Research Report

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Economic Opportunities in Sustainability for Southwestern Pennsylvania

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About This Report

This report describes the findings from a qualitative and quantitative assessment of the economic development potential of evolving and emerging sustainable sectors in the seven-county Pittsburgh region. This assessment focuses on the demand for and supply of "green" workers, as well as associated training pipelines and unique regional opportunities and barriers. A separate report, *Economic Opportunities in Sustainability for Southwestern Pennsylvania: Key Findings and Recommendations*, summarizes strengths, opportunities, and challenges for the most promising sustainable sectors in the region and is available at www.rand.org/t/rra2563-2. The report highlights potential areas of focus for regional philanthropic organizations, including the study funders. More broadly, the findings and recommendations are intended for local education and training institutions, workforce centers, employers, economic development organizations, policymakers, investors, and residents of the Pittsburgh region.

RAND Education and Labor

This study was undertaken by RAND Education and Labor, a division of the RAND Corporation that conducts research on early childhood through postsecondary education programs, workforce development, and programs and policies affecting workers, entrepreneurship, and financial literacy and decisionmaking.

More information about RAND can be found at www.rand.org. Questions about this report should be directed to acurtrig@rand.org, and questions about RAND Education and Labor should be directed to educationandlabor@rand.org.

Community Health and Environmental Policy Program

RAND Social and Economic Well-Being is a division of the RAND Corporation that seeks to actively improve the health and social and economic well-being of populations and communities throughout the world. This research was conducted in the Community Health and Environmental Policy Program within RAND Social and Economic Well-Being. The program focuses on such topics as infrastructure, science and technology, industrial policy, community design, community health promotion, migration and population dynamics, transportation, energy, and climate and the environment, as well as other policy concerns that are influenced by the natural and built environment, technology, and community organizations and institutions that affect well-being. For more information, email chep@rand.org.

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Summary

The history of Pittsburgh, Pennsylvania is one of economic transformation and success. In the 1990s, the city successfully emerged from under the rust of a declining steel industry to become a national hub for health care, education, and technology. Despite this economic recovery success story—or, perhaps, considering it—it is prudent to periodically ask: *Where should the Pittsburgh economy be headed next*? Doing so can help ensure that the region stays economically current by taking advantage of new opportunities—including the substantial federal investments that have come online under the current administration—in ways that can future-proof the economy and secure the equitable distribution of benefits and risks.

One potential opportunity to leverage existing regional assets is to expand a "green economy." An economy of green sectors—those which produce goods or services in ways that are more environmentally sustainable than traditional ones—can offer solid career pathways for those who do not hold college degrees as well as for those who do. In addition, a green economy can help further diversify the regional economy around sectors of growing global importance.

Recognizing the opportunities presented by national and international trends toward a green economy, the Richard King Mellon Foundation (RKMF) wanted to better understand the needs and opportunities for these emerging sectors in the Pittsburgh region. RKMF asked RAND Corporation researchers to perform sector and occupational analyses to better understand the needs and opportunities for the workforce in the emerging "green economy" in the Pittsburgh area. RAND assessed the potential *demand* signal for sustainable goods and services to be produced and deployed in the region as well as the associated regional *supply* needs for workers and training and education. We identify promising practices and emerging needs in sustainable goods and services to enable the success of a robust, equitable, and local "green economy" which leverages regional assets and offers opportunities across geographic and socio-economic boundaries.

How the Study Was Conducted

The research team set out to understand the potential future **demand** and **supply** for a green workforce in the Pittsburgh metropolitan region. We want to answer: what future green opportunities is Pittsburgh well-positioned to expand and create (demand), and will there be enough skilled workers to make these opportunities a successful reality (supply)? To do this, the team used a mix of qualitative and quantitative methods.

*What will **workforce demand** look like in the emerging Pittsburgh green economy*? To answer this, the team conducted a literature review and semi-structured interviews with regional stakeholders to identify green sectors of relevance to the Pittsburgh region as well as concerns

related to workforce supply. Stakeholders included representatives from Pittsburgh area economic development organizations, businesses, higher education and workforce training institutions, utility companies, and sustainable nonprofit groups, providing a diverse set of perspectives on what evolving and emerging green opportunities were expected to be the "demand signal" in the Pittsburgh region.

*Will the Pittsburgh region be able to **supply the workforce** necessary for the green economy?* Once regionally relevant green sectors were identified, the team assessed the supply of workers available to do associated jobs. First, the team determined *what kinds* of occupations would be important to build up the identified green sectors, classifying the workforce in these occupations as (potential) "green" workers. They also determined "close substitutes" for these occupations based on shared occupational characteristics. Second, the team assessed the number and type of "green" workers within the seven-county Pittsburgh region, which constitutes the near-term workforce supply green sectors. Third, they examined the "close occupations" to understand the medium-term labor supply that could be ready to work in green sectors with minimal training and education within about 2 years. Finally, the team assessed the potential to build a long-term (~5–10 year) labor supply by examining the region's available training resources, including both institutions and specific training programs.

Key Findings

Following are the main findings drawn from the RAND research team's analysis of Pittsburgh's possible future green economy, the workforce necessary to start up and maintain that economy, and if and how the Pittsburgh region can supply and sustain the necessary workforce.

The region has both unique and general opportunities to develop a green economy. Expert literature as well as stakeholder interviews suggest that the Pittsburgh region will have many of the same opportunities as other regions of the country, such the deployment of sustainable consumer goods and services. Other opportunities will be more uniquely suited to take advantage of regional attributes such as characteristics of the existing workforce, existing or expanded training opportunities, and distinct regional assets and natural resources.

Stakeholders agreed that interest in sustainability continues to grow. Stakeholders overwhelmingly agreed that, in the last decade or so, general attitudes around sustainability have shifted significantly, with a growing appreciation for the need for cross-sector "greening," especially in mitigating and adapting to climate change.

Stakeholders agreed on five sectors as especially promising for "greening" in Pittsburgh. Drawing on the region's relative strengths, stakeholders generally agreed on several sectors to build up or on when growing a green economy. They also noted barriers and risks associated with each. The five are a subset of the broader range of potentially economically important sectors for the region but rose to the top as offering a combination of broad

stakeholder acceptance and being most likely to benefit from modest near-term support, such as financial investments from philanthropic or venture capital or local policy changes.

- **Sustainable agriculture**. Respondents discussed opportunities in sustainable food production and more equitable food distribution. Others noted the value of using land to develop sustainable "mass timber" or to serve as a "carbon sink" that could be monetized in future carbon markets. Despite the range of potential opportunities, there may be limited economic potential for this sector relative to some others, and stakeholders expressed concern about extractive industries and suburban sprawl jeopardizing the success of agriculture and related sectors, such as outdoor recreation.
- **Circular economies.** A circular economy reuses materials to reduce waste and, ultimately, extract fewer resources from the earth**.** Many stakeholders felt this is especially well-suited for the Pittsburgh region, where people are traditionally practical and "thrifty." The workforce needs would likely range from labor-intensive entry-level positions to research and development jobs and could be distributed in both urban and rural locations, providing opportunities across geographies and educational levels. The deconstruction and reuse of building materials was noted as especially promising. Success of these sectors would likely require that clearer connections be made between less waste and practical benefits (such as saving money) and stronger regulatory or market signals would be needed for circularity to go beyond niche markets.
- **Green buildings.** Many stakeholders talked about the region's history and successes to date, and the national and international reputation for leadership and innovation in this area. Interviewees in and outside of the building sector made note of Green Building Alliance (GBA) as being particularly forward-thinking and generous in sharing best practices. Stakeholders discussed how the green building sector can be broadened in the area to include residences. Overall, expansion in this area was viewed positively as it likely would have good synergy with the region's historical strength in manufacturing and would involve many different workers, from those seeking to learn new skills on the job to those who would be charged with designing new buildings. Some stakeholders also noted that this was a chance to improve the lives of many people as how homes are built impacts health and wellness.
- **Outdoor recreation.** The stakeholders who called out this sector as one for potential growth did so enthusiastically as it can offer both direct and indirect workforce and economic development benefits. This sector requires a broad workforce that can perform many different services and could be a boon especially to smaller towns as recreation-related improvements can be made with a relatively small investment. Some interviewees discussed how a robust outdoor sector is essential to attracting and retaining younger workers and the growing number of remote workers. Risks were also noted, however. Some outdoor activities such as skiing were identified as inequitable as initial investments such as equipment and lessons can be expensive. Other concerns included the relatively low salaries of those working in the sector and potential impacts to the cost of living.
- **Water management.** The importance and challenges of this plentiful regional resource was noted by many stakeholders. Some observed how the two rivers offer an opportunity to leverage water-related assets more fully and sustainably, especially as other parts of the

nation become drier. Many talked about the difficulty of addressing legacy water impairment, stormwater management, and other costly issues. These difficulties could be an opportunity for innovation, however, as regional universities and firms offered engineering and other necessary expertise. Risks to growing in this area include getting access to state and federal funding and lack of collaboration across municipalities. The disconnected management of water resources and the concentration of expertise in the private sector, rather than with government agencies, were also mentioned.

- Stakeholders suggested cross-sector areas that Pittsburgh can leverage:
    - **Energy efficiency** and **conservation** as a foundational concept with cultural resonance.
    - Pittsburgh's reputation, culture, and capacity for **innovation**, including in the areas of **autonomy** and **robotics**.

Additionally, stakeholders noted that **clean energy** and **advanced manufacturing** both have historical and cultural significance in the region and potential for growth. For example, the clean energy labor market was recently estimated to employ more than 94,600 Pennsylvanians, with 5.1 percent annual growth, or 4,613 new jobs.[1] This growth represented a rebound after the pandemic, the first year of which the clean energy sector lost about 7,200 jobs (BW Research Partnership, 2022a). However, stakeholders disagreed about the specifics of the role for these sectors going forward, as discussed further below.

Stakeholders recognized potential challenges to green sector growth. These challenges included:

- **Branding and messaging:** Not all companies, workers, and investors in the region will be attracted to or even comfortable with the idea of "green" jobs. Rural and urban residents may not relate to lofty and often abstract "green" goals, and some populations may see such as a threat to their way of life.
- **Job opportunities:** Sectors and stakeholders will need to improve overall awareness of opportunities in sustainable sectors. Multiple interviewees expressed the value of educating students about green trades at an early age because high school or college is too often too late for them to change their trajectory.
- **Communication, coordination, and collaboration**: Stakeholders noted that there are perennial problems associated with Pennsylvania's municipalities. Working in silos, fragmented efforts, and "talking past" each other hinders growth in multiple areas. Some stakeholders talked about disconnections specific to "green" sectors, such as a "misalignment" of academic institutions with nonprofits and businesses.

[1] This report includes data on the trends from Q4 2020 to Q4 2021. The "clean energy sector" includes energy efficiency; clean energy generation; alternative transportation; clean grid and storage; and clean fuels.

- **Demographic trends:** Many stakeholders noted the expected insufficient numbers of existing and future workers to fill the new jobs in the growing green sectors. Again, there was emphasis on the need to work towards culturally sensitive communication.

Some stakeholders disagreed about the regional appropriateness or desirability of certain green sectors. Interviewees recognized current-day strengths of Pittsburgh's energy sector, and there was virtually unanimous agreement that "clean energy" can and should be important to Pittsburgh's economic future. However, there were mixed opinions about some clean energy options and no agreement on a clear "best" subsector for focus for the region. For example, "blue" hydrogen – that is, the production of hydrogen from natural gas, coupled with carbon capture and storage – had both strong proponents and detractors. There was also some disagreement around what the future of the manufacturing and industrial sectors sector can and should look like in the region.

Policy will need to change but there is no agreement yet as to how. Most interviewees agreed new or modified policy will be needed to seize new green opportunities. However, there was no agreement if polices should be regulatory, e.g., carbon reduction requirements, or incentivizing, e.g., renewable energy tax credits, with private sector stakeholders generally advocating for "carrots" rather than "sticks."

One year out: the region has a near-term workforce advantage for some "green" occupations. In total, the team identified 162 occupations as "green" by virtue of being among the set of occupations needed for one or more of the sustainable sectors deemed as appropriate to the region. Workers in these occupations might be able "step into" jobs in a burgeoning green economy.[2] Relative to other parts of the country, Pittsburgh is strong in its number of workers ready to work in the circular economy, the energy sector, green building, and manufacturing in the next two years.

Pittsburgh's current green workforce falls short on demographic diversity. Overall, about one-in-three workers ages 25 and up in the Pittsburgh region is in an occupation that will be needed to support or expand one or more of the seven sustainable sectors. The share of workers in these occupations is slightly higher in counties in the Pittsburgh region outside Allegheny County (35 percent) than in Allegheny County itself (31 percent). Workers in these occupations are overwhelmingly white, non-Hispanic (89 percent, higher even than the region's majority-white labor force overall), and a much smaller proportion is female than in the labor force overall (26 percent versus 47 percent).

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[2] We note that not everyone in these occupations could be considered working in the green or sustainable economy at present. In fact, in many cases, the jobs might not strike a casual observer as being especially "green" at all. Rather, these are occupations expected to be needed to support the green economy and its expansion.

Two-to-five years out: the region can grow its green workforce by upskilling or reskilling workers in jobs that are "green close." Looking a few years ahead, it will not be sufficient for workers working in non-green companies or roles to simply "swap" their jobs for similar jobs more clearly focused on sustainability. Rather, workers in other occupations would need to be retrained for the occupations needed for the green economy, or if younger, pursue education and training aligned with those occupations. Green-adjacent jobs include title examiners, compensation and benefits specialists, heavy equipment mechanics, and operations research analysts. There are limitations to relying on drawing from this latent labor supply, however. "Green close" jobs might offer comparatively higher wages or require higher levels of educational attainment than the newer green jobs, for example, or "might not be a common set of attributes on which the "green close" jobs differ from the green jobs around which to base a targeted training program.

Five-to-ten years out: the region can grow its long-term green workforce through the local education and training pipeline. Workers with all levels of education and training are needed to help expand Pittsburgh's green economy. Table S.1 shows that more than half of existing jobs in green occupations needed typically do not require education past high school for entry. For most such positions, workers can usually become competent with less than a year of on-the-job training. In addition, the region's sixteen high school career and technical education centers offer programs that enable high school students to earn industry-recognized entry-level credentials in construction, manufacturing, and other skilled occupations.

Table S.1. Typical Education Needed for Entry to Green Occupations

Typical education needed for entry	Percentage of all green occupations	Percentage of current green jobs, Pittsburgh region
Advanced degree	3	<1
Bachelor degree	39	29
Associate degree	9	2
Postsecondary nondegree award	3	7
Some college, no degree	1	4
High school diploma or equivalent	36	33
No formal educational credential	9	25
Total	100	100

SOURCES: BLS, Occupational Employment and Wage Statistics, 2021; BLS, Occupational Employment Projections Data, 2021-2031.
NOTE: The percentage of all green occupations calculated as a share of the full set of 162 green occupations with data available in the 2021 OEWS; data for 24 of these occupations are not available for the Pittsburgh MSA due to data suppression likely indicating small numbers of workers in the occupations.

However, Table S.1 also shows that building up a Pittsburgh green economy *to last* will also require workers with more developed technical knowledge and problem-solving skills that are best acquired through short- and long-term certificate programs (i.e., postsecondary nondegree awards) as well as associate, bachelor's, and advanced degree programs.

Postsecondary education. The analysis shows that there are 31 providers among Pittsburgh-area higher education institutions that offer preparation for green occupations. The most common credential is the sub-baccalaureate certificate (25 providers) across the region. These can lead to jobs in the circular economy, energy, green buildings, and manufacturing sectors. Associate degree programs are fewer in number but display a similar pattern. A little more than half (17 of 31) of providers with programs that prepare workers for green jobs offer bachelor's degrees in those program areas while a little less than half (13 of 31) offer either master's or doctoral programs in areas that may lead down a path to a green job. These bachelor's and higher degree offerings are more evenly distributed across green sectors. Coupled with our findings from the stakeholder interviews, this indicates that there are no significant gaps in training for the most promising sectors in the region.

Apprenticeships. Analysis identified 226 active apprenticeships in green occupations in the Pittsburgh region. These are split roughly in half between those in Allegheny County and one of the six surrounding counties. Most programs focus on occupations in the circular economy, energy, green buildings, and manufacturing sectors. There are few to no programs in the agriculture, water management, and outdoor recreation sectors. In total, there are nearly 4,000 active apprentices in these green apprenticeship programs (as of the fourth quarter of 2022).

Other training providers. This part of the analysis identified eight additional providers offering 35 individual programs aligned with green occupation. The most common green occupations for which these short-term training programs are truck drivers, welders, HVAC technicians, and electricians.

Recommendations

The study found that the Pittsburgh region has many strengths upon which to build a green economy in evolving and emerging sectors. With any opportunity, however, there come challenges. Below are recommendations drawn from the above analyses for this project. Interested stakeholders will include training and education providers; research entities such as universities and the National Energy Technology Laboratory; city, county, and state government; non-profits; philanthropy; small businesses; national and international corporations; and venture capital investors.

1. **Focus on regionally distinct opportunities with broad stakeholder support and that can most benefit from modest or incremental investments**. There may be value in leaning into opportunities that have a broad base of stakeholder support and that take advantage of unique attributes of the region. Circular economy and outdoor recreation, for example, present opportunities for rural and urban populations alike, and will require a workforce that spans a range of educational attainment levels. Both sectors have strong

regional training and educational opportunities and could benefit from relatively modest investments from philanthropic communities.

2. **Develop and support better and more investment mechanisms to seed and grow new industries.** Interviewees expressed concern that the region does not have sufficient financial support for emerging sustainable industries, such as relatively limited startup seed funding. Incubators and accelerators with more of a focus on existing and emerging green sectors are two options regional leaders should consider. Such programs provide funding and expertise to help startups launch successfully, with incubators generally focused on innovation and foundational activities and accelerators focused on scaling businesses at a later stage. Development of these options could support new or emerging industries in targeted sectors and help keep recent university graduates in the area.

3. **Develop and build support for policies that create appropriate regulatory and/or market signals—including at the local level.** Stakeholders had no consensus on what policies would be appropriate or most effective in the region but agreed that new policies are needed. More concerted efforts at the state-level are needed but there are opportunities to better align incentives at the regional and local level too. To lay the groundwork for truly circular sectors, for example, local government could work to improve education and standardization of related practices such as curbside recycling, focus initial attention on incentivizing specific subsectors and outreach to associated stakeholders, such as large building owners if focused on the building sector broadly, and increase coordination across municipalities to achieve economies of scale. Such growth could foster the creation of more robust related policies as well as signal the importance of the growing circular economy sector in Pittsburgh.

4. **Be proactive with outreach and education on the opportunities of evolving and emerging sustainable sectors and ensure that messaging is appropriate for your audiences.** Many interviewees noted the not-always-positive cultural connotations of "green" branding. There may be social, cultural, and ideological barriers for full participation of the labor force associated with these opportunities: historically marginalized POC in urban areas may not feel welcome due to historic underrepresentation in some of the underlying trades; rural workers may see "green" as an urban elite trend that threatens their culture and way of life; and women may worry that traditional male-dominated fields will remain so even as sectors become increasingly "green." It may be useful, for example, to emphasize practicality and economic benefits or make connections with positive associations (e.g., local sports teams who support sustainability initiatives). Communication that is crafted for specific populations may help bridge gaps and bring more talent into a growing green economy.

5. **Support existing and emerging workforce by bridging gaps in training and education, not by creating new programs.** The knowledge and skills that will be sought from the workforce to support sustainable industries have substantial overlap with those sought by other industries, ranging from general "soft" skills like adaptability and communication to basic digital to more advanced learning in data analytics, automation, and cybersecurity.

6. **Do not miss opportunities to increase diversity, equity, and inclusion. Fostering a green economy in the area is likely a positive once-in-a-generation economic opportunity.** In addition, it is also a way to increase diversity, equity, and inclusion in new and positive ways. However, this can only be realized if stakeholders are, in the words of one green nonprofit interviewee, "intentional" about making sure the benefits are distributed equitably. Thoughtful, culturally relevant outreach, as noted above, will be important. With thoughtful planning and policies, citizens from all demographic groups in the region have a chance to gain from new and lucrative career opportunities.

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Chapter 1. Introduction

The rise and fall of Pittsburgh, Pennsylvania's iron- and steel-based economy in the 19th and 20th centuries is a well-known history and an important part of the region's cultural identity (Spiegel, 2022). Following rapid declines in the 1980s, manufacturing employment in the Pittsburgh has continued to drop and now hovers around the national average (Venkatu, 2018) (King and Crommelin, 2021; Cilento, 2023) but factors such as state and local industrial policies and public-private-nonprofit partnerships have contributed to the transformation of Pittsburgh's economy around "eds and meds" and "high tech" sectors such as robotics and autonomous vehicles (Armstrong, 2021a; Armstrong, 2021b; Berglund, 2021; Blumgart, 2022). Despite this economic recovery success story—or, perhaps, considering it—it seems prudent to periodically ask: Where should the Pittsburgh economy be headed next? What can be done to support the workforce through expected changes and to ensure a more equitable distribution of benefits and risks as new opportunities arise?

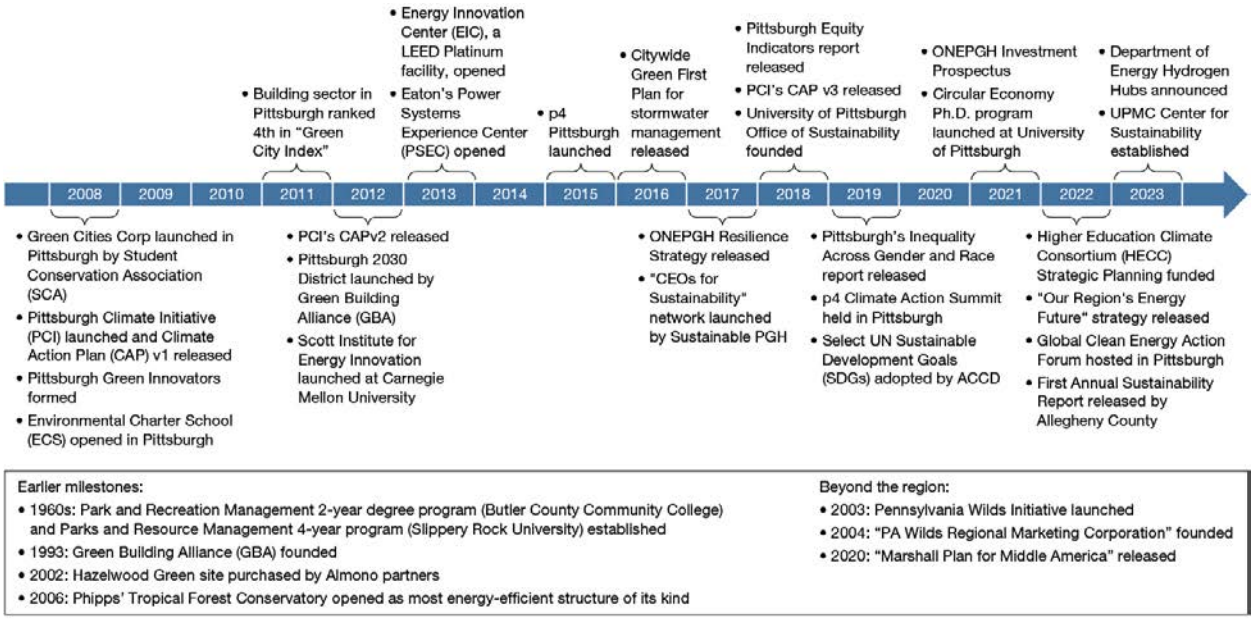
Sectoral diversification can contribute to overall economic resilience. And while education and health services have been quite successful and have become the dominant sectors for employment and economic activity in the seven-county Pittsburgh metropolitan statistical area (MSA) (U.S. Bureau of Labor Statistics, 2022b), other sectors such as the utility industry tend to generate more economic spillover benefits and may offer higher-paying opportunities for a broader range of residents in the region. One potential opportunity to leverage existing regional assets—such as "Pittsburgh's strong pathways for sub-baccalaureate jobs"—is to expand a "green economy" (Zaber et al., 2023). As noted in previous RAND research by Zaber and colleagues, growing these sectors can support diversification of the regional economy around goods and services of growing global importance and with strong potential for regional economic spillover. But what are the *"right" green opportunities* for southwestern Pennsylvania, and what challenges need to be overcome for their success? Is the regional workforce prepared to support the "greening" of traditional sectors and emergent green industries? Put another way: What future green opportunities is Pittsburgh well-positioned to expand or create (i.e., economic development and associated workforce **demand**), and will there be enough skilled workers to make these opportunities a successful reality (i.e., workforce **supply**)?

Economic Directions in Sustainability for Pittsburgh

Pittsburgh has been raised up as a model for rustbelt economic rebirth—made possible by purposeful restructuring and placing bets on relatively downturn-resilient sectors like education and healthcare (Streitfeld, 2009). But, as has been noted, "Pittsburgh must leverage … national attention into a long-term competitive position" (Andes et al., 2017). Over the last decade, many

analyses and reports have provided relevant insight into how to build on recent success. Unique regional assets have been identified, such as a diverse mix of existing industries, world-class higher educational institutions, existing innovation clusters and other technical strengths, a robust philanthropic sector, and a culture of collaboration. The energy sector, for example, has been called out as a long-term regional strength with the potential to drive economic growth into the future (Allegheny Conference on Community Development, 2022). However, significant challenges have also been noted, including prevailing demographics that create worker shortfalls and insufficient translation of research strengths into advanced industries (Allegheny Conference on Community Development, 2017; Andes et al., 2017).

Figure 1.1. Milestones in Sustainability for Southwestern Pennsylvania



Sources: Modified from figure by Higher Education Climate Consortium (Higher Education Climate Consortium, undated) with additional content from other sources (Carnegie Mellon University, 2012; Center for Sustainable Business, 2020; Allegheny Conference on Community Development, 2022; Innovators, 2023; Eaton, 2023; PGH20, 2023; U.S. Department of Energy, 2023b; Allegheny County, 2024; PA Wilds Center, 2024).

There have been significant initiatives and actions for the City of Pittsburgh and broader region related to sustainability over the last several decades, some of which are noted in Figure 1.1. Pittsburgh made an early entry into the "green building" sector in 1993 with the founding of the Green Building Alliance (GBA), the country's "first nonprofit organization…to focus exclusively on the greening of a region's commercial building sector" (Green Building Alliance, undated-a). In 2011, Pittsburgh was ranked in the U.S. and Canada Green City Index alongside other cities, and across nine distinct sector categories placed fourth (of 26) in the building sector but at or below fourteenth place in all other categories (Economist Impact, 2011). Today, Pittsburgh has the largest "2030 District" in North America, boasting 86.6 M square feet of

commercial real estate committed to energy reduction goals, and representing $267 M in energy savings and 2M metric tons of avoided CO_2 emissions as of 2021 (Green Building Alliance, undated-b). These successes illustrate the importance and potential of early and sustained focus on a sector.

Recognizing the opportunities presented by national and international trends toward a "green economy", the Richard King Mellon Foundation (RKMF) wanted to better understand the needs and opportunities for these emerging sectors in the Pittsburgh region. RKMF asked RAND Corporation researchers to perform sector and occupational analyses to better understand the need and opportunities for economic development and workforce in the emerging "green economy" in the greater Pittsburgh region. RAND assessed the potential *demand* signal for sustainable goods and services to be produced and deployed in the region as well as the associated regional *supply* needs for workers and training and education. We identify promising practices and emerging needs in sustainable goods and services to enable the success of a robust, equitable, and local "green economy" which leverages regional assets and offers opportunities across geographic and socio-economic boundaries. In this study, we define Southwestern Pennsylvania or "the Pittsburgh Region" as the seven-county MSA to which Pittsburgh and Allegheny County belong and focus on data and literature that is most relevant to that region.

The remainder of this chapter provides further introductory context to the study. Here, we define two key terms—*sustainable* and *green*—and highlight some of the current "green" trends and opportunities.

Sustainability and Green: Definitions, Trends, and Themes

Sustainability and *green* are often used interchangeably when discussing environmental topics, but the two in fact differ in terms of what they cover. *Sustainability* was described in 1987 by the United Nations (UN) Brundtland Commission as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations, undated). This definition is still widely used today, and the term is often assumed to include environmental, social, and economic elements. In recent years, *sustainability* has been redefined as a global "megatrend" because it is "likely to have broad, deep, and long-lasting impacts on our lives and institutions, and those of future generations" (Hale, 2018). Sustainability thus is perceived to be a "key driver of structural change" for startups and established companies alike, with different entities pursuing different sustainability-oriented "macro trends" such as "circular economy" and "clean tech" (Gaudig, Ebersberger, and Kuckertz, 2021).

In terms of public perception in the United States, and despite clear partisan differences in opinion, there is evidence of generally increasing levels of concern about environmental sustainability (McDonald, MacInnis, and Krosnick, 2020). This includes a growing awareness of the adverse impacts of climate change (Leppert, 2022) and a majority interest in deploying

mitigation strategies such as decarbonizing the energy sector (Tyson, Funk, and Kennedy, 2022). However, these overall trends may mask important regional differences in opinion, such as those between rural and urban populations.

The term ***green,*** on the other hand, is more often used in a more specific sense, bringing "attention to the importance and the need to protect the natural factor in the economy" (Adamowicz, 2022). Thus, *green* can be viewed as a subset of *sustainability.* One interviewee suggested defining a green economy as one in which there is "economic growth in a carbon-constrained world." But "green" is often defined more broadly across a range of environmental attributes or associated with a specific sector or activity, such as "green vehicles," "green chemistry," or "green growth," or used as a verb, as in "greening the economy" (Adamowicz, 2022; Pollin, 2015; United States Environmental Protection Agency, 2022a). Like the term sustainable, green must be understood in a relative sense (see Box 1). For example, a 2022 study noted that green jobs "is not a well-defined term" and their own definition includes all jobs associated with "businesses that produce goods or provide services that benefit the environment or conserve natural resources" (Hofman et al., 2022b), p. V). Rather than green, the U.S. EPA opts for the term "greener" and defines such a product as one that "poses less harm to human health or the environment compared to other products that serve the same purpose" (U.S. Environmental Protection Agency, 2023). Thus, there is a continuum of "greenness" relative to more traditional approaches. In addition to this nuance, views on "green" have in recent years become aligned with political identifies, such as the case of the politization of climate change (Murray, 2021; Carman et al., 2021).

Government policies both drive and respond to these overarching green trends and innovations. The proposal for a Green New Deal in the United States in 2019 signaled both a growing awareness of the need for more sustainable practices and at the same time underscored the political polarization to which sustainability is susceptible (Friedman and Gabriel, 2019). Individual states have often led environmental policymaking (Berg, 2022; Mazmanian, Jurewitz, and Nelson, 2020), but, despite partisan differences, federal policy has also played a significant role in advancing investments in sustainability, notably with the infusion of stimulus funding such as the American Recovery and Reinvestment Act of 2009 and more recently the Infrastructure Investment and Jobs Act of 2021 and Inflation Reduction Act of 2022.

Box 1. What *does* "green" mean?

Interviewees for this study often asked: "what do you mean by a 'green sector' or a 'green job'?"

- The definition we provided was intentionally broad and inclusive, namely: **green sectors** are those that produce goods or services in ways that are **more environmentally sustainable than the incumbent ones,** whether evolving from traditional sectors or emerging as entirely new ones.
- **Green jobs** are those associated with such sectors. And a **green economy** would be made up of green sectors and subsectors.

International attention to and analysis of global sustainability problems, such as the ongoing work of the UN Intergovernmental Panel on Climate Change since 1988, have led to the creation of international sustainability frameworks and goals, such as the 17 UN Sustainable

Development Goals (SDGs) established in 2015 (United Nations, 2015). Although the impact of the broadly defined SDGs appears, to date, to have largely been discursive, there is some evidence of impact on governance (Biermann et al., 2022). Regionally specific frameworks, such as the European Union (EU)'s taxonomy for sustainable activities (European Commission, undated-b), derive inspiration and substance from the SDGs and allow for greater specificity in setting and meeting targets. Developed to provide a "common language" of sustainability and support achievement of the goals of the European Green Deal (European Commission, undated-c), the Taxonomy Regulation provides a classification system for sustainable activities around six environmental objectives:

1. Climate change mitigation
2. Climate change adaptation
3. The sustainable use and protection of water and marine resources
4. The transition to a circular economy
5. Pollution prevention and control
6. The protection and restoration of biodiversity and ecosystems

This classification system is intended to be "robust" and provide "clarity on which activities qualify as 'green' or 'sustainable'" in a way that is "harmonised" across the EU. To be considered sustainable, economic activities must contribute "substantially to one or more of the environmental objectives" and not "significantly harm" the other objectives (Official Journal of the European Union, 2020). China, as the world's largest emitter of greenhouse gas emissions, has also made strides to move toward a lower-carbon economy; in reducing pollution and promoting sustainable urban planning; and in supporting regional partner countries in working towards meeting SDG goals (United Nations, 2023; Ministry of Foreign Affairs, 2021).

In the Pittsburgh region, too, there is substantial activity in sustainable initiatives, as highlighted in Figure. 1.1 above. For example, the Allegheny Conference on Community Development (ACCD), through a multi-sector "Sustainability and Community Committee," developed SDG-inspired Sustainability Principles that were adopted by the ACCD board in 2019. These principles were:

1. Community and Individual Well-Being
2. Resource Stewardship
3. Clean Energy
4. Innovation and Technology
5. Partnerships to Achieve the Principles

The principles were intended to be "aspirational and yet action oriented" (Allegheny Conference on Community Development, undated). Similarly, the regional nonprofit Sustainable PGH borrows the 1987 definition of sustainability and elaborates on it, stating:

> "Sustainable communities meet the needs of the present without sacrificing the ability of future generations to meet their own needs. These include environmental needs (e.g., healthy ecosystems), social needs (e.g., opportunities and resources for all), and economic needs (e.g., thriving economies and secure

> livelihoods). Public, private, and non-profit organizations play essential roles in supporting sustainable communities by reducing their resource use, growing quality jobs, promoting diversity and inclusion, and other tactics" (Sustainable Pittsburgh, undated).

The University of Pittsburgh's "Pitt Sustainability Plan" includes three themes: Stewardship, Exploration, and Community & Culture (University of Pittsburgh, 2018). For all three examples, the core emphasis on environmental sustainability and green initiatives is expanded to include some elements of economic and social wellbeing. These also illustrate an awareness of the need for place-based, stakeholder-engaged approaches to problems that often have inherently local and regional solutions.

Despite these examples of leadership in sustainability, there is a great deal of heterogeneity in the region in the level of commitment and associated activity to green initiatives and sustainability more broadly. For example, even within Allegheny County not all municipalities have climate action plans or similar goals, and the County itself is just now planning to release such a plan in July 2024 (Zenkevich, 2023). The mere existence of the Congress of Neighboring Communities (CONNECT)—which aims to coordinate and collaborate between 130 local governments including the City of Pittsburgh to identify shared public-policy challenges and solutions—is an indication of the challenge of fragmentation and need for finding common cause (Congress of Neighboring Communities, 2024).

The trends described here suggest three interrelated themes: 1) there is an increasing awareness of the importance of sustainability; 2) there is a broader acceptance of the need for policies to drive change; and 3) there is an expanding development of frameworks and metrics to hold organizations accountable and assess progress. The necessary attention around the global COVID-19 pandemic took some of the focus away from sustainability, particularly in the environmental sense of the word (Stoll, 2020; Vanian, 2022)—and resulted in political, economic, and lifestyle changes with both positive and negative environmental impacts that may or may not endure in a post-pandemic world (Echegaray et al., 2021; Kuzemko et al., 2020). Environmental problems have of course persisted during and beyond the pandemic, including extreme weather events (Lehnis, 2022), and will accelerate absent sufficient attention and investment in sustainability as well as broader climate change mitigation and adaptation. In many ways, the challenges of the COVID-19 pandemic only served to emphasize the need to increase society's sustainability in the broadest sense of the word (Lopes de Sousa Jabbour et al., 2020), and regardless of inevitable future major events and disasters, the reality that society is not presently functioning sustainably will persist.

Economic Opportunities of Sustainability

Local and global environmental problems, and the associated efforts required to increase the sustainability of society, are major challenges, but they also present significant economic

opportunity.[3] There will be a need to green existing goods and services, such as producing all electricity from net zero carbon sources. To move to truly sustainable economic activities, there will also be an emergence of entirely new concepts and industries, such as "Industry 4.0" and "Circular Economy," enabled by digitization and the use of data and automation (Patil, Seal, and Ramakrishna, 2020). As sustainability increasingly becomes required by policy and regulation, there may also be advantages for economies based in inherently lower-environmental impact activities—for example, healthcare or other service industries that are lower-carbon per unit of economic value compared to heavy industry—and potential synergies with other industries, such as outdoor recreation.[4]

Another important dimension is the lifecycle of these evolving and emerging green goods and services—from RD&D to product manufacturing and deployment to operations and maintenance to decommissioning—which present a range of economic development and workforce opportunities. For example, at the early research stages of developing a new porous material for green stormwater infrastructure, different training and skills are required to support activities relative to those required for production, system integration, and ongoing maintenance of the same material. And while there will be some investments that occur virtually everywhere, such as vehicle charging infrastructure to support electrification, there will be a finite number of locations where materials are gathered for large-scale recycling and "circularity," where devices and equipment are manufactured, or where geographically fixed resources are used, such as harvesting wind energy or conducting river rafting tours.

Environmental sustainability is already contributing significantly to GDP and jobs. The U.S. green economy was estimated to employ nearly 9.5 million people—4 percent of the working age population—and to represent $1.3 trillion in annual sales revenue, with a 20 percent growth rate over the 2-year period between 2012–13 and 2015–16 (Georgeson and Maslin, 2019). Based on this analysis, the authors conclude that the green economy appears to be "a significant contributor to U.S. economic development and the economic well-being of millions of people" and that "the U.S. should consider, as other economies are, developing energy, environmental, and educational policies relevant to the green economy to remain competitive in these areas."

In Pennsylvania, the "clean energy sector" was estimated to employ more than 66,000 workers in 5,900 businesses and establishments in 2015, representing about 1 percent of state

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[3]Although beyond the scope of this study, the debate between "green growth" and "sustainable development" versus "degrowth" is worth noting, with proponents of degrowth arguing that "growth" and "development" are inherently unsustainable Javier Lloveras, Adam P. Marshall, James S. Vandeventer, and Mario Pansera, "Sustainability marketing beyond sustainable development: towards a degrowth agenda," *Journal of Marketing Management*, Vol. 38, No. 17-18, 2022/11/22, 2022; Maria Sandberg, Kristian Klockars, and Kristoffer Wilén, "Green growth or degrowth? Assessing the normative justifications for environmental sustainability and economic growth through critical social theory," *Journal of Cleaner Production*, Vol. 206, 2019/01/01/, 2019; Antonio Miguel, *Sustainability is the biggest economic opportunity of our times*, World Business Council for Sustainable Development, 2020..

[4] This point was raised by one of our educational sector interviewees.

employment and a 15 percent increase over 2014 (Environmental Entrepreneurs (E2) and Keystone Energy Efficience Alliance, 2016). More recently, the clean energy labor market was estimated to employ more than 94,600 Pennsylvanians, with 5.1 percent annual growth, or 4,613 new jobs.[5] This growth represented a rebound after the pandemic, the first year of which the clean energy sector lost about 7,200 jobs (BW Research Partnership, 2022a). By comparison, Pennsylvania's broader energy sector (which includes "clean" energy) employed more than 258,000 workers and increased by 3.3 percent over the same period (BW Research Partnership, 2022b).

How This Report Is Organized

This technical report is intended to augment and provide detail not included in the shorter companion report, *Economic Opportunities in Sustainability for Southwestern Pennsylvania: Key Findings and Recommendations*. Taken together, the goal of these publications is to assist RKMF and other regional stakeholders to make impactful and coordinated decisionmaking and investments that benefit social and economic well-being of the entire region. In the next chapter, we describe the study research approach and methods. Chapters 3 and 4 offer key findings on the opportunities and challenges for economic development and workforce in sustainable sectors. Chapter 5 identifies lessons learned from case studies relevant to two of emergent sustainable sectors. In Chapter 6, we present recommendations drawn from the analysis that will help support the success of the "greening" of traditional goods and services and emerging sustainable sectors in the Pittsburgh region.

This work is supported by seven technical appendixes. Appendix A provides a list of stakeholders interviewed and sample questions. Detailed descriptions of methods for short- and medium-term occupational analysis and complete data tables for green and close green occupations (Appendix B and C, respectively) and long-term occupational analysis methods (Appendix D) are also provided. Appendix E provides an illustrative application of methods for short- and medium-term workforce supply analysis to determine sufficiency of supply for a single occupation and an example sector, circular economy. Appendix F includes details on the demographic characteristics of the existing portion of the workforce that could move into green occupations with little or no training, i.e., green occupations. Appendix G provides detailed information on regional education and training opportunities for workforce to transition into green occupations.

[5] This report includes data on the trends from Q4 2020 to Q4 2021. The "clean energy sector" includes energy efficiency; clean energy generation; alternative transportation; clean grid and storage; and clean fuels.

Chapter 2. Research Questions, Approach, and Methods

This chapter presents the research questions developed to guide the study and describes the mixed methods used to assess potential market demand and workforce supply for sustainable sectors in the Pittsburgh MSA. Qualitative interview data were collected and analyzed to understand both demand and, to a lesser extent, supply, and a quantitative occupational analysis provided the basis for understand near-, medium-, and long-term workforce supply.

Research Questions: A Problem of Worker Supply and Sector Demand

The goal of the project is to identify promising practices and pressing needs to enable the success of a robust local "green economy" which leverages regional assets and offers opportunities across geographic and socio-economic boundaries. In some ways, this is a basic "supply and demand" problem: what future "green" opportunities will Pittsburgh (be able to) support, and will there be enough skilled workers to make these opportunities a successful reality?

To better understand the potential future **demand** for workforce and training to supporting emerging sustainable sectors, RAND sought to answer the following questions:

- What are the "green" trends for products, processes, and services, both generally and for specific industries?
- What opportunities in sustainability are particularly suited to the Pittsburgh region? Are there industries and sectors that make less sense to maintain or build in the region?
- What are the barriers to the success of these industries, and what actions by stakeholders might help overcome these challenges?

To assess the existing and future workforce **supply** needed to support these emerging sustainable industries, including the training and education requirements, RAND asked:

- Can the existing and emerging workforce meet the needs of new and evolving sustainable industries? Does or will this workforce have the right skills?
- Are there gaps in training and education opportunities to better meet these needs of a "greening" economy?
- What are the prospects for a more diverse workforce and a more equitable distribution of benefits?
- What are other barriers and challenges to meeting workforce demand, and what can be done to bridge gaps?

Qualitative Methods for Assessing Economic Opportunities and Workforce Demand and Supply Concerns

To better understand the current and near-term economic development opportunities in the Pittsburgh region, which creates a *demand* for a supply of workers, we used two qualitative research methods: literature review and semi-structured interviews.

Literature Review of Regional and Peer-City Trends

The literature was identified via key word searches including "green economy", "circular economy", and "green workforce training", as well as by stakeholder recommendation. Keyword searches were used to find studies, reports, academic articles, or other published works for the following—with a geographical emphasis on the Pittsburgh metropolitan area, southwestern Pennsylvania, or Pennsylvania generally: economic trends, strengths, and weaknesses; workforce trends, strengths, and weaknesses; environmental and equity challenges; and emerging or potential "green" sectors. We also looked for "peer" city examples of successful focus on sustainable sectors, several of which became featured case studies. This literature review and synthesis formed the backdrop of our understanding of the salient issues and relevant sectors, which informed our interviewee selection and questions and factored into our case study selection.

Semi-Structured Interview Analysis

Dozens of stakeholders were interviewed for this study, representing a range of organization types and perspectives, as described in Appendix A. Interviewees were identified based on study team member working knowledge, with input from RKMF staff and snowballing from interviewee input, as well as the literature review. The content of all interviews was reviewed by one team member who captured highlights across specific questions and themes in a single spreadsheet (e.g., sectors identified as having comparative regional advantages, training and education needs for specific sectors and "green" jobs more broadly)— with interviewees identified only by interviewee number and organizational type—for the full team to review. For interviewees that provided information and opinions relevant to areas of focus (e.g., a specific sector that was a candidate for a case study), the original transcripts were reviewed by a second team member who added a second set of information into the master spreadsheet. Some of this material is directly cited herein but other sources provided general context and informed our interview process, i.e., helped us develop interview questions and identify relevant stakeholders to interview. A complete bibliography of sources reviewed can be provided upon request.

Limitations of Qualitative Analysis

There are important limitations in our qualitative findings. The opinions of individuals inherently represent individual biases and, while we have tried to bolster these opinions with

reference to peer-reviewed literature, opinions (1) have not been exhaustively "fact-checked" and (2) are illustrative not representative of stakeholder interests. For example, members of the workforce were not interviewed or surveyed and thus statements on their opinions and interests have been filtered through other stakeholder lenses. The findings herein could usefully be shared with worker focus groups as well as others (e.g., community groups and individuals living in areas impacted by economic development in a particular sector) for validation and modification. Additionally, the research team made some assumptions to guide the scope of the analysis, e.g., thresholds for "sustainable" as being relative to incumbent technologies and services, which led to inclusion, for example, of "blue" hydrogen production which some stakeholders do not view as sufficiently "green" for consideration.

Quantitative Methods for Assessing Potential Workforce Supply

Green sectors of relevance to the Pittsburgh region were identified through literature review and interviews, including with RKMF staff, as described above. The demand signal of these sectors implies an associated needed supply of workers. The Pittsburgh-specific supply of the needed occupations, and of "close substitutes" for these occupations based on shared occupational characteristics, will be a limiting factor to the growth of these sectors. If supply falls short of demand, this points to a need for more recruiting (e.g., from out of the region), retention (e.g., keeping more graduates from local educational institutions in the region), and (re) training. If green industries will need to rely on the broader "potential" supply of close substitutes, there will be specific skill and knowledge gaps that need to be bridged. In this analysis, we consider both consensus and controversial sectors and associated occupations. Data sources used for our analyses are summarized in Table 2.1.

Table 2.1. Data Sources for Quantitative Analyses

Data Source	Description	Use in Analyses
Stakeholder interviews	Individual and group interviews conducted by the RAND study team[a]	Informed selection of green sectors and occupations for analysis
Literature reviews	Review of academic and grey literature on approaches to identifying green jobs	Informed selection of green sectors and occupations for analysis, most notably Dierdorff et al. (Dierdorff et al., 2011)[b] and a report by the Outdoor Recreation Roundtable (Outdoor Recreation Roundtable, 2022)[c]
Bureau of Labor Statistics (BLS) Occupational Employment and Wage Statistics (OEWS)	National employer survey used to estimate employment and wages in 830 occupations at various levels of geographic granularity	Used data for the Pittsburgh MSA to assess short-term labor supply for green occupations and medium-term labor supply as indicated by employment in adjacent occupations
Occupational Information Network (O*NET)	Database of characteristics of occupations based on surveys of workers	Used to determine green-adjacent occupations by deriving standardized

	in those occupations on knowledge, skills, and abilities needed to perform the work; also identifies a set of green occupations based on the Dierdorff et al. (Dierdorff et al., 2011) framework	distance measures of each occupation from each other occupation
U.S. Census Bureau's American Community Survey (ACS)	National household survey that collects demographic, social, economic, and housing information from 3.5 million households each year	Used to analyze demographic characteristics of workers in green and green-adjacent occupations and the geographic distribution of these workers within the Pittsburgh region
BLS Education and Training Assignments Data	Data indicating the typical education needed for entry to occupations and typical on-the-job training needed to attain competency	Used to characterize education and training needs for green jobs
U.S. Department of Education's Integrated Postsecondary Education Data System (IPEDS)	Nationwide database of educational programs available, characteristics of providers offering programs, and data on program completions	Informed assessment of availability of programs to support the long-term supply of workers in green occupations
U.S. Department of Labor's Registered Apprenticeship Partners Information Database System (RAPIDS)	Information on registered apprenticeships available by occupation and their providers	Informed assessment of availability of programs to support the long-term supply of workers in green occupations
Pennsylvania Career Link	Information on training programs on Pennsylvania's Eligible Training Provider List (eligible for workforce development funding)	Informed assessment of availability of programs to support the long-term supply of workers in green occupations

NOTES: [a] Interviewee organizations and individuals are listed in Appendix A. [b] Dierdorff et al. (Dierdorff et al., 2011) and its associated list of green sectors and green occupations formed the backbone of our framework for defining green jobs; the U.S. Department of Labor-sponsored Occupational Information Network .(O*NET) similarly adopts this set of green jobs; O*NET Resource Center, "Green Occupations," undated. [c] The Outdoor Recreation Roundtable (Outdoor Recreation Roundtable, 2022) report provided a basis for identifying occupations important for an expansion of the outdoor recreation economy; this sector did not appear in the Dierdorff et al. (Dierdorff et al., 2011) framework but was identified in our stakeholder interviews as an important sector for the Pittsburgh region.

Green Occupation Classification and Analysis

Our quantitative occupational analysis considers the portion of the *current* labor supply in southwest Pennsylvania that could work in new and emerging green sectors to understand mismatches between future expected labor demand and potential labor supply. We supplement this information with demographic characteristics of the general labor force and green labor force to understand both the near- and medium-term labor supply. We then catalog the green training programs that are present in the Pittsburgh area to understand the potential to develop a longer-term pipeline of labor. Specifically, the steps of the analysis are:

(1) **Identify the suite of "green" sectors and associated occupations.** Previous studies and the U.S. Department of Labor-sponsored O*NET program define twelve green economic sectors and provide associated occupations by industry, and the Pittsburgh-specific sectors identified via qualitative methods (described above) are mapped against these.

(2) **Assess short-term labor supply.** BLS data is used to estimate the likely supply of those occupations within the seven county Pittsburgh MSA. Those occupations for which Pittsburgh has a comparative advantage over other regions are identified using the location quotient (LQ) within the MSA. LQ is defined as the ratio of regional supply to the national average, where LQ>1 means that Pittsburgh has more workers in that occupation than average. A relatively high LQ indicates a potential for near-term success of economic development opportunities that can leverage this comparative advantage. This provides insight into economic development opportunities that can immediately leverage these portions of the workforce, i.e., they have direct overlap of skills and relevant experience and require little or no training.

