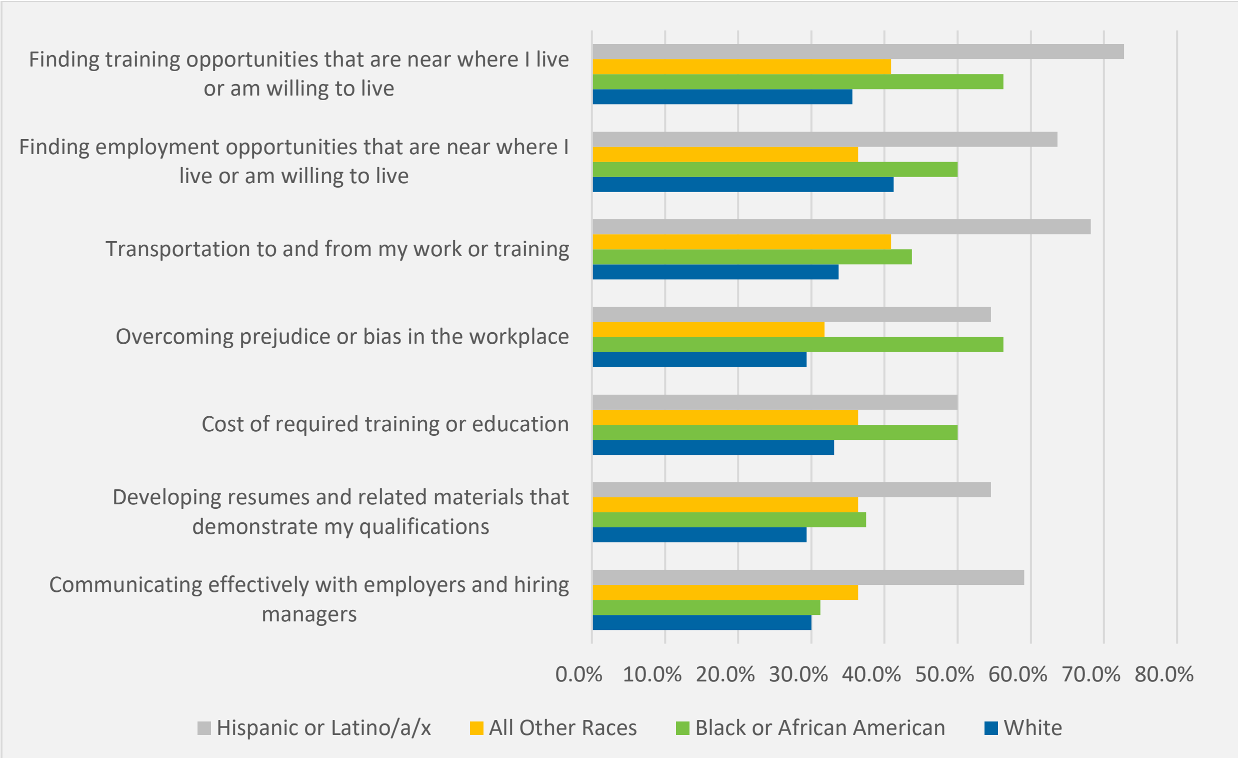
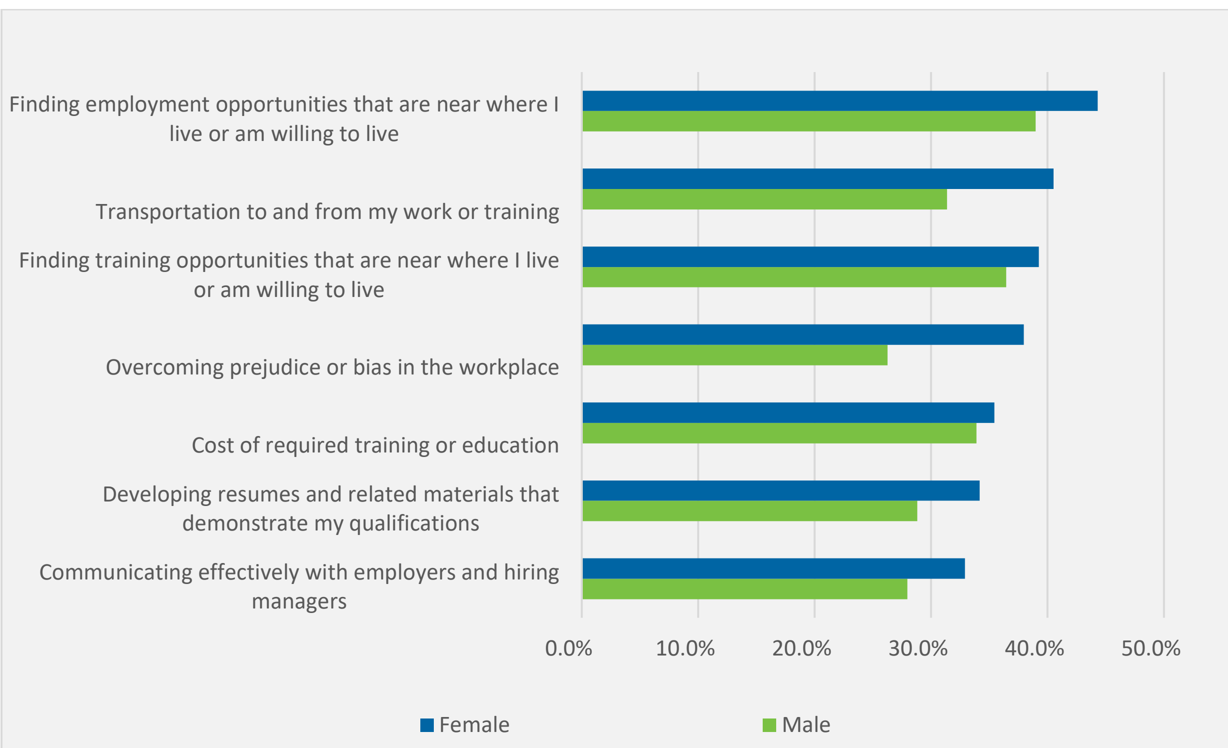
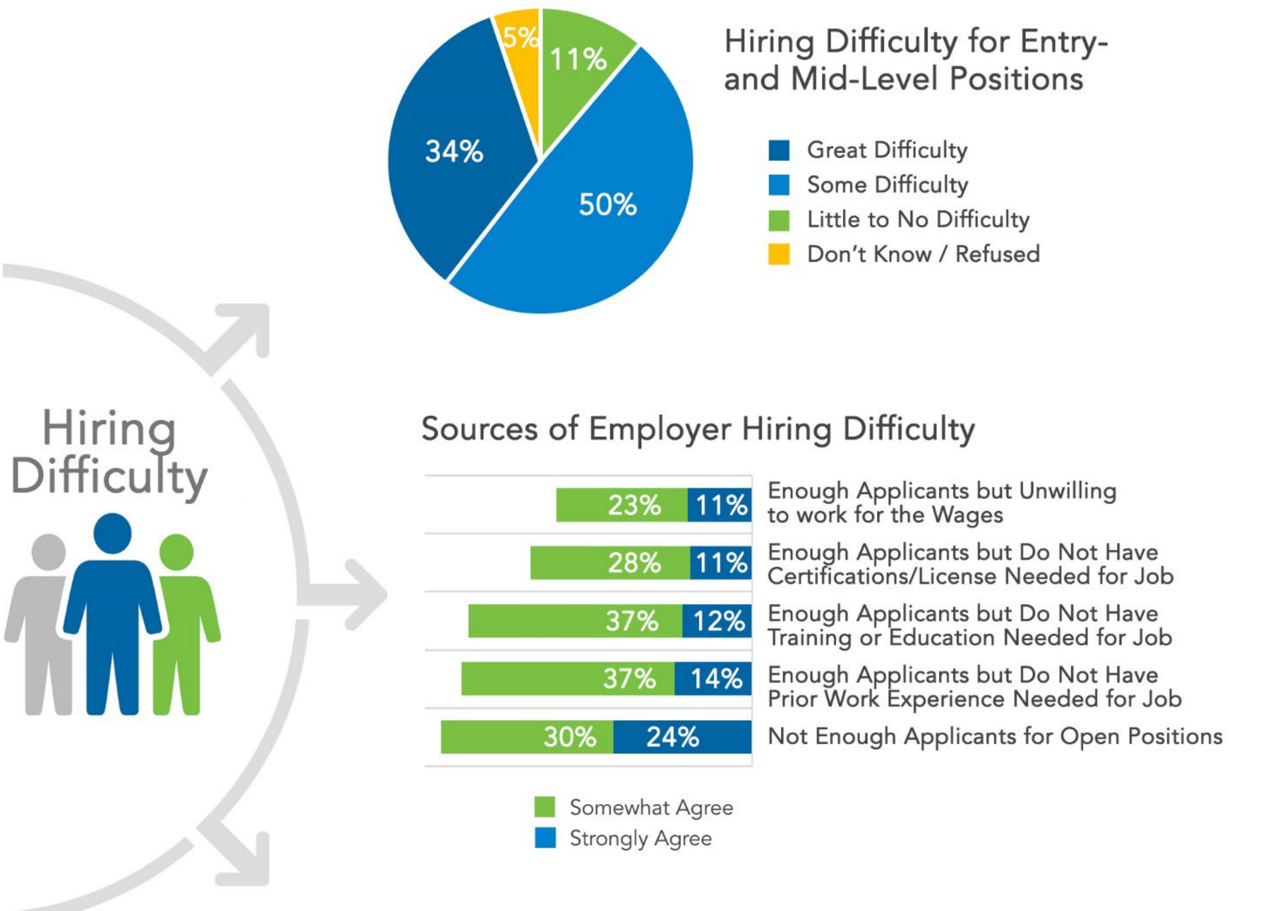


FIGURE 22. BARRIERS TO ENTRY INTO CLEAN ENERGY BY GENDER



Placing, Retaining and Advancing Workers

The 2022 Massachusetts Clean Energy Industry Report revealed that 88% of employers had difficulty hiring both entry-level and more experienced talent – the highest rate in the history of the report. Among the 283 employers surveyed for this report, 84% reported at least some hiring difficulty for both entry-level and more experienced roles (infographic on next page). When asked about the sources of hiring difficulty, 54% agreed with the statement that there were not enough applicants for their open positions, while 49% agreed that there were enough applicants, but they did not have the training or education needed for the job (infographic on next page). Additionally, when employers were asked to identify the top two reasons for hiring challenges, the lack of industry experience and skills across the candidate pool topped the list (infographic on next page).



Most Common Reasons for Employer Hiring Difficulty (Up to Two Selected)[88]

43%	33%	33%	21%	18%	9%	8%	3%	3%
Lack of Experience/ Industry Knowledge	Competiti on with Other Industries	Small Applicant Pool	Insufficient Non-Technical Skills	High Turnover	Insufficient Educational Attainment	Other	Insufficient Certifications	Don't Know / Refused

One of the most significant barriers to improving programmatic outcomes that training providers and CBOs identified was the lack of participation from employers. As part of a survey of clean energy employers, when asked what hiring sources employers used, 28% responded that they engaged with training providers "often" or "always," which was lower proportional to other sources (infographic on previous page).

The lack of communication between employers and training providers contributes to the reported hiring challenges of clean energy workers — training providers are unclear about the volume or prioritized skill demand for trained graduates while employers are unable to relay their needs and directly access program graduates. Most grant-funded workforce development resources require documented partnerships, but training providers consistently indicate that more employer partnerships are needed. Grant-funded support to create or expand training opportunities must prioritize increased employer input and higher-quality programmatic outcomes — both through funding decisions and direct support to help grantees improve programming and coordination. Creating stronger alignment between training providers and employers requires increased commitment and communication from both sides.

Creating stronger alignment between training providers and employers requires increased commitment and communication from both sides.

In addition to increasing their willingness to work with training providers, clean energy employers need to expand their resources for hiring overall. Employers largely relied on word of mouth when searching for qualified candidates, as well as LinkedIn, Indeed, Craigslist or friends and family. When asked about each of the hiring sources, 67% of employers reported that they "always" or "often" use word of mouth or ask current employees to recruit new workers. Over half of the companies surveyed responded that they "always" or "often" use LinkedIn when recruiting new workers. Fewer than 30% of companies report using training providers, MassHire Career Centers, Staffing Agencies or Headhunters (Figure 23).

Current employer hiring practices emphasize relational and network-based methods, both of which are likely to represent smaller pools of potential candidates. Additionally, relying on "word of mouth" or "friends and family" tends to reinforce existing social networks, which exacerbates the challenges for first-time job seekers or those without relevant social capital. Even LinkedIn tends to be insular, highlighting existing social networks when possible. Further, since currently almost 70% of the clean energy workforce is male and 74% is White, efforts to diversify the pipeline of clean energy workers will be stymied if current employer hiring practices remain in place.

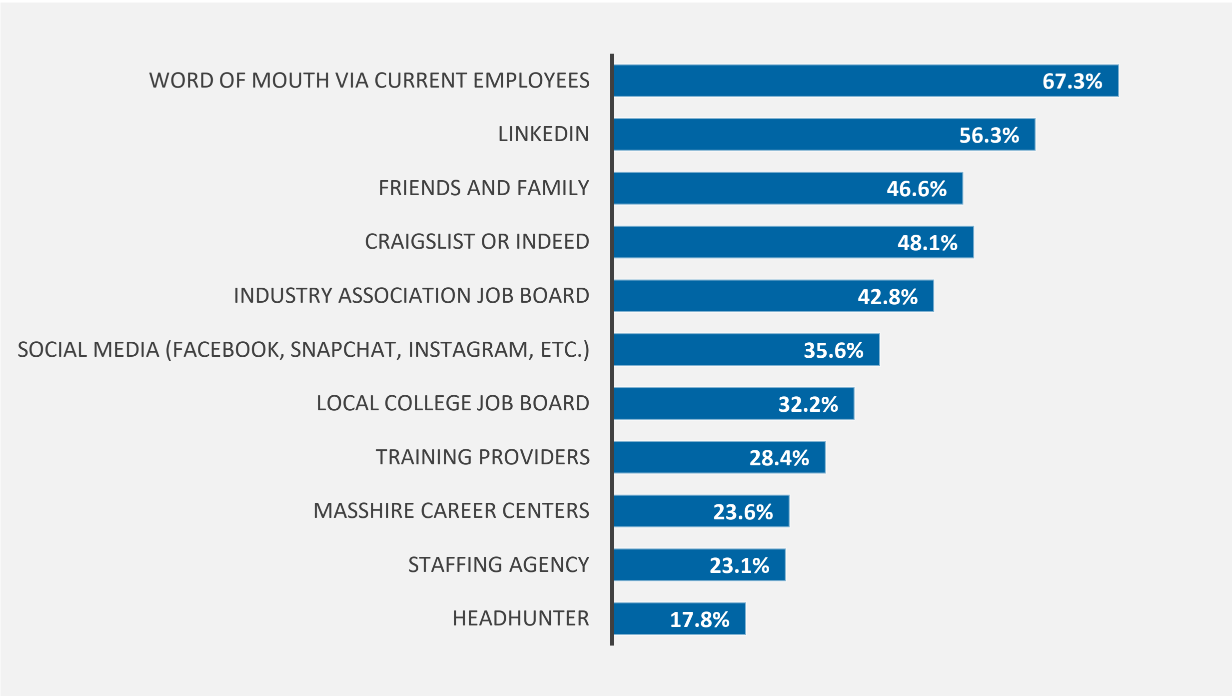
Current employer hiring practices emphasize relational and network-based methods, both of which are likely to represent smaller pools of potential candidates.

The top two methods that job seekers reported turning to were online job sites and company websites, with 42% and 41% of survey respondents indicating that they regularly use these resources, respectively. Websites like Craigslist and Indeed broadcast opportunities to all, but greater shares of Black or African American,

[100] Employers were asked to list their top two reasons for hiring difficulty, which is why these percentages exceed 100%.

Hispanic or Latino/a/x and female respondents indicated career awareness as a barrier to entry (see Figure 11 & Figure 12 on page 43), so not all job seekers may know what types of clean energy jobs they should search for. Increased career awareness outreach and coordination between entities serving job seekers and clean energy employers are needed to develop a larger clean energy workforce with workers from all backgrounds.

FIGURE 23. ALWAYS OR OFTEN-USED HIRING SOURCES FOR EMPLOYERS[101]



Support Services for New Hires

Employers revealed that new hires who were new to the type of work — or new to working altogether — were more likely to struggle with challenges like transportation, showing up to work consistently and knowing the expected behaviors of a workplace. Considering that many of the 29,700 additional clean energy workers are likely to fall under this category, developing and supporting systems that ease these transitions for workers and employers alike is important. For example, training programs that include comprehensive follow-up support upon placement can serve as an important intermediary resource to both the new hire and the employer, ensuring that job seekers successfully navigate the transition and some of the challenges that employers note, especially those related to acclimating to a new work environment. Other challenges, like

Employers and more experienced workers also need to play a role by recognizing the value of new employees by providing mentorship, guidance, and flexibility.

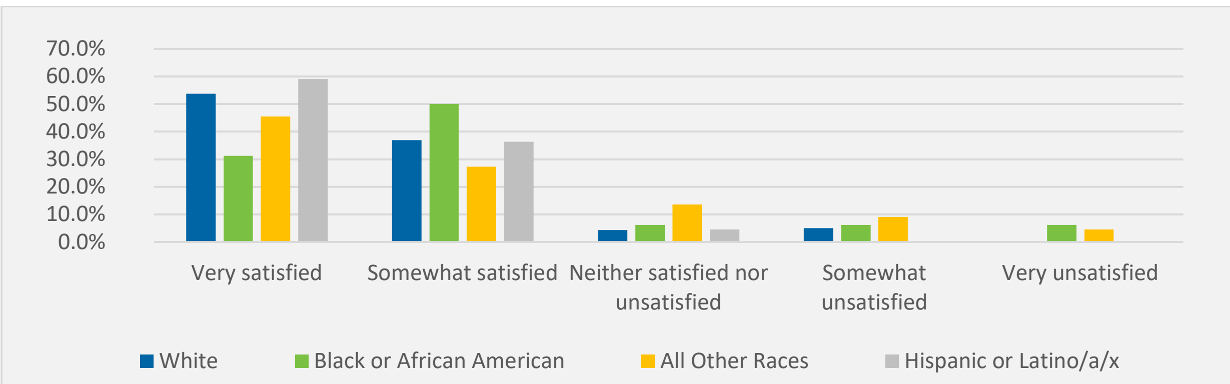
[101] Percentages will exceed 100% because employers could select multiple sources. Figure shows percent of employers who use hiring source 'always' or 'often.'

transportation issues, require a more robust set of support services so that employees have additional resources to address accessibility barriers. Finally, employers and more experienced workers also need to play a role by recognizing the value of new employees by providing mentorship, guidance, and flexibility.

Bolster Employee Satisfaction and Advancement

Ensuring that clean energy jobs are competitive and benefit from effective awareness and recruitment strategies will support strong placement rates, but supporting career satisfaction and advancement are critical to stronger retention. Overall, 89% of current clean energy workers surveyed reported being satisfied with their careers. White and Hispanic or Latino/a/x respondents reported high career satisfaction rates, while Black or African American respondents and those of All Other Races reported lower levels of satisfaction. Furthermore, Black or African American respondents and those of All Other Races were more likely to report somewhat negative feelings about their clean energy careers (Figure 24). Men and women reported being satisfied with their clean energy careers, but women are slightly more likely to be only "somewhat" satisfied with their clean energy career relative to men, though levels of unsatisfaction are roughly the same.

FIGURE 24. CAREER SATISFACTION IN CLEAN ENERGY BY RACE AND ETHNICITY



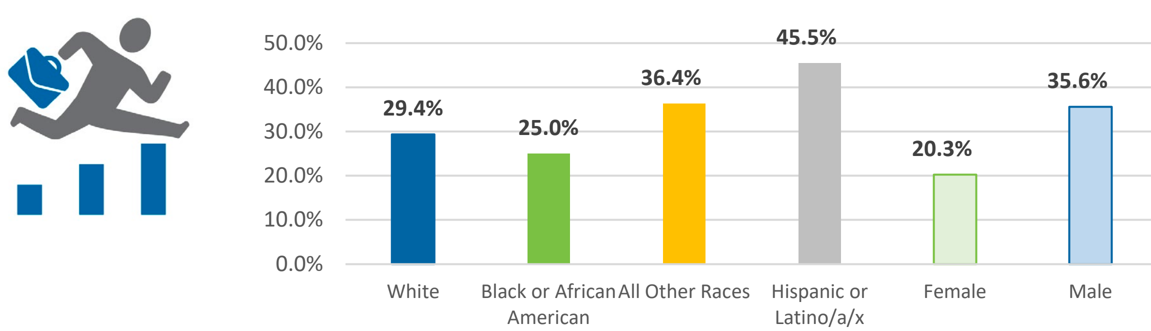
Importantly, those who reported lower satisfaction with their career were also more likely to report barriers to entry *and* barriers to advancement in their clean energy career. Higher rates of dissatisfaction not only impact retention but also affect the recruitment of future workers, as current workers are likely to share their experiences with prospective job seekers. Based on survey responses and more extensive feedback during focus groups and interviews, two core strategies could improve the retention and advancement of clean energy workers: embedding comprehensive DEI initiatives and inclusivity training, and providing clearer and more supportive routes for advancement and professional development.

