CITY of BOSTON

2026

CLIMATE READY WORKFORCE ACTION PLAN

Appendix A.
Technical Materials

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1. Detailed Methodology for Labor Demand Estimates

Traditional economists' input-output models cannot be readily applied to create adequate projections of how green infrastructure investments will stimulate specific green economic opportunities or how those will ripple throughout the economy. This is because the supply chains and materials involved in building climate-resilient infrastructure differ from those that drive traditional infrastructure investments (e.g., building roads or bridges) built with locally produced materials (e.g., concrete, rebar, etc). Instead, green projects often rely on different building materials, many of which are imported from outside the region. As a result, green projects are less likely to create local employment unless Boston entrepreneurs create new businesses to replace "imported" portions of the supply chain.

While our methods vary somewhat from other Boston-focused studies, the bottom-line results are fairly aligned (see Table A1). Compared to other studies, one strength of our study is that it covers short-term (2025-2030, mid-term (2025-2040) and long-term (2025-2050) projections. We also delve more deeply into the model inputs that are described in the Boston CAP by supplementing this information with stakeholder interviews with both City staff and external experts. Although we cover similar priority areas as outlined from the CAP (except for waste management), our report includes a more refined set of 45 green-related occupations than other Boston studies. We also have access to more detailed data on labor demand (e.g., Lightcast job postings), labor supply (e.g., direct union data on apprenticeships), and skills (e.g., machine learning analysis of job posting text).

Where we differ the most from other studies is in our methodology and key assumptions. Whereas other studies use a top-down method to apportion national or state estimates to the Boston region, ours uses the PERI IMPLAN estimates to model demand from the bottom up. This likely produces more conservative estimates since we do not include indirect nor induced jobs that are automatically part of any top-down approach. In addition, we make very explicit assumptions about the share of jobs supported that are net new to the economy, allowing for a relatively high degree of reallocation of the existing workforce that is not accounted for in the other studies.

Below we describe key details about our four-step estimation process that are not already contained in the text of the report.

1. Estimate total dollar investment for each CAP initiative
2. Project the total number of jobs supported by CAP investments
3. Determine the number of jobs supported per year based on the timing of projects
4. Disaggregate total jobs supported by broad industry sector

Table A1. Comparing Methodologies for Estimating Employment arising from Green Investments

	CoB Report (NU, BGI, CLU)	**MassCEC Report (BW Research)**	**C40 Report (K-Matrix)**
Geography	Greater Boston including Essex, Middlesex, Norfolk, Plymouth, and Suffolk counties	State-wide and apportioned to workforce regions including Greater Boston	Greater Boston (not defined).
Time period	Short-term: 2025-2030, Mid-term: 2025-2040, And Long-term: 2025-2050	Short-term: 2025-2030	Mid-term: 2025-2040
Inputs	Public investments from Boston Climate Action Plan, Private investments from Building Emissions Reduction and Disclosure Ordinance (BERDO) and the Coastal Flood Resilience Overlay District (CFROD) .	Massachusetts Clean Energy Industry Report (MACEIR); Macroeconomic Impact and Equity Analysis of the Massachusetts 2050 Decarbonization Roadmap; Vehicle mileage estimates from 2025 and 2030 CECP;	Boston Climate Action Plan and U.S. Nationally Determined Contribution; GDP (for country analysis)
CAP Priority Areas	Transportation and Electrification, Electrical Grid Upgrading, Coastal Resiliency and Nature-Based Solutions, Building Decarbonization	Energy Efficiency, Transportation, Renewable Energy, Other (not defined)	Construction, Transportation, and Waste Management
Economic Sectors and Occupations	Six Broad Sectors relating to Investments Comprising 45 Occupations	Six Broad Sectors relating to Industry Comprising 21 Technology Occupations	Eight Broad Employment Groups Comprising 13 Occupations (ISCO)
Data	Demand: BLS occupational employment projections, Lightcast job postings; Supply: BLS occupational exit projections, CLU union data Skills/Training: Machine learning analysis of Lightcast job postings;;	Demand: Long Term Occupation Projections from MA DUA; Supply: Current workers from U.S. Department of Labor's 2021 Registered Apprentices and Participation Trends; postsecondary awards available	Demand: K-Matrix triangulation using production, components, supply chain, and financial data Supply: Not listed Skills/Training: K-Matrix data from industry, academic, and other training providers

	interviews with employers, unions, training providers, community-based organizations, state and local government	through JobsEQ and vocational and technical school data from MA EOLWD. Skills/Training: Employer and worker surveys; interviews with employers, unions, training providers, community-based organizations, state and local government	
Methodology	Demand-side estimates obtained by applying PERI input-output model of direct effects to Boston's planned green investments; Supply side estimates include replacements due to retirements from BLS.	Demand-side estimates generated from projected staffing patterns by NAICS from 2019 U.S. Energy and Employment Report (USEER) applied to MACIER, MA Decarbonization Roadmap, and vehicle mileage estimates; Supply-side estimates from training and education pipeline.	Demand-side estimates generated from K-matrix Triangulation: if you know how many units were produced at each step in the supply chain, then you can back out how many workers were needed to produce it; Supply-side estimates from training and education pipeline.
Key Assumptions	Bottom-up approach assumes high percentage of crowding out of other capital investments (e.g., reallocation); modest assumptions for net new job creation.	Top-down approach apportions state-level inputs to Greater Boston region; no potential for reallocation among existing workers is accounted for.	Assume local supply chains are affected similarly to national ones; Uses FTE count with no potential for reallocation among existing workers.
Basis for Recommendations	Produces two scenarios: "Optimistic" scenario based on high degree of BERDO compliance versus "Pessimistic" scenario based on lower BERDO compliance	Produces one scenario	Produce two scenarios: "business as usual" versus "optimistic" (training slots increase by 50%; focus on worker migration across countries and regions as a solution
Bottom Line Estimates	2050: Total=67,000 jobs supported annually	2025: Total=56,900 jobs supported annually 2030: Total=59,200 jobs supported annually	2040: Total=61,000 jobs supported annually

A. Estimate the total dollar investment for each CAP initiative

To estimate the total dollar investment for each of the four CAP areas, we used the Boston CAP as a baseline understanding and supplemented with details from interviews conducted with City staff, advisory council members, and external experts. Table A2 summarizes our estimates which we describe in greater detail below, including the assumptions that underlie each dollar value. Of the four main areas identified from the Boston CAP, building decarbonization is by far the one that yields the highest dollar value of investment.

Table A2. Investment Modeling Projections for Boston CAP

CAP Area and Actions	Projected Spending
Transportation Electrification, 2025-2030	
BPS Yard Improvements	$50 million
MBTA Yard Improvements	$800 million
CoB Fleet EV Charging Installation	$10 million
Public EV Charging Installation	$25 million
Electrical Grid Upgrading, 2025-2040	
Substation and Transmission Improvements to be completed by 2030	$500 million – $1 billion
Substation and Transmission Improvements to be completed 2030-2035	$500 million – $1 billion
Per mile transmission improvements, 2025-2040	$500K - $9.5 million
Geothermal Installation	$50-$75K per unit
Coastal Resiliency and Nature-Based Solutions	
Green Infrastructure Implementation, 2025-2030	$25-50 million
District Level Coastal Infrastructure, 2025-2050	$8-15 billion
Coastal Resilience and Adaptation Investments, 2025-2050	$4-6 billion
Building Decarbonization	
BERDO Multi-family, 2025-2030	$2.7 billion
BERDO Commercial/Industrial, 2025-2030	$4.21 billion
Small Building Retrofits, 2025-2030	$1.15- 4.3 billion
BERDO Multi-family, 2025-2050	$10.8 billion
BERDO Commercial/Industrial, 2025-2050	$16.8 billion
Small Building Retrofits, 2025-2050	$11.5 billion

Source: Authors' calculations based on Boston CAP and stakeholder interviews with City of Boston staff and external experts.

(1). TRANSPORTATION ELECTRIFICATION

Estimated investments for transportation electrification were modeled through 2030, when the electrification goals are projected to be completed. To examine what kinds and numbers of jobs would be needed to electrify Boston's transportation, we explored the improvements and changes needed for Boston Public Schools (BPS), the City of Boston vehicle fleet, and the MBTA. All these would require significant improvements to yard facilities and charging infrastructure. All these will rely on building substations and electric transformers upgrades to handle increased demand. Estimates of spending are derived from interviews with BPS and MBTA fleet and yard management staff, staff in city infrastructure and fleet management, public capital expenditures plans from the city and MBTA, and public reporting.

To estimate the costs of bus yard improvements for BPS and the City and to install enough public charging infrastructure, we conducted a landscape analysis of construction costs, including information gathered from city interviews. Because BPS bus service has significant midday downtime while school is in session, the district has been able to deploy several hundred battery-based electric buses already and is working to improve charging speeds to fully adopt charging. BPS bus yards do not require significant retrofitting because they use a process called wet fueling, which uses fuel tankers, rather than in-ground fueling systems.

Through engagement with city staff, we also identified other implementation strategies that would support transportation electrification by expanding multimodal transportation. These included expanding bike lanes, installing new public bike stations, and expanding bus lanes throughout the city. However, we were unable to identify spending and investment plans for these projects, and so could not model implementation.

Our research also revealed several significant uncertainties in these projections for completing the CAP goals with regards to transportation electrification. First, funding is not yet fully allocated for these projects, meaning that fundraising for budgeted improvements will be required. Second, cost overruns also present significant challenges. For example, the Boston Globe reports that the MBTA has already spent over $400 million on improving just the Quincy MBTA garage for BEB preparation. This represents half of the estimated $800 million allocated to improve all 12 MBTA bus yards. It's unclear whether these additional costs will mean more workers employed. Much of the cost of electrifying transportation comes from the high prices for component parts. Those costs are hard to predict, given the increasing demand for these materials.

(2). ELECTRICAL GRID UPGRADING

The success of Boston's CAP depends on an upgraded power grid to incorporate renewable energy sources. The research team interviewed utility company representatives and reviewed and analyzed utility capital improvement plans and budgets extensively to get a sense of the projects that would contribute to renewable energy adoption. Given how complex the

negotiations between state authorities and regulated utilities are for grid upgrades, it is difficult to parse out costs that are directly related to upgrades for renewable energy and those that are related to general grid maintenance or repairs after a storm or other natural disaster. Utility capital plans lay out the investments the utility plans to make, including rough schedules, costs and priorities.

Potential spending estimates are developed from review of Eversource capital expenditure plans and interviews with capital planning staff at Eversource; Geothermal installation estimates based on review of the Framingham pilot and interviews and engagement with City of Boston Advisory Council members. In the near term, utility representatives identified key improvements planned by 2030. Those include installing at least 5 critical substations, improving existing substation, and upgrading transmission lines across the city due to electrical capacity and reliability problems in certain parts of the city. These new installations will add significant capacity for reaching the City's net-zero goals:

- City of Boston – New East Eagle Substation.
- City of Cambridge – New Cambridge Substation – Clean Energy Hub
- City of Boston – New Hyde Park/Dorchester Substation
- City of Somerville – Somerville Substation Expansion.
- City of Cambridge – Alewife Substation Transformer Addition.