(3) **Assess medium-term labor supply.** Occupations that are "adjacent" to green ones could provide a medium-term labor supply with minimal training and education that could enable these workers to move to a new sector within about 2 years. Here, we consider the "distance" between green occupations and those with similar characteristics. We then repeat the LQ analysis to identify those "close" occupations for which Pittsburgh has a relative advantage in terms of numbers of workers. The skills, knowledge gaps, and other characteristics that are lacking from the Pittsburgh labor force that are necessary for green occupations also provides insight into potential training programs that could be used to further enhance the green labor supply, which is used in step 4.

(4) **Assess long-term labor supply**. We consider the available training resources, including both institutions and specific training programs, to explore the most natural /easiest/obvious pathways among the green sectors for creating a robust labor supply on a 5-to-10-year timeframe.

Details of the methods used to perform the steps of this assessment are further summarized in Chapter Four and described in detail in Appendix B (Steps 1-3)—with complete tables of green occupations and close green occupations provided in Appendix C, sorted by those with more than 1000 workers and those with less—and Appendix D (Step 4). Appendix E provides examples of using Steps 1-3 to determine sufficiency of supply for a single occupation and an example sector, circular economy.

Outdoor Recreation Economy Workforce Analysis

For most of the Pittsburgh-specific green sectors identified in our stakeholder interviews, the green sectors (and occupations needed for them) identified by Dierdorff et al. (93) and used by O*NET align well, and we were able to crosswalk these sectors to the Pittsburgh-specific sectors to identify relevant occupations. However, this was not the case for outdoor recreation, which did not neatly align with any of the green sectors identified by Dierdorff et al. (93). To be inclusive of outdoor recreation in our analysis, we added to our set of green occupations those identified in a recent report from the Outdoor Recreation Roundtable (Outdoor Recreation

Roundtable, 2022) as important for the outdoor recreation economy. Additional information is provided in Appendix B.

Characteristics of Workers in Green Occupations

To better understand the characteristics of the segment of the existing workforce that would be well-suited to move into evolving and emerging green sectors, including their demographics, levels of educational attainment, and geographic distribution across counties in the Pittsburgh region, we used U.S. Census Bureau's American Community Survey (ACS) data. "Close green" occupations were also assessed. See Appendix F for additional details.

Postsecondary Education and Training Opportunities in the Pittsburgh Region

Appendix G provides detailed information on regional education and training opportunities for workforce to transition into green occupations. This is relevant to long-term worker supply.

Limitations of Quantitative Analysis

- While we leverage an established method of identifying occupations that share similarities with green occupations based on O*NET data on knowledge, skills, abilities, and other characteristics of occupations, we do not empirically validate whether workers in these close occupations have successfully transitioned into green occupations in the past. Future expansion in green economy sectors that results in growth in green occupations could yield opportunities to better understand which other occupations are serving as latent labor supply to the growing green occupations, either validating or refuting the set of close green occupations we identified using the O*NET data.
- We include some information on typical wages of workers in occupations needed for an expansion of sustainable sectors in the Pittsburgh region but do not conduct in-depth analyses of the wage premium to green jobs (relative to nongreen jobs) in Pittsburgh or nationally. Data limitations complicate these comparisons, for example, because occupations for which wage data are tabulated in the Bureau of Labor Statistics data may comprise both green and non-green sub-occupations (e.g., data for "Green Marketers" are not available separate from data for "Advertising and Promotions Managers" overall).

We describe the breadth of education and training providers in the region offering programs that prepare people for green jobs, and when available, provide information the number of recent completers of these programs. But we are unable to quantify the maximum possible throughput of education and training programs. In some cases, there is little reason to believe there is a binding cap on the number of people who could pursue the program (e.g., majors at local colleges and universities aligned with green occupations). In others, programs could be capacity-constrained, for example specific apprenticeship programs where demand may outstrip supply of slots in the program. Additionally, while we draw upon crosswalks of education program areas to occupations developed by the Department of Education and Department of Labor, we are unable

to empirically verify whether workers in green occupations went through those programs or whether graduates of those programs pursued green occupations.

These analyses were limited to publicly available, quantitative data and do not incorporate information relevant to the opinions and preferences of the workers themselves. In other words, simply because a worker has the relevant knowledge and skills to apply in an evolving or emerging green sector does not mean they will be interested and feel comfortable in those jobs. Collecting such primary data, e.g., via focus groups, was beyond the scope of this study.

Methods for Case Study Identification and Development

Drawing on our literature review and stakeholder interviews, we sought to identify examples of leadership and innovation in economic or workforce development around the most promising sectors for the region. On the economic development side, we looked for examples of focused initiatives executed at the city or state level to bolster the demand side of two promising green sectors for the region: circular economy (CE) and outdoor recreation (OR). The focus on these two sectors was based on:

- Perceived suitability for the region by interviewees.
    - All interviewees with which OR was discussed perceived an expansion in outdoor recreation in the region to be a positive option.
    - All interviewees with which CE was discussed perceived an expansion in CE in the region to be a positive option, with one interviewee expressing concern that significant infrastructure would need to be built for a circular economy to be successful.
- Potential for RKMF to have significant impact through their philanthropic investments based on:
    - Identification as aligned to regional strengths and cultural resonance in interviews and RAND research into the region;
    - Alignment and synergies with existing RKMF programs;
    - The potential to have a relatively large impact with modest investments;
    - Risk of the sector not realizing the full potential if relying solely on market forces or state and federal policy.
- Non-polarizing: perceived as less likely than other sectors identified in the interviews to face significant social/political resistance.

Existing literature within the fields of OR and CE—and green jobs more broadly—was examined to identify examples of leadership and innovation at city, regional, national, and international scales. Results included Charlotte, North Carolina's "Circular Charlotte" initiative (Gladek, Kennedy, and Thorin, 2018), the first city in the U.S. to commit to adopting a circular economy, a circular economy enterprise in Gothenburg, Sweden to provide green jobs for disadvantaged groups (Urban Sustainability Exchange, undated), Zagreb, Croatia's initiative to

green public spaces through training and employment of the long-term unemployed (European Commission, 2015), the Green Workforce Accelerator Program in Austin, Texas (AustinTexas.Gov, undated), and other city and state initiatives across the United States and internationally. This included potential case studies explored in the RAND publication *'Green' jobs and skills development for disadvantaged groups* (Hofman et al., 2022b) which examined green jobs across 10 European cities.

In addition, each interviewee was asked to identify potential case studies that could be relevant to the region. Results included Boulder, Colorado's outdoor recreation economy(University of Colorado Boulder, undated; Downtown Boulder, undated), Butler County Community College's Park and Recreation Management degree and training (Butler County Community College, undated), the Baltimore Wood Project (The Baltimore Wood Project, undated), and the Circular Economy Ph.D. program at the University of Pittsburgh (University of Pittsburgh, undated).

Several case studies were then selected within each sector for further examination based on their relevance to the region and potential to provide best practices for the regional outdoor recreation and circular economies. The case studies examine both specific influential institutions and geographic areas and, as has been employed in related studies (Hofman et al., 2022b), the goal was to balance the case studies between those employing or educating people with low educational qualifications and those employing or educating other groups.

Chapter 3. Key Findings on Expected Demand from Sustainable Sectors

This study aims to identify both the opportunities and challenges of the expected increase in demand for more sustainable goods and services, the associated economic opportunities, and the required workforce to support these new or evolving sectors in the southwestern Pennsylvania region. Combining the qualitative and quantitative methods described in Chapter 2, a multidimensional and nuanced picture of demand and supply emerges. The analysis described in this Chapter points to potential actions and investments for stakeholders in public and private sectors, which will be described in Chapter 4.

> To assess potential future climate change-related market **demand** signals, and the associated workforce **supply** that will be needed to build new sectors, "think about **which industries have to change** or will need to evolve... Then look at **what kinds of jobs and opportunities are created** out of those."
> - Nonprofit economic development stakeholder

There are Both Unique and General Opportunities and Challenges in Sustainable Sectors for the Region

As described in Chapter 1, there will be substantial economic opportunities associated with a transition to a more sustainable economy. The Pittsburgh region will have many of the same opportunities as other regions of the country, such as economic activity associated with widespread **deployment** of more sustainable consumer goods and services. Other opportunities will be more uniquely suited to take advantage of regional attributes; a successful subset of new or evolved industries would leverage the existing workforce, existing or expanded training opportunities, or distinct regional natural resources and would contribute to the **creation** of new goods and services not just their deployment.

> I think biggest challenge is that we're trying to **build supply and demand at the same time**. We're trying to build demand for these green technologies…while also building a pipeline of the products themselves, as well as the qualified individuals to install and maintain them.
> - Private sector stakeholder

The most promising areas for expected future demand for sustainable goods and services in and from the Pittsburgh region—and the associated overarching economic sectors and workforce needs—were identified with literature review and stakeholder input and are described below. This analysis yielded insights into which opportunities are generally agreed-upon to be well-suited for, and beneficial to, the Pittsburgh region and uncovered some of the perceived barriers and challenges to the success of these sustainable sectors. Differences in stakeholder perspectives in the literature and interviews pointed to potentially promising sectors where there is a lack of consensus on fit for the Pittsburgh region or for which there is potentially substantial downside risk or uncertainty of success. For some of these sectors, large amounts of investments by

national or international entities, e.g., the U.S. federal government, multinational corporations, will be required to move the needle. In these cases, more limited or tailored investments of capacity and resources from local or regional government and philanthropy may be appropriate.

The literature and stakeholders also provided information on supply-side issues, such as gaps in workforce training, which will be discussed in Chapter 4 along with the quantitative analysis of near-, medium-, and long-term supply.

Sectors Which Stakeholders Identified as Opportunities Due to Comparative Advantage or Expected Stakeholder Support in the Region

Stakeholders agreed that, in the last decade or so, general attitudes around sustainability have shifted significantly, with a growing appreciation for the need for cross-sector "greening" especially in mitigating and adapting to climate change. As one private sector stakeholder put it, "decarbonization is absolutely a trend" for their industry's operations and across their global value chain. Additionally, there was general agreement on several existing and emerging sectors that make sense in Pittsburgh, based on unique regional assets, cultural resonance, or other factors (see Box 2). These are certainly not the only potential opportunities for the region in emerging sustainable sectors—others are discussed below—but they represent areas in which the region may have a comparative advantage and for which there is likely to be *general support from diverse stakeholders*. These sectors were: agriculture, circular economy (CE), green buildings, outdoor recreation (OR) economy, and water management. Cross-sector areas identified were innovation—especially in automation and robotics—and energy efficiency.

Box 2. Economic Opportunities in Sustainability for Southwestern Pennsylvania

Stakeholders called out several sectors as being already important or promising for the Pittsburgh region:

- **Sustainable agriculture**, both food production and non-traditional sectors, such as carbon credit markets.
- Industries that embrace **circular economy** practices and services.
- **Green building sector** with a broadened scope, i.e., extend commercial building success to residential.
- **Outdoor recreation economy** to provide direct economic activity and support the region's "green" reputation and livability.
- A **water management** sector that supports both remediation and sustainable uses of this unique regional resource.

Cross-sector areas to leverage were:

- **Energy efficiency** and **conservation** as a foundational concept with cultural resonance.
- The reputation, culture, and capacity for **innovation**, including in the areas of **autonomy** and **robotics**.

Sustainable Agriculture Sectors

Although not viewed as a major driver of employment,[6] several respondents noted potential growth for the region's sustainable agricultural sector, particularly in the more rural areas. As one green nonprofit stakeholder said, "some regions… have a more functional middleman

[6] One economic development nonprofit interviewee described it as being a "boutique" opportunity.

arrangement on how local crops move to restaurants and CSAs and to food desert communities. In Pittsburgh, that's a more informal arrangement…So that's a specific area we need to fill, more green jobs … and make that system more organized."[7]. Respondents spoke of the region's overall potential as a generally moderate and water-rich climate—likely to become increasingly valuable as other food-producing regions like California grow dryer and hotter—and the region's ability to scale up as locally sourced sustainable food becomes more of a priority.[8]

On the other hand, obstacles for the sector were noted by stakeholders from one green nonprofit, such as the risk of suburban sprawl and economic strain on the sector, and the need to protect and rethink the next generation of farmers. One stakeholder from philanthropy expressed concern that "ag has been off our radar" and stated that agricultural lands are at risk of being converted into other uses: "Agriculture is clearly a threatened sector of our economy."

Adjacent to food production, individuals from one green nonprofit noted the potential in the region for production of mass timber, and another philanthropic interviewee pointed out the broader Appalachian region's value as a carbon sink which could potentially be monetized in future carbon markets. There may be a need to assess tradeoffs and make choices between these concepts, e.g., large-scale timber production versus forests valued for carbon credits. Some concepts may be more aligned with other opportunities, e.g., timber production and green buildings, carbon credit forests, small-scale organic farming, and outdoor recreation. For both reasons, sustainable agriculture should be considered within the broader portfolio of opportunities.

Circular Economy Sectors

The circular economy was a concept in sustainability that resonated with many interviewees and was widely assessed as being well-suited for the region. Circular economy concepts are "closed-loop"—as opposed to the predominantly "take-make-waste" economic model of modern society—and can be practiced with respect to a single sector (e.g., municipal solid waste (MSW) and enhanced reuse, recycling, composting, and waste-to-energy; building construction, deconstruction, and reconstruction) or multiple sectors in conjunction (Raimi, Carley, and Konisky, 2022) The City of Pittsburgh has previously described what a "Roadmap to Zero Waste" would look like (City of Pittsburgh, 2017) but the region more broadly has not taken this on. Multiple interviewees noted a "cultural" fit of circular economy concepts for rural counties—with an historically practical and "thrifty" mentality—then in the case of some other emerging

[7] They specifically said: "If you look in Lancaster, for example, they have over 100 organic farmers who take their food to one place, they're all part of one collective, and that collective moves the food on to restaurants, food islands, non-profits, and places that provide food for the needy, CSAs."

[8] This sentiment was expressed in conversations with several stakeholders from at least one green nonprofit and one economic development nonprofit.

green industries. Minimizing waste and increasing efficiency is naturally appealing to Pittsburghers, who, in the words of one private sector stakeholder, do things "because they are the right thing to do." The broad range of job opportunities needed to support circular economy—from labor-intensive entry-level positions that can be done without a high school degree to RD&D jobs that require a B.S. or Ph.D. (see Box 3), and potentially geographically distributed in both urban and rural settings—was also seen as a benefit.[9] And the potential for increasing equity—such as providing opportunities for the formerly incarcerated and individuals with disabilities—was noted by one green nonprofit interviewee, assuming that a pathway can be developed specifically to support these individuals. One workforce/sector-specific nonprofit interviewee pointed to the proximity of Pittsburgh to both Midwest and East Coast markets, and the potential for "green" products to flow to those quickly, inexpensively, and with minimal carbon footprint. As one other green nonprofit interviewee succinctly put it, the "circular economy should be a big part of Pittsburgh's future."

There were several subsectors noted as promising for the Pittsburgh region. With an aging housing stock that has often not been well-maintained and, in many instances, is beyond repair, deconstruction and reuse of building materials in the Pittsburgh region is large potential resource to tap. In this sector, the opportunity is bigger than the capacity of existing local organizations to manage and utilize according to one green nonprofit stakeholder. But residential buildings are not the only potential Pittsburgh-region niche. As noted by one private sector interviewee, the healthcare sector, as a major economic force and employer for the regions *and* a major consumer of single use items, could also be an innovator in circularity. And Pittsburgh-based Thread International, founded in Homewood in 2015, provides an example of what can be done in the textile subsector drawing on a global supply chain (Fast Company, 2015; Bauknecht, 2020). One green nonprofit interviewee described the desirability of developing a broader "products ecosystem" for the region where innovation in circular economy, reducing carbon emissions, and other sustainability goals could be most effectively pursued with a suite of related goods and services.

Box 3. Illustrative Circular Economy Sub-Sectors and Associated Jobs

- Private building deconstruction sector: architects and designers; general contractors; operating engineers (IUOE and non-union); materials scientists and chemical engineers; procurement professionals.
- Public municipal zero-waste sector: facilities managers; collection truck drivers; agronomic advisors; repair technicians; process operators.

Sources:(Aguirre, 2022; Circle Economy, undated).

There is already a recognition in the region that circular economy (CE) subsectors are promising, and there are several for- and non-profit actors working in this space. City of Pittsburgh-based non-profit Construction Junction, for example, is conducting a building deconstruction pilot project with the City of Pittsburgh targeting 1,700 condemned properties

[9] These points were made by green nonprofit and educational stakeholders.

(Construction Junction, 2021). Keep Pennsylvania Beautiful is a nonprofit that provides resources for counties across the commonwealth to reduce waste and increase recycling, including offering special waste collection events that help expand recycling to include more materials and more locations in Pennsylvania (Keep Pennsylvania Beautiful, 2021). In the fall of 2021, Covestro and the University of Pittsburgh launched a new graduate program in Circular Economy in anticipation of increasing demand for a workforce trained to design circularity into materials at the beginning of product lifecycles (University of Pittsburgh, undated). While it is perhaps not surprising that an international company—with substantial presence in Europe where CE is already quite important—is interested in expanding their CE workforce, one green nonprofit observed that there is also a growing interest by more traditional, Pittsburgh-based companies in getting support to develop reduced- or zero-waste business models.

On Circular Economy as a Pittsburgh-Region Opportunity

"…circular economy should be a big part of Pittsburgh's future."
- Green nonprofit interviewee

CE appeals to Pittsburgh's culture because "we've got midwestern roots, and we do things …because they are the right thing to do…" Additionally, "you can do so many (CE) projects… that can be profitable."."
- Private sector interviewee

Despite general enthusiasm, several potential barriers and concerns were raised by stakeholders. One philanthropic stakeholder expressed a need to make CE work for people on a "practical" level, stating that if there needs to be a connection between less waste and benefits to their daily lives, like saving money. In their assessment, "recycling hasn't really worked for anyone on the practical side" because of the conceptual and financial disconnect. Another educational interviewee similarly noted that "cultural change" will be required just to make common curbside recycling truly successful, much less full-scale circularity. One green nonprofit suggested other substantial requirements for the success of CE, including: connecting academic work in circularity with the on-the-ground work of reuse so people are working across silos; obtaining more and better data to quantify what materials are truly reusable and to understand the magnitude of the opportunity; and better articulation of the multidimensional value proposition of CE. One private sector and one green nonprofit interviewee pointed out that, in terms of workforce, improved sorting technology and other advances in automation will undermine growth in jobs and limit potential. However, given the general demographics of the region which limit the availability of workers, and given the region's strengths in autonomous technology, even this downside has silver linings for the Pittsburgh region.

This sector is discussed further in Chapter 4, with inclusion of several case studies describing efforts in circularity in other locations internationally and in the United States. The key strengths, opportunities, and challenges for OR are summarized in Box 4.

Box 4. Strengths, Opportunities, and Challenges for a Circular Economy Building Sector in the Pittsburgh Region

Sustainability in the building sector is both a long-term strength for the City of Pittsburgh and an area of immense opportunity for improvement in the region.

Strengths:

- **Non-profit leadership** such as the Green Building Alliance (GBA), Construction Junction, and Phipps Conservancy.
- **Educational opportunities** including Building Construction (CCAC), Civil & Environmental Engineering (CMU), and Circular Economy (Pitt)
- **Private sector involvement** such as CEOs for Sustainability and specific companies, e.g., Covestro.

Opportunities:

- **Climate mitigation**: The building sector currently accounts for more than 80 percent of greenhouse gas emissions in Pittsburgh.[a]
- **Synergies** with other zero waste concepts such as downcycling material for waste-to-energy.
- **Resilience**: Targeted deconstruction and reconstruction can create more connected, safer neighborhoods.
- **Equity**: More than 30 percent of households earning less than $75K a year live in neighborhoods with abandoned or poor condition buildings, as opposed to 5% of those earning more than $75K; 20% of black residents live in such areas, whereas only 6% non-black residents do. [b]

To realize the potential in this subsector of circular economy, several challenges must be overcome.

Weaknesses and Threats:

- **Fragmentation** of governance and services will present challenges for economies of scale.
- **Disinvestment** in neighborhoods with these assets will need to be reversed.
- **Gentrification** is a risk if reinvestment is not done with intention, with stakeholder input, and with explicit consideration of equity.

Sources: RAND analysis, City of Pittsburgh (City of Pittsburgh, 2018), and University of Pittsburgh (University Center for Social & Urban Research (UCSUR)).

Green Buildings Sectors

As noted earlier in this report, Pittsburgh-region stakeholders and organizations placed a focus on green buildings relatively early in the emergence of these concepts and today the region not only has many high-performing buildings (e.g., LEED certification, participation in the 2030 District) but has a national and international reputation for leadership and innovation in this space. Multiple interviewees specifically mentioned the early and ongoing work of the Green Building Alliance (GBA) as being particularly forward-thinking and influential.[10] Even stakeholders outside of the building sector noted GBA's leadership, with one private sector interviewee crediting the organization's proactive willingness to share best practices and to articulate the value proposition of efficiency as one reason why their own business was now ahead of competitors. Interviewees suggested that these successes can and should be leveraged for new and expanded economic opportunities and for burnishing the region's reputation and additional brand building in related areas.

Also in Pittsburgh's favor is the ample opportunity for the region to do more. While progress in commercial buildings has been notable, according to one green nonprofit there's also "so much existing residential stock that can be activated" to increase quality housing availability. A

[10] Mentioned by at least two economic development nonprofit and two private sector interviewees.

Home Energy Score analysis of market-rate homes owned by middle-income and higher homeowners in Pittsburgh found that these homes performed poorly against the national average. While these homes were volunteered by their owners and therefore not randomly selected, one interviewee from a green nonprofit noted that it's still an "indicator that it's not just homes occupied by low-income homeowners that are performing terribly, terribly, abysmally, against the national average." Homes in Pittsburgh are twice as "leaky" (from an energy efficiency perspective) as the national average. The interviewee saw this as an opportunity to stand-up small businesses owned by women and minorities to do work in weatherization, because, while weatherization may not be the most glamourous work, "there's a lot of room to do that work…but there's not enough people to do it." Several interviewees noted also obvious synergies with circular economy, both deconstruction specifically and materials sourcing more broadly, and with the important cross-sector emphasis on energy efficiency (discussed below).

For new builds, expanding interest and markets in modular housing regionally and nationally might have a good synergy with the region's historical strengths in manufacturing, and factories are able to train and supervise new workers onsite, which can enable less-experienced workers to get started more quickly than traditional homebuilding allows. According to interviewees from one green nonprofit, this can be good for low-skill workers and good for employers struggling with labor shortages.

There is a potential for increasing equity in the way we approach this sector; as one economic development nonprofit interviewee put it, not being thoughtful about how we rebuild homes "has an appreciable impact on the health and wellness of people." Rebuilding Together Pittsburgh was mentioned as an organization working at this intersection of sustainability and equity, with a focus on providing "safe and healthy homes" and "improved quality of life and peace of mind for homeowners in need, strengthening their families and communities in the process" rather than explicitly emphasizing green (Rebuilding Together Pittsburgh, undated).

Outdoor Recreation Sectors

The outdoor recreation sector (OR) is distinct from other sectors considered in this study because the workforce is so diverse, even relative to broad areas like CE, and because this is largely a sector of services and not goods. It is also a sector which directly leverages the benefits of environmental stewardship as much as it is a sector which is itself able to be practiced in sustainable ways, and participation in this sector has the potential to increase awareness and appreciation of sustainability more broadly. While not explicitly discussed with every stakeholder, this sector was universally met with enthusiasm when it was,

On Outdoor Recreation as a Pittsburgh-Region Opportunity

Pittsburgh is unusual because "nature is right inside the City… [whereas] most cities are built in a way that excludes nature." Pittsburgh has natural assets "right at its fingertips"
– environmental nonprofit interviewee

Pittsburgh "should be the Boulder, Colorado of the East Coast"
- economic development interviewee

with interviewees noting the potential for both direct and indirect workforce and economic development benefits. With respect to the former, direct economic and workforce implications could potentially be significant for smaller towns that have lost economic opportunities (government interviewee) and rural areas with small scale economies like those in the PA Wilds, where you can "leverage a lot… with less money" (green nonprofit). Box 5 provides some examples of OR occupations in private, non-profit, and public sectors.

OR was seen as a "fertile" area for growth (economic development nonprofit), with adjacent small business opportunities such as furniture making and sustainable agriculture that can also serve OR tourists (green nonprofit). Expanding and connecting trails, and "trails-to-town" programs, was called out specifically by several stakeholders. The positive indirect effects of strengthening and growing outdoor recreation in the region was also frequently discussed. For example, one philanthropic interviewee noted that OR can build on and reinforce success in other sustainable sectors, both substantively in terms of shared knowledge and workforce and in terms of regional branding.

Box 5. Illustrative Outdoor Recreation Sub-Sectors and Associated Jobs

- Private sector: technicians for manufacturers and facilities; small business entrepreneurs; business analysts, logisticians, and accountants; general managers for retail; chefs for restaurants.
- Non-profit: trade association staff; community group directors; environmental organization fundraisers; environmental justice experts; program managers.
- Public sector: state agency directors and staff, e.g., biologists and ecologists; park rangers; customer service representatives; land managers.

Source: (Outdoor Recreation Roundtable, 2022).

Beyond being merely beneficial or nice-to-have, some interviewees went even further to assert that a robust outdoor sector is essential to attracting and retaining a larger regional workforce, expressing the view that many younger workers expect access to outdoor opportunities as part of a greater focus on quality of life (workforce/sector specific and government). It was noted that Boise, Idaho, and the Salt Lake City region are both fast growing tech areas in part due to the combination of affordability and access to outdoor recreation (green nonprofit). It was also noted by an economic development nonprofit that some cities like Atlanta and Phoenix do not have such nearby access to nature, which the City of Pittsburgh has within and immediately outside. The potential to leverage trends in remote work was noted by more than one interviewee in workforce/sector-specific nonprofits, including both the opportunity to attract and retain individuals with jobs in other areas of the country that can live in the region to enjoy the cost of living and access to outdoors in their leisure time as well as remote work supporting the ability of working partners to co-locate with remote OR workers.

One concern raised around this sector was a real and perceived lack of diversity and inclusivity. This was mentioned for some other "green" sectors but seemed to be particularly a concern for OR. "Skiing is a very 'white' sport…rock climbing is a very 'white' sport," and can require substantial investments to participate so can shut out socioeconomic diversity according to one workforce/sector-specific nonprofit interviewee. On the other hand, the diversity of activities that fall in this category—from hunting, fishing, and boating to water coloring and

birdwatching—has the potential to appeal to virtually anyone. Other concerns were raised regarding workforce, such as often relatively low salaries, the frequent need to relocate to find jobs that are often rural, and the potential impact of the cost of living—and especially housing costs—increasing as the success of an OR economy grows. The key strengths, opportunities, and challenges for OR are summarized in Box 6. This sector, including several case studies, is discussed further in Chapter 5.

Box 6. Strengths, Opportunities, and Challenges for Outdoor Recreation Sectors in Southwestern Pennsylvania

The many parks and outdoor assets within the City of Pittsburgh and the tremendous outdoor recreation opportunities in the broader region can be an engine for economic development.

Strengths:

- **Alignment with philanthropy** including RKMF.
- **Non-profit leadership** such as Bike PGH, the Pennsylvania Environmental Council (PEC), Riverlife, and Landforce.
- **Educational opportunities** at Butler County Community College and Slippery Rock University.
- **Proximity** to population centers on the East Coast**.**

Opportunities:

- Coming out of the worst of the COVID-19 pandemic, **increased interest in outdoor activities** and the potential for **remote work** offer a window of opportunity to showcase the region's outdoor assets.
- **Private sector entities** outside the OR economy may be interested in supporting a sector which can improve the quality of life for employees and increase recruiting and retention of younger workers.

To realize the potential of a regional outdoor recreation economy, several challenges must be overcome.

Weaknesses and Threats:

- **Fragmentation Private sector involvement**
- cooperation across many municipalities and at the state level.
- A real and perceived **lack of diversity** in both workers and participants in OR could limit the economic development potential of this sector.

Sources: RAND analysis of stakeholder interviews.

Water Management Sectors

The historic and continued importance of water resources in the Pittsburgh region was noted by many interviewees. Two separate stakeholders, one from a green nonprofit, and one from the private sector, described the rivers and the abundance of water more generally as both "an opportunity and a challenge"—that everything is built along the rivers is an opportunity to leverage those assets more fully and more sustainably, that as some regions of the country get drier the region's water assets will become more valuable, but that as climate change makes weather wetter and rainstorms more flashy, there will be many investments required to manage water. The importance of the rivers for transportation and connectivity, especially in an increasingly climate-constrained world, was also noted by philanthropic, green nonprofit, and government stakeholders. Overall, the uniqueness of this regional resource, and the difficulty of addressing legacy water impairment, stormwater management, and other costly issues, were both widely acknowledged.

The potential to innovate in water sectors was also brought up. The strength of regional universities and engineering expertise, for example, was noted by a green nonprofit stakeholder

as a real opportunity that is not being fully leveraged. Several related small companies were also mentioned. In a concept that combines circularity and water management, North Allegheny-based Hydroblox, with manufacturing plant in Meadville, is creating drainage blocks from used plastics and working with state DOTs to deploy the technology (Hydroblox, undated). Regional innovation in stormwater management was recently highlighted in the 2023 National Climate Assessment, noting the city's status as an early adopter of climate-conscious water planning and the use of green infrastructure to augment traditional grey (Hurdle, 2024).

On the other hand, one green nonprofit stakeholder asserted that the public-sector nature of water resources makes success in these sectors less about "innovation" and more about getting access to and using state and federal funding; water quality "is a money problem." Another stakeholder suggested that the potential for expanded green stormwater infrastructure was being "stymied by bad state policy."[11] The need to collaborate across jurisdictions, e.g., combined sewer overflow is a City of Pittsburgh and Allegheny County issue, was noted by a green nonprofit stakeholder as a barrier, and the potential utility of a multi-state organizing authority, e.g., a new "Ohio River Valley Authority," was noted. More than one interviewee noted the number of municipalities in the region and the state as a problem, in general but for water in particular. The "ad hoc" management of water resources and the concentration of expertise in the private sector, rather than with government agencies, were also mentioned by a green nonprofit stakeholder. From a near-term workforce development perspective, a lack of expertise in government is not necessarily a bad thing, but it could create difficulties in achieving common goals across a patchwork of municipalities and over time. This could ultimately limit the larger economic potential of this sector in addition to risking proper management of this important regional resource.

Finally, stakeholders pointed to the clear links between water management and other sustainable sectors, including OR—both in terms of water quality and the impact on outdoor recreation such as boating and fishing, and in terms of the potential for positive branding of the Pittsburgh region.

Cross-sector Strengths to Emphasize and Leverage

Two cross-sector themes with virtually universal appeal were efficiency and innovation. In addition to offering direct economic development and employment opportunities in the sectors themselves[12], emphasizing these elements across other sustainable industries offers opportunity

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[11] This is according to one philanthropic interviewee, who suggested that renewable energy was similarly being held back by a lack of state-level policy leadership.

[12] For example, of 12,705 "clean energy" job in Allegheny County in 2022, more than 75 percent (9,658) were identified as "energy efficiency" jobs. In Washington and Westmoreland Counties, energy efficiency jobs were 81 percent (1,154 of 1,428) and 71.5 percent (1,592 of 2,224) of all clean energy jobs, respectively. See: https://cleanjobsamerica.e2.org/#map.

to gain greater competitive advantages. Although there was not always agreement on exactly how to apply these concepts to existing and emerging sectors—for example, does Pittsburgh's edge in innovation point to a focus on autonomous mobility or advanced manufacturing, or both?—they were viewed as foundational to fully realizing Pittsburgh's "green" potential.

Cross-Sector Efficiency

The potential for increasing sustainability by increasing efficiency of the use of energy, water, and other resources is not a uniquely Pittsburgh opportunity. However, the age of infrastructure and the need to replace, rebuild, and restore these assets presents a unique opportunity for efficiency improvement with marginal investments above what is already going to be required. The building sector was noted as being particularly "low hanging fruit" in both urban and rural areas (philanthropy). It was also noted that energy efficiency often directly benefits households and communities: "it is more economical, has more benefit, meets people where they are" (green nonprofit). In addition to being a potential driver of economic activity and source of jobs (E2, 2024), a focus on efficiency can support equity. For example, low-income households spend a disproportionate percentage of their income on energy costs, resulting in an "energy burden" that is, on average, three times higher than for non-low-income households (U.S. Department of Energy, 2024).

Cross-Sector Innovation

Pittsburgh "punches above its weight" in local "skilled expertise", in the opinion of one workforce/sector-specific interviewee, and many others agreed that the obvious strengths and successes of the regions "eds and meds" can and should be leveraged in sustainable sectors. One educational stakeholder described the combination of educational and research powerhouses like Carnegie Mellon and the University of Pittsburgh with the relatively affordable cost of living in Pittsburgh as "innovation on a budget," stating that "this is where Pittsburgh shines." Many stakeholders noted the ongoing transition from traditional industrial to innovation-driven sectors, e.g., robotics and automation, with some also asserting that this can and should be a relative strength for "green" sectors in Pittsburgh.[13] The greater Pittsburgh region was also noted, due to the relatively affordable cost of living, as a potential hub for remote high-tech workers; this could be bolstered by, and reinforcing for, a robust OR sector.

Conversely, at least four separate stakeholders[14] expressed concern about insufficient funding and support for translating research into innovation, such as a lack of local incubators or accelerators for sustainable sector startups. This is a longstanding issue; it was previously noted

[13] As noted by stakeholders from philanthropy, economic development nonprofits (2), green nonprofit, and an educational institution.

[14] These stakeholders represented educational institutions (2) and economic development nonprofits (2).

that "pre-seed and other startup support activities are insufficient to meet the needs of the city's deep bench of research entrepreneurs, and the gap is only growing" (Andes et al., 2017). This issue is particularly stark in the context of historic federal funding now available, with the lack of "upfront bridge funding for projects eligible for IRA tax credits" being recently described as "in some ways the largest single barrier facing Pennsylvania" to leverage these resources (Freedman Consulting, undated). Relatedly, there was a recognition that to retain highly trained talent coming out of universities, local companies need to have strong connections to schools and offer direct pipelines through internships and other mechanisms.[15]

Barriers and Potential Challenges to the Success of Promising Green Sectors

In addition to general agreement on many of the sectoral opportunities for the Pittsburgh region, stakeholders identified some common key challenges for success. The existence of a mutually agreed upon barriers presents clear opportunities for diverse stakeholders to collaborate on overcoming them. These are described below and summarized in Box 7.

Box 7. General Barriers for Sustainable Sectors

Stakeholders agreed on several issues being challenges for the Pittsburgh region, including:

- The potential for **branding and messaging** of "green" opportunities to miss the mark with some demographic groups
- **Insufficient collaboration and coordination** of existing organizations and entities and the impulse to instead create new organizations and programs to solve problems
- **Insufficient investment** in nascent concepts to bridge the gap from innovation to commercialization
- **Overall demographic trends** that will limit workforce availability for new sustainable sectors and the "greening" of more mature ones.

The Importance of the Right Branding and Messaging for the Right Stakeholders Should Not Be Underestimated

Many stakeholders observed that not all companies, workers, and investors in the region will be attracted to or even comfortable with the idea "green" jobs. This is an issue for both rural regions outside of the Pittsburgh metropolitan core and for communities of color in disinvested urban neighborhoods. For many constituencies, one green nonprofit interviewee asserted that "it's not the 'green' economy, it's the economy". As one private sector interviewee put it: "people hear 'green jobs' and they think 'What does that mean? There is no opportunity for me.'" Based on their own interactions with the private sector, one economic development nonprofit interviewed noted that some employers themselves "get scared" when they hear "green opportunity." Another economic development stakeholder suggested that green jobs are

[15] As noted by stakeholders from the private sector (2), and educational institutions (2).

perceived by urban communities of color as "wonky, white Pittsburgh nonsense" that require "a lot of education." Traditional blue color workers from more white rural communities may view these as "jobs, not careers" due to concerns that the opportunities will be more transient and less lucrative than steel and coal jobs. This lack of cultural connection creates the potential for missed opportunities for equity and inclusion for both urban and rural populations. Mentioning lofty and often abstract goals set by the United Nations, noted one green nonprofit, will have little relevance and interest for many communities and individuals, and the focus instead should be on concepts such as improving health, affordability, or quality of life, not on becoming "greener." Even the term "sustainable" was viewed by stakeholders as being more broadly appealing than "green," illustrating the subtleties of messaging. Finally, it will be important to directly address perception and reality that job quality and quantity may be different in non-traditional sectors, being up front about required training and expected benefits of these new jobs.

Several organizations were mentioned as leaders in culturally resonant sustainability initiatives for rural communities. Coalfield Development, for example, with funding from the Appalachian Regional Commission Power Grant, has an Appalachian ReUse Corridor initiative "invested in reintegrating the traditional values of resource conservation and material reuse within their business models to create jobs, strengthen economies, and build resilient communities"(Coalfield Development, undated). According to one workforce/sector-specific stakeholder, "green" is sometimes viewed as a "threat" to existing jobs or culture, and one educational interviewee suggested that highlighting other elements of green jobs—such as respect for the land or working with ones' hands—may appeal to rural workers and communities. Solar Holler has been successful in a rural area because, in the opinion of one philanthropic interviewee, their value proposition is "practical" and is thus more "culturally appropriate." The potential to deepen interest and broaden the audience through an association with sports was also noted. One private sector interviewee noted, for example, that the PPG Paints Arena was the first NHL venue to be LEED Gold certified, and that both the Pirates (MLB team) and Penguins (NHL team) have waste reduction initiatives. (Pittsburgh Penguins, 2023; Pittsburgh Pirates, undated) This interviewee suggested that increasing awareness of such programs—and expanding them—can build positive associations for fans around "green" initiatives. So, as one interviewee from an economic development nonprofit put it, there are clearly ways to bridge the rural urban divide.

In the same vein, Greening Youth Foundation (GYF) aims "to engage under-represented youth and young adults, while connecting them to the outdoors and careers in conservation. GYF's cultural-based environmental education programming engages children from local communities and exposes them to healthy lifestyle choices to create an overall healthy community."(Greening Youth Foundation, 2023a) GYF's The Bridge Program is a public-private partnership that focuses specifically on bringing under-represented youth into the conservation workforce and "to create an inclusive and innovative hiring pathway that will embolden and diversify conservation employment practices."(Greening Youth Foundation,

2023b) The Student Conservation Association (SCA) works to cultivate "the next generation of conservation leaders" by providing hands-on experiences to "young people of all backgrounds."(Student Conservation Association, 2023) Both organizations have a regional presence.

The common theme across all these organizations and activities is cultural awareness and sensitivity. Stakeholders stressed that social, cultural, and ideological barriers could prevent full participation of the labor force. For example, historically marginalized POC in urban areas may not feel welcome due to historic (and continued) underrepresentation in some of the underlying trades; rural workers may see "green" as an urban elite trend that threatens their culture and way of life; and women may worry that traditional male-dominated fields will remain so even as sectors become increasingly "green." Outreach and appeal to diverse groups can only be successful if these future workers are able to see themselves in these sectors and understand the links between sustainability and the health of their own communities. For example, appealing to a practical, thrifty culture and the naturally "circular" nature of historic economies in rural areas—rather than stressing potentially politically polarizing concepts like "green"—is likely to yield more success in growing these sectors outside of the City of Pittsburgh.

General Lack of Awareness of Job Opportunities Is Problematic

Related to branding and messaging, many stakeholders noted the importance of improving overall awareness of opportunities in sustainable sectors. For example, multiple interviewees[16] expressed the value of educating students about green trades at an early age because high school or college is too often too late for them to change their trajectory. Earlier information can increase and expand interest and better enable students to understand what is needed to get the jobs that are available. Stakeholders from green nonprofit, economic development nonprofit, and educational organizations mentioned the value of better coordination with educational institutes on green building skills and career pathways, both to improve student awareness but also to keep up with industry trends.

Better Communication, Coordination, and Collaboration Is Needed

Interviewees frequently expressed a need for better regional coordination among stakeholders. The perennial problems associated with Pennsylvania's many distinct municipalities were noted, but other issues raised were specific to "green" sectors. Numerous stakeholders[17] lamented insufficient regional "leadership," lack of state-level "strategy," not enough "intention" or "coordination," and too much working in silos, fragmentation, and

[16] This was noted by philanthropic (1), green nonprofit (2), and workforce/sector-specific nonprofit (2) organizations.

[17] These included philanthropic (2), economic development nonprofit (2), and green nonprofit (6) stakeholders.

"talking past" one another, referring to private and public sectors or both. Multiple interviewees[18] expressed concerns about disconnect and "misalignment" of academic institutions with nonprofits and businesses and a desire for more partnerships. One educational interviewee stated that often stakeholders have "no idea" what major companies in the region are doing, which limits the ability to learn from one another. Relatedly, the DISCOVER[19] network has been working to fight fragmentation and "create a shared, inclusive framework for tracking sustainability performance, communicating regional needs and progress, and driving coordinated interventions toward regional sustainability outcomes and policies."(Sustainable Pittsburgh, 2023) Existing organizations and frameworks such as this could be leveraged to improve coordination on "green" economic development.

Other stakeholders[20] expressed frustration with having a difficult time promoting green sectors because it was difficult to figure out the workforce pipeline and the full set of relevant stakeholders. Sector-specific concerns were also noted, such as lack of oversight for the dozens of water and sewer authorities (green nonprofit) and a disconnect between the entities that set local codes and standards, regional planners, and the firms and nonprofits working to put green infrastructure projects in place (private sector). These concerns can stymie the growth of demand for new green goods and services.

On the other hand, one green nonprofit stakeholder expressed the opinion that regional coordination and communication have recently improved, and the existing active links between some training and education organization and employers was noted, especially at the sub-baccalaureate level.[21] There was also some optimism expressed by a workforce/sector-specific nonprofit about the prospects of improvement of collaboration on workforce and other elements required for sustainable transitions given the increasing sense of urgency—and the abundance of funding available right now.

The need to have a shared understanding of opportunities and risks, and the prevalence of "bad information" and "mixed messaging" around the benefits of "green, was noted by philanthropic and workforce/sector-specific interviewee, respectively. There is also potential benefit in broader regional collaboration in some emerging sectors, e.g., a tri-state cooperation on blue hydrogen and carbon capture and storage (CCS), a state-wide system of trails and associated entrepreneurial opportunities.

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[18] These included a green nonprofit, an economic development nonprofit, an educational institution, and private sector organization.

[19] Participants in Defining Intersectional Sustainability to Collaboratively Optimize for a Vibrant and Equitable Region (DISCOVER) are organized into a steering committee and four cross-sector working groups: Equity, Environment, Health, and Infrastructure. See https://sustainablepittsburgh.org/take-action/networks/discover/.

[20] This was expressed by at least one philanthropic and one government stakeholder.

[21] Noted by stakeholders in educational institutions (4).

More Support and Investment for Commercialization Paths Could Be Beneficial

Many interviewees noted the regional technological expertise and innovative ideas being produced by local universities and DOE's National Energy Technology lab. However, the need to financially support and de-risk emerging sustainable industries was noted by multiple interviewees, including the need to incubate, accelerate, and provide seed funding for startups.[22] There was a frustration that "too much IP" is being "left on the shelf" (government interviewee) and that not enough investment was being brought into the region in low-carbon and other sustainability opportunities (private sector interviewee). One educational interviewee expressed the need for connections with sector-specific incubators and accelerators. These are programs that provide funding and expertise to help startups launch successfully: "incubators" are generally focused on innovation and foundational activities, while "accelerators" are typically focused on scaling businesses at a later stage of startup maturity. These could be based in the region or elsewhere and could possibly help with the need to "de-risk" green sectors, as one economic development nonprofit interviewee put it.

Philanthropy too has a potentially important role, as suggested by one green nonprofit stakeholder, in the form of impact investing. By providing initial investments and lowering risk, regional foundations may enable larger amounts of commercial capital to be attracted. Another philanthropic interviewee suggested that organizations in the region have struggled with seizing federal resources because "putting together a package of investment is always a challenge."

Overall, there was a sense of missed opportunity that could be supported by greater financial support and more coordination and organization around going after resources. This sentiment echoes earlier findings that "the difference between the level of innovation inputs (patents, R&D investments, etc.) and the level of economic outputs (jobs, output, and firms in advanced industries) is stark" in the Pittsburgh area (Andes et al., 2017).

Regional Demographic Trends Will Make Finding Workers for Emerging Sustainable Sectors Difficult—But This is Not Unlike Other Sectors, and Not Just a Pittsburgh Problem

Many stakeholders noted that insufficient numbers of existing and future workers would be a challenge, worrying that there will simply not be enough people to fill the jobs. This is certainly not a unique challenge for sustainable sectors (Zaber et al., 2023), but this shortfall underscores the need to increase awareness of opportunities in this sector and to bridge cultural divides, as discussed earlier in this section. Relatedly, providing incentives and supports alongside building awareness of opportunities—such as financial aid, disability support, and childcare (Hofman et

[22] The specific quotes and points provided in the remainder of the paragraph represent the opinion of six different stakeholders, but some version of these general points was made in at least *four additional* interviews: philanthropy (1), government (1), and education (2).

al., 2022b)—could help underrepresented groups contribute to regional economic performance. In other words, building diversity and inclusion and growing the green workforce can be mutually reinforcing.[23] This topic will be explored quantitatively in the next chapter and in several appendixes focused on understanding workforce supply.

Stakeholders Did Not Fully Agree on Some Demand Trends and Opportunities

As noted earlier in this chapter, virtually everyone interviewed for this study recognized the broader societal trends toward greater sustainability, especially decarbonization of the economy. Even individuals and the entities they represented for whom these transitions could be difficult appreciated that successfully navigating the changes might offer once-in-a-generation economic opportunities, and that ignoring or even fighting these changes would be detrimental to their interests long term. But despite the areas of consensus detailed in the previous sections, there was also considerable disagreement on several topics, including what constitute the "best" opportunities for improving the long-term prospects of a healthy economy and environment for the region. The next several sections provide some examples of areas with a lack of clear consensus on direction for Southwestern Pennsylvania.

There Was a Lack of Consensus on the Right Subsector(s) of Focus to Best Leverage the Region's Relative Strengths in the Energy Sector

Interviewees recognized and noted the historical and current-day strengths of Pittsburgh's energy sector, and there was virtually unanimous agreement that "clean energy" can and should be important to Pittsburgh's economic future. Some interviewees, in fact, asserted that this could be the most important "sustainable" sector for the region in economic terms. However, much like definitions of "green" and "sustainable," the term "clean" has different meaning to different stakeholders. Because the switch from coal to natural gas for electric power production can reduce air pollution—both conventional and greenhouse gas emissions—gas is generally accepted to be clean*er* than coal but not without environmental impact and so is not considered to be "clean energy" (Burney, 2020). Similarly, several recently announced "Clean Hydrogen Hubs" plan to use natural gas to make hydrogen—including one of the two projects that involve the Commonwealth of Pennsylvania. Thus, as defined by the DOE, "blue hydrogen" is clean (U.S. Department of Energy, 2023b). But, as discussed below, not all stakeholders agree with this assessment.

Previous analysis indicated that the Pittsburgh region's energy sector was one of only two of eleven identified "advanced industry clusters" for which performance was strong or moderate

[23] One of our reviewers stressed the importance of this point.

compared to the rest of the United States across all categories considered.[24] More recently, multiple energy subsectors have been specifically called out as economic development and workforce opportunities for the region. (Allegheny Conference on Community Development, 2022; Ohio River Valley Institute, 2022a) However, in weighing the pros and cons of these various subsectors, and considering the perspective of different stakeholders, disagreement emerges. Examples of subsectors that elicited mixed stakeholder responses were "blue" hydrogen, solar PV, and advanced nuclear, as discussed in the following sections.

Blue hydrogen

The abundance of shale gas in the region has recently contributed to economic benefits to electricity ratepayers and has substantially lowered the average emissions of electricity generation (Simeone, 2017), but extraction of the natural gas has also been linked to environmental and health issues (Zhang et al., 2022) and is associated with economic "boom and bust" cycles (Klasic et al., 2022). One potential use of the abundant regional natural gas would be to produce "blue hydrogen" via steam-methane reformation combined with CCS of the resulting CO_2 waste (U.S. Energy Information Administration, 2022), a concept that has received a much attention since the Department of Energy announced substantial funding for "Regional Clean Hydrogen Hubs."(U.S. Department of Energy, undated) However, there was considerable disagreement between stakeholders—and mixed feelings for many stakeholders individually—about the desirability of a large-scale blue hydrogen industry in the region. As one green nonprofit interviewee put it, shale gas in the region is both a "complication" and "an opportunity" for sustainable transitions. Box 8 captures some of the conflicting viewpoints.

Those skeptical of the net benefits of a regional industrial hub for hydrogen raised several concerns. One private sector interviewee expressed the opinion that the region should first establish a CCS industry and associated infrastructure before seriously committing to generating hydrogen that depends on CCS, stating that they viewed hydrogen as significant on a longer time horizon than some nearer term applications for CCS. Conversely, one green nonprofit interviewee described the idea of developing new markets for natural gas products such as blue hydrogen as putting too much focus on transitional technologies and not doing enough to focus on long-term sustainability goals. Another interviewee from the private sector expressed skepticism of the importance of hydrogen "on a large scale" but instead suggested hydrogen would find use for more niche applications, indicating a concern about unrealistic expectations for economic development for the region of this sector.[25] A number of interviewees mentioned

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[24] See Table A-8 in Andes et al Scott Andes, Mitch Horowitz, Ryan Helwig, and Bruce Katz, *Capturing the next economy: Pittsburgh's rise as a global innovation city*, Brookings, 2017..

[25] This interviewee did not believe it would be economical—and that it would also be very difficult from a regulatory perspective—to build out extensive hydrogen distribution systems, especially when distribution for

Shell's Butler County cracker plant as an example of something that, in their opinion, was oversold and that has not and will not provide benefits commensurate with downside risks.