The Role of Diversity Equity and Inclusion Initiatives

From initial awareness to hiring to advancement, women, Hispanic or Latino/a/x and non-White respondents indicated greater levels of barriers. The high rates of prejudice and bias that current clean energy workers reported while entering the workforce (Figures 20 & 21) persist throughout their experience. Twice the number of women reported that overcoming prejudice or bias in the workplace was a barrier to career advancement compared to men, and Black or African American respondents were more than three times as likely to indicate bias as a barrier to advancement (see infographic below). Interviews with training providers and CBOs that work with diverse candidates reinforced this concern and a staff member from a CBO helping to support placement explained that “People are getting the jobs, but there is low retention due to workplace culture, management differences and dealing with micro and macro aggressions.” These experiences shape employees’ opportunities to advance and these inequities were evident across the results of the worker survey. Men were 75% more likely to cite “opportunity for advancement” as a factor they like about their job than women were (see infographic below). Affinity industry organizations like New England Women in Energy and the Environment (NEWIEE) and the National Society of Black Engineers (NSBE) leverage networking, advocacy and mentorship to overcome inequity, but employers also need to commit to addressing prejudice, discrimination and biased practices. Browning the Green Space engaged their coalition of employers in signing and implementing an organizational diversity, equity, inclusion and justice pledge —expansions of this type of work are critical to ensuring that all clean energy workers have equitable opportunities to advance.[102]

> “People are getting the jobs, but there is low retention due to workplace culture, management differences and dealing with micro and macro aggressions.”
>
> - Community-Based Organization

FIGURE 25. CURRENT WORKERS THAT SELECTED ‘OPPORTUNITY FOR CAREER ADVANCEMENT’ AS MOST FAVORABLE ASPECT OF CURRENT CLEAN ENERGY JOB, BY RACE, ETHNICITY AND GENDER



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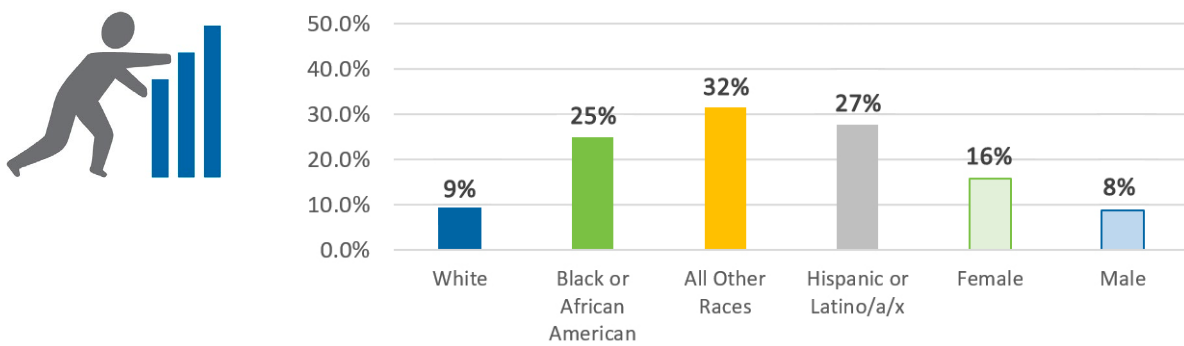
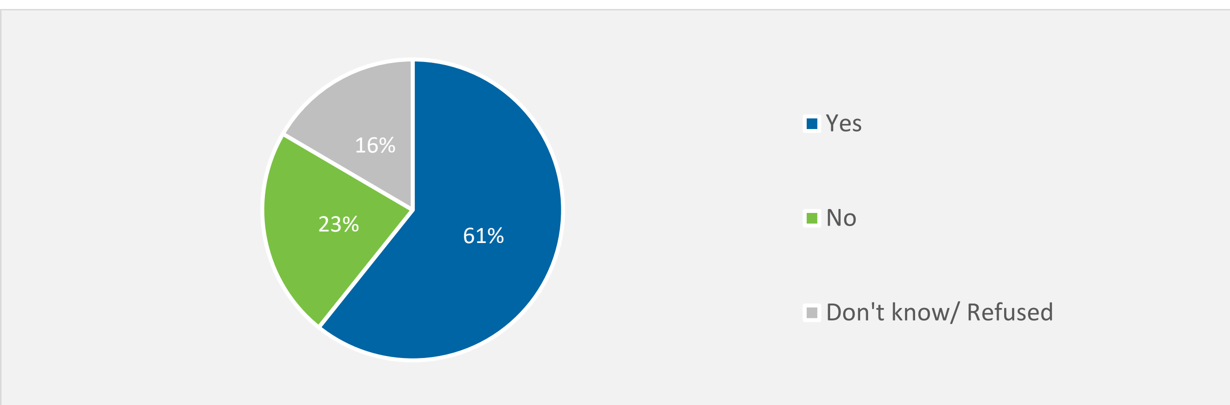
[102] https://www.browningthegreenspace.org/wp-content/uploads/2022/11/Revised_BGS-Member-Organizational-DEIJ-Pledge_June-2022_w-contact.pdf

Figure 26. Current Workers that Selected 'Overcoming Prejudice or Bias' as a Barrier to Advancement, by Race, Ethnicity and Gender



Increasing and improving the content, usage and efficacy of DEI initiatives among more clean energy employers will be an important step to combatting existing prejudices and biases that are hindering the industry's capacity to be inclusive and effectively expand its workforce. While over half (61%) of all clean energy employers reported having DEI initiatives (Figure 27), only 22% of current workers reported that their companies have DEI initiatives. This suggests there is either a failure to communicate and operate DEI initiatives with employees or these programs are not robust enough to be noticeable to employees.

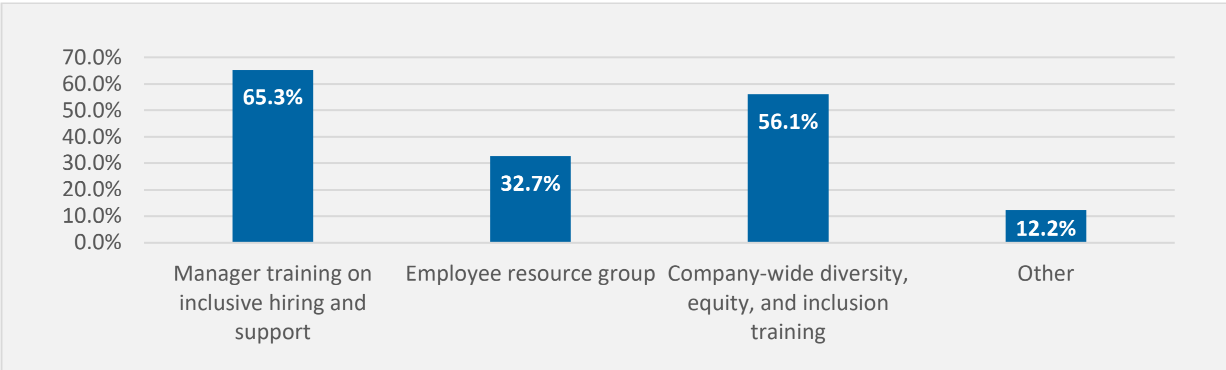
FIGURE 27. CLEAN ENERGY EMPLOYERS WITH DEI INITIATIVES



Of those providing DEI initiatives, 65% are providing manager training on inclusive hiring and support and 56% offer company-wide DEI training. Approximately a third of these companies are offering employee resource groups and 12% are offering some other undefined DEI initiative (Figure 28). More than half (59%) of all clean energy businesses in Massachusetts are small businesses that employ one to 10 employees, which may contribute to their ability to devote resources to extensive DEI initiatives. Adequate support of clean energy companies — especially smaller clean energy companies — is critical to ensuring that investments in workforce development efforts don't yield diminishing returns due to retention challenges. Creating formal toolkits that employers can use or customize for their organization may help improve the quantity and quality of DEI programs within clean energy companies. Additionally, the Equity Workforce funding administered by

MassCEC engages a wide cross section of stakeholders and may be well positioned to provide, coordinate and fund expanded DEI resources.

FIGURE 28. DEI INITIATIVE BY TYPE



PROFESSIONAL DEVELOPMENT: ADVANCING CLEAN ENERGY WORKERS

Nearly 3,000 additional full-time clean energy management-level positions will be needed within the clean energy workforce by 2030 (Figure 7). As such, continued professional development within the clean energy workforce is essential to guaranteeing that there are appropriate supervisors, managers and experienced workers who can oversee projects and timelines. Over three-quarters of clean energy employers reported offering professional development opportunities for their employees (Figure 29). Over 82% reported that they offer on-the-job training and over 67% offer participation at conferences or professional networking opportunities. Over 63% offer tuition or training reimbursement and just over 56% provide mentorship (Figure 30).

FIGURE 29. EMPLOYERS OFFERING PROFESSIONAL DEVELOPMENT OPPORTUNITIES

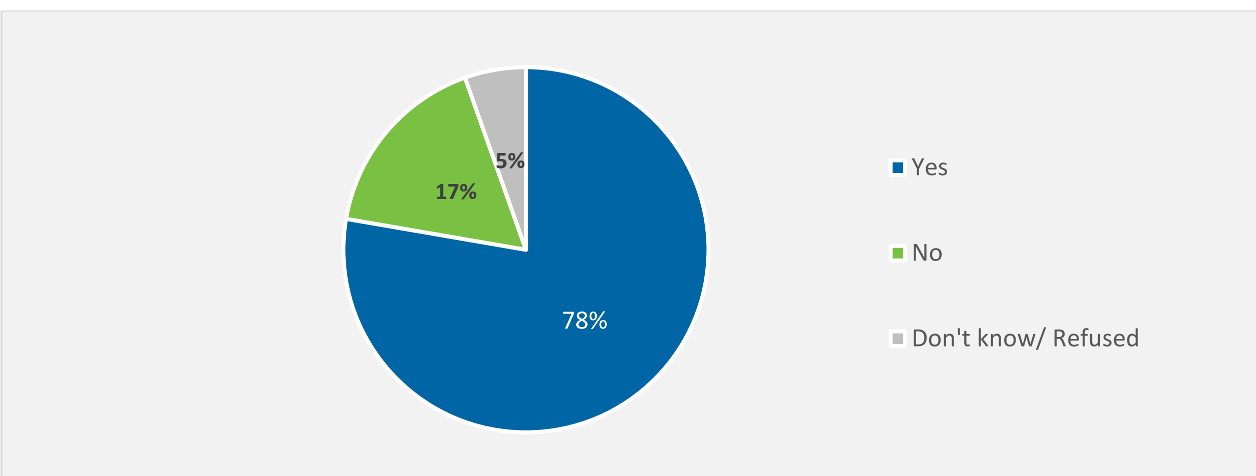
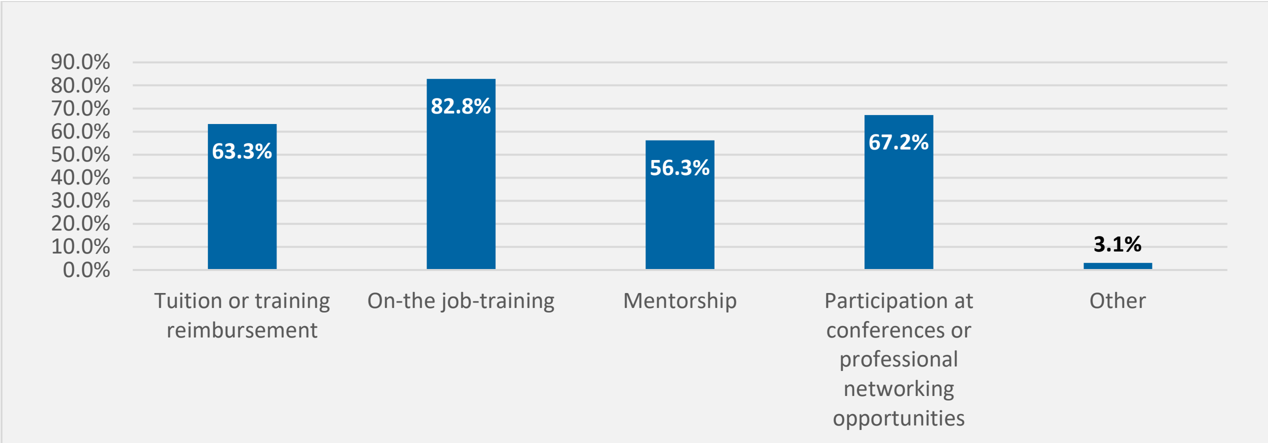
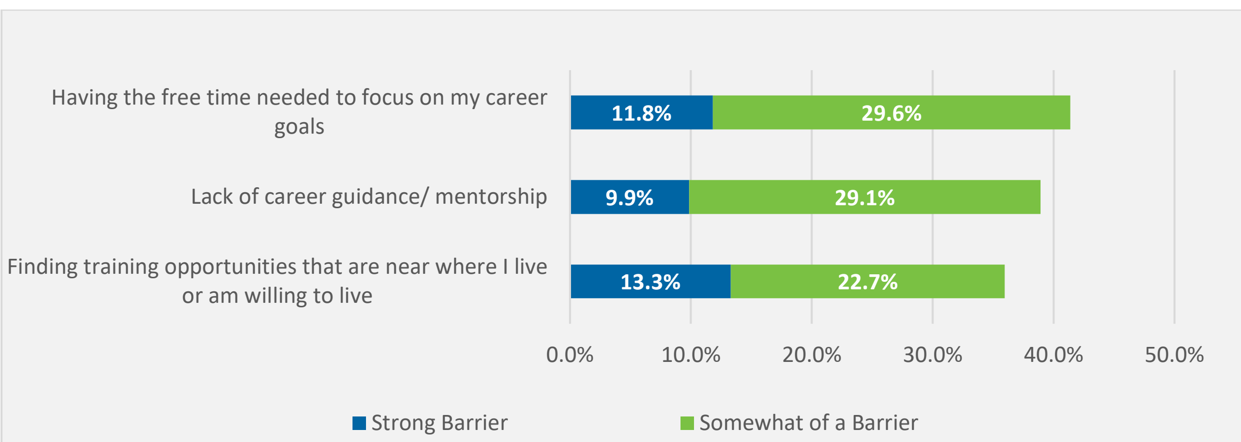


Figure 30. Types of Professional Development Opportunities



When surveyed about barriers to their career advancement, 41% of current workers reported that having the free time to focus on their career goals was a strong or somewhat of a barrier. Additionally, similar shares of respondents identified lack of career guidance or mentorship and the location of work opportunities as strong or moderate barriers (Figure 31). Finally, a number of clean energy workers identified that English was not their native language and that this presented a barrier to their advancement. This barrier affected 36% of Hispanic or Latino/a/x respondents and almost 19% of Black or African American respondents, which is only slightly lower than when presented as a barrier to entry into profession. This suggests that professional development opportunities, services and programs need to include English language support and access to primary language materials.

Figure 31. Barriers to Career Advancement



The state-funded Express Grants program provides an avenue for employers to offer professional development training to current workers — often at little to no cost. More extensive utilization of this program could support expanded professional development opportunities within clean energy employees' regular work week, which would address the top advancement barrier that survey respondents indicated. Currently, the number of clean energy-specific training opportunities available through the program are limited, so raising awareness among relevant training providers and employees is an important next step. Additionally, small- and mid-size clean energy employers have indicated that, even with the cost of training covered or defrayed, it is challenging to support training for current workers because of the lost revenue alongside the need to cover wages of workers engaging in training. Opportunities for training that offer immediate upsides to business revenue, like those that are part of Mass Save's Heat Pump Installer Network, are attractive to employers and underscore the need to help employers understand how investing in their workers upskilling can have direct impacts on revenue generation and cost reductions.[103]

[103] The Heat Pump Installer networks had enrolled nearly 850 contractors according to reporting form March of 2023. https://energynews.us/2023/03/03/massachusetts-heat-pump-installer-network-has-momentum-in-second-year/

https://www.masssave.com/partners/heat-pump-installer-network

Chapter 4: Occupational Snapshots and Strategies

Workforce Gap Analysis

One of the goals of this workforce needs assessment is to evaluate the current workforce and the anticipated clean energy workforce needs by the year 2030. This section of the report focuses on key occupations that are projected to see substantial growth as a result of decarbonization policies and the most likely to pose potential workforce challenges going forward. These roles were also selected because an inadequate supply of these jobs will likely hinder the state's ability to meet its decarbonization goals. The potential for a worker shortage is viewed through five lenses, including current hiring challenges, age of the current workforce, increases in demand relative to the existing workforce, forecasted supply and demand and occupation training requirements and duration.

Based on these lenses, there are a set of occupations that present the greatest risk to the state's decarbonization goals.

Relative Risk of Bottleneck

SEVERE RISK

Electricians

All indications point to challenges concerning an adequate supply of Electricians. Employers across different clean energy sectors already report hiring challenges for Electricians. A high increase in demand for Electricians economywide is anticipated, and the following gap analysis suggests that supply challenges will only get worse. Electricians also represent an older workforce compared to the overall labor market. The role also requires extensive training and apprenticeship, so the time horizon for backfilling for those that retire and adding new electricians in addition to meet demand is out of sync. Finally, the fact that much of the above dynamics are also true for Solar Photovoltaic Installers, who also need Electrician certifications, means that expanding entrants into this occupation is crucial.

Heating, Ventilation, Air Conditioning and Refrigeration (HVAC-R) Mechanics and Installers

Clean energy employers report that the HVAC-R Mechanics and Installers occupation is already very difficult to hire for. HVAC-R Mechanics and Installers also represent an older workforce than the overall labor market, and the position requires formal training requirements. This occupation will see a substantial overall increase in demand, while current hiring challenges suggest there is already an undersupply of these workers that will only increase with higher demand.

HIGH RISK

Electric Power-Line Installers and Repairers

The Electric Power-Line Installers and Repairers occupation represents an older workforce than the overall labor market, requires extensive training and will see a high proportional increase in demand. These factors all suggest that working with utilities will be necessary to ensure that there is an adequate number of workers who can support deployment of transmission, distribution, interconnection, and other grid improvements.

Construction Laborers

The sheer number of Construction Laborers demanded makes this a high-demand occupation, while a relatively older workforce means that new workers will be needed to both replace those retiring and meet growing demand. Fortunately, relatively lower barriers to entry make this occupation more accessible for many, but attraction and retention may prove a challenge.

Construction and Building Inspectors (including Energy Analysts and HERS Raters)

Construction and Building Inspectors will see a significant increase in demand proportional to the existing number of workers. This occupation also requires training and experience that makes the role less accessible for first-time workers.

MODERATE RISK

Insulation Workers

The Insulation Workers occupation was identified as a top occupation that is currently difficult to hire for, will see high demand and has an older workforce. Because this occupation requires relatively little formal training, like Construction Laborers above, attraction and retention will likely present the greatest challenges.

Cost Estimators

Cost Estimators represent a relatively older workforce requiring greater training and education requirements. The projected large increase in workers means that this occupation requires attention and planning, but the relative magnitude of the increase places this occupation at a moderate risk of future supply challenges.

Pipelayers, Plumbers, Pipefitters and Steamfitters

The Pipelayers, Plumbers, Pipefitters and Steamfitters occupation will see a moderate increase in demand, but has an older workforce and requires extensive training that takes upwards of five years. This means that the occupation should receive some continued attention and support, but is not in a higher risk category.

TABLE 10. CURRENT AND PROJECTED CLEAN ENERGY AND TOTAL ECONOMYWIDE JOBS AMONG KEY OCCUPATIONS [104] [105]

	Current Clean Energy Jobs	Net Change in Clean Energy Jobs by 2030	Percent Change in Clean Energy Jobs	Current Economywide Jobs in Occupation	Percent Change in Total Economywide Jobs by 2030
Electricians	6,470	4,444	69%	17,219	31%
Solar Photovoltaic Installers		*726*			
Heating, Ventilation, Air Conditioning and Refrigeration Mechanics and Installers	3,844	650	17%	9,330	11%
Electric Power-Line Installers and Repairers	739	722	98%	5,903	17%
Construction Laborers	6,955	2,288	33%	27,399	12%
Construction and Building Inspectors (including Energy Analysts & HERS Raters)	2,096	532	25%	2,981	22%
Insulation Workers	3,820	965	25%	3,820*	<1%
Cost Estimators	938	331	35%	6,063	10%
Pipelayers, Plumbers, Pipefitters and Steamfitters	3,563	397	11%	14,497	11%
Miscellaneous Assemblers and Fabricators	1,534	358	23%	11,800	-12%
Operating Engineers and Other Construction Equipment Operators	1,272	574	45%	8,740	11%

[104] Economywide Jobs in an Occupation means the total number of jobs for that occupation across the state, inclusive of all clean energy and non-clean energy-related jobs. An Electric Power Line Installer who spends 100% of their time on fiberoptic cable installations would be captured as an economywide job, though not as a clean energy job, while an Electric Power Line Installer who spent some or all of their time upgrading transmission and distribution systems would be captured both as a clean energy and economywide job. Data from Massachusetts Department of Economic Research – Executive Office of Labor and Workforce Development, Long Term Occupational Projections, All Available Occupations (2018 – 2028), https://lmi.dua.eol.mass.gov/LMI/LongTermOccupationProjections/LTOPResultAll?A=01&GA=000025&Cmd=Go&Type=long&Dopt=TEXT

[105] *Economywide Insulation Workers have been adjusted to meet the number of current clean energy Insulation Workers. Because of classification differences, BLS may label some Insulation Workers identified here as general Construction Laborers, even though they predominantly work on insulation activities.

Electricians

As use of fossil fuels shifts to electricity, Electricians will be involved in almost every facet of decarbonization efforts. Electricians will play the leading role in electrifying Massachusetts' economy by installing, maintaining and repairing residential and commercial electrical infrastructure and equipment, including EV charging stations, connecting electrical wiring in renewable energy generation stations and wiring electric circuits in homes and businesses. Installing new electric air source heat pumps in homes requires an electrician and many buildings will require significant electrical capacity upgrades to electrify heating systems and subsequently increase demand for electricity. Without the appropriate number of Electricians, the state's decarbonization strategy simply won't work.

25th Percentile Wages	Median Wages	75th Percentile Wages
$24.70	$37.02	$48.19

DEMOGRAPHICS

This report uses the U.S. Census Bureau's definitions of Race and Ethnicity, and therefore sum totals may not equal 100%.