These planned installations are expected to add capacity for charging approximately 75,000 EVs and 15-20,000 heat pumps per substation. While some of these substations are outside of Boston proper, they help create capacity for the city and close gaps in current capacity – and could be built by Boston residents. Costs are estimated to be between $500 million and $1 billion total. Eversource capital plans identify a similar set of improvements scheduled for 2030-2035. Additional improvements after 2040 are indeterminate at the time of this report.

Geothermal installation is also seen as a critical investment opportunity for the city. Several pilot installations of geothermal heating and cooling have incurred high initial costs. For example, one project to install geothermal service for 36 housing units cost a total of $15 million. These costs are estimated to significantly drop in the future, as stakeholder interviews revealed that much of the current costs (up to 60 percent) come from retrofitting and weatherization that are not directly related to the geothermal installations themselves. We also estimate that per-unit costs may drop once installation is occurring at scale. As a result, we assume a cost of $50-75K per installation in our projections. However, if costs remain as they are today, it could be over $400K per unit, inclusive of other required investments for installation, like weatherization of buildings.

(3). COASTAL RESILIENCY AND NATURE-BASED SOLUTIONS

Larger long-term investments in coastal resiliency and nature-based solutions for major infrastructure projects are still in the planning and design stages. Investment estimates were developed from city staff interviews and the Boston Foundation; job support estimates based on calculations using PERI model estimates. Broadly, these investments are in district-level infrastructure to mitigate coastal flooding and manage stormwater systems. District-level

infrastructure could include sea walls, major water infrastructure to mitigate flooding and flood risk, and many other options. These investments will require partnering with the Army Corps of Engineers and are not likely to be completely determined, scoped, or financed until 2028. As such, we use potential cost estimates of between $8 and $15 billion from City staff preparing plans for applications to the Army Corps of Engineers.

(4). BUILDING DECARBONIZATION

Estimates of the potential spending effects associated with building decarbonization are based on calculations developed from information provided by City of Boston Buildings Department and estimates of the cost of building decarbonization developed by RMI. We also assume that an additional 5 percent of Boston's small building stock will be retrofitted to become fully carbon-neutral. Our estimate is small, because owners must invest a significant amount to retrofit small buildings. Those investments, since they are elective, will depend on a variety of market factors. By offering subsidy programs and tax credits, the federal, state, and local governments could encourage more retrofitting. Subsidies may have to be quite large to drive decarbonization investments. However, since most of the tradespeople able to implement such retrofits will likely be employed in larger (and more remunerative) Boston CAP projects and therefore unavailable to work on homes and small buildings, even 5 percent may be an optimistic estimate.

Overall, BERDO regulations and private demand for decarbonized buildings could employ a significant number of workers in the city and broader region. This level of spending could employ 25% to 47% of the approximately 125,000 construction jobs by 2030 in trade and trade-adjacent jobs. This suggests that over the next few years, the current workforce could handle the retrofitting needed. However, with so much demand across the market, it could also absorb new workers. These investments in retrofitting will also likely employ significant numbers of workers in Project Implementation and Green Operations over this period.

B. Project the total number of jobs supported by CAP investments

Funding against priorities is a major driver of uncertainty for implementation of the Boston CAP. Many projects have 2040 or 2050 attainment goals, but limited funding to get there, or rely on private investments – which could take time to materialize. Below we describe the degree of confidence in each of the four CAP areas along with a discussion of the downside risks as summarized in Table A3.

(1). TRANSPORTATION ELECTRIFICATION

- Transportation electrification is in transition mode currently and nearing initial attainment – new technologies (batteries especially) likely keep the target moving, but initial attainment is close

- Much of the work in transportation electrification is focused on maintenance shed/yard facility upgrades to improve charging efficiency as well as speed.
    - Speed is especially critical for MBTA busses that do not have a mid-day charging window.
    - BPS can deploy a full battery powered fleet with level two chargers because of the mid-day charging opportunity and the current location of bus yards – this is much more difficult in winter and in many places, upgrades to level three are essential
- Yard costs are driven by quickly changing component prices (transformers for high voltage level three chargers are often supply chain snags and costs continue to rise on them) – finding and purchasing these transformers is often a major dependency
- Overall, the projects are relatively small in scale through BPS
- MBTA spending on bus facilities is scheduled at just over $800 million. The Quincy Garage has cost over $400 million, so cost overruns could be likely.
- BPS estimates that they will crowd out or bid against other projects rather than drive new entrants to the field.
- Improvements to the bus facilities likely support 2,000 to 3,000 workers annually over the next 5 years to meet attainment of bus fleet electrification

(2). Electrical Grid Upgrading

- Grid upgrading is ongoing and in many ways all encompassing – a number of important renewable projects are identified in 5- and 10-year plans but transmission upgrades, fixing and improving lines after storms and general maintenance make this an ongoing priority that is difficult to "attain"
    - Major milestones like behind meter production and negative meters are important
- Substation plans and associated transmission upgrades in the 5-year plan likely support 9K to 18.2K jobs over 5 years.
    - This level of employment support is then repeated again in the 2029-2034 timeframe.
- This is likely absorbed through current employment in the region – between current utility workers, linemen, and electricians, and associated operations workers. Annual estimates to implement these projects are ~2K to 4K workers.
- Estimating overall transmission line upgrades is difficult to identify where improvements will lead to improved grid performance
- Geothermal implementation is difficult to project at scale
- Reaching last mile renewable grid improvement is very difficult – as utilities have to balance costs of projects with approved rate changes – and last mile changes can be costly to implement. This means that equity in renewable service and transmission is important to consider and support
- Maturity of geothermal options in the region make employment projections for the sector difficult – geothermal impacted roles are likely to see some effects – and recategorization like drillers. Others like plumbers and pipefitters are likely to remain in scaled and growing.

(3). Coastal Resiliency and Nature-Based Solutions

- Indeterminate timeframe of CFROD is similarly a downside risk to potential projections
- Coastal resilience planning, design, and implementation will require significant investment in scattered infrastructure and strategies to mitigate flood risks
- Urban Heat Island Mitigation requires long-term investments in canopy and urban forest protections – but in comparison to other investments is smaller – as is the workforce that manages urban canopy
- Modeling both heat mitigation and coastal resiliency in the long term is potentially the most difficult because of changing climate, flooding and storm risks, and other factors that make projection difficult.
- The Coastal Flood Resilience Overlay District (CFROD) is an important regulation in setting expectations for meeting coastal resilience goals, but unlike BERDO doesn't have immediate enforcement requirements – the CFROD is enforceable for large projects, but not smaller projects beyond consultation and review. This may mute the overall short-term impact of the district and likely pushes its impact from a near-term to a longer-term impact strategy

(4). Building Decarbonization

- Moonshot goals are the most relevant in building decarbonization and coastal resilience – with clear levels of attainment (net-zero and a storm resilient coast)
- Enforcement and management of BERDO compliance (and ultimate spending) is a major part of downside risk in the estimates of jobs supported
- How does the city react and enforce BERDO in a poor macroeconomic climate?
- New builds represent the largest unknown – theoretically these will capture new building standards and code that older buildings do not
- Pace of development and macroeconomic conditions are some of the largest factors in determining pace of labor demand
- If we assume that all new buildings meet the general standards outlined towards net-zero buildings, then assuming that general models of labor growth adequately capture demand for work – and then the primary focus is on how trades roles change because of new building standards
- Private market spending by families and small investors is more difficult to determine – subsidy programs make an important difference, but pace and speed of retrofit often begin to implicate additional, often costly retrofits (like powering tankless water heaters, powering HVAC systems, capping or removing abandoned gas lines in electrified houses).

Table A3. Confidence and Risk Assessment across Estimation Scenarios

CONFIDENCE LEVEL	DOWNSIDE RISKS TO CONSIDER
ELECTRIFYING TRANSPORTATION	

Medium Confidence – Clear plan between BPS and city bus fleet purchasing, MBTA clear fleet transition plans; electric charging installation;	• Unallocated funding for remaining fleet upgrades • Fleet at MBTA may require waiver for diesel heat
Low Confidence – garage/depot and maintenance yard upgrading for electric busses	• Estimates/allocations are low relative to current spending • Changing technology in batteries and charging could change needs in depot
ELECTRICAL GRID UPGRADING	
Low Confidence – grid upgrading – substation buildout and costs	• Funding is available via negotiation with utilities and set by rate payer fees, but less clarity on how much and exactly when it is deployed.
Low Confidence – creating line and system upgrades for "backwards metering"	• Important improvement but timing is uncertain • Difficult to parse out "regular" line upgrading from upgrades that facilitate renewable energy
Low Confidence – geothermal rollout and installation	• Initial pilots show very high costs, uncertainty as to feasibility of rollout and scale
COASTAL RESILIENCY & NATURE BASED SOLUTIONS	
High Confidence – urban forestry and green infrastructure strategies, installation of green infrastructure	• Limited, unmeasured impacts from investments in these areas – some skill changes, but limited
Medium Confidence – coastal resilience investments and CFROD compliance presents a mappable and clear set of standards as buildings upgrade	• Boston Foundation and City estimates give some clarity, but how and when rollout will happen remains uncertain.
BUILDING DECARBONIZATION	
High Confidence – BERDO multifamily and commercial real estate upgrades. Clear policy goals and standards, third party cost estimates available for planning	• Potential adverse impact of changing economy on real estate markets; New development may be muted if CRE investors are required to spend significantly on compliance • Long term nature of the legislation through 2050 creates uncertainty regarding implementation; Costs of small building development may be bid up due to regulatory driven retrofit
Low/Medium Confidence – small building retrofit and weatherization, decarbonization. Clear and easily identifiable costs to meeting decarbonization	• Difficult to estimate demand for retrofits as there are no policy or regulatory levers for enforcement. • Current subsidies mute, but do not eliminate cost differentials, providing weak incentives for adoption.

Source: Authors' calculations applying PERI estimates to Boston CAP projected spending.

C. Determine the number of jobs supported per year based on the timing of projects

As discussed in the text, we determine the number of jobs supported per year based on the timing of the projects. For example, the transportation electrification is planned to occur over a 5-year period from 2025-2030 so we divide the estimated number of job-years during that period by 5 to determine the number of jobs per year that will be supported. Note that since we do not have any additional information on the timing of these investments, we assume that they occur linearly over the period with the same number of jobs supported each year. Although that is unlikely to be the case, it provides a rough estimate of the number of workers needed each year and provides some guidance on the breadth and depth of the training that is needed.

We also aggregate the scenarios from each of the four investment areas into one unified set of estimates to come up with an overall best-, conservative-, and worst-case scenario for the Boston CAP as a whole. This allows for greater transparency of our aggregate estimates which come from mixing and matching the various optimistic and pessimistic scenarios based on the degree of confidence we had from our research into the magnitude and timing of each CAP investment. Altogether, we anticipate that the Boston CAP will result in anywhere from $53B to $148B in spending which will support 44,244 to 132,665 jobs each year from 2025 through 2050. In the text we opt to present the conservative case as we consider this to be the most likely to occur.