Relatedly, some stakeholders mentioned potential health implications of large-scale blue hydrogen production, with one green nonprofit interviewee worrying that disadvantaged communities will bear the brunt of any health burdens. One green nonprofit interviewee asserted that expanding natural gas extraction and adding associated industries such as blue hydrogen and CCS would potentially be "foreclosing opportunities" in outdoor recreation and related areas.

Other stakeholders expressed enthusiasm for the development of a blue hydrogen sector. One educational sector interviewee indicated that, given the central importance of reducing GHG emissions, hydrogen could become an important way to decarbonize some of the top contributors to emissions from the region; they cited industrial applications, e.g., steel and cement, and export of natural gas as sectors where "clean" hydrogen—which they defined to include blue hydrogen—could substantially reduce emissions relative to the status quo. Individuals from one workforce/sector-specific nonprofit went ever further to say that hydrogen "has to" be part of the future green energy solution set for the region. One private sector interviewee believed that the region should maximize investment in natural-gas-based hydrogen and CCS because it is a good fit for the region's assets and, in their opinion, it is going to be "huge." They specifically called out the use of hydrogen to address the intermittency of renewable energy (RE) like wind and solar. Another private sector interviewee noted synergies between a blue hydrogen hub and the CCS infrastructure that would be associated with a regional carbon-negative "21st Century Power Plant,"(Clark, 2022) noting that power and hydrogen production plants could be "anchor tenants" for a robust regional CCS network. And, countering concerns expressed by some stakeholders that a regional emphasis on hydrogen would be negatively impact the overall "sustainable" image of the region, one government interviewee expressed the opinion that it is not necessary to

Box 8. A regional (blue) hydrogen economy?

There is a **lack of consensus** about the feasibility, net benefit, and overall desirability of large-scale regional production of hydrogen from natural gas, coupled with carbon capture and storage (CCS), also known as "blue" hydrogen.

- A regional hydrogen industry has been described as having "**great potential**" but also "**many risks and challenges**" (Gough, 2022)
- Some groups view blue hydrogen as a **key component of decarbonization** of the energy sector (Allegheny Conference on Community Development, 2022)
- Others have called the concept "**costly, unproven, and significantly less effective** than other means of reducing climate-warming carbon emissions" (Ohio River Valley Institute, 2022b)

The U.S. Department of Energy's recently awarded "Clean Hydrogen Hubs" include funding for a WV-OH-PA consortium which is intended to test the concept at scale and, in theory, resolve some of this uncertainty around the technology and its potential impacts, positive and negative, for the region (U.S. Department of Energy, 2023b).

natural gas and electricity already exist. They saw potential for applications such as such as long-haul freight or on-site energy storage for utility-scale renewables, but not for things like electricity generation or use by individual homes.

choose between extractive industries and "green" sectors such as outdoor recreation, citing the success and pervasiveness of both in the state of West Virginia as an example.

In addition to the fact that stakeholders were divided on opinions of a regional hydrogen industry, there is already considerable interest and support for a hydrogen hub from the governor of PA (and of neighboring WV and OH), industry, and other interest groups. The U.S. DOE has put significant resources on the table for Hydrogen Hubs, and there are multiple coalitions of organizations that submitted applications to be funded. For example, the Decarbonization Network of Appalachia (DNA) Project Team, led by Team PA, included Shell and Mitsubishi Power Americas (Team Pennsylvania, 2023). Regardless of the outcome of the DOE awards, the success of a regional hydrogen industry will require overcoming regulatory barriers (e.g., citing pipelines for hydrogen distribution, permitting CCS locations) to make natural gas-derived hydrogen viable in the context of climate mitigation. These are issues that public and private sector stakeholders are actively working but are not trivial and will require substantial infrastructure investment.

Solar Photovoltaics

There was strong agreement from stakeholders that there is much room for expansion of RE as an important tool for decarbonization, especially solar photovoltaics (PV) for electricity production, in Southwestern Pennsylvania and the greater Commonwealth. More than a dozen interviewees called out the untapped potential of solar. Multiple stakeholders expressed frustration with insufficient leadership and a need for more supportive policies at the state level,[26] including lowering barriers to community solar projects. The need to build the workforce for installing solar was also noted by at least one green nonprofit and one private sector interviewee, including the potential to expand if the sector can attract a more diverse set of potential workers and increase the representation of women and people of color.

However, there was disagreement among stakeholders about the magnitude and duration of the potential positive economic impacts of PV, with many noting the inherent limitations of solar in the Commonwealth.[27] An important distinction was observed between the potential economic impact and jobs associated with PV manufacturing—the region has little relative advantage for fabricating solar wafers or making solar panels but *does* have the potential to support the solar supply chain in other areas, such as utility scale trackers (Singla, 2022) —and jobs at the other end of the solar supply chain, e.g., installation and long-term operations and maintenance

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[26] This issue was raised by philanthropic institutions (2), economic development nonprofits (2), a green nonprofit, a workforce/sector-specific nonprofit, and a government organization.

[27] This was both a general statement about the inherent limitations of solar to provide firm power—which gets increasingly difficult and expensive to manage as solar penetration increases—as well as a specific statement about the resource in the region. On the latter see: solar-annual-ghi-2018-usa-scale-01.jpg (5101×3301) (nrel.gov).

(O&M). With respect to the potential of installation and O&M workforce, several interviewees[28] expressed concern about low pay for these jobs, especially relative to the types of (generally unionized) jobs associated with traditional energy production. The flip side of this, of course, is that less training is often required for solar installation jobs than is for becoming an electrician, opening opportunities for low- and semi-skilled workforce. And one economic development nonprofit interviewee cautioned that the region should not get "wrapped up" in debating whether the region should or should not be emphasizing solar, but rather should allow an "all of the above" approach to happen more organically with general policies that support innovation and decarbonization.

Advanced Nuclear

Several interviewees mentioned the regional economic development and decarbonization potential of nuclear, especially advanced nuclear including small modular reactors (SMRs). As one economic development nonprofit stakeholder put it, nuclear "very likely" has an important role to play in decarbonization for the region. One educational interviewee suggested that nuclear could continue to be a major contributor of "firm power" for the region, paired with other things like intermittent RE and storage. One private sector interviewee suggested that SMRs be located on existing nuclear or coal power sites, with another private sector interviewee stating that their company was considering both nuclear and solar at the site of at least one formerly coal-powered facility. Indeed, the concept of deploying SMRs in this way is receiving attention throughout "coal country" and beyond (Halper, 2023). One workforce/sector-specific interviewee saw potential being electricity generation, such as providing heat for manufacturing or industrial sites, or for producing "pink" hydrogen. However, nuclear was not mentioned in stakeholder discussions nearly as frequently as blue hydrogen or solar, and one economic development interviewee called out the barrier of low public acceptance of nuclear and the influence of public opinion on important state policies. It is also certainly the case the current focus on hydrogen opportunities has captured much of the regional bandwidth for potentially large-scale emerging energy technologies.

Manufacturing and Industrial Sectors

The mixed sentiments around the industrial and manufacturing sectors expressed by stakeholders were not unlike those related to energy. Namely, there was a general recognition of the historic importance, and the corresponding regional strengths, of industrial sectors. But there was some disagreement around what the future of these sectors can and should look like for the region and whether "green" manufacturing and industrial should be an area of emphasis. One

[28] This was noted by representatives from the private sector (2), a workforce/sector-specific nonprofit, and an educational institution.

philanthropic interviewee called out the rural manufacturing workforce as an important regional asset while an educational interviewee suggested that a "listening tour" of the region would be needed to really understand the underlying regional skillsets and determine if the workforce sees manufacturing as a future which they want to be a part of. Another interviewee from a workforce/sector-specific organization expressed the concern that education and information is limiting the promise of manufacturing, and that many people do not really understand what a manufacturing of the future job entails. This interviewee also noted an increasing interest in remote work, and the difficulty of supporting that preference in the manufacturing sector.

The concern that Pittsburgh is still "smoke stack chasing" rather than pursuing forward-looking opportunities was raised by one philanthropic interviewee, who specifically called out green steel as an example of an industry that could and should have been a Pittsburgh idea first.[29] Divided opinions on the Shell cracker plant are illustrative: one economic development nonprofit interviewee described it as a "huge win" for local manufacturing and supply chain but at the same time noted the general lack of public support for a plastics industry as a key component of regional economic development.

Some stakeholders enthusiastically noted a range of potential areas of focus for manufacturing—from batteries to green modular buildings—most of which had at least one existing firm in the region to point to. Workforce/sector-specific stakeholders were particularly bullish, mentioning SMRs, hydrogen and associated industries, and a reinvigorated steel sector. And stakeholders rightly noted the core regional strengths that can be leveraged for advanced manufacturing—such as innovation in automation, robotics, and artificial intelligence. But there was no consensus on a specific sector for focus, and some expression that our industrial days are (or should be) behind us and that continued attention in these areas is based more on nostalgia than objective assessment of opportunity.

Regional Approach to Focusing Efforts and Overall Outlook on the Region's Prospects

As noted in the previous several sections, differences of opinion arose regarding the "right" areas of focus for sustainable sectors in the region. Relatedly, there was also a lack of consensus on whether such a lack of consensus is problematic. As one economic development nonprofit put it when asked what areas of sustainability are particularly promising for the Pittsburgh region: "I don't know… and that is maybe both our biggest opportunity *and* weakness." For comparison, they said that anyone in the "energy transformation" business in Houston would be able to provide a discrete list of products for which they aim to lead the world, whereas if you ask the same question in Pittsburgh, "you will get 100 different answers." They viewed this as problematic, and said they hoped that that the region could come together to identify a finite list of technologies or "clusters" on which to focus which build on regional strengths (e.g., AI,

[29] The interviewee specifically referred to Boston Metal (Decarbonizing Steel Production – Boston Metal).

manufacturing, green buildings) and for which a competitive cost advantage can be sustained. A second economic development interviewee expressed the view that the region needs to be more "intentional" about opportunities and associated workforce development because there is no consensus about what a successful green economy would look like. Others interviewed argued for the value of a diversified, multi-sector approach. One green nonprofit interviewee pointed out that the very nature of sustainability is "so multi-pronged" that the region needs to move forward on many fronts.[30]

One interesting qualitative distinction observed between stakeholders was the level of optimism for, or confidence in, the economic prospects of the region, which seemed to be greater for interviewees *not* based in southwestern Pennsylvania. Individuals with statewide or national organizations generally viewed the diversity of the region's economy—one of the most diverse in the country, by one interviewee's account—as a great strength. Whereas representatives from local and regional entities frequently worried about the region not having enough focus and coordination across organizations—and associated past and potential future missed opportunities—one interviewee from outside the region assessed that Pittsburgh does a good job defining economic its directions and of self-advocating at the state level. A second state-level perspective was that Pittsburgh's innovation and entrepreneurship environment is as good if not better than anywhere else in the Commonwealth and that there is a strong sense of collaboration—of shared "purpose"— which is fostered in part by the generosity and vision of the local philanthropic community. They specifically called out Carnegie Mellon as doing a good job, relative to peer organizations, of getting ideas to market. In contrast, some regional stakeholders felt that the region has been relatively unsuccessful of tech-to-market transitions.

The Role of Policy

Most interviewees agreed new or modified policy will be needed to seize the opportunities of evolving and emerging sustainable sectors. As stated by one green nonprofit interviewee: "Government has a huge, huge role to play" in creating incentives. Disagreement was found, not surprisingly, on what stakeholders believe good policy looks like. On the one hand, one education sector interviewee stressed the need for "regulatory pressure" to enable green transitions. Interviewees recommended some specific policies that might apply such pressure, from local to federal, and many singled-out gaps or weakness in state-level policy. On the other hand. some—but notably not all—private firms and associated organizations advocated for softer levers, "carrots" rather than "sticks." As one private sector interviewee put it, "incentivizing behavior, generally, is always better than regulating behavior" for increasing the sustainability of

[30] This stakeholder was primarily focused on the *deployment* side of sustainable technologies and ecosystem sustainability in these remarks, so the comments are somewhat distinct from others made regarding manufacturing and production of technologies.

goods and services produced by firms and for encouraging internal-facing initiatives in environment, social, and governance (ESG), too. However, there are some opportunities which may not be fully realized in the absence of regulation, such as circularity and extended producer responsibility (EPR) laws.

As an example of differing opinions, the RAND team discussed Regional Greenhouse Gas Initiative (RGGI) (Pennsylvania Department of Environmental Protection, undated) with multiple interviewees, with generally positive support of the policy but by no means a consensus on its importance relative to other policies, or on its chances of full implementation. One philanthropic interviewee stated the Commonwealth's delay in joining RGGI was an example of how state policy (or lack thereof) slows down progress on sustainability and associated economic opportunity. One private sector interviewee described themselves as a "big fan" of Pennsylvania joining, while other interviewees declined to provide comment on RGGI at all. One green nonprofit interviewee noted that RGGI is not the only way to achieve intended outcomes of reducing emissions and gave renewable portfolio standards (RPSs) as an example of another mechanism that can produce similar outcomes.

Chapter 4. Key Findings on Potential Workforce Supply for Sustainable Sectors

The previous chapter brought together stakeholder insights on the sustainable sectors that are likely to continue to grow in the Pittsburgh region. These sectors—agriculture, circular economy, energy, green buildings, manufacturing, water management, and outdoor recreation—are those that are likely to generate and/or increase the demand for a workforce who can bring the right skills to related jobs. Will the region be able to supply such a workforce? Do we have workers ready to step into these jobs now? What about in 2 and 10 years from now?

Here, we answer these questions by first sharing insights on workforce supply issues from our interviews with stakeholders. We then examine the skills and knowledge needed by workers supporting the major Pittsburgh sectors. Finally, we assess the current workforce's ability to support the growth of these sectors in the short-, and medium terms. To assess the region's capacity to build and maintain a skilled green workforce in the longer term, we reviewed opportunities in postsecondary learning, professional credential programs, apprenticeships, and other training prospects.

Quantitative Analysis of Workforce Supply for Sustainable Sectors

To understand if the region has – and will continue to have – enough workers able to support and grow the important sustainable sectors identified through stakeholder interviews, we first identified the occupations expected to contribute to each sustainable sector and assessed the current supply of workers in those occupations in the Pittsburgh region. This analysis sheds light on the short-term potential to expand in sustainable sectors. We then used data on the specific knowledge, skills, and abilities required—both for occupations needed in sustainable sectors and other occupations—to determine whether there are non-green jobs that have considerable overlap with green jobs in terms of what's required for them. Workers in these occupations might be able "step into" jobs in a burgeoning green economy over the medium term, with the timeline varying based on the nature of the differences that do exist between the jobs needed for sustainable sectors and the occupations that are relatively close to them.

Last, to understand how the region might sustain green economic growth over the longer term, we looked across the region's current education and training landscape. Existing programs could help prepare workers for occupations needed in each of the sustainable sectors. Most sectors will require a workforce with a mix of levels of education and training to mature, from workers with a high school diploma and a few months of on-the-job training to those with advanced degrees. Thus, it was critical to understand if there are enough opportunities for people

needing to obtain the degrees, professional certifications, apprenticeships, and other forms of training that would enable them to work towards growing the green economy.

Short Term Outlook: the Pittsburgh Region Has a Relative Workforce Advantage in Some Occupations

We first sought to understand strengths and weaknesses of the existing regional workforce in occupations needed to generate growth in the green economy. To do this, we first needed to determine the set of occupations expected to contribute to each green sector. We leveraged prior work which identified 12 green sectors and the occupations needed for them based on a large and comprehensive literature review (Dierdorff et al., 2011). Importantly, this analysis included the specific occupational codes for the occupations that appear in Bureau of Labor Statistics data. We cross walked the 12 sectors defined in that study to the seven sectors described in our stakeholder interviews, finding generally good overlap except for outdoor recreation. As a result, while we could determine which occupations are needed for most of the sectors from our stakeholder interviews by looking at the literature cross-walked occupations, we needed to take an alternative approach for outdoor recreation. In that case, we consulted a list of occupations developed by sector experts (108) and used Census data (109) to determine the most appropriate occupational code for the occupation. Appendix B provides additional details on our approach to bounding the set of green occupations in our analysis.

It is important to note upfront that not everyone in these occupations could be considered working in the green or sustainable economy at present. In fact, in many cases, the jobs might not strike a casual observer as being especially "green" at all. Rather, these are occupations expected to be needed to support the green economy and its expansion. Many green jobs are largely *"just jobs"* – that is, many jobs needed in a green economy are the same jobs, from a skills perspective, that are needed in the traditional economy. For example, green companies need accountants and stock and material movers, and these workers in non-green companies would not need further education or skills training beyond on-the-job-training to move into a job in the green economy. This reality creates a tension between, on the one hand, wanting to take advantage of regional marketing benefits associated with a robust green industry and an interest by some stakeholder groups in creating associated specialized green training and, on the other, the reality that many of the skills needed are, in fact, general ones that do not always require new programs and that green branding might not even appeal to everyone.

In total, we identified 162 occupations as "green" by virtue of being among the set of occupations needed for one or more of the seven sustainable sectors we analyzed; 138 of these had Pittsburgh-area data available in BLS' 2021 Occupational Employment and Wage Statistics

(OEWS) program, the most recent data available at the time the analysis was conducted.[31] We consider two key measures from the OEWS data in assessing whether the existing workforce in occupations needed for sustainable sectors likely is large enough in size to support an expansion of the sustainable sectors. First, we look to the ratio of the share of employment in the occupation locally to the national share of employment in the occupation, known as the location quotient. When this is greater than one, it means the Pittsburgh area has a disproportionate share of workers in the occupation and would be at a relative advantage when looking to grow in sectors that draw upon the occupation. Second, we consider the raw number of workers in the occupation. We use 1,000 as a rough gauge of whether there are enough workers in the occupation to expect some could support the green economy without disadvantaging other local industries, but this threshold is ultimately somewhat arbitrary.

Table 4.1. Top 5 Occupations by Location Quotient, Overall and Among Occupations Employing At Least 1,000 People, Pittsburgh Metropolitan Statistical Area, 2021

Occupation Title	Total Employment	Location Quotient	Sustainable Sectors
Overall			
Nuclear Technicians	300	7.52	Clean energy
Service Unit Operators, Oil and Gas	880	3.62	Clean energy
Electro-Mechanical and Mechatronics Technologists and Technicians	270	3.20	Circular economy; Advanced manufacturing; Cross-sector
Health and Safety Engineers, Except Mining Safety Engineers and Inspectors	400	2.33	Circular economy; Advanced manufacturing
Nuclear Engineers	220	2.31	Cross-sector
Occupations with Employment of At Least 1,000			
Mechanical Engineers	4,130	2.01	Circular economy; Clean energy; Green buildings; Cross-sector
Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	3,800	1.89	Circular economy; Advanced manufacturing
Computer Numerically Controlled Tool Operators	2,190	1.87	Circular economy; Advanced manufacturing
Operating Engineers and Other Construction Equipment Operators	5,010	1.67	Circular economy; Green buildings
Bus Drivers, Transit and Intercity	1,750	1.63	Clean energy

SOURCE: Bureau of Labor Statistics, Occupational Employment and Wage Statistics, 2021
NOTE: "Across sectors" indicates that occupation expected to contribute to all sustainable sectors by virtue of inclusion among the set of occupations needed for the Research, Design, and Consulting Services, and Government and Regulatory Administration sectors as defined in the literature (Dierdorff et al., 2011). Specific sectors are listed as well when the occupation also is needed for one of the other ten sectors and that sector crosswalks to the sustainable sector based on the crosswalk presented in Appendix B.

[31] The Pittsburgh area in the Bureau of Labor Statistics Occupational Employment and Wage Statistics program is defined as the seven-county Metropolitan Statistical Area including the counties of Allegheny, Armstrong, Beaver, Butler, Fayette, Washington, and Westmoreland.

Table 4.1 above displays the top five occupations by location quotient, overall and among occupations employing 1,000 or more people locally. The rightmost column lists the sustainable sectors to which the occupation is expected to contribute based on our mapping against the 12 literature sectors to the seven sustainable sectors we analyze in Pittsburgh. Employment and location quotient data for all green occupations across all sustainable sectors is presented in Appendix C, Tables C.1 and C.2. The detailed appendix tables provide information on areas of comparative strength and weakness in the region. For example, among occupations with more than 1,000 workers locally, the five with the lowest location quotients are shipping, receiving, and inventory clerks; miscellaneous assemblers and fabricators; production, planning, and expediting clerks; industrial truck and tractor operators; and business operations specialists, all other. The appendix tables also include information on the median wage and typical education and on-the-job training requirements for each green occupation.

From a raw numbers standpoint, occupations needed for sustainable sectors currently employing the most people in the Pittsburgh area include retail workers (who might opt to work in a growing outdoor recreation sector), general and operations managers, truck drivers, maintenance and repair workers, and construction laborers (see Table B.2 in Appendix B for the top ten). Relative to other parts of the country, strengths include several occupations needed to expand the circular economy, energy, green buildings, and manufacturing sectors. Workers in these occupations are well-positioned to step into jobs in sustainable sectors immediately, drawing upon the knowledge and skills they already have, only needing on-the-job training in company- or position-specific aspects of the job to get up to speed.

Overall, 339,060 workers were in an occupation that will be needed to support or expand one or more of the seven sustainable sectors, or about one-in-three workers in the Pittsburgh area according to the 2021 OEWS data. This matches the portion of the regional workforce in occupations needed for the sustainable sectors from our analyses of American Community Survey (ACS) data, despite several differences between the surveys that prevent a direct comparison of counts of workers.[32] Our ACS analyses found that the share of workers in these occupations is slightly higher in counties in the Pittsburgh region outside Allegheny County (35 percent) than in Allegheny County itself (31 percent). With respect to the demographic

[32] There are several differences between the OEWS and ACS data that prevent a direct comparison of counts of workers in green occupations in the Pittsburgh region. OEWS data are from BLS' May 2021 estimates and reflect counts of employed workers during the reference period for this survey of employers. The ACS data we used are from the five-year Public Use Microdata Sample (PUMS) spanning 2017 to 2021 and include unemployed and part-year workers who reflect potential labor supply not captured in the OEWS. Additionally, in some cases, multiple occupations in the OEWS data combine to form an occupation in the ACS data, and we identified green occupations in the ACS by calculating employment-weighted shares of the ACS occupations that were green occupations in the OEWS data. Last, while OEWS data are for the seven-county Pittsburgh MSA, ACS data from the PUMS include three non-MSA counties within a Public Use Microdata Area that includes an MSA county, resulting in the ACS analyses including three more counties (Greene, Indiana, and Lawrence). See Appendix F for details on our ACS analyses. See (8) for further discussion of differences between the OEWS and ACS data.

characteristics, workers in these occupations are overwhelmingly white, non-Hispanic (89 percent, higher than the region's labor force overall), and a much smaller proportion is female than in the labor force overall (26 percent versus 47 percent). Workers in occupations needed for the green economy are less likely than the labor force overall to have a bachelor's degree, with 38 percent with at least a bachelor's degree versus 43 percent of the workforce overall, with the lowest shares with a bachelor's degree in occupations supporting the manufacturing, circular economy, and green buildings sectors (at 22, 25, and 27 percent, respectively). Appendix F includes additional details on the demographic characteristics of workers in these occupations.

Mid-Term Outlook: the Pittsburgh Region Can Grow its Green Workforce by Upskilling or Reskilling Workers in Jobs That Share Similarities with Green Occupations

Though the Pittsburgh area already has a strong labor supply in many occupations needed to support growth of sustainable sectors, this is not universally the case, as occupations low in numbers or with low location quotients in Tables C.1 and C.2 suggest. In these cases, it would not be sufficient for workers employed in occupations needed for the green economy but working in non-green companies or roles to simply "swap" their jobs for similar jobs more clearly focused on sustainability. Rather, workers in other occupations would need to be retrained for the occupations needed for the green economy, or young people just starting their careers would need to pursue education and training aligned with those occupations.

We begin by considering occupations that share similarities with the occupations needed for the green economy, which might be considered a latent potential labor supply for the green economy; with just a bit of targeted education or training, these workers could contribute to a green economy expansion over the medium term. To identify these "close" occupations, we use O*NET data regarding on the knowledge, skills, and abilities required for each occupation, as well as other characteristics of the jobs, building off the approach used in previous RAND analysis (Wenger et al., 2017; Wenger, Hastings Roer, and Wong, 2023). Across 232 occupational attributes, we calculate a distance measure from each occupation to each other occupation, normalizing this on a scale of zero to 100 with 100 indicating perfect alignment. We define any occupation scoring at least 80 using this measure of distance when comparing it to one of the "green" occupations as a "green close" occupation, meaning that it has considerable overlap with one or more green occupations.[33] In total, we identified 123 occupations that were "close" to one or more of the 138 occupations on the initial list of occupations needed to help grow the region's green economy.

[33] We chose 80 as the threshold so that most green occupations had at least one close occupation. However, this threshold is somewhat arbitrary. We conducted sensitivity analyses varying the threshold and identified 82 green close jobs using a threshold of 90 and 511 using a threshold of 70 (compared to the 123 with a threshold of 80).

Table 4.2 displays the five "close green" occupations with the highest location quotients (indicating a relative advantage for the region) from among those "close green" occupations employing at least 1,000 people in the Pittsburgh area. Tables C.5 and C.6 provide this information for all 123 "close green" occupations. Workers in occupations listed in Table 4.2 and in appendix tables are broadly like occupations needed for a green economy expansion along numerous dimensions. However, there are specific knowledge or skill attributes on which they differ from green occupations, and targeted on-the-job or short-term training programs might be needed to bridge those differences and facilitate these workers' entry into occupations needed in sustainable sectors.

Table 4.2. Top Five Green Close Occupations with at Least 1000 Employees, by Location Quotient, Pittsburgh Metropolitan Statistical Area, 2021

Occupation title	Total employment	Location quotient
Private Detectives and Investigators	1,020	4.80
Title Examiners, Abstractors, and Searchers	1,420	3.75
Compensation, Benefits, and Job Analysis Specialists	1,320	2.04
Eligibility Interviewers, Government Programs	1,860	1.66
Mobile Heavy Equipment Mechanics, Except Engines	1,740	1.62
Operations Research Analysts	1,180	1.61
Child, Family, and School Social Workers	3,890	1.54
Medical Secretaries and Administrative Assistants	6,880	1.42

There are limitations to drawing upon this latent labor supply, however. Occupations close to the types of green jobs where Pittsburgh is comparatively weak might not exist in ample supply in the Pittsburgh region either. The "green close" jobs might offer comparatively higher wages or require higher levels of educational attainment than the green jobs, making workers in those "green close" jobs less likely to want to transition to a green job.[34] Or there might not be a common set of attributes on which the "green close" jobs differ from the green jobs around which to base a targeted training program. Appendix E works through an example of how this analysis can be leveraged to understand the potential medium-term labor supply for a single occupation (structural iron and steel workers) and a single green economy sector (the circular

[34] OEWS data show an average annual wage across green occupations in the Pittsburgh area of $60,600 versus an average annual wage of $62,800 in close green occupations, suggesting that in the aggregate, there might be a slight disincentive to transition from a close green to a green occupation. However, excluding retail salespersons and fast food and counterworkers (needed for an expansion of the outdoor recreation economy), the finding reverses, showing average wages of $66,000 for the remainder of green occupations. In any case, these aggregate comparisons have significant limitations; each individual green occupation will vary in terms of its wage premium or lack thereof relative to non-green occupations that are close to it. Appendix E includes an example of a specific occupation and occupations close to it, some that pay more and others that pay less than the green occupation.

economy). It suggests potential to bolster the supply of labor for the green economy by drawing on workers in "green close" occupations but also that there are no silver bullets.

Longer-Term Outlook: the Pittsburgh Region Can Grow its Green Workforce Through the Local Education and Training Pipeline

Over the longer term, workers entering occupations needed for a green economy expansion might come from wholly different occupations or directly from their secondary or postsecondary education and training into the workforce. Workers with all levels of education and training are needed to help expand Pittsburgh's green economy. Table 4.3 shows that more than half of existing jobs in green occupations needed typically do not require education past high school for entry. For most of these positions not requiring education past high school, workers can usually become competent with less than a year of on-the-job training, as shown in Table 4.4. In addition, the region's sixteen high school career and technical education centers offer programs that enable high school students to earn industry-recognized entry-level credentials in construction, manufacturing, and other skilled occupations.

Table 4.3. Typical Education Needed for Entry to Green Occupations

Typical education needed for entry	Percentage of all green occupations	Percentage of current green jobs, Pittsburgh region
Advanced degree	3	<1
Bachelor degree	39	29
Associate degree	9	2
Postsecondary nondegree award	3	7
Some college, no degree	1	4
High school diploma or equivalent	36	33
No formal educational credential	9	25
Total	100	100

SOURCES: BLS, Occupational Employment and Wage Statistics, 2021; BLS, Occupational Employment Projections Data, 2021-2031.
NOTE: Percentage of all green occupations calculated as a share of the full set of 162 green occupations with data available in the 2021 OEWS; data for 24 of these occupations are not available for the Pittsburgh MSA due to data suppression likely indicating small numbers of workers in the occupations.

Table 4.3 also shows that building up a Pittsburgh green economy *to last* will also require workers with more developed technical knowledge and problem-solving skills that are best acquired through more formal routes. These include short- and long-term certificate programs (i.e., postsecondary nondegree awards) as well as associate, bachelor's, and advanced degree programs. In the sections below, we consider whether the Pittsburgh area offers such postsecondary opportunities for young people and workers looking to "upskill" or "reskill" to enter a green occupation. We also investigate whether there are apprenticeship positions available for the occupations that demand them, and briefly explore other training opportunities for occupations needed for the green economy.

Table 4.4. Typical On-the-Job Training Needed to Attain Competency in Green Occupations, Occupations Typically Not Requiring Postsecondary Education for Entry

Typical on-the-job training needed to attain competency	Percentage of All Green Occupations	Percentage of Current Green Jobs, Pittsburgh MSA
Apprenticeship (~3-5 years)	4	4
Long-term on-the-job training (>1 year)	5	3
Moderate-term on-the-job training (1-12 months)	22	14
Short-term on-the-job training (<1 month)	9	32
None	6	6
Total	45	58

SOURCES: BLS, Occupational Employment and Wage Statistics, 2021; BLS, Occupational Employment Projections Data, 2021-2031.
NOTE: Percentage of all green occupations calculated as a share of the full set of 162 green occupations with data available in the 2021 OEWS; data for 24 of these occupations are not available for the Pittsburgh MSA due to data suppression likely indicating small numbers of workers in the occupations.

Postsecondary Education

Each year, postsecondary institutions report their program offerings, enrollments, and program completions to the U.S. Department of Education's Integrated Postsecondary Education Data System (IPEDS). We used 2020-2021 IPEDS data to examine these factors to assess how well the region's community colleges, public four-year schools, nonprofits and private, for-profit schools, and vocational institutes can support the growth of a skilled green workforce.

The analysis shows that Pittsburgh-area higher education institutions offer a range of programs that prepare people to work in green occupations, with 31 providers in total offering at least one such program—about half of the 63 providers in the region included in the IPEDS data. Table 4.5 tabulates providers by credential levels offered and by green sector, based on whether their programs offer preparation for occupations needed for an expansion of each sector. The most common credential offering in a program area aligned with green occupations is a sub-baccalaureate certificate, offered by 25 providers across the region. These sub-baccalaureate credential offerings are concentrated in program areas that lead to jobs in green occupations needed for an expansion of the circular economy, energy, green buildings, and manufacturing sectors. Associate degree programs are fewer in number but display a similar pattern in terms of their distribution across sectors (i.e., the sectors needing workers in the occupations for which their programs offer preparation).

A little more than half (17 of 31) of providers with programs that prepare workers for green jobs offer bachelor's degrees in those program areas while a little less than half (13 of 31) offer either master's or doctoral programs in areas that may lead down a path to a green job. These bachelor's and higher degree offerings are more evenly distributed across green sectors (aside from agriculture and green buildings. We identified just one bachelor's degree program aligned with an occupation in the green buildings sector (Carnegie Mellon's environmental design and architecture program), and Pennsylvania State University was the only provider with bachelor's and advanced degree programs leading to green occupations needed in the agriculture sector.

Table 4.5. Green Education and Training Providers, by Green Sector and Credential Level, IPEDS Institutions Pittsburgh Metropolitan Statistical Area

	Advanced Degree	Bachelor Degree	Post-Bacc. Certificate	Associate Degree	Sub-Bacc. Certificate	Total Providers
Agriculture	1	1	0	1	1	1
Circular Economy	9	13	7	14	19	28
Energy	9	10	8	11	17	26
Green Buildings	6	1	6	9	15	23
Manufacturing	4	13	3	12	18	26
Water Management	7	15	4	5	5	20
Outdoor Recreation	11	15	8	10	12	22
Cross Sector	10	16	10	9	13	22
Overall	13	17	11	16	25	31

SOURCE: RAND analysis of data from IPEDS.
NOTE: Total providers column may not equal the sum of the columns by credential because providers may offer green programs at multiple credential levels. Overall row may not equal the sum of the rows by green sector because the sectors are not mutually exclusive. Cross sector category includes occupations in the Research, Design, and Consulting Services, and Government and Regulatory Administration (Dierdorff et al., 2011).

In total, programs at Pittsburgh-area providers offering preparation for green occupations had nearly 28,000 completions across credential levels in 2020-21. This reflects about 45 percent of program completions in the region across all program areas (totaling about 60,000). Though we are unable to gauge the maximum possible throughput of individuals through these programs using the IPEDS data, these numbers show that a sizable portion of the region's higher education infrastructure is already engaged in delivering programs preparing people for jobs needed to expand green economy sectors. Table D.4 in Appendix D provides completion data broken down by credential level, with bachelor's degrees accounting for the largest number of completions and having the largest share of completions in program areas aligned with green occupations.

Registered Apprenticeship Programs

Apprenticeship programs, often sponsored by labor unions or individual private businesses, pair on-the-job training in an occupation with related instruction. The U.S. Department of Labor and, in Pennsylvania, the Department of Labor and Industry's Apprenticeship & Training Office oversee *registered apprenticeship* programs (Collins, 2021). These programs must include at least 2,000 hours of on-the-job training and 144 hours of related instruction, provided either by the apprenticeship sponsor or a partner postsecondary institution (Pennsylvania Career Link, undated-a). Apprenticeships result in earning an industry-recognized credential while earning a paycheck (Apprenticeship USA, 2023). They are most common in the construction trades and utilities sectors though there are ongoing efforts to expand their use in other sectors (Elliott et al., 2022; Goger and Sinclair, 2021). We analyzed the U.S. Department of Labor's Registered

Apprenticeship Partners Information Database System (RAPIDS), to identify which green occupations have apprenticeship programs available in the Pittsburgh area.

Our analysis identified 226 active apprenticeship programs in green occupations in the Pittsburgh region. These are split roughly in half between those in Allegheny County and one of the six surrounding counties. Table 4.6 shows that there are large numbers of programs in occupations needed for an expansion of the circular economy, energy, green buildings, and manufacturing sectors, and few to no programs in occupations needed for the agriculture, water management, and outdoor recreation sectors. In total, there are nearly 4,000 active apprentices in apprenticeship programs in occupations needed for an expansion of the green economy (as of the fourth quarter of 2022), or nearly 80 percent of all active apprentices across all occupations.

Table 4.6. Registered Apprenticeships in Green Occupations by Green Sector, Pittsburgh Metropolitan Statistical Area, Allegheny versus Surrounding Counties, Fourth Quarter 2022

	Pittsburgh Region Overall	Allegheny	Surrounding Counties
Total Number of Programs in Green Occupations	226	110	116
Agriculture	0	0	0
Circular Economy	213	98	115
Energy	110	46	64
Green Buildings	105	67	38
Manufacturing	125	42	83
Water Management	2	1	1
Outdoor Recreation	11	10	1
Cross Sector	13	8	5
Total Number of Active Apprentices in Programs in Green Occupations	3,927	2,718	1,209

SOURCE: U.S. Department of Labor, Registered Apprenticeship Partners Information Database System, Fourth Quarter 2022.
NOTE: Registered apprenticeship program refers to a registered apprenticeship in an occupation at a provider categorized using the O*NET-SOC system. Providers that offer apprenticeships in multiple occupations are multiple counted in this analysis. Total of green sectors does not match total number of programs because occupations may be in multiple green sectors. Cross sector category includes occupations in the Research, Design, and Consulting Services, and Government and Regulatory Administration (Dierdorff et al., 2011).

When ranking these programs by number of active apprentices for green occupations overall, we found that carpenter apprentices, with more than 1,200, were largest in number. They were followed by electricians and plumbers, pipefitters, and steamfitters. Among these occupations, the one with the most individual programs is machinists (74 providers), but each provider has fewer active apprentices than the providers for occupations with more active apprentices on this list (the three occupations mentioned above plus operating engineers and other construction equipment operators and sheet metal workers). Though we did not explore whether each of these apprenticeship programs is at capacity, and therefore are unable to estimate the maximum possible throughput of the programs, interviewees indicated that some union-affiliated programs have demand that outstrips their capacity to offer training. A program announced by the Pennsylvania governor's office in July 2023 (Pennsylvania, 2023) could help to mitigate training

supply constraints by incentivizing on-the-job training (including apprenticeships) at employers receiving funds through the Investment and Jobs Act or the Inflation Reduction Act.

Additional Training Providers

The Pittsburgh region also offers training programs not tabulated in IPEDS or the apprenticeship data that can prepare people to enter or upskill for the growing green economy. These include higher education institutions offering programs that do not yield credit-bearing credentials and other public and private training services for which eligible recipients may receive funding through federal workforce development programs. We used January 2023 Pennsylvania CareerLink data to identify which programs and providers on the Eligible Training Provider List (ETPL) (providers offering programs eligible for federal workforce development funding) offered education or training programs that prepare people for green occupations.

This part of the analysis identified eight additional providers offering 35 individual programs aligned with green occupations that were not captured in the higher education- and apprenticeship-related analysis. Among these providers were five career and technical education centers that offer programs for adults as well as high school students. Three private providers offer preparation courses towards earning a commercial driver's license. These programs are typically short term and do not result in earning college credits. The most common green occupations for which they offer preparation are truck drivers, welders, HVAC technicians, and electricians. With respect to green sectors, alignment with the energy sector is most common (truck drivers are included in this sector), followed by the circular economy, green buildings, and manufacturing sectors.

Stakeholder Insights on Workforce Supply Issues

In addition to the wealth of information on expected sustainable sector *demand* gleaned from stakeholder interviews, which was discussed in Chapter 3, interviewees provided useful perspectives on the workforce supply that will be needed to support these evolving and emerging industries. Specifically, interviewees provided their reflections on:

- Can the existing (and emerging) workforce meet the needs of new and evolving industries?
- Do workers (or will workers) have the right skills?
- Are there gaps in training and education opportunities to better meet these needs?
- What are the prospects for a more diverse workforce and a more equitable distribution of benefits?
- What are other barriers and challenges to meeting workforce demand?

As before, responses to these questions produced both areas of agreement and areas of less than full consensus.

Stakeholders Generally Agreed that Regional Training and Education is Fairly Robust and Comprehensive, But Needs Better Coordination and Messaging

On gaps in training and education

The training gap is in "coordination of technical [mid-skill] training programs with industry… as companies pivot to more green lines of business or green applications"
- environmental nonprofit interviewee

There "hasn't been a clear articulation of what industry needs"
- educational institution interviewee

There was qualitatively more agreement on workforce supply issues than there was for demand signal, and the story was mostly positive for the region. And in general, stakeholders saw more opportunities than could likely be filled without substantial augmentation of the workforce. One private sector interviewee noted there would be many new jobs that need to be filled for accounting and certification alone—for assessing the carbon footprint or circularity of products and entire industries—as one example. This emphasizes the importance of ensuring that training and education is up to the task of meeting these supply needs.

There are many existing educational entities and programs, and the fundamental of training and education for "green" jobs are similar to many other existing and emerging fields.

Stakeholders pointed to many existing training and education opportunities, both general and sector-specific and for a range of education and skill levels. Examples, by sector, included:

- Circular economy: Construction Junction trains at the low skill level, and University of Pittsburgh offers a Ph.D.;
- Clean energy and grid modernization: the Energy Innovation Center (EIC) offers training at the semi-skilled to skilled levels, and the private sector offers on-the-job-training, e.g., Duquesne Light;
- Green Buildings: Green Building Alliance provides training for both low skill and skilled workers, Community College of Allegheny County (CCAC) offers a certification;
- Outdoor Recreation: Butler County Community College (BC3) offers an associate degree, and Slippery Rock University a bachelor degree;
- Advanced Manufacturing: associated skills taught by unions, community colleges, and on-the-job training.

The availability of training is examined quantitatively as part of this study, as discussed below.

Stakeholders also generally agreed that the core competencies required for many of the evolving and emerging green occupations would be like many existing fields, and that most sectors, sustainable and otherwise, will increasing demand that workers be computer savvy and have functional knowledge of advanced concepts. This observation was made with respect to a range of skill and training levels and across workforce populations: from production workers on the floor to scientists with advanced degrees in research labs, "they're going to need better digital skills … as well as big data analysis skills … and then understanding how to analyze it for

productive use" (private sector interviewee). Stakeholders also saw the relevance of traditional sectors to new and emerging ones, with one educational stakeholder noting that even very traditional fossil extraction sectors produce workers with skills that are "to some extent transferable" to several green sectors.

These observations are consistent with a recent analysis which found that "(a)ttitudes (such as ability to adapt to change, ability to work independently, being reliable and motivated) and 'general' skills (communication, teamwork, management skills) were the most important for green jobs. They also noted the importance of "generic rather than technical skills."(Hofman et al., 2022b) This emphasis on general skills is consistent with importance of companies themselves educating their own workforce in sustainability, including, as suggested by private sector interviewees, not just those directly focused on "greening" goods and services but all staff.

Gaps in Training and Education Opportunities Are Practical More than Substantive

In general, stakeholders noted gaps in connectively of training and education to workers and to employers, but not major substantive gaps in regional training and education programs. Admittedly, there will be less overlap, for example, between skills and knowledge of coal-plant workers with those required for solar installers than with workers at a carbon capture and storage or SMR facility (workforce/sector specific interviewee), but across the range of "green" opportunities stakeholders in this study generally did not see the availability of training and education as a major stumbling block. Specifically, stakeholders expressed the need for:

- Better coordination between and across educational entities
- More consistent coordination of training and education with industry and across industries
- Ensuring that unions keep up with the needs of greening industries
- Raising awareness of opportunities for potential workforce, especially in underrepresented populations, to improve pipeline
- Making sure training is directly linked to industry demand.

Stakeholders expressed concern less with gaps in ways to provide workers with needed skills but with worker supply in terms of sheer numbers, with the issue being explicitly raised as a major concern by several private sector, economic development, and workforce/sector specific stakeholders. The idea that a shortage of workers may "choke growth potential" (Rankin, 2020) is consistent with academic and popular literature on the topic (Zaber et al., 2023).

Stakeholders Also Agreed that Insufficient Knowledge of and Access to Training and Education is an Equity Issue

The need to improve educational awareness and access was noted by many stakeholders. One of the reasons for concern in this area is, as discussed above, the basic issue of insufficient labor supply. Another related concern is around the issue of equity. Financial constraints of potential workers can be a real barrier to entry, making it harder to improve individual lives with these

new opportunities and limiting the region's ability to increase the socioeconomic, racial, and gender diversity of evolving and emerging green sectors. As an example, one philanthropic interviewee noted that the Green Building Alliance has a passive building training that is nearly $2000, too expensive for many potential workers to access. And as observed by one economic development nonprofit interviewee, people need to be able to earn while they learn. These economic realities can compound issues already noted in this report, such as "green" jobs being viewed as less reliable, shorter term, and lower paying than "traditional" jobs, or "sustainability" potentially being politically fraught, in more rural areas. For less-affluent demographic groups, any perception that green jobs are in unwelcoming sectors, and which are not a fit for them is only reinforced by unpaid internships and high costs for certifications and degrees.

On the bright side, examples of regional leadership in equity were noted: Sustainable PGH and GBA were both called out as organizations committed to equity. On philosophical grounds, one economic development nonprofit stakeholder suggested that labor unions and Allegheny County Labor Council can and should lead in diversity, equity, and inclusion as well. However, more than one interviewee noted the overall lack of diversity in the trades and the existence of both perceived and real sexism and racism that will, if not addressed, limit the potential to make these opportunities available for more workers and stymie the growth of new sectors. The trades need to be seen as welcoming and inclusive if the region expects to meet workforce demands in these areas.

Stakeholders Disagreed on Some Nuances of Training and Education Needs

The main point of disagreement among stakeholders mirrors themes already discussed in this report, namely that specifically labeling or siloing green opportunities and associated training and education may or may not be necessary or productive. And even this lack of consensus was somewhat nuanced. Some interviewees felt that the region needs more clearly articulated green workforce development leadership, including specialized industry working groups on sustainable topics at community colleges and more specific tracks or certificates in green topics. The potential utility of new green programs for Workforce Development Boards, or the value of state-level "high priority" occupations list methodologies and criteria that better keep up with emerging green jobs, were both noted. These interviewees viewed the lack of clear or intentional emphasis on green job training and workforce opportunities to as potentially allowing opportunities to be missed.

Others asserted that training can and should be more skills-based rather than industry- or sector-based. This is related to the idea that, from a skills perspective, green jobs are often "just jobs." A focus on skills can also mitigate the concern that, for some perspective workers, a green characterization could be a distraction or even a detriment. Additionally, according to one educational stakeholder, there are words besides "green" that indicate to workers that the skills will be useful in the future. For example, students know that "efficiency is one of those words that's going to be driving the economy because they know that what we're doing right now isn't

sustainable, so as they look to future-proof themselves the word 'green' isn't the seller by itself." These stakeholders also noted that skills-based approaches may have both a practical and cultural benefit. From the practical side, skills can often be useful across sectors, where some could be considered green and some not and it can be empowering to emphasize someone's skills, which they can take across sectors. Furthermore, some trades and union workers are already sensitized to being reskilled or upskilled into a sector which may or may not lead to stable, long-term employment.

Going Forward

Overall, our quantitative and qualitative analyses of the existing workforce in occupations needed for sustainable sectors, workers in occupations that share similarities with these occupations, and training and education opportunities in the Pittsburgh region indicates that the green sectors recognized as critical by our stakeholders have the potential to be successful in the region. In some instances, the existing labor supply is sufficient to support expansion of the green sectors, and workers could easily "step into" green jobs without further education or training beyond what's needed for the specific employer. In others, workers are in closely related jobs that, with some minor, often on-the-job or short-term training, could enable them to play important roles in the green economy. Last, when the short- and medium-term pipeline is insufficient, our review of the region's training and education landscape suggests that there are ample opportunities to prepare a workforce to lead in green economic growth over the longer term—conditional on retaining people in the region after they finish these programs.

Of note is the fact that Pittsburgh's current green workforce falls short on demographic diversity. Overall, about one-in-three workers ages 25 and up in the Pittsburgh region is in an occupation that will be needed to support or expand one or more of the seven sustainable sectors. The share of workers in these occupations is slightly higher in counties in the Pittsburgh region outside Allegheny County (35 percent) than in Allegheny County itself (31 percent). Workers in these occupations are overwhelmingly white, non-Hispanic (89 percent, higher than the region's labor force overall), and a much smaller proportion is female than in the labor force overall (26 percent versus 47 percent). This points to a role for emerging sustainable jobs to increase equity in the region, and the potential of underrepresented workers to provide the needed labor for these jobs of the future.

There are remaining questions that could be addressed in part with an extension this type of quantitative analysis. Potential future directions for this work include:

- Exploration of whether the close green occupations we identify using the O*NET data are in fact serving as onramps into occupations needed to expand sustainable sectors as well as whether the education and training programs we identify as offering preparation for green occupations are pursued by workers who end up in these occupations. To the extent there is growth in green occupations in the years ahead, this could offer opportunities to understand the pathways that workers entering those green occupations

take, including their prior occupations and education and training. These analyses could include quantitative analyses of ACS data on the occupations workers in green occupations held prior to working in the green occupation.

- Analyses that explore wage differentials between green occupations and occupations that share similarities with them and therefore may serve as latent labor supply to an expansion of sustainable sectors. These analyses could shed light on which workers in close green occupations would be more likely to seek to transition to which green occupations because they could earn higher wages. These analyses also could take into account differences in the premium (or lack thereof) to green occupations in Pittsburgh versus other regions, adding an additional dimension to analyses of Pittsburgh's comparative advantage in an expanding green economy.
- Deeper dives in the occupational requirements of specific industries that show promise in the Pittsburgh region within the broad green sectors we analyze, or the occupational composition of specific industries that may face contraction and job losses associated with decarbonization. This could illuminate which occupations will be in greatest demand as part of an expansion of sustainable sectors and which occupations may be most important to target for potential transition into green occupations to the extent they draw upon similar knowledge and skills.

Chapter 5. Case Studies on Emerging Sustainable Sectors

This chapter presents case studies within two sectors, circular economy (CE)[35] and outdoor recreation (OR), which were both identified as having the potential to enhance adaptive capacity of Pittsburgh and create expanded economic opportunities across the region. We also provide a description of the New York State Energy Research and Development Authority (NYSERDA), an exemplar state-level entity that aims "to reduce greenhouse gas emissions, accelerate economic growth, and improve the quality of life for all New Yorkers equitably."

