The greater Pittsburgh region is often held up as an example of successful economic rebirth and transformation, having shed the rust of a declining steel industry to become a national hub for education, health care, and technology—what has been called an “eds, meds, and tech” economy (Armstrong, 2021). But this economic success has been unevenly distributed (Warren May et al., 2017; City of Pittsburgh, 2018), and by some accounts, the region has, at times, fallen short of its economic potential (Andes et al., 2017). At the same time, Southwestern Pennsylvania appears to be poised to lead in key growth areas (Allegheny Conference on Community Development [ACCD], undated). Creating and expanding a green economy—one that focuses on producing more sustainable goods and services, which we discuss in detail below—is a promising opportunity for the region to consider.

A green economy offers the possibility of bringing together existing regional assets and strengths with significant funding from the federal government, including the Infrastructure Investment and Jobs Act of 2021 and Inflation Reduction Act of 2022. Resources of this magnitude offer enormous economic development and job creation potential.

Strengthening green sectors could provide

**KEY RECOMMENDATIONS**

- Focus on sustainable sectors that support regionally distinct opportunities, have broad stakeholder support, and can do the most with modest or incremental investments, such as a circular economy (centered on a potential building materials subsector) and outdoor recreation.

- Develop and support better and more investment mechanisms to seed and grow new businesses within the most promising sectors.

- Develop and build support for policies that create appropriate regulatory or market signals at the local and regional levels, when possible.

- Make sure that proposed projects have proactive outreach and education.

- Support existing education and training providers that seek to bridge gaps rather than create new programs.

- Target opportunities that can increase diversity, equity, and inclusion and avoid unintended negative consequences.
solid career pathways for workers with a variety of educational attainment levels and diversify the regional economy around delivering goods and services of growing national and global importance. Pittsburgh has already established its reputation as a leader in sustainability—especially in such areas as green building, where the region has been and remains ahead of the curve—and this leadership has led to additional opportunities for showcasing its success, such as hosting the Global Clean Energy Forum in 2022.

Recognizing the growth potential of a green economy in the greater Pittsburgh region, especially in the context of historic federal funding, the Richard King Mellon Foundation (RKMF) asked RAND researchers to identify opportunities for local and regional stakeholders to build and grow robust and equitable green economic sectors in the region. We considered the ways in which the region’s workforce, education, and training providers; existing industries and nonprofits; and other distinguishing attributes could be leveraged across geographic and socioeconomic boundaries and identified challenges to the success of promising sectors. This short report provides key observations and recommendations from a study described in full in Economic Opportunities in Sustainability for Southwestern Pennsylvania (Curtright et al., 2024). In this report, we describe how the study was conducted; review recent trends in sustainability with a focus on the Southwestern Pennsylvania region; discuss strengths, opportunities, and challenges for a subset of green sectors that we identified as particularly promising for the region; and make recommendations for maximizing the potential benefits of these new and growing sectors.

**How the Study Was Conducted**

The study aimed to identify and compare green sectors with the potential to future-proof economic growth in the greater Pittsburgh region. To do so, we sought to answer the following questions related to three keys areas for economic development:

- **Strengths:** What green and green-adjacent sectors are strong in the region now? Which sectors leverage regional assets and attributes? Which sectors are likely to have broad stakeholder support and interest?
- **Opportunities:** Which sectors demonstrate the potential to grow or progress? Which sectors provide the best opportunities for equity and inclusion?
- **Challenges:** Which factors could hinder the growth or development of these sectors going forward? Which sectors have uneven stakeholder support or risk creating regional divides?

We used a mix of qualitative and quantitative methods to answer these questions. We reviewed relevant literature on green economies across the United States and in Europe, focusing especially on recent peer-city trends, successes, and challenges within the past five to ten years. We also conducted semi-structured interviews with dozens of stakeholders in the greater Pittsburgh region from June 2022 to March 2023. These stakeholders are representatives from economic development organizations, businesses, higher education and workforce training institutions, utility companies, and nonprofit groups who shared information and insights pertaining to each sector’s potential and challenges. We do not identify individual stakeholders when we quote interview data in this report to maintain their anonymity.