98% Male	2% Female

88% White	6% Black
3% Asian	13% Hispanic

32%	45%	23%
Under 35 Years of Age	35-54 Years of Age	55+ Years of Age

83%
Without a Bachelor's Degree

4.4 / 5
State Occupation Star Ranking

JOB OPPORTUNITIES ACROSS CLEAN ENERGY SECTOR

2,192	764	1,488
Alternative Transportation	Energy Efficiency	Renewable Energy

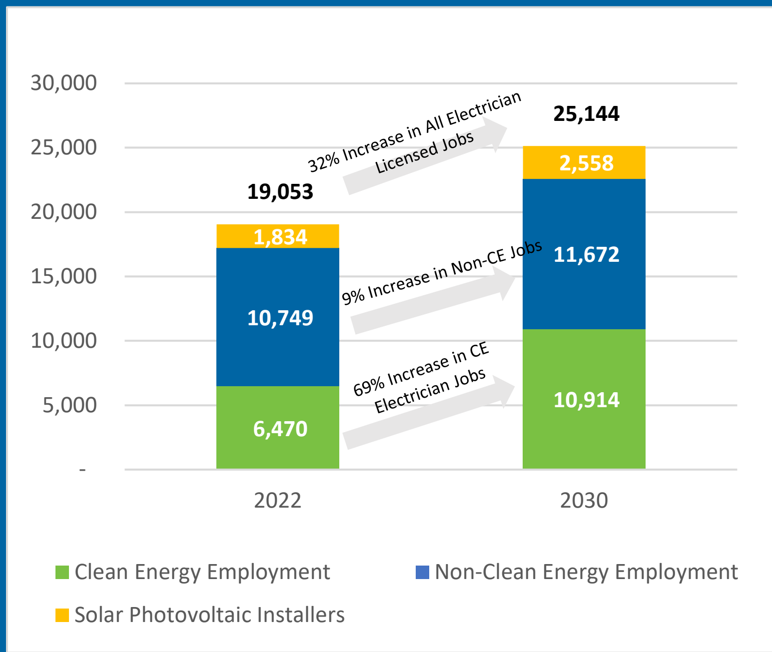
Occupation Summary

There are several different paths to becoming an Electrician, with different options in each path. Electricians are required to be licensed in Massachusetts and the licensing process includes 8,000 hours of electrical trade experience (often an apprenticeship), 600 hours of coursework and passing a state exam. An aspiring Electrician may first seek some educational experience, either through vocational and technical schools, post-secondary education or through an on-the-job helper role. This experience is important to be competitive for an apprenticeship seat, and ensures that a candidate is aware of the typical demands of the job. Once an individual has some electrical experience under their belt, they will seek to secure an Electrician apprenticeship position. A job seeker going through the union track will often proceed directly to the apprenticeship stage or gain experience first through a pre-apprenticeship program. The typical timeframe to complete an apprenticeship is 5 years, which can overlap with some educational coursework, during which apprentices are paid increasing wages. Once an apprenticeship is completed, a job seeker will sit for a state exam and, upon receiving a passing grade, achieve state certification as an Electrician Journeyworker.

Projected Demand

An estimated 4,440 additional clean energy Electricians will be required by 2030 to meet the state's decarbonization goals. This makes Electricians the highest-demand occupation by absolute number. These additional clean energy workers represent a 69% increase in clean energy-related Electricians. The state additionally projects economywide demand for Electricians to increase by an additional 920 jobs during this time, meaning the total number of additional clean energy and non-clean energy Electricians needed by 2030 is nearly 5,400, or a 31% increase from 2022 figures.

Furthermore, an additional 730 Solar Photovoltaic Installers will be needed by 2030. While Solar Photovoltaic Installers are a different occupation from Electricians, they are required to have electrician licenses in Massachusetts, making the total number of additional workers with Electrician licenses in excess of 6,000, or a 32% increase in Electrician licenses.



> *For the solar side of the business, we always need technicians. These are Electricians that have the diagnostic and analytic capabilities to identify problems with inverters and monitoring systems. We pay them \$10-\$15 more per hour than traditional Electricians and the market demands that."*
> **- Employer**

Institution or Program Host Type	Electrician Training Programs Identified in Massachusetts
Community College	4
Private College/University	2
Private Training Company/Technical College	8
Public College/University	1
Union or Union-Industry Collaborative	4
Vocational and Technical High School	44
Total	**63**

Trainings

The analysis identified 63 different training programs relevant to Electricians across the state. More than two-thirds (70%) of these programs are vocational and technical high school programs. Some regions have greater representation[1] of Electrician training programs than others. Both the Berkshire region and the Cape Cod and Islands region have only two Electrician-related training programs. Technical and vocational schools are a major pipeline into apprenticeship programs, graduating 700 students in 2021 compared to under 40 at community colleges and some private institutions. Of the 559 vocational and technical school graduates who responded to the survey, 319 had secured related employment (57%) and 206 were completing related education (37%), including 126 apprenticeships.[2] Given the role that these schools play in the Electrician pipeline, expanding the number of locations and the number of seats at existing locations is essential to ensuring the state has an adequate number of Electricians by 2030.

There are also four union-run Electrician training centers throughout the state in Boston, Worcester, Springfield and Taunton. Although fewer in number than vocational and technical schools, community colleges and private companies and colleges, union-run training centers are a critical training pipeline. The largest training center, IBEW 103 in Boston, graduates 250–300 apprentices per year, many of whom continue on to receive state licensure and become practicing electricians. Continuing on the same trajectory, this training center will have trained over 1,700 apprentices by 2030.

Another important consideration is the split of union and non-union training programs. Union Electrician trainers reported turning down roughly four interview-qualifying candidates for every open seat. This highlights that there is interest in these positions among job seekers, but a mismatch in demand.

Electricians will be involved in almost all parts of the clean energy transition, sometimes requiring additional education or certification to complete specific types of projects. Electricians working on offshore wind turbines at sea will have to complete a Global Wind Organization Basic Safety training to ensure that they are safe at sea. Electricians building out charging infrastructure may not be required to attain an Electric Vehicle Infrastructure Training Program (EVITP) certificate but it may be preferred for certain projects. Electricians installing solar electric systems may seek out a North American Board of Certified Energy Practitioners (NABCEP) certification. While specialization can sometimes be learned on the job, employers need to be proactive in prioritizing opportunities to train and upskill their workers, including providing the appropriate time, resources and supports to do so.

Challenges and Opportunities

There are several challenges to increasing the supply of Electricians:

1) In a 2022 survey of clean energy employers, Electricians were the second-most difficult non-management position to hire for among non-union Installation, Maintenance, and Repair employers. This suggests that supply of Electricians may already be constrained within the parts of the current labor market.
2) Increasing the pipeline of the total number of Electricians by 31% in eight years presents a challenge for training providers.
3) State laws require certified Electricians to maintain no more than one apprentice, thereby constraining the number of Electrician apprentices. Nearby states mitigate this constraint through scaled ratios based on apprentice experience - such as the system in New Hampshire - or a flat increase of this cap - such as that in Maine.

It is no surprise that Electricians—who will be primarily responsible for electrifying the economy—are projected to be in the greatest demand. Along with the exceptional growth rates in demand for these jobs, there are several other factors that make Electricians a likely key bottleneck. First, the occupation takes nearly half a decade to prepare a fully-licensed worker. Second, the need for apprenticeships ultimately caps the number of Electricians who can be in training at any given time. Third, Electricians were identified as the second-most difficult to hire non-management position among Installation, Maintenance and Repair companies. Fourth, two-thirds of all Electricians (68%) in the state are 35 or older, 22% of which are 55 or older. In a physically-intensive occupation like Electricians, these numbers suggest a large number of these workers may be looking to retire in the future. Additioanlly, the demographics of Electricians are also heavily White and male, a dynamic that could impact recruitment and retention of underrepresented populations.

All of the factors outlined above indicate that Electricians and the accompanying required electrical licenses will be the greatest potential workforce bottleneck as the state looks to meet its decarbonization goals.

Recommended Next Steps

Electricians are likely the greatest potential workforce chokepoint that could prevent the state meeting its clean energy ambitions. To address this challenge, existing Electrician training programs will have to expand their offerings, and new electrician training programs will be needed to supplement these expansions. In particular, training programs for individuals who are beyond high school age are needed, as many areas of the state have only vocational and technical high schools as relevant training opportunities. Leveraging the training pipelines of unions and their existing waitlist of interested workers is an important consideration that could help rapidly address some of the projected workforce gaps. Efforts to increase diversity in recruitment, retention and promotion should also be pursued.

[1] "Representation" of training programs geographically is determined by comparing the current proportion of training programs within a region relevant to a particular occupation to the proportion of workers in that occupation that are projected to work within that region. For example, even though the Berkshire region is projected to account for fewer than 5% of statewide demand for Electricians, the lack of any training programs means that this region has an "underrepresentation" of electrician training programs.

[2] Percentages not fully additive. Some graduates working while continuing education. 2021 Graduate Follow-up Survey Results. Massachusetts Department of Elementary and Secondary Education. https://www.doe.mass.edu/ccte/cvte/data/default.html?yr=2021#survey-results

Heating, Ventilation, Air Conditioning and Refrigeration (HVAC-R) Mechanics and Installers

HVAC-R Mechanics and Installers will play a pivotal role in efforts to electrify and decarbonize buildings. HVAC-R Mechanics and Installers will replace legacy fossil fuel heating systems with electrified systems, such as air-source heat pumps and other clean heating and cooling technologies. Electrifying buildings is a core component of the state's decarbonization strategy, and without a sufficient supply of HVAC-R Mechanics and Installers, this goal will not be achieved.

25th Percentile Wages	Median Wages	75th Percentile Wages
$24.80	$31.26	$38.44

DEMOGRAPHICS

89% Male

11% Female

87% White	**7%** Black
1% Asian	**16%** Hispanic

31%	**41%**	**28%**
Under 35 Years of Age	35-54 Years of Age	55+ Years of Age

87%
Without a Bachelor's Degree

4 / 5
State Occupation Star Ranking

JOB OPPORTUNITIES ACROSS CLEAN ENERGY SECTOR

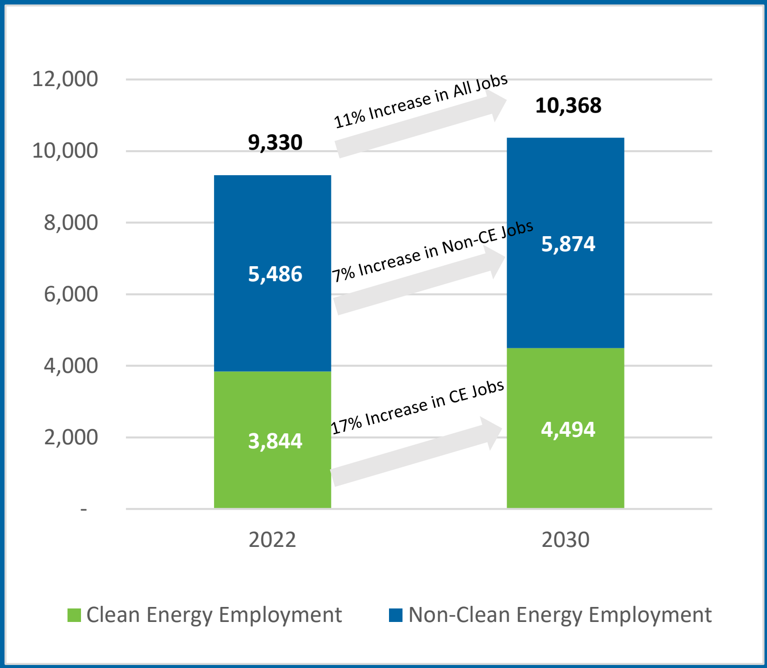
0	**506**	**145**
Alternative Transportation	Energy Efficiency	Renewable Energy

Occupation Summary

HVAC-R Mechanics and Installers will be responsible for installing much of the new electrified heating and cooling systems, including heat pumps. While certifications are not legally required[1] for HVAC-R Mechanics and Installers in Massachusetts, formal training or certifications, such as the EPA 608 Technician Certification and North American Technician Excellence (NATE) Certification, are preferred. There are several pathways to becoming an HVAC-R Mechanic and Installer. An aspiring HVAC-R Mechanic and Installer may enter a relevant training program at vocational and technical schools, community college or a private training program. The typical training duration is four years through vocational and technical high schools and two semesters or five to eight months through college or private trainers. Once a job seeker has some familiarity, they may look to start working in a helper or apprentice capacity.

Projected Demand

An estimated 650 additional full-time clean energy HVAC-R Mechanics and Installers will be needed by 2030, as well as an estimated additional 390 economywide HVAC-R Mechanics and Installers. This represents a 17% increase in clean energy HVAC-R Mechanics and Installers and an 11% increase in the total number of HVAC-R Mechanics and Installers in Massachusetts. HVAC-R Mechanics and Installers were also the most difficult-to-hire among Installation, Maintenance and Repair non-union employers, suggesting a workforce gap already exists. The current talent pool is also relatively old: 27% are 55 or older and another 41% are 35 or older, meaning a significant wave of retirements is likely to occur as decarbonization efforts ramp up. These factors, paired with the projected high demand for this occupation, make it another occupation that could lead to a bottleneck in meeting the state's 2030 GHG emission reduction targets.



Institution or Program Host Type	HVAC-R Training Programs Identified in Massachusetts
Community College	10
Community-Based or Non-Profit Organization	1
Industry Association	2
Private College or University	3
Private Training Company or Technical School	13
Public College or University	1
Union or Union-Industry Collaboration	1
Vocational and Technical High School	26
Total	**57**

[1] Unless installing commercial refrigeration units, in which case a refrigeration certification is required.

Trainings

The analysis identified 57 different training programs relevant to HVAC-R Mechanics and Installers. Most of these trainings were at vocational and technical high schools (46%), as well as private training companies (23%) and community colleges (18%). There is one union-run training program for HVAC-R Mechanics and Installers through the Local 537 Pipefitters. Graduates of these programs can proceed directly to applying for HVAC-R Mechanic and Installer roles at HVAC-R employers.

Vocational and technical schools, as well as community colleges and private training organizations, were major pipelines of HVAC-R talent. In 2021, 324 students completed HVAC-R-related vocational and technical school programs, compared to 216 students at community colleges and some private institutions. While the analysis does not have as granular data for community colleges or private institutions, we know 118 of the 236 vocational and technical school HVAC-R graduating survey respondents (52%) went into relevant employment opportunities, and 32 (14%) respondents pursued related education, 22 of which were apprenticeship programs. 49 of these respondents were working and pursuing education at the same time.[1]

Although the analysis didn't capture whether these training programs currently include instruction on heat pump technologies, interviews with different training providers revealed that incorporation of the theory of heat pump technologies and building out heat pump infrastructure in training labs is occurring in some locations, while interest from training providers is increasing more broadly. Additionally, Mass Save's Heat Pump Installer Network is an important resource for contractors and homeowners alike, as the network provides resources to find qualified contractors, information on where to find technical heat pump training for contractors and workers, and access to exclusive rebates and financing opportunities.

[1] 2021 Graduate Follow-up Survey Results, Massachusetts Department of Elementary and Secondary Education, https://www.doe.mass.edu/ccte/cvte/data/default.html?yr=2021#survey-results.

Challenges and Opportunities

HVAC-R Mechanics and Installers were reported to be the most difficult occupation to currently hire for among Installation, Maintenance, and Repair employers, suggesting that there is a current shortage in workers. Demand will continue to grow as HVAC-R Mechanics and Installers will play a pivotal role in the decarbonization transition. Based on surveys and interviews of various training providers, expanding training capacity to support an 11% increase of HVAC-R Mechanics and Installers would likely be feasible and unlikely to significantly overburden them, if given sufficient notice and incentives to expand. Some training providers also highlighted that some HVAC-R trainings being offered were undersubscribed, and efforts to expand training capacity would need to be paired with enhanced outreach and engagement to increase student enrollment and retention.

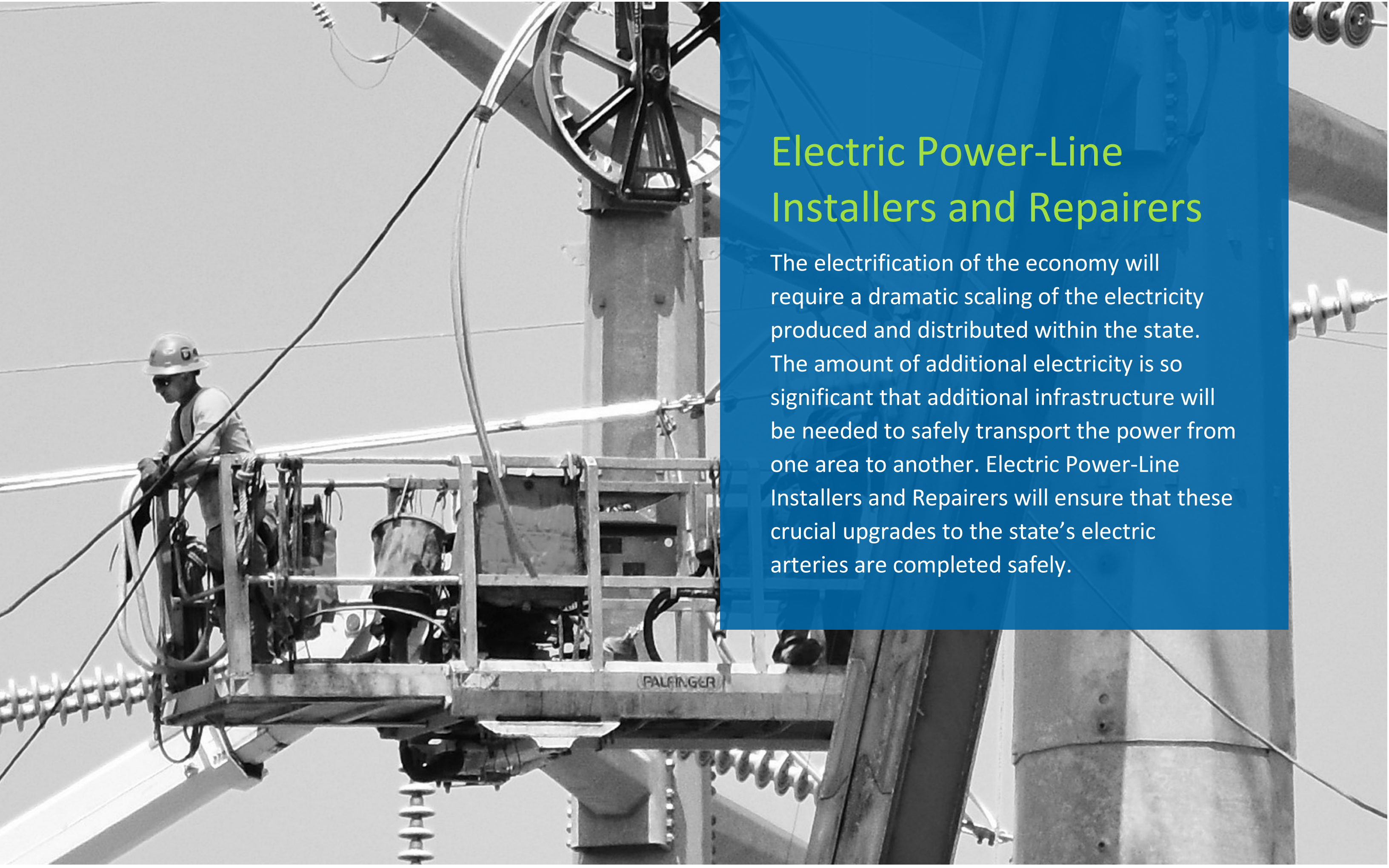
Recommended Next Steps

It is important to increase the supply of HVAC-R workers by increasing training capacity in current programs at vocational-technical schools, post-secondary institutions and other training programs, as well as supporting awareness campaigns to increase enrollment, whether through Community-Based Organizations, or more broadly. Additionally, there needs to be support efforts to stand up new training programs at vocational and technical schools where there are no HVAC-R trainings in the region. These efforts can help ensure the next generation of HVAC-R Mechanics and Installers are trained.

Employers of HVAC-R Mechanics and Installers often noted a preference for North American Technician Excellence (NATE) certifications, so working with vocational and technical schools, post-secondary institutions and other training programs to incorporate this curriculum could help future graduates and prospective employers.

Additionally, sponsor informational sessions between contractors and heat pump manufacturers. These sessions will ensure that HVAC-R Mechanics and Installers, who are often looked to provide recommendations to homeowners, are familiar with the range of products, incentives and projected cost savings of efficient HVAC-R equipment and can relay that information to homeowners. There is additional value in engaging Mass Save as part of these efforts.

Lastly, develop strategies to support training providers to update curriculum and training labs to incorporate and expand hands-on training for heat pump and other clean heating and cooling technologies.



Electric Power-Line Installers and Repairers

The electrification of the economy will require a dramatic scaling of the electricity produced and distributed within the state. The amount of additional electricity is so significant that additional infrastructure will be needed to safely transport the power from one area to another. Electric Power-Line Installers and Repairers will ensure that these crucial upgrades to the state's electric arteries are completed safely.

25th Percentile Wages	Median Wages	75th Percentile Wages
$40.98	$48.02	$52.60

DEMOGRAPHICS

96% Male

4% Female

82% White	**11%** Black
1% Asian	**17%** Hispanic

36% Under 35 Years of Age	**45%** 35-54 Years of Age	**18%** 55+ Years of Age

82% Without a Bachelor's Degree

3.3 / 5 State Occupation Star Ranking

JOB OPPORTUNITIES ACROSS CLEAN ENERGY SECTOR

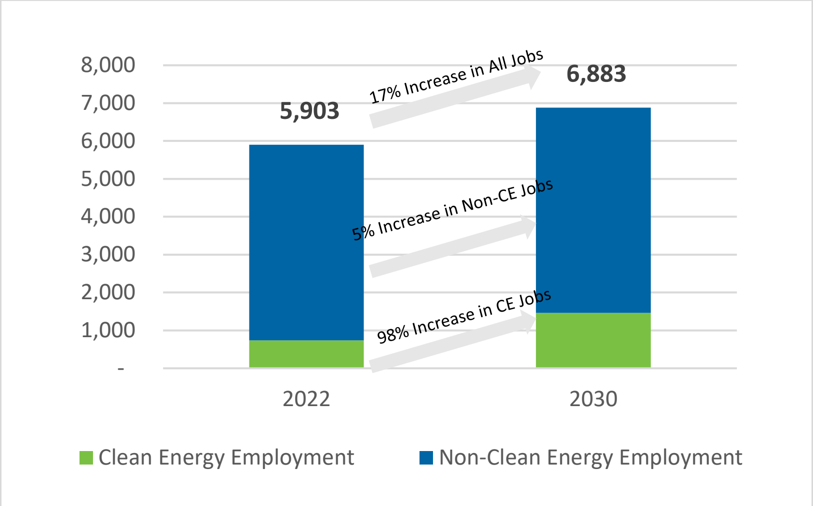
70 Alternative Transportation	**476** Energy Efficiency	**176** Renewable Energy

Occupation Summary

The electrification of the Massachusetts economy will require hundreds of miles of additional and upgraded transmission and distribution wires. Electric Power-Line Installers and Repairers will play the primary role in completing this work. An aspiring Electric Power-Line Installer and Repairer will start by receiving some formal education, often through a program hosted by a community college, labor union or utility, or some joint offering by these parties. After this training, a job seeker will work as an apprentice for 8,000 hours or four years.

Projected Demand

An estimated 720 additional full-time clean energy Electric Power-Line Installers and Repairers will be needed by 2030, as well as an estimated 260 economywide workers. This means that the total number of Electric Power-Line Installers and Repairers will increase by 17% between 2022 and 2030.