Circular Economy

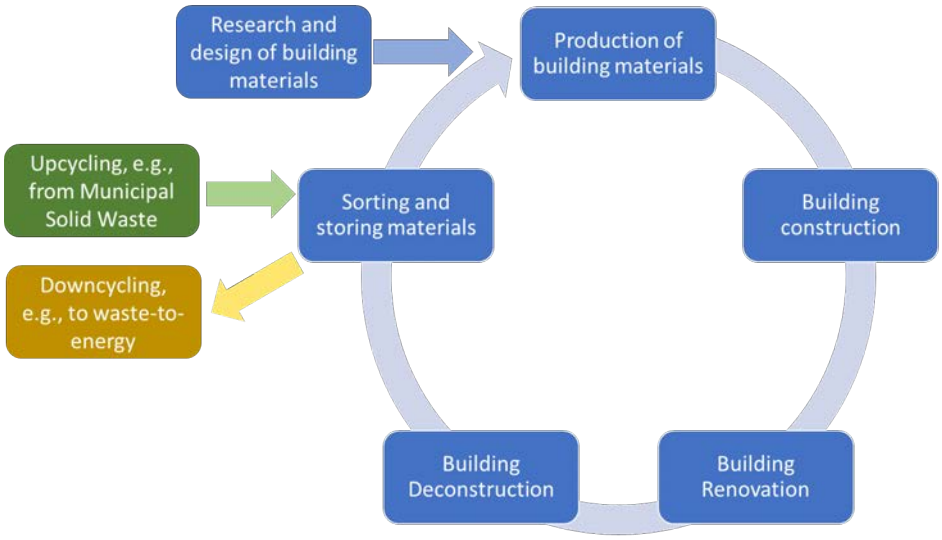
Humanity's use of resources far outstrips the earth's rate of regeneration: global resource demand in 2021 was 1.7 times the earth's annual regeneration rate (Werner et al., 2022). The Ellen MacArthur Foundation defines CE as an economy "that is restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value at all times" (Ellen MacArthur Foundation, 2016). Circular economy practices, which bypass the current "take-make-waste" economic model and are known as "closed-loop," have been found to enhance adaptive capacity in the face of both climate change impacts and challenges resulting from mitigation strategies such as decarbonization (Raimi, Carley, and Konisky, 2022). Given that a transition away from fossil fuels is vital to meet international climate targets such as 1.5C or 2C of global warming, circular economy practices may be an instrumental strategy to improve resilience to challenges that will arise during and after this transition (National Academies of Sciences, 2021). Figure 5.1 provides an illustration of what the circular economy in the buildings sector might entail.

In 2012, recycling and reuse activities in the United States were estimated to account for 681,000 jobs, $37.8 billion in wages, and $5.5 billion in tax revenues, accounting for only 0.47, 0.58, and 0.78 percent of the U.S. economy, respectively (United States Environmental Protection Agency, 2022c). However, nearly 68 percent of municipal waste in the United States follows the "take-make-waste" cycle (United States Environmental Protection Agency, 2022b), so there is a large opportunity for grown in the United States. Globally, CE has been estimated to represent a $4.5 trillion in U.S. dollars growth opportunity by 2030 (Lacy, Long, and Spindler, 2020).

[35] The interested reader is also referred to Appendix E where CE is featured as the example sector for which a sector-specific workforce sufficiency analysis is presented.

In the current study, CE was explicitly discussed with about 20 percent of our interviewees—those with specific knowledge of this sector as well as interviewees that had a more global perspective across various sectors—and was identified as worthy of stronger focus and investment in the Pittsburgh region. CE is viewed as having the potential to leverage the region's key comparative strengths - such as its strong culture of innovation, diverse human capital, and history as a U.S. industrial and manufacturing hub. On this basis, Pittsburgh has the potential to become a national leader in circularity. CE was also identified by multiple interviewees (green nonprofit, private sector, educational, and philanthropic) as a sector with untapped opportunities in both rural and urban areas.

Figure 5.1. Schematic of a Hypothetical Circular Building Economy and Illustrative Interactions with Other Sectors



Source: RAND analysis and New York Times (Aguirre, 2022).

Conversely, one education stakeholder expressed the opinion that both regulatory pressure and important cultural shifts need to occur in the state of Pennsylvania for a circular economy in Pittsburgh to be successful. At the same time, new recycling regulations and enforcement for Pittsburgh were implemented in 2023, and an education interviewee noted that many rural counties already operate in a frugal, somewhat "circular" fashion (City of Pittsburgh, 2023). As noted by several interviewees and described earlier in this report, the CE sector may therefore have the potential to resonate in 'red' counties, as well as in more urban areas. This contrasts with other emerging 'green' industries that may be perceived as having specific cultural or political connotations.

Several examples of CE approaches in the United States and around the world are described below. These examples demonstrate various opportunities to operationalize and drive the

transition from a linear to circular economy. The ways in which best practices from these examples may apply to Pittsburgh and the surrounding region are explored.

European Union Leadership, and Examples of Local Approaches

The European Union is ahead of the United States in its implementation of circular economy policies and practices, as evidenced in EU actions and policies (European Commission, undated-a) and as noted by several study interviewees. In March 2020, the European Union approved and adopted the Circular Economy Action Plan for "a cleaner and more competitive Europe" (EUR-Lex, 2020). Scaling up the circular economy is an essential component of the European Green Deal, a strategy for a "climate-neutral, resource-efficient, and competitive [European] economy" (EUR-Lex, 2020). The Circular Economy Action plan focuses on establishing a circular economy policy framework to avoid overburdening businesses and individuals. Within this regulatory push, specific initiatives focus on circularity in production processes, supply chains, waste, and other subsectors of the circular economy (EUR-Lex, 2020). Over 70 cities across Europe have signed onto the Circular Cities Declaration, which was created within the above initiatives. The Circular Cities Declaration aims to provide a shared vision of the circular economy, as well as create a community of practice in which cities and practitioners can share best practices, successes, and challenges (Circular Cities Declaration, undated).

Circular economy approaches across Europe had begun even before the Circular Economy Action Plan was adopted in 2020. In 2016, the Netherlands committed to a waste-free economy by 2050 (Aguirre, 2022), and there were also many examples of circular enterprises at city and local levels across Europe. For example, the "Recycling House" in Gothenburg, Sweden, which has been running since at least 2014, supports the employment of individuals who have been out of the labor market for several years while promoting a circular economy through the selling of recycled and upcycled items (Urban Sustainability Exchange, undated). At the end of the Recycling House training program (3-6 months for most individuals), staff provide support for trainees to find continued employment elsewhere. Another training program, Lombardia Circolare or Circular Lombardy, located in Lombardy, Italy, provides free webinars to micro-, small- and medium-sized businesses to develop skills in circular economy business models, sustainability, and innovation (Hofman et al., 2022b).

Data collected from interviews and literature reviews indicate that similar strategies as those employed in Europe could succeed in Pittsburgh. For example, a multi-pronged approach that integrates circular economy policies with economic opportunities, equity, and strengthening local businesses may support the cultural shift that was cited by interviewees as necessary for acceptance of CE in the region. Using this approach would also allow for the strengths of rural frugality and existing circularity to be highlighted, which may be an important factor to success – a social framing or branding of CE in the region that overlooked the ways in which CE already exists, such as circularity in rural areas, would likely miss out on potentially vital support.

Europe's Circular Economy Action Plan and data from interviewees and relevant literature also highlight the need for a circular economy regulatory framework to take pressure off individuals and local enterprises. Utilizing strategies from current examples and leaders in the field, combined with regional cultural branding, creates the potential for Pittsburgh to become not only a national leader in circular economy, but also in overcoming the "liberal vs. conservative" and "red vs. blue" debate that often arises in conversation about green jobs and the green economy.

Emerging Circularity in the United States

According to one private-sector interviewee in this study, the United States is "years behind" Europe on policy and practices that drive circularity, such as extended producer responsibility (EPR) laws. Despite this lag, there are examples of CE concepts beginning to take hold in some U.S. cities and states. For example, several have enacted EPR laws, and many more are considering bills (Felton, 2022). Several cities are looking at "deconstruction" laws to take down old buildings more sustainably (Marshall, 2022), and the "Baltimore Wood Project" is one example of such efforts (The Baltimore Wood Project, undated). Cleveland was recently profiled for their CE efforts (Chilcote, 2022) and, in Pittsburgh, new curbside recycling policies (City of Pittsburgh, 2023) and deconstruction initiatives (Construction Junction, 2021) illustrate the importance of local government initiatives. At the level of federal government, there is interest to "understand the key opportunities and challenges associated with increased material circularity to inform DOE's upcoming efforts to advance circular economy technologies and systems in the United States" (U.S. Department of Energy, 2023a) And some U.S.-based companies are starting to drive circularity, especially those with a presence or market in Europe or with an explicit environmental mission (REI Co-op, 2021).

"Circular Charlotte" as an Example of Vision and Action

An existing leader in advancing a Circular Economy in the United States is Charlotte, North Carolina. Charlotte was the first city in the U.S. to adopt CE as a public sector strategy (Gladek, Kennedy, and Thorin, 2018). It aims to become the first fully circular city in the United States through materials reuse, green manufacturing, and a "green industrial revolution" that will improve the resiliency of Charlotte and all who live there. Their model uses seven pillars of the Circular Economy (Gladek, Kennedy, and Thorin, 2018 p. 23), which are:

1. Materials in the economy are cycled at continuous high value
2. All energy is based on renewable sources
3. Water is extracted at a sustainable rate and resource recovery is maximized
4. Biodiversity is structurally supported and enhanced
5. Human society and culture are preserved
6. The health and wellbeing of humans and other species is structurally supported
7. Human activities generate value in measures beyond just financial.

While Charlotte has a significantly larger population than Pittsburgh (approximately 880,000 compared to Pittsburgh's approximate 300,000) (U.S. Census Bureau, 2022), both Charlotte and Pittsburgh have a strong history of manufacturing, industry, and innovation. Currently, manufacturing consists of approximately 30 percent of Charlotte's regional economy. The report *Circular Charlotte: Towards a Zero Waste and Inclusive City* outlines the challenges faced by the city in a transition to a circular economy. These are similar to the challenges reported in our interviews with local and regional stakeholders in Pittsburgh: social and cultural challenges such as individual motivation to participate in sustainability and CE initiatives, economic challenges such as working with the market to develop financial incentives for participation in the CE, and political and legal challenges such as existing regulations that may interrupt forward movement (Gladek, Kennedy, and Thorin, 2018).

Multiple levels of outreach and analysis were conducted to build the Circular Charlotte plan. This included waste generation and lifecycle analyses to assess the current circularity of the city, as well as quantifying the opportunities of a circular economy in Charlotte. For example, it was found that, as more than 144,000 tons of plastics go to landfills in Charlotte, a focus on recycling plastics and diverting these wastes from landfills could create over $35 million in revenue and over 1,000 jobs. The city also co-designed the report with stakeholders, which included conversations about the barriers and opportunities of CE in Charlotte from individual and community perspectives (Figure 5.2).

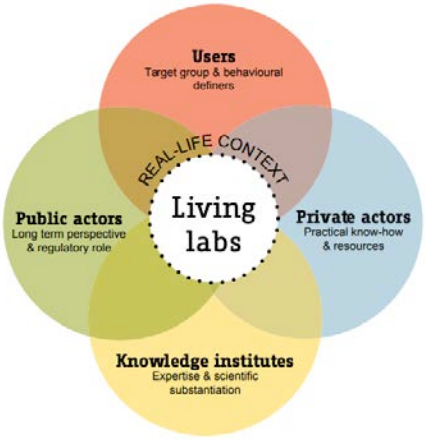
Figure 5.2. Key Barriers to Circularity Identified in Stakeholder Sessions in Charlotte North Carolina

Physical and Technological	Economic and Financial
Collection from multi-family housing	Low value of recyclables - finding proven circular business cases that work
Space requirements	High cost of some equipment - small recyclers can't afford capital investment
Sorting capabilities - technology still needs to advance	Misalignment of financial incentive structures (no pricing of externalities)
Health and safety of recycled materials	Lack of appropriate funding vehicles
Mixed materials in products: lack of design for reuse/ disassembly/recycling	Risk aversion of financial partners (i.e., banks)
Lack of infrastructure for collection and processing	**Political, Regulatory, and Legal**
	Solid waste management / agreements between municipalities and levels of local/regional government
Social and Cultural	Resistance to new legislation / taxation
Lack of participation from residents	Difficulty in passing any local laws without state involvement
Lack of training and knowledge	State and national political climate opposed to innovation on sustainability
Consumption patterns	Health and safety of recycled materials (contamination)

Lack of capacity and workforce	Fear of lawsuits and actual risk of lawsuits (i.e., compost quality)
Lack of recognition for stakeholders who contribute to solutions	Land use and zoning regulations (i.e., with food production)
Difficulty establishing partnerships and getting supply chain parties to cooperate	Regulations on how waste can be used
	Labeling reform (for food, recyclable materials, etc.)

Source: Circular Charlotte: Towards a Zero Waste and Inclusive City (Gladek, Kennedy, and Thorin, 2018).

Figure 5.3. Living Labs in the City of Charlotte's Innovation Barn



SOURCE: Reproduced from Steen and van Bueren, 2017, p. 33. Used with permission (Steen and van Bueren, 2017).

To reach its goals, Charlotte opened an Innovation Barn in 2021 to improve circular innovation and entrepreneurship. The Innovation Barn is intended to be a "Living Lab" (Figure 5.3), which are defined as "user-centered, open innovation ecosystems where new solutions are found to real-life (urban) issues."(Gladek, Thibault, and Corbin, 2019) The goal is for the Innovation Barn to embody seven pillars of the circular economy:

- Circular construction materials;
- Fully renewable energy supply;
- Water efficiency, including rainwater cycling;
- Local biodiversity and ecosystem benefits;
- Mental and physical health benefits through design;
- Culture, including connections across all socioeconomic layers of Charlotte;
- Value over time, including long-term economic and non-economic value.

Charlotte aims to use the Innovation Barn to hold activities and events that move the city towards its vision of a circular economy. This includes serving as a community hub and space

for innovation, hosting two-directional commerce events, providing space for startups and organizations that focus on circular development, and more. Similar steps could be taken by the city of Pittsburgh to advance the circular economy in Pittsburgh and Western Pennsylvania.

Outdoor Recreation Economy

Outdoor recreation was generally agreed upon by interviewees to be a sector that has significant untapped potential in the Pittsburgh region, as well as one that supports economic growth in other areas by offering quality of life benefits to locals. So, while the potential direct economic impact is relatively small, growth in this sector will likely face fewer political hurdles than some other green sectors while providing benefits for both people and nature. There is also the potential for philanthropy to support existing unique regional outdoor recreation training and educational programs in the region such as those offered by Butler County Community College and Slippery Rock University.

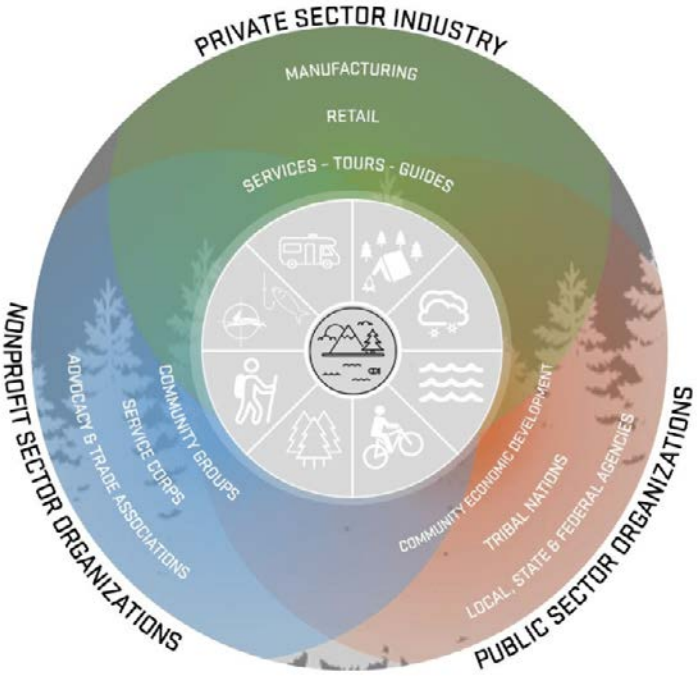
Outdoor recreation was one of the most discussed sectors with interviewees. Among the quarter of the stakeholders with which it was discussed—include both individuals with specific subject matter expertise in the area and with general knowledge across sectors—it was universally viewed as a positive opportunity for Pittsburgh and Southwestern Pennsylvania, and at least one governmental interviewee recognized that the RKMF has been strategic in its support of outdoor recreation in the region thus far. Stakeholders repeatedly spoke of the outdoor opportunities, such as biking, hiking, town-to-trail programs, fishing, hunting, and swimming, that the region could increasingly offer with a larger focus on outdoor recreation. One economic development nonprofit stakeholder stated that, given the combination of natural resources and geographic location, Pittsburgh "should be the Boulder, Colorado of the East."

Across the United States, the outdoor recreation economy accounts for 2 percent of U.S. GDP (Outdoor Recreation Roundtable, 2022). Within the state of Pennsylvania, outdoor recreation accounts for 1.6 percent of the state's GDP (U.S. Bureau of Economic Analysis, 2021). As the outdoor recreation economy grows, so too does the outdoor workforce skills gap. This gap has been estimated to include tens of thousands of open jobs in the field of outdoor recreation, which includes jobs in the private, non-profit, and public sectors (Outdoor Recreation Roundtable, 2022). Figure 5.4 provides examples of recreation economy subsectors.

With an outdoor recreation GDP of 1.6 percent, Pennsylvania ranks 42nd in the country in terms of the percentage of its GDP generated by outdoor recreation (Headwaters Economics, 2023). The potential economic benefit of increasing outdoor recreation in the region was highlighted by multiple interviewees, including one government interviewee noting the opportunity to strengthen the economies of smaller towns formerly focused on the extractive industry. At the same time, one workforce/sector-specific nonprofit stakeholder we interviewed recognized that the price of housing could become a point of concern for outdoor industry workers, who could struggle to afford housing near their jobs due to increasing expenses.

Research conducted by Headwaters Economics found that, on average, "housing costs are higher in recreation counties than in non-recreation counties while wages are lower" (Headwaters Economics, 2020). The study examined all "recreation dependent" counties in the U.S., which included economies reliant on outdoor recreation. An example of this is Carbon County, Montana, which is adjacent to Yellowstone National Park (Headwaters Economics, 2020). This research finding raises the need to ensure that outdoor recreation, if scaled in the region, is scaled with a strong focus on equity for outdoor industry workers and others in the region who may struggle with increasing housing costs.

Figure 5.4. Recreation Economy Careers and Sectors



SOURCE: Center for the Outdoor Recreation Economy graphic reproduced from Outdoor Recreation Roundtable, 2022, p. 4. Used with permission.

Another topic raised in the interviews was the need to separate outdoor recreation policies and endeavors from the rest of the green economy. As a relatively uncontroversial topic, interviewees from an economic development nonprofit reported this separation is needed to ensure that outdoor recreation isn't "muddled" or wrapped up in controversies or backlash to clean technology such as solar panels.

Potential case studies in this sector were identified through interviews with stakeholders across the region and through RAND literature reviews. These case studies are examples of best practices that can be applied to, or expanded within, Pittsburgh and Southwestern Pennsylvania. The following pages will explore two case studies of other locations where outdoor recreation

has been successful, the PA Wilds and Boulder, Colorado, and the outdoor recreation educational program at Butler County Community College.

Pennsylvania Success Story: The PA Wilds

The PA Wilds were mentioned as an example of a successful combination of state efforts and federal investment and as an area with significant potential for growth in outdoor recreation. Approximately 50 million people are located within 6 hours of the Pennsylvania Wilds, and interviewees from the green nonprofit, workforce/sector specific nonprofit, and government saw this proximity as an opportunity to create apprenticeship programs, involve young people in trail development, support former extractive towns that have lost economic opportunities, and bring more people into this conserved land that is roughly the size of Yellowstone and filled with rivers, mountains, trees, and elk.

One way in which to do this is the Town Trail Program. The Town Trail Program is a revitalization project that "aims to power community development through outdoor tourism across PA, WV, and MD" (Trail Town Program, undated). The program supports rural towns to connect with trails and provide amenities so that cyclists and other outdoor recreation enthusiasts will stop in a town or even use it as an overnight destination. The program has already found that this creates economic growth, jobs, grows and supports local businesses, creates jobs, and preserves trails and surrounding nature (Trail Town Program, undated). One government interviewee noted that there are efforts underway to connect the PA Wilds to Pittsburgh through this program.

Another opportunity cited by interviewees to support both towns and outdoor recreation in the Pennsylvania Wilds is through remote working opportunities. One government interviewee highlighted that in this "foot loose" economy, a place like the Pennsylvania Wilds can be very attractive to people who have remote employment elsewhere but want to live somewhere with easily accessible outdoor recreation. This was seen by interviewees as having high potential with the right marketing. This marketing has already started through "The Wilds Are Working: A Remote Lifestyle Experience", a project administered by the PA Wilds Center for Entrepreneurship, Inc. and funded by the Appalachian Regional Commission (Madera, 2023). The program funds remote workers for one month to live in the communities of Emporium or Warren, PA. Chosen participants are placed in free accommodation and given a stipend. The project seeks to address the significant outmigration occurring from rural areas to cities and is piloting this program to market the PA Wilds communities to remote workers.

National Success Story: Boulder, Colorado

The state of Colorado ranks 11th in the country for the percentage of GDP generated by outdoor recreation (Headwaters Economics, 2023). Located in Boulder Valley, the city sits at the foothills of the Rocky Mountains where they meet the Great Plains (Colorado Encyclopedia, 2015). Due to its unique location, Boulder has many opportunities for outdoor recreation

activities, including hiking, mountain biking, skiing, snowboarding, rock climbing, and more. Boulder also has a strong legacy of environmentalism, from the city's purchase of land in 1920 to help prevent the Red Rocks from being mined, to becoming one of the first cities to offer recycling in 1976, to its recognition as a "Tree City of the World" in 2020 (City of Boulder, 2021).

The educational opportunities in Boulder reflect the commitment to the environment and outdoor recreation that is found in the city and region. For example, the University of Colorado, Boulder offers multiple educational opportunities in the field of outdoor recreation. These include a Master of Science in Outdoor Recreation Economy, graduate certificates that focus on subsectors of outdoor recreation such as natural resources policy and economic development, and the opportunity to enroll in courses for professional development as a nondegree student. These educational programs provide opportunities to deepen professional experience or pivot into the outdoor recreation field, as well as support students to grow the outdoor recreation economy in their own communities (University of Colorado Boulder, undated).

Like Boulder, Pittsburgh has a geography and landscape conducive to outdoor recreation, with its direct river, trail, and park access. However, Pittsburgh and the surrounding areas, as noted by multiple interviewees, including governmental, has untapped outdoor recreation potential—it is not yet known as "the Boulder of the East". To reach this potential, interviewees suggested a variety of opportunities, including town-to trail programs, a trail network from the Pennsylvania Wilds into Pittsburgh, and improving water quality and water access in Pittsburgh.

Several barriers would need to be overcome, as discussed earlier in this report. One interviewee from an economic development nonprofit observed that outdoor recreation "can be very white" and that this limits participation by POC as workers or as consumers. Interviewees noted potential safety concerns in outdoor recreation nationwide for multiple minority groups, including racial, ethnic, gender and sexual minorities. Issues such as this will need to be addressed to realize the full potential of economic development and employment in this sector.

Butler County Community College Outdoor Recreation Program

The associate degree in Park and Recreation Management at Butler County Community College (BC3) was established in 1967. It remains the only two-year Park and Recreation Management Associate degree program in Pennsylvania. This program was cited by interviewees as one of, if not the only, educational institution in the state with intentional training in the field of outdoor recreation. This degree aims to prepare students to be "multi-skilled park and recreation professionals,"(Butler County Community College, undated) and supports students who wish to work after graduating or transfer to a four-year college. Butler County Community College also has a Park and Recreation Management – Park Law Enforcement option, which emphasizes law enforcement in its curriculum.

Upon successful completion of this program, graduates obtain several professional certifications in the field of outdoor recreation, including:

- Emergency Medical Responder
- CPR/AED for the Professional Rescuer
- Water Rescue and Emergency Response
- Ice Rescue and Emergency Response
- Advanced Line Systems Rescue
- Firefighter Training (S-130)(Butler County Community College, undated)

Additional skills acquired include:

- Adventure education
- Recreation leadership
- Environmental interpretation
- Park safety
- Park administration and visitor services
- Forest and wildlife management

Graduates of the course go on to recreation and resource management positions in national parks, state parks, and others (Butler County Community College, undated).

Given that this is a unique program in the state, there is a natural opportunity for further growth in outdoor recreation education in Pennsylvania. By expanding outdoor recreation opportunities and educational programs to equip future workers in the field, Pennsylvania could grow its outdoor recreation labor demand and supply simultaneously and provide jobs in the state for program graduates.

The New York State Energy Research and Development Authority and Economic and Workforce Development

NYSERDA is a relatively unique state-level entity that aims "to reduce greenhouse gas emissions, accelerate economic growth, and improve the quality of life for all New Yorkers equitably" (New York State Energy Research & Development Authority, 2024c). NYSERDA has numerous initiatives and funding sources around workforce development and training, in total more than $170 million and with an overall goal of 40 percent of climate action benefits accruing to disadvantaged communities in the state (New York State Energy Research & Development Authority, 2024f). Activities target entry level workers, such as paid internships (New York State Energy Research & Development Authority, 2024d) and a Climate Justice Fellowship (New York State Energy Research & Development Authority, 2024a), as well as workers already in the field across a range of clean energy and adjacent sectors (New York State Energy Research & Development Authority, 2024e). Engagement and coordination with employers is a key feature in programs that leverage state-wide resources and economies of scale. NYSERDA also manages tech-to-market programs to support early-stage innovators in the "climate tech ecosystem" (New York State Energy Research & Development Authority, 2024b).

Lessons Learned from Case Studies

1. **There is a growing interest in working in the environmental sector, but lack of awareness of "green careers."** The "green" job sector is growing, and interest in both academic and blue collar "green" jobs is growing as well. Interviewees across sectors and organization types shared that while they recognize this as true, there is a lack of awareness of what these jobs are and how to build experience in order to get one, especially for blue collar jobs. One workforce/sector-specific nonprofit interviewee shared that even when she was looking for a job in the white-collar environmental sector, she spoke with over 200 people to understand the options. She felt that it took that amount of effort to understand what was out there.
2. **Without the ability to "earn while you learn", significant barriers to enter the environmental field are created.** Building experience for and obtaining a green job can be immensely difficult. Paid internships can be a great avenue to improve exposure to and experience in green jobs, especially for young people and those early in their careers, while reducing barriers to entry to the field. Apprenticeship programs, such as the Recycling House in Sweden, and others in which workers earn a progressively higher wage as their skills increase, are extremely useful to build green skills in the economy, improve equity outcomes, diversify the field, and support workers of all ages and skillsets. Certification programs are an avenue that people with the means can undertake to improve their marketability to the field, but the high price of these certifications can create equity issues.
3. **The transition to a circular economy requires drastic shifts in physical structures, processes, and mindsets.** While advancing the Circular Charlotte initiative, the city, along with stakeholders, identified multiple challenges arising in their transition to a circular economy. These challenges can be grouped into four categories: physical/technological, social/cultural, economic/financial, and political/legal. Oftentimes, challenges in multiple categories need to be addressed to complete one aspect of the circular economy. For example, one of the challenges the city faced came from the need to process huge amounts of material – especially as the initiative gained popularity and more people began to drop off their goods for reuse. Not only did the city need to identify *how* to reuse/refurbish/recycle that material, which was a physical and technological challenge, it also needed to identify *where* to process the material. In the context of a city like Charlotte and many others, that is a social, financial, and political challenge. If a processing site is within the city limits, residents nearby may be forced to deal with smells, noises, and other unpleasant experiences, which can become an issue of environmental justice. While a processing site outside of city limits may be cheaper, impact fewer people negatively, and raise fewer immediate equity concerns, a site that is too far away limits the ability for residents of all kinds to drop off their material.

4. **Utilizing circular economy best practices from Europe and elsewhere around the world is a useful step to advance a circular economy in the United States.** Representatives from the city of Charlotte visited multiple cities in Europe and one city in Brazil before they began implementing the Circular Charlotte initiative. This allowed them to better understand strategies, best practices, and challenges of the transition to a circular economy. While some may argue that the U.S. is fundamentally different than Europe, some of the same major challenges will always arise in any city's or country's transition from a linear to circular economy. Learning from the living examples abroad is a practical step to successfully advancing a circular economy, or circular economies, within the United States.

Chapter 6. Recommendations for Supporting the Success of Sustainable Sectors in the Pittsburgh Region

Pittsburgh's has many strengths in sustainability upon which to build

As noted by one green nonprofit interviewee, "Pittsburgh is an unusually fortunate city in having so many strong conservation organizations." The region also has many "implementers" of economic growth, including local universities, and has engaged in "political activities that build new partnerships and support new projects (which) can enable economic transformation" (Armstrong, 2021a). Pittsburgh has established a reputation for leadership in sustainability—especially in areas like green buildings where the region has been and remains ahead of the curve—and this has led to additional opportunities for showcasing success, such as hosting the Global Clean Energy Forum in 2022.

The many examples of regional stakeholders–including the higher education (Higher Education Climate Consortium, undated) and regional business communities (Sustainable Pittsburgh, 2017)—convening on sustainability is illustrative of the capacity of the region to get behind big ideas and work together to common purpose. As one private sector stakeholder suggested, making the region even more "livable", e.g., bike lanes in the city and trails in and outside of the urban core, and having major employers embrace sustainability, such as regional economic powerhouse UPMC (University of Pittsburgh Medical Center, 2022), can help burnish the region's brand and attract and retain younger workers which can, in turn, help grow regional businesses.

The absence of stakeholder consensus around a single "most promising" sector indicates that there is no one right path that Pittsburgh can take. Fortunately, "sectoral diversification" can "improve the economic resilience of the region's employers and workers" (Zaber et al., 2023). But this is not to say that the region does not need to make choices and be strategic about investments of time, expertise, and financial resources. The findings from this study support several recommendations for regional focus and coordination among key stakeholders, such as local and regional government, philanthropic organizations, educational institutions, and potential private investors.

Recommendation 1: Focus on regionally distinct opportunities with broad stakeholder support and that can most benefit from modest or incremental investments

The Pittsburgh region has many historical and current day strengths that can be applied to a range of future sustainable economic opportunities, as indicated both by stakeholder interview

assessment and quantitative analysis of occupational attributes of the region's workforce and training and educational opportunities. However, there may be value in leaning into opportunities that have a broad base of stakeholder support and that take advantage of unique attributes of the region. For example, both CE and OR had virtually universal appeal across a very broad set of stakeholders, and both can leverage regionally distinct characteristics such as substantial housing stock beyond repair and the proximity of nature to the urban core. Both sectors present opportunities for rural and urban populations and will require a workforce that spans a range of educational attainment levels. Both sectors have strong regional training and educational opportunities to support a long-term workforce supply. And both CE and OR could benefit from relatively modest investments from philanthropic communities, due to the emergent nature of these sectors and the opportunity for small investments to have meaningful impacts. On this latter point, smaller-scale investment opportunities exist for both sectors, allowing for experimentation and broad engagement of would-be entrepreneurs and employees. These are examples of sectors around which specific "clusters" could potentially be formed.

Some sectors do not have universal stakeholder support but may already have substantial momentum behind them

By contrast some sectors and sub-sectors already have substantial support and/or will in part succeed (or not) based on larger market forces. And some industries have less universal stakeholder appeal. For example, while "clean energy" is clearly a broad area in which Pittsburgh can and probably should lead, there are mixed opinions about how to define clean. In the specific case of blue hydrogen, the region has relative advantages that would support the success of such an industry, most obviously workforce and natural gas resources, but there is disagreement regarding the balance of positive and negative impacts that would result from this industry. There are also already substantial resources and clout behind the concept of a regional blue hydrogen industry—including major private sector interests—and multiple teams in the region have applied for federal funding of a "hub," so not only is this concept not unanimously embraced, but additional support by the philanthropic community would likely not move the needle on the success or failure of this industry in the region.

Some sectors will see substantial deployment in the region but will not necessarily be "made in PA"—and that is OK

Furthermore, when considering producing goods (as opposed to providing services), it is useful to distinguish where along the supply chain Pittsburgh's opportunities are the strongest. Some clean energy technologies will likely be widely deployed in the region, such as solar PV installations and EV charging stations, and this inherently local deployment will require a local workforce and will generate local economic activity. However, this does not mean these technologies will necessarily be *manufactured* in the region. For example, large-scale electrification of passenger vehicles may be supported by regional innovation in automation, but

that does not make it likely that the vehicles will be built here when there are other regions of the country that already have that manufacturing capacity. The workforce needs at different points of the supply chain are different—e.g., often deployment jobs do not require highly specialized training in advance of employment, the longevity of these jobs is different than manufacturing ones—and should be considered in assessing the opportunity for the region and the needs for new or expanded training and education.

Finally, recent analysis suggests that focus on picking "implementers"—identifying the individuals and organizations that can advance new industries and support economic growth—may be more important than picking specific technological winners (Armstrong, 2021a; Armstrong, 2021b). This being the case, having the right experts and champions assembled will be key regardless of which sectors and subsectors ultimately emerge as successful.

Recommendation 2: Develop and support better and more investment mechanisms to seed and grow new industries

As discussed in Chapter 3, interviewees expressed concern that the region does not have sufficient financial support for emerging sustainable industries, including seed funding for startups. While individuals and entities in the region have connections to existing green tech incubators and accelerators in other parts of the country, several stakeholders expressed the utility of having these supports based in the region or focused on sustainable sectors of specific relevance to the region. As one private sector interviewee put it, after students are educated and complete internships locally, the incubator is "the second step" in keeping recent university graduates—and their innovations—in the Pittsburgh region. Another economic development nonprofit interviewee similarly stressed the need to have a more robust "commercialization pipeline" with a focus on areas that have disparities between the number of publications and patents coming out of universities and the startups in the corresponding areas. There is strong agreement that additional resources need to be brought to bear to ensure a robust ecosystem of sustainable industries, and there is a potential role for philanthropy to play in this space. For example, if a focus on circular economy for the building sector were of interest to local foundations, a dedicated pool of grants or loans specifically in this area could increase the level of investment, provide opportunity for branding, and potentially help attract and retain students specifically interested in emerging concepts in sustainability.

Recommendation 3: Develop and build support for policies that create appropriate regulatory and/or market signals—including at the local level

The need for policy to support emerging sustainable businesses and industries was noted by many stakeholders. As noted in Chapter 3, there is no consensus on what policies are appropriate or most effective—with private sector stakeholders generally advocating for "carrots" such as tax

credits rather than "sticks" such as carbon reduction requirements which were mentioned by stakeholders in other sectors. However, more than interviewee asserted that market signals will be needed and lamented the lack of support in the Commonwealth's legislature. But there are opportunities to better align incentives at the regional and local level, too. Taking CE as an example, consumer preferences will drive companies to include more recycled content in products and to design circularity into products from the beginning to a point, but ultimately a company's willingness and ability to pay for more expensive feedstocks will limit true circularity. Federal- or state-level extended producer requirements (EPRs) would drive the market, but absent leadership at those levels there is still much that can be done at the regional and local level such as: improve the quality and quantity of local recycling by increasing education and standardization, focus on specific subsectors and associated stakeholders, e.g., large building owners, and increase coordination across municipalities to achieve economies of scale. The City of Pittsburgh has some examples of taking initiative in CE areas (City of Pittsburgh, undated; City of Pittsburgh, 2021) but there is much more that could be done. For the example of solar PV, the Commonwealth's Alternative Energy Portfolio Standard Could be more aggressive with solar requirements and participation in RGGI would certainly increase PV deployment. But the importance of barriers to deployment at the local level can be stymied by codes and standards, so the importance of these policies should not be overlooked, especially because they do not require statewide agreement.

Recommendation 4: Be proactive with outreach and education on the opportunities of evolving and emerging sustainable sectors, and ensure that messaging is appropriate for your audiences

As discussed at length in Chapter 3, many interviewees noted the cultural connotations of "green" branding and cautioned that tailoring outreach on sustainable economic opportunities, including jobs, will be important to attracting and retaining a sufficient workforce. There may be social, cultural, and ideological barriers for full participation of the labor force associated with these opportunities: historically marginalized POC in urban areas may not feel welcome due to historic underrepresentation in some of the underlying trades; rural workers may see "green" as an urban elite trend that threatens their culture and way of life; and women may worry that traditional male-dominated fields will remain so even as sectors become increasingly "green." There is a role for philanthropy to take leadership on messaging, outreach, and education, including coordinating with educational institutions, nonprofits, and the private sector in the region. Not only must awareness be raised, but it must be done in a way that resonates with the communities in which employers hope to recruit.

Recommendation 5: Support existing and emerging workforce by bridging gaps in training and education, not by creating new programs

The knowledge and skills that will be sought from the workforce to support sustainable industries have substantial overlap with those sought by other industries, ranging from general "soft" skills (e.g., adaptability, reliability, communication, teamwork) and basic digital literacy (Hofman et al., 2022a) to more advanced topics in data analytics, automation, and cybersecurity sector (Catalyst Connection, 2022; Zaber et al., 2023; Sustainable Pittsburgh, 2023). The quantitative analyses conducted as part of this study also demonstrated there is much potential for the near- and medium-term workforce supply for virtually all the green sectors that stakeholders noted as promising, including both "consensus" and "controversial" ones.

However, additional training will be needed. As recently noted, "A concentrated effort to make Pittsburgh a center of green industries—coupled with revamping education and training programs to provide knowledge and skills that are in demand for green jobs …could … position the region to be a leader in the industries of the future... (and) would capitalize on Pittsburgh's strong pathways for sub-baccalaureate jobs because many of these jobs do not require a four-year degree. These efforts could include building out a set of short term training programs for aspiring green jobs workers."(Zaber et al., 2023) The majority of stakeholders interviewed in this study indicated that this does not mean building new "green" training from scratch—which, as noted, above could lead to counterproductive siloing and branding—and also emphasized the value of developing curricula in close consultation with industry, or even relying heavily or solely on-the-job training beyond education in the fundamentals. And if industry is proactive in working with regional training and educational institutions—such as Covestro identifying a need and working with Pitt to launch a Ph.D. program to fill those needs—the gaps in existing programs can be filled thoughtfully and selectively.

Recommendation 6: Do not miss opportunities to increase diversity, equity, and inclusion

The transition to a more sustainable society presents an enormous economic opportunity for regions that provide goods and services to support it, and for *all regions* as investments associated with deployment are made—particularly if the substantial federal resources that have and will become available for these deployments can be leveraged. This once-in-a-generation opportunity can also be a tool for increasing diversity, equity, and inclusion, but only if stakeholders are, in the words of one green nonprofit interviewee, "intentional" about making sure the benefits are distributed equitably. As a recent report notes, "disadvantaged groups risk being left behind" in sustainable transitions, but with thoughtful policy, it can be possible to "unlock green jobs for people from disadvantaged groups, including those with low qualifications" (Hofman et al., 2022b). Not only is this the right thing to do, but increasingly it

will be mandated, as the "Justice40" requirements associated with the substantial federal outlay "to tackle the climate crisis" illustrate (The White House, 2021).

The importance of equity and inclusion was also illustrated in this study. Many stakeholders expressed concern that general demographic trends that are leading and will continue to lead to workforce shortfalls may be more acute in Southwestern Pennsylvania than in other areas of the country. This increases the importance of bringing more people that already live in the region into the job market—which can be best accomplished if a more diverse pool of potential workers is tapped—as well as finding ways to achieve a net influx of people into the region, for which recent immigrant populations to the United States could provide opportunities. On the latter point, demographic trends show increases in Latinx and Asian population in recent year which could potentially be bolstered and leveraged to attract certain immigrant groups.

Leadership in this area can and should come from Commonwealth-wide initiatives, such as DCNR's program in Diversity, Equity, and Inclusion that works to provide access and benefits to "all the people" as required by Pennsylvania's constitution (Pennsylvania Department of Conservation and Natural Resources, undated). But there is much that can be done at the regional and local level, and, in fact, the most beneficial role of state government may be in "activities that build new partnerships and support new projects" and "as a convener and monitor—but not necessarily as a funder or policy designer." As articulated by a coalition of 35 Pittsburgh environmental groups in early 2022: "To create a sustainable future, we must meet the fullest needs of *all* people in our communities, for today and tomorrow" (Sustainable Pittsburgh, 2022).

Appendix A: Stakeholder Input Information and Methods

Semi-Structured Interview Participants

The direct input and feedback of representatives from dozens of organizations informed this study. Table A.1 lists those that participated in formal semi-structured interviews of approximately 60 minutes in length with two or more members of the RAND study team. With permission, the specific person(s) with whom the RAND team spoke is also provided in Table A.1. All in all, we spoke with 94 individuals across the 55 organizations interviewed. Two additional organizations declined to participate, and one organization did not respond to our invitation. Organizations with a local or regional focus constituted 45 percent of the interviewees (24 of 55); the balance, 31 organizations, have a presence that either extends beyond or is entirely outside of the Southwestern Pennsylvania Region.

Table A.1. Stakeholder Organizations and Individuals Interviewed

Organization	Name(s) Listed Alphabetically
Within the Southwestern Pennsylvania Region	
Allegheny Conference on Community Development	Jim Futrell; Brian Jensen; Majestic Lane; Linda Topoleski
Butler County Community College (BC3)	Chris Calhoun
Carnegie Mellon University	Katelyn Haas-Conrad; Valeria Karplus; Reed McManigle; Daniel Tkacik
Catalyst Connection	Petra Mitchell
Chatham Sustainability	Deborah DeLong
City of Pittsburgh	Ose Akinlotan; Rebecca Kiernan; Flore Marion
Community College of Allegheny County (CCAC)	Stuart Blacklaw; Jamie McMahon; Michael Rinsem; Justin Starr
CONSOL Energy	Jacqueline Fidler
Construction Junction	Mike Gable
Duquesne Light Company	Lindsay Baxter
Energy Innovation Center (EIC)	Rich DiClaudio; Paul Metro
Green Building Alliance	Jenna Cramer; Leslie Montgomery
Heinz Endowments	Matthew Baron; Andrew McElwaine; Rob Stephany
InnovatePGH.com	Sean Luther; Lindsay Powell
Partner4Work	Susie Puskar
Pittsburgh Public Schools (PPS)	Errika Fearbry Jones; Angela Mike
R.K. Mellon Foundation	Curan Bonham; Gabriella Gonzalez; Brian Hill
Slippery Rock University	Shawn Davis
Southwestern Pennsylvania Commission	Dan Alwine; Jennifer Lasser; Vincent Valdes
Sustainable Pittsburgh	Gina Johnson; Joylette Portlock
University of Pittsburgh	Eric Beckman; Melissa Bilec; Brian Vidic
Western Pennsylvania Conservancy	Thomas Saunders
Westmoreland County Community College	Byron Kohut
Westmoreland-Fayette Workforce Investment Board	Josephine Kuhn; Janet Ward
Beyond the Southwestern Pennsylvania Region	
American Forest Foundation	Rita Hite; Natalie King; Dawn Simmons
Claude Worthington Benedum Foundation	Melanie Claxton; Jen Giovannitti
International Brotherhood of Boilermakers	Michael Stanton; Martin Williams
City of Charlotte, North Carolina	Victoria Johnson
Covestro	Tim Thiel
DMI Companies	Doug Gudenburr; Raymond Yeager

Eaton Corporation	John Vernacchia
EQT	David Porges (retired)
Evoqua Water Technologies	Julia Saintz
GYF/The Bridge Program	Laurene Hamilton; Hannah Malvin
Hillman Family Foundations	Ty Gourley
In-2-Market	Michael Docherty; William (Pat) Getty; Betsy McIntyre
International Brotherhood of Electrical Workers (IBEW)	Kris Anderson
Keep PA Beautiful	Sharon Reiter
Keystone Energy Efficiency Alliance	Jeaneen Zappa
National Energy Technology Laboratory (NETL)	James Ferguson
Office of the Governor (from line above)	Samuel Robinson
Outdoor Recreation Roundtable	Chris Perkins
Pennsylvania Department of Community and Economic Development (DCED)	Adam Walters
Pennsylvania Department of Conservation & Natural Resources (DCNR)	Meredith Hill
Pennsylvania Department of Environmental Protection (DEP)	Geoffrey Bristow; David Zatezalo
PA Solar Center	Sharon Pillar
Penn State University	Andrew Mowen
Pennsylvania Environmental Council	Jim Denova; John Walliser; Davitt Woodwell
PPG	Diane Kappas
SciTek Consultants, Inc.	Jason Baguet
Shell	Hilary Mercer
Student Conservation Association (SCA)	Matt Gray; Joanna Lemmon; Kelly Runzel
Team PA	Max Drickey; Abby Smith
The Conservation Fund	Larry Selzer
The Water Institute	Jordan Fischbach

NOTE: In cases where individuals are not identified by name, the number of participants from that organization is instead listed. “Beyond the region” includes organizations that have both a local and non-local presence.

To assess the balance of stakeholder perspectives represented in our interviews, we categorized each of the above 55 organizations into one of seven categories. Interviewees from organizations without a sector- or industry-specific interest included:

1. economic development nonprofits;
2. educational institutions; and
3. government agencies.

Overall, 40 percent (22 organizations) fell into one of these three categories and were therefore expected to be more likely to represent relatively broad and balanced perspectives on opportunities and barriers for the region’s economic success. Organizations for which specific interests are set by boards, shareholders, members, constituents, or organizational philosophy are naturally expected to bring perspectives that reflect those interests. These organization were categorized into four groups:

1. philanthropic organizations;
2. environmental and sustainability nonprofits;
3. workforce or sector-specific nonprofits; and
4. private sector businesses.

Overall, 60 percent (33 organizations) were classified as entities in this second broad category, i.e., as representing relatively narrow interests or specific organizational agendas, but also offering relative depth in their understanding of the sectors or interests they represented. We note that several of the organizations we interviewed could arguably be included in more than one organizational category (e.g., environmental nonprofit and workforce or economic development), but each was assigned to one primary category by consensus of the RAND research team.

Sample Interview Materials

Each interview included a different subset of questions depending on the organizational type and expertise of the individual(s) with whom RAND spoke, as well as the specific direction that the interview took.

Interview Preamble

About the RAND Study. The Richard King Mellon Foundation has asked RAND to assess the Pittsburgh region's "green" economic development and workforce opportunities. RAND's study will explore the potential to create new and expanded industries in Southwest Pennsylvania, including low-carbon energy industries, circular economy, and conservation and restoration services. This study will help RKMF make synergistic investments to bridge gaps and support coordination with other regional stakeholders, such as state and local government and other philanthropic organizations.

To inform this study, we are conducting interviews with local and regional stakeholders in the private, public, educational, and non-profit sectors. We will use this information to better understand the relevant regional economic and employment landscape in green technologies and services, to support an occupational data analysis of relevant fields, and to develop one or more case studies describing regional or local best practices. Our goal is for this interview to take less than an hour of your time, with potential follow-up questions by email.

Sample Discussion Questions for Employers

Based on your expertise/organizational role, we would like to get your perspective on the most significant or promising opportunities in "green" industries for the region. We are also interested in your thoughts on barriers and challenges to the success of these industries, and on potential opportunities that have yet to be considered or tested in the region.

Limits in your knowledge may not permit you to answer all these questions, but please provide answers to the best of your ability. If you have colleagues or associates that could potentially fill in gaps for your organization (or collaborators in other organizations), please let us know and we can reach out to them for input.

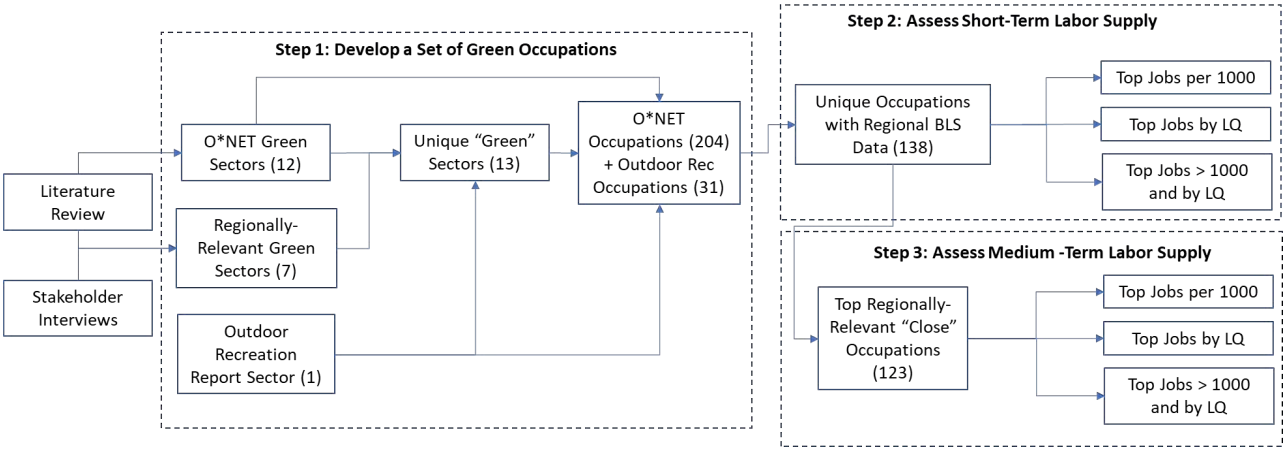
1. What are the "green" trends in your industry? What are the top challenges for making your industry more sustainable, e.g., decarbonization, reducing impacts on water quality?

2. What level of interest is there from current workers and employers in your industry to include/adopt green trends? What social or ideological challenges exist to this adoption?
3. What new products, processes, or services are emerging to support sustainability in your industry?
4. What economic development and workforce opportunities do these new "green" lines of work present for the Southwestern Pennsylvania region?
5. What challenges might "green" trends in your industry present for the Pittsburgh area, for example any changes to supply chains or labor needs that may make other regions better poised to capitalize on "green" trends than Pittsburgh?
6. Can you comment on the geographic reach of benefits and possible negative impacts within the Pittsburgh area?
7. What new skills might workers need?
8. What gaps do you see in education and training for the workforce to support "green trends in your industry?
9. Do you believe the education and training landscape in the region offers sufficient opportunities for current and prospective workers to gain the skills needed to capitalize on green opportunities in your industry? Are there specific types of programs (by subject matter or credential level) that are unavailable or in short supply?
10. Could you describe whether and to what extent you as an employer work in collaboration with local educational institutions (high school or postsecondary), workforce development organizations, labor unions, or others to help align education/training pipelines with your evolving needs as an employer?
11. Are there policies—at the local, state, or national level—that would support your industry's ability to develop/expand sustainable practices as well as ensure an ample supply of talent to work in these "green" lines of work?