We conducted quantitative analyses to understand whether the region’s existing and potential

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**Abbreviations**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>ACCD</td>
<td>Allegheny Conference on Community Development</td>
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<tr>
<td>CCAC</td>
<td>Community College of Allegheny County</td>
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<tr>
<td>CCS</td>
<td>carbon capture and storage</td>
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<tr>
<td>CMU</td>
<td>Carnegie Mellon University</td>
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<tr>
<td>CO₂</td>
<td>carbon dioxide</td>
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<tr>
<td>CSO</td>
<td>combined sewer overflow</td>
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<td>GBA</td>
<td>Green Building Alliance</td>
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<td>LQ</td>
<td>location quotient</td>
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<tr>
<td>NYSERDA</td>
<td>New York State Energy Research and Development Authority</td>
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<td>RKMF</td>
<td>Richard King Mellon Foundation</td>
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<tr>
<td>SMR</td>
<td>small modular reactor</td>
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future workforce were capable of supporting emerging green sectors. We considered labor supply across three distinct time horizons in our quantitative analyses: (1) short-term supply, an existing workforce that could immediately apply its skills to the relevant green sector; (2) medium-term supply, an existing workforce with green-adjacent skills that with minimal training could participate in a green economy within about two years; and (3) long-term supply, a potential workforce that available regional training and education opportunities could create within five to ten years.

This study has important limitations. For example, individual stakeholder opinions inherently represent individual biases. Reliance on publicly available quantitative data limits our ability to generalize. We bolster stakeholder input with peer-reviewed literature and our quantitative analysis (provided in Curtright et al., 2024), but we acknowledge that stakeholder opinions (1) have not been exhaustively fact-checked and (2) are not statistically representative or inclusive of all regional stakeholders’ interests. Our quantitative analysis suggests areas of promise, but it has not been empirically validated with examples of successful transitions from more traditional to green occupations. Future focus groups with regional workers and community members would enable us to validate our findings and provide additional nuance to guide policy and investment.

What Is “Green” and What Are the Leading Trends?

A green economy aims to create economic growth and jobs by promoting resource efficiency and mitigating environmental harm, often with a focus on addressing the challenge of climate change. In this context, green generally refers to the environmentally focused aspects of the broader concept of sustainability, a megatrend that was first defined in 1987 by the United Nations Brundtland Commission as “meeting the needs of the present without compromising the ability of future generations to meet their own needs” (United Nations Academic Impact, undated). In this report, we define green as it has often been framed—in relative terms (see the box above). Our use of the term sustainability refers principally to environmental sustainability and, thus, is synonymous with green in this report. Sustainable sectors might include those that deliver a variety of goods and services—from greener alternatives of traditional energy sources to sectors with inherently lighter environmental footprints, such as health care or outdoor recreation, which also can be made greener. For products, their entire life cycle affects sustainability, including research and development, fabrication and production, delivery and deployment, operations and maintenance, and end-of-life decommissioning, upcycling, and recycling.

Our review of recent trends in sustainability identified three themes:

- an increasing awareness of the importance of sustainability
- a broader acceptance of the need for government policies to drive change
- significant examples of such policies across government and the private sector.  

In terms of public perception of sustainability in the United States—and despite some clear partisan differences in opinion—there is evidence of generally increasing levels of concern about environmental sustainability (Krosnick and MacInnis, 2020). This public concern includes a growing awareness of the adverse impacts of climate change (Leppert, 2022) and an interest among a majority of Americans in deploying mitigation strategies to address these
impacts, such as decarbonizing the energy sector (Tyson, Funk, and Kennedy, 2022).

In the United States, government policies both drive and respond to the need to increase sustainability by incentivizing the greening of products, processes, and entire sectors (i.e., making them more environmentally sustainable). Although not signed into law, the 2019 proposal for a Green New Deal signaled a growing awareness of the need for more-sustainable practices (Friedman and Gabriel, 2019). Individual states, such as California and New York, have often been at the vanguard of environmental policymaking (Mazmanian, Jurewitz, and Nelson, 2020; Berg, 2022), but federal policy has also played a significant role in advancing investments in sustainability. Stimulus funding, such as the American Recovery and Reinvestment Act of 2009 and the more recent Infrastructure Investment and Jobs Act of 2021 and Inflation Reduction Act of 2022, demonstrate a sizable commitment to creating economic opportunities that promote clean energy objectives and prioritize equity. Many examples of policies at local, regional, and state levels also illustrate the same growing commitment and investments.

One factor of bipartisan interest driving this trend is the promise of economic development and job creation (Miguel, 2020). Increasing sustainability will be a difficult and complex endeavor, but as the rollout of federal infrastructure spending in the United States illustrates, such an effort can also create significant economic opportunities. To date, 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 two two-year periods between 2012–2013 and 2015–2016 (George and Maslin, 2019). These authors conclude that the green economy will be “a significant contributor” to U.S. economic development and that the United States “should consider, as other economies are, developing energy, environmental and educational policies relevant to the green economy to remain competitive in these areas” (p. 1).