Trainings

To become an Electric Power-Line Installer and Repairer, a job seeker must complete a formal training program and then enter the workforce as an apprentice. A majority of these trainings in Massachusetts are hosted by community colleges, though industry associations and unions also offer training programs. The analysis identified 8 Electric Power-Line Installer and Repair programs, and many of these programs are devised in cooperation with utilities, including National Grid and Eversource. This strong partnership with industry ensures participants have a strong pipeline to prospective employers.

Institution or Program Host Type	Electric Power-Line Installer & Repairer Training Programs Identified in Massachusetts
Community College	4
Industry Association	1
Private College/University	1
Public College/University	1
State Agency	1
Total	**8**

Challenges and Opportunities

Because there are relatively few training programs in total, it is more likely that each training program will have to expand the number of current seats offered. Expanding to meet the projected 17% increase in workers over an eight-year span may be easier for some programs than for others.

Recommended Next Steps

Creating new training programs and expanding the capacity of existing programs is important. Fewer training providers means that there is less margin for error as programs look to increase their capacity. This will likely require a more hands-on approach with each of the training providers, as well as close communication and coordination with utility providers, who already work closely with some training providers and will have greater clarity into specific needs and demand for workers.

Construction and Building Inspectors
(Including Energy Analysts & HERS Raters)

Retrofitting homes and businesses to improve energy efficiency will require Energy Auditors as well as Building Inspectors, both of which fall under the Construction and Building Inspectors title. While their roles are slightly different, these workers will ensure that retrofits are cost-effective, improve thermal barriers and are safe for occupants.

25th Percentile Wages	Median Wages	75th Percentile Wages
$25.13	$36.58	$42.32

DEMOGRAPHICS

91% Male

9% Female

91% White	**5%** Black
3% Asian	**5%** Hispanic

16%	**33%**	**50%**
Under 35 Years of Age	35-54 Years of Age	55+ Years of Age

50% Without a Bachelor's Degree

3.2 / 5 State Occupation Star Ranking

JOB OPPORTUNITIES ACROSS CLEAN ENERGY SECTOR

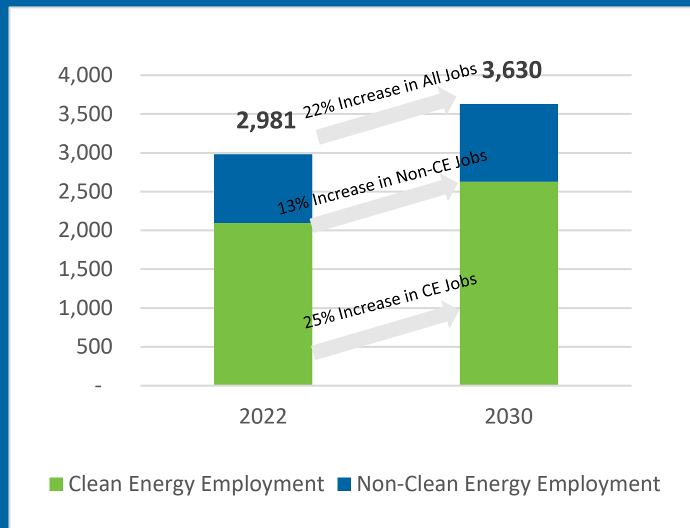
0	**532**	**0**
Alternative Transportation	Energy Efficiency	Renewable Energy

Occupation Summary

Construction and Building Inspectors is a technical occupational definition that contains a number of different specializations within it. There are municipal-level inspectors who examine construction projects to ensure that buildings meet relevant codes. Additionally, there are private sector counterparts and energy analysts and auditors, including HERS Raters, who examine structures for their heat retention and energy efficiency. The latter specialization is most directly relevant to clean energy activities; however, the two former specializations are important roles in any construction project, including in the construction of new high-efficiency buildings.

Projected Demand

By 2030, an additional 530 Construction and Building Inspectors will be needed, along with an additional 120 economy-wide inspectors, resulting in a 22% increase in employment in this occupation. However, as noted above, not all of these occupations may be energy auditors. Zippia, a jobs data aggregator[1], estimates that there are roughly 250 energy analysts in Massachusetts, which means that roughly one in ten Construction and Building Inspectors is an energy auditor. Using this same proportion, about 50 additional energy auditors would be needed by 2030, representing a 20% increase, though this is likely an underestimate since retrofits and high-efficiency construction, which require energy auditors, will make up an increasing share of construction activities. The revised Stretch Energy Code, which requires new construction to meet energy efficiency requirements, will drive higher demand for these roles as well.



Trainings

The analysis identified 20 different training programs relevant to energy auditing, primarily through Building Performance Institute (BPI) or HERS Rater training programs. BPI and HERS Rater courses can take one to five days to complete, but scheduling testing and completing certification can take longer. Nearly all of these programs are available through a private third-party organization and most are available in an online format, which alleviates geographic challenges but raises concerns for job seekers who may not have access to technology or may learn better in an in-person format. Furthermore, while online training can provide technical knowledge, some hands-on experience is required to demonstrate practical application. Promoting training opportunities that provide hands-on experience alongside technical knowledge is important.

Institution or Program Host Type	Construction & Building Inspector Training Programs Identified in Massachusetts
Community College	4
Community-Based/Non-Profit Organization	3
Industry Association	1
Private Training Company/Technical School	12
Total	**20**

Challenges and Opportunities

The prevalence of training programs means that these programs are relatively accessible. However, roughly half of all Construction and Building Inspectors have a bachelor's degree, which raises questions around accessibility for all job seekers. Second, many energy auditor trainings are offered online through private organizations. The relatively short training period may not be a good fit for trainees facing systemic barriers to entry, where hands-on training and additional work readiness preparation can support successful placement and retention.

Recommended Next Steps

Integrating the broad suite of relevant training programs into publicly available or subsidized programs can help ensure that these programs are accessible to a broader audience. For example, Bunker Hill Community College, which is a minority-serving institution, offers a BPI weatherization program through which students can access the training alongside the support systems that the community college offers. There may also be an advantage to linking these trainings with building technician or construction trade training programs. Lastly, promoting these trainings to those with some construction experience may also offer a strong career pathway opportunity.

[1] Energy Auditor Demographics and Statistics in the US, Updated September 9, 2022, Zippia, https://www.zippia.com/energy-auditor-jobs/demographics/.

Construction Laborers

Construction Laborers are the key to ensure clean energy projects of all sizes and technologies can be completed. They will play support roles in building efficiency retrofit projects and help install infrastructure surrounding charging stations as well as the bracketing and piling that supports utility-scale solar projects.

25th Percentile Wages	Median Wages	75th Percentile Wages
$22.08	$27.90	$35.81

DEMOGRAPHICS

96% Male

4% Female

86% White	**7%** Black
3% Asian	**32%** Hispanic

37% Under 35 Years of Age	**43%** 35-54 Years of Age	**20%** 55+ Years of Age

85% Without a Bachelor's Degree

4.1 / 5 State Occupation Star Ranking

JOB OPPORTUNITIES ACROSS CLEAN ENERGY SECTOR

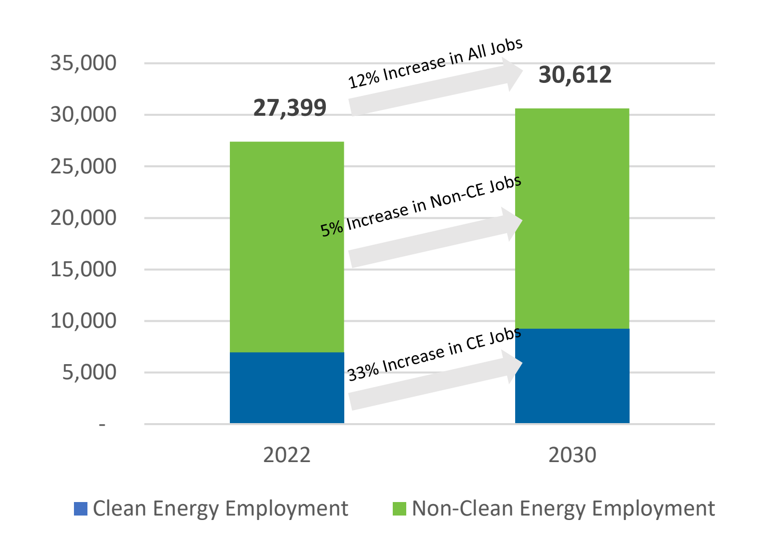
64 Alternative Transportation	**1,856** Energy Efficiency	**368** Renewable Energy

Occupation Summary

Construction Laborers are the generalists of clean energy infrastructure projects and these projects could not be completed without them. Aspiring Construction Laborers may opt to attend a formal training program or may look to directly enter the workforce in a helper role. Additional specialization will allow these workers to earn more throughout their careers.

Projected Demand

An estimated additional 2,290 Construction Laborers will be needed by 2030. When including the expected economywide demand of 930 additional workers during this time, the total demand for Construction Laborers is expected to grow by 12% between 2022 and 2030. There is also demand for an estimated 990 additional workers that fall under roles that can be described as “ancillary construction support roles,” such as Painters, Paperhangers and Drywall Installers, which are not directly involved in clean energy work but are necessary to complete many clean energy projects.



Trainings

Because Construction Laborers are somewhat generic roles that can complete a range of construction-related tasks, workers can have little or no formal training but have the opportunity to upskill to more specialized roles. There are still opportunities for formal training, including a union training center located in Hopkinton, Massachusetts.

Challenges and Opportunities

There are several factors that may make achieving the number of additional workers a challenge. First, the absolute number of workers needed that are either Construction Laborers or more ancillary construction support roles is significant, especially in a labor market with relatively little slack. These are also physically intensive roles that are often outside, which can limit the number of interested workers in these roles. It is also notable that a Construction Supervisor License (CSL), a license that Construction Laborers with experience could attain to subsequently receive a significant pay increase, was identified as one of the most in-demand certifications by clean energy employers involved in construction-related work.

Recommended Next Steps

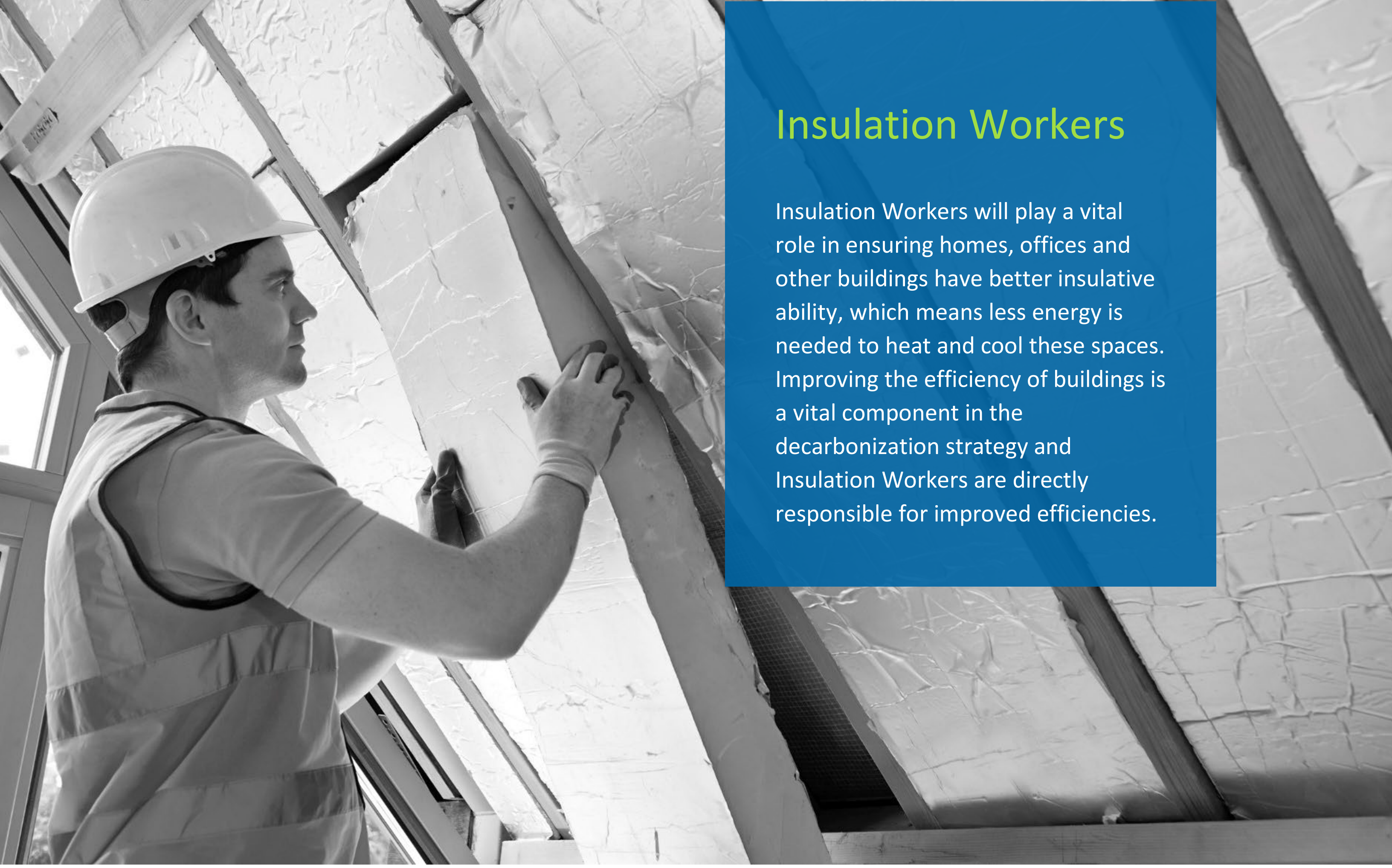
Ensuring greater access and entry into general construction roles can be supported through a number of actions, including expanding support programs that provide job seekers with hands-on experience at an early age, such as pre-apprenticeships or vocational and technical high school programs, to allow future construction workers to build foundational skills and help them specialize later.

Integrate equity-based recommendations from other sections of this report, including in the employer section, to diversify incoming talent pools and help companies address exclusionary culture.

Explore how a broader group of participants could meet the physical nature of the work.

Highlight and promote the absence of formal requirements and the relatively easily accessible entry into this career.

Consider a program that subsidizes the cost of further career certifications (such as a CSL or Certified Cost Professional (CCP) certification) for experienced workers to promote upward mobility and specialization within clean energy.



Insulation Workers

Insulation Workers will play a vital role in ensuring homes, offices and other buildings have better insulative ability, which means less energy is needed to heat and cool these spaces. Improving the efficiency of buildings is a vital component in the decarbonization strategy and Insulation Workers are directly responsible for improved efficiencies.

25th Percentile Wages $20.73

Median Wages $24.75

75th Percentile Wages $35.38

DEMOGRAPHICS

96% Male

4% Female

80% White

10% Black

2% Asian

35% Hispanic

39% Under 35 Years of Age

50% 35-54 Years of Age

11% 55+ Years of Age

89% Without a Bachelor's Degree

2.0 / 5 State Occupation Star Ranking

JOB OPPORTUNITIES ACROSS CLEAN ENERGY SECTOR

0 Alternative Transportation

965 Energy Efficiency

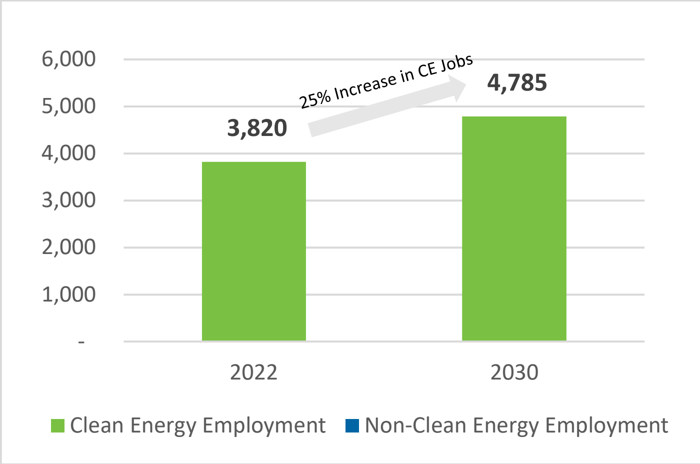
0 Renewable Energy

Occupation Summary

Insulation Workers are responsible for gaining access to and working within the attics, nooks and crannies of buildings and homes, to better insulate these spaces to prevent loss of heat. This is a vital job for improving efficiency of homes; however, it is often dirty and physically intensive work that is also exposed to seasonal temperature swings.

Projected Demand

Nearly 1,000 additional Insulation Workers are estimated to be needed by 2030, which is a growth rate of 25%. All of these positions are clean energy jobs. The number of Insulation Workers in 2022 and the estimated number of Insulation Workers in 2030 was developed through the use of staffing patterns, survey responses and interviews with insulation employers and exceeds the state estimate of less than 700 current Insulation Workers, likely because these roles are often conflated with Construction Laborers.



Trainings

Similar to Construction Laborers, there is less formal training required, aside from an OSHA 10 certification. Although most workers are trained on the job, some trainings exist, such as through the Mass Save Clean Energy Pathways program, which seeks to graduate individuals with the ability to pass the BPI Weatherization Analyst and Envelope Pro certifications. Additionally, some formal training programs are offered through agencies that also administer the federally funded Low-Income Weatherization Assistance Program (WAP), including weatherization trainings through the SMOC Green Jobs Academy. There are also training opportunities for specialization and leadership roles. A North American Technician Excellence (NATE) certification or Mass SAVE Weatherization Crew Chief certification are all opportunities for Insulation Workers to specialize and increase their earning potential.

Challenges and Opportunities

The primary challenges for meeting the number of additional Insulation Workers anticipated is the total number of workers needed and the type of work combined with the relatively low accompanying wages of these roles. Employers paying close to minimum wage will face challenges hiring and retaining workers as the work is physically challenging and, at times, uncomfortable.

It will be important to emphasize to job seekers that Insulation Workers as a career is a first step into an industry that can have upward potential. The relatively quick promotional timeline to a role such as a crew chief, which offers higher pay, may make this occupation more appealing for some prospective workers.

Recommended Next Steps

Similar to recommendations for Construction Laborers, providing job seekers with early information about low barriers to entry, career pathways with strong wage growth opportunity and an opportunity to work in a hands-on environment will be crucial in attracting additional talent.

Additionally, consider programs that subsidize the cost of upward career progression training for experienced Insulation Workers. This could include the Mass SAVE Weatherization Crew Chief certification, a NATE certification or even a BPI certification, allowing workers to directly leverage their time and experience into upward career mobility within clean energy.

Cost Estimators

Any construction site will require an approximation of costs and evaluation of strategies to make sure a project is complete. Cost Estimators are particularly important for clean energy projects, which often incorporate greater complexity or nuance than inefficient construction.

25th Percentile Wages $34.47

Median Wages $46.87

75th Percentile Wages $61.30

DEMOGRAPHICS

85% Male

15% Female

91% White

2% Black

4% Asian

4% Hispanic

21% Under 35 Years of Age

48% 35-54 Years of Age

31% 55+ Years of Age

42% Without a Bachelor's Degree

3.9 / 5 State Occupation Star Ranking

JOB OPPORTUNITIES ACROSS CLEAN ENERGY SECTOR

55 Alternative Transportation

200 Energy Efficiency

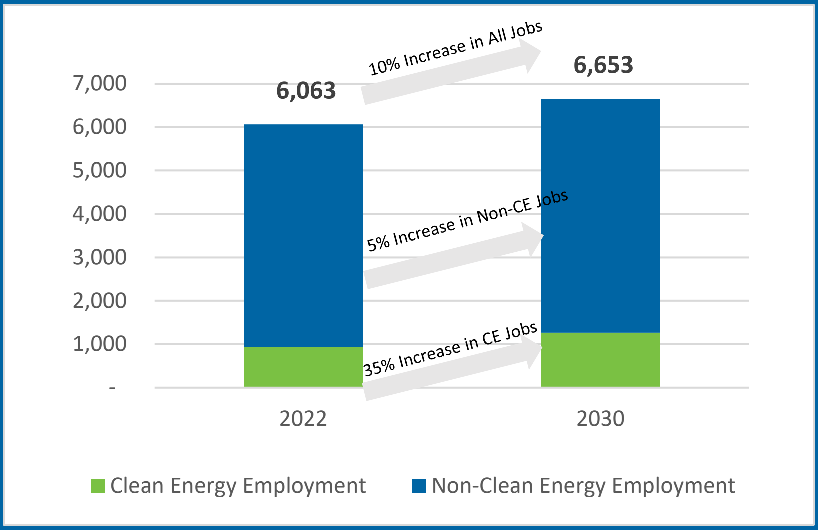
77 Renewable Energy

Occupation Summary

Cost Estimators play an important role in evaluating the cost of a proposed project and determining if projects are feasible. While a four-year degree is not required, more than half (57%) of current Cost Estimators have at least a bachelor's degree.

Projected Demand

An additional 330 full-time clean energy-related Cost Estimators are projected to be needed by 2030, as well as 259 additional economywide Cost Estimators, representing a 10% increase in these total workers statewide.



Trainings

A Certified Cost Professional (CCP) credential is required, and, though it is not required, many Cost Estimators have a bachelor's degree. Clean energy Cost Estimators may also benefit from having certain clean energy-specific certifications, including an array of BPI certifications that demonstrate their competency in high efficiency structures.

Challenges and Opportunities

CCP Certifications are broadly available online or in a blended format, which can be good for accessibility provided that individuals have Internet access. One potential equity obstacle is the preference for Cost Estimators to have a bachelor's degree or more. Given the inequal opportunity to attain a four-year degree, this may mean that this occupation is perceived as unobtainable for some.

Recommended Next Steps

One way to address the potential barrier of a bachelor's degree would be to develop or support a program that helps experienced Construction Workers with less than a bachelor's degree to obtain CCP licenses. This program could be developed with employers so that they feel confident in the quality of the candidates that complete the programs. Additionally, increasing the awareness of Cost Estimators as a career choice and potentially lucrative stepping-stone for workers already in the construction industry could increase interest in this occupation.

Miscellaneous Assemblers and Fabricators

While all of the occupations above are involved in the installation of systems or devices, Miscellaneous Assemblers and Fabricators will be responsible for manufacturing many of the systems that are used to generate electricity. This may include assembling components of offshore wind turbines or the smaller electrical components used in EV charging stations, smart home thermostats or other technologies. This demand presents the opportunity to revive some manufacturing jobs within the state.