Table A4. Bounding the Estimates: Best-Conservative-Worst Case Scenarios

INVESTMENT AREA	BEST CASE SCENARIO	CONSERVATIVE CASE SCENARIO	WORST CASE SCENARIO
Electrifying Transportation (same scenario)	Total Spending=$885M Annual Jobs Supported=3,233	Total Spending=$885M Annual Jobs Supported=3,233	Total Spending=$885M Annual Jobs Supported=3,233
Electrical Grid Upgrading	**Optimistic** Total Spending=$2B Annual Jobs Supported=7,306	**Pessimistic** Total Spending=$1B Annual Jobs Supported=3,653	**Pessimistic** Total Spending=$1B Annual Jobs Supported=3,653
Coastal Resiliency & Nature Based Solutions	**Optimistic Coastal** Total Spending=$21B Annual Jobs Supported=15,343 **Optimistic Nature-Based** Total Spending=$0.5B Annual Jobs Supported=183	**Pessimistic Coastal** Total Spending=$12B Annual Jobs Supported=8,767 **Optimistic Nature-Based** Total Spending=$0.5B Annual Jobs Supported=183	**Pessimistic Coastal** Total Spending=$12B Annual Jobs Supported=8,767 **Pessimistic Nature-Based** Total Spending=$0.25B Annual Jobs Supported=91
Building Decarbonization	**Optimistic CRE/MFH** Total Spending=$103.5B Annual Jobs Supported=75,600 **Optimistic Small Building** Total Spending=$42.9B Annual Jobs Supported=31,000	**Pessimistic CRE/MFH** Total Spending=$27.6B Annual Jobs Supported=20,100 **Optimistic Small Building** Total Spending=$42.9B Annual Jobs Supported=31,000	**Pessimistic CRE/MFH** Total Spending=$27.6B Annual Jobs Supported=20,100 **Pessimistic Small Building** Total Spending=$11.5B Annual Jobs Supported=8,400
TOTAL	**Total Spending=$148B** **Annual Jobs Supported=132,665**	**Total Spending=$85B** **Annual Jobs Supported=66,936**	**Total Spending=$53B** **Annual Jobs Supported=44,244**

An important caveat is that our analysis estimates the total number of ***jobs supported*** through spending related to the strategies outlined in Boston's CAP, which are not necessarily all ***net new jobs*** added to the Greater Boston economy. By "supported," we mean positions where someone will be working on green projects stimulated by the CAP, even if those workers were already employed in that occupation but on non-green projects instead. Importantly, most of this impact reflects the upgrading of skills and reallocation of existing workers into green roles, rather than net new job creation.

To determine the number of net new jobs, we look to other studies in the literature that have examined this question more robustly for an estimate that can then be applied to the total number of jobs supported. For example, the PERI models suggest that far fewer jobs will be newly created compared to the jobs that will continue to be supported. For instance, they estimate that the combined effects of the BIL, IRA, and CHIPS legislative initiatives will lead to an 8.0 percent demand increase for Construction Laborers (see Exhibit A1).

Other sources such as Xie et al. (2023) combine a power-sector optimization model with the IMPLAN model to produce state-level job estimates of low-carbon transitions under current policies, a 95% emission reduction by 2050 compared to 2005 levels (95% by 2050)

and a 100% reduction by 2035 (100% by 2035). These estimate reveal substantial variation across states, largely depending on their initial reliance on the carbon-based sector. For example, although decarbonization brings consistent job growth across most states, the net gains tend to be small with major fossil-fuel producing states actually seeing significant declines. Generally, coastal states, such as Massachusetts, see more opportunities with high consistency across assumptions. According to their estimates, Massachusetts will experience an employment change of roughly 5,000 jobs between 2022 and 2050, of which 1,000 (20 percent) are estimated to be net new jobs (see Exhibit A2).

Given this range of estimates in the literature (8 percent to upwards of 20 percent), we apply a conservative estimate of 10 percent to project the number of net new jobs that are created by spending related to the strategies outlined in Boston's CAP. Given that these indirect macro effects are likely to be small at the local level, we feel confident that our analysis provides a fair, and conservative estimate of the number of jobs likely to be supported versus created if spending on CAP-related work proceeds as planned in Boston.

Exhibit A1. PERI Estimates of Annual Direct Jobs as a Percentage of Total Direct Jobs.

TABLE 6.

***Absolute Level* or *Percentage* Labor Demand Increases:**

48 Occupations with Either Largest Absolute Amount or Percentage Increase in Labor Demand due to BIL, IRA, and CHIPS

Occupation Title	Number of Annual Direct Jobs	Annual Direct Jobs Added as % of 2022 Employment	Annual Direct Jobs Added as % of Total Direct Jobs
Construction laborers	80,900	3.8%	8.1%
First-line supervisors of construction trades and extraction workers	40,000	3.0%	4.0%
Electrical power-line installers and repairers	34,500	16.4%	3.5%
Operating engineers and other construction equipment operators	32,500	6.7%	3.3%
General and operations managers	29,000	0.6%	2.9%
Bus drivers, school	27,000	3.5%	2.7%
Carpenters	23,800	1.1%	2.4%
Miscellaneous assemblers and fabricators	22,900	1.4%	2.3%
Construction managers	22,100	2.3%	2.2%
Project management specialists	21,200	1.3%	2.1%
Shuttle drivers and chauffeurs	19,800	3.1%	2.0%
Office clerks, general	18,300	0.5%	1.8%
Electrical, electronic, and electromechanical assemblers, except coil winders, tapers, and finishers	18,100	6.3%	1.8%
Heavy and tractor-trailer truck drivers	17,300	0.6%	1.7%
First-line supervisors of mechanics, installers, and repairers	16,200	1.8%	1.6%
Telecommunications line installers and repairers	15,400	9.7%	1.5%
Welders, cutters, solderers, and brazers	14,400	3.0%	1.4%
Secretaries and administrative assistants, except legal, medical, and executive	12,700	0.5%	1.3%
Bookkeeping, accounting, and auditing clerks	12,200	0.5%	1.2%
Bus drivers, transit and intercity	11,700	3.7%	1.2%
Electricians	11,700	3.6%	1.2%
Laborers and freight, stock, and material movers, hand	11,400	0.3%	1.1%
First-line supervisors of production and operating workers	9,900	1.4%	1.0%
Software developers	9,700	0.3%	1.0%
Customer service representatives	9,100	0.2%	0.9%
Accountants and auditors	9,000	0.4%	0.9%
Inspectors, testers, sorters, samplers, and weighers	8,800	1.3%	0.9%
Civil engineers	8,400	1.8%	0.8%
Sales representatives of services, except advertising, insurance, financial services, and travel	7,900	0.5%	0.8%
Industrial engineers	7,700	2.0%	0.8%

Continued

TABLE 6. *(continued)*

Absolute Level or Percentage Labor Demand Increases

48 Occupations with Either Largest Absolute Amount or Percentage Increase in Labor Demand due to BIL, IRA, and CHIPS

Occupation Title	Number of Annual Direct Jobs	Annual Direct Jobs Added as % of 2022 Employment	Annual Direct Jobs Added as % of Total Direct Jobs
Plumbers, pipefitters, and steamfitters	5,500	3.1%	0.6%
Electrical engineers	5,200	2.1%	0.5%
School bus monitors	5,000	3.5%	0.5%
Mobile heavy equipment mechanics, except engines	5,000	2.4%	0.5%
Computer numerically controlled tool operators	3,900	2.1%	0.4%
Water and wastewater treatment plant and system operators	3,500	13.2%	0.4%
Electrical and electronic engineering technologists and technicians	3,000	2.7%	0.3%
Occupational health and safety specialists	3,000	2.3%	0.3%
Wind turbine service technicians	1,800	7.6%	0.2%
Industrial engineering technologists and technicians	1,800	2.5%	0.2%
Sheet metal workers	1,700	2.4%	0.2%
Crane and tower operators	1,600	3.2%	0.2%
Radio, cellular, and tower equipment installers and repairers	1,500	8.0%	0.2%
Solar photovoltaic installers	1,300	12.3%	0.1%
Pile driver operators	1,200	31.8%	0.1%
Semiconductor processing technicians	1,200	6.0%	0.1%
Coil winders, tapers, and finishers	1,100	9.6%	0.1%
Pipelayers	1,100	5.0%	0.1%
All 48 occupations	*632,000*		*63.4%*

Note: Figures in table are rounded.

Source: Wicke-Lim, Jeanette and Robert Pollin, 2024. Labor Supply, Labor Demand, and Potential Labor Shortages Through New U.S. Clean Energy, Manufacturing, and Infrastructure Laws. Political Economy Research Institute, University of Massachusetts Boston. https://peri.umass.edu/wp-content/uploads/joomla/images/publication/PERI_BGA_Labor_2_28_24.pdf

Exhibit A2. Xie et. al. (2023) State Estimates of Net New Job Creation Arising from IRA

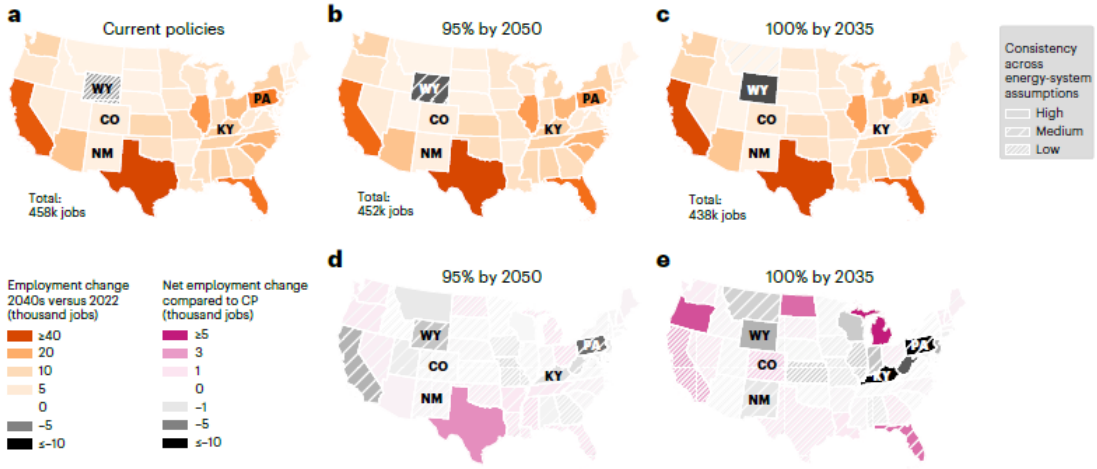


Fig. 2 | Modelled employment change and net employment change under the mid-case emission-reduction scenarios in the 2040s. Employment change (equation (7)) describes the difference of the workforce in the decade before mid-century compared to today while accounting for natural retirement. A value of 1 indicates that 1,000 new entrants would be required to deliver the transition. A value of −5 indicates that 5,000 current workers may lose their jobs in addition to natural retirement. Net employment change (equation (8)) is the employment change of an emission-reduction trajectory compared to that of the current policies trajectory. A value of 1 means that said emission trajectory creates 1,000 more jobs than current policies in the 2040s. **a**–**c**,The top row of maps shows the employment change under current policies (**a**), 95% reduction by 2050 (**b**) and 100% reduction by 2035 (**c**). States coloured orange see employment growth, whereas grey states see employment decline. **d**–**e**, The bottom row of maps shows the net employment change under 95% reduction by 2050 (**d**) and 100% reduction by 2035 (**e**) compared to current policies. States coloured pink see more employment under decarbonization than CP, whereas grey states see less. Hatching denotes the level of consistency across energy-system assumptions within each group. High consistency means all energy-system assumptions have the same sign of change as the mid-case. Medium and low consistencies represent more than and less than 80% of the 14 energy-system assumptions sharing the same sign as the mid-case, respectively. The base maps are from the US Census Bureau[85]. CP, current policies.