In the greater Pittsburgh region, there have been and continue to be significant initiatives in sustainability, as highlighted in Figure 1. Recent environmental and sustainability initiatives, such as the ACCD’s multisector Sustainability and Community Committee (ACCD, undated) and the University of Pittsburgh’s (Pitt’s) sustainability plan (University of Pittsburgh, 2018), more often explicitly emphasize economic and social well-being as desired outcomes.

Despite a general growing interest in and emphasis on sustainability, green policy and green technology have not been immune to politicization. Relatedly, levels of commitment to sustainability and associated activities vary across the region. In Allegheny County, for example, not all municipalities have climate action plans or stated sustainability goals; in fact, Allegheny County is only now planning to release such a plan in July 2024 (Zenkevich, 2023). The Congress of Neighboring Communities (CONNECT) aims to coordinate collaboration among 130 local governments, including the City of Pittsburgh, to identify shared public policy challenges and solutions. The mere existence of this working group indicates that the region faces challenges related to fragmentation and that there is a need for finding common cause (CONNECT, undated).

Drawing from our analysis, we developed a short list of green or potentially green sectors that are among the most promising for economic growth in the region. A coordinated focus on the growth of one (or a limited number) of these sectors by local and regional governments and other entities, such as philanthropic organizations, might offset the fragmentation that can erode a sense of common purpose in a community. Careful consideration of the pros and cons associated with these potential sectors is critical to effective decisionmaking, however, and it is to this task that we turn to next.

Strengths, Opportunities, and Challenges for Promising Green Sectors in Southwestern Pennsylvania

From a review of relevant literature, stakeholder interviews, and occupational data analyses, a short list of seven promising sectors emerged for which the greater Pittsburgh region would be especially
FIGURE 1

Milestones in Sustainability for Southwestern Pennsylvania

- 2008: Pittsburgh launched Energy Innovation Center (EIC), a LEED Platinum facility, opened
- 2009: OnePGH Resilience Strategy released
- 2010: University of Pittsburgh Office of Sustainability founded
- 2011: p4 Pittsburgh launched
- 2012: Select UN Sustainable Development Goals (SDGs) adopted by ACCD
- 2013: Green Cities Corps launched in Pittsburgh by Student Conservation Association (SCA)
- 2014: Pittsburgh Climate Initiative (PCI) launched and Climate Action Plan (CAP) v1 released
- 2015: Pittsburgh’s Inequality Across Gender and Race report released
- 2016: OnePGH Investment Prospectus issued
- 2017: New PECF (Philanthropic Energy Conservation Fund) announced
- 2018: Pittsburgh’s Equity Indicators report released
- 2019: Phipps’ Tropical Forest Conservatory opened as most energy-efficient structure of its kind
- 2020: Marshall Plan for Middle America released
- 2021: Pittsburgh Equity Indicators report released
- 2022: Department of Energy Hydrogen Hubs announced
- 2023: UPMC Center for Sustainability established

Earlier milestones:
- 1960s: Park and Recreation Management two-year degree program (Butler County Community College) and Parks and Resource Management four-year program (Slippery Rock University) established
- 1993: GBA founded
- 2002: Hazelwood Green site purchased by Almono partners
- 2006: Phipps’ Tropical Forest Conservatory opened as most energy-efficient structure of its kind

Beyond the region:
- 2003: Pennsylvania Wilds (PA Wilds) Initiative launched
- 2004: PA Wilds Regional Marketing Corporation founded
- 2020: Marshall Plan for Middle America released

SOURCES: Adapted from Curtright et al., 2024, Figure 1.1, using information from Higher Education Climate Consortium, undated, with additional content from Pittsburgh Green Innovators, undated; Eaton, undated; ACCD, 2022; PGH20, undated; CMU, 2012; U.S. Department of Energy, 2023; Allegheny County, undated; PA Wilds Center for Entrepreneurship, undated; Marshall et al., 2020.

NOTE: CAP = climate action plan; LEED = Leadership in Energy and Environmental Design; p4 = People, Planet, Place, and Performance (initiative); PCI = Pittsburgh Climate Initiative; UN = United Nations; UPMC = University of Pittsburgh Medical Center.
Economic Opportunities in Sustainability for Southwestern Pennsylvania

Our analysis identified seven sectors as already important or potentially promising as green sectors to focus on in the greater Pittsburgh region.