25th Percentile Wages	Median Wages	75th Percentile Wages
$16.31	$18.94	$23.09

66% Male

34% Female

DEMOGRAPHICS

76% White	12% Black
7% Asian	17% Hispanic

35% Under 35 Years of Age	40% 35-54 Years of Age	25% 55+ Years of Age

85% Without a Bachelor's Degree

2.5 / 5 State Occupation Star Ranking

JOB OPPORTUNITIES ACROSS CLEAN ENERGY SECTOR

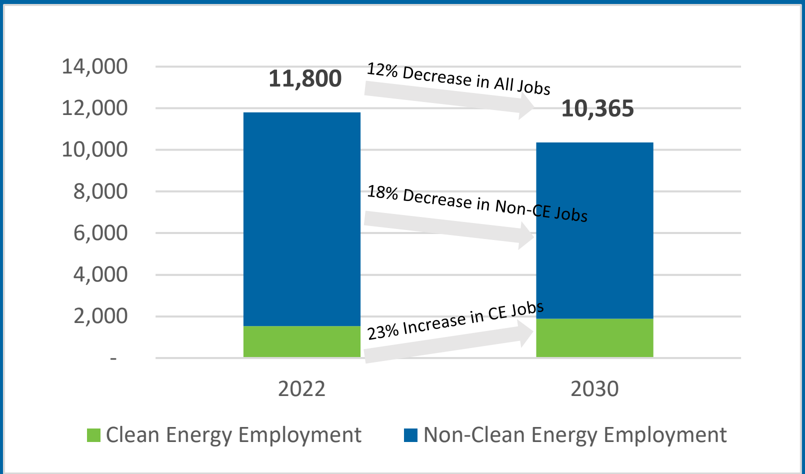
23 Alternative Transportation	198 Energy Efficiency	137 Renewable Energy

Occupation Summary

Miscellaneous Assemblers and Fabricators are responsible for a range of clean energy activities, including assembly of components for solar photovoltaic systems, electrical distribution and EV charging infrastructure and offshore wind turbine components, as well as any other products that may have components assembled within Massachusetts. The range of products manufactured in Massachusetts may expand as federal legislation, including the Inflation Reduction Act, incentivizes domestic manufacturing of clean energy products. An entry-level Miscellaneous Assembler and Fabricator position may not require much formal training outside of several months of on-the-job training with an employer as well as an OSHA 10 certificate, which itself is quick process, but job seekers may have more success entering these positions if they have some previous training through vocational and technical schools or community colleges.

Projected Demand

An additional 360 Miscellaneous Assemblers and Fabricators will be needed by 2030. It is also notable that these types of roles economywide in Massachusetts are projected to shed nearly 1,800 workers in a 10-year span, meaning that the growth in clean energy employment has the potential to offset the loss of some of these jobs.



Trainings

While there is relatively little formal training required for entry, aside from basic safety training such as an OSHA 10 certification, most employers prefer to see some experience, either through a certificate, training at a vocational-technical school, an associate degree from a post-secondary institution, or previous manufacturing experience. There are a number of more specialized trainings that allow workers to advance and specialize within their designated field. Manufacturing roles also increasingly require computer and CAD-related knowledge, meaning that basic computer literacy is increasingly a foundational requirement for these roles.

Challenges and Opportunities

Despite the knowledge and experience required for assembly of advanced products, these roles can pay less than other similar alternatives. However, these types of roles do offer excellent entry-level career opportunities to gain experience in manufacturing while attaining additional education or certification to advance to higher-paying portions of the manufacturing process that require expertise with advanced manufacturing machinery. The recent federal legislation that incentivizes domestic production of clean energy products means that the number of manufacturing jobs may increase within the state beyond these projections.

Recommended Next Steps

The projected loss of nearly 1,800 current economywide Miscellaneous Assemblers and Fabricators by 2030 can be transitioned to open clean energy positions. These existing workers are likely to require some on-the-job training, including some manufacturer-specific reskilling. Creating a formal database or jobs board for these workers may help these transitions. Additionally, continuing to attract first-time workers for an opportunity to enter manufacturing careers will be important.

Operating Engineers and Other Construction Equipment Operators

Every construction site needs to safely move heavy materials and structures. Without the appropriate number of trained Operating Engineers and Other Construction Equipment Operators, these construction projects will be slowed significantly and crucial energy generation projects like Offshore Wind will not be completed on time.

25th Percentile Wages	Median Wages	75th Percentile Wages
$25.87	$31.69	$43.77

DEMOGRAPHICS

Male	Female
97%	3%

89% White	7% Black
0% Asian	16% Hispanic

Under 35 Years of Age	35-54 Years of Age	55+ Years of Age
30%	42%	28%

94%
Without a Bachelor's Degree

4.0 / 5
State Occupation Star Ranking

JOB OPPORTUNITIES ACROSS CLEAN ENERGY SECTOR

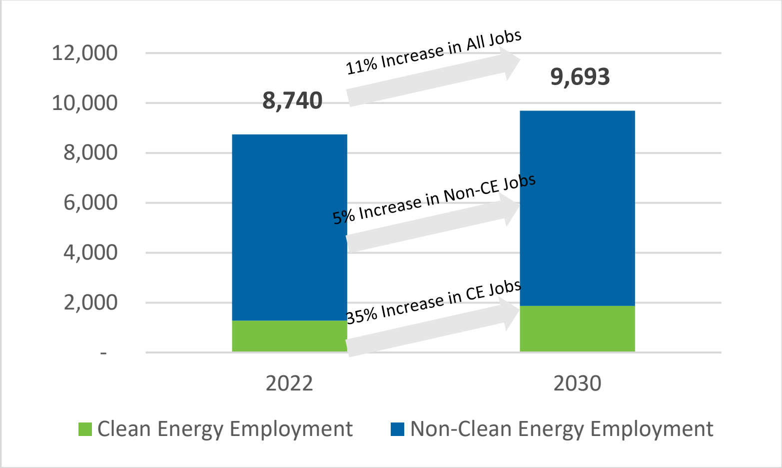
Alternative Transportation	Energy Efficiency	Renewable Energy
0	408	166

Occupation Summary

Operating Engineers and Other Construction Equipment Operators will be responsible for lifting and placing heavy materials and components during construction projects, including the transportation and installation of offshore wind turbines, construction materials for new and retrofitted high efficiency buildings and laying long lines of transmission wires. Aspiring Operating Engineers and Other Construction Equipment Operators will likely want to attend a union-affiliated or private training program to receive training and experience. After this preparation, job seekers will have to attain a required Massachusetts state hoisting license.

Projected Demand

An estimated 570 clean energy-related Operating Engineers and Other Construction Equipment Operators will be needed by 2030, on top of 370 additional economywide workers, representing an 11% increase in workers. There is also an anticipated need for 13 full-time Pile Drivers who will assist in fixing the foundations of offshore wind turbines to the ocean floor.



Trainings

Operating Engineers and Other Construction Equipment Operators can have a range of certifications. Operators of any machines that can hoist 500 or more pounds into the air are required to have a hoisting license in Massachusetts. Everything from Forklifts to Tower Cranes meet this qualification. There is also equipment-specific training required for larger equipment. Some other smaller equipment requires experience and a commercial driver's license. There are eight relevant training centers that prepare students for the required state exam, and two of these locations are union operated.

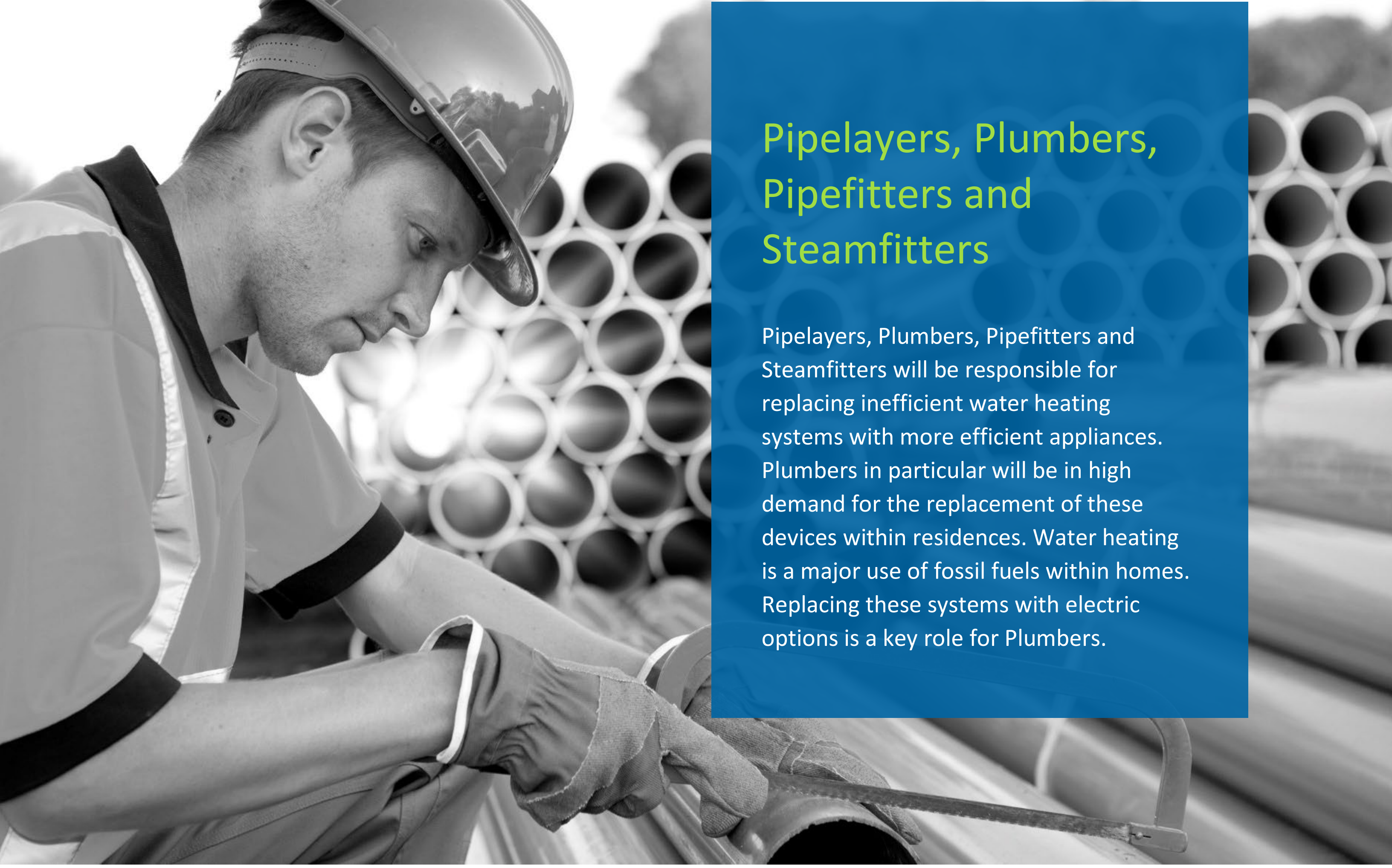
Challenges and Opportunities

Because these occupations require specific licenses and experience with specific heavy machinery, it will be important for Contractors of large projects to have a firm understanding of their personnel needs and sources. These positions are also frequently drug tested, including for marijuana, which employers have noted tends to screen out many candidates. Early awareness and demonstrated firmness in this requirement is essential to ensuring job seekers and training providers do not waste time when drug tests will not be passed. There is also a need to increase formal training opportunities to increase "behind the wheel" experience so that prospective workers have a chance to develop the physical skills alongside the technical knowledge.

Recommended Next Steps

These roles are highly skilled and specialized. Work with union halls and third-party trainers to ensure that the cumulative demands of upcoming projects can be met with talent. Inter-regional collaboration to train these workers will also be important, as training centers are clustered in and around the eastern portion of the state. Increasing availability of hands-on training opportunities is also a crucial step, as this experience is often difficult for job seekers to secure.

Additionally, creating a specific network connecting employers with training providers may mitigate any challenges among these highly specialized occupations.



Pipelayers, Plumbers, Pipefitters and Steamfitters

Pipelayers, Plumbers, Pipefitters and Steamfitters will be responsible for replacing inefficient water heating systems with more efficient appliances. Plumbers in particular will be in high demand for the replacement of these devices within residences. Water heating is a major use of fossil fuels within homes. Replacing these systems with electric options is a key role for Plumbers.

25th Percentile Wages	Median Wages	75th Percentile Wages
$27.24	$37.91	$50.08

DEMOGRAPHICS

98% Male	2% Female

87% White	6% Black
2% Asian	16% Hispanic

34%	42%	24%
Under 35 Years of Age	35-54 Years of Age	55+ Years of Age

87% Without a Bachelor's Degree

3.6 / 5 State Occupation Star Ranking

JOB OPPORTUNITIES ACROSS CLEAN ENERGY SECTOR

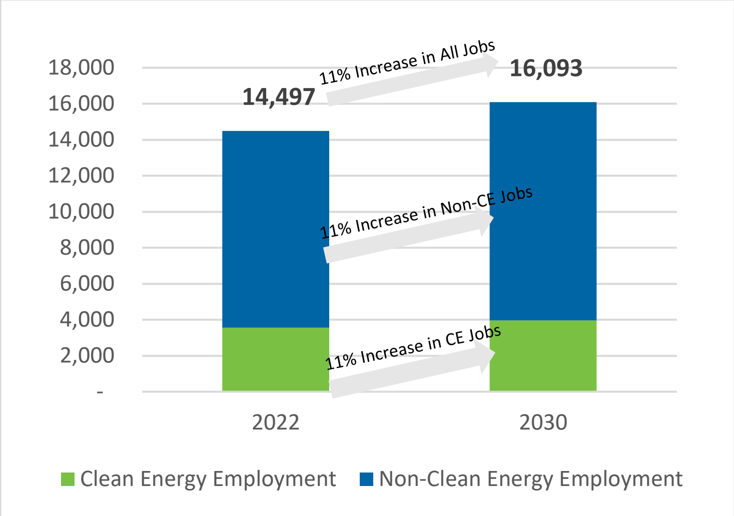
0	232	165
Alternative Transportation	Energy Efficiency	Renewable Energy

Occupation Summary

Pipelayers, Plumbers, Pipefitters and Steamfitters are similar but different occupations. Pipelayers and Pipefitters often work on larger-scale industrial projects that transport oil, natural gas or water. Plumbers are most often oriented towards residential or commercial properties. Steamfitters work on high-pressure systems. The primary clean energy activity within these workers will be Plumbers connecting energy efficient water heaters and other installation roles in high-efficiency buildings.

Projected Demand

An additional 400 clean energy Pipelayers, Plumbers, Pipefitters and Steamfitters will be needed by 2030, as well as a projected 1,200 economywide workers by this time, representing an 11% increase from current levels. While Pipelayers and Pipefitters play a notable role in the current Natural Gas economy, the models used in this report indicate that the maintenance and construction of pipeline infrastructure does not diminish between 2022-2030, meaning that any displacement of these roles is not likely to occur until beyond 2030, allowing for more time to plan for displacement of these workers. Additional technologies, such as Hydrogen or Network Geothermal, present future additional opportunities for Pipelayers, Pipefitters and Steamfitters if these technologies are deployed at scale.



Trainings

Pipelayers, Plumbers, Pipefitters and Steamfitters are required to achieve a Journeyman status in Massachusetts. This typically requires a 12-month training through a community college or a vocational high school followed by passing a Journeyman exam. Apprenticeships are also a common option for workers seeking to attain Journeyman status.

Institution or Program Host Type	Pipelayers, Plumbers, Pipefitters and Steamfitters Training Programs Identified in Massachusetts
Community College	2
Industry Association	1
Private Training Company/Technical School	8
Union	4
Vocation and Technical High School	33
Total	**48**

Challenges and Opportunities

While the additional clean energy-related demand is relatively modest compared to the existing number of workers in the state, the anticipated economywide demand for these workers may create capacity constraints among trainers.

Potential Solutions

Start discussing with relevant stakeholders plans to transition displaced fossil fuel workers in the longer-term. Close monitoring of the Natural Gas industry and the Pipelayers who support that industry can provide early awareness and early intervention for displaced workers.

Monitoring the capacity constraints among relevant training programs will be important to ensure that existing systems are not overwhelmed.

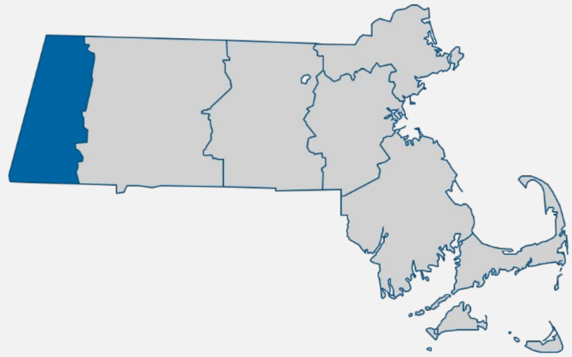
Chapter 5: Workforce Skills Cabinet Regional Snapshots and Strategies

Regional Workforce Strategies

While Massachusetts as a whole is working to decarbonize, different parts of the state will encounter different clean energy projects and infrastructure, obstacles and challenges and even the types of workers needed. Workers — particularly those involved in Construction, Installation, Maintenance and Repair activities — are often fluid between regions, but this analysis provides a useful benchmark for understanding the likely workforce needed within each region relative to its local training capacities.[106] This section discusses some of the geographic-specific challenges and opportunities within different regions of the state. Additionally, see Appendix C: Occupational Tables on page 129, which includes an expanded table of 2022 and projected 2030 clean energy jobs by Massachusetts WSC Region.

[106] Using the Massachusetts Regional Workforce Blueprint regional definitions.

BERKSHIRE REGION



1,581	2,075	494	31%
2022 Clean Energy Jobs in Region	2030 Projected Clean Energy Jobs	Projected New Jobs Added	Percent Growth (2022 – 2030)

In 2022, clean energy jobs made up 2.6% of all economywide jobs in the Berkshire region. By 2030, the Berkshire region is projected to add roughly 500 new clean energy jobs, or about eight new clean energy job for every 1,000 existing economywide jobs in the region. The MassCEC focus areas projected to add the greatest number of jobs are High-Efficiency Buildings, Net Zero Grid and Alternative Transportation. There may be some employment related to Offshore Wind in this part of the state, though that largely depends on the intensity and siting of component manufacturing projects related to Offshore Wind. The table below highlights the ten occupations with the highest number of jobs created within the Berkshire Region. The additional demand for nearly 100 workers with electrical licenses presents a significant challenge for the region, especially considering there are currently only 150 clean energy Electricians and Solar Photovoltaic Installers already working in the region.

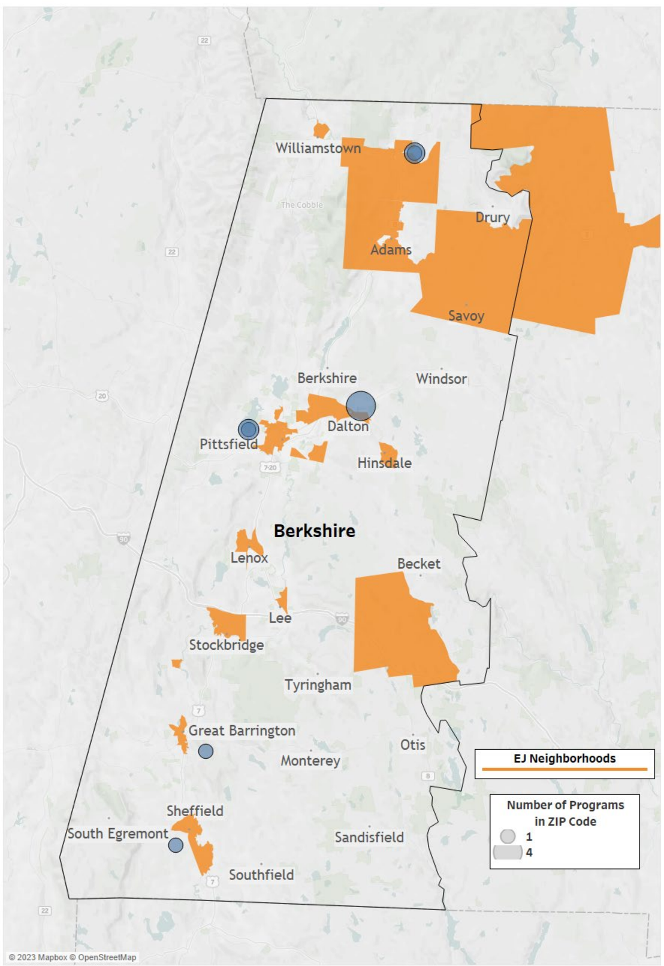
Highest-Growth Occupations	2022 Clean Energy Jobs	Increase in Jobs (2022-2030)
Electricians	119	82
Solar Photovoltaic Installers[107]	*32*	*13*
Construction Laborers	134	44
General and Operations Managers	77	27
First-Line Supervisors of Construction Trades and Extraction Workers	72	25
Insulation Workers	74	19
Office Clerks, General	53	16
Construction Managers	51	16
Heating, Ventilation, Air Conditioning and Refrigeration Mechanics and Installers	77	14
Electric Power-Line Installers and Repairers	13	14

The Berkshire region has relatively few training or academic programs geared towards workforce priority occupations, and very few programs geared towards non-high school-age job seekers. There are eight

[107] Solar Photovoltaic Installers are required to be licensed Electricians in Massachusetts.

vocational and technical high schools that offer some relevant programming and only one relevant community college program. Given the importance of these schools in introducing and training talent in clean energy-related jobs, this is a regional challenge that requires increased investment to ensure that prospective job seekers are prepared to take advantage of clean energy job opportunities in the region and across the state. There is a need for significantly expanding electrical programs, as well as standing up new programs for both HVAC-R Mechanics and Installers and Electrical Power-Line Installers and Repairers, particularly for individuals who are looking for training opportunities outside of vocational and technical high schools. Given that these occupations are among the highest-demand roles and the elevated risk that shortages could acta as a bottleneck to state and regional decarbonization efforts, ensuring there are adequate training opportunities for these workers in the Berkshire region is paramount.