D. Disaggregate total jobs supported by broad industry sector

This last step requires disaggregating the total number of jobs supported by the City's CAP investments across the six key economic sectors that are most likely to be affected: Trades, Design and Inspection, Green Operations, Nature Based Solutions, Community Engagement, and Project Implementation. Table A5 summarizes the parameters we used from the PERI model based on a combination of estimates from both their BIL and IRA projections. The investments in transportation electrification and grid upgrading for renewable energy are most similar to investment modeling for the Bipartisan Infrastructure Law – which capitalized major investments in electrification and infrastructure upgrading. Using this method, we believe that Transportation Electrification and the Grid Upgrading priorities create significant demand for construction related roles, particularly those with significant responsibilities and skills related to electrical systems. Because there could be a significant amount of spending on coastal resiliency and potential major infrastructure projects, we use combined PERI models for BIL investments focused on water and land/resiliency.

Table A5. Estimated Job Demand by Occupational Sector

Occupational Group	Transportation Electrification	Electrical Grid Upgrading	Coastal Resiliency and Nature-Based Solutions	Building Decarbonization
Trade and Trade Adjacent	47.6%	47.6%	26.6%	60.8%
Design and Inspection	5.9%	5.9%	13.2%	7.5%
Green Operations	5.6%	5.6%	8.7%	8.3%
Nature Based Solutions	5.0%	5.0%	6.5%	1.4%
Project Implementation	23.1%	23.1%	18.2%	20.7%
Community Engagement	5.0%	5.0%	5.0%	1.4%

Source: Authors' calculations of occupational groupings matched to demand analysis developed in PERI estimates.
Note: Percentages do not sum to 100 because of direct job creation outside of the occupational priority areas.

We identified these occupations within each of our six sectors based on the percentage of direct jobs estimated by PERI to be in each major occupation group (by two-digit Standard Occupational Classification code) as described in Table A6 below. Note that the level of employment generated within these six sectors through the Boston CAP investments, accounts

for most, but not all, of the total employment creation through these initiatives. The remaining employment creation is sprinkled across many other smaller occupations throughout the economy. However, to guide the City's strategy with respect to workforce development, we focused on only those six sectors of the economy that we identified as being in high demand due to Boston's CAP investments.

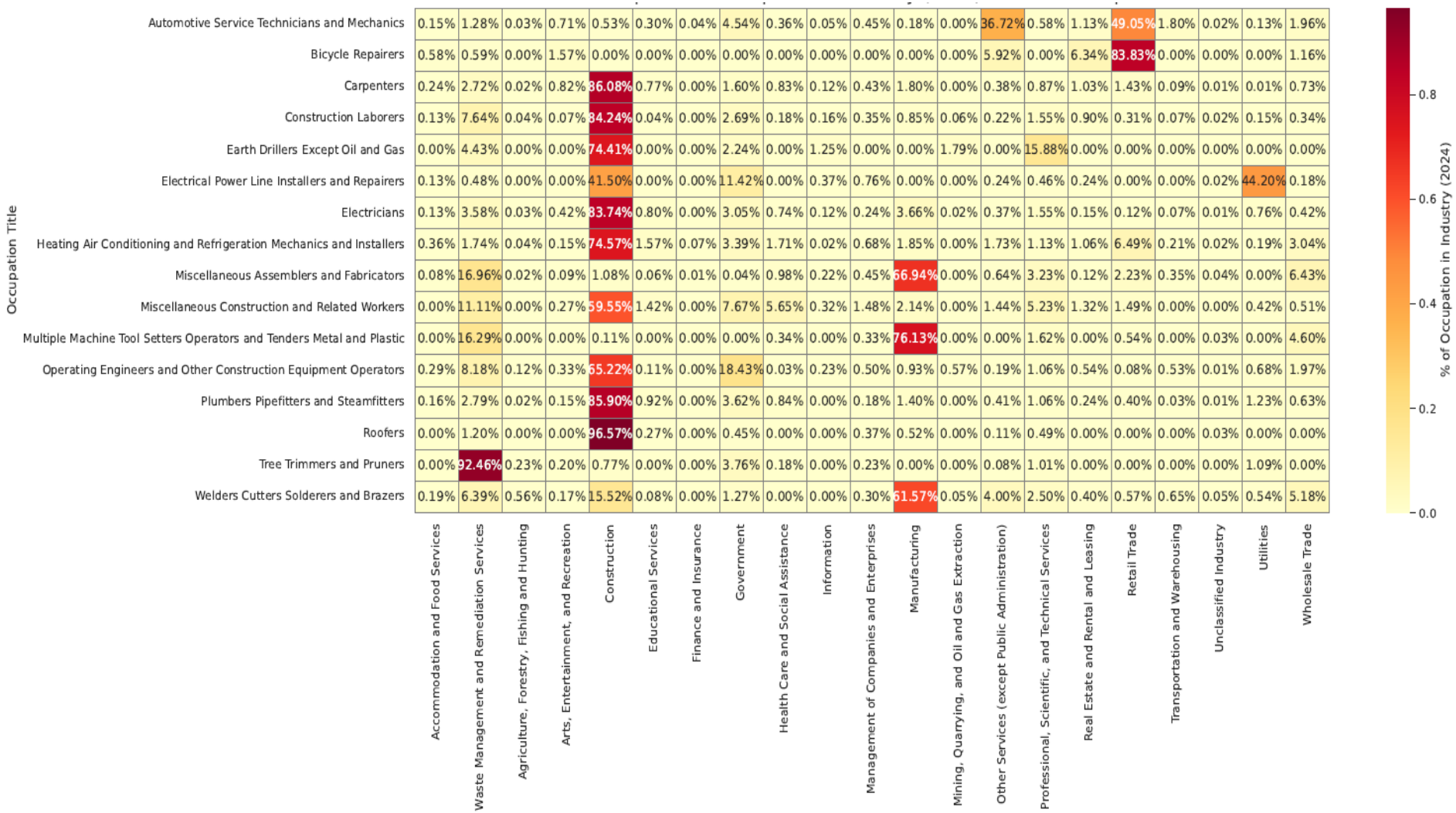
We should note that these occupational sectors cut across multiple industries, many of which will need to be engaged in preparing workers to learn the skills needed for the green transition—either through informal on the job training or workforce development programs. Figures A1 through A6 provide heat maps identifying the share of jobs in each of the six sectors that lie within each industry based on reverse staffing patterns. For example, most employment in the trades lies within the construction industry, followed by manufacturing, although there are also some occupations that are concentrated in the retail sector such as automotive service technicians.

Table A6. Key Green-Related Economic Sectors, Major Occupation Groups, and Detailed Occupations

KEY GREEN-RELATED ECONOMIC SECTOR	MAJOR OCCUPATION GROUP(S)	DETAILED OCCUPATIONS
Trades and trade-related: This includes trades workers who will be directly involved in constructing and producing green buildings, systems, and products.	Construction, Production	Construction worker; General contractor; Carpenter; Plumber; Wind welder; Electrician/Solar installer; Weatherization technician; Heavy equipment operator; Machine operator; Driller; Vehicle manufacturing assembly line worker; HVAC technician; Linesperson; Roof technician
Project implementation workers. This includes office workers who will oversee what is needed to get green projects completed in terms of planning, project management, finance, and compliance.	Management, Office and Administrative Support, Business Operations	Project manager, Project finance analyst, Purchasing agent, Power market analyst
Design and inspection. This includes STEM workers who will ensure green projects meet high quality standards in terms of architecture, engineering, and building codes.	Architecture and Engineering, and Technicians	GIS data analyst, Data scientist, Quality control inspector, Civil engineer, Mechanical engineer, Architect, Electrical engineer, Building/OCI inspector, Energy auditor, Energy modeler, Urban/regional planner, GIS technician, Green roof designer
Green operations. This includes technicians who will manage green infrastructure once it is built to ensure these systems are properly maintained and upgraded as needed.	Installation, Maintenance and Repair, Transportation and Material Moving	City/town manager, Building systems operator, Building automation system technician, Stormwater manager, Wind turbine technician, EV repair/maintenance, Bicycle mechanic
Nature-based. This includes natural scientists and manual workers caring for the city's existing environment or natural green infrastructure found on land and in water.	Building and Grounds Cleaning and Maintenance Occupations	Landscaper, Stormwater technician, Tree maintenance (trimmers, pruners), Arborist, Inventory Arborist, Urban Forester
Community engagement. This includes advocates who organize communities as well as public relations professionals who work with communities on behalf of utilities, developers, and government agencies involved in the greening process.	Community and Social Service Occupations	Energy advocate; community outreach specialist

Source: Authors' categorization based on PERI model estimates of percentage of direct jobs in each sector.