- **Sustainable agriculture**, both food production and nontraditional sectors, such as carbon credit markets. Relevant occupations include agricultural inspectors, buyers and purchasing agents, and first-line supervisors of farming, fishing, and forestry workers.
- Businesses that embrace **circular economy** practices and services. Relevant occupations include architects and drafters, operating engineers, and refuse and recyclable material collectors.
- Multiple subsectors of the energy industry in the region—from blue hydrogen to solar to advanced nuclear—can be considered **clean energy**. Relevant occupations include nuclear technicians, electrical engineers, and electrical power-line installers and repairers.
- **Green building** with a broadened scope (i.e., extending commercial successes to the residential sector). Relevant occupations include construction and building inspectors; heating, air-conditioning, and refrigeration mechanics and installers; and carpenters.
- **Advanced manufacturing** with an enhanced emphasis on process efficiency and green economy goods. Relevant occupations include computer numerically controlled tool operators; welders, cutters, solderers, and brazers; and machinists.
- **Outdoor recreation** to provide direct economic activity and support the region’s green reputation and livability. Relevant occupations include conservation and biological scientists, maintenance and repair workers, retail salespersons, and food service workers.
- **Water management** supports both remediation and the sustainable use of this unique regional resource. Relevant occupations include civil engineers, environmental scientists and specialists, and hazardous materials removal workers.

NOTE: In many cases, the same occupation could contribute to multiple sectors because the workforce needs of green sectors overlap.

well positioned to grow. These sectors are listed in the box on p. 6 with some illustrative occupations. We summarize our assessment of the strengths, opportunities, and challenges associated with each sector in subsequent sections, as well as note illustrative training and education providers. Table 1 on p. 17 highlights some of these attributes and lists examples of regional nonprofits that could contribute to the potential growth of these sectors in the greater Pittsburgh region. Considering federal and private sector interests and investments, we assess that all seven sectors would be likely to provide some economic opportunities for the region in the short, medium, and long terms.

**Sustainable Agriculture**

By **sustainable agriculture**, we refer to a broad agricultural sector that encompasses growing food in more-sustainable ways and less traditional products, such as monetized carbon credits for maintaining or reforesting natural land. Adjacent sectors include water management and outdoor recreation subsectors, such as hospitality (e.g., farm-to-table dining).

**Strengths.** There are many opportunities for economic growth in sustainable agriculture, such as increased sustainable food production in both urban and rural parts of the region. Stakeholders noted that the region’s generally moderate and water-rich climate will become increasingly valuable as other food-producing regions, such as California, become dryer and hotter because of the changing climate. Proximity to East Coast markets is also a plus.³ There is also notable regional nonprofit leadership in this area (e.g., Phipps Conservatory’s Homegrown program and Grow Pittsburgh).

**Opportunities.** The opportunities related to sustainable food production multiply by considering
adjacent sectors. Some concepts may be well aligned with other successful or promising sectors, such as mass timber production and green building, or monetized carbon credits, small-scale organic farming, and outdoor recreation activities, such as hiking and biking on trails. Several stakeholders noted that a more robust regional food distribution system could also help ensure more equitable food access and support farm-to-table businesses.

**Challenges.** Despite the variety of opportunities in this sector, the magnitude of its economic potential may be limited relative to the other promising sectors identified in this study. Stakeholder concerns included the high costs for farming, suburban sprawl, and extractive industries. For example, one stakeholder stated, “Agriculture is clearly a threatened sector of our economy.” Another stakeholder noted the lack of a strong regional distribution chain for small-scale farming: “Some regions have a more functional middleman arrangement on how local crops move to restaurants, to CSAs [community-supported agriculture organizations], and to food desert communities.” It may be necessary to make choices between subsectors (e.g., focus on large-scale mass timber production or forests valued for carbon credits). For this reason, and because of its potential for synergies with other sectors, sustainable agriculture should be considered within the broader portfolio of opportunities.

There may also be limitations in short-, medium-, and long-term workforce supply in the region. Relevant to the near term, the region is not particularly strong in its existing workforce numbers for directly relevant occupations, both in the total number of workers and in the number of workers relative to other regions’ workforces. Additionally, the only nearby provider of a bachelor’s or advanced degree program for green jobs in the agriculture sector, Penn State University, has its main campus located outside the region. Penn State’s large size and reach to regional campuses could nonetheless present an opportunity for developing a long-term, homegrown sustainable agriculture workforce, but its status as the area’s sole provider of related education and training opportunities could pose a challenge.

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**Illustrative Circular Economy Subsectors and Associated Jobs**

- **Private building deconstruction:** architects and designers, general contractors, operating engineers (both union [International Union of Operating Engineers] and non-union workers), materials scientists and chemical engineers, and procurement professionals
- **Public municipal zero waste:** facilities managers, collection truck drivers, agronomic advisors, repair technicians, and process operators

SOURCE: Authors’ analysis of information from Aguirre, 2022; Circle Economy, undated.