Appendix B: Details of Occupational Analysis of Short- and Medium-Term Labor Supply

This appendix provides information on analysis of short-term (immediate) and medium-term (~2 years) labor supply for new, emerging, and evolving sustainable sectors that are regionally relevant to the Pittsburgh area. Table 2.1 listed all the data sources used to support these analyses. The steps described in this appendix are summarized in Figure B.1, and the details of these steps are provided below.

Figure B.1. Schematic of the Steps of the Short- and Medium-Term Labor Supply Analysis



Sources: RAND analysis and Wenger et al (2017; 2023).

Step 1. Developing a Set of Green Sectors and Occupations

Drawing on interviews and literature review, we identified a set of sectors[36] that have or are expected to have the potential for strong regional demand signal, which includes both "consensus" sectors and those with mixed stakeholder opinions. In other words, we reviewed data relevant to both the sectors recommended for philanthropic and local government and non-profit support *as well as* the sector that was assessed to be likely to flourish or dwindle *independent* of that type of investment (i.e., energy). Thus, the list of sectors considered was:

[36] As discussed in Chapter 3, these include sectors with a very broad consensus of support across the stakeholders interviewed (e.g., outdoor recreation) as well as sectors for which there was some disagreement about the sector's relative importance or about the specific sub-sectors that might be most appropriate or desirable for the region's future (e.g., energy subsectors).

1. Agriculture
2. Circular Economy
3. Energy
4. Green Buildings
5. Manufacturing
6. Water Management
7. Outdoor Recreation

A set of corresponding occupations for each of these sectors is required to conduct both short- and medium-term occupational analyses.

The U.S. Department of Labor provides definitions and characterizations of occupations in O*NET Data (O*Net Online, 2023) and the Standard Occupation Classification (SOC) system (U.S. Bureau of Labor Statistics, 2023b) that allows for the characterization of occupations across a wide set of skills, knowledge, abilities, and work styles. Since most of these sectors of interest in this study are not standard economic sectors embedded within a classification system such as the North American Industry Classification System (NAICS) (NAICS Association, 2023), a non-standard approach that capture occupations in these sectors is needed. Dierdorff et al. (Dierdorff et al., 2011) identified green sectors and green occupations based on a large and comprehensive literature review.[37] Importantly, the study defines twelve green economy sectors (listed in the first column of Table B.1) and their associated occupations based on data from the Bureau of Labor Statistics and other sources.

Although there is not perfect alignment with the seven regionally relevant sectors identified in this study, there is considerable overlap. As shown in the mapping in Table B.1, some sectors are aligned with multiple Pittsburgh-specific sectors, e.g., energy efficiency is linked to both energy and green buildings. In these cases, all occupations in the sector have been linked to both Pittsburgh-specific sectors. Additionally, individual occupations may contribute to multiple sectors. In two instances of our sector-to-sector mapping—Research, Design, and Consulting Services, and Government and Regulatory Administration—the Dierdorff et al. (Dierdorff et al., 2011) sector is mapped to all seven Pittsburgh-specific sectors, e.g., we expect that research occupations are relevant to any of the other seven sectors. As a result, workers in occupations aligned with those two Dierdorff et al. (Dierdorff et al., 2011) sectors might contribute labor supply to any of the seven Pittsburgh-specific sectors.

[37] This review covered not only academic literature related to the green economy but also white papers, government reports, and commissioned reports.

Table B.1. Sector-to-Sector Mapping

Dierdorff *et al.* Sectors (12)	Pittsburgh-Specific Sector(s)
Renewable Energy Generation	Energy
Transportation	Energy
Energy Efficiency	Energy; Green Buildings
Green Construction	Circular Economy; Green Buildings
Energy Trading	Energy
Energy and Carbon Capture & Storage	Energy
Research, Design, and Consulting Services	All Sectors
Environment Protection	Water Management
Agriculture and Forestry	Agriculture
Manufacturing	Circular Economy; Manufacturing
Recycling and Waste Reduction	Circular Economy
Government and Regulatory Administration	All Sectors

Note: There are seven regionally specific sectors for the Pittsburgh MSA, which do not map 1-to-1 with the twelve from the literature. Specifically, the Outdoor Recreation sector does not map to any of the Dierdorff et al sectors and is not included in this table.
Sources: Dierdorff *et al.* (Dierdorff et al., 2011) and RAND analysis.

Importantly, although forestry was linked to the Outdoor Recreation (OR) sector by some stakeholders we interviewed, OR occupations are *not* explicitly included in any of the sectors identified in the literature. Therefore, in addition to these twelve occupations, our analysis includes a set of outdoor recreation sector occupations which was developed with expert input (Center for the Outdoor Recreation Economy, 2023). These additional occupations were then mapped to specific SOCs using the set of occupation titles associated with each of the SOCs on O*NET as well as a Census crosswalk used to assign occupational codes to self-reported write-in information provided by Census survey respondents (U.S. Census Bureau, 2023a). We used the Census source, which includes more than 30,000 possible permutations of occupations and assigns them to an occupational code, to verify if an occupation could not be mapped to an occupational code. In some cases, there is overlap between the occupations identified in Dierdorff et al. (Dierdorff et al., 2011). but in most cases, there was not. Based on these two sets of occupations, we have a starting point for the universe of green occupations associated with the sectors identified as important to the Pittsburgh context. This approach provides us with a set over 200 occupations—204 and 31 from the two sources, respectively—that can be considered green.

There are a few important considerations that need to be clear when using this list. First, Dierdorff et al (Dierdorff et al., 2011). distinguish between three types of green occupations: increasing demand, enhanced skills, and new and emerging occupations. These set of occupations are roughly split equally between these categories though the new and emerging occupations have slightly more. In most cases, the new and emerging occupations are a sub-occupation of an existing occupation and do not have a distinct SOC but are included in a broader category of occupations. For increasing demand and enhanced skill occupations, not the people in that occupation will necessarily be green. For example, an electrician who performs residential solar panel installation would be considered a green electrician but not all electricians are green. As our goal is to understand *the potential* for expansion of the green economy in Pittsburgh, this should allow us to identify the current potential though we need to recognize that even in an increasing demand green occupation, there may be the need for knowledge or skills development specific to the green aspects of the occupation.

Step 2. Pittsburgh's Short-term Potential for Green Expansion

Because the 204 specialized "green" occupations identified with the Dierdorff approach use extended, eight digit, SOC codes, rather than the standard six-digit SOC codes for identifying employment and wages from the Occupational Employment and Wages Statistics (OEWS), our analysis requires a crosswalk of the original data to the most recent BLS SOC codes. Additionally, Dierdorff uses the 2010 version of the SOC. After this mapping, we are left with 144 green occupations with BLS data. Additionally, from the outdoor recreation analysis of the occupations identified in the Outdoor Recreation Roundtable report, there are 31 outdoor recreation occupations. Of those, 13 were previously identified in the Dierdorff approach with 18 new occupations. Thus, we have a total of 162 occupations identified as green. However, only 138 of these green occupations have data available for Pittsburgh (see complete list of all 138 split into Tables C.1 and C.2 in Appendix C). The remaining 24 are not reported for the Pittsburgh MSA due to OEWS data suppression rules, most likely owing to the small number of workers in the occupation in the Pittsburgh region.[38] (U.S. Bureau of Labor Statistics, 2023a)

To first consider the short run green economy expansion, we consider two statistics from the OEWS: jobs per 1000 and the location quotient. The first of these is simply a measure of the size of the workforce in that occupation. The location quotient is a measure the relative size of the local workforce compared to the average US location. For example, if 10 percent of the jobs in Pittsburgh are in manufacturing and 5 percent nationally are in manufacturing then the Pittsburgh location quotient for manufacturing is 2, suggesting that Pittsburgh would have more jobs in

[38] We note that self-employed workers are not included in the OEWS and are therefore excluded from the occupational analyses in this report.

manufacturing than the average community. Alternatively, if the national average were 20 percent, then the location quotient would be 0.5. This provides us a way to consider the occupations for which Pittsburgh has a relative advantage (or disadvantage) over other communities. Table B.2 provides a list of the top ten occupations by jobs per 1000 and Table B.3 provides a list of the top ten by location quotient.

Table B.2. Pittsburgh's Top Ten Green Occupations by Total Employment and by Jobs per 1000

SOC Code	Occupation Title	Total Employment	Jobs per 1000
41-2031	Retail Salespersons	26,240	25.2
35-3023	Fast Food and Counter Workers	24,410	23.4
11-1021	General and Operations Managers	23,690	22.7
43-4051	Customer Service Representatives	20,080	19.3
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	16,150	15.5
53-3032	Heavy and Tractor-Trailer Truck Drivers	14,950	14.3
43-3031	Bookkeeping, Accounting, and Auditing Clerks	12,500	12.0
49-9071	Maintenance and Repair Workers, General	10,000	9.6
47-2061	Construction Laborers	9,890	9.5
15-1252	Software Developers	8,720	8.4

Source: U.S. Occupational Employment and Wage Statistics (U.S. Bureau of Labor Statistics, 2023a)

Table B.3. Pittsburgh's Top Ten Occupations by Location Quotient

SOC Code	Occupation Title	Total Employment	Jobs per 1000	Location Quotient
19-4051	Nuclear Technicians	300	0.3	7.52
47-5013	Service Unit Operators, Oil and Gas	880	0.8	3.62
17-3024	Electro-Mechanical and Mechatronics Technologists and Technicians	270	0.3	3.20
17-2111	Health and Safety Engineers, Except Mining Safety Engineers and Inspectors	400	0.4	2.33
17-2161	Nuclear Engineers	220	0.2	2.31
17-2041	Chemical Engineers	370	0.4	2.08
17-2141	Mechanical Engineers	4,130	4.0	2.01
19-2042	Geoscientists, Except Hydrologists and Geographers	340	0.3	1.95
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	3,800	3.6	1.89
19-4031	Chemical Technicians	810	0.8	1.89

Source: U.S. Occupational Employment and Wage Statistics (U.S. Bureau of Labor Statistics, 2023a).

Based on total employment (Table B.2), Pittsburgh appears to have an absolute advantage in retail occupations (which fall within the outdoor recreation sector), general and operations managers, truck drivers, maintenance and repaid workers, and construction laborers, among others. In terms of location quotient, Pittsburgh is strong in several engineering and technician

occupations, though eight of the top ten by LQ account for fewer than 1000 workers in the MSA, making them unlikely to provide a substantial portion of the labor supply to the green economy.

Table B.4 provides the top ten by location quotient where there are at least 1000 people employed in that occupation. Once we consider both the location quotient and employment, Pittsburgh has a comparative advantage in three engineering and architectural occupations, two production occupations, and bus drivers and automotive technicians. In addition, three construction occupations land in the top ten: construction laborers, construction and building inspectors, and operating engineers and other construction equipment operators. This finding suggests it may be possible to expand the circular economy especially with respect to building deconstruction akin the work of organizations like Construction Junction.

Table B.4. Pittsburgh's Top Ten Occupations with More than 1000 Jobs by Location Quotient

SOC	Occupation Title	Total Employment	Jobs per 1000	Location Quotient
17-2141	Mechanical Engineers	4,130	4.0	2.01
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	3,800	3.6	1.89
51-9161	Computer Numerically Controlled Tool Operators	2,190	2.1	1.87
47-2073	Operating Engineers and Other Construction Equipment Operators	5,010	4.8	1.67
53-3052	Bus Drivers, Transit and Intercity	1,750	1.7	1.63
17-2071	Electrical Engineers	2,190	2.1	1.59
47-2061	Construction Laborers	9,890	9.5	1.38
17-3011	Architectural and Civil Drafters	1,040	1.0	1.38
49-3023	Automotive Service Technicians and Mechanics	6,390	6.1	1.37
47-4011	Construction and Building Inspectors	1,200	1.1	1.37

Source: U.S. Occupational Employment and Wage Statistics (U.S. Bureau of Labor Statistics, 2023a).
Note: Overall row may not equal the sum of the rows by green sector because the sectors are not mutually exclusive. Cross sector category includes occupations in the Research, Design, and Consulting Services, and Government and Regulatory Administration (Dierdorff et al., 2011).

Overall, we find that roughly one-in-three workers in the Pittsburgh MSA is in a green occupation as we have defined them (325.1 per 1000 jobs, as Table B.5 shows). When considering how the current supply of labor in the region aligns with the Pittsburgh-specific sectoring scheme we presented above, we find that the most individual occupations (74) and the most workers (more than 140,000) map to the circular economy sector (i.e., the combination of the green construction, manufacturing, and recycling and waste reduction sectors from Dierdorff et al. (Dierdorff et al., 2011). A full list of these occupations is in Appendix C, and we explore these occupations in greater depth in the CE example in Appendix E.

Table B.5. Employment in Green Occupations by Pittsburgh-Specific Sector, 2021 OEWS

Pittsburgh-Specific Sector	Number of Green Occupations (Nationally)	Number of Workers in Green Jobs (Pittsburgh MSA)	Jobs Per 1000 (Pittsburgh MSA)	Share of Employment in Green Occupations (Pittsburgh MSA)
Agriculture	7	26,890	25.8	8%
Circular Economy	74	140,420	134.6	41%
Energy	56	116,610	111.8	34%
Green Buildings	39	110,150	105.6	32%
Manufacturing	45	82,750	79.3	24%
Water Management	26	22,560	21.6	7%
Outdoor Recreation	31	129,690	124.3	38%
Cross Sector	61	96,010	92.1	28%
Overall	162	339,060	325.1	100%

SOURCE: U.S. Occupational Employment and Wage Statistics (U.S. Bureau of Labor Statistics, 2023a).
NOTE: Overall row may not equal the sum of the rows by green sector because the sectors are not mutually exclusive. Cross sector category includes occupations in the Research, Design, and Consulting Services, and Government and Regulatory Administration (Dierdorff et al., 2011).

The sets of occupations expected to contribute to the energy, green buildings, and outdoor recreation sectors all account for more than 10 percent of existing Pittsburgh MSA employment (i.e., more than 100 jobs per 1000). The smallest sectors as gauged by the sum of occupations that contribute to them are the agriculture and water management sectors. About 9 percent of local workers are in an occupation that links to either the Research, Design, and Consulting Services or Government and Regulatory Administration sector (Dierdorff et al., 2011), identified in Table B.1 as occupations that map to "all sectors." We refer to these occupations here and elsewhere in the report as "cross-sector" occupations. Workers in these occupations are not counted in the tabulations for each individual Pittsburgh-specific sector unless that occupation maps to the Pittsburgh-specific sector through one of the other ten sectors (Dierdorff et al., 2011).

Step 3. Pittsburgh's Medium Term Green Economy Labor Potential

The analysis above only provides us with the ability to consider only those occupations that have been designated as green or partially green occupations. Importantly even those employees that we have characterized as green may not possess the appropriate knowledge or skills necessary to carry out the green aspects of the occupation. Thus, we should consider the previous analysis as a maximum short-term potential of the Pittsburgh landscape. Additionally, we want to explore those occupations that are "close" to the set of green occupations that could expand the economy further into the green space in the medium term.

Our approach to identifying those occupations builds off the work of Wenger *et al.* (2017) that used the O*NET data regarding occupational knowledge, skills, and abilities together with

our identified green occupations to calculate a normalized distance across 232 different dimensions. This gives us a distance from any of the green occupations to any other occupation where 100 means the occupations have all the same characteristics and 0 means they have none of the same characteristics. For all the green occupations, we choose those occupations that have a score of 80 or above (a total of 123, listed in Tables C.4 and C.4 in the next appendix) and redo the previous analysis to identify total employment, jobs per 1000, and the location quotient. We present the top ten by location quotient with more than 1000 employees in Table B.6. We provide illustrative examples of how we identify green-close occupations along with the specific dimensions on which they differ from the green occupations for a subset of occupations expected to contribute to the circular economy in the case study in the next chapter of this report.

Table B.6. Pittsburgh's Top Ten Green Close Occupations with at Least 1000 Employees, by Location Quotient

SOC	Occupation Title	Total Employ-ment	Jobs per 1000	Location Quotient
33-9021	Private Detectives and Investigators	1,020	1.0	4.80
23-2093	Title Examiners, Abstractors, and Searchers	1,420	1.4	3.75
13-1141	Compensation, Benefits, and Job Analysis Specialists	1,320	1.3	2.04
43-4061	Eligibility Interviewers, Government Programs	1,860	1.8	1.66
49-3042	Mobile Heavy Equipment Mechanics, Except Engines	1,740	1.7	1.62
15-2031	Operations Research Analysts	1,180	1.1	1.61
21-1021	Child, Family, and School Social Workers	3,890	3.7	1.54
43-6013	Medical Secretaries and Administrative Assistants	6,880	6.6	1.42
13-1051	Cost Estimators	1,990	1.9	1.31
21-1023	Mental Health and Substance Abuse Social Workers	1,070	1.0	1.29

Source: U.S. Occupational Employment and Wage Statistics (U.S. Bureau of Labor Statistics, 2023a).

Appendix C: Complete Tables of Green Occupations and Close Green Occupations

This appendix provides the complete list of green occupations (138) and close green occupations (123), sorted by location quotient (LQ). Table C.1 provides the green occupations that have more than 1000 workers in each occupation, and Table C.2 provides those with 1000 or less. These tables indicate with an "X" whether each green occupation is needed to support an expansion of each green sector. Note that green sectors are not mutually exclusive. In the table column headers, "AG" = agriculture; "CE" = circular economy; "EN" = energy; "GB" = green buildings; "MF" = manufacturing; "WM" = water management; "OR" = outdoor recreation; "CR" = cross-sector occupations. Cross-sector occupations could contribute across each of the other seven sectors; this category includes occupations in the sectors of Research, Design, and Consulting Services, and Government and Regulatory Administration in the Dierdorff et al. (93) framework.

Tables C.3 and C.4 replicate the lists of green occupations and provide information on typical wages and education and on-the-job training needed for each (with more than 1000 and less than 1000 workers, respectively). Table C.5 provides this information for the close occupations that have more than 1000 workers in each occupation, and Table C.6 provides it for those with 1000 or less.

Table C.1. Sixty Green Occupations with More than 1000 Total Employment with Corresponding Sectors, Sorted by Location Quotient, in the Pittsburgh Metropolitan Statistical Area

SOC Code	Occupation Title	Total Employment	Location Quotient	AG	CE	EN	GB	MF	WM	OR	CS
17-2141	Mechanical Engineers	4,130	2.01		X	X	X				X
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	3,800	1.89		X			X			
51-9161	Computer Numerically Controlled Tool Operators	2,190	1.87		X			X			
47-2073	Operating Engineers and Other Construction Equipment Operators	5,010	1.67		X		X				
53-3052	Bus Drivers, Transit and Intercity	1,750	1.63			X					
17-2071	Electrical Engineers	2,190	1.59		X	X	X				X
17-3011	Architectural and Civil Drafters	1,040	1.38		X		X				
47-2061	Construction Laborers	9,890	1.38		X		X				
47-4011	Construction and Building Inspectors	1,200	1.37		X	X	X				X
49-3023	Automotive Service Technicians and Mechanics	6,390	1.37			X				X	

SOC Code	Occupation Title	Total Employment	Location Quotient	AG	CE	EN	GB	MF	WM	OR	CS
41-3031	Securities, Commodities, and Financial Services Sales Agents	4,060	1.28			X					X
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	3,330	1.26		X	X	X				
13-2052	Personal Financial Advisors	2,410	1.24								X
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	6,130	1.24			X					
11-9041	Architectural and Engineering Managers	1,650	1.19			X			X		X
39-3091	Amusement and Recreation Attendants	2,290	1.18							X	
17-2051	Civil Engineers	2,590	1.15		X	X	X		X		X
49-9041	Industrial Machinery Mechanics	3,150	1.14		X			X			
43-3031	Bookkeeping, Accounting, and Auditing Clerks	12,500	1.12							X	
13-2051	Financial and Investment Analysts	2,370	1.10		X	X	X				X
11-1011	Chief Executives	1,610	1.09								X
11-1021	General and Operations Managers	23,690	1.07	X		X	X				
35-3023	Fast Food and Counter Workers	24,410	1.07							X	
53-3032	Heavy and Tractor-Trailer Truck Drivers	14,950	1.06			X					
47-2031	Carpenters	5,180	1.05		X		X				
15-1299	Computer Occupations, All Other	2,860	1.04							X	X
15-1253	Software Quality Assurance Analysts and Testers	1,420	1.01								X
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	3,910	1.00		X			X			
11-9151	Social and Community Service Managers	1,130	0.98							X	
49-3031	Bus and Truck Mechanics and Diesel Engine Specialists	1,900	0.98			X					
13-1041	Compliance Officers	2,390	0.97								X
13-1081	Logisticians	1,360	0.97		X	X		X		X	X
43-4051	Customer Service Representatives	20,080	0.97							X	X
11-2021	Marketing Managers	1,980	0.96								X
41-2031	Retail Salespersons	26,240	0.96							X	
51-4121	Welders, Cutters, Solderers, and Brazers	2,820	0.96		X		X	X			
49-9071	Maintenance and Repair Workers, General	10,000	0.95		X	X	X	X	X	X	
51-4041	Machinists	2,340	0.95		X	X		X			
47-2152	Plumbers, Pipefitters, and Steamfitters	2,870	0.93		X	X	X				
13-1020	Buyers and Purchasing Agents	2,940	0.90	X							X
13-1111	Management Analysts	5,100	0.90							X	
51-1011	First-Line Supervisors of Production and Operating Workers	4,180	0.90		X			X			
17-2112	Industrial Engineers	1,890	0.87		X			X			X
11-3051	Industrial Production Managers	1,220	0.86		X	X		X			
15-1252	Software Developers	8,720	0.86							X	X
53-1047	First-Line Supervisors of Transportation and Material Moving Workers, Except Aircraft Cargo Handling Supervisors	3,510	0.86		X						

SOC Code	Occupation Title	Total Employment	Location Quotient	AG	CE	EN	GB	MF	WM	OR	CS
51-4031	Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic	1,110	0.84		X			X			
47-2111	Electricians	3,970	0.82		X		X				
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	16,150	0.80		X		X	X			
13-1151	Training and Development Specialists	1,970	0.79		X	X	X				X
47-2051	Cement Masons and Concrete Finishers	1,090	0.79		X		X				
43-5032	Dispatchers, Except Police, Fire, and Ambulance	1,110	0.77			X					
11-9199	Managers, All Other	2,770	0.75			X			X		X
27-3031	Public Relations Specialists	1,310	0.73						X		X
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	2,980	0.73		X			X			X
43-5071	Shipping, Receiving, and Inventory Clerks	4,220	0.72		X	X		X			X
51-2090	Miscellaneous Assemblers and Fabricators	6,650	0.68		X			X			
43-5061	Production, Planning, and Expediting Clerks	1,640	0.60		X			X			
53-7051	Industrial Truck and Tractor Operators	3,080	0.55		X	X	X				
13-1199	Business Operations Specialists, All Other	3,760	0.49							X	X

SOURCE: Features data from BLS, Occupational Employment and Wage Statistics, 2021.
NOTE: Green sectors are not mutually exclusive. “AG” = (sustainable) agriculture; “CE” = circular economy; “EN” = (clean) energy; “GB” = green buildings; “MF” = (advanced) manufacturing; “WM” = water management; “OR” = outdoor recreation; “CR” = cross-sector occupations.

Table C.2. Seventy-Eight Green Occupations with Fewer than 1000 Total Employment with Corresponding Sectors, Sorted by Location Quotient, in the Pittsburgh Metropolitan Statistical Area

SOC Code	Occupation Title	Total Employment	Location Quotient	AG	CE	EN	GB	MF	WM	OR	CS
19-4051	Nuclear Technicians	300	7.52			X					
47-5013	Service Unit Operators, Oil and Gas	880	3.62			X					
17-3024	Electro-Mechanical and Mechatronics Technologists and Technicians	270	3.20		X			X			X
17-2111	Health and Safety Engineers, Except Mining Safety Engineers and Inspectors	400	2.33		X			X			X
17-2161	Nuclear Engineers	220	2.31								X
17-2041	Chemical Engineers	370	2.08								X
19-2042	Geoscientists, Except Hydrologists and Geographers	340	1.95						X		X
19-4031	Chemical Technicians	810	1.89		X			X			
17-2081	Environmental Engineers	580	1.84						X		X
19-2031	Chemists	930	1.55		X			X			X
17-3029	Engineering Technologists and Technicians, Except Drafters, All Other	780	1.43		X	X		X			X
19-4042	Environmental Science and Protection Technicians, Including Health	350	1.37						X		

SOC Code	Occupation Title	Total Employment	Location Quotient	AG	CE	EN	GB	MF	WM	OR	CS
47-5041	Continuous Mining Machine Operators	150	1.36			X					
49-2094	Electrical and Electronics Repairers, Commercial and Industrial Equipment	510	1.35		X			X			X
51-8021	Stationary Engineers and Boiler Operators	290	1.32			X	X				
19-5011	Occupational Health and Safety Specialists	1,000	1.27		X			X			X
17-3023	Electrical and Electronic Engineering Technologists and Technicians	950	1.26		X			X			X
51-9011	Chemical Equipment Operators and Tenders	930	1.18		X			X			
51-2041	Structural Metal Fabricators and Fitters	530	1.16		X		X	X			
47-4041	Hazardous Materials Removal Workers	370	1.14		X		X		X		
17-1012	Landscape Architects	130	1.05	X	X		X		X	X	
19-4043	Geological Technicians, Except Hydrologic Technicians	70	1.05			X					X
19-3011	Economists	120	1.04						X		
47-3012	Helpers--Carpenters	210	1.01		X		X				
17-3022	Civil Engineering Technologists and Technicians	480	1.00							X	
25-4022	Librarians and Media Collections Specialists	950	1.00							X	
39-1014	First-Line Supervisors of Entertainment and Recreation Workers, Except Gambling Services	490	0.98							X	
49-9051	Electrical Power-Line Installers and Repairers	900	0.98			X	X				
15-1254	Web Developers	600	0.96							X	
19-2041	Environmental Scientists and Specialists, Including Health	550	0.96						X		
51-9012	Separating, Filtering, Clarifying, Precipitating, and Still Machine Setters, Operators, and Tenders	350	0.96		X	X		X			
49-9044	Millwrights	270	0.94		X			X			
17-1011	Architects, Except Landscape and Naval	690	0.93		X		X				X
11-2033	Fundraising Managers	160	0.91							X	
11-9121	Natural Sciences Managers	500	0.90						X		
19-2099	Physical Scientists, All Other	130	0.90								X
11-9081	Lodging Managers	230	0.88							X	
13-1121	Meeting, Convention, and Event Planners	630	0.87							X	
17-2199	Engineers, All Other	970	0.86		X	X	X	X			X
51-9023	Mixing and Blending Machine Setters, Operators, and Tenders	690	0.86		X			X			
19-3051	Urban and Regional Planners	240	0.84		X		X			X	X
17-3027	Mechanical Engineering Technologists and Technicians	250	0.83		X	X		X			X
17-2031	Bioengineers and Biomedical Engineers	100	0.82		X			X			X
27-3023	News Analysts, Reporters, and Journalists	240	0.82						X		X
17-3026	Industrial Engineering Technologists and Technicians	360	0.79		X			X			X

SOC Code	Occupation Title	Total Employment	Location Quotient	AG	CE	EN	GB	MF	WM	OR	CS
19-4099	Life, Physical, and Social Science Technicians, All Other	360	0.78								X
53-6051	Transportation Inspectors	150	0.78			X	X				X
47-2221	Structural Iron and Steel Workers	380	0.75		X		X	X			
11-3071	Transportation, Storage, and Distribution Managers	800	0.74		X	X		X			X
47-2211	Sheet Metal Workers	670	0.73		X	X	X	X			
53-7081	Refuse and Recyclable Material Collectors	680	0.73		X						
17-3025	Environmental Engineering Technologists and Technicians	70	0.68						X		
19-1031	Conservation Scientists	110	0.68						X	X	X
19-1029	Biological Scientists, All Other	230	0.66							X	
47-2181	Roofers	610	0.64		X		X				
11-2032	Public Relations Managers	280	0.63							X	
51-8013	Power Plant Operators	130	0.63		X	X	X				
19-1013	Soil and Plant Scientists	70	0.61						X		
51-4032	Drilling and Boring Machine Tool Setters, Operators, and Tenders, Metal and Plastic	30	0.60		X			X			
23-1022	Arbitrators, Mediators, and Conciliators	30	0.56								X
19-3099	Social Scientists and Related Workers, All Other	130	0.52			X				X	X
27-1021	Commercial and Industrial Designers	110	0.52		X			X		X	X
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	980	0.50		X	X		X			X
45-1011	First-Line Supervisors of Farming, Fishing, and Forestry Workers	100	0.50	X					X		
47-4090	Miscellaneous Construction and Related Workers	120	0.50			X	X				
49-9098	Helpers--Installation, Maintenance, and Repair Workers	330	0.50		X		X				
13-2099	Financial Specialists, All Other	450	0.49								X
17-2072	Electronics Engineers, Except Computer	370	0.47			X					X
49-9099	Installation, Maintenance, and Repair Workers, All Other	570	0.47			X					
11-2011	Advertising and Promotions Managers	80	0.46								X
43-5011	Cargo and Freight Agents	290	0.46			X					
19-5012	Occupational Health and Safety Technicians	70	0.43		X			X			
13-2054	Financial Risk Specialists	150	0.37		X	X	X				X
37-3019	Grounds Maintenance Workers, All Other	40	0.35							X	
11-9021	Construction Managers	710	0.33		X		X		X		
45-2011	Agricultural Inspectors	30	0.33	X							X
51-8099	Plant and System Operators, All Other	40	0.33			X					
19-1022	Microbiologists	40	0.30							X	

SOURCE: Features data from BLS, Occupational Employment and Wage Statistics, 2021.

SOC Code	Occupation Title	Total Employment	Location Quotient	AG	CE	EN	GB	MF	WM	OR	CS

NOTE: Green sectors are not mutually exclusive. “AG” = agriculture; “CE” = circular economy; “EN” = energy; “GB” = green buildings; “MF” = manufacturing; “WM” = water management; “OR” = outdoor recreation; “CR” = cross-sector occupations; excludes 24 green occupations without information available for the Pittsburgh MSA.

Table C.3. Sixty Green Occupations with More than 1000 Total Employment, Sorted by Location Quotient, in the Pittsburgh Metropolitan Statistical Area, Typical Wages and Education and Training Required

SOC Code	Occupation Title	Total Employment	Jobs per 1000	Location Quotient	Annual Median Wage	Typical Education Needed for Entry	Typical OJT Training Needed for Competency
17-2141	Mechanical Engineers	4,130	4	2.01	$96,400	Bachelor's	None
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	3,800	3.6	1.89	$37,920	HS Diploma	1-12 Months
51-9161	Computer Numerically Controlled Tool Operators	2,190	2.1	1.87	$47,590	HS Diploma	1-12 Months
47-2073	Operating Engineers and Other Construction Equipment Operators	5,010	4.8	1.67	$54,830	HS Diploma	1-12 Months
53-3052	Bus Drivers, Transit and Intercity	1,750	1.7	1.63	$49,610	HS Diploma	1-12 Months
17-2071	Electrical Engineers	2,190	2.1	1.59	$100,290	Bachelor's	None
47-2061	Construction Laborers	9,890	9.5	1.38	$47,050	No credential	<1 Month
17-3011	Architectural and Civil Drafters	1,040	1	1.38	$60,730	Associate's	None
49-3023	Automotive Service Technicians and Mechanics	6,390	6.1	1.37	$46,920	Certificate	<1 Month
47-4011	Construction and Building Inspectors	1,200	1.1	1.37	$60,400	HS Diploma	1-12 Months
41-3031	Securities, Commodities, and Financial Services Sales Agents	4,060	3.9	1.28	$62,160	Bachelor's	1-12 Months
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	3,330	3.2	1.26	$48,100	Certificate	>1 Year
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	6,130	5.9	1.24	$74,810	HS Diploma	None
13-2052	Personal Financial Advisors	2,410	2.3	1.24	$120,820	Bachelor's	>1 Year
11-9041	Architectural and Engineering Managers	1,650	1.6	1.19	$151,730	Bachelor's	None
39-3091	Amusement and Recreation Attendants	2,290	2.2	1.18	$20,640	No credential	<1 Month
17-2051	Civil Engineers	2,590	2.5	1.15	$97,090	Bachelor's	None
49-9041	Industrial Machinery Mechanics	3,150	3	1.14	$60,120	HS Diploma	>1 Year
43-3031	Bookkeeping, Accounting, and Auditing Clerks	12,500	12	1.12	$38,680	Some College	1-12 Months
13-2051	Financial and Investment Analysts	2,370	2.3	1.1	$77,750	Bachelor's	None
11-1011	Chief Executives	1,610	1.5	1.09	N/A	Bachelor's	None
35-3023	Fast Food and Counter Workers	24,410	23.4	1.07	$22,740	No credential	<1 Month

SOC Code	Occupation Title	Total Employment	Jobs per 1000	Location Quotient	Annual Median Wage	Typical Education Needed for Entry	Typical OJT Training Needed for Competency
11-1021	General and Operations Managers	23,690	22.7	1.07	$97,740	Bachelor's	None
53-3032	Heavy and Tractor-Trailer Truck Drivers	14,950	14.3	1.06	$48,320	Certificate	<1 Month
47-2031	Carpenters	5,180	5	1.05	$49,290	HS Diploma	Apprenticeship
15-1299	Computer Occupations, All Other	2,860	2.7	1.04	$79,780	Bachelor's	None
15-1253	Software Quality Assurance Analysts and Testers	1,420	1.4	1.01	$79,050	Bachelor's	None
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	3,910	3.7	1	$71,960	HS Diploma	None
49-3031	Bus and Truck Mechanics and Diesel Engine Specialists	1,900	1.8	0.98	$48,460	HS Diploma	>1 Year
11-9151	Social and Community Service Managers	1,130	1.1	0.98	$62,180	Bachelor's	None
43-4051	Customer Service Representatives	20,080	19.3	0.97	$36,890	HS Diploma	<1 Month
13-1041	Compliance Officers	2,390	2.3	0.97	$69,680	Bachelor's	1-12 Months
13-1081	Logisticians	1,360	1.3	0.97	$71,350	Bachelor's	None
41-2031	Retail Salespersons	26,240	25.2	0.96	$27,400	No credential	<1 Month
51-4121	Welders, Cutters, Solderers, and Brazers	2,820	2.7	0.96	$47,700	HS Diploma	1-12 Months
11-2021	Marketing Managers	1,980	1.9	0.96	$127,690	Bachelor's	None
49-9071	Maintenance and Repair Workers, General	10,000	9.6	0.95	$39,680	HS Diploma	1-12 Months
51-4041	Machinists	2,340	2.2	0.95	$47,890	HS Diploma	>1 Year
47-2152	Plumbers, Pipefitters, and Steamfitters	2,870	2.8	0.93	$61,810	HS Diploma	Apprenticeship
13-1111	Management Analysts	5,100	4.9	0.9	$77,750	Bachelor's	None
51-1011	First-Line Supervisors of Production and Operating Workers	4,180	4	0.9	$62,860	HS Diploma	None
13-1020	Buyers and Purchasing Agents	2,940	2.8	0.9	$62,970	Bachelor's	1-12 Months
17-2112	Industrial Engineers	1,890	1.8	0.87	$79,820	Bachelor's	None
15-1252	Software Developers	8,720	8.4	0.86	$99,880	Bachelor's	None
53-1047	First-Line Supervisors of Transportation and Material Moving Workers, Except Aircraft Cargo Handling Supervisors	3,510	3.4	0.86	$51,830	HS Diploma	None
11-3051	Industrial Production Managers	1,220	1.2	0.86	$102,740	Bachelor's	None
51-4031	Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic	1,110	1.1	0.84	$38,230	HS Diploma	1-12 Months
47-2111	Electricians	3,970	3.8	0.82	$62,480	HS Diploma	Apprenticeship
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	16,150	15.5	0.8	$31,770	No credential	<1 Month
13-1151	Training and Development Specialists	1,970	1.9	0.79	$61,850	Bachelor's	None
47-2051	Cement Masons and Concrete Finishers	1,090	1	0.79	$47,950	No credential	1-12 Months
43-5032	Dispatchers, Except Police, Fire, and Ambulance	1,110	1.1	0.77	$46,330	HS Diploma	1-12 Months
11-9199	Managers, All Other	2,770	2.7	0.75	$127,660	Bachelor's	None

SOC Code	Occupation Title	Total Employment	Jobs per 1000	Location Quotient	Annual Median Wage	Typical Education Needed for Entry	Typical OJT Training Needed for Competency
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	2,980	2.9	0.73	$46,210	HS Diploma	1-12 Months
27-3031	Public Relations Specialists	1,310	1.3	0.73	$61,930	Bachelor's	None
43-5071	Shipping, Receiving, and Inventory Clerks	4,220	4	0.72	$36,980	HS Diploma	<1 Month
51-2090	Miscellaneous Assemblers and Fabricators	6,650	6.4	0.68	$36,500	HS Diploma	1-12 Months
43-5061	Production, Planning, and Expediting Clerks	1,640	1.6	0.6	$48,670	HS Diploma	1-12 Months
53-7051	Industrial Truck and Tractor Operators	3,080	3	0.55	$38,370	No credential	<1 Month
13-1199	Business Operations Specialists, All Other	3,760	3.6	0.49	$66,560	Bachelor's	None

SOURCE: Features data from BLS, Occupational Employment and Wage Statistics, 2021; BLS, Occupational Employment Projections Data, 2021-2031.
NOTE: “OJT” = on-the-job training; “N/A” indicates not available; excludes 24 green occupations without information available for the Pittsburgh MSA.

Table C.4. Seventy-Eight Green Occupations with Fewer than 1000 Total Employment, Sorted by Location Quotient, in the Pittsburgh Metropolitan Statistical Area, Typical Wages and Education and Training Required

SOC Code	Occupation Title	Total Employment	Jobs per 1000	Location Quotient	Annual Median Wage	Typical Education Needed for Entry	Typical OJT Training Needed for Competency
19-4051	Nuclear Technicians	300	0.3	7.52	$78,990	Associate's	1-12 Months
47-5013	Service Unit Operators, Oil and Gas	880	0.8	3.62	$38,680	No credential	1-12 Months
17-3024	Electro-Mechanical and Mechatronics Technologists and Technicians	270	0.3	3.2	$48,920	Associate's	None
17-2111	Health and Safety Engineers, Except Mining Safety Engineers and Inspectors	400	0.4	2.33	$76,650	Bachelor's	None
17-2161	Nuclear Engineers	220	0.2	2.31	$102,880	Bachelor's	None
17-2041	Chemical Engineers	370	0.4	2.08	$97,640	Bachelor's	None
19-2042	Geoscientists, Except Hydrologists and Geographers	340	0.3	1.95	$71,510	Bachelor's	None
19-4031	Chemical Technicians	810	0.8	1.89	$59,710	Associate's	1-12 Months
17-2081	Environmental Engineers	580	0.6	1.84	$100,290	Bachelor's	None
19-2031	Chemists	930	0.9	1.55	$97,320	Bachelor's	None
17-3029	Engineering Technologists and Technicians, Except Drafters, All Other	780	0.7	1.43	$59,330	Associate's	None
19-4042	Environmental Science and Protection Technicians, Including Health	350	0.3	1.37	$45,770	Associate's	None
47-5041	Continuous Mining Machine Operators	150	0.1	1.36	$48,180	No credential	1-12 Months
49-2094	Electrical and Electronics Repairers, Commercial and Industrial Equipment	510	0.5	1.35	$60,190	Certificate	>1 Year
51-8021	Stationary Engineers and Boiler Operators	290	0.3	1.32	$60,910	HS Diploma	>1 Year

SOC Code	Occupation Title	Total Employment	Jobs per 1000	Location Quotient	Annual Median Wage	Typical Education Needed for Entry	Typical OJT Training Needed for Competency
19-5011	Occupational Health and Safety Specialists	1,000	1	1.27	$77,240	Bachelor's	None
17-3023	Electrical and Electronic Engineering Technologists and Technicians	950	0.9	1.26	$61,730	Associate's	None
51-9011	Chemical Equipment Operators and Tenders	930	0.9	1.18	$46,510	HS Diploma	1-12 Months
51-2041	Structural Metal Fabricators and Fitters	530	0.5	1.16	$38,730	HS Diploma	1-12 Months
47-4041	Hazardous Materials Removal Workers	370	0.4	1.14	$47,820	HS Diploma	1-12 Months
17-1012	Landscape Architects	130	0.1	1.05	$61,470	Bachelor's	Intern/residency
19-4043	Geological Technicians, Except Hydrologic Technicians	70	0.1	1.05	$48,060	Associate's	1-12 Months
19-3011	Economists	120	0.1	1.04	$104,920	Advanced	None
47-3012	Helpers--Carpenters	210	0.2	1.01	$38,730	No credential	<1 Month
25-4022	Librarians and Media Collections Specialists	950	0.9	1	$60,360	Advanced	None
17-3022	Civil Engineering Technologists and Technicians	480	0.5	1	$59,320	Associate's	None
49-9051	Electrical Power-Line Installers and Repairers	900	0.9	0.98	$80,740	HS Diploma	>1 Year
39-1014	First-Line Supervisors of Entertainment and Recreation Workers, Except Gambling Services	490	0.5	0.98	$47,380	HS Diploma	None
15-1254	Web Developers	600	0.6	0.96	$63,350	Bachelor's	None
19-2041	Environmental Scientists and Specialists, Including Health	550	0.5	0.96	$63,220	Bachelor's	None
51-9012	Separating, Filtering, Clarifying, Precipitating, and Still Machine Setters, Operators, and Tenders	350	0.3	0.96	$44,040	HS Diploma	1-12 Months
49-9044	Millwrights	270	0.3	0.94	$60,460	HS Diploma	Apprenticeship
17-1011	Architects, Except Landscape and Naval	690	0.7	0.93	$78,240	Bachelor's	Intern/residency
11-2033	Fundraising Managers	160	0.2	0.91	$106,190	Bachelor's	None
11-9121	Natural Sciences Managers	500	0.5	0.9	$118,120	Bachelor's	None
19-2099	Physical Scientists, All Other	130	0.1	0.9	$106,270	Bachelor's	None
11-9081	Lodging Managers	230	0.2	0.88	$48,550	HS Diploma	None
13-1121	Meeting, Convention, and Event Planners	630	0.6	0.87	$48,880	Bachelor's	None
17-2199	Engineers, All Other	970	0.9	0.86	$99,340	Bachelor's	None
51-9023	Mixing and Blending Machine Setters, Operators, and Tenders	690	0.7	0.86	$47,440	HS Diploma	1-12 Months
19-3051	Urban and Regional Planners	240	0.2	0.84	$64,890	Advanced	None

SOC Code	Occupation Title	Total Employment	Jobs per 1000	Location Quotient	Annual Median Wage	Typical Education Needed for Entry	Typical OJT Training Needed for Competency
17-3027	Mechanical Engineering Technologists and Technicians	250	0.2	0.83	$60,360	Associate's	None
27-3023	News Analysts, Reporters, and Journalists	240	0.2	0.82	N/A	Bachelor's	None
17-2031	Bioengineers and Biomedical Engineers	100	0.1	0.82	$89,340	Bachelor's	None
17-3026	Industrial Engineering Technologists and Technicians	360	0.3	0.79	$59,330	Associate's	None
19-4099	Life, Physical, and Social Science Technicians, All Other	360	0.3	0.78	$45,570	Associate's	None
53-6051	Transportation Inspectors	150	0.1	0.78	$63,100	HS Diploma	1-12 Months
47-2221	Structural Iron and Steel Workers	380	0.4	0.75	$64,620	HS Diploma	Apprenticeship
11-3071	Transportation, Storage, and Distribution Managers	800	0.8	0.74	$100,190	HS Diploma	None
53-7081	Refuse and Recyclable Material Collectors	680	0.7	0.73	$30,550	No credential	<1 Month
47-2211	Sheet Metal Workers	670	0.6	0.73	$75,790	HS Diploma	Apprenticeship
19-1031	Conservation Scientists	110	0.1	0.68	$60,380	Bachelor's	None
17-3025	Environmental Engineering Technologists and Technicians	70	0.1	0.68	$61,620	Associate's	None
19-1029	Biological Scientists, All Other	230	0.2	0.66	$71,010	Bachelor's	None
47-2181	Roofers	610	0.6	0.64	$39,300	No credential	1-12 Months
11-2032	Public Relations Managers	280	0.3	0.63	$103,110	Bachelor's	None
51-8013	Power Plant Operators	130	0.1	0.63	$81,100	HS Diploma	>1 Year
19-1013	Soil and Plant Scientists	70	0.1	0.61	$65,550	Bachelor's	None
51-4032	Drilling and Boring Machine Tool Setters, Operators, and Tenders, Metal and Plastic	30	0	0.6	$47,440	HS Diploma	1-12 Months
23-1022	Arbitrators, Mediators, and Conciliators	30	0	0.56	$69,640	Bachelor's	1-12 Months
19-3099	Social Scientists and Related Workers, All Other	130	0.1	0.52	$66,560	Bachelor's	None
27-1021	Commercial and Industrial Designers	110	0.1	0.52	$74,860	Bachelor's	None
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	980	0.9	0.5	$78,100	Bachelor's	1-12 Months
49-9098	Helpers--Installation, Maintenance, and Repair Workers	330	0.3	0.5	$30,410	HS Diploma	<1 Month
47-4090	Miscellaneous Construction and Related Workers	120	0.1	0.5	$54,810	HS Diploma	1-12 Months
45-1011	First-Line Supervisors of Farming, Fishing, and Forestry Workers	100	0.1	0.5	$46,860	HS Diploma	None
13-2099	Financial Specialists, All Other	450	0.4	0.49	$76,640	Bachelor's	None

SOC Code	Occupation Title	Total Employment	Jobs per 1000	Location Quotient	Annual Median Wage	Typical Education Needed for Entry	Typical OJT Training Needed for Competency
49-9099	Installation, Maintenance, and Repair Workers, All Other	570	0.5	0.47	$39,080	HS Diploma	1-12 Months
17-2072	Electronics Engineers, Except Computer	370	0.4	0.47	$100,190	Bachelor's	None
43-5011	Cargo and Freight Agents	290	0.3	0.46	$48,220	HS Diploma	<1 Month
11-2011	Advertising and Promotions Managers	80	0.1	0.46	$103,470	Bachelor's	None
19-5012	Occupational Health and Safety Technicians	70	0.1	0.43	$74,460	HS Diploma	1-12 Months
13-2054	Financial Risk Specialists	150	0.1	0.37	$91,100	Bachelor's	None
37-3019	Grounds Maintenance Workers, All Other	40	0	0.35	$61,820	No credential	<1 Month
11-9021	Construction Managers	710	0.7	0.33	$100,940	Bachelor's	1-12 Months
51-8099	Plant and System Operators, All Other	40	0	0.33	$59,740	HS Diploma	1-12 Months
45-2011	Agricultural Inspectors	30	0	0.33	$63,670	Bachelor's	1-12 Months
19-1022	Microbiologists	40	0	0.3	$46,360	Bachelor's	None

SOURCE: Features data from BLS, Occupational Employment and Wage Statistics, 2021; BLS, Occupational Employment Projections Data, 2021-2031.
NOTE: “OJT” = on-the-job training; “N/A” indicates not available; excludes 24 green occupations without information available for the Pittsburgh MSA.