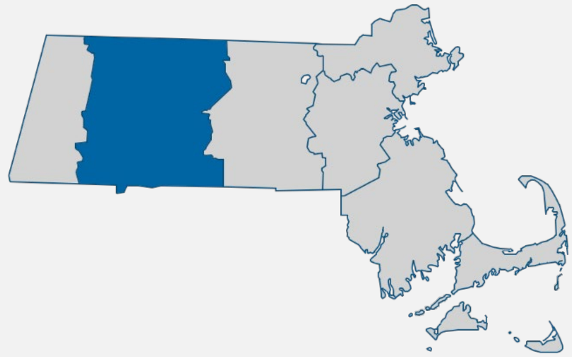
FIGURE 32. TRAINING PROGRAMS AND ENVIRONMENTAL JUSTICE NEIGHBORHOODS IN THE BERKSHIRE REGION



Environmental Justice neighborhoods can be found throughout the Berkshire region and there is a general lack of clean energy training programs in those neighborhoods, including those near Becket, Adams and Savoy. Ensuring that these populations have the opportunity to access clean energy training for high-demand occupations is an important priority. For some Environmental Justice neighborhoods further south within the region, leveraging the existing opportunities in the nearby Pioneer Valley region may be a viable option in the near-term, though long drive times present a clear barrier to access. The creation of new local clean energy training programs may be the best solution for most residents in this region and for other Environmental Justice neighborhoods that are further away.

Region-Specific Recommendations: The Berkshire Region needs to increase the number of relevant clean energy training opportunities within the region, or otherwise expand the mobility of interested job seekers to pursue training in the nearby Pioneer Valley region or out of state. While a range of additional clean energy training programs would be useful, except for BPI trainings, which are already represented in the region, programs for Electricians and HVAC-R Maintenance and Installation workers are particularly important. Expanded vocational and technical high school programs in electricity at Taconic High School and Charles McCann Vocational Technical would be particularly useful. These schools could also incorporate HVAC-R-relevant training programs, of which there are currently none in the region. Creating new training programs at community colleges and union apprenticeship programs should be explored, particularly in electricity and HVAC-R. In planning the development of any new training programs, the Environmental Justice neighborhoods in the northern part of the region near Adams and Savoy should receive particular attention. These training programs could be developed in tandem with the Pioneer Valley region, which also has a shortage of relevant training programs in nearby Environmental Justice neighborhoods. Siting of new training centers or programs will need to be mindful of transportation barriers, with consideration to providing commuting support services such as shuttle service or subsidized car sharing systems.

PIONEER VALLEY REGION



6,768	9,048	2,280	33.7%
2022 Clean Energy Jobs in Region	2030 Projected Clean Energy Jobs	Projected New Jobs Added	Percent Growth (2022 – 2030)

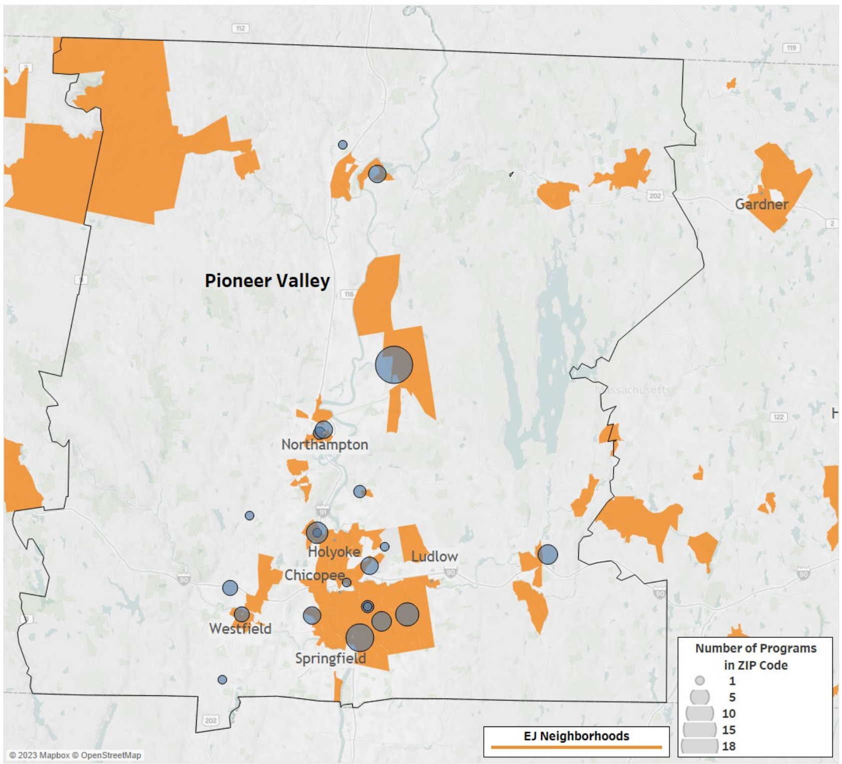
In 2022, clean energy jobs made up 2.1% of all economywide jobs in the Pioneer Valley region. Between 2022 and 2030, an estimated 2,280 full-time clean energy workers will be needed in the Pioneer Valley Region. This equates to 7.2 new clean energy jobs for every 1,000 current economywide jobs in the region. Electricians are the occupation with the greatest projected demand, adding 320 jobs between 2022 and 2030, which is a significant addition on top of the estimated 474 clean energy Electricians currently working in the region. One hundred and twenty-four additional Electric Power-Line Installers and Repairers more than doubles the number of current clean energy workers within an occupation that is credentialed and takes years to earn.

Highest-Growth Occupations	2022 Clean Energy Jobs	Increase in Jobs (2022-2030)
Electricians	474	321
Solar Photovoltaic Installers	*127*	*50*
Construction Laborers	527	171
Electric Power-Line Installers and Repairers	103	124
General and Operations Managers	319	119
First-Line Supervisors of Construction Trades and Extraction Workers	283	98
Insulation Workers	291	74
Construction Managers	199	61
Office Clerks, General	199	60
Customer Service Representatives	99	50

The Pioneer Valley region currently has a robust range of training offerings for job seekers interested in clean energy, including community colleges, vocational and technical high schools and four-year institutions. The Pioneer Valley also has many trainings relevant to specific occupations projected to see the greatest growth, including ten vocational and technical high school programs relevant for Electricians and one of the eight training programs in the state for Electric Power-Line Installers and Repairers. However, most of these training programs are available in the southern part of the region near Springfield and Holyoke.

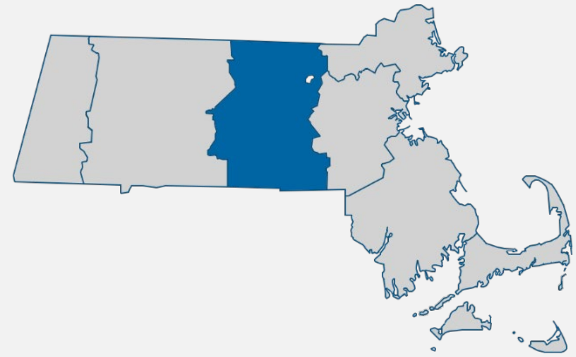
Pioneer Valley has a robust number of clean energy training programs near Springfield and Amherst, though Environmental Justice neighborhoods near Charlemont and Hawley do not have any clean energy-related training programs. Given the distance of these communities from most training programs in the region, developing new programs within existing institutions or considering inter-regional or inter-state training opportunities may be viable solutions, with clear consideration given to transportation obstacles that residents may face.

FIGURE 33. TRAINING PROGRAMS AND ENVIRONMENTAL JUSTICE NEIGHBORHOODS IN THE PIONEER VALLEY REGION



Region-Specific Recommendations: A key recommendation is to investigate ways to bolster the existing programs in the region. Pioneer Valley has a robust number of clean energy-related programs; however, the capacity and completion rate of those programs is less well known. Additional Electrician-relevant programs at community colleges may be helpful in supporting job seekers who are outside of high school age. Another recommendation is to take concrete actions to remedy the training desert that exists in the Northeast corner of the region, near Charlemont, Hawley, and Orange. As noted previously, the Pioneer Valley region can collaborate with the Berkshire region to develop inter-regional training programs, potentially focused on high-demand occupations like Electricians and HVAC-R Maintenance and Installation workers. Ensuring that there are adequate pre-work programs, such as pre-apprenticeship and vocational and technical school opportunities is also important. There are no pre-apprenticeship programs in the region, and while there are vocational and technical school programs, their demand far exceeds their current capacity. Expanding the trades vocational and technical high school programs, particularly in electricity and HVAC-R (of which there are none in the northern portion of the region), at Turner High or Franklin County Technical could help fill the gap and potentially service the Environmental Justice neighborhoods of Hawley and Charlemont mentioned above.

CENTRAL MASSACHUSETTS REGION



11,083	14,210	3,127	28.2%
2022 Clean Energy Jobs in Region	2030 Projected Clean Energy Jobs	Projected New Jobs Added	Percent Growth (2022 – 2030)

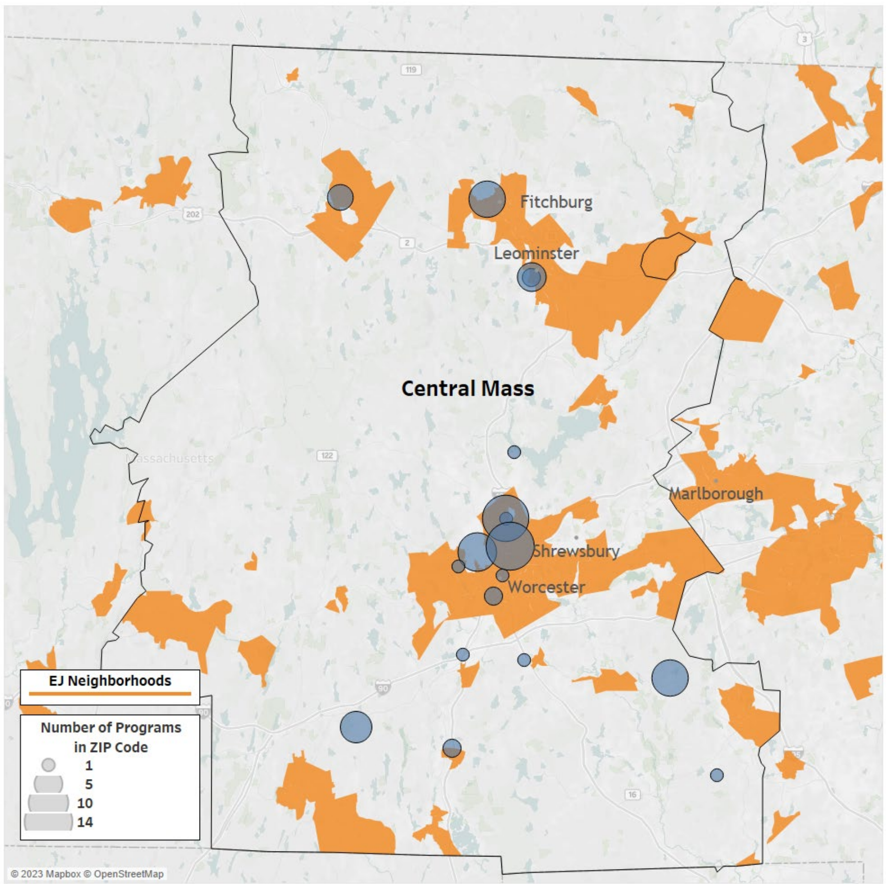
In 2022, clean energy jobs made up 3.0% of all economywide jobs in the Central Massachusetts region. The region will see 3,130 new clean energy jobs by 2030, which represents an estimated 8.4 additional clean energy jobs by 2030 for every current 1,000 economywide jobs. Electricians are the highest-demand occupation in this region, with an estimated 450 new Electricians needed by 2030, which is a 65% increase in clean energy Electricians in the region. An additional 80 Solar Photovoltaic Installers will also require new electrical license certification. Construction Laborers, as well as the managers and logistics staff that support them, also comprise a significant share of the jobs added in the region.

Highest-Growth Occupations	2022 Clean Energy Jobs	Increase in Jobs (2022-2030)
Electricians	697	445
Solar Photovoltaic Installers	*189*	*75*
Construction Laborers	774	252
General and Operations Managers	507	153
First-Line Supervisors of Construction Trades and Extraction Workers	417	142
Insulation Workers	428	108
Construction Managers	295	89
Office Clerks, General	296	85
Heating, Ventilation, Air Conditioning and Refrigeration Mechanics and Installers	420	72
Construction Equipment Operators	142	66

With its range of 28 vocational and technical high school programs, nine relevant clean energy community college programs, three union training centers and a half-dozen relevant programs at 4-year institutions, the Central Massachusetts region is likely well prepared to meet the additional need for new clean energy workers, particularly among the demand for trades workers and engineers.

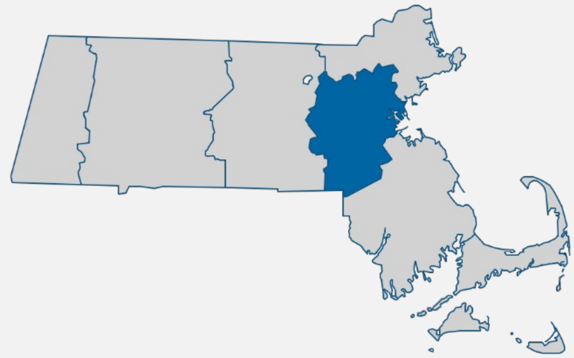
Many of the largest Environmental Justice neighborhoods in the Central Mass region have training programs relevant to clean energy located nearby, though Southbridge, Brookfield and Devens have few or no relevant training programs. This challenge could be mitigated by improving transportation options between these regions and larger regional hubs, such as Worcester and Fitchburg, or by supporting new training programs within existing institutions in or near those Environmental Justice neighborhoods.

FIGURE 34. TRAINING PROGRAMS AND ENVIRONMENTAL JUSTICE NEIGHBORHOODS IN THE CENTRAL REGION



Region-Specific Recommendations: The Central Massachusetts region should first address any capacity challenges among clean energy-relevant vocational and technical school programs, as well as support increasing capacity within the Building Pathways pre-apprenticeship program in Worcester. There is also a need to examine the transportation feasibility for job seekers, particularly in the southwestern corner near Southbridge, Brookfield and Devens. If job seekers are not able to access training programs in Worcester, transportation solutions (e.g., vouchers, shared bus lines, etc.) should be considered. Additionally, expanding capacity at vocational and technical programs geared towards the trades hosted at Bartlett Jr Sr High School could support increasing access within these neighborhoods. For the Environmental Justice neighborhoods in the southeastern portion of the region near Brookfield, programs hosted at Tantasqua Regional Vocational School in neighboring Pioneer Valley may also provide increased access.

GREATER BOSTON REGION



46,906	59,246	12,341	26.3%
2022 Clean Energy Jobs in Region	2030 Projected Clean Energy Jobs	Projected New Jobs Added	Percent Growth (2022 – 2030)

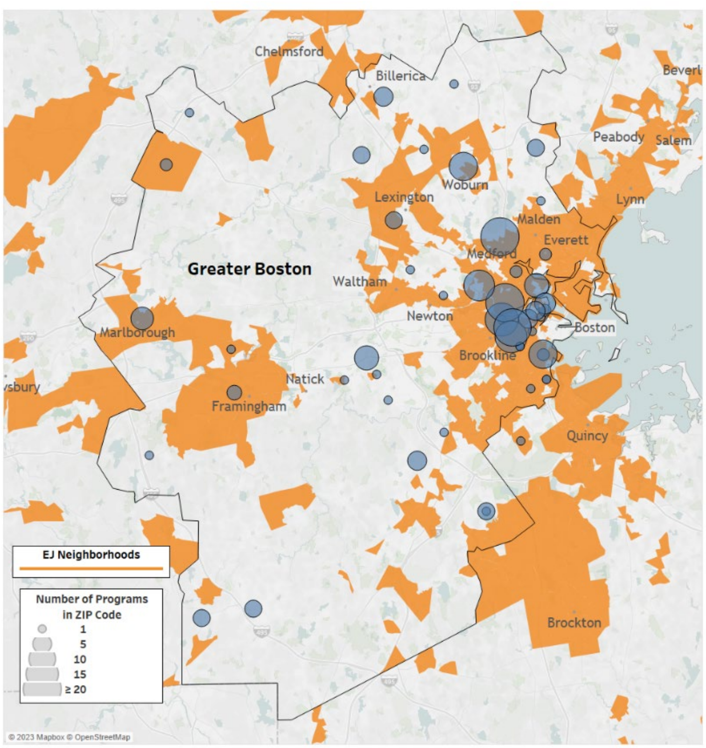
In 2022, clean energy jobs made up 2.7% of all economywide jobs in the Greater Boston region. The region is projected to see an additional 7.1 clean energy jobs for every 1,000 current economywide workers by 2030, which is the lowest proportion of any region in the state. However, it is projected to see the largest increase in clean energy workers, projected at 12,340 additional full-time workers, which means the examination of training programs in this region is particularly important. The number of clean energy Electricians are projected to increase by 71% in the region, and Electric Power-Line Installers and Repairers are projected to roughly double between 2022 and 2030.

Highest-Growth Occupations	2022 Clean Energy Jobs	Increase in Jobs (2022-2030)
Electricians	2,385	1,699
Construction Laborers	2,541	839
General and Operations Managers	2,426	694
First-Line Supervisors of Construction Trades and Extraction Workers	1,381	491
Office Clerks, General	1,364	354
Insulation Workers	1,394	352
Secretaries and Administrative Assistants	1,538	312
Software and Web Developers, Programmers and Testers	2,301	301
Construction Managers	964	300
Electric Power-Line Installers and Repairers	285	290

While the region has 102 identified training and academic programs geared towards clean energy workforce priority occupations, the analysis reveals that the number of training programs relative to the expected increase in workers means these existing training programs may see capacity constraints. For example, 42% of additional clean energy jobs by 2030 are projected to be in the Greater Boston region, but only 20% of clean energy-relevant vocational and technical high school programs are located in the region. While the size of these programs and placement of graduates will likely affect these proportions, the discrepancy is likely to hold. This means that increasing the number and capacity of programs within the Greater Boston region is essential.

Additionally, the figure below shows that the Greater Boston region's training programs tend to be centered around downtown and surrounding areas. While public transit can make these trainings more accessible to those further outside the city, the challenges of "last-mile" travel and other considerations may mean the commute to these trainings is more difficult or time consuming. Many of the region's Environmental Justice neighborhoods outside of the immediate Boston area do not have clean energy training programs nearby. Northern areas like Everett and Malden have few programs, if any. Southern regions like Roslindale and Dorchester similarly lack robust training offerings. Meeting many of these workers closer to where they live will be important in ensuring that clean energy opportunities are available to Massachusetts residents of all backgrounds. An additional consideration is that although a larger number of trainings located within the city of in Boston may be accessible by public transportation, employers hiring for workers graduating from these trainings are often not located near public transit, or require that workers travel to different work sites. Even if a job site is accessible from public transit, many construction-focused occupations have early start times that may conflict with when public transit is operating. Access to reliable transportation is a major barrier for many underserved and underrepresented populations. In order to facilitate a just transition, employers, training providers, CBO's and workforce agencies will need to grapple with this and other major barriers to entry, such as access to childcare, to provide appropriate supports to increase new worker placement, retention and promotion.

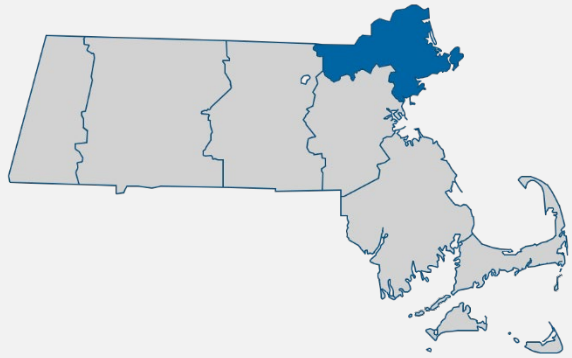
FIGURE 35. TRAINING PROGRAMS AND ENVIRONMENTAL JUSTICE NEIGHBORHOODS IN THE GREATER BOSTON REGION



Region-Specific Recommendations: Although the region has many clean energy training and academic programs, the number of seats for virtually all these programs will likely need to grow, which will require additional funding and support. Creating new building trades vocational and technical programs at Everett

High School could also increase access to students in that area of the Greater Boston region. Programs for Electricians and Electric Power-Line Installers and Repairers should specifically receive significant boosts in funding, as well as an examination if new facilities are required or if expansions to existing facilities are sufficient. The region's relatively high number of Operating Engineers and Other Construction Equipment Operators is limited in part due to trainings being virtual or not offering hands-on learning opportunities, which are more likely to lead to graduates finding job placements. This suggests that the region should work with other regions, particularly the nearby Southeast region, to help fulfil training needs while limiting duplication of expensive training infrastructure needs.

NORTHEAST REGION



15,036	19,332	4,296	28.6%
2022 Clean Energy Jobs in Region	2030 Projected Clean Energy Jobs	Projected New Jobs Added	Percent Growth (2022 – 2030)

In 2022, clean energy jobs made up 3.3% of all economywide jobs in the Northeast region. This region is projected to need 4,300 additional clean energy workers by 2030, equating to 9.3 additional clean energy workers for every 1,000 current economywide workers. Electricians (68% increase in clean energy jobs), Construction Laborers (33% increase) and the roles that manage and support construction crews will see the greatest demand. There is also potential for nearly 100 manufacturing roles through Electrical, Electronics and Electromechanical Assemblers.

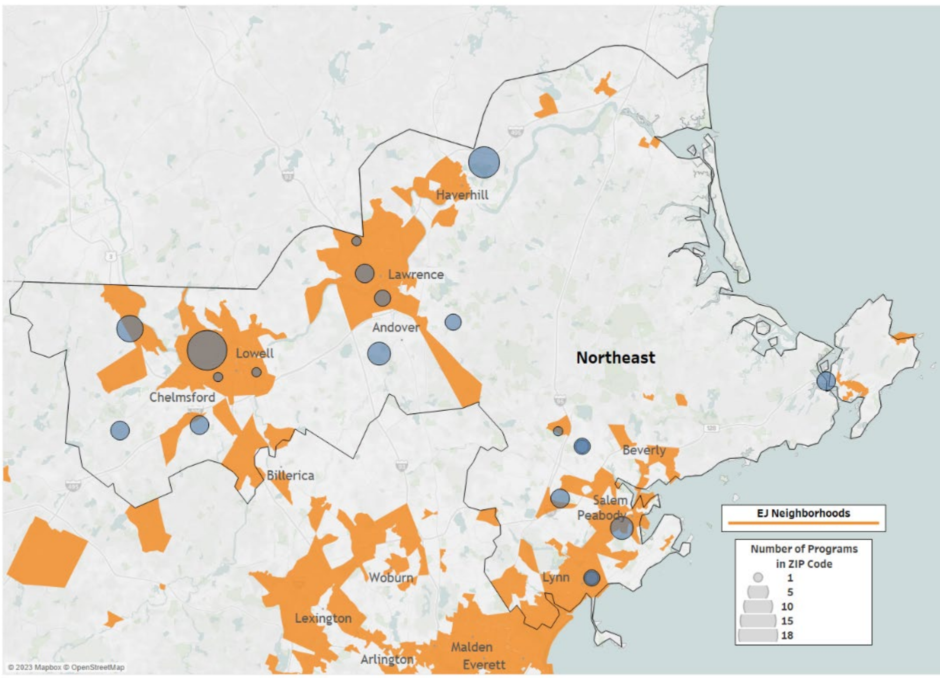
Highest-Growth Occupations	2022 Clean Energy Jobs	Increase in Jobs (2022 – 2030)
Electricians	932	637
Solar Photovoltaic Installers	*266*	*105*
Construction Laborers	999	329
General and Operations Managers	686	210
First-Line Supervisors of Construction Trades and Extraction Workers	542	189
Insulation Workers	548	139
Construction Managers	379	117
Office Clerks, General	385	113
Electrical, Electronics, and Electromechanical Assemblers	619	93
Heating, Ventilation, Air Conditioning and Refrigeration Mechanics and Installers	550	92

The Northeast region is home to 53 training programs relevant to the workforce priority clean energy occupations, and roughly three quarters of these are vocational and technical high schools. There are currently no programs for Electricians outside of vocational and technical high schools and very few for HVAC-

R Mechanics and Installer workers. Offering training opportunities within these key occupations for job seekers beyond high school age will be crucial.