**Circular Economy**

A circular economy reuses products—through reuse and repurposing or through the downcycling, upcycling, and recycling of materials—to reduce waste, use less water and energy, and extract fewer resources from the earth. Circular economy concepts form a closed-loop system as opposed to the predominantly take-make-waste economic model of a linear economy in most modern societies. The concepts can be practiced within one subsector, such as select components of municipal solid waste (MSW) being recycled rather than going to a landfill, but they can also integrate multiple subsectors, such as when material reuse, waste-to-energy, and composting are added to MSW end uses (Raimi, Carley, and Konisky, 2022). During our analysis of the greater Pittsburgh region, we did not constrain consideration to a single subsector, but stakeholders often focused on the one or several subsectors that they viewed as most promising or about which they knew the most.

**Strengths.** In 2017, the City of Pittsburgh described what a “roadmap to zero waste” would look like (City of Pittsburgh, 2018). Since then, several for- and non-profit actors have made in-roads in this direction. For example, the Pittsburgh-based nonprofit Construction Junction is conducting a building deconstruction pilot project with the City of Pittsburgh that targets 1,700 condemned properties (Gable, 2021). Beyond the region, Keep Pennsylva-
nia Beautiful provides resources for counties across the commonwealth to reduce waste and increase recycling and offers special waste collection events that help expand recycling to include more hard-to-recycle materials and more locations in Pennsylvania (Keep Pennsylvania Beautiful, undated). One interviewee noted that more traditional Pittsburgh-based companies are becoming interested in the circular economy and are seeking support to develop reduced- or zero-waste business models. Several stakeholders also noted that this sector is a good cultural fit for the region, including rural communities. They discussed Southwestern Pennsylvania’s historically practical and “thrifty” approach. Minimizing waste and increasing efficiency is also naturally appealing to Pittsburghers, who, in the words of one stakeholder, do things “because they are the right thing to do.”

From the perspective of short-term workforce supply, the region is strong in many occupations of direct relevance to this sector. Our analysis shows that half of the occupations (14 of 28) have significant numbers of workers in the region, as well as a relative advantage in the size of the workforce compared with those of other regions that could directly support circular economy businesses. This finding represents the highest overlap between anticipated sector needs and short-term worker supply among all the sectors that we considered.7

In 2021, Covestro, a European corporation dedicated to a polymer circular economy, launched a circular economy graduate program with Pitt. The program was created in anticipation of increasing demand for a workforce trained to design circularity into materials at the beginning of product life cycles (University of Pittsburgh, undated). Thus, there is a strong long-term worker pipeline with programs that span training levels from entry-level workers (e.g., training and jobs with Construction Junction) to Pitt’s advanced degrees (e.g., Ph.D. in chemical and petroleum engineering or civil and environmental engineering, with a circular design curriculum explicitly embedded). In fact, among all the sectors considered, circular economy had the largest number of regional providers of education and training—28 separate entities—and multiple options for certificates and degrees across all levels of education.

Opportunities. There are numerous promising circular economy subsectors for the region, from health care materials to textiles (“The CEO of Thread . . .,” 2015; Bauknecht, 2020). One interviewee envisioned a broader “products ecosystem” across Southwestern Pennsylvania to coordinate efforts and create economies of scale. Because these concepts are still new, Pittsburgh could lead with collaboration and innovation, support adjacent sustainability goals, and offer a suite of related goods and services. The proximity of Pittsburgh to both Mid-
west and East Coast markets was noted, highlighting the potential for green products to flow to those markets quickly, inexpensively, and with a minimal carbon footprint. Perhaps most promising, given the region’s aging housing stock (often not well maintained and beyond repair), is building deconstruction and materials reuse. This subsector has obvious links to the region’s strong expertise, success, and reputation in green building more broadly.

Development of this sector also holds the potential for supporting equity. Analysis of the circular economy workforce indicates a variety of needs, from labor-intensive entry-level positions to research and development jobs, as well as the potential for economic development in urban and rural areas. Onboarding programs could be developed for specific populations—such as formerly incarcerated individuals—with potential for acquiring more-advanced skills.

**Challenges.** As noted, the ideas underlying a circular economy fit in well with the region’s “waste not, want not” mindset. However, there will be a need to send out clear messages to show how creating less waste can save money and to coordinate the activities of nonprofit, private-sector, and educational organizations. Collecting materials for repurposing is generally an inherently distributed and disaggregated activity; however, while stakeholders recognized the need to better coordinate across organizations and sectors more generally for the region, several stakeholders emphasized this challenge in our conversations about a circular economy. Ongoing issues with the most basic of concepts in circularity, such as curbside recycling, illustrate this challenge: Not all recyclable materials are, in fact, collected and recycled, and there are often low participation rates and resident errors, such as including plastic bags in curbside waste bins. Additionally, there will likely be a need for stronger policy and market signals to instill a circular economy beyond niche markets.