Table C.5. Forty-Three Close Green Occupations with More than 1000 Total Employment, Sorted by Location Quotient, in the Pittsburgh Metropolitan Statistical Area

SOC Code	Occupation Title	Total Employment	Jobs per 1000	Location Quotient	Annual Median Wage	Typical Education Needed for Entry	Typical OJT Training Needed for Competency
23-2093	Title Examiners, Abstractors, and Searchers	1,420	1.4	3.75	$42,310	HS Diploma	1-12 Months
13-1141	Compensation, Benefits, and Job Analysis Specialists	1,320	1.27	2.04	$60,570	Bachelor's	None
43-4061	Eligibility Interviewers, Government Programs	1,860	1.78	1.66	$51,290	HS Diploma	1-12 Months
49-3042	Mobile Heavy Equipment Mechanics, Except Engines	1,740	1.67	1.62	$50,540	HS Diploma	>1 Year
15-2031	Operations Research Analysts	1,180	1.13	1.61	$79,040	Bachelor's	None
21-1021	Child, Family, and School Social Workers	3,890	3.73	1.54	$47,140	Bachelor's	None
43-6013	Medical Secretaries and Administrative Assistants	6,880	6.6	1.42	$36,310	HS Diploma	1-12 Months
13-1051	Cost Estimators	1,990	1.91	1.29	$65,580	Bachelor's	1-12 Months
21-1023	Mental Health and Substance Abuse Social Workers	1,070	1.02	1.26	$38,580	Advanced	Intern/residency

SOC Code	Occupation Title	Total Employment	Jobs per 1000	Location Quotient	Annual Median Wage	Typical Education Needed for Entry	Typical OJT Training Needed for Competency
13-2011	Accountants and Auditors	11,670	11.19	1.2	$66,190	Bachelor's	None
25-2031	Secondary School Teachers, Except Special and Career/Technical Education	9,040	8.67	1.2	$78,830	Bachelor's	None
35-9031	Hosts and Hostesses, Restaurant, Lounge, and Coffee Shop	2,860	2.7	1.19	$22,720	No credential	<1 Month
43-6014	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	15,930	15.28	1.18	$37,540	HS Diploma	<1 Month
41-1012	First-Line Supervisors of Non-Retail Sales Workers	2,120	2.04	1.18	$79,680	HS Diploma	None
43-3051	Payroll and Timekeeping Clerks	1,290	1.23	1.16	$47,530	HS Diploma	1-12 Months
43-6012	Legal Secretaries and Administrative Assistants	1,320	1.26	1.15	$48,510	HS Diploma	1-12 Months
15-1211	Computer Systems Analysts	4,270	4.1	1.14	$80,290	Bachelor's	None
41-3021	Insurance Sales Agents	3,560	3.42	1.14	$48,890	HS Diploma	1-12 Months
43-9061	Office Clerks, General	21,650	20.75	1.13	$37,450	HS Diploma	<1 Month
43-9041	Insurance Claims and Policy Processing Clerks	1,810	1.74	1.12	$38,360	HS Diploma	1-12 Months
11-3021	Computer and Information Systems Managers	3,990	3.82	1.11	$130,120	Bachelor's	None
11-3121	Human Resources Managers	1,370	1.31	1.11	$123,120	Bachelor's	None
23-2011	Paralegals and Legal Assistants	2,750	2.63	1.1	$58,470	Associate's	None
13-1161	Market Research Analysts and Marketing Specialists	5,850	5.61	1.09	$61,850	Bachelor's	None
43-4131	Loan Interviewers and Clerks	1,910	1.83	1.08	$38,210	HS Diploma	<1 Month
11-3031	Financial Managers	5,260	5.05	1.04	$130,760	Bachelor's	None
43-1011	First-Line Supervisors of Office and Administrative Support Workers	10,970	10.52	1.03	$60,530	HS Diploma	None
27-1024	Graphic Designers	1,550	1.49	1.03	$49,230	Bachelor's	None
35-3031	Waiters and Waitresses	13,580	13.02	1.02	$23,780	No credential	<1 Month
11-9033	Education Administrators, Postsecondary	1,160	1.11	1	$97,550	Advanced	None
15-1251	Computer Programmers	1,130	1.1	1	$81,220	Bachelor's	None
43-9021	Data Entry Keyers	1,080	1.04	0.99	$35,300	HS Diploma	<1 Month
15-1241	Computer Network Architects	1,220	1.2	0.97	$100,330	Bachelor's	None
13-1031	Claims Adjusters, Examiners, and Investigators	1,970	1.9	0.96	$60,820	HS Diploma	>1 Year
43-3021	Billing and Posting Clerks	2,920	2.8	0.92	$37,450	HS Diploma	1-12 Months
11-9111	Medical and Health Services Managers	2,950	2.83	0.91	$98,650	Bachelor's	None
43-4171	Receptionists and Information Clerks	6,170	5.92	0.85	$29,280	HS Diploma	<1 Month

SOC Code	Occupation Title	Total Employment	Jobs per 1000	Location Quotient	Annual Median Wage	Typical Education Needed for Entry	Typical OJT Training Needed for Competency
13-2072	Loan Officers	2,040	1.96	0.81	$63,510	Bachelor's	1-12 Months
11-9141	Property, Real Estate, and Community Association Managers	1,370	1.31	0.79	$58,710	HS Diploma	None
11-9032	Education Administrators, Kindergarten through Secondary	1,490	1.42	0.73	$99,520	Advanced	None
11-2022	Sales Managers	2,340	2.2	0.7	$126,100	Bachelor's	None
43-3011	Bill and Account Collectors	1,080	1.03	0.68	$37,820	HS Diploma	1-12 Months
43-6011	Executive Secretaries and Executive Administrative Assistants	2,220	2.13	0.64	$61,190	HS Diploma	None

SOURCE: Features data from BLS, Occupational Employment and Wage Statistics, 2021; BLS, Occupational Employment Projections Data, 2021-2031.
NOTE: “OJT” = on-the-job training; “N/A” indicates not available; excludes 26 close green occupations without information available for the Pittsburgh MSA.

Table C.6. Eighty Close Green Occupations with Fewer than 1000 Total Employment, Sorted by Location Quotient, in the Pittsburgh Metropolitan Statistical Area

SOC Code	Occupation Title	Total Employment	Jobs per 1000	Location Quotient	Annual Median Wage	Typical Education Needed for Entry	Typical OJT Training Needed for Competency
33-9021	Private Detectives and Investigators	1,020	0.98	4.8	$50,510	HS Diploma	1-12 Months
43-9022	Word Processors and Typists	910	0.87	2.92	$38,630	HS Diploma	<1 Month
51-4071	Foundry Mold and Coremakers	270	0.3	2.71	$46,210	HS Diploma	1-12 Months
47-5071	Roustabouts, Oil and Gas	620	0.6	2.44	$39,190	No credential	1-12 Months
15-2011	Actuaries	410	0.39	2.4	$97,970	Bachelor's	>1 Year
25-1021	Computer Science Teachers, Postsecondary	610	0.6	2.18	$98,070	Advanced	None
13-1075	Labor Relations Specialists	940	0.9	2	$77,500	Bachelor's	None
51-4033	Grinding, Lapping, Polishing, and Buffing Machine Tool Setters, Operators, and Tenders, Metal and Plastic	990	0.95	1.97	$39,990	HS Diploma	1-12 Months
17-2151	Mining and Geological Engineers, Including Mining Safety Engineers	110	0.1	1.96	$66,280	Bachelor's	None
13-2041	Credit Analysts	900	0.9	1.77	$90,500	Bachelor's	None
51-9195	Molders, Shapers, and Casters, Except Metal and Plastic	500	0.5	1.76	$37,380	HS Diploma	>1 Year
51-4191	Heat Treating Equipment Setters, Operators, and Tenders, Metal and Plastic	190	0.18	1.76	$47,440	HS Diploma	1-12 Months
13-2061	Financial Examiners	760	0.73	1.7	$78,050	Bachelor's	>1 Year
17-3012	Electrical and Electronics Drafters	250	0.2	1.63	$71,040	Associate's	None
47-2021	Brickmasons and Blockmasons	670	0.6	1.62	$60,830	HS Diploma	Apprenticeship

SOC Code	Occupation Title	Total Employment	Jobs per 1000	Location Quotient	Annual Median Wage	Typical Education Needed for Entry	Typical OJT Training Needed for Competency
17-2131	Materials Engineers	260	0.25	1.62	$101,780	Bachelor's	None
51-4111	Tool and Die Makers	750	0.72	1.59	$48,340	Certificate	>1 Year
51-9022	Grinding and Polishing Workers, Hand	180	0.17	1.53	$37,740	No credential	1-12 Months
43-9111	Statistical Assistants	70	0.1	1.52	$53,620	Bachelor's	None
15-1242	Database Administrators	930	0.9	1.47	$79,050	Bachelor's	None
43-4011	Brokerage Clerks	440	0.42	1.47	$48,920	HS Diploma	1-12 Months
47-2072	Pile Driver Operators	40	0	1.43	$77,450	HS Diploma	1-12 Months
25-1193	Recreation and Fitness Studies Teachers, Postsecondary	140	0.14	1.39	$77,170	Advanced	None
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	350	0.3	1.38	$79,510	HS Diploma	1-12 Months
41-9031	Sales Engineers	600	0.6	1.36	$98,900	Bachelor's	1-12 Months
11-3111	Compensation and Benefits Managers	150	0.1	1.34	$99,880	Bachelor's	None
25-1011	Business Teachers, Postsecondary	780	0.7	1.32	$98,920	Advanced	None
43-4161	Human Resources Assistants, Except Payroll and Timekeeping	1,000	1	1.31	$46,910	Associate's	None
51-4034	Lathe and Turning Machine Tool Setters, Operators, and Tenders, Metal and Plastic	180	0.18	1.27	$46,910	HS Diploma	1-12 Months
21-1015	Rehabilitation Counselors	840	0.81	1.26	$37,860	Advanced	None
17-2171	Petroleum Engineers	210	0.2	1.26	$127,690	Bachelor's	None
13-1131	Fundraisers	760	0.73	1.25	$60,350	Bachelor's	None
13-2082	Tax Preparers	740	0.71	1.2	$48,410	HS Diploma	1-12 Months
43-3061	Procurement Clerks	540	0.52	1.19	$39,940	HS Diploma	1-12 Months
25-1063	Economics Teachers, Postsecondary	100	0.1	1.19	$105,080	Advanced	None
15-2051	Data Scientists	910	0.87	1.16	$80,290	Bachelor's	None
11-9031	Education and Childcare Administrators, Preschool and Daycare	470	0.45	1.13	$47,820	Bachelor's	None
15-1255	Web and Digital Interface Designers	680	0.7	1.12	$73,270	Bachelor's	None
51-4021	Extruding and Drawing Machine Setters, Operators, and Tenders, Metal and Plastic	480	0.5	1.09	$46,210	HS Diploma	1-12 Months
11-3061	Purchasing Managers	550	0.5	1.07	$126,630	Bachelor's	None
15-1243	Database Architects	390	0.37	1.03	$99,880	Bachelor's	None
13-2071	Credit Counselors	230	0.2	0.99	$38,400	Bachelor's	1-12 Months
15-2041	Statisticians	230	0.2	0.99	$73,900	Advanced	None
49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	160	0.2	0.94	$79,530	Certificate	1-12 Months
13-2053	Insurance Underwriters	740	0.71	0.93	$73,350	Bachelor's	1-12 Months
27-3041	Editors	590	0.57	0.9	$59,680	Bachelor's	None
25-1111	Criminal Justice and Law Enforcement Teachers, Postsecondary	90	0.09	0.89	$62,310	Advanced	None
41-3011	Advertising Sales Agents	610	0.6	0.85	$48,880	HS Diploma	1-12 Months

SOC Code	Occupation Title	Total Employment	Jobs per 1000	Location Quotient	Annual Median Wage	Typical Education Needed for Entry	Typical OJT Training Needed for Competency
47-2151	Pipelayers	200	0.19	0.82	$60,160	No credential	<1 Month
15-1221	Computer and Information Research Scientists	180	0.17	0.78	$109,030	Advanced	None
51-9041	Extruding, Forming, Pressing, and Compacting Machine Setters, Operators, and Tenders	320	0.31	0.77	$42,360	HS Diploma	1-12 Months
11-9161	Emergency Management Directors	60	0.06	0.75	$62,920	Bachelor's	None
11-3131	Training and Development Managers	200	0.19	0.74	$107,180	Bachelor's	None
25-1122	Communications Teachers, Postsecondary	150	0.1	0.73	$78,900	Advanced	None
15-1212	Information Security Analysts	840	0.81	0.72	$99,340	Bachelor's	None
19-4061	Social Science Research Assistants	150	0.1	0.71	$39,380	Bachelor's	None
51-4072	Molding, Coremaking, and Casting Machine Setters, Operators, and Tenders, Metal and Plastic	850	0.81	0.7	$31,500	HS Diploma	1-12 Months
25-9031	Instructional Coordinators	920	0.88	0.67	$65,440	Advanced	None
13-2081	Tax Examiners and Collectors, and Revenue Agents	260	0.25	0.67	$49,450	Bachelor's	1-12 Months
43-4151	Order Clerks	600	0.6	0.6	$37,280	Some College	<1 Month
13-2031	Budget Analysts	210	0.2	0.59	$73,050	Bachelor's	None
27-1025	Interior Designers	260	0.25	0.56	$59,660	Bachelor's	None
51-9032	Cutting and Slicing Machine Setters, Operators, and Tenders	230	0.2	0.56	$38,160	HS Diploma	1-12 Months
49-9043	Maintenance Workers, Machinery	230	0.2	0.55	$54,810	HS Diploma	>1 Year
51-7041	Sawing Machine Setters, Operators, and Tenders, Wood	180	0.18	0.55	$37,380	HS Diploma	1-12 Months
43-4041	Credit Authorizers, Checkers, and Clerks	70	0.1	0.55	$36,910	HS Diploma	1-12 Months
25-1062	Area, Ethnic, and Cultural Studies Teachers, Postsecondary	40	0	0.55	$79,120	Advanced	None
27-2012	Producers and Directors	540	0.52	0.53	$61,680	Bachelor's	None
41-3041	Travel Agents	140	0.14	0.52	$37,710	HS Diploma	1-12 Months
21-2021	Directors, Religious Activities and Education	80	0.1	0.51	$38,580	Bachelor's	None
49-3041	Farm Equipment Mechanics and Service Technicians	130	0.1	0.49	$48,440	HS Diploma	>1 Year
11-3012	Administrative Services Managers	740	0.71	0.45	$98,500	Bachelor's	None
51-9198	Helpers--Production Workers	640	0.61	0.42	$33,080	HS Diploma	<1 Month
17-2061	Computer Hardware Engineers	220	0.2	0.4	$102,280	Bachelor's	None
51-4122	Welding, Soldering, and Brazing Machine Setters, Operators, and Tenders	90	0.08	0.39	$38,360	HS Diploma	1-12 Months

SOC Code	Occupation Title	Total Employment	Jobs per 1000	Location Quotient	Annual Median Wage	Typical Education Needed for Entry	Typical OJT Training Needed for Competency
51-6062	Textile Cutting Machine Setters, Operators, and Tenders	30	0	0.39	$29,750	HS Diploma	1-12 Months
51-7042	Woodworking Machine Setters, Operators, and Tenders, Except Sawing	150	0.1	0.31	$36,370	HS Diploma	1-12 Months
49-2091	Avionics Technicians	40	0	0.28	$56,580	Associate's	None
51-4035	Milling and Planing Machine Setters, Operators, and Tenders, Metal and Plastic	30	0	0.28	$49,010	HS Diploma	1-12 Months
43-4031	Court, Municipal, and License Clerks	220	0.2	0.2	$43,670	HS Diploma	>1 Year

SOURCE: Features data from BLS, Occupational Employment and Wage Statistics, 2021; BLS, Occupational Employment Projections Data, 2021-2031.
NOTE: “OJT” = on-the-job training; “N/A” indicates not available; excludes 26 close green occupations without information available for the Pittsburgh MSA.

Appendix D: Details of Occupational Analysis of Long-Term Labor Supply

The analyses described in Appendix B provide insight into short- to medium-term opportunities given the current labor force participants. This Appendix describes the approach to considering long-term labor supply, i.e., on the 5–10-year timeframe, which can be influenced by training and education.

Step 4. Pittsburgh's Long-term Potential for Green Expansion: Education and Training for Green Occupations

Workers of all levels of education and training can contribute to an expansion of the green economy in Pittsburgh. In fact, more than half of existing jobs in green occupations in the Pittsburgh area typically do not require education past high school for entry (see Table D.1). Most of these jobs are in occupations that take less than a year of on-the-job training to attain competency (see Table D.2), making them viable pathways for a broad cross-section of workers in the region to take part in the green economy. The Pittsburgh area's sixteen high school career and technical education centers, at least one in each county in the MSA, offer programs of study that can yield industry-recognized credentials that support entry to green occupations not requiring education past high school, for example in construction and manufacturing fields. (Pennsylvania Department of Education, 2023)

Table D.1. Typical Education Needed for Entry to Green Occupations

Typical Education Needed for Entry	Share of All Green Occupations	Share of Current Green Jobs, Pittsburgh MSA
Advanced degree	3%	<1%
Bachelor degree	39%	29%
Associate degree	9%	2%
Postsecondary nondegree award	3%	7%
Some college, no degree	1%	4%
High school diploma or equivalent	36%	33%
No formal educational credential	9%	25%
Total	100%	100%

SOURCE: BLS, Occupational Employment and Wage Statistics, 2021; BLS, Occupational Employment Projections Data, 2021-2031.
NOTE: share of all green occupations calculated as a share of the full set of 162 green occupations with data available in the 2021 OEWS; data for 24 of these occupations are not available for the Pittsburgh MSA due to data suppression likely indicating small numbers of workers in the occupations.

Table D.2. Typical On-the-Job Training Needed to Attain Competency in Green Occupations, Occupations Typically Not Requiring Postsecondary Education for Entry

Typical on-the-job training needed to attain competency	Share of All Green Occupations	Share of Current Green Jobs, Pittsburgh MSA
Apprenticeship (~3-5 years)	4%	4%
Long-term on-the-job training (>1 year)	5%	3%
Moderate-term on-the-job training (1-12 months)	22%	14%
Short-term on-the-job training (<1 month)	9%	32%
None	6%	6%
Total	45%	58%

SOURCE: features data from BLS, Occupational Employment and Wage Statistics, 2021; BLS, Occupational Employment Projections Data, 2021-2031.
NOTE: share of all green occupations calculated as a share of the full set of 162 green occupations with data available in the 2021 OEWS; data for 24 of these occupations are not available for the Pittsburgh MSA due to data suppression likely indicating small numbers of workers in the occupations.

Most green jobs that do require education beyond high school are in occupations that typically require a bachelor's degree for entry (39 percent of green occupations, 29 percent of existing green jobs in Pittsburgh). About 15 percent of green occupations typically require sub-baccalaureate postsecondary education for entry, whether an associate degree, a nondegree postsecondary credential, or some college but necessarily a degree, including Heating, Air Conditioning, and Refrigeration Mechanics and Installers, and various engineering technician roles. Tables C.1-C.2 in Appendix C provide the typical education needed for entry and on-the-job training needed to attain competency for all green occupations in the Pittsburgh area.

In this section, we describe the array of postsecondary opportunities in the Pittsburgh area for young people and workers looking to upskill or reskill to gain the knowledge and skills needed to enter green occupations. In some instances, these education and training programs might not strictly be needed to enter the field but could open opportunities for higher wages or more stable employment. We analyzed data from three sources that allowed us to systematically identify education and training providers that offer programs geared toward preparing people for green jobs: (1) the U.S. Department of Education's Integrated Postsecondary Education Data System (IPEDS), which covers programs at public, nonprofit, and for-profit postsecondary institutions that are eligible to process federal financial aid; (2) the U.S. Department of Labor's Registered Apprenticeship Partners Information Database System (RAPIDS), which includes data on registered apprenticeship programs; and (3) Pennsylvania's Eligible Training Provider List (ETPL) which includes programs eligible for workforce development funding through the Workforce Innovation and Opportunity Act. We discuss data, methods, and results from these sources in turn. Additional detailed data tables are available in Appendix G.

Postsecondary Education Providers and Programs

Numerous Pittsburgh-area institutions of higher education grant credentials in subject areas aligned with green occupations as we have defined them in this report—from certificates

designed for people without a bachelor's degree that take only a few weeks to earn, to associate and bachelor's degrees, to doctorates. Each year, these institutions report to IPEDS on their program offerings, student enrollments, and program completions, detailed at a level that supports an analysis of program offerings that prepare people for green jobs.[39]

Data and Methods

IPEDS collects annual data on all credit-bearing offerings of postsecondary schools eligible to process federal financial aid.[40] To process aid, institutions must be accredits, authorized to operate by their state, and offer training programs "to prepare students for gainful employment in a recognized occupation."[41] In the Pittsburgh region, these include everything from county community colleges and public four-year schools to nonprofits to private, for-profit schools and vocational institutes. A comprehensive scan of the Pittsburgh-area education and training landscape conducted for a 2023 report on the region's science- and technology-focused workforce ecosystem found that most local education and training providers are within the IPEDS universe of institutions (Zaber et al., 2023).

For this report, we downloaded complete data files available as of January 2023, which included institutional characteristics for the 2021-2022 school year and program completions data—which we use to identify program offerings—for the 2020-2021 school year (National Center for Education Statistics, 2023c). The completions data are reported using six-digit Classification of Instructional Program (CIP) codes, a taxonomy developed by the Department of Education's National Center for Education Statistics to facilitate consistent tracking of program offerings across institutions (National Center for Education Statistics, 2023b). Notably, IPEDS data list a zero when there are no completions in the year in question in a program area that is offered at the school—but simply do not include a row for the CIP code when there is no program offered. Data are reported by credential level—the type of degree or certificate awarded upon successful completion of the program.

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[39] The IPEDS analysis approach builds upon the data sources and methods described in Appendix C Melanie A. Zaber, Linnea Warren May, Tobias Sytsma, Brian Phillips, Stephanie J. Walsh, Rosemary Li, Elizabeth D. Steiner, Jeffrey B. Wenger, Éder Sousa, and Jessica Arana, *Assessing Pittsburgh's Science- and Technology-Focused Workforce Ecosystem*, RAND Corporation, 2023.

[40] These institutions are known as "Title IV" institutions after the Higher Education Act section that outlines federal financial aid programs Alexandra Hegji, *Institutional Eligibility for Participation in Title IV Student Financial Aid Programs*, Congressional Research Service, R43159, 2019.. We note that inconsistencies in data reporting may result in some non-credit-bearing programs and completions being captured alongside credit-bearing courses of study. For a discussion of difficulties parsing between credit- and non-credit-bearing certificate programs, see Miller et al Abby Miller, Mason Erwin, Samantha Richardson, and Monika Arntz, *Collecting and Disseminating Data on Certificate Awards*, National Postsecondary Education Cooperative, 2016..

[41] HEA §102(b)(1)(A); U.S. Code, Title 20, Section 1002(b)(1)(A).

The 2020-2021 data by CIP code parse by 12 award levels, from very short-term certificates to doctor's degrees.[42] We group these into a smaller number of categories for our analysis: sub-baccalaureate certificates (of any length); associate degrees, bachelor's degrees, advanced degrees (either master's or doctoral degrees) and post-baccalaureate certificates.

We identify programs that offer preparation for green occupations at the six-digit CIP level using a CIP-to-SOC crosswalk published by O*NET, which links academic programs to the more detailed, eight-digit SOC codes, i.e., the level at which the O*NET program and associated researchers identified green occupations (O*Net Online, 2023). The O*NET crosswalk builds upon a crosswalk developed though a collaboration between the National Center for Education Statistics and the Bureau of Labor Statistics—at the six-digit SOC level—that is designed for use both by students looking for programs to prepare for jobs of interest, and employers seeking to understand which courses of study may lend themselves well to entering their workforce (National Center for Education Statistics, 2023a). The CIP-to-SOC crosswalk is "many to many," meaning that a program of study may prepare people to enter more than one occupation, and, that multiple programs of study may prepare people for work in the same occupation. Moreover, the crosswalk is developed based on experts applying their judgment on which programs best align with which occupations—it is not based on actual data on where students end up (National Center for Education Statistics, 2023a)—and it is certainly possible that other programs not listed as linked to an occupation might also offer suitable preparation.

To define the bounds of "green programs" at the six-digit CIP code level for our analysis, we required that at least one-in-three of the occupations to which the CIP code is linked in the crosswalk be among the green occupations as we have defined them in this report—the combination of O*NET enhanced skills, increased demand, and new and emerging green occupations and the additional occupations we identified in the outdoor recreation sector.[43] We considered both green occupations overall, as well as those falling within each of seven overlapping green sectors. For sector-specific program tabulations, we similarly require that at least one-in-three of the occupations to which the CIP code maps be in the sector. We separately tabulate program offerings leading to occupations in the two sectors identified in Dierdorff et al

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[42] The 12 award levels are: (1) Postsecondary awards, certificates, or diplomas of less than 300 clock hours (or the equivalent); (2) Postsecondary awards, certificates, or diplomas of 300-899 clock hours (or the equivalent); (3) Postsecondary award, certificate, or diploma of at least 900, but less than 1800 clock hours (or the equivalent); (4) Associate's degree; (5) Postsecondary award, certificate, or diploma of 1800 or more clock hours (or the equivalent); (6) Bachelor's degree; (7) Postbaccalaureate certificate; (8) Master's degree; (9) Post-master's certificate; (10) Doctor's degree - research/scholarship; (11) Doctor's degree - professional practice; and (12) Doctor's degree – other. https://surveys.nces.ed.gov/ipeds/public/survey-materials/instructions?instructionid=30080. For definitions of these award levels, see https://surveys.nces.ed.gov/ipeds/public/glossary

[43] In two cases, we used expert judgment to assign a CIP code as associated with green occupations despite not meeting the one-third of occupations standard; we do this for Parks, Recreation, and Leisure Studies and Parks, Recreation, and Leisure Facilities Management, which prepare people for work in the outdoor recreation sector.

(Dierdorff et al., 2011) that contribute across all seven sectors—Research, Design, and Consulting Services, and Government and Regulatory Administration—in lieu of counting them in all seven sectors.

We limit our analysis to institutions located in the seven-county Pittsburgh MSA, with the notable exception that we include all programs at Pennsylvania State University. This is for two reasons: (1) many students from and intending to return to the Pittsburgh area pursue their higher education at Penn State; and (2) IPEDS data do not allow us to distinguish between programs offered at Penn State's four branch campuses in the Pittsburgh MSA from those offered at the university's main campus in Centre County. While Pittsburgh-area workers may have earned their credentials outside the region, and those educated in Pittsburgh may leave the area, we view this set of schools as the most likely destinations for Pittsburgh-area residents seeking higher education, and where much of the local green labor supply would have attended school.

Results

Pittsburgh-area higher education institutions offer a range of credential types that offer preparation for green occupations, with 31 providers in total offering at least one such program—about half of the 63 providers in total across the region. The most common credential offering is a sub-baccalaureate certificate, offered by 25 providers across the region. Table D.3 shows that these sub-baccalaureate credential offerings are concentrated in program areas that lead to jobs in the circular economy, energy, green buildings, and manufacturing sectors. Associate degree programs are fewer in number but display a similar pattern in terms of the distribution of sectors for which they offer preparation.

A little more than half (17/31) of providers with programs that prepare workers for green jobs offer bachelor's degrees in those program areas while a little less than half (13/31) offer either master's or doctoral programs in areas that may lead down a path to a green job. These bachelor's and higher offerings are more evenly distributed across green sectors, with the exception that just one provider offers a bachelor's degree program in an area preparing for jobs in the green building sector (an environmental design/architecture program at Carnegie Mellon), and only one provider (Penn State) offers bachelor's or advanced degree programs in preparation for green jobs in the agriculture sector.

With respect to the location of providers offering green programs, we find 15 of them are in Allegheny County, 15 more are distributed across the surrounding six counties (with 6 in Westmoreland topping the list), plus Penn State, which has campuses in four Pittsburgh MSA counties in addition to its main campus in Centre County. Ten providers are public schools, 14 are private nonprofits, and seven are private, for-profit institutions. Private nonprofits account for a majority providers offering bachelor's and advanced degrees, while public schools (e.g., county community colleges) are most common among those offering associate degrees and sub-baccalaureate certificates. See Appendix G for complete data.

Table D.3. Green Education and Training Providers, by Green Sector and Credential Level, IPEDS Institutions

	Advanced Degree	Bachelor Degree	Post-Bacc. Certificate	Associate Degree	Sub-Bacc. Certificate	Total Providers
Agriculture	1	1	0	1	1	1
Circular Economy	9	13	7	14	19	28
Energy	9	10	8	11	17	26
Green Buildings	6	1	6	9	15	23
Manufacturing	4	13	3	12	18	26
Water Management	7	15	4	5	5	20
Outdoor Recreation	11	15	8	10	12	22
Cross Sector	10	16	10	9	13	22
Overall (Green Programs)	13	17	11	16	25	31
Overall (Any Programs)	19	17	15	24	53	63

SOURCE: RAND analysis of data from IPEDS.
NOTE: Total providers column may not equal the sum of the columns by credential because providers may offer green programs at multiple credential levels. Overall row may not equal the sum of the rows by green sector because the sectors are not mutually exclusive. Cross sector category includes occupations in the Research, Design, and Consulting Services, and Government and Regulatory Administration (Dierdorff et al., 2011).

Table D.4 presents information on the number of graduates of green education and training programs at the providers tabulated above in the 2020–21 academic year (most recent available data as of this writing). To contextualize green programs as a share of all offerings, we also include in the bottom row the total number of completions across all program areas (green and nongreen). In total, there were nearly 28,000 green program completions across credential levels in that year (about 45 percent of all completions), with bachelor's degrees accounting for more than 60 percent of them. Notably, the Penn State system accounted for about 60 percent of bachelor's degree and 40 percent of advanced degree completions—and while these graduates may have ties to the Pittsburgh region or be good targets for recruitment to the region—many are from other portions of the state or from out-of-state and lack ties to the Pittsburgh area.

Table D.4. Graduates of Green Education and Training Programs, by Green Sector and Credential Level, IPEDS Institutions, 2020-2021

	Advanced Degree	Bachelor Degree	Post-Bacc. Certificate	Associate Degree	Sub-Bacc. Certificate	Total Graduates
Agriculture	13	268	0	0	34	315
Circular Economy	676	866	122	479	719	2,862
Energy	1,740	2,462	132	273	1,193	5,800
Green Buildings	171	0	15	234	510	930
Manufacturing	483	866	107	348	381	2,185
Water Management	408	1,532	10	29	197	2,176
Outdoor Recreation	1,144	3,212	108	257	175	4,739

Cross Sector	2,781	4,157	188	244	276	7,646
Overall (Green Programs)	6,508	16,671	682	1,559	2,227	27,647
Overall (All Programs)	15,493	31,279	1,816	5,274	7,099	60,961

SOURCE: RAND analysis of data from IPEDS.
NOTE: Data reflect counts of program completions not individuals. If an individual earned multiple credentials, they would be multiple counted. Overall row may not equal the sum of the rows by green sector because the sectors are not mutually exclusive and because a program might meet the threshold of at least one-in-three of the occupations to which it crosswalks being green (across all sectors) but not for any one individual sector. Cross sector category includes occupations in the Research, Design, and Consulting Services, and Government and Regulatory Administration (Dierdorff et al., 2011).

Experimental data available from the U.S. Census Bureau for Penn State (but not for other institutions in Pennsylvania) show that 42 percent of main campus bachelor's degree graduates (from 2013 to 2015) who were working full time five years after graduation were living in Pennsylvania.[44](U.S. Census Bureau, 2023b) Rates of living in Pennsylvania five years post-graduation were higher than average among graduates of programs in several areas connected to the green economy: Parks, Recreation, Leisure, Fitness, and Kinesiology (47 percent), Agricultural/Animal/Plant/Veterinary Science and Related Fields (54 percent), and Natural Resources and Conservation (53 percent). However, they were a little lower for bachelor's degree recipients in Engineering (39 percent) and Business, Management, Marketing, and Related Support Services (37 percent), other program areas that may prepare workers for a variety of green occupations. Rates of living in Pennsylvania were higher for graduates of the four Penn State branch campuses in the Pittsburgh MSA, but these numbers are much smaller and program-level data are either unavailable or based on unreliably small numbers.

Graduates of other local universities may also have ties to other parts of the country and may intend to return to those places. While data are limited, preliminary analyses conducted for a project tracking graduates over the 2010 to 2018 period found that about 20 percent of Carnegie Mellon graduates stayed in the Pittsburgh region versus about half of University of Pittsburgh (main campus) graduates and about 80 percent of graduate community colleges in Allegheny and Westmoreland counties (Conzelmann et al., 2022). This mirrors the distribution of states of origin for entering students, for which data are available from the U.S. Department of Education and which may serve as a proxy measure of likelihood to be inclined to remain in the area. Data show that upwards of 90 percent of incoming undergraduate degree- or certificate-seeking students at local community colleges and public institutions such as Slippery Rock and PennWest California are from Pennsylvania versus between about 60 and 80 percent for Pitt, Duquesne, Robert Morris, and Point Park and only about 10 percent for Carnegie Mellon (Zaber et al., 2023).

[44] Based on the 2013–2015 cohort of graduates, the most recent with data available five years post-graduation.

On balance, given this information and the mix of institutions offering credentials at different levels, it is reasonable to expect that the overwhelming majority of associate and certificate program completers will form part of the regional labor supply. However, it is difficult to say what portion of bachelor's and advanced degree students can reasonably be expected to remain in the Pittsburgh area, and targeted recruitment efforts may be needed to increase the likelihood that these graduates stay locally and form the pool of labor supply for the green economy.

Tables D.5, D.6, and D.7 display the programs that prepare workers for green occupations offered by the largest number of providers region-wide for sub-baccalaureate, associate degree, and bachelor's degree credentials, respectively. The right-most two columns in the tables indicate the number of O*NET occupations for which the program area offers preparation (according to the many-to-many CIP-to-SOC crosswalk) and the percentage of those occupations that are green. In a few cases, for example HVAC technicians, programs are linked to just one occupation that is green. More often, the program can lead graduates down an array of paths, some involving work in green occupations and some not. We include any programs for which at least one-in-three occupations it may lead to are green, considering graduates of these programs as part of the potential green labor supply in the region.

Detailed tables in Appendix G provide a full tabulation of which local institutions offer programs at each credential level in preparation for jobs in each green sector. It also includes a list of all program areas that meet our definition of "green" as well as the number of providers offering those programs at each credential level.

Table D.5. Pittsburgh-Area Green Education and Training Programs, Sub-baccalaureate Certificates, Top Programs by Number of Providers, IPEDS Institutions

Program Area	# Providers	# Occs	% Occs. Green
Welding Technology/Welder	12	2	50%
Heating, Air Conditioning, Ventilation and Refrigeration Maintenance Technology/Technician	7	1	100%
Business/Commerce, General	6	33	52%
Entrepreneurship/Entrepreneurial Studies	6	11	64%
Truck and Bus Driver/Commercial Vehicle Operator and Instructor	6	6	33%
Business Administration and Management, General	4	45	56%
Plumbing Technology/Plumber	4	5	60%
Logistics, Materials, and Supply Chain Management	4	12	83%

SOURCE: RAND analysis of data from IPEDS.
NOTE: " Occs." = number of occupations to which the CIP code crosswalks; "% Occs. Green" = the percentage of occupations to which the CIP code crosswalks that meet our definition of green occupation. Eleven programs tied for ninth with three providers each.

Table D.6. Pittsburgh-Area Green Education and Training Programs, Associate Degrees, Top Programs by Number of Providers, IPEDS Institutions

Program Area	# Providers	# Occs	% Occs. Green
Heating, Air Conditioning, Ventilation and Refrigeration Maintenance Technology/Technician	8	1	100%
Business Administration and Management, General	6	45	56%
Electrical, Electronic, and Communications Engineering Technology/Technician	6	7	43%
Welding Technology/Welder	5	2	50%
Electrician	5	5	40%
Mechanical/Mechanical Engineering Technology/Technician	5	5	80%
Computer and Information Sciences, General	4	24	46%

SOURCE: RAND analysis of data from IPEDS.
NOTE: "# Occs." = number of occupations to which the CIP code crosswalks; % Occs. Green" = the percentage of occupations to which the CIP code crosswalks that meet our definition of green occupation. Seven programs tied for eighth with three providers each.

Table D.7. Pittsburgh-Area Green Education and Training Programs, Bachelor Degrees, Top Programs by Number of Providers, IPEDS Institutions

Program Area	# Providers	# Occs	% Occs. Green
Biology/Biological Sciences, General	16	16	56%
History, General	16	10	60%
Political Science and Government, General	16	10	40%
Chemistry, General	14	9	44%
Marketing/Marketing Management, General	13	8	38%
Business Administration and Management, General	12	45	56%
Finance, General	11	18	33%
Physics, General	10	6	33%
Economics, General	10	13	46%
International Business/Trade/Commerce	9	9	78%
Biochemistry	9	8	38%

SOURCE: RAND analysis of data from IPEDS.
NOTE: "# Occs." = number of occupations to which the CIP code crosswalks; % Occs. Green" = the percentage of occupations to which the CIP code crosswalks that meet our definition of green occupation.

Registered Apprenticeship Programs

Apprenticeship programs, often sponsored by labor unions or individual private businesses, pair on-the-job training in an occupation with related instruction. The U.S. Department of Labor and, in Pennsylvania, the Department of Labor and Industry's Apprenticeship & Training Office oversee *registered apprenticeship* programs (Collins, 2021). These programs must include at least 2,000 hours of on-the-job training and 144 hours of related instruction, provided either by the apprenticeship sponsor or a partner postsecondary institution (Pennsylvania Career Link,

undated-a). Apprenticeships result in earning an industry-recognized credential while earning a paycheck (Apprenticeship USA, 2023). They are most common in the construction trades and utilities sectors though there are ongoing efforts to expand their use in other sectors (Elliott et al., 2022; Goger and Sinclair, 2021). We analyzed data on registered apprenticeships to identify which green occupations have apprenticeship programs available in the Pittsburgh area.

Data and Methods

The U.S. Department of Labor systematically collects and publishes data on registered apprenticeships (U.S. Department of Labor, 2021). Program-level and de-identified individual-level data on registered apprenticeships typically are available for download from the web as well, though at the time of this writing, were only available via request (U.S. Department of Labor, 2021). We requested and received program-level data in January 2023, reflecting offerings as of the fourth quarter of calendar year 2022. We restricted the list to apprenticeships in the seven-county Pittsburgh MSA: the counties of Allegheny, Armstrong, Beaver, Butler, Fayette, Washington, and Westmoreland. We included all apprenticeships with a program status of "registered" even if the data indicated there were no active apprentices in the program; we excluded those with a program status of "cancelled."

The program-level data included the eight-digit O*NET-SOC codes for each apprenticeship. Since our set of green occupations was initially defined at this level, the inclusion of this occupational code in the RAPIDS data enabled us to easily identify which apprenticeship programs prepare workers for green occupations as we have defined them.[45] We preserved our indicators for seven overlapping green sectors as well as O*NET categorizations of green occupations as enhanced skills, increased demand, or new and emerging occupations. We tabulated apprenticeship availability for green occupations overall and for these groupings.

Results

Our analysis identified 226 active apprenticeships in green occupations in the Pittsburgh region, split roughly in half between those in Allegheny County and one of the six surrounding counties. Table D.8 shows that there are large numbers of programs in occupations in the circular economy, energy, green buildings, and manufacturing sectors, and few to no programs in occupations in the agriculture, water management, and outdoor recreation sectors. In total, there are nearly 4,000 active apprentices in these green apprenticeship programs (as of the fourth quarter of 2022), with about two-thirds of them at programs based in Allegheny County.

[45] We note that the inclusion of O*NET-SOC codes in the RAPIDS data is a recent development. Prior work leveraged an O*NET-SOC to RAPIDS code crosswalk to conduct similar analyses. See Appendix C Zaber et al., 2023.

Table D.8. Registered Apprenticeships in Green Occupations by Green Sector, Pittsburgh Metropolitan Statistical Area, Allegheny versus Surrounding Counties, Fourth Quarter 2022

	Pittsburgh Region Overall	Allegheny	*Surrounding Counties*
Total Number of Programs in Green Occupations	226	110	116
Agriculture	0	0	0
Circular Economy	213	98	115
Energy	110	46	64
Green Buildings	105	67	38
Manufacturing	125	42	83
Water Management	2	1	1
Outdoor Recreation	11	10	1
Cross Sector	13	8	5
Total Number of Active Apprentices in Programs in Green Occupations	3,927	2,718	1,209

SOURCE: U.S. Department of Labor, Registered Apprenticeship Partners Information Database System, Fourth Quarter 2022

NOTE: Registered apprenticeship program refers to a registered apprenticeship in an occupation at a provider categorized using the O*NET-SOC system. Providers that offer apprenticeships in multiple occupations are multiple counted in this analysis. Total of green sectors does not match total number of programs because occupations may be in multiple green sectors. Cross sector category includes occupations in the Research, Design, and Consulting Services, and Government and Regulatory Administration (Dierdorff et al., 2011).

Table D.9 ranks these programs by number of active apprentices, for green occupations overall. Topping the list is carpenter apprentices, with more than 1,200, followed by electricians and plumbers, pipefitters, and steamfitters. Among these occupations, the one with the most individual programs is machinists (74 providers), but each provider has fewer active apprentices than the providers for occupations with more active apprentices on this list (the three occupations mentioned above plus operating engineers and other construction equipment operators and sheet metal workers). Tables in Appendix G provide these tabulations of occupations separately by green sector, though there is considerable overlap (as in our other analyses), with many occupations having the potential to contribute to multiple green sectors.

Table D.9. Registered Apprenticeships by Detailed Occupation, Top 20 Green Occupations by Number of Active Apprentices, Pittsburgh Metropolitan Statistical Area, Fourth Quarter 2022

Occupation	Number of active apprentices	Number of providers with programs
Carpenters	1,219	7
Electricians	724	27
Plumbers, Pipefitters, and Steamfitters	716	22
Operating Engineers and Other Construction Equipment Operators	209	3
Sheet Metal Workers	208	3
Machinists	151	74
Heating, Air Conditioning, and Refrigeration Mechanics and Installers	123	16
Structural Iron and Steel Workers	118	2
Millwrights	83	6
Industrial Machinery Mechanics	71	15
Construction Laborers	67	4
Boilermakers	49	1

Cement Masons and Concrete Finishers	44	3
Roofers	36	3
Industrial Engineering Technologists and Technicians	27	3
Electrical and Electronics Repairers, Commercial and Industrial Equipment	23	2
Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic	11	2
Automotive Service Technicians and Mechanics	9	8
Welders, Cutters, Solderers, and Brazers	9	4
Computer Numerically Controlled Tool Operators	7	2

SOURCE: U.S. Department of Labor, Registered Apprenticeship Partners Information Database System, Fourth Quarter 2022
NOTE: Ordered by number of active apprenticeships across all providers with a registered apprenticeship in the occupation. Occupations are categorized using the O*NET-SOC system.

Programs on Pennsylvania's Eligible Training Provider List

The final source we consulted to systematically identify programs offering preparation for green occupations was the Eligible Training Provider List (ETPL), available online as part of the Pennsylvania CareerLink (Pennsylvania Career Link, undated-b). This list includes programs for which eligible participants (typically unemployed and dislocated adult workers) may receive public financial support through the Workforce Innovation and Opportunity Act (WIOA). The programs must be approved for inclusion by local Workforce Development Boards (WDBs) and the state Department of Labor and Industry (DLI) (Pennsylvania Department of Labor & Industry, 2022a). Moreover, the programs must offer preparation for jobs in High Priority Occupations, identified through an iterative process by DLI and local WDBs based on data analysis and expert opinion as those "that are in demand by employers, have evolving skill needs, and are likely to provide family-sustaining wages" (Pennsylvania Department of Labor & Industry, 2022b).

Providers on the ETPL may include the following types of entities:

- An accredited institution of higher education that provides a program leading to a recognized post-secondary credential;
- An entity that carries out programs registered under the Act of August 16, 1937 (commonly known as the "National Apprenticeship Act"; 60 Stat. 664, Chapter 663, 29 U.S.C. 50 et seq.);
- Another public or private provider of a program of training services, which may include joint labor-management organizations, and eligible providers of adult education and literacy activities under WIOA title II, if such activities are provided in combination with occupational skills training;
- Provider of on-the-job training (OJT), customized training (CT), incumbent worker training (IWT), internships, and paid or unpaid work experience opportunities, or transitional employment; or
- An entity that, in limited circumstances, is contracted by the local board to provide training services (Pennsylvania Department of Labor & Industry, 2022b).

The top two categories clearly overlap with our earlier analyses of programs in the Department of Education IPEDS data and the U.S. Department of Labor RAPIDS data on

Registered Apprenticeships. As such, we focused the ETPL analysis on programs at providers not captured in those other two datasets.

Data and Methods

The CareerLink website provides a filterable list of providers and programs across the state. We accessed the site in January 2023 and downloaded the full list of entries for the seven counties in the Pittsburgh MSA. Information downloaded included the provider and its county, the name of the program, the program's cost and length, and the credential earned upon completion of the program. We used filters on the website to restrict entries to programs for which participants are not eligible to receive federal Pell Grants; by construction, Pell-eligible programs are offered at providers in the IPEDS data described above. We also screened out apprenticeships, for which more comprehensive data are available in RAPIDS. For each program remaining after applying these filters, we retrieved online entries with additional information—including the occupation(s) for which it offered preparation. We reviewed these occupations to identify which programs at which providers on the ETPL offered education or training programs that prepare people for green occupations and in which green sectors these occupations fall.

Results

In total, we identified eight additional providers offering 35 individual programs aligned with green occupations that we did not capture in the analysis of IPEDS and RAPIDS data. Among the providers on the list were five career and technical education centers that offer programs for adults in addition to high school students and three private providers offering training in preparation for earning a Commercial Driver's License. These programs are typically short term and do not result in earning college credits. The most common green occupations for which they offer preparation are truck drivers, welders, HVAC technicians, and electricians. With respect to green sectors, alignment with the energy sector is most common (truck drivers are included in this sector), followed by the circular economy, green buildings, and manufacturing sectors.

Appendix E: Steps to Evaluating the Sufficiency of Regional Workforce to Support Expansion of a New or Emerging Sustainable Sector

The occupational analyses for all the regionally relevant green sectors in aggregate (described in detail in Appendix B) can also be used to understand the relative strengths and weakness of short- and medium-term labor supply for a single occupation or single sector. This narrower analysis can support investment decisions in the expansion of the green economy. In this appendix, we first walk through an example of how a decision tree can be implemented around this analysis for a single occupation (structural iron and steel workers) and a single sector (circular economy).

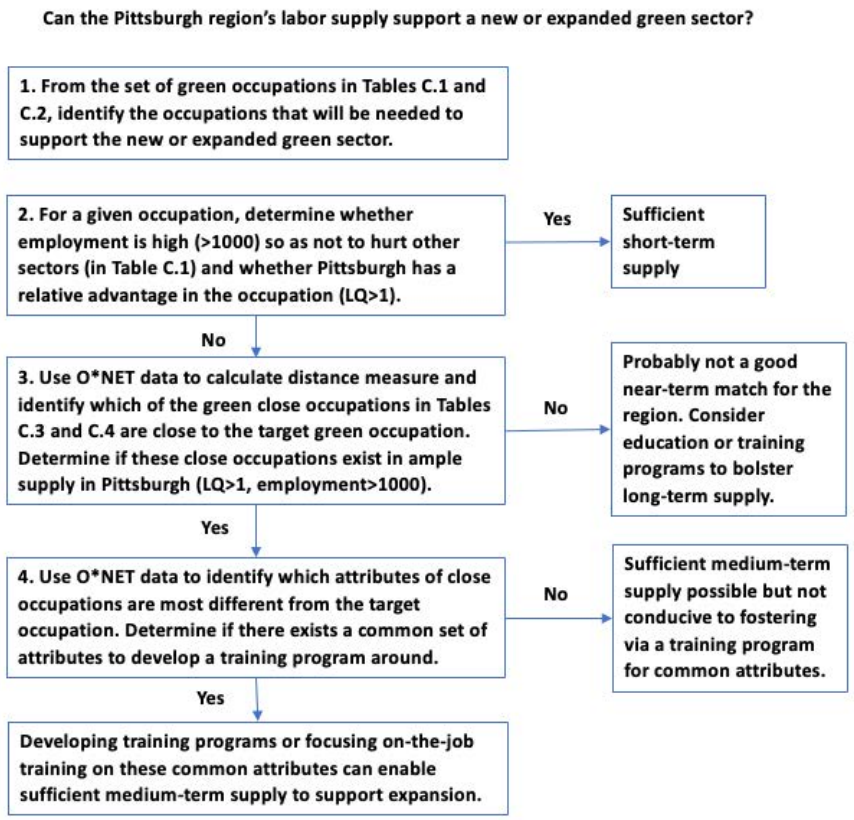
Consider a proposal for supporting expansion of a green sector in a specific area. The starting point for using the occupational analysis is to consider what occupations are likely to be expanded. The Dierdorff et al. (Dierdorff et al., 2011) study provides a mapping from the 11 green sectors identified by their work to specific occupations and are supplemented with the outdoor recreation analysis. Sector-to-sector mapping (Table B.1) links those sectors to those identified from the stakeholder interviews. These can be used to identify occupations that need to be considered when considering the expansion of an area of the green economy. It may be the entire suite of occupations associated with a sector or a subset of those occupations.

Once the set of occupations have been identified (Step 1 Figure E.1), an initial consideration of the labor force availability can be done using Tables C.1 and C.2 in Appendix C (Step 2). First, the location quotient is a measure of the relative size of the labor force compared to the nation. It provides a means to see if a location has a relative advantage in that occupation over other areas. If the location quotient is greater than 1, the location has a relatively high proportion of that occupation. Additionally, the total employment and jobs per 1000 provides us a means to see if there is sufficient labor force that can be employed in the green sector and not disadvantage other, pre-existing sectors. If all occupations are in sufficient supply and relatively plentiful, then there probably exists sufficient short-term labor supply to support the expansion.

Alternatively, there may not exist ample supply of the specific occupations but there may exist occupations that are close in terms of the nature of the work, skills, knowledge, and abilities necessary to perform the job (Step 3, Figure E.1). Appendix B describes our approach to identifying these occupations. Specifically, for each green occupation, we use O*NET data across 232 dimensions to calculate a normalized distance to all other occupations. For each occupation-to-occupation pair, a normalized distance of 100 is as similar as possible and zero is as dissimilar as possible. We define a close occupation as one scoring more than 80 out of 100. Tables C.3 and C.4 in Appendix C provide a list of occupations that are close to one or more

green occupations. Table C.3 provides a set of close occupations with more than 1000 individuals employed, and Table C.4 provides close occupations for which the region has relatively low total numbers. For these close green occupations, we can use a similar process as outlined above to see if Pittsburgh has a relative advantage in the occupation (location quotient greater than 1) and whether the occupation is relatively plentiful (more than 1000 workers).

Figure E.1. Schematic of Steps for Determining Sufficiency of Labor Supply



NOTE: Step 3 entails using O*NET data to calculate distances from green occupations to other occupations while Step 4 entails identifying the job characteristics on which the close occupations still differ from the green occupations. We work through this process for a single occupation (structural iron and steel workers) in this appendix. The underlying data tables for all green occupations are available upon request.

If there are close occupations present in large numbers and where the Pittsburgh area has a relative advantage, this suggests that there could be sufficient medium-term labor supply for the green occupation(s) to which these occupations are close—if training opportunities exist or could be created to bridge the gaps between the close jobs and the target occupation(s). In this case, one would look to identify the largest gaps that do exist between the attributes of the target green occupation and the close occupations (step 4 Figure E.1). If there are attributes in common that differentiate several close occupations from the green occupation, this means that developing training programs around those attributes could foster a medium-term labor supply for the green

occupation. If there are not common differences, the path to building up labor supply over the medium term would need to be more multifaceted—with different close occupations needing different knowledge or skills to enable transitions into the green occupation.

Last, if neither the green occupation nor occupations close to it are in ample supply in the Pittsburgh area, the area may not be a good fit from a labor force perspective for a short- to medium-term expansion of the green economy sectors that draw heavily upon workers in that occupation. If an expansion in the sector were nonetheless considered important, efforts should turn toward building up a labor supply in the target occupations over the longer term via education and training programs or recruitment of workers from outside the region.