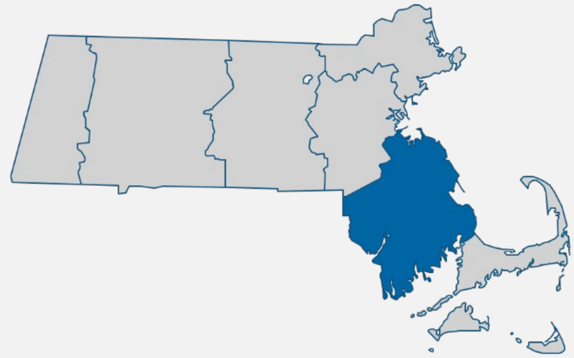
Some Environmental Justice neighborhoods closer to Boston, such as Lynn and Saugus, have few or no clean energy training programs. Ensuring that job seekers in these communities can access training programs through public transit options is an important consideration. If trainings in Boston are inaccessible via public transit, revised routes or transportation planning may be necessary.

FIGURE 36. TRAINING PROGRAMS AND ENVIRONMENTAL JUSTICE NEIGHBORHOODS IN THE NORTHEAST REGION



Region-Specific Recommendations: While there are nine different vocational and technical schools in the region with programs that prepare Electricians, there are no community college, union apprenticeship or other relevant training opportunities. This needs to be addressed, as the more than 600 additional Electricians are not likely to be met exclusively from graduates from vocational and technical high schools, and the absence of another training program prevents those beyond school age from entering the field. Additionally, while there are some opportunities for non-high school-aged jobs seekers in HVAC-R, expanding the number and capacity of relevant HVAC-R trainings is also important.

SOUTHEAST REGION



18,676	24,497	5,821	31.2%
2022 Clean Energy Jobs in Region	2030 Projected Clean Energy Jobs	Projected New Jobs Added	Percent Growth (2022 – 2030)

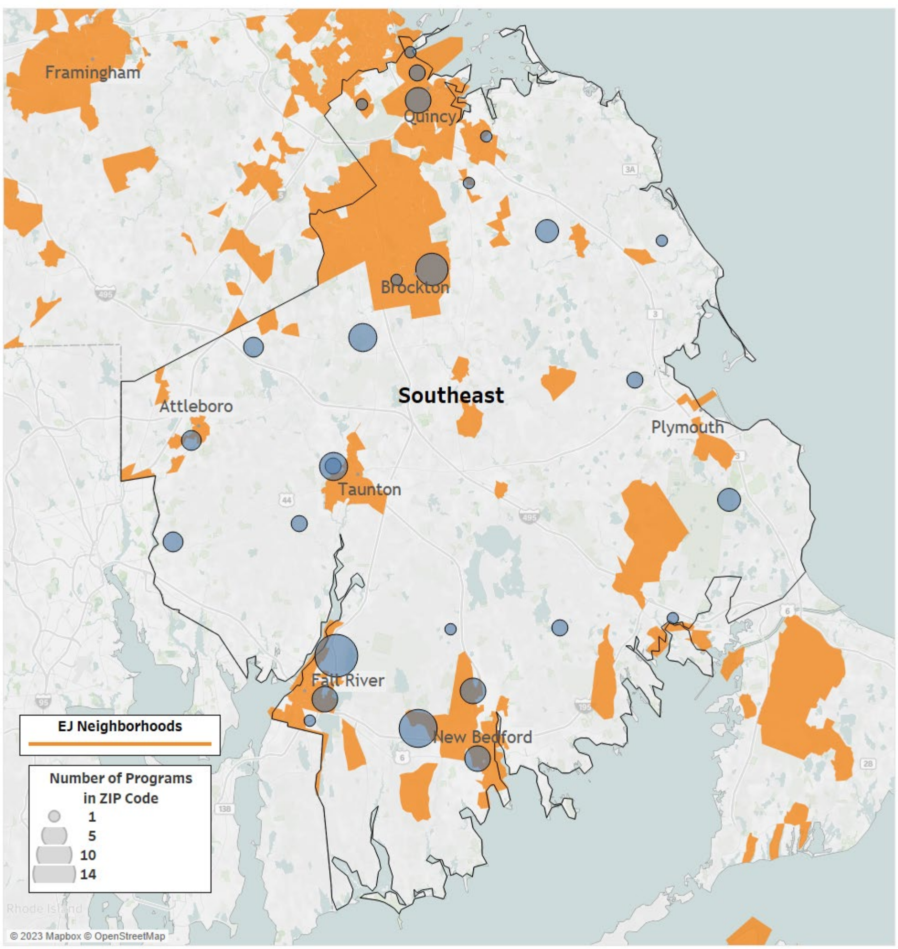
In 2022, clean energy jobs made up 3.2% of all economywide jobs in the Southeast region. The region is forecasted to see 10 clean energy jobs created for every 1,000 current economywide jobs. This means that the economic impact of decarbonization will be significant. The additional demand of 1,070 Electricians (and 180 additional Solar Photovoltaic Installers) will place high demand on electrical licenses in the region. Construction Equipment Operators also see a 46% increase in clean energy jobs between 2022 and 2030. Similar to other regions, most of the additional jobs in this region will be among construction trades. However, a notable portion of these jobs will be tied to the Offshore Wind sector as construction, installation and maintenance activities will likely take place through ports in this region.

Highest-Growth Occupations	2022 Clean Energy Jobs	Increase in Jobs (2022-2030)
Electricians	1,511	1,066
Solar Photovoltaic Installers	*451*	*179*
Construction Laborers	1,546	516
General and Operations Managers	861	306
First-Line Supervisors of Construction Trades and Extraction Workers	848	304
Insulation Workers	842	213
Construction Managers	588	184
Office Clerks, General	568	175
Heating, Ventilation, Air Conditioning and Refrigeration Mechanics and Installers	881	147
Construction Equipment Operators	285	132

Similar to the Northeast region, the Southeast region also has a strong array of programs. Sixty-six relevant clean energy training programs were identified, covering all the highest in-demand occupations. However, these programs account for a smaller share (16%) of statewide clean energy programs than the regional share of new clean energy jobs the state is projected to see (20% of statewide jobs). These shortages are visible within training programs for Electricians and HVAC-R Mechanics and Installers, which need more relevant training programs outside of vocational and technical high schools.

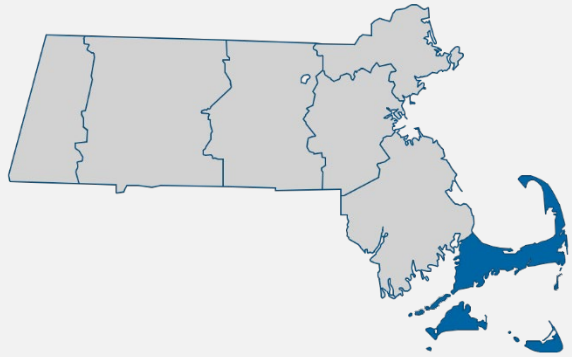
Environmental Justice neighborhoods within the Southeast region of the state tend to have clean energy training programs, though there are still some gaps, particularly near Bridgewater and Carver. New Bedford and Fall River both have training programs relevant for Electricians, HVAC-R Mechanics and Installers as well as Offshore Wind-relevant certification, including the necessary GWO Certifications for any workers who will leave port and spend time on the water. As Offshore Wind grows exponentially over the coming years, employers will be faced with the dilemma of hiring locally or bringing in candidates internationally who may have more extensive experience. MassCEC's Offshore Wind Works initiative is partnering with CBO's, vocational technical schools, and post-secondary institutions to both increase awareness of careers in Offshore Wind, and formalize appropriate training facilities and programs to build the pipeline of trained workers from the region in time to scale in line with demand for workers.

FIGURE 37. TRAINING PROGRAMS AND ENVIRONMENTAL JUSTICE NEIGHBORHOODS IN THE SOUTHEAST REGION



Region-Specific Recommendations: The Southeast region's high number of jobs created in the region means that capacity must be increased for existing programs. While Offshore Wind activity is sure to attract many workers, it will also be important that there are sufficient workers to retrofit homes, install EV charging stations and upgrade electric distribution networks. Increasing support for the 43 vocational and technical school programs to increase capacity and enhance job and apprenticeship placements will be key. Additionally, this applies to supporting the single pre-apprenticeship program in the region and the community college network. These steps are crucial to ensuring that new workers are able to meet the demand for the thousands of additional jobs needed in the region.

CAPE COD AND ISLANDS REGION



4,234	5,564	1,330	31.4%
2022 Clean Energy Jobs in Region	2030 Projected Clean Energy Jobs	Projected New Jobs Added	Percent Growth (2022 – 2030)

In 2022, clean energy jobs made up 3.4% of all economywide jobs in the Cape Cod and Islands region. The region is estimated to see the greatest proportional increase in jobs relative to its underlying economy, with 10.7 additional clean energy jobs created for every current 1,000 economywide jobs by 2030, equating to a net increase of 1,330 jobs. Similar to the Southeast region, the Cape Cod and Islands region will see increased economic activity through Offshore Wind development alongside MassCEC's other three focus areas. Many of the 200 Electricians (55% increase in clean energy jobs), 140 Construction Laborers (32% increase) and 40 Electric Power-Line Installers and Repairers (98% increase) will be involved in Offshore Wind related activity.

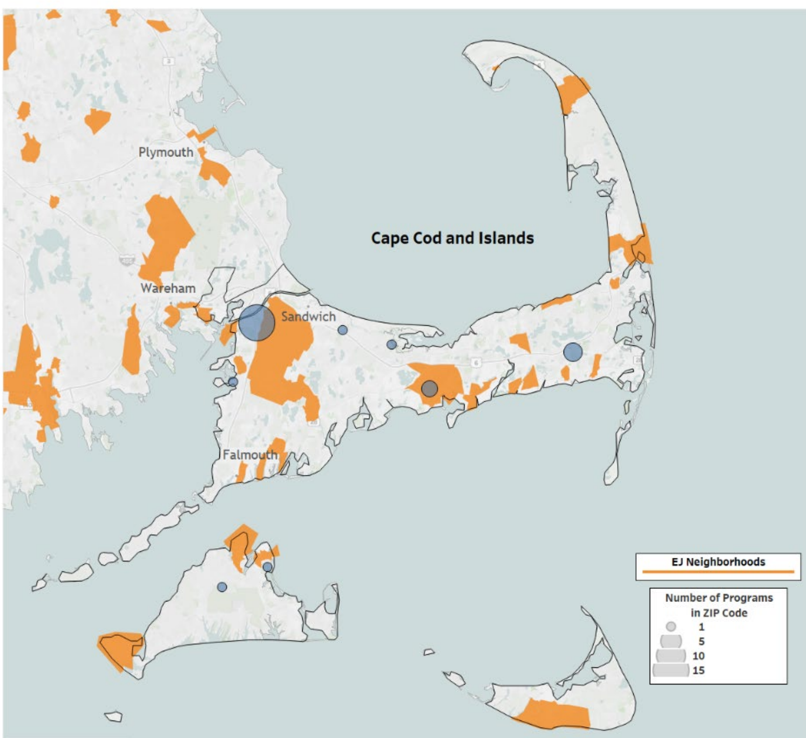
Highest-Growth Occupations	2022 Clean Energy Jobs	Increase in Jobs (2022-2030)
Electricians	352	195
Solar Photovoltaic Installers	*86*	*34*
Construction Laborers	434	138
First-Line Supervisors of Construction Trades and Extraction Workers	230	74
General and Operations Managers	195	70
Insulation Workers	243	62
Construction Managers	164	48
Office Clerks, General	146	43
Heating, Ventilation, Air Conditioning and Refrigeration Mechanics and Installers	228	40
Electric Power-Line Installers and Repairers	39	40

Training opportunities relevant to clean energy can be found throughout the Cape Cod and Islands Region. It is no surprise that many of these training programs are related to Offshore Wind, spanning GWO Basic Safety courses, Captain's licenses and Energy Systems Engineering programs. Additionally, there are a few Electrician and HVAC-R Mechanics and Installers programs that will support the training pipelines for some of the most in-demand occupations, however additional Electrician-related programs outside of vocational and technical high schools are needed. Given the high rate of seasonal employment in the region, one opportunity for these communities is to introduce seasonal workers to clean energy careers through pre-apprenticeships that run during the off season.

> *"Cape Cod is facing immeasurable challenges; housing is not available and housing costs are a lot higher than compensation companies can provide. This is mostly a problem on the Solar Technician side and some white-collar jobs, depending on salary range. Anything under $60,000 is harder to fill and $65,000 and over is easier."*
>
> **-Employer**

A relatively high number of Environmental Justice neighborhoods within the Cape Cod and Islands region are located near current training programs, though ensuring the residents of more remote locations, such as Truro and Aquinnah, can easily reach trainings in Sandwich, especially during heavily trafficked summer months, is an important consideration to ensure equity in access.

FIGURE 38. TRAINING PROGRAMS AND ENVIRONMENTAL JUSTICE NEIGHBORHOODS IN THE CAPE COD AND ISLANDS REGION



Region-Specific Recommendations: The more than doubling of the number of clean energy Electric Power-Line Installation and Repair workers in the region requires that a program be developed in the region, likely through a community college. Creating additional Electrician and HVAC-R programs outside of vocational and technical programs is also required in order to meet projected demand while allowing non-high school-aged talent to access relevant training.

Chapter 6: Conclusions and Next Steps

Massachusetts' commitment to reducing greenhouse gas emissions by 50% by 2030 and achieving net zero by 2050 will require rapid and sustained clean energy job growth. Even conservative estimates from this report project that by 2030, the effort will require contributions equivalent to that of 29,700 additional full-time workers, which likely means closer to an increase of 38,100 additional clean energy workers by headcount, as the work will be distributed across both workers that spend all or some of their time working on clean energy projects.

From a workforce development perspective, all of these 38,100 additional clean energy workers will require preparation and support to enter into or transition to clean energy roles. Furthermore, the entire Massachusetts clean energy workforce, which if projected to expand to more than 130,000 workers by 2030 and 180,000 workers by 2050, will require ongoing upskilling to keep pace with constantly advancing technologies and strategies that promise a decarbonized future.

> Significant intervention is needed to ensure that there are enough interested and qualified job seekers to meet the projected demand for clean energy workers. From advancing early career awareness to expanding training opportunities and supports to retaining and upskilling current workers, these efforts will require strategic coordination across key stakeholders.

As this report clarifies, significant intervention is needed to ensure that there are enough interested and qualified job seekers to meet the projected demand. From advancing early career awareness to expanding training opportunities and supports to retaining and upskilling current workers, these much-needed efforts will require strategic coordination across key stakeholders. Additionally, to have the greatest impact, key tenets of any workforce strategy should include (1) prioritizing efforts to engage, support and reduce barriers to entry and promotion of diverse workers; (2) early coordination to support transitioning fossil fuel workers into clean energy career paths; and (3) developing programs and initiatives that are coordinated across agencies and stakeholders to foster and maximize the potential for coupling industry growth with jobs that offer sustainable wages and opportunities for career progression. The table below highlights many of the recommendations and next steps discussed throughout this report by stakeholder category and central domains of workforce development intervention.

Advance Clean Energy career awareness to build an expanded pipeline of new workers.	
	Recommendations and Next Steps
Policymakers and Funders	Expand funding and the scope of clean energy workforce development programming to include resources for early clean energy career awareness in the K-12 education system. Support ongoing career awareness campaigns for adults at the statewide level and more targeted place-based and community-focused awareness efforts. Across awareness efforts, emphasize the positive environmental impacts of these climate-critical careers that will lead our state through significant reductions in greenhouse gas emissions, leading to Net Zero by 2050. Prioritize reaching greater shares of individuals from Environmental Justice neighborhoods and underserved and underrepresented populations. Include promotion of reskilling and upskilling opportunities in career awareness campaigns to engage career-changers and to support increased understanding of opportunities for current fossil fuel workers to transition to clean energy careers.
Education, Training, and Workforce Development Partners	Increase coordination between post-secondary institutions and the K-12 education system, with a focus on providing current middle and high school students with information about climate-critical careers, the skills needed to access these opportunities, and exposure to the training opportunities available during high school and beyond. Additionally, develop partnerships with Community-Based Organizations that can provide expanded on-ramps and career navigation support to job seekers considering a transition into climate-critical occupations.
Employers, Unions, and Industry Organizations	Partner with educational institutions, workforce development organizations, and CBOs to share more information about current and anticipated career opportunities. Prioritize participating in local technical vocational high school and CTE advisory committees and organized efforts to expand career exploration in the broader K-12 educational system. Clarify the reasons why a job seeker might want to pursue the various available careers with the understanding that in a tight labor market, it is all the more important to provide multiple, clear advantages to positions. Articulate career pathway ladders to workers and make accessible and transparent advancement options part of the pitch from the start.

Expand the availability, accessibility, and quality of Clean Energy workforce development programs through increased data-driven prioritization, coordination, and a central commitment to addressing worker barriers.

	Recommendations and Next Steps
Policymakers and Funders	Approach expanded funding for clean energy workforce development with a data-informed lens to determine the relative value and impact of launching new training programs as compared to scaling or enhancing existing programs. This approach should be conducted at the state and regional level. Recognize the challenges and drivers of different parts of the current training and workforce development ecosystem. The greatest barriers to expanding training via union Joint Apprenticeship Training Centers, vocational, technical and CTE programs, post-secondary institutions, and private training providers are different and require policy and funding strategies that are intentional and flexible enough to support scaling, even though the levers to do so may vary greatly. Union training programs may scale training seats based on current and projected labor demand, while launching or expanding vocational, technical and CTE programs may require increased funding coupled with additional strategies to address specific barriers, such as teacher shortages for in-demand vocations. Prioritize supporting programs that address both the most critical supply gaps and that expand access and supports to Environmental Justice neighborhoods and historically underrepresented populations, from increasing career awareness and navigation, job readiness and training programs, including pre-apprenticeship models, and supports that facilitate job placement, retention, upskilling and promotion. Ensure that expanded support services for barrier removal are a key component across all publicly funded programs and recognize that some persistent barriers such as lack of affordable and reliable transportation will require a whole of government approach to address effectively. Increased coordination can also support greater utilization of federal funding opportunities. Pursue additional research to answer questions not fully explored in this needs assessment, including funding more regional planning approaches, investigating post-2030 workforce needs, and the strategies needed to support the broader range of roles that are slated to grow.
Education, Training, and Workforce Partners	Increase coordination with employers to ensure that programs are designed to meet the need of current and forecasted employment opportunities. Seek out opportunities to blend and braid different funding streams to provide a more robust set of services and support. Resist the tendency to view other programs as competitors in the ecosystem and look for opportunities to partner effectively, especially when it comes to addressing employer and prospective participant needs.

	Seek out leadership support and funding sources to expand in-house or partner-based support services for trainees, including added supports to reduce systemic barriers and foster career readiness, successful job placement and retention. Investigate how programs can be structured to offer greater ongoing support to participants in their initial transition to the next stage, whether that is direct employment or additional training.
Employers, Unions, and Industry Organizations	Increase engagement and coordination with training providers with applicable training programs. Support updates to curriculum, programming and placement services by providing guidance and insight into the skillsets needed for particular occupations to gain job placement at their firms, by providing feedback through a formal advisory role, or through periodic outreach and information sharing. Engage with training provider career services departments or directly with teachers or trainers to facilitate job placement opportunities with training graduates. Encourage and support current employees to participate in opportunities to upskill, add stackable credentials and advance in their careers.

Embrace hiring practices that diversify the pipelines of new workers and professional development practices that improve retention and advancement opportunities.	
	Recommendations and Next Steps
Policymakers and Funders	Prioritize funding to workforce development programming that includes employer commitments about inclusive hiring practices. Work across agencies to include diversity, equity, inclusion and just transition practices in publicly funded projects, and support the spread of effective practices through technical assistance and grant opportunities that help employer partners access the resources and expertise to deploy these strategies. Continue to provide support for Minority and Women-owned Business Enterprises in climate-critical industries in recognition that business ownership is a form of career advancement.
Education, Training, and Workforce Partners	Work collaboratively with employer partners to develop to ensure that the skills targeted in training match the requirements of the role and can be adequately demonstrated during the interview process and initial period on the job. Clarify with employers which job requirements are most likely to present additional barriers to new entrants and be a partner in addressing those barriers through support services or potential employer accommodations. Prioritize awareness of advancement pathways into the initial training so that program graduates have a clearer understanding of the various ways that they can grow in the field that they are about to enter.

<table>
<tr><td>Employers, Unions, and Industry Organizations</td><td>Revisit current hiring practices to include more coordination with workforce development programs, training providers and post-secondary institutions. Explore registered apprenticeship programs and public workforce programs that may offer opportunities to offset the cost of the initial work period for new employees to make positions more accessible to candidates who need to learn while they earn.

Utilize publicly funded programs that offset the cost of upskilling to ensure that current workers have a pathway to gain additional skills and advancement. Take the time to articulate these advancement pathways in a transparent way for all employees. Work together and through industry organizations to identify gaps and share best practices for strategic workforce development programs.