Moreover, although the greater Pittsburgh region is strong in many occupations needed to support an expansion of the circular economy, there are weak spots in the short-term labor supply as well—occupations with lower numbers of workers or disadvantages relative to workforces in other regions. Such occupations include sheet metal workers, roofers, and construction managers. Bolstering these occupations through transitions over the medium term from occupations that rely on similar knowledge and skills or via education and training programs will be important to realizing the sector’s potential in this region.

**Clean Energy**

From oil and coal to nuclear and natural gas, Southwestern Pennsylvania has a long, varied, and important history in energy production for the region and the country. *Clean energy* refers to various technologies that generally have a lighter environmental footprint than traditional approaches to providing energy, such as using natural gas instead of coal to produce electricity or using solar, wind, and geothermal energy instead of natural gas for electricity and heat. In these examples, cleaner technology reduces water and air pollution, including such major greenhouse gases as carbon dioxide (CO₂) and methane.

**Strengths.** The greater Pittsburgh region’s energy sector has a clear and strong national standing and was called out as one of only two (of 11) “advanced industry clusters” (Andes et al., 2017, Table A-8). More recently, diverse energy subsectors were identified as key economic development and workforce opportunities for the region (Energy Task Force of the Allegheny Conference on Community Development, 2022; Strategen Consulting, 2022). In interviews, stakeholders recognized the historical and current strengths of Pittsburgh’s energy sector. In fact, there was virtually unanimous agreement that clean energy can and should be important to the region’s economic future. Some interviewees, in fact, asserted that clean energy could be *the* most important sustainable sector for the region in economic terms.

Across the commonwealth, the clean energy labor market was recently estimated to employ more than 94,600 Pennsylvanians, with 5.1 percent in annual growth or 4,613 new jobs. This growth represented a rebound after the coronavirus disease 2019 (COVID-19) pandemic-related economic downturn; the clean energy sector lost about 7,200 jobs in the first year of the COVID-19 pandemic (BW Research Partnership, 2022a). By comparison, Pennsylvania’s broader energy sector (which includes clean energy)
employed more than 258,000 workers and grew by 3.3 percent over the same period (BW Research Partnership, 2022b).

From the perspective of short-term workforce availability, the region is relatively strong in occupations of direct relevance to the sector, second only to the circular economy in terms of the number of occupations. In terms of worker pipeline in the long term, our analysis identified 26 separate providers of relevant education and training. In aggregate, these providers offer credentials that are well distributed across skill levels and credential types. For example, in the City of Pittsburgh, such providers include the Energy Innovation Center, local unions, CMU, and Pitt. Again, this regional strength is second only to providers of training and education relevant to the circular economy and represents the same number as providers serving manufacturing sectors.

Opportunities. There are multiple subsectors of clean energy that might be advanced successfully in the Southwestern Pennsylvania region; however, stakeholders viewed several of these subsectors to be especially promising. Most notably, there is blue hydrogen—made from regionally abundant natural gas and coupled with carbon capture and storage (CCS) to avoid CO₂ emissions from the process—which received much attention in our conversations with regional stakeholders and, more broadly in recent months, in the media. Some stakeholders enthusiastically spoke of amping up large-scale regional production of blue hydrogen and investing in both the associated infrastructure for transporting, storing, and using hydrogen as feedstock and fuel and the CCS infrastructure necessary to manage CO₂ waste. One stakeholder characterized this subsector as “essential” to decarbonizing the region. Another stakeholder suggested that the development of a hydrogen hub in the region could “anchor” a larger CCS network to serve both blue hydrogen and a broader range of industries. In late 2023, the U.S. Department of Energy announced substantial funding for a consortium of partners in West Virginia, Ohio, and Pennsylvania to test the concept at scale as part of a larger national hydrogen hub program (U.S. Department of Energy, 2023), bolstering the chances of success of this new sector.