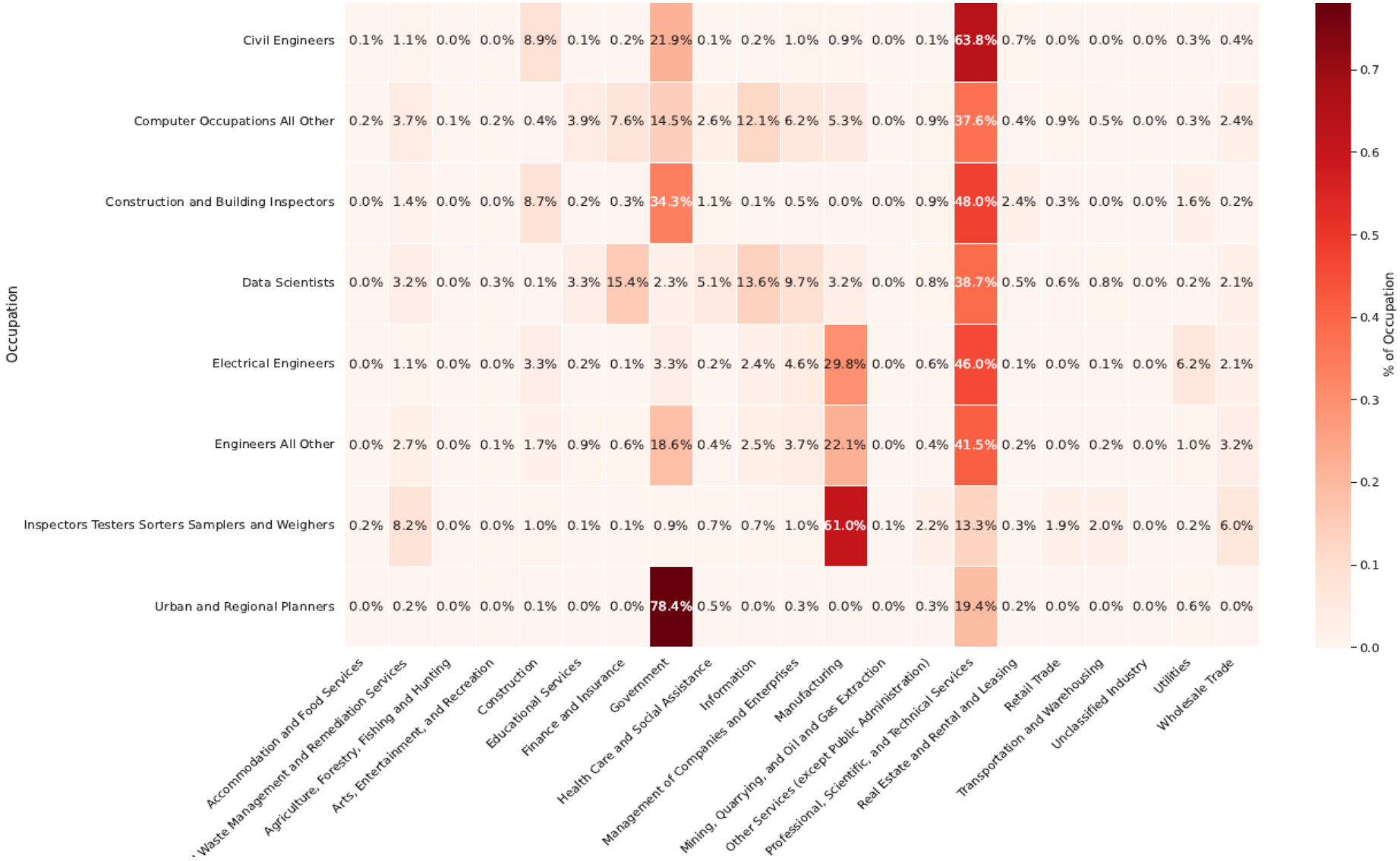
Figure A1. Greater Boston Occupation by Industry Staffing Patterns for the Trade-Related Sector, 2024



Source: Bureau of Labor Statistics' (BLS) Occupational Employment and Wage Statistics (OEWS).

Note: Greater Boston is defined as the combination of the Boston, Metro North, and Metro South/West WDAs.

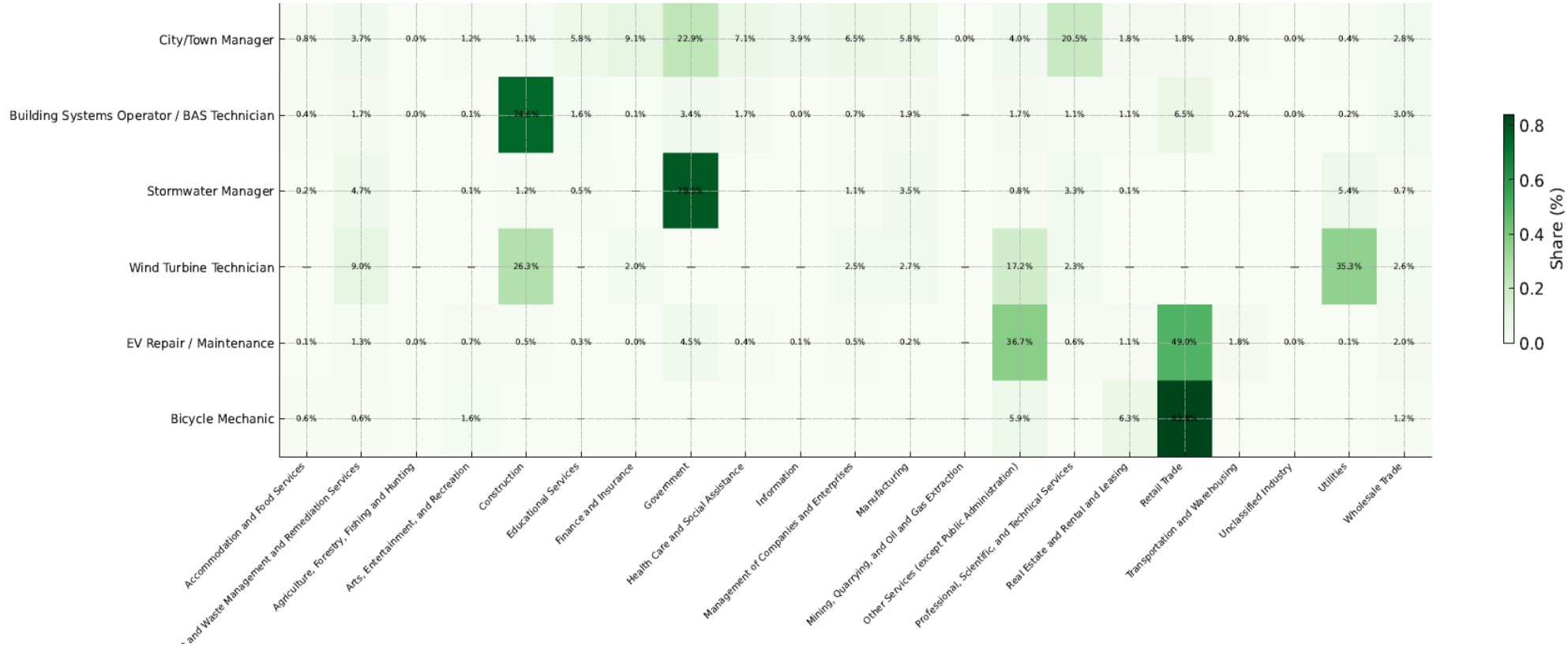
Figure A2. Greater Boston Occupation by Industry Staffing Patterns for the Design and Inspection Sector, 2024



Source: Bureau of Labor Statistics' (BLS) Occupational Employment and Wage Statistics (OEWS).

Note: Greater Boston is defined as the combination of the Boston, Metro North, and Metro South/West WDAs.

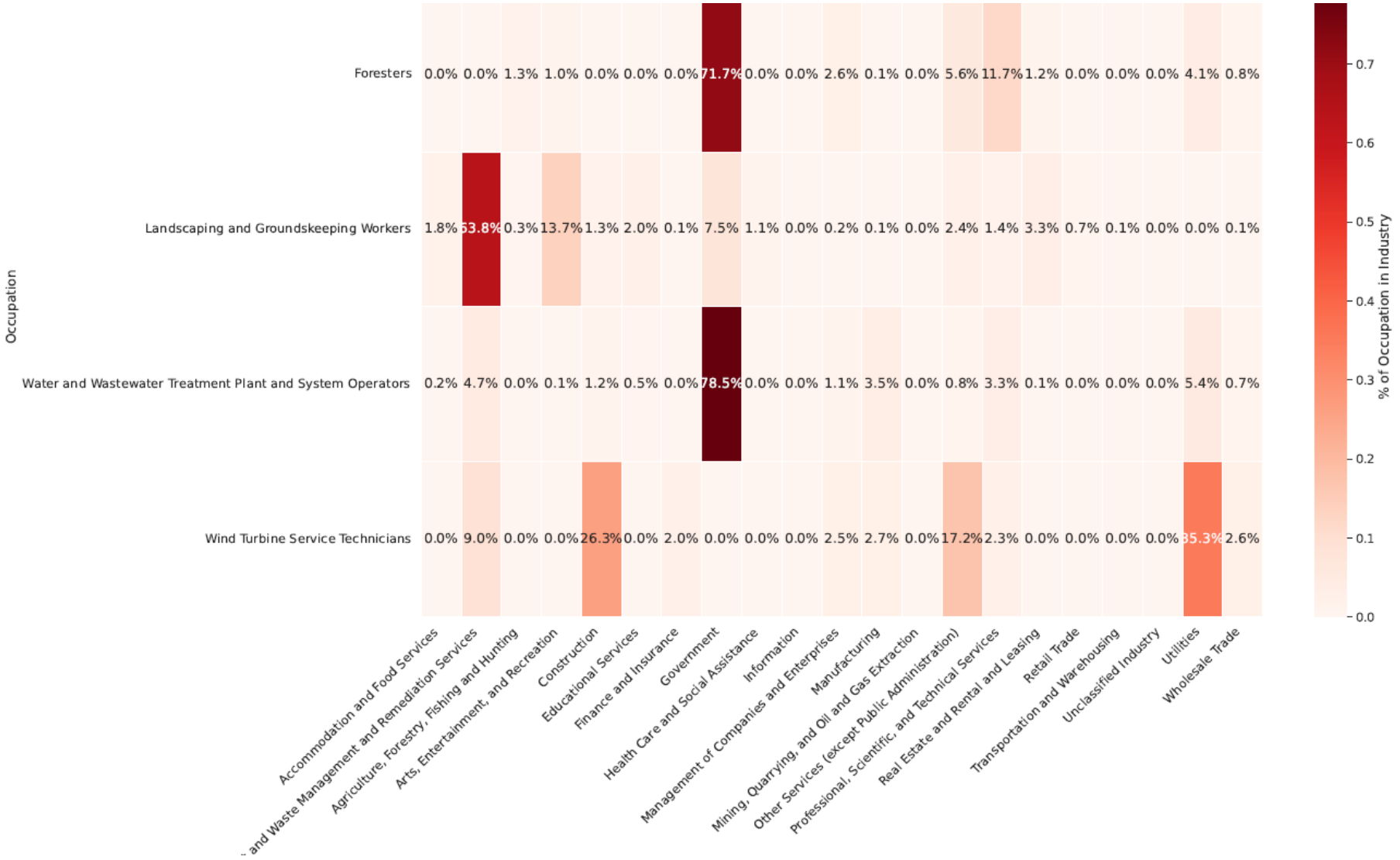
Figure A3. Greater Boston Occupation by Industry Staffing Patterns for the Green Operations Sector, 2024



Source: Bureau of Labor Statistics' (BLS) Occupational Employment and Wage Statistics (OEWS).

Note: Greater Boston is defined as the combination of the Boston, Metro North, and Metro South/West WDAs.