Support a just transition for current fossil fuel workers to equivalent roles in the clean energy workforce by taking advantage of public programs that can support reskilling.</td></tr>
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Appendices

Appendix A: Report Methodology

SURVEY RESEARCH

Massachusetts Clean Energy Employer Survey

BW Research conducted employer interviews with clean energy organizations throughout Massachusetts. The survey sample included a compilation of known energy efficiency firms that had completed surveys for the United States Energy and Employment Report (USEER) in the last 3 years, samples from industry associations, online panel through a third party of relevant businesses and a sample of firms known to employ the relevant industry codes (NAICS) from DataAxle. The survey instrument was programmed internally by BW Research and each respondent was assigned a unique ID to prevent duplication.

The employer survey was fielded in 2022 between August 3rd and October 6th, resulting in 210 total completes by firm accounting for 1,306 occupations. The average survey duration was 13 minutes.

Massachusetts Current Worker Survey

BW Research conducted a survey of current clean energy workers in Massachusetts. To qualify for the survey, potential respondents had to be working in Massachusetts in a job that provides clean energy products or services. Current worker respondents were recruited through listed sample and online panel of employed residents in the Commonwealth of Massachusetts. The survey instrument was programmed internally by BW Research and each respondent was assigned a unique ID to prevent duplication.

The current worker survey was fielded between in 2022 between August 4th and October 6th, resulting in 219 total completes. The average survey duration was 9.3 minutes.

QUALITATIVE RESEARCH

The research team conducted numerous interviews and three stakeholder meetings to better understand the obstacles and challenges that clean energy employers, unions, training providers and CBOs are most burdened with. Below is a list of the stakeholders involved in this qualitative research. Several organizations appear under more than one category because the research team spoke with them on more than one occasion as the organization operates within more than one capacity.

Stakeholder Type	Number Interviewed
Employers	14
Unions	5
Training Providers	13
Community-Based Organizations	12
State and Local Government	5

Stakeholder Meetings

These meetings contained smaller groups of individuals and were designed to give the research team deeper insight into challenges that stakeholders face, challenge assumptions and discuss potential solutions.

Stakeholder Type	Number Interviewed
Employers	4
Unions	6
Training Providers	5

QUANTITATIVE RESEARCH

Employment Modeling

Inputs and Assumptions

Baseline values for 2022 clean energy employment and value chain composition were derived from the 2022 Massachusetts Clean Energy Industry Report (MACEIR). Employment estimates and value chain composition for the forecasted employment were derived from the Macroeconomic Impact and Equity Analysis of the Massachusetts 2050 Decarbonization Roadmap.[108]

Vehicle mileage estimates for 2021 and 2030 were built from models used in the 2025 and 2030 CECP, including the estimated proportion of electric vehicle to non-electric vehicle activity and its corresponding impact on employment. For example, if EVs account for an estimated 20% of all vehicle miles traveled by 2030, 20% of projected automotive employment is modeled to be involved in EVs and the remaining 80% is categorized as employment related to internal combustion.

2030 Employment Forecasting

The overall employment impacts by sub technology and high-level industry and occupational categorization were developed during the Macroeconomic Impact and Equity Analysis of Decarbonization Pathways in Massachusetts study and, as referenced as the 2025 & 2030 CECP throughout this report, for the Massachusetts Executive Office of Energy and Environmental Affairs (EEA) in early 2022. These high-level estimates of jobs created within specific sectors were then used as inputs for this project. For example, a forecasted acceleration in home appliance replacement rates (spurred through policy incentives and/or

[108] https://www.mass.gov/info-details/ma-decarbonization-roadmap

mandates that drive the switch to electrification) results in additional workers needed — in this case, additional Electricians and/or HVAC-R Installers and Repairers. It should be noted that the 2025 & 2030 CECP report captured all energy-related employment, including fossil fuels, using 2019 MA Clean Energy Industry Report data as baseline data (compared to 2022 MA Clean Energy Industry Report figures used as baselines throughout this memorandum) and reported all additional employment in full-time equivalent workers. This means that while the magnitude and drivers of changes in the EEA report are used in this research, the findings will not be directly comparable to each other without additional analysis to adjust for these differences.

Occupation-Level Modeling

The research team built a Staffing Pattern model to facilitate analysis of the occupational characteristics of Massachusetts' current and forecasted clean energy workforce. The model was built at the technology and sub-technology level.[109] Each technology/sub technology is split by seven value chain segments:

I. Construction
II. Manufacturing
III. Other Supply Chain[110]
IV. Professional Services
V. Utilities
VI. Wholesale Trade

Staffing patterns were developed for each[111] of these (7 x 21) sub-technologies and value chain combinations. The staffing pattern for each sub technology in the state of Massachusetts was created using an industry mix from the North American Industry Classification System (NAICS) Codes that match the industry characteristics of each sub technology and value chain. Staffing patterns were developed from industries of companies with known energy employment from the 2019 U.S. Energy and Employment Report (USEER) data collection.

Staffing patterns often contain "long-tails" of occupations that account for a marginal share of employment. To reduce the noise from this characteristic, the research team removed any occupations that comprised <1% of the original staffing pattern.

Geographic Distribution of Employment

The research team modeled geographic distribution of employment by using the proportion of employment within relevant industries by value chain.

[109] Separate staffing patterns were developed for Buildings, Land-based Wind, Offshore Wind, Distributed PV, Utility-Scale Solar, Hydrogen, Hydropower, Biomass, Storage, Natural Gas Generation, Other Fossil Fuel Generation, Nuclear, Motor Vehicles (electric), Motor Vehicles (non-electric), Motor Vehicles (other), Bioenergy, Hydrogen Fuels, Petroleum Fuels, Natural Gas Fuels, Natural Gas Distribution, Grid and Other Electric Power Generation (including Geothermal, Tidal Power, etc.).

[110] The "Other" value chain incorporates the industries related to the sub technology that are not considered in the other value chain definitions. This includes Education, Entertainment, Finance/Insurance/Real Estate (FIRE), Government, Healthcare, Hospitality, Information, Agriculture and Mining & Extraction.

[111] Utilities, Professional Services, Wholesale Trade and Other parts of the value chain were often standardized across sub technologies because of similarities in these industry profiles.

Projected Economywide Job Growth and Occupational Gaps

The research team leveraged two primary datasets to approximate the economywide occupational trends in supply and demand of workers: Long Term Occupation Projections from the Massachusetts Department of Unemployment Assistance and the Economic Research Department to understand economywide employment projections. This data forecasts 5-digit occupational demand at the 5-digit SOC code level. To estimate the annual supply of workers relevant to Workforce Priority Occupations, the research team leveraged data from the U.S. Department of Labor's 2021 Registered Apprentices and Participation Trends database, postsecondary awards available through JobsEQ and vocational and technical school data provided to the research team by the Massachusetts Executive Office of Labor and Workforce Development.

There are two notable characteristics of postsecondary awards data. First, to some extent it relies on CIP-SOC code crosswalks, which are an imperfect, albeit the most common, way to connect education programs to occupations. Since many roles do not require a specific education linked to a CIP code (say, General and Operations Managers), the crosswalk results in an undercounting of these roles and they were therefore excluded from the list. Second, because of limited public data, the extent of private program completions is less understood. Vocational and technical school completions were proportioned to the state's overall rate of program completers who go on to be employed in a relevant field, which in this case is roughly 33% according to the Career Vocational Technical Education Graduate Follow-up Survey,[112] though rates vary significantly across programs. The survey showed that many (50%) vocational and technical school graduates go on to pursue additional education.

Training Inventory

Developing the Training Inventory

The research team compiled a list of training programs in Massachusetts that would provide interested individuals with the foundational and/or additional skills needed to enter the clean energy industry. The team categorized programs with the following metrics:

1. **Institution/Program Type**
   Assigned based on the type of institution that hosts a specific program (regardless of collaborators). Institution types could fall into any of these categories: community college, community-based/non-profit organization, high school, industry association, private college/university, private training company/technical school, public college/university, state agency, union and vocational and technical high school.
2. **Program Focus (1 & 2)**
   A general category to capture the activities that training programs train for. Activities could be related to specific occupations (e.g., Energy Auditor, Ship and Boat Captains) or value chain activities (e.g., Construction, Operations and Maintenance, Planning and Development). Where applicable, programs may have more than one program focus.
3. **Outcomes**
   Assigned based on the degree or certification outcomes listed in program descriptions. If no degrees or certificates are available, outcomes are assigned based on the purpose of the program (e.g., test or examination preparation, job readiness, apprenticeships, course credits). Additional notes are provided for outcomes where applicable.
4. **Focus Area (1 & 2)**

[112] All Ch74 completions in 2020-2021.

Assigned program activities based on MassCEC focus areas (e.g., High-Performance Buildings, Clean Transportation, Net Zero Grid and Offshore Wind) as well as general construction and manufacturing for trainings that are applicable across focus areas.

5. **Regional Transit Authority**
   The collection of transit authorities and the towns served was matched to the towns in which programs are hosted. The matching system prioritized town access to the commuter rail, subway, bus and paratransit access through the Massachusetts Bay Transportation Authority (MBTA). Where towns do not have access to MBTA systems, regional transit authorities are matched to the town.

6. **MBTA Access**
   Matching system as described for Regional Transit Authority but only restricted to the bus, subway and commuter rail systems.

7. **Relevance to Workforce Priority Occupations**
   The workforce priority occupations that each training are relevant to are identified with a numeric code. The numbers relay the level of relevance of that training to an occupation.
   A. This is a training, or equivalent knowledge and certification, to be required for entry into an occupation.
   B. This is a training that is preferred by employers for this occupation but not necessarily required.
   C. This is training that offers an opportunity for workers in the selected occupation to upskill or specialize and potentially attain higher wages.
   D. This is a two- or four-year degree program that may be relevant to an occupation. Many workforce priority occupations do not require a specific type of degree or a degree at all.

Appendix B: Training Inventory

The training inventory is available as part of the MA Clean Energy Workforce Needs Assessment Workbook, found online and for download through the following link: c

Appendix C: Occupational Tables

The occupational tables and accompanying data are available as part of the MA Clean Energy Workforce Needs Assessment Workbook, found online and for download through the following link: https://www.masscec.com/resources/massachusetts-clean-energy-workforce-needs-assessment

Appendix D: Employer Survey Toplines

The employer survey toplines are available as part of the MA Clean Energy Workforce Needs Assessment Workbook, found online and for download through the following link: https://www.masscec.com/resources/massachusetts-clean-energy-workforce-needs-assessment

Appendix E: Current Worker Survey Toplines

The current worker survey toplines are available as part of the MA Clean Energy Workforce Needs Assessment Workbook, found online and for download through the following link: https://www.masscec.com/resources/massachusetts-clean-energy-workforce-needs-assessment

Appendix F: MassCEC Workforce Priority Occupation Profiles

The workforce priority occupation profiles are available as part of the MA Clean Energy Workforce Needs Assessment Workbook, found online and for download through the following link: https://www.masscec.com/resources/massachusetts-clean-energy-workforce-needs-assessment

Appendix G: Common Practices for Just Transitions from Fossil Fuels

Below is a list of resources that were reviewed to understand trends and common practices among just transitions.

"Real People, Real Change - Strategies for just energy transitions", Global Subsidies Initiaitive , https://www.iisd.org/system/files/publications/real-people-change-strategies-just-energy-transitions.pdf

"Case studies from transition processes in coal dependent communities", Greenpeace, https://www.greenpeace.org/static/planet4-africa-stateless/2019/04/52eea778-jt-case-studies-report.pdf

"Jobs Beyond Coal: A Manual for Communities, Workers, and Environmentalists," Jeremy Brecher, Labor Network for Sustainability, http://report.labor4sustainability.org/coal_2012.pdf.

"As U.S. Coal Plants Shutter, One Town Tests an Off-Ramp," Alex Brown, Sophie Quinton, PEW Research, https://www.pewtrusts.org/en/research-and-analysis/blogs/stateline/2020/03/04/as-us-coal-plants-shutter-one-town-tests-an-off-ramp.

"Options and Opportunities for Coal Plant Communities Pennsylvania and the Regional Greenhouse Gas Initiative," Joseph Cullen, Ohio Valley River Institute, https://ohiorivervalleyinstitute.org/wp-content/uploads/2021/06/RGGI-Report-Final.pdf.

"Workers and Communities in Transition: Report of the Just Transition Listening Project," Just Transition Listening Project, Labor Network for Sustainability, https://www.labor4sustainability.org/files/JTLP_report2021.pdf.

"Just Transition - A Report for the OECD," Samantha Smith, Just Transition Center, https://www.oecd.org/environment/cc/g20-climate/collapsecontents/Just-Transition-Centre-report-just-transition.pdf.

"How Ontario Is Putting an End To Coal-Burning Power Plants," Keith Schneider, Yale 360, https://e360.yale.edu/features/how_ontario_is_putting_an_end_to_coal-burning_power_plants.

"Ontario, Canada: Reorienting Local Economies by Converting the Atikokan and Thunder Bay Coal-Fired Generating Stations," World Resources Institute, https://www.wri.org/update/ontario-canada-reorienting-local-economies-converting-atikokan-and-thunder-bay-coal-fired.

"New Mexico's coal transition law still faces an uncertain timeline," Jonathan P. Thompson, Energy News Network, https://nmindepth.com/2022/new-mexicos-coal-transition-law-still-faces-an-uncertain-timeline/.

"Case studies from transition processes in coal dependent communities," Greenpeace, https://www.greenpeace.org/static/planet4-africa-stateless/2019/04/52eea778-jt-case-studies-report.pdf.

"Iceland's Sustainable Energy Story: A Model for the World?" Halla Hrund Logadóttir, Reykjavík University , https://www.un.org/en/chronicle/article/icelands-sustainable-energy-story-model-world.

"Eliminating fossil fuels: Iceland's transition from coal and oil to geothermal district heating, 1930–1980," Odinn Melsted, Maastricht University, https://www.tandfonline.com/doi/pdf/10.1080/07341512.2022.2033386.

"Chapter 7: Accelerating and Smoothing the Clean Energy Transition," White House, https://www.whitehouse.gov/wp-content/uploads/2022/04/Chapter-7-new.pdf.

"Initial Report to the President on Empowering Workers Through Revitalizing Energy Communities," Interagency Working Group on Coal and Power Plant Communities and Economic Revitalization, Department of Energy, https://netl.doe.gov/sites/default/files/2021-04/Initial%20Report%20on%20Energy%20Communities_Apr2021.pdf.

"Steps to Aid US Fossil Fuel Workers in the Clean Energy Transition," Devashree Saha and Jillian Neuberger, World Resources Institute, https://www.wri.org/insights/steps-aid-us-fossil-fuel-workers-clean-energy-transition.

"Ensuring a Fair Transition for US Fossil Fuel Workers in Economic Recovery," Devashree Saha, World Resources Institute, https://www.wri.org/insights/ensuring-fair-transition-us-fossil-fuel-workers-economic-recovery.

"Economic Development for Communities in Transition," EDF and Resources for the Future, https://www.edf.org/economic-development-communities-transition.

Appendix H: List of Common Categories of Training Providers

1. **Vocational and technical high schools** are training programs throughout Massachusetts that offer hands-on learning opportunities for high school students. These training programs are among the most numerous of all clean energy-related training programs across the state. They also offer students potential exposure to clean energy careers at an early age and the training necessary for those careers. Graduates of these programs often continue on to apprenticeships, community college or enter relevant industries directly. Program participants are not paid during this program.

2. **Private training providers** are for-profit enterprises that offer a range of training programs, ranging from HVAC-R instruction, BPI certifications and OSHA 10 Certifications. These providers can be online, in-person or hybrid and often offer an “accelerated” avenue towards a specific career. Out-of-pocket costs can range from a couple hundred to thousands of dollars.

3. **Pre-apprenticeship programs** also target younger participants, offer experiential learning and are often geared towards roles in the trades. These programs often offer support services so participants can access resources, such as mentoring and mental health counseling. Program participants often receive a stipend while they complete the program. Apprenticeship program administrators identified pre-apprenticeship graduates as the most likely to prove successful in apprenticeship programs.

4. **Apprenticeship programs** may be preferred, or even required, for some occupations by employers because they give job seekers a chance to learn on the job while working directly with employers. Apprenticeship programs can be offered through employers or union affiliates. Apprenticeships pay job seekers as they complete the training program.

5. **Post-secondary institutions** such as community college and private 2-year technical colleges offer job seekers flexibility, as they can attain a certificate or associate degree in two or fewer years while also having the option of applying those credits towards a four-year degree at another institution. Accordingly, community colleges offer a wide range of career pathways. The City of Boston offers access to tuition-free community college for lower-income residents. Though this resource is not available throughout the rest of the state, in March of 2023, Governor Healey proposed $20 million in funding as part of the state’s 2024 budget to make community college free for residents over 25.[113]

[113] https://www.mass.gov/news/ahead-of-fy24-budget-filing-governor-healey-and-lieutenant-governor-driscoll-announce-massreconnect-workforce-development-investments

6. **Four-year and advanced degree universities** include public and private institutions. These academic programs are typically geared toward clean energy occupations in professional services, including engineers, lawyers or certain types of management.
7. **Community-Based Organizations (CBOs)** sometimes offer training programs along with support services. These models often offer smaller-scale training programs. CBOs can offer trainings for a range of careers, from jobs in the trades to customer service roles. These trainings can be paid or unpaid.

Appendix I: Occupational Categories

Office and Administrative Support: Workers in this occupational group prepare and organize documents, track products and provide information to the public. Examples of the 13 occupations in this group include Customer Service Representatives, Financial and General Office Clerks and Receptionists.

Business and Financial: Workers in this occupational group are involved in the day-to-day activities of running a business or with matters related to money. Examples of the 22 occupations in this group include Accountants, Cost Estimators and Market Research Analysts.

Management: Workers in this occupational group establish plans and policies, direct business activities and oversee people, products and services. Examples of the 24 occupations in this group include Construction Managers, Financial Managers and Top Executives.

Production: Workers in this occupational group operate machines and other equipment to assemble goods or distribute energy. Examples of the 15 occupations in this group include Miscellaneous Assemblers and Fabricators, Metal and Plastic Machine Workers, Power Plant Operators and Welders.

Computer and Mathematics: Workers in this occupational group use arithmetic and apply advanced techniques to make calculations, analyze data and solve problems. The four occupations in this group include actuaries, data scientists, operations research analysts, mathematicians and statisticians.

Appendix J: Offshore Wind Methodology and Analysis

Offshore Wind Local Content Scenarios

The three scenarios describe differing Massachusetts local content projections that stem from variations in public sector intervention to support supply chain and workforce development in the state. The efforts being taken to increase Massachusetts local content are reflected as either an increase in supply chain capability, an acceleration of when capability becomes available, or both. Each progressive scenario builds upon the previous one.

Scenario 1: “Business as Usual”

This scenario describes the current path for additional supply chain and workforce development in state. This includes: support to existing companies with capability captured in Scenario 1 to diversify and expand their service offering; identifying and connecting new lower-tier manufacturers with opportunities to supply components in OSW; and increased presence of skilled workforce to support quayside finishing of components and offshore installation and commissioning services. Further workforce training support is anticipated to result in an increased number of local workers to provide offshore O&M. This scenario is what is utilized in this report.

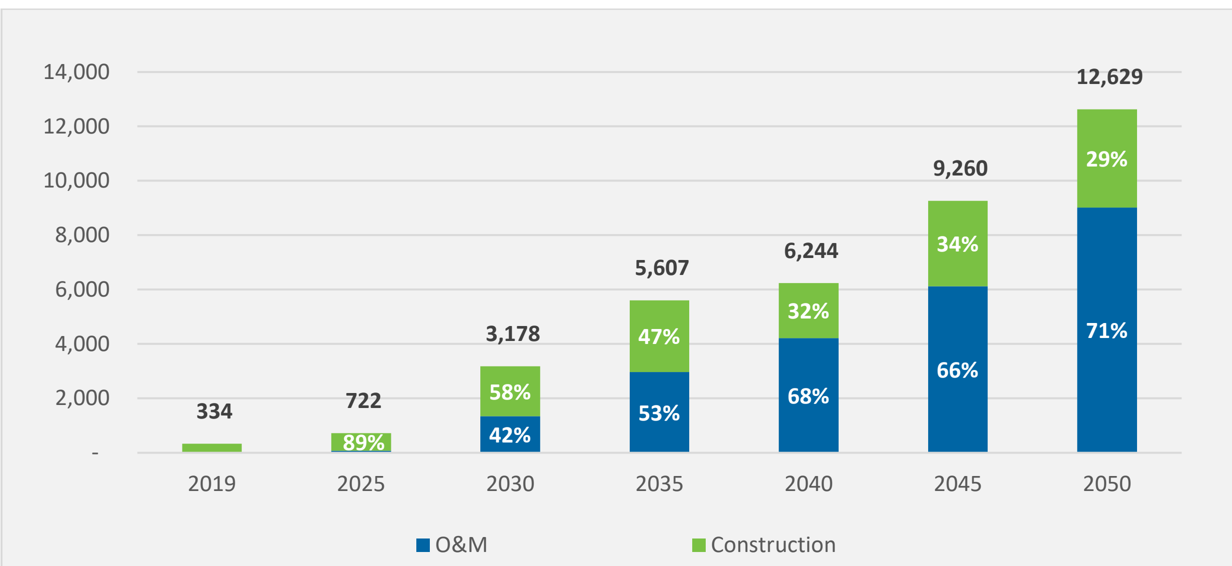
Scenario 2: "Plausible but Optimistic"

This scenario describes an achievable supply chain development pathway that results in significant additional Tier 1 manufacturing to land in the state. This scenario includes the establishment of facilities to manufacture towers, transition pieces and blades in Massachusetts as well as an expansion of the capabilities of the expected export cable facility to also produce array cables. These facilities are considered the most achievable to capture due to the current gaps in the U.S. East Coast OSW supply chain landscape working in combination with the expected Massachusetts project pipeline opportunity, providing a plausible investment case for OEMs. The scenario also includes uncovering or better connecting a greater number of lower-tier suppliers or attracting them to set up in the state to support Tier 1 supply.

Scenario 3: "Long Shot"

This scenario describes the potential best case for local content that assumes additional component manufacturing and expansion of supply chain services beyond those captured in previous scenarios. This includes the establishment of a turbine nacelle assembly facility and a facility to manufacture electrical subcomponents for the offshore substation transmission infrastructure. This additional manufacturing capability will be more challenging to capture in state due to the limited requirement for U.S. facilities, more challenging investment case for suppliers and strong competition from other states to secure supply.

Employment by Activities (Operations & Maintenance or Construction)



Employment Growth by Value Chain and Scenario