Several stakeholders also assessed small modular reactors (SMRs) and other advanced nuclear concepts as potentially important to large-scale decarbonization and aligned with regional strengths, which could allow this subsector to be a major contributor to economic development. According to several stakeholders, the concept of deploying SMRs may have cultural resonance in “coal country” and leverage specific skills of workers in the shrinking coal industry. One concept stakeholders mentioned was to locate SMRs at existing nuclear or coal power sites. An interviewee noted that they were aware of at least one example

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Leadership in Clean Energy Workforce Development: New York State Energy Research and Development Authority

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

SOURCES. Features information from NYSERDA, undated-b; NYSERDA, undated-c; NYSERDA, undated-e; NYSERDA, undated-f.
* NYSERDA, undated-a.
+ NYSERDA, undated-d.
of SMRs and solar energy—or a combination of the two—being considered at a former coal-powered facility. Stakeholders noted that nuclear energy could be a major contributor of “firm power” for the region: Put another way, this power generation technology does not require storage or other ways of managing the intermittency experienced with some forms of renewable energy. In terms of existing workforce, nuclear occupations had among the highest relative advantage in regional numbers.

**Challenges.** As much enthusiasm as there was for clean energy as an economic driver and job creator in the region, there was substantial disagreement about which subsectors were most desirable, suitable, and likely to future-proof the economy of Southwestern Pennsylvania. For example, one interviewee described producing and building substantial new markets for blue hydrogen as focusing too much on transitional technologies and not enough on long-term sustainability. Another interviewee expressed skepticism about the large-scale importance of and demand for hydrogen, suggesting that it may only find use for more niche applications. Several stakeholders mentioned Shell’s Butler County cracker plant as an example of something that, in their opinion, was “oversold” and not likely to provide economic benefits commensurate with downside risks, such as negative impacts on air quality. One interviewee worried that disadvantaged communities would bear the brunt of any health-related burdens from a large-scale blue hydrogen industry, citing ample historical examples of such inequities.

Stakeholders also noted the perennially low public acceptance of nuclear energy and how public opinion can influence policy and technology deployment. One stakeholder lamented the current focus on hydrogen, which they suggested was consuming all the interest and appetite for large-scale emerging energy projects and crowding out investment in nuclear energy. Finally, advanced nuclear concepts may impose some limitations on equitable access to employment because jobs in the nuclear industry generally require a bachelor’s degree or higher.

More than a dozen stakeholders discussed the untapped potential for renewable energy production in the region and across the commonwealth, especially solar power. Interviewees expressed frustration with insufficient leadership and a need for additional supportive state policies, including lowering barriers to community solar projects and setting more-aggressive statewide renewable energy goals. While there is no clear competitive advantage for manufacturing many of the components of solar panels in the region, stakeholders noted the potential for more economic development and employment in other parts of the supply chain (e.g., utility-scale solar trackers, utility-scale batteries), for system installation, and for the long-term operations and maintenance of renewables, although the latter is an inherently more limited opportunity because of the generally low-maintenance requirements of this fuel-free electricity source. Less training is often required for solar installation jobs than to become an electrician, so this could provide opportunities for an entry-level workforce. The flip side of this opportunity is that wages in this sector tend to be lower than for more traditional union jobs in electrical fields and more traditional energy production subsectors.

**Green Building**

The green building sector includes both the sustainable materials and processes necessary to design, build, maintain, and deconstruct or reconstruct environmentally friendly and resource-efficient buildings. Among important considerations for sustainability are materials and methods of construction, which account for about one-third of the energy associated with buildings, and long-term operations and maintenance, which account for the balance of the associated energy use and embodied carbon of buildings. Economic development and workforce opportunities for Pittsburgh span the full life cycle in this sector.
Pittsburgh already has a strong record of accomplishment in green building and is relatively strong in many occupations of direct relevance to that sector.

**Strengths.** Pittsburgh already has a strong record of accomplishment in green building. The region has many new and retrofitted high-performing buildings that have earned it a positive national and international reputation. For example, the Pittsburgh 2030 District—an initiative of GBA that supports building owners and managers in their efforts to reduce energy and water consumption and emissions—is the largest of 23 international districts participating in the 2030 District program with more than 87 million square feet of buildings and more than $390 million in energy and water costs savings since 2012 (GBA, undated). Multiple interviewees both in and outside the green building sector noted the early and ongoing work of GBA as particularly forward-thinking and influential. GBA was credited with proactively sharing best practices and articulating the value of green building and related concepts, such as energy efficiency. From the perspective of short-term workforce availability, the region is relatively strong in many occupations of direct relevance to the green building sector, closely following the substantial number of workers in occupations of relevance to the circular economy and clean energy sectors.

**Opportunities.** Interviewees suggested that GBA’s successes can and should be leveraged for new and expanded economic opportunities. Moreover, the alliance’s presence can be leveraged to burnish the region’s reputation in sustainability. Commercial green buildings have been the early focus in the City of Pittsburgh, but the residential sector in the city and buildings in the broader region offer additional opportunities. As one interviewee put it, “There is so much existing residential stock that can be activated” because homes in Pittsburgh are twice as “leaky” (i.e., the building envelope is not energy efficient) as the national average across all levels of homeowner income (City of Pittsburgh, 2018).