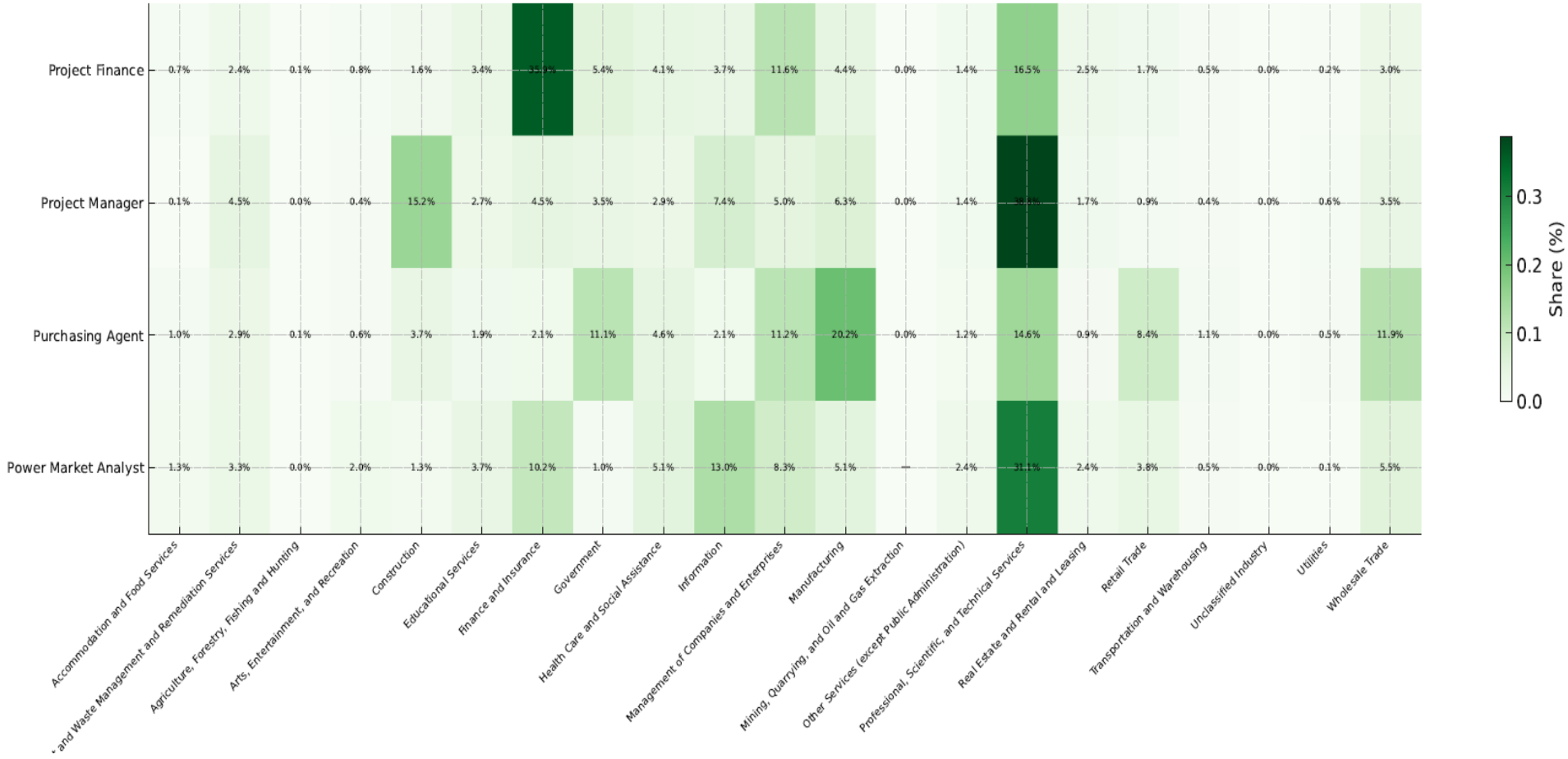
Figure A4. Greater Boston Occupation by Industry Staffing Patterns for the Coastal Resiliency and Nature-Based Sector, 2024



Source: Bureau of Labor Statistics' (BLS) Occupational Employment and Wage Statistics (OEWS).

Note: Greater Boston is defined as the combination of the Boston, Metro North, and Metro South/West WDAs.

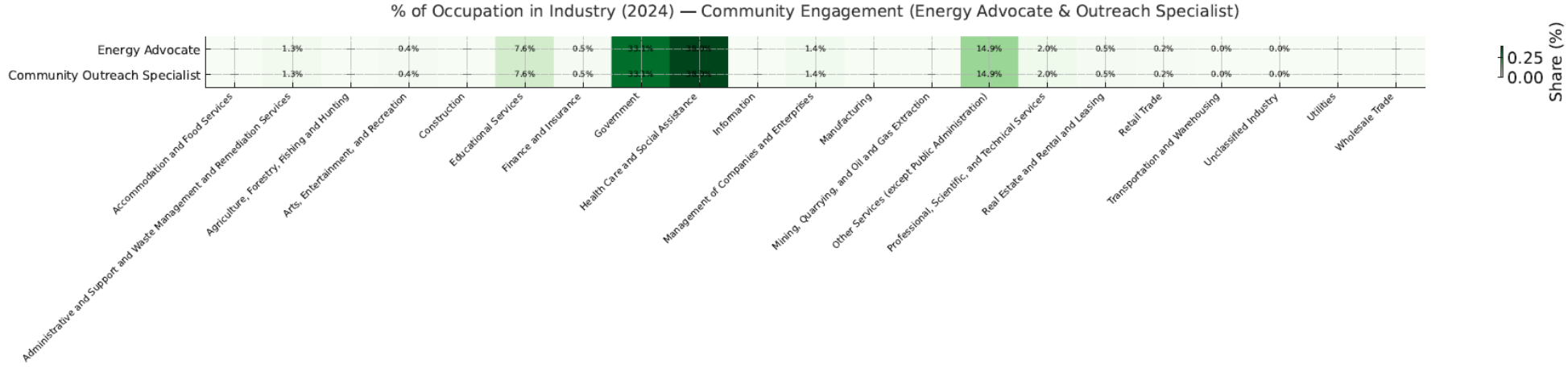
Figure A5. Greater Boston Occupation by Industry Staffing Patterns for the Project Implementation Sector, 2024



Source: Bureau of Labor Statistics' (BLS) Occupational Employment and Wage Statistics (OEWS).

Note: Greater Boston is defined as the combination of the Boston, Metro North, and Metro South/West WDA

Figure A6. Greater Boston Occupation by Industry Staffing Patterns for the Community Engagement Sector, 2024



Source: Bureau of Labor Statistics' (BLS) Occupational Employment and Wage Statistics (OEWS).

Note: Greater Boston is defined as the combination of the Boston, Metro North, and Metro South/Wes

2. Detailed Methodology for Skills Analysis

A. Labor Supply

(1). CURRENT AND PROJECTED NUMBER OF GREEN WORKERS

To measure the current and projected number of available green workers, we use the 2023 BLS employment data for our 45 green-related occupations as a baseline. We then use a cohort component model where we "age" the current workforce by one decade to estimate the number of workers that will need to be replaced due to retirements. Specifically, we calculate the share of workers aged 55+ years for each of our six economic sectors using national data disaggregated by age and occupation. We then apply those occupation-specific shares to the 2023 employment levels for each of our six occupational sectors for Greater Boston to estimate the number of retiring workers that will need to be replaced by 2033. Note that this is a somewhat conservative estimate since the average age of the workforce in Massachusetts is slightly higher than that of the U.S. However, this gives us some sense of the current levels and expected replacement needs over the next decade.

(2). CURRENT AND PROJECTED FLOW OF NEWLY TRAINED GREEN WORKERS

The existing landscape of green training assets in Boston includes a mix of formal educational programs at high school and community colleges, union apprenticeship programs, and short-term workforce development programs offered through nonprofit organizations, utility companies, and the City of Boston. For a more complete picture of green workforce training, we supplemented the completion data with qualitative data from other sources. Specifically, we interviewed career and technical education leaders as well as community college program administrators that also track their own certification and degree programs.

Formal educational programs

To estimate the number of workers trained for green occupations in formal educational programs, where possible we analyzed completions data by the Classification of Instructional Programs (CIP) codes that correspond with green fields of study. However, because IPEDS does not explicitly track "green" programs, this approach requires careful methodology and has notable limitations.

(1) Identify green-related CIP codes

The first step is to identify the relevant CIP codes. This requires mapping green occupations, as defined by sources like the **O*NET** list of "green occupations" corresponding to postsecondary instructional programs.

(2) Assess completion using data from secondary and post-secondary sources

Once the relevant CIP codes were identified, we estimated the number of students completing a green-related credential using data from career and technical high school programs collected by the Department of Elementary and Secondary Education (DESE) and data from community college programs collected by the Integrated Post-Secondary Education Data System (IPEDS). The IPEDS data can be disaggregated by award level (e.g., certificate versus associate's) to capture training across different educational tiers.

These estimates derived from formal educational program data have several important limitations. First, not all green occupations align perfectly with a single CIP code. Many green jobs, such as energy auditors, are performed by people with various educational backgrounds. Second, deciding which CIP codes to include is subjective. For example, a student with a degree in civil engineering may or may not go into a green-related job. Third, formal educational programs track degrees and completions, not actual employment. Graduates may not enter a "green" occupation, and many green workers are trained via other means.

Union apprenticeship programs

To estimate the number of workers flowing through joint apprenticeship programs each year, we used data obtained from the Massachusetts Division of Apprenticeship Standards (DAS). Many registered union apprenticeship programs that combine on-the-job and classroom training are found in the building trades. These are rigorous, paid, multi-year training sponsored jointly with a group of employers and directed by a Joint Apprenticeship and Training Committee (JATC), typically resulting in some type of formal certification and licensure.

We also supplemented this administrative data by conducting interviews with leaders from the Boston Building Trades Unions, an umbrella organization with comprehensive knowledge of building trades training in the area. The interviews helped identify pre-apprenticeship programs as well as a small number of training programs that are not registered apprenticeships but do prepare trainees to work green union jobs.

B. Skills Analysis

To identify jobs that are driven by the green economy we used several statistical techniques to identify linkages between job roles and industries or the job functions that will drive green implementation. First, we developed a set of skills that are core to roles that are squarely in the green economy and meeting net zero goals – for example these include skills like solar panel installation and maintenance, electric vehicle charging installation, urban forestry management, or wetland restoration. In total there are several hundred core “very green” skills (or ones that rarely, if ever, show up in roles without association to green applications or

meeting net zero goals), and several hundred "green" skills (or ones that are highly associated with green tasks and outputs – these include heat pump installation, weatherization, and energy auditing for example).

We then used specific job postings to understand the skill content of each job in roles associated with Boston CAP goals. To do this, we used natural language processing, a machine learning technique to transform written language into a usable database of skills and job requirements. Functionally, we parsed the skill demands in every electrician job posting across the labor market to identify what skills are requested by employers when they appear to be engaged in green work relative to non-green work. We then built skill profiles of "green" occupations using job ads that showed demand for green skills at 10 times the rate of other roles in the same occupations.