Single Occupation Example: Structural Iron and Steel Workers

To better understand how we can use the underlying data, we focus on a single target occupation: structural iron and steel workers. This occupation is considered a green "increased demand" occupation under the Dierdorff et al. (Dierdorff et al., 2011) scheme and is expected to contribute to several green sectors: circular economy, green construction, and manufacturing. However, there are fewer than 1000 people in this occupation in the Pittsburgh area and the occupational location quotient is below one, meaning that there likely does not exist a sufficient supply of the occupation to support a short-term expansion of sectors that rely on it. We then look to identify occupations that are close to it based on the nature of the job and knowledge, skills, and abilities required. We identify seven such occupations: (1) Brickmasons and blockmasons (47-2021); (2) Roustabouts, oil and gas (47-5071); (3) Derrick operators, oil and gas (47-5011); (4) Reinforcing iron and bar workers (47-2171); (5) Boilermakers (47-2011); (6) Rail car repairers (49-3043); and (7) Helpers – Brickmasons and blockmasons (47-3011).

We then look to see what attributes of these close jobs distinguish them from structural iron and steel workers. We focus on knowledge and skills attributes as these may be used to inform training programs to transition individuals from one occupation to the target occupation. Table F.1 provides the top ten largest differences on knowledge and skills for each of these occupations compared to structural iron and steel workers. Of these seven close occupations, six have "Learning Strategies" as part of its top ten; five have "Public Safety and Security," "Instructing," "Customer and Personal Services," "Coordination," and "Building and Construction." Thus, a training program to transition workers in these seven occupations to structural iron and steel workers would need to incorporate these dimensions as they are the largest differences between these close occupations and the target occupation.

Table E.1. Top Ten Largest Differences Relative to Structural Iron and Steel Workers for Seven Occupations

Rank	Brickmasons and blockmasons (47-2021)	Roustabouts, oil and gas (47-5071)	Derrick operators, oil and gas (47-5011)	Reinforcing iron and bar workers (47-2171)	Boilermakers (47-2011)	Rail car repairers (49-3043)	Helpers: Brickmasons and blockmasons (47-3011)
1	Building and Construction	Operation and Control	Mechanical	Building and Construction	Building and Construction	Building and Construction	Building and Construction
2	Coordination	Learning Strategies	Active Learning	Customer and Personal Service	Customer and Personal Service	Reading Comprehension	Coordination
3	Transportation	Operations Monitoring	Operations Monitoring	Mathematics	Design	Customer and Personal Service	Mathematics
4	Public Safety and Security	Instructing	Learning Strategies	Administration and Management	Operations Analysis	Learning Strategies	Learning Strategies
5	Instructing	Transportation	Customer and Personal Service	Public Safety and Security	Engineering and Technology	Mathematics	Instructing
6	English Language	Active Learning	Instructing	Education and Training	Technology Design	Operations Analysis	Personnel and Human Resources
7	Administration and Management	Mechanical	Active Listening	Operations Monitoring	Coordination	Design	English Language
8	Psychology	Coordination	Public Safety and Security	Active Learning	Mathematics	Coordination	Psychology
9	Management of Personnel Resources	Customer and Personal Service	Service Orientation	Learning Strategies	Public Safety and Security	Operation and Control	Operations Analysis
10	Learning Strategies	Complex Problem Solving	Management of Personnel Resources	Operation and Control	Installation	Instructing	Public Safety and Security

SOURCE: Occupational Information Network (O*NET)
NOTE: Considers knowledge and skills attributes only.

Among the occupations close to the target occupation, two appear most promising for possible transitions based on their local location quotients: brickmasons and blockmasons and roustabouts, oil and gas. Additionally, in both cases, typical wages are higher in the structural iron and steel worker occupation than in the close occupations, potentially motivating workers to consider transitioning occupations. In several other instances, low location quotients for the close occupations make them less feasible to draw upon as a talent pool to bolster the structural iron and steel worker workforce in the region.

Full Sector Example: Circular Economy Occupations

It is more complex to consider a full sector analysis given that the set of close occupations and the attributes on which the close occupations differ from green occupation will differ for each occupation needed to expand each green sector. But it is possible and proceeds by replicating the above steps for each of the occupations within the sector. Using the circular economy as an example, Table E.2, below, provides the set of occupations that are associated with the circular economy, broadly defined. This table finds that for most of the occupations in the circular economy, there does not exist sufficient excess supply of those occupation and a relative dominance in the Pittsburgh area. Rather, in most cases, either the location quotient is below one, there are fewer than 1000 workers in the occupation in the region, or both.

Table E.2 Occupations associate with the Circular Economy

SOC	Title	Total Employment	more than 1000	Jobs per 1000	Location Quotient
Occupations with 1000 or More Workers, Sorted by Location Quotient					
17-2141	Mechanical Engineers	4,130	1	4.0	2.0
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	3,800	1	3.6	1.9
51-9161	Computer Numerically Controlled Tool Operators	2,190	1	2.1	1.9
47-2073	Operating Engineers and Other Construction Equipment Operators	5,010	1	4.8	1.7
17-2071	Electrical Engineers	2,190	1	2.1	1.6
17-3011	Architectural and Civil Drafters	1,040	1	1.0	1.4
47-2061	Construction Laborers	9,890	1	9.5	1.4
47-4011	Construction and Building Inspectors	1,200	1	1.1	1.4
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	3,330	1	3.2	1.3
17-2051	Civil Engineers	2,590	1	2.5	1.2
49-9041	Industrial Machinery Mechanics	3,150	1	3.0	1.1
13-2051	Financial and Investment Analysts	2,370	1	2.3	1.1
47-2031	Carpenters	5,180	1	5.0	1.1
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	3,910	1	3.7	1.0

13-1081	Logisticians	1,360	1	1.3	1.0
51-4121	Welders, Cutters, Solderers, and Brazers	2,820	1	2.7	1.0
49-9071	Maintenance and Repair Workers, General	10,000	1	9.6	1.0
51-4041	Machinists	2,340	1	2.2	1.0
47-2152	Plumbers, Pipefitters, and Steamfitters	2,870	1	2.8	0.9
51-1011	First-Line Supervisors of Production and Operating Workers	4,180	1	4.0	0.9
17-2112	Industrial Engineers	1,890	1	1.8	0.9
11-3051	Industrial Production Managers	1,220	1	1.2	0.9
51-4031	Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic	1,110	1	1.1	0.8
47-2111	Electricians	3,970	1	3.8	0.8
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	16,150	1	15.5	0.8
13-1151	Training and Development Specialists	1,970	1	1.9	0.8
47-2051	Cement Masons and Concrete Finishers	1,090	1	1.0	0.8
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	2,980	1	2.9	0.7
43-5071	Shipping, Receiving, and Inventory Clerks	4,220	1	4.0	0.7
51-2090	Miscellaneous Assemblers and Fabricators	6,650	1	6.4	0.7
43-5061	Production, Planning, and Expediting Clerks	1,640	1	1.6	0.6
53-7051	Industrial Truck and Tractor Operators	3,080	1	3.0	0.6
Occupations with Fewer Than 1000 Workers, Sorted by Location Quotient					
17-3024	Electro-Mechanical and Mechatronics Technologists and Technicians	270	0	0.3	3.2
17-2111	Health and Safety Engineers, Except Mining Safety Engineers and Inspectors	400	0	0.4	2.3
19-4031	Chemical Technicians	810	0	0.8	1.9
19-2031	Chemists	930	0	0.9	1.6
17-3029	Engineering Technologists and Technicians, Except Drafters, All Other	780	0	0.7	1.4
49-2094	Electrical and Electronics Repairers, Commercial and Industrial Equipment	510	0	0.5	1.4
19-5011	Occupational Health and Safety Specialists	1,000	0	1.0	1.3
17-3023	Electrical and Electronic Engineering Technologists and Technicians	950	0	0.9	1.3
51-9011	Chemical Equipment Operators and Tenders	930	0	0.9	1.2
51-2041	Structural Metal Fabricators and Fitters	530	0	0.5	1.2
47-4041	Hazardous Materials Removal Workers	370	0	0.4	1.1
17-1012	Landscape Architects	130	0	0.1	1.1
47-3012	Helpers--Carpenters	210	0	0.2	1.0
51-9012	Separating, Filtering, Clarifying, Precipitating, and Still Machine Setters, Operators, and Tenders	350	0	0.3	1.0
49-9044	Millwrights	270	0	0.3	0.9
17-1011	Architects, Except Landscape and Naval	690	0	0.7	0.9
17-2199	Engineers, All Other	970	0	0.9	0.9
51-9023	Mixing and Blending Machine Setters, Operators, and Tenders	690	0	0.7	0.9
19-3051	Urban and Regional Planners	240	0	0.2	0.8
17-3027	Mechanical Engineering Technologists and Technicians	250	0	0.2	0.8

17-2031	Bioengineers and Biomedical Engineers	100	0	0.1	0.8
17-3026	Industrial Engineering Technologists and Technicians	360	0	0.3	0.8
47-2221	Structural Iron and Steel Workers	380	0	0.4	0.8
11-3071	Transportation, Storage, and Distribution Managers	800	0	0.8	0.7
47-2211	Sheet Metal Workers	670	0	0.6	0.7
53-7081	Refuse and Recyclable Material Collectors	680	0	0.7	0.7
47-2181	Roofers	610	0	0.6	0.6
51-8013	Power Plant Operators	130	0	0.1	0.6
51-4032	Drilling and Boring Machine Tool Setters, Operators, and Tenders, Metal and Plastic	30	0	0.0	0.6
27-1021	Commercial and Industrial Designers	110	0	0.1	0.5
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	980	0	0.9	0.5
49-9098	Helpers--Installation, Maintenance, and Repair Workers	330	0	0.3	0.5
19-5012	Occupational Health and Safety Technicians	70	0	0.1	0.4
13-2054	Financial Risk Specialists	150	0	0.1	0.4
11-9021	Construction Managers	710	0	0.7	0.3

SOURCE: Bureau of Labor Statistics, Occupational Employment and Wage Statistics, May 2021
NOTE: Sorted by location quotient first for occupations with 1000 or more workers and then for occupations with fewer than 1000 workers.

To support an expansion of the circular economy in the aggregate, the region would need to increase labor supply in a number of occupations. For those occupations that have a location quotient less than 0.75 based on the analysis above, and therefore the ones for which the region has the most pronounced relative disadvantage, we extract the set of close occupations based on the distances calculated from the O*NET data. Table E.3 provides a listing of the circular economy occupations together with the number of close occupations for each. For about half of the circular economy occupations, there does not exist a close occupational analog, complicating the short- to medium-term pathway for the region to expand across-the-board in the circular economy. However, these data do suggest strengths for the region; importantly, it appears that a greater focus on construction-related dimensions of the circular economy may dovetail well with the current supply side of the labor market in the Pittsburgh area.

Table E.3. Close Occupations to those with low Location Quotient for the Circular Economy

SOC	Title	Employment	Jobs per 1000	LQ	Number of Close Occupations
47-2221	Structural Iron and Steel Workers	380	0.4	0.75	7
11-3071	Transportation, Storage, and Distribution Managers	800	0.8	0.74	9
47-2211	Sheet Metal Workers	670	0.6	0.73	2
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	2,980	2.9	0.73	0

53-7081	Refuse and Recyclable Material Collectors	680	0.7	0.73	0
43-5071	Shipping, Receiving, and Inventory Clerks	4,220	4	0.72	0
51-2090	Miscellaneous Assemblers and Fabricators	6,650	6.4	0.68	0
47-2181	Roofers	610	0.6	0.64	1
51-8013	Power Plant Operators	130	0.1	0.63	6
43-5061	Production, Planning, and Expediting Clerks	1,640	1.6	0.6	0
51-4032	Drilling and Boring Machine Tool Setters, Operators, and Tenders, Metal and Plastic	30	0	0.6	2
53-7051	Industrial Truck and Tractor Operators	3,080	3	0.55	0
27-1021	Commercial and Industrial Designers	110	0.1	0.52	0
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	980	0.9	0.5	0
49-9098	Helpers--Installation, Maintenance, and Repair Workers	330	0.3	0.5	6
19-5012	Occupational Health and Safety Technicians	70	0.1	0.43	2
13-2054	Financial Risk Specialists	150	0.1	0.37	0
11-9012	Construction Managers	710	0.7	0.33	0

SOURCE: Bureau of Labor Statistics, Occupational Employment and Wage Statistics, May 2021; Occupational Information Network (O*NET) data
NOTE: Sorted by location quotient among circular economy occupations with a location quotient of 0.75 or less.

Appendix F: Characteristics of Workers in Green Occupations

We used data from the U.S. Census Bureau's American Community Survey (ACS) to analyze characteristics of Pittsburgh-area workers in green occupations. Characteristics included age, sex, race/ethnicity, and educational attainment. We also used ACS data to explore county-level patterns of where workers in green occupations live and work in the Pittsburgh region. We compare green workers to people in occupations that are not green. We also analyzed characteristics of workers in occupations that we identified as "close green" occupations. First, we describe our data sources and methods.[46] Next, we summarize our main results. Detailed data tables are provided in the last section of this appendix.

Data and Methods for Characterizing the Green Workforce

The ACS collects detailed demographic, economic, and other information from about 3.5 million households across the country each year, including the occupations of people in surveyed households (U.S. Census Bureau, 2020). The U.S. Census Bureau releases numerous data products derived from the survey, either based on one or five years of data. These include summary and detailed tables as well as a sample of individual, deidentified records known as the Public Use Microdata Sample (PUMS) (U.S. Census Bureau, 2020). Since we were seeking to analyze characteristics of workers for a specific set of occupations not grouped together in published tables, we used PUMS data for our analysis. Specifically, we used the five-year ACS PUMS spanning 2017 to 2021, released by the U.S. Census Bureau in January 2023. We downloaded raw PUMS data from the U.S. Census Bureau (U.S. Census Bureau, undated). We prepared the data for analysis using Stata statistical analysis software, modifying code made available by the Center for Economic Policy Research (CEPR) (CEPR Data, undated).

PUMS data are reported at the level of the Public Use Microdata Area (PUMA), which have at least 100,000 residents and can be a portion of one county, equivalent to a county, or span multiple counties. To determine which ACS respondents were in the Pittsburgh metropolitan statistical area (MSA), we used a PUMA to MSA crosswalk published by IPUMS USA (IPUMS USA, undated). In three instances, a PUMA included a county (or a portion of a county) in the Pittsburgh MSA and a county outside the MSA. We include all PUMAs at least partially in the Pittsburgh MSA in our analysis, resulting in the addition of Indiana, Lawrence, and Greene

[46] The ACS analysis approach builds upon the data sources and methods described in Appendix A of Zaber et al., 2023.

counties to the MSA set of counties of Allegheny, Armstrong, Beaver, Butler, Fayette, Washington, and Westmoreland.

To identify green occupations in the ACS, we leveraged a BLS SOC to ACS occupation code crosswalk produced by BLS (U.S. Bureau of Labor Statistics, 2022a). ACS occupation codes often combine multiple BLS SOC codes. To determine which ACS codes reflect green occupations, we used 2021 OEWS national data to construct the employment-weighted share of each ACS occupation that met our definition of green occupation at the BLS SOC level. More than 90 percent were either zero (74 percent) or one (19 percent), indicating that either none or all the BLS SOC codes that form the ACS occupation code are green. For the remaining 7 percent, we used a threshold of 0.33 to determine whether the ACS code is green, meaning that we require at least one-in-three of the jobs in the BLS SOCs that compose the ACS code to meet our green occupation definition. We replicated this process to define the set of ACS occupational codes in each of our seven green sectors: agriculture, circular economy, energy, green buildings, manufacturing, water management, and outdoor recreation. As with our BLS analyses, occupations may be in multiple sectors. We separately consider the sets of occupations that form the sectors(Dierdorff et al., 2011) that contribute across all seven of these sectors (Research, Design, and Consulting Services, and Government and Regulatory Administration) as opposed to including them in all seven sectors. Additionally, we used a similar process to map "close green" occupations to ACS codes.

We present results for workers at least 25 years old who are in the civilian labor force. This includes workers employed full-time or part-time as well as unemployed workers (who are available for and actively looking for work). The age restriction allows us to assess educational attainment at a point when most workers who pursue it would have completed their undergraduate education. The inclusion of the full labor force provides a broad sense for characteristics of available labor supply in green occupations, who might become employed or shift from part- to full-time as labor market conditions and their own circumstances evolve.

Results of Characterization of Green Labor Supply

About one-in-three workers ages 25 and up in the Pittsburgh region is in a green occupation, with a slightly higher share of workers outside of Allegheny in one of these occupations (see last row of Table F.1). The county with the highest share of its labor force in green occupations is Fayette County at 39 percent while the lowest share is Allegheny at 31 percent. Relatedly, we find that those in the counties surrounding Allegheny account for a little over half (53 percent) of the metropolitan area's green workforce versus a little under half (49 percent) of its labor force overall. We do, however, find that green workers in the surrounding counties are a little more likely, on average, to work in Allegheny County than workers not in green occupations. See the tables in the last section of this appendix for detailed tabulations on where green workers live and work in the Pittsburgh area.

Table F.1. Size and Distribution of the Population, Workforce, and Green Workforce, Pittsburgh Metropolitan Statistical Area, Allegheny County versus Surrounding Counties, 2017-2021

	Pittsburgh Region Overall		*Surrounding Counties Total*
		Allegheny	
Population	2,572,322	1,245,378	1,326,944
Percentage of MSA population	100%	48%	52%
Labor force	1,166,073	590,643	575,430
Percentage of MSA labor force	100%	51%	49%
Green labor force	382, 980	180,897	202,083
Percentage of MSA green labor force	100%	47%	53%
Percentage of labor force in green occupations	33%	31%	35%

SOURCE: Features data from the ACS; 5-Year PUMS, 2017-2021; CEPRdata, "ACS Programs," webpage, 2023.
NOTE: MSAs in our ACS analyses are broader than in our other analyses because PUMAs, the most granular level of geography identified in the PUMS, may combine a county in the MSA with one outside it. Labor force refers to individuals ages 25 or older who are employed full-time or part-time or who are unemployed and available and looking for work.

With respect to the demographic characteristics of green workers, Table F.2 shows that they are overwhelmingly white, non-Hispanic (89 percent, higher than the region's labor force overall), and that a much smaller proportion is female than in the labor force overall (26 percent versus 47 percent). In both dimensions, these factors are more pronounced in the counties surrounding Allegheny, where just 6 percent of green workers are not white, non-Hispanic, and just 23 percent are female. The average age of green workers (46 among workers ages 25 and up) mirrors the average for the labor force overall as does the share of these workers who are foreign born (5 percent). Green workers are less likely than the labor force (ages 25 and up) overall to have a bachelor's degree, with 38 percent with at least a bachelor's degree versus 43 percent of the workforce overall. The shares of the green workforce with less than a bachelor's degree are highest in the manufacturing, circular economy, and green buildings sectors (at 78, 75, and 73 percent, respectively), and lowest in the water management sector (at 42 percent with less than a bachelor's degree). Occupations that contribute across sectors—in the Research, Design, and Consulting Services, and Government and Regulatory Administration sectors(Dierdorff et al., 2011) have an even lower share of workers without a bachelor's degree, at 38 percent.

Table F.2. Demographic Characteristics of the Green Workforce by Sector, Overall Workforce, and Population, Pittsburgh Metropolitan Statistical Area, 2017-2021

	% Of Green Labor Force	**% Female**	**% White, Non-Hispanic**	**Average Age**	**% Less Than Bach. Degree**	**% Bach. Degree or Higher**	**% Foreign Born**
Population	N/A	51%	85%	42	65%	35%	4%
Labor force	N/A	47%	87%	46	57%	43%	5%
Green labor force	100%	26%	89%	46	62%	38%	5%
Agriculture	4%	36%	93%	47	52%	48%	3%
Circular Economy	41%	13%	90%	46	75%	25%	4%
Energy	39%	16%	91%	47	65%	35%	3%
Green Buildings	29%	10%	90%	45	73%	27%	4%

Manufacturing	23%	17%	89%	46	78%	22%	4%
Water Management	14%	27%	91%	46	42%	58%	4%
Outdoor Recreation	27%	46%	86%	46	53%	47%	7%
Cross Sector	40%	34%	87%	45	38%	62%	7%

SOURCE: Features data from the ACS; 5-Year PUMS, 2017-2021; CEPRdata, "ACS Programs," webpage, 2023.
NOTE: MSAs in our ACS analyses are broader than in our other analyses because PUMAs, the most granular level of geography identified in the PUMS, may combine a county in the MSA with one outside it. Labor force refers to individuals ages 25 or older who are employed full-time or part-time or who are unemployed and available and looking for work. Cross sector category includes occupations in the Research, Design, and Consulting Services, and Government and Regulatory Administration (Dierdorff et al., 2011).

A set of tables in the last section of this Appendix lists the green occupations accounting for the most members of the green labor force in the Pittsburgh area, according to the ACS data. The tables provide this information both for the green workforce overall and by sector.

Lastly, we replicated these analyses for "close green" occupations, which require knowledge, skills, and abilities with considerable overlap with those needed for green occupations. We find that 10 percent of workers in the Pittsburgh MSA overall are in "close green" occupations, on top of the 33 percent in green occupations themselves. Unlike green occupations, a slightly higher share of the Allegheny County workforce (11 percent) is in "close green" occupations than in the surrounding counties (8 percent). Workers in "close green" occupations are much more likely to be female (46 percent) than workers in green occupations (26 percent). Both sets of occupations are overwhelmingly white, non-Hispanic (89 percent of workers in both groups). There is a sizable different in educational attainment: while just 38 percent of workers in green occupations in the Pittsburgh MSA have a bachelor's degree or higher, two-thirds (67 percent) of workers in "close green" occupations have at least a bachelor's degree.

Characteristics of Green Workers Detailed Tables

The following tables provide additional granularity on the number, locations, and characteristics of workers in green occupations in the Pittsburgh region. Table F.3 presents information by county on the share of workers in green occupations and the share of the regionwide green workforce, overall workforce, and population located in the county. Table F.4 compares where workers in green occupations live versus where they work, for example, showing by county the portion of green workers who work in that county, in Allegheny County, in one of the surrounding counties, or outside the Pittsburgh MSA. Table F.5 provides this information for workers in occupations not included in our set of green occupations, comparing where they live by county to where they work. Table F.6 shows how the green workforce compares to the overall workforce and area population with respect to the share female and white non-Hispanic. The next tables present information broken down by sector of the green workforce on demographic characteristics (Table F.7), average age of workers (Table F.8), place of birth and whether they have moved recently (Table F.9), and educational attainment (Table F.10).

Table F.3. Size and Distribution of the Population, Workforce, and Green Workforce, Pittsburgh Metropolitan Statistical Area, by County, 2017-2021

	Allegheny	**Armstrong/ Indiana**	**Beaver / Lawrence**	**Butler**	**Fayette**	**Washington/ Greene**	**Westmoreland**	***Surrounding Counties Total***	***Pittsburgh Region Overall***
Population	1,245,378	149,529	254,770	192,481	129,501	245,430	355,233	1,326,944	2,572,322
Labor force	590,643	58,698	112,703	87,814	51,368	105,533	159,314	575,430	1,166,073
Green labor force	180,897	20,397	38,637	30,389	19,837	37,425	55,398	202,083	382,980
% labor force in green occupations	31%	35%	34%	35%	39%	35%	35%	35%	33%
% MSA population	48%	6%	10%	7%	5%	10%	14%	52%	100%
% MSA labor force	51%	5%	10%	8%	4%	9%	14%	49%	100%
% MSA green labor force	47%	5%	10%	8%	5%	10%	14%	53%	100%

SOURCE: Features data from the ACS; 5-Year PUMS, 2017-2021; CEPRdata, "ACS Programs," webpage, 2023.
NOTE: MSAs in our ACS analyses are broader than in our other analyses because PUMAs, the most granular level of geography identified in the PUMS, may combine a county in the MSA with one outside it. Labor force refers to individuals ages 25 or older who are employed full-time or part-time or who are unemployed and available and looking for work.

Table F.4. Where Green Workers Live Versus Where They Work, Pittsburgh Metropolitan Statistical Area, by County, 2017-2021

County of Residence	**# Green Workers**	**% Work in Own County**	**% Work in Allegheny County**	**% Work in Other Surrounding County**	**% Work Outside Pittsburgh MSA**	**% Unemployed**
Allegheny	180,897	82%	N/A	10%	2%	6%
Armstrong/ Indiana	20,397	51%	12%	20%	10%	6%
Beaver/Lawrence	38,637	52%	24%	11%	7%	7%
Butler	30,389	60%	23%	8%	4%	5%
Fayette	19,837	53%	7%	25%	6%	10%
Washington/ Greene	37,425	59%	24%	6%	6%	5%
Westmoreland	55,398	60%	25%	7%	2%	6%

SOURCE: Features data from the ACS; 5-Year PUMS, 2017-2021; CEPRdata, "ACS Programs," webpage, 2023.
NOTE: MSAs in our ACS analyses are broader than in our other analyses because PUMAs, the most granular level of geography identified in the PUMS, may combine a county in the MSA with one outside it. In this table, "% Work in Own Country" refers to the percentage working in either their home county or the other county in the same PUMA for the three sets of counties that are combined to create a PUMA. Analysis includes labor force members ages 25 or older who are employed full-time or part-time or who are unemployed and available and looking for work.

Table F.5. Where Workers Not in Green Occupations Live Versus Where They Work, Pittsburgh Metropolitan Statistical Area, by County, 2017-2021

County of Residence	# Not Green Workers	% Work in Own County	% Work in Allegheny County	% Work in Other Surrounding County	% Work Outside Pittsburgh MSA	% Unemployed
Allegheny	407,690	86%	N/A	7%	1%	6%
Armstrong/ Indiana	38,030	66%	8%	13%	7%	6%
Beaver/Lawrence	73,587	59%	20%	9%	5%	7%
Butler	57,187	61%	24%	4%	3%	7%
Fayette	31,034	60%	5%	20%	9%	6%
Washington/ Greene	67,759	63%	21%	5%	6%	6%
Westmoreland	103,264	63%	23%	7%	2%	5%

SOURCE: Features data from the ACS; 5-Year PUMS, 2017-2021; CEPRdata, “ACS Programs,” webpage, 2023.
NOTE: MSAs in our ACS analyses are broader than in our other analyses because PUMAs, the most granular level of geography identified in the PUMS, may combine a county in the MSA with one outside it. In this table, “% Work in Own Country” refers to the percentage working in either their home county or the other county in the same PUMA for the three sets of counties that are combined to create a PUMA. Analysis includes labor force members ages 25 or older who are employed full-time or part-time or who are unemployed and available and looking for work.

Table F.6. Demographic Characteristics of the Green Workforce, Overall Workforce, and Population, Pittsburgh Metropolitan Statistical Area, Allegheny County Versus Surrounding Counties, 2017-2021

	Number of Individuals			% Female			% White, Non-Hispanic		
	Pittsburgh Region Overall	Allegheny County	Surrounding Counties	Pittsburgh Region Overall	Allegheny County	Surrounding Counties	Pittsburgh Region Overall	Allegheny County	Surrounding Counties
Population	2,572,322	1,245,378	1,326,944	51%	51%	50%	85%	78%	92%
Labor force	1,166,073	590,643	575,430	47%	48%	46%	87%	81%	94%
Green labor force	382,980	180,897	202,083	26%	29%	23%	89%	83%	94%
Percentage labor force in green occupations	33%	31%	35%	N/A	N/A	N/A	N/A	N/A	N/A

SOURCE: Features data from the ACS; 5-Year PUMS, 2017-2021; CEPRdata, "ACS Programs," webpage, 2023.
NOTE: MSAs in our ACS analyses are broader than in our other analyses because PUMAs, the most granular level of geography identified in the PUMS, may combine a county in the MSA with one outside it. Labor force refers to individuals ages 25 or older who are employed full-time or part-time or who are unemployed and available and looking for work.

Table F.7. Demographic Characteristics of the Green Workforce by Green Sector, Pittsburgh Metropolitan Statistical Area, Allegheny County Versus Surrounding Counties, 2017-2021

	% Green Labor Force in Group			% Female			% White, Non-Hispanic		
	Pittsburgh Region Overall	Allegheny County	Surrounding Counties	Pittsburgh Region Overall	Allegheny County	Surrounding Counties	Pittsburgh Region Overall	Allegheny County	Surrounding Counties
Agriculture	4%	4%	4%	36%	38%	34%	93%	89%	96%
Circular Economy	41%	35%	46%	13%	13%	13%	90%	84%	94%
Energy	39%	36%	42%	16%	20%	14%	91%	86%	95%
Green Buildings	29%	27%	31%	10%	11%	9%	90%	84%	95%
Manufacturing	23%	18%	27%	17%	18%	17%	89%	81%	93%
Water Management	14%	16%	13%	27%	30%	25%	91%	88%	95%
Outdoor Recreation	27%	32%	22%	46%	45%	47%	86%	80%	94%
Cross Sector	40%	47%	33%	34%	34%	34%	87%	83%	94%

SOURCE: Features data from the ACS; 5-Year PUMS, 2017-2021; CEPRdata, "ACS Programs," webpage, 2023.
NOTE: Percentages do not add to 100 percent because occupations may in multiple green sectors. MSAs in our ACS analyses are broader than in our other analyses because PUMAs, the most granular level of geography identified in the PUMS, may combine a county in the MSA with one outside it. Labor force refers to individuals ages 25 or older who are employed full-time or part-time or who are unemployed and available and looking for work. Cross sector category includes occupations in the Research, Design, and Consulting Services, and Government and Regulatory Administration.(Dierdorff et al., 2011)

Table F.8. Average Age of the Green Workforce by Green Sector, Overall Workforce, and Population, Pittsburgh Metropolitan Statistical Area, Allegheny County Versus Surrounding Counties, 2017-2021

	Pittsburgh Region Overall	Allegheny County	Surrounding Counties
Overall population	42	41	43
Labor force	46	45	47
Green labor force	46	45	47
Agriculture	47	46	47
Circular Economy	46	45	46
Energy	47	46	48
Green Buildings	45	45	46
Manufacturing	46	45	47
Water Management	46	45	47
Outdoor Recreation	46	45	47
Cross Sector	45	44	47

SOURCE: Features data from the ACS; 5-Year PUMS, 2017-2021; CEPRdata, "ACS Programs," webpage, 2023.
NOTE: Occupations may in multiple green sectors. MSAs in our ACS analyses are broader than in our other analyses because PUMAs, the most granular level of geography identified in the PUMS, may combine a county in the MSA with one outside it. Labor force refers to individuals ages 25 or older who are employed full-time or part-time or who are unemployed and available and looking for work. Cross sector category includes occupations in the Research, Design, and Consulting Services, and Government and Regulatory Administration (Dierdorff et al., 2011).

Table F.9. Place of Birth and Mobility of the Green Workforce by Green Sector, Overall Workforce, and Population, Pittsburgh Metropolitan Statistical Area, Allegheny County Versus Surrounding Counties, 2017-2021

	% Foreign Born			% Born Out of State			% Moved in the Past Year		
	Pittsburgh Region Overall	Allegheny County	Surrounding Counties	Pittsburgh Region Overall	Allegheny County	Surrounding Counties	Pittsburgh Region Overall	Allegheny County	Surrounding Counties
Overall population	4%	6%	2%	20%	24%	16%	12%	13%	10%
Labor force	5%	7%	2%	23%	28%	18%	11%	13%	9%
Green labor force	5%	8%	2%	23%	29%	18%	10%	12%	9%
Agriculture	3%	4%	1%	20%	25%	15%	12%	16%	9%
Circular Economy	4%	7%	2%	19%	24%	15%	10%	12%	9%
Energy	3%	6%	2%	21%	25%	18%	10%	12%	9%
Green Buildings	4%	6%	2%	19%	24%	15%	10%	11%	9%
Manufacturing	4%	8%	2%	20%	24%	17%	10%	12%	9%
Water Management	4%	7%	1%	24%	30%	18%	10%	12%	8%
Outdoor Recreation	7%	11%	3%	27%	33%	20%	10%	12%	8%
Cross Sector	7%	11%	3%	29%	35%	21%	11%	13%	9%

SOURCE: Features data from the ACS; 5-Year PUMS, 2017-2021; CEPRdata, "ACS Programs," webpage, 2023.
NOTE: Occupations may in multiple green sectors. MSAs in our ACS analyses are broader than in our other analyses because PUMAs, the most granular level of geography identified in the PUMS, may combine a county in the MSA with one outside it. Labor force refers to individuals ages 25 or older who are employed full-time or part-time or who are unemployed and available and looking for work. Cross sector category includes occupations in the Research, Design, and Consulting Services, and Government and Regulatory Administration (Dierdorff et al., 2011).

Table F.10. Educational Attainment of the Green Workforce by Green Sector, Overall Workforce, and Population, Ages 25 and Older, Pittsburgh Metropolitan Statistical Area, Allegheny County Versus Surrounding Counties, 2017-2021

	% Less Than a Bachelor Degree			% Bachelor Degree or Higher		
	Pittsburgh Region Overall	Allegheny County	Surrounding Counties	Pittsburgh Region Overall	Allegheny County	Surrounding Counties
Overall population	65%	56%	72%	35%	44%	28%
Labor force	57%	48%	66%	43%	52%	34%
Green labor force	62%	51%	72%	38%	49%	28%
Agriculture	52%	39%	65%	48%	61%	35%
Circular Economy	75%	67%	81%	25%	33%	19%
Energy	65%	55%	72%	35%	45%	28%
Green Buildings	73%	65%	79%	27%	35%	21%
Manufacturing	78%	69%	83%	22%	31%	17%
Water Management	42%	35%	50%	58%	65%	50%
Outdoor Recreation	53%	44%	65%	47%	56%	35%
Cross Sector	38%	30%	47%	62%	70%	53%

SOURCE: Features data from the ACS; 5-Year PUMS, 2017-2021; CEPRdata, "ACS Programs," webpage, 2023.
NOTE: MSAs in our ACS analyses are broader than in our other analyses because PUMAs, the most granular level of geography identified in the PUMS, may combine a county in the MSA with one outside it. Labor force refers to individuals who are employed full-time or part-time or who are unemployed and available and looking for work. Analysis includes people ages 25 and older. Cross sector category includes occupations in the Research, Design, and Consulting Services, and Government and Regulatory Administration (Dierdorff et al., 2011).

Top Occupations of Green Workers

The following tables (F.11 to F.19) tabulate, for each sector, the top occupations in the Pittsburgh region based on data from the ACS. We include the number of workers, the share of the workforce, and a set of columns indicating whether the occupation in question is considered a green enhanced skills, increased demand, or new and emerging occupation (Dierdorff et al., 2011). We provide this information to shed light on the distribution of occupations that contribute to the descriptive analyses of worker characteristics presented above. However, we caution that OEWS data (such as those presented in Appendix C) are more appropriate for tabulating the number of workers in green occupations in the Pittsburgh region.

Table F.11 displays the ranking across all green occupations as we've defined them. Tables F. 12 to F.18 present information for each individual sector. Table F.19 displays occupations in our "cross-sector" grouping—which includes occupations in the Research, Design, and Consulting Services, and Government and Regulatory Administration (Dierdorff et al., 2011). These are occupations we expect could contribute to any of the seven other green sectors: agriculture, circular economy, energy, green buildings, manufacturing, water management, and outdoor recreation. We note that the flags for green enhanced skills, increased demand, or new & emerging occupations are not populated for most outdoor recreation occupations because of the alternative method we used to derive that list of occupations (beyond Dierdorff et al (Dierdorff et al., 2011)).

Table F.11. Green Workforce by Detailed Occupation, Overall, Top 20 Occupations by Workers Ages 25 and Older, Pittsburgh Metropolitan Statistical Area, 2017-2021

Occupation	Number of Workers	Share of Overall Green Workforce	Green Enhanced Skills	Green Increased Demand	Green New & Emerging
Other managers	32,736	8.5%			X
Driver/sales workers and truck drivers	27,358	7.1%	X		
Retail salespersons	20,230	5.3%			
Customer service representatives	18,556	4.8%		X	
Laborers and freight, stock, and material movers, hand	17,425	4.5%		X	X
Software developers	12,687	3.3%		X	
Carpenters	10,527	2.7%		X	
Construction laborers	10,181	2.7%	X		
Chief executives and legislators	9,945	2.6%			X
Management analysts	9,237	2.4%			
General and operations managers	8,256	2.2%	X		
Bookkeeping, accounting, and auditing clerks	7,692	2.0%			
First-line supervisors of construction trades and extraction workers	6,799	1.8%			X
First-line supervisors of production and operating workers	6,283	1.6%		X	
Inspectors, testers, sorters, samplers, and weighers	6,264	1.6%	X		
Construction managers	6,198	1.6%	X		
Automotive service technicians and mechanics	6,091	1.6%	X		
Computer occupations, all other	5,853	1.5%			X
Electricians	5,849	1.5%		X	
Other engineers	5,616	1.5%	X		X

SOURCE: Features data from the ACS; 5-Year PUMS, 2017-2021; CEPRdata, "ACS Programs," webpage, 2023.
NOTE: MSAs in our ACS analyses are broader than in our other analyses because PUMAs, the most granular level of geography identified in the PUMS, may combine a county in the MSA with one outside it. Labor force refers to individuals who are employed full-time or part-time or who are unemployed and available and looking for work. Analysis includes people ages 25 and older.

Table F.12. Green Workforce by Detailed Occupation, Agriculture Sector, All Occupations by Workers Ages 25 and Older, Pittsburgh Metropolitan Statistical Area, 2017-2021

Occupation	Number of Workers	Share of Green Sector Workforce	Green Enhanced Skills	Green Increased Demand	Green New & Emerging
General and operations managers	8,256	54.3%	X		
Purchasing agents, except wholesale, retail, and farm products	3,081	20.3%	X	X	
Farmers, ranchers, and other agricultural managers	1,790	11.8%	X		
Wholesale and retail buyers, except farm products	1,640	10.8%	X	X	
Landscape architects	164	1.1%	X		
Agricultural inspectors	108	0.7%		X	
Agricultural and food science technicians	107	0.7%	X		X
First-line supervisors of farming, fishing, and forestry workers	55	0.4%		X	

SOURCE: Features data from the ACS; 5-Year PUMS, 2017-2021; CEPRdata, "ACS Programs," webpage, 2023.
NOTE: MSAs in our ACS analyses are broader than in our other analyses because PUMAs, the most granular level of geography identified in the PUMS, may combine a county in the MSA with one outside it. Labor force

refers to individuals who are employed full-time or part-time or who are unemployed and available and looking for work. Analysis includes people ages 25 and older. Excludes one occupation with fewer than 10 workers.

Table F.13. Green Workforce by Detailed Occupation, Circular Economy Sector, Top 20 Occupations by Workers Ages 25 and Older, Pittsburgh Metropolitan Statistical Area, 2017-2021

Occupation	Number of Workers	Share of Green Sector Workforce	Green Enhanced Skills	Green Increased Demand	Green New & Emerging
Laborers and freight, stock, and material movers, hand	17,425	11.2%		X	X
Carpenters	10,527	6.8%		X	
Construction laborers	10,181	6.5%	X		
First-line supervisors of production and operating workers	6,283	4.0%		X	
Inspectors, testers, sorters, samplers, and weighers	6,264	4.0%	X		
Construction managers	6,198	4.0%	X		
Electricians	5,849	3.8%		X	
Other engineers	5,616	3.6%	X		X
Maintenance and repair workers, general	5,167	3.3%	X		
Machinists	5,045	3.2%	X		
Other assemblers and fabricators	4,698	3.0%	X	X	
Plumbers, pipefitters, and steamfitters	4,487	2.9%	X		X
Construction equipment operators	4,437	2.9%		X	
Welding, soldering, and brazing workers	4,035	2.6%		X	
Civil engineers	3,856	2.5%	X		X
Shipping, receiving, and inventory clerks	3,486	2.2%	X		
Industrial and refractory machinery mechanics	3,211	2.1%		X	
Other engineering technologists and technicians, except drafters	3,162	2.0%	X		X
Heating, air conditioning, and refrigeration mechanics and installers	2,836	1.8%	X	X	
Industrial production managers	2,598	1.7%		X	X

SOURCE: Features data from the ACS; 5-Year PUMS, 2017-2021; CEPRdata, “ACS Programs,” webpage, 2023.
NOTE: MSAs in our ACS analyses are broader than in our other analyses because PUMAs, the most granular level of geography identified in the PUMS, may combine a county in the MSA with one outside it. Labor force refers to individuals who are employed full-time or part-time or who are unemployed and available and looking for work. Analysis includes people ages 25 and older.

Table F.14. Green Workforce by Detailed Occupation, Energy Sector, Top 20 Occupations by Workers Ages 25 and Older, Pittsburgh Metropolitan Statistical Area, 2017-2021

Occupation	Number of Workers	Share of Green Sector Workforce	Green Enhanced Skills	Green Increased Demand	Green New & Emerging
Other managers	32,736	21.8%			X
Driver/sales workers and truck drivers	27,358	18.2%	X		
General and operations managers	8,256	5.5%	X		
First-line supervisors of construction trades and extraction workers	6,799	4.5%			X
Automotive service technicians and mechanics	6,091	4.1%	X		
Other engineers	5,616	3.7%	X		X
Maintenance and repair workers, general	5,167	3.4%	X		
Machinists	5,045	3.4%	X		
Plumbers, pipefitters, and steamfitters	4,487	3.0%	X		X
Civil engineers	3,856	2.6%	X		X

Shipping, receiving, and inventory clerks	3,486	2.3%	X		
Other engineering technologists and technicians, except drafters	3,162	2.1%	X		X
Bus drivers, transit and intercity	2,948	2.0%		X	
Heating, air conditioning, and refrigeration mechanics and installers	2,836	1.9%	X	X	
Industrial production managers	2,598	1.7%		X	X
Electrical and electronics engineers	2,457	1.6%	X		
Bus and truck mechanics and diesel engine specialists	2,430	1.6%	X		
Industrial truck and tractor operators	2,186	1.5%		X	
Transportation, storage, and distribution managers	2,182	1.5%	X		X
Mechanical engineers	2,136	1.4%	X		X

SOURCE: Features data from the ACS; 5-Year PUMS, 2017-2021; CEPRdata, “ACS Programs,” webpage, 2023.
NOTE: MSAs in our ACS analyses are broader than in our other analyses because PUMAs, the most granular level of geography identified in the PUMS, may combine a county in the MSA with one outside it. Labor force refers to individuals who are employed full-time or part-time or who are unemployed and available and looking for work. Analysis includes people ages 25 and older.

Table F.15. Green Workforce by Detailed Occupation, Green Buildings Sector, Top 20 Occupations by Workers Ages 25 and Older, Pittsburgh Metropolitan Statistical Area, 2017-2021

Occupation	Number of Workers	Share of Green Sector Workforce	Green Enhanced Skills	Green Increased Demand	Green New & Emerging
Laborers and freight, stock, and material movers, hand	17,425	15.7%		X	X
Carpenters	10,527	9.5%		X	
Construction laborers	10,181	9.2%	X		
General and operations managers	8,256	7.4%	X		
Construction managers	6,198	5.6%	X		
Electricians	5,849	5.3%		X	
Other engineers	5,616	5.1%	X		X
Maintenance and repair workers, general	5,167	4.6%	X		
Plumbers, pipefitters, and steamfitters	4,487	4.0%	X		X
Construction equipment operators	4,437	4.0%		X	
Welding, soldering, and brazing workers	4,035	3.6%		X	
Civil engineers	3,856	3.5%	X		X
Heating, air conditioning, and refrigeration mechanics and installers	2,836	2.6%	X	X	
Electrical and electronics engineers	2,457	2.2%	X		
Industrial truck and tractor operators	2,186	2.0%		X	
Mechanical engineers	2,136	1.9%	X		X
Financial and investment analysts	2,043	1.8%	X		X
Architects, except landscape and naval	1,533	1.4%	X		
Structural iron and steel workers	1,330	1.2%		X	
Roofers	1,195	1.1%	X		

SOURCE: Features data from the ACS; 5-Year PUMS, 2017-2021; CEPRdata, “ACS Programs,” webpage, 2023.
NOTE: MSAs in our ACS analyses are broader than in our other analyses because PUMAs, the most granular level of geography identified in the PUMS, may combine a county in the MSA with one outside it. Labor force refers to individuals who are employed full-time or part-time or who are unemployed and available and looking for work. Analysis includes people ages 25 and older.

Table F.16. Green Workforce by Detailed Occupation, Manufacturing Sector, Top 20 Occupations by Workers Ages 25 and Older, Pittsburgh Metropolitan Statistical Area, 2017-2021

Occupation	Number of Workers	Share of Green Sector Workforce	Green Enhanced Skills	Green Increased Demand	Green New & Emerging
Laborers and freight, stock, and material movers, hand	17,425	19.8%		X	X
First-line supervisors of production and operating workers	6,283	7.1%		X	
Inspectors, testers, sorters, samplers, and weighers	6,264	7.1%	X		
Other engineers	5,616	6.4%	X		X
Maintenance and repair workers, general	5,167	5.9%	X		
Machinists	5,045	5.7%	X		
Other assemblers and fabricators	4,698	5.3%	X	X	
Welding, soldering, and brazing workers	4,035	4.6%		X	
Shipping, receiving, and inventory clerks	3,486	4.0%	X		
Industrial and refractory machinery mechanics	3,211	3.7%		X	
Other engineering technologists and technicians, except drafters	3,162	3.6%	X		X
Industrial production managers	2,598	3.0%		X	X
Production, planning, and expediting clerks	2,298	2.6%		X	
Transportation, storage, and distribution managers	2,182	2.5%	X		X
Industrial engineers, including health and safety	2,163	2.5%		X	X
First-line supervisors of mechanics, installers, and repairers	1,667	1.9%		X	
Electrical, electronics, and electromechanical assemblers	1,475	1.7%		X	
Structural iron and steel workers	1,330	1.5%		X	
Chemists and materials scientists	1,169	1.3%		X	
Computer numerically controlled tool operators and programmers	1,056	1.2%		X	

SOURCE: Features data from the ACS; 5-Year PUMS, 2017-2021; CEPRdata, "ACS Programs," webpage, 2023.
NOTE: MSAs in our ACS analyses are broader than in our other analyses because PUMAs, the most granular level of geography identified in the PUMS, may combine a county in the MSA with one outside it. Labor force refers to individuals who are employed full-time or part-time or who are unemployed and available and looking for work. Analysis includes people ages 25 and older.

Table F.17. Green Workforce by Detailed Occupation, Water Management Sector, Top 20 Occupations by Workers Ages 25 and Older, Pittsburgh Metropolitan Statistical Area, 2017-2021

Occupation	Number of Workers	Share of Green Sector Workforce	Green Enhanced Skills	Green Increased Demand	Green New & Emerging
Other managers	32,736	60.0%			X
Construction managers	6,198	11.4%	X		
Maintenance and repair workers, general	5,167	9.5%	X		
Civil engineers	3,856	7.1%	X		X
Architectural and engineering managers	1,602	2.9%	X		X
Public relations specialists	1,125	2.1%	X		
News analysts, reporters, and journalists	560	1.0%	X		
Environmental scientists and specialists, including health	501	0.9%		X	X
Environmental science and geoscience technicians, and nuclear technicians	431	0.8%	X		

Geoscientists and hydrologists, except geographers	399	0.7%	X	X	
Natural sciences managers	372	0.7%		X	X
Hazardous materials removal workers	306	0.6%	X		
Environmental engineers	233	0.4%	X		
Agricultural and food scientists	219	0.4%	X		
Forest and conservation workers	202	0.4%		X	
Economists	191	0.3%			X
Landscape architects	164	0.3%	X		
Conservation scientists and foresters	153	0.3%	X		
Fish and game wardens and parking enforcement officers	58	0.1%		X	
Atmospheric and space scientists	58	0.1%	X		

SOURCE: Features data from the ACS; 5-Year PUMS, 2017-2021; CEPRdata, "ACS Programs," webpage, 2023.
NOTE: MSAs in our ACS analyses are broader than in our other analyses because PUMAs, the most granular level of geography identified in the PUMS, may combine a county in the MSA with one outside it. Labor force refers to individuals who are employed full-time or part-time or who are unemployed and available and looking for work. Analysis includes people ages 25 and older.

Table F-18. Green Workforce by Detailed Occupation, Outdoor Recreation Sector, Top 20 Occupations by Workers Ages 25 and Older, Pittsburgh Metropolitan Statistical Area, 2017-2021

Occupation	Number of Workers	Share of Green Sector Workforce	Green Enhanced Skills	Green Increased Demand	Green New & Emerging
Retail salespersons	20,230	19.6%			
Customer service representatives	18,556	18.0%		X	
Software developers	12,687	12.3%		X	
Management analysts	9,237	8.9%			
Bookkeeping, accounting, and auditing clerks	7,692	7.4%			
Automotive service technicians and mechanics	6,091	5.9%	X		
Computer occupations, all other	5,853	5.7%			X
Maintenance and repair workers, general	5,167	5.0%	X		
Social and community service managers	4,142	4.0%			
Business operations specialists, all other	3,393	3.3%			X
Fast food and counter workers	2,433	2.4%			
Librarians and media collections specialists	1,337	1.3%			
Supervisors of personal care and service workers	990	1.0%			
Web developers	897	0.9%			
Other entertainment attendants and related workers	864	0.8%			
Logisticians	782	0.8%			X
Public relations and fundraising managers	650	0.6%			
Biological scientists	549	0.5%		X	
Meeting, convention, and event planners	477	0.5%			
Lodging managers	419	0.4%			

SOURCE: Features data from the ACS; 5-Year PUMS, 2017-2021; CEPRdata, "ACS Programs," webpage, 2023.
NOTE: MSAs in our ACS analyses are broader than in our other analyses because PUMAs, the most granular level of geography identified in the PUMS, may combine a county in the MSA with one outside it. Labor force refers to individuals who are employed full-time or part-time or who are unemployed and available and looking for work. Analysis includes people ages 25 and older.