To develop curricula that prepare workers for in demand jobs under the Boston CAP, it is important to think about the critical or foundational skills to perform at a high level in the occupation in addition to the green skills. Often to perform well in a green focused job, a worker will need to be able to perform a series of tasks and have knowledge and skills that sit outside of traditional "green skills." For example, a green specialized electrician needs to know the basics of electrical systems and installations and safety to perform either green or non-green work. Using the same skill architectures for roles that help to implement the green economy, we perform two statistical techniques to identify the foundational skills and the differentiating skills for these roles.

We perform an analysis of revealed comparative advantage (RCA) of skills and a measure called total frequency inverse document frequency (TFIDF) – both are measures of how central skills are to a role. These measures are like a location quotient – they help to identify the importance of skills within a role relative to other skills for that role – and how important the skills are to the role relative to how important that skill is in other roles. These help us understand specialization. For example, nearly every job in the labor market demands "communication," an important skill to build across the labor market and to integrate into workforce training and educational programs and into work-based learning experiences, but it is not often a differentiating skill in the technical demands of a role. Our approaches identify the foundational skills as well as differentiating skills (skills that make a worker more productive or valuable). We use these methods to identify skill value, especially of green skills that provide distinctive value to roles.

3. Detailed Methodology for Analysis of Boston's Green Careers Education and Training Programs

A. Non-profit and school based Workforce and Career Awareness Programs

(1). INTERVIEW PROTOCOL

Our research questions were derived from the City of Boston RFP. We started by identifying research-based criteria for effective training and career awareness programs that focus on green occupations.

Table A7. Criteria for Effective Training and Career Awareness Programs

Experiential learning is an educational approach where students learn by engaging in direct experiences and reflecting on them. This method emphasizes hands-on activities, allowing learners to apply theoretical knowledge to real-world situations. The process typically involves a cycle of experiencing, reflecting, thinking, and acting, which helps deepen understanding and retention of the material. Examples of experiential learning include internships, laboratory experiments, fieldwork, and service-learning projects. By actively participating in these experiences, students develop critical thinking, problem-solving, and decision-making skills, making the learning process more dynamic and impactful.[1]
Paid training: One of the key reasons students from historically disadvantaged backgrounds drop out of community college and training programs is that they cannot afford to forgo income.[2] As Boston's GND seeks to create an inclusive green workforce, the earn-and-learn model becomes an important aspect in making sure that these trainings are accessible to low-income, unemployed, or underemployed populations who are unable to take time off work or have

[1] Sisson, G. 2001.

[2] *Expanding Equity in Manufacturing with On-the-Job Training*. 2022. National Fund for Workforce Solutions.; Goger, A. 2020. Desegregating work and learning through 'earn-and-learn' models. Brookings.

barriers to employment. In our study, paid training comes in the form of stipends and hourly wages.
Employer partnerships take on various forms, including coming in to give a talk, hosting trainees on site visits, involvement in training curriculum development, hiring trainees through internships, and employment commitments. Studies have shown that sector-based workforce programs with employer partnerships yield higher employment rates and starting wages.[3] These partnerships are a two-way street that allow training to align with employment needs, as well as removing employer bias towards certain groups or misconceptions around degree requirements as a proxy for skills on certain jobs.[4]
Employability skills: Typically described as 'soft skills,' these encompass a range of skills, competencies, behaviors, attitudes, and personal qualities that enable individuals to work well with others, maneuver various environments, and perform well in the workplace. Employability skills are equally important as 'hard skills' in helping people get hired and stay in jobs.[5] This includes communication skills, time management, reliability, teamwork, emotional intelligence, conflict management, digital literacy, creativity, and adaptability.[6] Our study also included elements of job readiness training (JRT), such as mock interviews and resume reviews, in this category. Training programs in our study provide students from historically disadvantaged groups and returning citizens additional support through mentorship, case managers, and counseling.
Stackable credentials: A certificate of knowledge is a credential awarded to individuals who have successfully completed a specific course or program of study, demonstrating their understanding and proficiency in a particular subject area. Certificates are typically issued by educational institutions or professional organizations and provide formal recognition of the individual's acquired knowledge and skills. For entry-level workers, having industry-recognized certifications, which often includes some work experience through training, serve as stackable credentials to secure employment with career advancement potential.
Comprehensive services (or 'wraparound services') help mitigate various barriers participants from disadvantaged communities may face, such as housing, transportation, food, clothing, need for emergency funds, and mental health.[7] These services also build necessary skills, like financial

[3] Amin et. al., 2020.; Spaulding, S and Martin-Caughey, A. 2015. The Goals and Dimensions of Employer Engagement in Workforce Development Programs.

[4] Goger, A. 2020. Desegregating work and learning through 'earn-and-learn' models. Brookings.

[5] Lippman et al. 2015. Key "Soft Skills" That Foster Youth Workforce Success: Toward A Consensus Across Fields.

[6] Poláková, M et.al. 2023. Soft skills and their importance in the labour market under the conditions of Industry 5.0

[7] Amin et. al., 2020; Spaulding and Martin-Caughey, 2015. *The Goals and Dimensions of Employer Engagement in Workforce Development Programs*. Washington, D.C.: The Urban Institute.; Alssid

literacy, for individuals to complete programs and achieve long-term success in the workplace. Some comprehensive services intersect with employability skills mentioned above (i.e., being paired with counselors or case managers). Many programs provide a combination of third-party referrals and in-house services, particularly for training run by social service organizations.

Using a list provided by the city, MassCEC, and the Barr Foundation, we identified programs serving Boston residents by filtering for programs located within I-95 and then asking programs if they served Boston residents. We then started a national scan of education and training programs focused on green occupations. Starting with the team's knowledge of programs as a starting point, two graduate research assistants used keywords to search programs in several cities nationally with strong climate action plans and policies and a historic commitment to addressing inequality. In total, we interviewed 24 training providers, representing 43 of the 44 Boston-serving training programs, and 7 training providers across the country.

In both sets of programs, we are asking the following questions:

- To what extent do they focus on or serve residents of disadvantaged communities?
- What is the experiential learning component?
- Do they pay participants? How much per hour for how many hours?
- What employability skills are offered?
- What comprehensive services are offered?
- What roles do employers play?
- What role do credentials such as certificates play in program completion?
- How is the program funded? How secure is the funding over time?
- What is an average cohort size? How many cohorts do you run in a year?
- What is the program's graduation and job placement rate?

To answer these questions, we begin by developing profiles based on the program's website, then search for other information about the program, such as news articles and grant announcements. We then conduct interviews with providers to answer the questions above and any additional questions. We send the completed profile to the providers to confirm that all information is accurate.

This analysis will allow us to address the following research questions:

- What is the success rate of these programs in graduating and placing students?
- What determines how many students are served? (e.g. funding, ability to find instructors)
- What barriers do providers face in delivering and expanding programs?
- Which type of certificates are valued by employers? Which are needed for advancement?

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et.al., 2002. *Building a Career Pathways System: Promising Practices in Community College-Centered Workforce Development.*

- Are there elements from leading practice programs throughout the country that need to be incorporated by Boston-serving providers?

Once the profiles are completed, we will circle back to the labor analysis by the Burning Glass Institute to assess program capacity against projected need. The research questions we will address at this point include:

- What is the capacity of the existing training programs to meet the current and projected demand for training in green occupations?
- Are any green occupations underrepresented (in terms of serving training)?
- Are there any gaps in green pathways (allowing advancement)?
- Are there any technical skills gaps across current certifications and credentials?
- Are there new policy initiatives, workforce development programs or funding sources needed to address deficiencies in the green jobs training ecosystem?

(2). EMPLOYER SURVEY AND INTERVIEW

To inform our analysis, we conducted an employer survey that was distributed through the team's professional networks. (see end of appendix for list). Despite extensive outreach through this network, the response rate was considerably lower than expected.

From August to December 2024, the team received 78 responses, the majority of which came from contractors, consultancies, and community-based organizations located in Boston and throughout Massachusetts. Over half of those who filled out the survey identified themselves as Executive Management, meaning either CEO, COO, CFO, ED, or Cabinet Head.

Table A8. Employer count by priority area

GND priority area	Employer count
Building Decarbonization	32
Clean Energy	6
Transportation Electrification	1
Resilience & Nature	2
All/Multiple	9
Total	50

From the 78 survey responses, 50 employ workers in Boston. Most of the employers represented the building sector, which was reflected in the higher hiring trends in the building sector as compared to the other sectors. Between October 2024 to January 2025, the team

conducted a total of 11 interviews, starting with 7 employers identified from the survey who shared challenges related to hiring generally and any experiences working with training programs. The interviews also covered a range of employers from small to large businesses.

The team later expanded the interviews to Mass Save home performance contractors, heat pump installers, and HVAC contractors. Additionally, we identified employers from the tree care industry, which were not represented in the survey results and had occupations that matched the analysis in Section 2.

Figure A7. Employers by sector that employ workers in Boston.

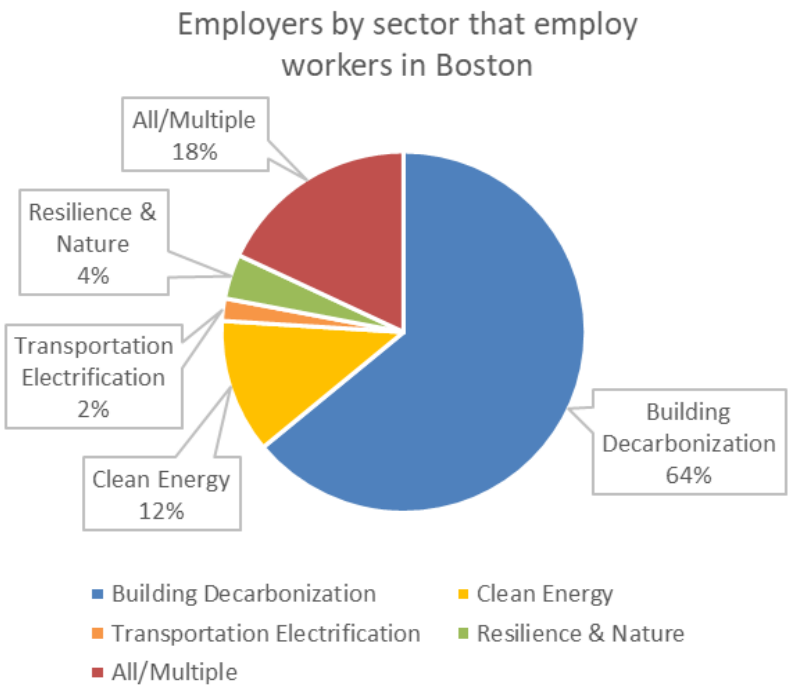
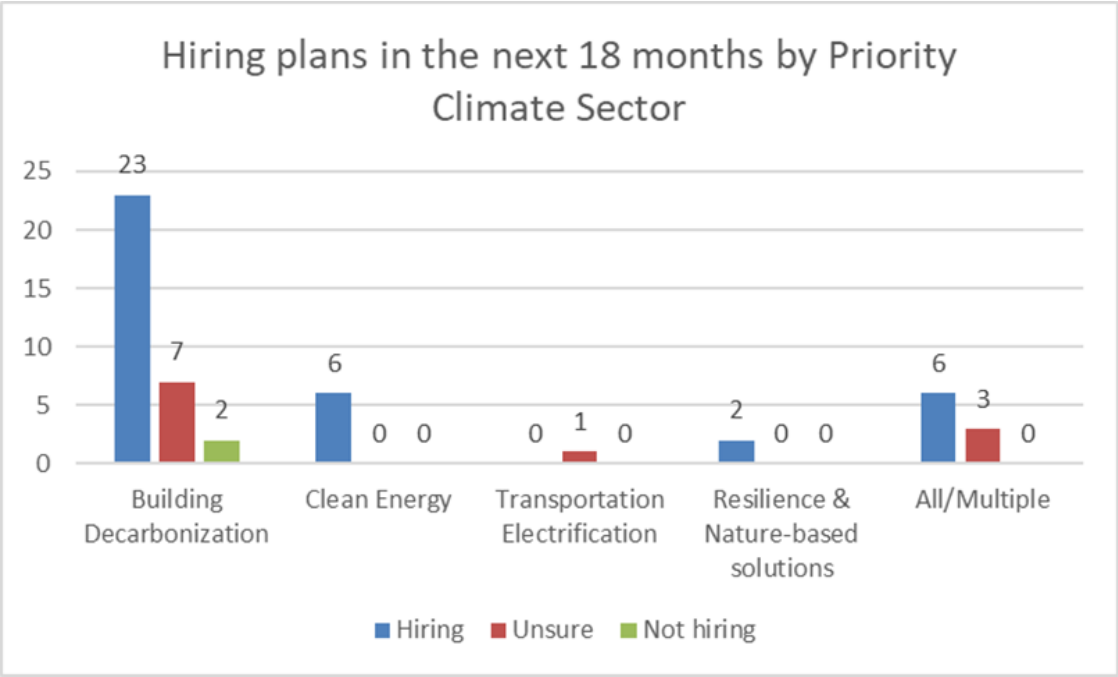


Figure A8. Employer's hiring plans in the next 18 months.



Through semi-structured interviews, the team asked questions around hiring practices, hiring challenges, career advancement opportunities for entry-level positions, and connections with training programs in the Boston area.

(3). Employer interview protocol

1. Has the Bipartisan Infrastructure Bill in 2021 and the Inflation Reduction Act in 2022 had any impact on your business? What are some other drivers for hiring right now?
2. How many workers do you currently employ for your operations (breakdown by each occupation like management, sales, technicians)?
3. How many workers per occupation do you plan on hiring in the next 18 months?
4. What is the average wage of an [insert entry level position]?
5. Is there much advancement potential in each of these entry level positions?
6. How long does it take for each advancement?
7. Where/how do workers receive training?
8. How do you attract these workers?
9. Have you connected with training programs? If so, what was your experience with them? To what degree were you involved in training?
10. As part of the diversity goals, could you please describe your outreach to underrepresented groups?

B. Union Apprenticeship Programs, Pre-Apprenticeship Programs, and Community Groups

Community Labor United interviewed union apprenticeship programs preparing Boston residents for green jobs. CLU also interviewed pre-apprenticeship programs preparing Bostonians for the union building trades and membership-based community groups serving Boston residents.

(1). APPRENTICESHIP INSTRUMENT

Program characteristics and job sites numbers

- How long has your program been in place?
- Can you describe the basic structure of your training program
- If not answered, probe:
- Length of program
- Do you place apprentices in jobs?
- Average starting wage rate first year apprentices
- Are apprentices enrolled in a full benefits package?
- What is the ratio of apprentices to journey level workers on most jobs?
- What is your allowable ratio of apprentices to journey level workers?

Application and Recruitment--Tell me about how you recruit participants and what the application process is like.

- Entry requirements for apprentices.
- Number of applications received most recent cycle
- Number of candidates accepted in most recent cycle
- Number of applications expected next cycle
- Percentage of admitted candidates enrolling?
    - If admitted candidates do not enroll, do you collect data on why?
    - If yes, what are the most common reasons?
- How do you recruit new applicants to your apprenticeship program?
- How do your applicants typically find out about a program?
- By when do you decide the size of each year's apprentice class?
- What would allow you to expand your class size?
    - How many of new enrollees are from Boston?
    - How many remain in Boston?

Retention and post-apprenticeship employment

- What kind of supports exist for apprentices if they are struggling?
- Do you see any special struggles faced by women or POC apprentices?
    - How do you track or address those?
- Are there any formal or informal mentoring programs or support groups? For women or POC or otherwise?
- Do you track retention by race or gender?
- What percentage remain in the program for the entire time?/What is your apprentice graduation rate?
    - Licensing exam rate?
- For apprentices who do not complete, do you collect data on why
    - If so, please share top reasons with us

Green jobs

The city of Boston is working with researchers to identify Green Jobs and projected job growth in the coming years. We want to make clear to the city that many of these jobs aren't new jobs, but rather jobs that union members already are trained for and work in.

Green jobs include:

- Jobs in businesses that produce goods or provide services that benefit the environment or conserve natural resources
- Jobs in which workers' duties involve making their establishment's production processes more environmentally friendly or use fewer natural resources.

With those definitions in mind:

- When there is talk of Green Jobs in your sector, what work is covered?
- Do you anticipate growth in the number of green jobs in your trade?
- Does your apprenticeship program currently prepare members to do green jobs?
- Do you see a need for your apprenticeship program to **change or adjust** to address a growth in green jobs?
    - If so, what do you need to change or adjust your training?
- Do you see a need for your apprenticeship program to **expand** to address a growth in green jobs?
    - If so, what do you need to expand your training?
- Have you needed to incorporate new training into your program to accommodate a shift toward a green economy?
- Anything else it would be good for us to know about your training program and your sector or work with relation to green jobs and the growing green economy?

The City of Boston wants to ensure their Green New Deal investments are creating opportunities for women and people of color who, historically and in present day, are underrepresented in the construction sector.

- How have you been making changes to your program to address the need to ensure equity?
- What additional changes could be made?
- Do you allow contractors to jump your out of work list for women or people of color or Boston residents?
- Do you have an expedited application process for graduates of pre-apprenticeship programs or CTE programs?

Barriers to growth

- What are the biggest barriers to accepting more apprentices?
- What are the biggest barriers to growing the number of people of color in your apprentice classes?
- What are the biggest barriers to growing the number of women in your apprentice classes?
- What resources and capacity would you need to scale up your program?
- How could the City of Boston support your apprenticeship program?

(2). PRE-APPRENTICESHIP INSTRUMENT

Program characteristics and job sites numbers

- How long has your program/org been in place?
- Can you describe the basic structure of your training program?
- If not answered, probe:
- Length of program
- Do you place participants in apprenticeships programs?
- Participants receive any stipend, pay, benefits
- Can you share demographic information on enrollment year by year
    - How many total?
    - What percentage are women?
    - What percentage are persons of color?
    - What percentage from Boston?

Application and Recruitment--Tell me about how you recruit participants and what the application process is like.

- Entry requirements
- Number of applications received most recent cycle
- Number of candidates accepted in most recent cycle
- Number of applications expected next cycle
- Percentage of admitted candidates enrolling?
    - If admitted candidates do not enroll, do you collect data on why?
    - If yes, what are the most common reasons?
- How do you recruit new applicants ?
- How do your applicants typically find out about a program?
- By when do you decide the size of each year's class?
- What would allow you to expand your class size?

Retention and post-apprenticeship employment

- What kind of supports exist for participants if they are struggling?
- Do you see any special struggles faced by women or POC apprentices?
    - How do you track or address those?
- Are there any formal or informal mentoring programs or support groups? For women or POC or otherwise?
- Do you track retention by race or gender?
- What percentage remain in the program for the entire time?/What is your graduation rate?
- For people who do not complete, do you collect data on why
    - If so, please share top reasons with us

- Do you follow graduates through their union apprenticeships? Any data on completion and job placement post-graduations

Green jobs

The city of Boston is working with researchers to identify Green Jobs and projected job growth in the coming years. We want to make clear to the city that many of these jobs aren't new jobs, but rather jobs that union members already are trained for and work in.

Green jobs include:

- Jobs in businesses that produce goods or provide services that benefit the environment or conserve natural resources
- Jobs in which workers' duties involve making their establishment's production processes more environmentally friendly or use fewer natural resources.

With those definitions in mind:

- Can you tell me how your program currently prepares members to do green jobs?
- Do you see a need for your apprenticeship program to **change or adjust** to address a growth in green jobs?
    - If so, what do you need to change or adjust your training?
- Do you see a need for your program to **expand** to address a growth in green jobs?
    - If so, what do you need to expand your training?
- Have you needed to incorporate new training into your program to accommodate a shift toward a green economy?
- Anything else it would be good for us to know about your training program and your sector or work with relation to green jobs and the growing green economy?

The City of Boston wants to ensure their Green New Deal investments are creating opportunities for women and people of color who, historically and in present day, are underrepresented in the construction sector.

- How have you been making changes to your program to address the need to ensure equity?
- What additional changes could be made?

Barriers to growth

- What are the biggest barriers to accepting more people into your program?
- What are the biggest barriers to growing the number of people of color in your apprentice classes?
- What are the biggest barriers to growing the number of women in your apprentice classes?
- What resources and capacity would you need to scale up your program?

- How could the City of Boston support your program?

(3). COMMUNITY SURVEY

Membership characteristics

- Can you describe your membership (neighborhood, race/ethnic identity, gender, age, other…)
- Prompt on Boston residence, race/ethnicity
- How many members do you have?
- How do you define membership in your organization? How does one become a member?

Employment and job searching

- What kinds of jobs do your members have? Do some of your members belong to unions? Which ones?
- When your members are looking for jobs: What resources or methods do they use to find training or jobs?

Assistance in finding training or employment

- Do you help connect members to training or employment?
- Do you connect members to any apprenticeship or pre-apprenticeship programs? Which ones?
- What other kinds of training do you connect members to?
- What kinds of employment opportunities/jobs do you connect them to?

Knowledge of union programs/careers

- Do you have relationships or knowledge of union apprenticeship or pre-apprenticeship programs?
- Do you see these as a good option for your members? Why or why not?

Barriers to union programs/careers

- To your knowledge, have your members experienced barriers to participating in union apprenticeship programs? Explain.

Can prompt:

- Don't have or feel they don't have enough skills to enter the program
- Don't know about union apprenticeship or pre-apprenticeship programs
- Tried to join apprenticeship program but not accepted
- Racism or sexism//perception that union is not for people like me

- Negative opinion of unions otherwise
- Physical limitations
- Language
- Transportation
- Childcare
- CORI concerns
- Drug testing concerns
- No HS degree/GED
- No legal status to work in US

Removing Barriers

- What would be helpful for your members to gain access to union training programs and union employment?
- How could the City of Boston help?