Table F.19. Green Workforce by Detailed Occupation, Cross Sector Occupations, Top 20 Occupations by Workers Ages 25 and Older, Pittsburgh Metropolitan Statistical Area, 2017-2021

Occupation	Number of Workers	Share of Cross Sector Workforce	Green Enhanced Skills	Green Increased Demand	Green New & Emerging
Other managers	32,736	21.5%			X
Customer service representatives	18,556	12.2%		X	
Software developers	12,687	8.3%		X	
Chief executives and legislators	9,945	6.5%			X
Inspectors, testers, sorters, samplers, and weighers	6,264	4.1%	X		
Computer occupations, all other	5,853	3.8%			X
Other engineers	5,616	3.7%	X		X
Personal financial advisors	4,000	2.6%	X		
Civil engineers	3,856	2.5%	X		X
Marketing managers	3,695	2.4%	X		
Shipping, receiving, and inventory clerks	3,486	2.3%	X		
Business operations specialists, all other	3,393	2.2%			X
Other engineering technologists and technicians, except drafters	3,162	2.1%	X		X
Purchasing agents, except wholesale, retail, and farm products	3,081	2.0%	X	X	
Compliance officers	2,719	1.8%			X
Electrical and electronics engineers	2,457	1.6%	X		
Physical scientists, all other	2,247	1.5%			X
Transportation, storage, and distribution managers	2,182	1.4%	X		X
Industrial engineers, including health and safety	2,163	1.4%		X	X
Mechanical engineers	2,136	1.4%	X		X

SOURCE: Features data from the ACS; 5-Year PUMS, 2017-2021; CEPRdata, "ACS Programs," webpage, 2023.
NOTE: MSAs in our ACS analyses are broader than in our other analyses because PUMAs, the most granular level of geography identified in the PUMS, may combine a county in the MSA with one outside it. Labor force refers to individuals who are employed full-time or part-time or who are unemployed and available and looking for work. Analysis includes people ages 25 and older. Cross sector category includes occupations in the Research, Design, and Consulting Services, and Government and Regulatory Administration (Dierdorff et al., 2011).

Appendix G: Postsecondary Education and Training for Green Occupations

This appendix provides detailed information on postsecondary education and training for green occupations, including: the number of educational providers (Table G.1) and the number of graduates (G.2) by county and credential level; the number of educational providers by control type (i.e., public, nonprofit, or private for profit) and credential level (Table G.3); the names of all providers in the IPEDS data with programs offering preparation for green occupations along with information on their county and control and the levels at which they offer credentials for each green sector (Table G.4); and a complete list of academic program areas in the region offering preparation for one or more green occupations along with counts of the number of Pittsburgh-area providers offering that program at each credential level (Table G.5).

The next set of tables in this appendix pertains to registered apprenticeship programs, with tables for: the number of these programs by county and green occupational sector (Table G.6); the number of programs and individual active apprenticeships by occupation across all green occupations along with flags for whether those are green enhanced skills, increased demand, or new & emerging occupations in the Dierdorff et al (Dierdorff et al., 2011) scheme (Table G.7); this same information on counts of programs and apprenticeships provided separately for each of the green sectors (Tables G.8 to G.13); and, last, a list of apprenticeship programs and counts of apprentices in occupations considered "cross-sector" occupations able to work across green sectors (Table G.14). Note that there were no apprenticeships linked to the agriculture sector.

Table G.1. Green Education and Training Providers, by County and Credential Level, Institutions in IPEDS

County	Advanced Degree	Bachelor's Degree	Post-Bacc. Certificate	Associate Degree	Sub-Bacc. Certificate	Total Providers
Allegheny	7	9	7	7	12	16
Armstrong	0	0	0	0	0	0
Beaver	1	1	0	2	1	2
Butler	1	1	1	1	2	2
Fayette	0	0	0	1	1	1
Washington	1	2	1	2	2	3
Westmoreland	2	3	1	2	6	6
Penn State	*1*	*1*	*1*	*1*	*1*	*1*
Overall	13	17	11	16	25	31

SOURCE: RAND analysis of data from IPEDS

NOTE: Total providers column may not equal the sum of the columns by credential because providers may offer green programs at multiple credential levels.

Table G.2. Graduates of Green Education and Training Programs, by County and Credential Level, Institutions in IPEDS, 2020-2021

County	Advanced Degree	Bachelor's Degree	Post-Bacc. Certificate	Associate Degree	Sub-Bacc. Certificate	Total Completions
Allegheny	3,675	5,374	70	878	1,556	11,553
Armstrong	0	0	0	0	0	0
Beaver	18	150	0	32	1	201
Butler	104	673	3	158	28	903
Fayette	0	0	0	12	17	29
Washington	93	558	3	36	107	795
Westmoreland	67	451	4	193	123	838
Penn State	2,551	9,465	602	250	395	13,171
Overall	6,508	16,671	682	1,559	2,227	27,647

SOURCE: RAND analysis of data from IPEDS
NOTE: Data reflect counts of program completions not individuals. If an individual earned multiple credentials, they would be multiple counted.

Table G.3. Green Education and Training Providers, by Type of Control and Credential Level, Institutions in IPEDS

Control	Advanced Degree	Bachelor's Degree	Post-Bacc. Certificate	Associate Degree	Sub-Bacc. Certificate	Total Providers
Public	4	5	4	6	10	10
Nonprofit	9	12	7	5	8	14
Private, for-profit	0	0	0	5	7	7
Overall	13	17	11	16	25	31

SOURCE: RAND analysis of data from IPEDS
NOTE: Total providers column may not equal the sum of the columns by credential because providers may offer green programs at multiple credential levels.

Table G.4. Pittsburgh-Area Green Education and Training Providers, by County and by Credential Level, IPEDS Institutions

				Availability of Programs by Green Sector							
County	Provider	Control	Credential Level	AG	CE	EN	GB	MF	WM	OR	CR
Allegheny	All-State Career School-Pittsburgh	For-profit	Sub-Bacc. Cert.		X	X	X	X			
Allegheny	Carlow University	Nonprofit	Adv. Deg.								
			B. Deg.							X	
			Post-Bacc. Cert.		X	X	X			X	X

County	Provider	Control	Credential Level	Availability of Programs by Green Sector							
				AG	CE	EN	GB	MF	WM	OR	CR
Allegheny	Carnegie Mellon University	Nonprofit	Adv. Deg.		X	X		X	X	X	X
			B. Deg.		X	X	X	X	X	X	X
			Post-Bacc. Cert.								X
Allegheny	Chatham University	Nonprofit	Adv. Deg.		X		X		X	X	X
			B. Deg.			X			X	X	X
			Post-Bacc. Cert.						X		X
Allegheny	Community College of Allegheny County	Public	A. Deg.		X	X	X	X	X	X	X
			Sub-Bacc. Cert.		X	X	X	X		X	X
Allegheny	Duquesne University	Nonprofit	Adv. Deg.		X	X	X	X	X	X	X
			B. Deg.		X	X		X	X	X	X
			Post-Bacc. Cert.		X	X	X	X	X	X	X
Allegheny	Forbes Road Career and Technology Center	Public	Sub-Bacc. Cert.		X	X	X	X	X	X	X
Allegheny	Institute of Medical Careers	For-profit	A. Deg.								
			Sub-Bacc. Cert.		X		X	X			
Allegheny	La Roche University	Nonprofit	B. Deg.		X			X	X	X	X
			Sub-Bacc. Cert.								
Allegheny	Pittsburgh Institute of Aeronautics	Nonprofit	A. Deg.		X			X			
			Sub-Bacc. Cert.			X					
Allegheny	Pittsburgh Technical College	Nonprofit	B. Deg.		X			X			X
			A. Deg.		X	X	X	X		X	X
			Sub-Bacc. Cert.		X	X	X	X			
Allegheny	Point Park University	Nonprofit	Adv. Deg.		X	X	X		X	X	X
			B. Deg.		X	X		X	X	X	X
			A. Deg.		X			X		X	X
			Post-Bacc. Cert.		X	X	X			X	X
			Sub-Bacc. Cert.			X					X
Allegheny	Robert Morris University	Nonprofit	Adv. Deg.			X				X	X
			B. Deg.		X			X	X	X	X
			Post-Bacc. Cert.			X				X	X
			Sub-Bacc. Cert.		X	X	X	X		X	X
Allegheny	Rosedale Technical College	Nonprofit	A. Deg.		X	X	X			X	
			Sub-Bacc. Cert.		X	X	X	X		X	
Allegheny	Triangle Tech Inc-Pittsburgh	For-profit	A. Deg.		X	X	X	X			
			Sub-Bacc. Cert.		X		X	X			

County	Provider	Control	Credential Level	Availability of Programs by Green Sector							
				AG	CE	EN	GB	MF	WM	OR	CR
Allegheny	University of Pittsburgh-Pittsburgh Campus	Public	Adv. Deg.		X	X		X	X	X	X
			B. Deg.		X	X		X	X	X	X
			Post-Bacc. Cert.		X	X		X	X	X	X
			Sub-Bacc. Cert.		X	X		X	X	X	X
Beaver	Community College of Beaver County	Public	A. Deg.		X	X	X	X	X	X	X
			Sub-Bacc. Cert.		X	X	X	X	X		X
Beaver	Geneva College	Nonprofit	Adv. Deg.								
			B. Deg.		X	X		X	X	X	X
			A. Deg.		X	X		X		X	X
Butler	Butler County Community College	Public	A. Deg.		X	X	X	X	X	X	X
			Sub-Bacc. Cert.		X	X		X		X	X
Butler	Slippery Rock University of Pennsylvania	Public	Adv. Deg.		X	X	X		X	X	X
			B. Deg.		X	X		X	X	X	X
			Post-Bacc. Cert.		X	X	X			X	X
			Sub-Bacc. Cert.		X	X	X		X	X	X
Centre	The Pennsylvania State University	Public	Adv. Deg.	X	X	X	X	X	X	X	X
			B. Deg.	X	X	X		X	X	X	X
			A. Deg.	X	X	X		X	X	X	X
			Post-Bacc. Cert.		X	X	X	X	X	X	X
			Sub-Bacc. Cert.	X	X	X	X	X	X	X	X
Fayette	Laurel Business Institute	For-profit	A. Deg.								
			Sub-Bacc. Cert.		X		X	X			
Washington	California University of Pennsylvania	Public	Adv. Deg.							X	X
			B. Deg.		X	X		X	X	X	X
			A. Deg.		X			X		X	X
			Post-Bacc. Cert.		X	X	X			X	X
			Sub-Bacc. Cert.		X	X		X		X	X
Washington	Penn Commercial Business/Technical School	For-profit	A. Deg.		X	X	X				
			Sub-Bacc. Cert.		X	X	X	X			
Washington	Washington & Jefferson College	Nonprofit	B. Deg.						X	X	X
Westmoreland	Douglas Education Center	For-profit	Sub-Bacc. Cert.			X					
Westmoreland	Saint Vincent College	Nonprofit	Adv. Deg.		X	X				X	
			B. Deg.		X	X		X	X	X	X

County	Provider	Control	Credential Level	Availability of Programs by Green Sector							
				AG	CE	EN	GB	MF	WM	OR	CR
Westmoreland	Seton Hill University	Nonprofit	Sub-Bacc. Cert.							X	
			Adv. Deg.		X	X	X			X	X
			B. Deg.		X			X	X	X	X
			Post-Bacc. Cert.								
			Sub-Bacc. Cert.		X			X		X	X
Westmoreland	Triangle Tech Inc-Greensburg	For-profit	A. Deg.		X	X	X	X			
			Sub-Bacc. Cert.		X		X	X			
Westmoreland	University of Pittsburgh-Greensburg	Public	B. Deg.						X		X
			Sub-Bacc. Cert.								X
Westmoreland	Westmoreland County Community College	Public	A. Deg.		X	X	X	X	X	X	X
			Sub-Bacc. Cert.		X	X	X	X		X	X

SOURCE: RAND analysis of data from IPEDS.
NOTE: Green sectors are not mutually exclusive. "AG" = agriculture; "CE" = circular economy; "EN" = energy; "GB" = green buildings; "MF" = manufacturing; "WM" = water management; "OR" = outdoor recreation; "CR" = cross-sector occupations.

Table G.5. Pittsburgh-Area Green Education and Training Programs, by Classification of Instructional Programs Code, IPEDS Institutions

CIP Code	Program Area	# Occs.	% Occs. Green	# Programs by Credential Level				
				Sub-Bacc Cert.	A. Deg.	B. Deg.	Adv. Deg.	Post-Bacc Cert.
01.0000	Agriculture, General	6	50%	0	0	1	0	0
01.0102	Agribusiness/Agricultural Business Operations	2	50%	0	0	1	0	0
01.0199	Agricultural Business and Management, Other	3	67%	0	1	0	0	0
01.0801	Agricultural and Extension Education Services	1	100%	0	0	1	2	0
01.0901	Animal Sciences, General	7	71%	0	0	1	2	0
01.1101	Plant Sciences, General	7	86%	0	0	1	0	0
01.1102	Agronomy and Crop Science	7	86%	2	0	0	2	0
01.1103	Horticultural Science	4	75%	0	0	1	2	0
01.1199	Plant Sciences, Other	2	50%	0	0	0	2	0
01.1201	Soil Science and Agronomy, General	4	75%	0	0	0	2	0
03.0101	Natural Resources/Conservation, General	6	67%	0	0	1	1	0
03.0103	Environmental Studies	11	45%	0	0	4	1	0
03.0104	Environmental Science	12	58%	0	1	8	1	1
03.0201	Environmental/Natural Resources Management and Policy, General	5	60%	0	0	1	0	0

CIP Code	Program Area	# Occs.	% Occs. Green	# Programs by Credential Level				
				Sub-Bacc Cert.	A. Deg.	B. Deg.	Adv. Deg.	Post-Bacc Cert.
03.0204	Environmental/Natural Resource Economics	10	60%	0	0	0	1	0
03.0206	Land Use Planning and Management/Development	4	75%	1	0	0	0	0
03.0502	Forest Sciences and Biology	5	60%	0	0	1	0	0
03.0506	Forest Management/Forest Resources Management	5	60%	0	0	0	2	0
03.0511	Forest Technology/Technician	2	100%	0	1	1	0	0
03.0601	Wildlife, Fish and Wildlands Science and Management	5	80%	0	1	1	0	0
04.0201	Architecture	4	75%	0	0	3	4	0
04.0301	City/Urban, Community, and Regional Planning	5	60%	0	0	1	1	0
04.0401	Environmental Design/Architecture	5	80%	0	0	1	0	0
04.0501	Interior Architecture	4	50%	0	0	2	1	0
04.0601	Landscape Architecture	4	75%	1	0	1	1	0
04.0901	Architectural Technology/Technician	1	100%	0	0	0	1	0
04.0902	Architectural and Building Sciences/Technology	4	75%	1	0	1	3	0
09.0100	Communication, General	10	40%	0	1	4	0	0
09.0102	Mass Communication/Media Studies	6	33%	1	0	4	1	0
09.0404	Photojournalism	3	33%	0	0	1	0	0
09.0499	Journalism, Other	2	50%	1	0	0	1	0
09.0702	Digital Communication and Media/Multimedia	9	33%	1	1	3	2	0
09.0900	Public Relations, Advertising, and Applied Communication	6	67%	0	0	4	1	0
09.0901	Organizational Communication, General	3	33%	1	1	0	0	0
09.0902	Public Relations/Image Management	6	67%	1	0	1	1	1
09.0903	Advertising	2	50%	1	0	1	0	0
09.0906	Sports Communication	6	33%	0	0	2	0	0
09.0907	International and Intercultural Communication	4	75%	1	0	0	0	1
11.0101	Computer and Information Sciences, General	24	46%	1	4	7	1	0
11.0104	Informatics	5	40%	0	0	0	5	3
11.0201	Computer Programming/Programmer, General	8	38%	2	3	0	0	0
11.0202	Computer Programming, Specific Applications	3	67%	1	1	0	0	0
11.0301	Data Processing and Data Processing Technology/Technician	10	100%	1	0	1	0	0
11.0401	Information Science/Studies	18	61%	1	1	4	6	2
11.0701	Computer Science	26	50%	0	1	7	7	0
11.1004	Web/Multimedia Management and Webmaster	3	33%	0	0	0	1	0
11.1005	Information Technology Project Management	18	72%	0	0	2	3	0
13.0501	Educational/Instructional Technology	3	67%	2	0	0	8	6
13.0601	Educational Evaluation and Research	3	67%	0	0	0	1	1

CIP Code	Program Area	# Occs.	% Occs. Green	# Programs by Credential Level				
				Sub-Bacc Cert.	A. Deg.	B. Deg.	Adv. Deg.	Post-Bacc Cert.
13.0603	Educational Statistics and Research Methods	5	40%	0	0	0	0	1
13.0699	Educational Assessment, Evaluation, and Research, Other	5	40%	0	0	1	0	0
13.1201	Adult and Continuing Education and Teaching	3	33%	0	0	0	3	1
13.1334	School Librarian/School Library Media Specialist	1	100%	0	0	0	1	0
14.0101	Engineering, General	12	83%	2	3	5	4	0
14.0201	Aerospace, Aeronautical, and Astronautical/Space Engineering, General	3	67%	1	0	1	2	0
14.0301	Agricultural Engineering	4	50%	0	0	1	2	1
14.0401	Architectural Engineering	13	77%	0	0	1	2	0
14.0501	Bioengineering and Biomedical Engineering	4	75%	0	0	4	7	1
14.0701	Chemical Engineering	4	75%	0	0	4	6	0
14.0801	Civil Engineering, General	6	83%	2	0	5	6	0
14.0803	Structural Engineering	6	83%	0	0	1	0	1
14.0804	Transportation and Highway Engineering	6	83%	0	0	1	0	0
14.0899	Civil Engineering, Other	6	83%	0	0	0	2	1
14.0901	Computer Engineering, General	10	40%	0	0	2	3	1
14.0903	Computer Software Engineering	7	57%	0	0	1	2	1
14.1001	Electrical and Electronics Engineering	8	63%	0	0	4	6	1
14.1101	Engineering Mechanics	15	87%	0	0	0	3	0
14.1201	Engineering Physics/Applied Physics	16	75%	0	0	1	0	0
14.1301	Engineering Science	12	83%	0	1	2	3	0
14.1401	Environmental/Environmental Health Engineering	6	67%	0	0	2	4	0
14.1801	Materials Engineering	5	40%	0	0	1	4	0
14.1901	Mechanical Engineering	8	75%	0	0	5	6	0
14.2001	Metallurgical Engineering	4	50%	0	0	0	2	1
14.2101	Mining and Mineral Engineering	4	50%	0	1	1	0	1
14.2301	Nuclear Engineering	4	75%	1	0	1	3	1
14.2501	Petroleum Engineering	4	50%	0	0	2	3	0
14.2701	Systems Engineering	18	72%	1	0	0	2	2
14.3201	Polymer/Plastics Engineering	5	60%	0	0	1	0	0
14.3301	Construction Engineering	16	81%	0	0	0	2	0
14.3501	Industrial Engineering	13	77%	0	0	3	4	1
14.3601	Manufacturing Engineering	17	76%	2	1	1	2	0
14.3701	Operations Research	5	40%	0	0	1	2	0
14.3801	Surveying Engineering	15	67%	0	0	1	0	0
14.4201	Mechatronics, Robotics, and Automation Engineering	12	83%	1	2	2	2	0
14.4501	Biological/Biosystems Engineering	13	85%	0	0	0	1	0
14.9999	Engineering, Other	14	79%	2	0	3	5	1

CIP Code	Program Area	# Occs.	% Occs. Green	# Programs by Credential Level				
				Sub-Bacc Cert.	A. Deg.	B. Deg.	Adv. Deg.	Post-Bacc Cert.
15.0000	Engineering Technologies/Technicians, General	5	80%	0	0	0	1	0
15.0201	Civil Engineering Technologies/Technicians	2	50%	0	2	1	0	0
15.0303	Electrical, Electronic, and Communications Engineering Technology/Technician	7	43%	2	6	4	0	0
15.0399	Electrical/Electronic Engineering Technologies/Technicians, Other	1	100%	1	1	0	0	0
15.0401	Biomedical Technology/Technician	5	40%	0	1	0	0	0
15.0403	Electromechanical/Electromechanical Engineering Technology/Technician	3	67%	0	0	1	0	0
15.0404	Instrumentation Technology/Technician	4	50%	0	2	0	0	0
15.0405	Robotics Technology/Technician	2	100%	1	1	0	0	0
15.0499	Electromechanical Technologies/Technicians, Other	2	100%	0	1	0	0	0
15.0501	Heating, Ventilation, Air Conditioning and Refrigeration Engineering Technology/Technician	4	75%	1	0	0	0	0
15.0507	Environmental/Environmental Engineering Technology/Technician	2	100%	0	1	0	1	0
15.0607	Plastics and Polymer Engineering Technology/Technician	3	67%	3	1	0	0	0
15.0611	Metallurgical Technology/Technician	3	67%	0	1	0	0	0
15.0612	Industrial Technology/Technician	2	100%	0	1	0	0	0
15.0613	Manufacturing Engineering Technology/Technician	2	100%	3	3	0	0	0
15.0699	Industrial Production Technologies/Technicians, Other	2	100%	1	2	1	0	0
15.0701	Occupational Safety and Health Technology/Technician	1	100%	1	0	1	0	0
15.0703	Industrial Safety Technology/Technician	3	100%	0	0	0	0	1
15.0805	Mechanical/Mechanical Engineering Technology/Technician	5	80%	1	5	2	0	0
15.0903	Petroleum Technology/Technician	2	50%	1	0	0	0	0
15.1201	Computer Engineering Technology/Technician	5	80%	0	1	1	0	0
15.1202	Computer/Computer Systems Technology/Technician	5	80%	1	2	1	0	0
15.1203	Computer Hardware Technology/Technician	3	67%	1	0	0	0	0
15.1303	Architectural Drafting and Architectural CAD/CADD	1	100%	0	2	0	0	0
15.1304	Civil Drafting and Civil Engineering CAD/CADD	1	100%	1	0	0	0	0
15.1501	Engineering/Industrial Management	16	75%	0	0	0	4	1
15.1502	Engineering Design	12	83%	0	0	0	1	0
15.1601	Nanotechnology	9	89%	3	0	1	1	0
15.1703	Solar Energy Technology/Technician	4	75%	0	0	0	0	1
19.0707	Family and Community Services	1	100%	0	0	1	0	0
25.0101	Library and Information Science	5	60%	0	0	0	2	0
26.0101	Biology/Biological Sciences, General	16	56%	1	3	16	9	0
26.0202	Biochemistry	8	38%	0	0	9	2	0

CIP Code	Program Area	# Occs.	% Occs. Green	# Programs by Credential Level				
				Sub-Bacc Cert.	A. Deg.	B. Deg.	Adv. Deg.	Post-Bacc Cert.
26.0203	Biophysics	6	50%	0	0	2	1	0
26.0204	Molecular Biology	11	64%	0	0	2	1	0
26.0206	Molecular Biophysics	5	60%	0	0	0	2	0
26.0305	Plant Pathology/Phytopathology	10	80%	0	0	0	2	0
26.0307	Plant Physiology	10	80%	0	0	0	1	0
26.0401	Cell/Cellular Biology and Histology	16	44%	0	0	0	2	0
26.0403	Anatomy	10	60%	0	0	0	2	0
26.0406	Cell/Cellular and Molecular Biology	11	64%	0	0	0	2	0
26.0499	Cell/Cellular Biology and Anatomical Sciences, Other	11	82%	0	0	1	0	0
26.0502	Microbiology, General	7	43%	0	0	1	1	0
26.0503	Medical Microbiology and Bacteriology	12	58%	0	0	1	2	0
26.0507	Immunology	11	73%	0	0	0	4	0
26.0508	Microbiology and Immunology	12	67%	0	0	0	2	0
26.0702	Entomology	10	80%	0	0	0	2	0
26.0707	Animal Physiology	9	78%	0	0	0	2	0
26.0801	Genetics, General	8	63%	0	0	0	2	0
26.0802	Molecular Genetics	10	70%	0	0	0	2	0
26.0910	Pathology/Experimental Pathology	10	70%	0	0	0	4	0
26.1001	Pharmacology	11	64%	0	0	0	1	0
26.1004	Toxicology	15	73%	0	0	1	0	0
26.1005	Molecular Toxicology	6	67%	0	0	0	1	0
26.1101	Biometry/Biometrics	11	64%	0	0	1	2	0
26.1102	Biostatistics	14	50%	0	0	1	3	0
26.1103	Bioinformatics	15	67%	0	0	2	4	3
26.1104	Computational Biology	25	68%	0	0	2	4	0
26.1199	Biomathematics, Bioinformatics, and Computational Biology, Other	14	43%	0	0	0	3	0
26.1201	Biotechnology	9	78%	3	1	0	2	0
26.1301	Ecology	15	73%	0	0	0	3	0
26.1307	Conservation Biology	10	80%	0	0	1	0	0
26.1310	Ecology and Evolutionary Biology	13	77%	0	0	1	0	0
26.1501	Neuroscience	9	67%	0	0	4	5	0
26.1503	Neurobiology and Anatomy	9	67%	0	0	0	4	0
26.1599	Neurobiology and Neurosciences, Other	9	67%	0	0	2	1	0
26.9999	Biological and Biomedical Sciences, Other	10	70%	0	0	2	3	0
27.0199	Mathematics, Other	5	40%	0	0	2	0	0
27.0305	Financial Mathematics	17	35%	0	0	3	3	0
27.0306	Mathematical Biology	15	47%	0	0	1	0	0
30.0101	Biological and Physical Sciences	5	40%	2	2	3	0	0
30.0501	Peace Studies and Conflict Resolution	3	67%	0	0	0	1	0

CIP Code	Program Area	# Occs.	% Occs. Green	# Programs by Credential Level				
				Sub-Bacc Cert.	A. Deg.	B. Deg.	Adv. Deg.	Post-Bacc Cert.
30.0601	Systems Science and Theory	8	63%	0	0	2	1	0
30.0801	Mathematics and Computer Science	23	57%	0	0	0	1	0
30.1001	Biopsychology	7	43%	0	0	2	0	0
30.1501	Science, Technology and Society	4	50%	0	0	2	2	0
30.1601	Accounting and Computer Science	18	61%	0	0	0	0	1
30.1801	Natural Sciences	7	43%	0	1	1	0	0
30.1901	Nutrition Sciences	15	53%	0	0	2	2	0
30.2301	Intercultural/Multicultural and Diversity Studies	3	67%	3	0	1	0	1
30.2501	Cognitive Science, General	3	33%	0	0	1	0	0
30.2601	Cultural Studies/Critical Theory and Analysis	3	33%	0	0	1	0	2
30.2701	Human Biology	12	67%	0	0	1	0	0
30.3001	Computational Science	21	57%	0	0	1	4	1
30.3101	Human Computer Interaction	15	67%	0	0	0	1	0
30.3301	Sustainability Studies	15	87%	2	0	2	4	1
31.0101	Parks, Recreation, and Leisure Studies	1	0%*	0	1	0	1	0
31.0301	Parks, Recreation, and Leisure Facilities Management	4	25%*	0	0	1	1	0
40.0101	Physical Sciences, General	4	50%	0	1	2	0	0
40.0201	Astronomy	3	33%	0	0	2	2	0
40.0401	Atmospheric Sciences and Meteorology, General	7	57%	1	0	1	2	0
40.0404	Meteorology	4	75%	0	1	0	0	0
40.0499	Atmospheric Sciences and Meteorology, Other	5	60%	0	0	0	0	1
40.0501	Chemistry, General	9	44%	0	3	14	8	0
40.0507	Polymer Chemistry	5	60%	0	0	1	1	0
40.0508	Chemical Physics	6	50%	0	0	1	0	0
40.0509	Environmental Chemistry	12	75%	0	0	2	0	0
40.0510	Forensic Chemistry	5	40%	0	0	1	0	0
40.0599	Chemistry, Other	5	60%	0	0	2	2	0
40.0601	Geology/Earth Science, General	6	83%	0	0	4	4	0
40.0699	Geological and Earth Sciences/Geosciences, Other	4	75%	2	0	2	0	1
40.0801	Physics, General	6	33%	0	3	10	6	0
40.0810	Theoretical and Mathematical Physics	5	40%	0	0	1	0	0
40.0899	Physics, Other	5	40%	0	0	1	0	0
40.1001	Materials Science	7	57%	0	0	2	3	0
40.1099	Materials Sciences, Other	4	50%	0	0	1	0	0
40.9999	Physical Sciences, Other	6	50%	0	0	1	1	0
43.0103	Criminal Justice/Law Enforcement Administration	6	33%	0	1	3	2	0
43.0301	Homeland Security	6	33%	2	0	1	1	2

CIP Code	Program Area	# Occs.	% Occs. Green	# Programs by Credential Level				
				Sub-Bacc Cert.	A. Deg.	B. Deg.	Adv. Deg.	Post-Bacc Cert.
43.0302	Crisis/Emergency/Disaster Management	8	50%	1	0	0	0	0
43.0303	Critical Infrastructure Protection	7	43%	3	1	1	1	0
43.0403	Cyber/Computer Forensics and Counterterrorism	16	63%	0	0	2	1	0
44.0000	Human Services, General	3	33%	0	2	2	0	0
44.0201	Community Organization and Advocacy	3	33%	0	0	0	2	1
44.0401	Public Administration	15	67%	2	0	2	5	1
44.0702	Youth Services/Administration	2	50%	0	0	1	0	0
45.0101	Social Sciences, General	11	55%	0	1	5	2	0
45.0501	Demography and Population Studies	10	70%	0	0	0	1	1
45.0601	Economics, General	13	46%	0	0	10	3	0
45.0602	Applied Economics	14	43%	0	0	1	0	1
45.0603	Econometrics and Quantitative Economics	16	38%	0	0	3	6	0
45.0604	Development Economics and International Development	11	55%	0	0	1	0	0
45.0605	International Economics	10	60%	0	0	1	0	0
45.0699	Economics, Other	10	60%	0	0	1	2	0
45.0701	Geography	9	56%	3	0	3	2	1
45.0702	Geographic Information Science and Cartography	8	38%	2	0	0	1	1
45.0799	Geography, Other	6	50%	0	0	0	1	0
45.0901	International Relations and Affairs	7	43%	0	0	5	2	1
45.0902	National Security Policy Studies	6	33%	0	0	1	1	0
45.1001	Political Science and Government, General	10	40%	0	0	16	4	0
45.1101	Sociology, General	10	50%	0	1	8	4	0
45.1103	Rural Sociology	10	50%	0	0	1	0	0
45.1201	Urban Studies/Affairs	10	60%	0	0	2	0	0
45.1301	Sociology and Anthropology	8	38%	0	0	1	0	0
45.9999	Social Sciences, Other	6	50%	0	0	2	4	0
46.0201	Carpentry/Carpenter	3	67%	1	1	0	0	0
46.0301	Electrical and Power Transmission Installation/Installer, General	3	67%	1	2	0	0	0
46.0302	Electrician	5	40%	2	5	0	0	0
46.0399	Electrical and Power Transmission Installers, Other	1	100%	1	0	0	0	0
46.0401	Building/Property Maintenance	6	33%	1	1	0	0	0
46.0415	Building Construction Technology/Technician	3	67%	0	1	0	0	0
46.0503	Plumbing Technology/Plumber	5	60%	4	1	0	0	0
47.0101	Electrical/Electronics Equipment Installation and Repair Technology/Technician, General	3	33%	1	1	0	0	0
47.0201	Heating, Air Conditioning, Ventilation and Refrigeration Maintenance Technology/Technician	1	100%	7	8	0	0	0

CIP Code	Program Area	# Occs.	% Occs. Green	# Programs by Credential Level				
				Sub-Bacc Cert.	A. Deg.	B. Deg.	Adv. Deg.	Post-Bacc Cert.
47.0303	Industrial Mechanics and Maintenance Technology/Technician	7	43%	2	2	0	0	0
47.0604	Automobile/Automotive Mechanics Technology/Technician	3	33%	3	2	0	0	0
47.0605	Diesel Mechanics Technology/Technician	1	100%	1	1	0	0	0
47.0609	Avionics Maintenance Technology/Technician	3	33%	0	1	0	0	0
47.0613	Medium/Heavy Vehicle and Truck Technology/Technician	2	100%	1	0	0	0	0
48.0503	Machine Shop Technology/Assistant	9	33%	3	2	0	0	0
48.0506	Sheet Metal Technology/Sheetworking	5	40%	1	1	0	0	0
48.0508	Welding Technology/Welder	2	50%	12	5	0	0	0
49.0101	Aeronautics/Aviation/Aerospace Science and Technology, General	2	100%	0	0	1	0	0
49.0104	Aviation/Airway Management and Operations	2	100%	0	2	0	0	0
49.0205	Truck and Bus Driver/Commercial Vehicle Operator and Instructor	6	33%	6	0	0	0	0
50.0402	Commercial and Advertising Art	3	33%	3	1	3	0	0
50.1001	Arts, Entertainment, and Media Management, General	6	33%	1	1	1	1	0
50.1002	Fine and Studio Arts Management	6	33%	1	0	5	0	0
51.2003	Pharmaceutics and Drug Design	3	33%	0	0	0	2	0
51.2009	Industrial and Physical Pharmacy and Cosmetic Sciences	6	50%	0	0	0	1	0
51.2202	Environmental Health	9	67%	0	0	0	2	1
51.2312	Assistive/Augmentative Technology and Rehabilitation Engineering	12	67%	1	0	0	0	0
51.2706	Medical Informatics	13	77%	0	0	0	1	1
52.0101	Business/Commerce, General	33	52%	6	2	6	0	1
52.0201	Business Administration and Management, General	45	56%	4	6	12	15	2
52.0203	Logistics, Materials, and Supply Chain Management	12	83%	4	0	3	1	2
52.0205	Operations Management and Supervision	16	69%	1	0	1	3	1
52.0206	Non-Profit/Public/Organizational Management	18	56%	1	0	0	0	0
52.0208	E-Commerce/Electronic Commerce	7	71%	1	0	0	0	0
52.0211	Project Management	9	56%	0	0	0	0	3
52.0213	Organizational Leadership	12	58%	0	1	3	3	0
52.0409	Parts, Warehousing, and Inventory Management Operations	1	100%	0	0	1	0	0
52.0601	Business/Managerial Economics	6	50%	0	0	4	2	0
52.0701	Entrepreneurship/Entrepreneurial Studies	11	64%	6	1	3	3	1
52.0703	Small Business Administration/Management	10	50%	1	2	0	0	0
52.0801	Finance, General	18	33%	0	0	11	3	0
52.0804	Financial Planning and Services	4	50%	1	0	1	1	0
52.0903	Tourism and Travel Services Management	11	45%	0	1	0	0	0

CIP Code	Program Area	# Occs.	% Occs. Green	# Programs by Credential Level: Sub-Bacc Cert.	A. Deg.	B. Deg.	Adv. Deg.	Post-Bacc Cert.
52.0904	Hotel/Motel Administration/Management	9	67%	2	2	0	0	0
52.0905	Restaurant/Food Services Management	2	50%	1	0	0	0	0
52.0907	Meeting and Event Planning	1	100%	2	0	0	0	0
52.0999	Hospitality Administration/Management, Other	8	63%	0	3	1	2	0
52.1005	Human Resources Development	1	100%	0	0	0	1	1
52.1101	International Business/Trade/Commerce	9	78%	1	0	9	1	0
52.1301	Management Science	9	33%	3	1	2	4	3
52.1401	Marketing/Marketing Management, General	8	38%	1	1	13	2	0
52.2001	Construction Management, General	1	100%	1	1	0	0	0
52.2101	Telecommunications Management	8	50%	0	0	0	2	0
54.0101	History, General	10	60%	1	2	16	8	0
54.0104	History and Philosophy of Science and Technology	10	60%	0	0	1	2	0
54.0105	Public/Applied History	12	42%	1	0	1	1	0
54.0199	History, Other	5	40%	0	0	1	1	0

SOURCE: RAND analysis of data from IPEDS.
NOTE: “Occ.” = number of occupations to which the CIP code crosswalks; “% Occs. Green” = the percentage of occupations to which the CIP code crosswalks that meet our definition of green occupation; “Sub-Bacc. Cert” = subbaccalaureate certificate program; “A. Deg.” = associate degree; “B. Deg.” = bachelor’s degree; “Adv. Deg.” = advanced degree (master’s or doctorate); “Post-Bacc. Cert.” = post-baccalaureate certificate program. “*” indicates that we used expert judgment to assign CIP code as associated with green occupations despite not meeting the one-third of occupations standard; we do this in just two cases to capture programs aligned with Parks, Recreation, and Leisure Studies and Facilities Management, which we view as preparing people for work in the outdoor recreation sector.

Table G.6. Registered Apprenticeships in Green Occupations, Pittsburgh Metropolitan Statistical Area, by County and Green Sector, Fourth Quarter 2022

	Allegheny	**Armstrong**	**Beaver**	**Butler**	**Fayette**	**Washington**	**Westmoreland**	***Surrounding Counties Total***	***Pittsburgh Region Overall***
Total Number of Programs in Green Occupations	110	4	4	21	8	26	53	116	226
Agriculture	0	0	0	0	0	0	0	0	0
Circular Economy	98	4	4	21	7	26	53	115	213
Energy	46	4	0	11	5	7	37	64	110
Green Buildings	67	0	2	9	2	13	12	38	105
Manufacturing	42	4	2	13	6	14	44	83	125
Water Management	1	0	0	1	0	0	0	1	2
Outdoor Recreation	10	0	0	1	0	0	0	1	11
Cross Sector	8	0	0	2	0	2	1	5	13
Total Number of Active Apprentices in Programs in Green Occupations	2,718	3	150	597	17	68	374	1,209	3,927

SOURCE: U.S. Department of Labor, Registered Apprenticeship Partners Information Database System, Fourth Quarter 2022

NOTE: Registered apprenticeship program refers to a registered apprenticeship in an occupation at a provider categorized using the O*NET-SOC system. Providers that offer apprenticeships in multiple occupations are multiple counted in this analysis. Total of green sectors does not match total number of programs because occupations may be in multiple green sectors. Cross sector category includes occupations in the Research, Design, and Consulting Services, and Government and Regulatory Administration (Dierdorff et al., 2011).

Table G.7. Registered Apprenticeships by Detailed Occupation, Top 20 Green Occupations by Number of Active Apprenticeships, Pittsburgh Metropolitan Statistical Area, Fourth Quarter 2022

Occupation	Number of Active Apprentices	Number of Providers with Programs	Green Enhanced Skills	Green Increased Demand	Green New & Emerging
Carpenters	1,219	7	0	1	0
Electricians	724	27	0	1	0
Plumbers, Pipefitters, and Steamfitters	716	22	1	0	0
Operating Engineers and Other Construction Equipment Operators	209	3	0	1	0
Sheet Metal Workers	208	3	1	0	0
Machinists	151	74	1	0	0
Heating, Air Conditioning, and Refrigeration Mechanics and Installers	123	16	1	1	0
Structural Iron and Steel Workers	118	2	0	1	0
Millwrights	83	6	0	1	0
Industrial Machinery Mechanics	71	15	0	1	0
Construction Laborers	67	4	1	0	0
Boilermakers	49	1	0	1	0
Cement Masons and Concrete Finishers	44	3	0	1	0
Roofers	36	3	1	0	0
Industrial Engineering Technologists and Technicians	27	3	1	0	1
Electrical and Electronics Repairers, Commercial and Industrial Equipment	23	2	0	1	0
Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic	11	2	0	1	0
Automotive Service Technicians and Mechanics	9	8	1	0	0
Welders, Cutters, Solderers, and Brazers	9	4	0	1	0
Computer Numerically Controlled Tool Operators	7	2	0	1	0

SOURCE: U.S. Department of Labor, Registered Apprenticeship Partners Information Database System, Fourth Quarter 2022
NOTE: Ordered by number of active apprenticeships across all providers with a registered apprenticeship in the occupation. Occupations are categorized using the O*NET-SOC system.

Table G.8. Registered Apprenticeships by Detailed Occupation, Circular Economy Sector, Pittsburgh Metropolitan Statistical Area, Fourth Quarter 2022

Occupation	Number of Active Apprentices	Number of Providers with Programs	Green Enhanced Skills	Green Increased Demand	Green New & Emerging

Carpenters	1,219	7	0	1	0
Electricians	724	27	0	1	0
Plumbers, Pipefitters, and Steamfitters	716	22	1	0	0
Operating Engineers and Other Construction Equipment Operators	209	3	0	1	0
Sheet Metal Workers	208	3	1	0	0
Machinists	151	74	1	0	0
Heating, Air Conditioning, and Refrigeration Mechanics and Installers	123	16	1	1	0
Structural Iron and Steel Workers	118	2	0	1	0
Millwrights	83	6	0	1	0
Industrial Machinery Mechanics	71	15	0	1	0
Construction Laborers	67	4	1	0	0
Boilermakers	49	1	0	1	0
Cement Masons and Concrete Finishers	44	3	0	1	0
Roofers	36	3	1	0	0
Industrial Engineering Technologists and Technicians	27	3	1	0	1
Electrical and Electronics Repairers, Commercial and Industrial Equipment	23	2	0	1	0
Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic	11	2	0	1	0
Welders, Cutters, Solderers, and Brazers	9	4	0	1	0
Computer Numerically Controlled Tool Operators	7	2	0	1	0
Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	6	1	1	0	0

SOURCE: U.S. Department of Labor, Registered Apprenticeship Partners Information Database System, Fourth Quarter 2022
NOTE: Ordered by number of active apprenticeships across all providers with a registered apprenticeship in the occupation. Occupations are categorized using the O*NET-SOC system.

Table G.9. Registered Apprenticeships by Detailed Occupation, Energy Sector, Pittsburgh Metropolitan Statistical Area, Fourth Quarter 2022

Occupation	Number of Active Apprentices	Number of Providers with Programs	Green Enhanced Skills	Green Increased Demand	Green New & Emerging
Sheet Metal Workers	208	3	1	0	0
Machinists	151	74	1	0	0
Heating, Air Conditioning, and Refrigeration Mechanics and Installers	123	16	1	1	0
Boilermakers	49	1	0	1	0
Automotive Service Technicians and Mechanics	9	8	1	0	0

Electrical Power-Line Installers and Repairers	5	2	0	1	0
Stationary Engineers and Boiler Operators	2	1	0	1	0
Maintenance and Repair Workers, General	2	2	1	0	0
Engineering Technologists and Technicians, Except Drafters, All Other	1	1	0	0	1
Insulation Workers, Floor, Ceiling, and Wall	0	1	0	1	0
Mechanical Engineers	0	1	1	0	0

SOURCE: U.S. Department of Labor, Registered Apprenticeship Partners Information Database System, Fourth Quarter 2022
NOTE: Ordered by number of active apprenticeships across all providers with a registered apprenticeship in the occupation. Occupations are categorized using the O*NET-SOC system.

Table G.10. Registered Apprenticeships by Detailed Occupation, Green Buildings Sector, Pittsburgh Metropolitan Statistical Area, Fourth Quarter 2022

Occupation	Number of Active Apprentices	Number of Providers with Programs	Green Enhanced Skills	Green Increased Demand	Green New & Emerging
Carpenters	1,219	7	0	1	0
Electricians	724	27	0	1	0
Plumbers, Pipefitters, and Steamfitters	716	22	1	0	0
Operating Engineers and Other Construction Equipment Operators	209	3	0	1	0
Sheet Metal Workers	208	3	1	0	0
Heating, Air Conditioning, and Refrigeration Mechanics and Installers	123	16	1	1	0
Structural Iron and Steel Workers	118	2	0	1	0
Construction Laborers	67	4	1	0	0
Boilermakers	49	1	0	1	0
Cement Masons and Concrete Finishers	44	3	0	1	0
Roofers	36	3	1	0	0
Welders, Cutters, Solderers, and Brazers	9	4	0	1	0
Electrical Power-Line Installers and Repairers	5	2	0	1	0
Structural Metal Fabricators and Fitters	3	3	0	1	0
Stationary Engineers and Boiler Operators	2	1	0	1	0
Maintenance and Repair Workers, General	2	2	1	0	0
Insulation Workers, Floor, Ceiling, and Wall	0	1	0	1	0
Mechanical Engineers	0	1	1	0	0

SOURCE: U.S. Department of Labor, Registered Apprenticeship Partners Information Database System, Fourth Quarter 2022
NOTE: Ordered by number of active apprenticeships across all providers with a registered apprenticeship in the occupation. Occupations are categorized using the O*NET-SOC system.

Table G.11. Registered Apprenticeships by Detailed Occupation, Manufacturing Sector, Pittsburgh Metropolitan Statistical Area, Fourth Quarter 2022

Occupation	Number of Active Apprentices	Number of Providers with Programs	Green Enhanced Skills	Green Increased Demand	Green New & Emerging
Sheet Metal Workers	208	3	1	0	0
Machinists	151	74	1	0	0
Structural Iron and Steel Workers	118	2	0	1	0
Millwrights	83	6	0	1	0
Industrial Machinery Mechanics	71	15	0	1	0
Industrial Engineering Technologists and Technicians	27	3	1	0	1
Electrical and Electronics Repairers, Commercial and Industrial Equipment	23	2	0	1	0
Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic	11	2	0	1	0
Welders, Cutters, Solderers, and Brazers	9	4	0	1	0
Computer Numerically Controlled Tool Operators	7	2	0	1	0
Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	6	1	1	0	0
Structural Metal Fabricators and Fitters	3	3	0	1	0
Electrical and Electronic Engineering Technologists and Technicians	2	2	1	1	1
Maintenance and Repair Workers, General	2	2	1	0	0
Production, Planning, and Expediting Clerks	1	1	0	1	0
Electro-Mechanical and Mechatronics Technologists and Technicians	1	1	1	0	1
Robotics Technicians	0	1	0	0	1
Inspectors, Testers, Sorters, Samplers, and Weighers	0	1	1	0	0

SOURCE: U.S. Department of Labor, Registered Apprenticeship Partners Information Database System, Fourth Quarter 2022
NOTE: Ordered by number of active apprenticeships across all providers with a registered apprenticeship in the occupation. Occupations are categorized using the O*NET-SOC system.

Table G.12. Registered Apprenticeships by Detailed Occupation, Water Management Sector, Pittsburgh Metropolitan Statistical Area, Fourth Quarter 2022

Occupation	Number of Active Apprentices	Number of Providers with Programs	Green Enhanced Skills	Green Increased Demand	Green New & Emerging
Maintenance and Repair Workers, General	2	2	1	0	0

SOURCE: U.S. Department of Labor, Registered Apprenticeship Partners Information Database System, Fourth Quarter 2022
NOTE: Ordered by number of active apprenticeships across all providers with a registered apprenticeship in the occupation. Occupations are categorized using the O*NET-SOC system.

Table G.13. Registered Apprenticeships by Detailed Occupation, Outdoor Recreation Sector, Pittsburgh Metropolitan Statistical Area, Fourth Quarter 2022

Occupation	Number of Active Apprentices	Number of Providers with Programs	Green Enhanced Skills	Green Increased Demand	Green New & Emerging
Automotive Service Technicians and Mechanics	9	8	1	0	0
Maintenance and Repair Workers, General	2	2	1	0	0
Customer Service Representatives	0	1	0	1	0

SOURCE: U.S. Department of Labor, Registered Apprenticeship Partners Information Database System, Fourth Quarter 2022.
NOTE: Ordered by number of active apprenticeships across all providers with a registered apprenticeship in the occupation. Occupations are categorized using the O*NET-SOC system.

Table G.14. Registered Apprenticeships by Detailed Occupation, Cross Sector Green Occupations, Pittsburgh Metropolitan Statistical Area, Fourth Quarter 2022

Occupation	Number of Active Apprentices	Number of Providers with Programs	Green Enhanced Skills	Green Increased Demand	Green New & Emerging
Industrial Engineering Technologists and Technicians	27	3	1	0	1
Electrical and Electronics Repairers, Commercial and Industrial Equipment	23	2	0	1	0
Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	6	1	1	0	0
Electrical and Electronic Engineering Technologists and Technicians	2	2	1	1	1
Electro-Mechanical and Mechatronics Technologists and Technicians	1	1	1	0	1
Mechanical Engineers	0	1	1	0	0
Customer Service Representatives	0	1	0	1	0
Inspectors, Testers, Sorters, Samplers, and Weighers	0	1	1	0	0
Robotics Technicians	0	1	0	0	1

SOURCE: U.S. Department of Labor, Registered Apprenticeship Partners Information Database System, Fourth Quarter 2022.
NOTE: Ordered by number of active apprenticeships across all providers with a registered apprenticeship in the occupation. Occupations are categorized using the O*NET-SOC system. Cross sector category includes

occupations in the Research, Design, and Consulting Services, and Government and Regulatory Administration (Dierdorff et al., 2011)

Abbreviations

ACCD	Allegheny Conference on Community Development
ACS	American Community Survey
AI	Artificial intelligence
BLS	Bureau of Labor Statistics
CCAC	Community College of Allegheny County
CCS	carbon capture and storage
CE	circular economy
CIP	classification of instructional program
CMU	Carnegie Mellon University
CONNECT	Congress of Neighboring Communities
DLI	Department of Labor and Industry
DOE	Department of Energy
EE	energy efficiency
EIC	Energy Innovation Center
EPA	Environmental Protection Agency
EPR	extended producer responsibility
ESG	environment, social, and governance
ETPL	Eligible Training Provider List
EU	European Union
EV	electric vehicle
GBA	Green Building Alliance
GDP	gross domestic product
GHG	greenhouse gas
GYF	Greening Youth Foundation
HVAC	heating, ventilation, and air conditioning
IPEDS	Integrated Postsecondary Education Data System
IRA	Inflation Reduction Act
LEED	Leadership in Energy and Environmental Design
LQ	location quotient
MLB	Major League Baseball
MSA	metropolitan statistical area
MSW	Municipal solid waste
NAICS	North American Industry Classification System
NHL	National Hockey League
NYSERDA	New York State Energy Research & Development Authority

OEWS	Occupational Employment and Wage Statistics
OR(E)	outdoor recreation (economy)
PEC	Pennsylvania Environmental Council
PGH	Pittsburgh
Pitt	University of Pittsburgh
POC	people/person of color
PUMS	Public Use Microdata Sample
PV(s)	photovoltaic(s)
RAPIDS	Registered Apprenticeship Partners Information Database System
RD&D	research, development, and demonstration
RE	renewable energy
RGGI	Regional Greenhouse Gas Initiative
RKMF	Richard King Mellon Foundation
SDGs	sustainable development goals
SMR	small modular reactor
SOC	Standard Occupation Classification
UN	United Nations
UPMC	University of Pittsburgh Medical Center
WDB	workforce development boards
WIOA	Workforce Innovation and Opportunity Act

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