Expanding interest in energy-efficient modular housing regionally and nationally would be one opportunity to leverage the region’s historical strengths in manufacturing and support low- and semi-skilled workers. Modular manufacturers can train and supervise new workers on-site, which would enable less-experienced workers to start more quickly than those entering traditional homebuilding. This relationship with workers would also benefit the employers, should they continue to struggle with labor shortages.

Finally, development in this sector could lighten some equity-related housing problems, such as poor indoor air quality, disproportionate energy costs, and overall housing quality and affordability for low-income households. Culturally, expanding green buildings in the region could resonate with residents if this connection were made clear. Interviewees mentioned Rebuilding Together Pittsburgh as an organization working at this intersection of sustainability and equity. The organization’s focus is 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 building (Rebuilding Together Pittsburgh, undated). One interviewee noted that a robust demand for “greening” existing housing can support small businesses, including those owned by women and people who identify with minoritized groups underrepresented in building more broadly.

**Challenges.** As with the development of a more robust circular economy, outreach and messaging to all stakeholders will be key. More specifically, the direct benefits to homeowners and potential workers will need to be clearly articulated. From a future workforce perspective, there is only one bachelor’s degree program specifically in the green
building sector, an environmental design/architecture program at CMU. The Community College of Allegheny County (CCAC) recently stopped offering courses for its “Green and Sustainable Building Design” certificate because of insufficient demand, although changes to the core curriculum for its building construction programs reflect a shift to more-sustainable practices in the general training offered. On the other hand, there are nearly two dozen entities providing relevant green building training when associate degree and subbaccalaureate programs are included.

Advanced Manufacturing

Advanced manufacturing applies innovation and emerging technology to traditional industries, producing goods with increased automation, information, and advanced concepts in computation, such as machine learning (Peduto, undated). Green advanced manufacturing thus leverages these advances specifically to use less energy and water, create less waste, and use environmentally friendly materials to create products that might themselves better support sustainability than their predecessors.

Strengths. Manufacturing has a historic importance in Southwestern Pennsylvania, as the significant number of factories, mills, and corresponding coal, railroad, and steel industries reminds all regional stakeholders. Today, regional entities from Catalyst Connection to CCAC to CMU support advanced manufacturing and aim to future-proof existing and emerging manufacturers in the region. Current and future workers can acquire the associated skills necessary for advanced manufacturing through a variety of means, including training by local unions, community college courses and certifications, and on-the-job training. For the medium- to long-term pipeline, our analysis identified 26 providers of education and training that, in aggregate, provide credentials spanning all required skill levels. This availability of providers is second only to the number of providers of training and education relevant to the circular economy and equals the number of providers serving the clean energy sector.11

Opportunities. In interviews, stakeholders noted a variety of potential areas of focus for advanced manufacturing in the region, from batteries for solar backup to green modular buildings. Many of these areas already have at least one successful firm in the region on which to model operations or collect lessons learned. Stakeholders with direct involvement in the advanced manufacturing sector were particularly bullish. They noted that the region is well positioned to go forward in this direction by producing, for example, SMRs for carbon-free energy. They also pointed out that advanced manufacturing benefits from regional blue hydrogen production as a feedstock and clean energy source. These stakeholders also noted the region's reinvigorated steel manufacturing sector and how advanced manufacturing tools and techniques could continue to improve this area. In addition, the region already has core workforce and facility strengths that could be leveraged in the advanced manufacturing sector, as well as innovation in automation, robotics, and artificial intelligence.

Challenges. There was some stakeholder disagreement around the future of advanced manufacturing in the region. Some interviewees expressed concern that the region's industrial days are (or should be) in the past and that continued attention in these areas is based more on nostalgia than an objective assessment of opportunity. There were also concerns about future workforce interest in advanced manufacturing. One interviewee called out the rural manufacturing workforce as an important regional asset for this sector, but another suggested that not enough is really understood about whether this potential workforce views manufacturing as a future that they want to be a part of. A third interviewee expressed the concern that education and information is limiting the promise of manufacturing as a career; that is, many people today do not really understand what an advanced manufacturing job really is. This interviewee also noted the challenges of increasing interest in remote work and the difficulty of supporting that preference in a sector where workers would likely need to be on-site during hours of operation.

Despite the strength of the training and education opportunities noted above, we identified relatively few occupations needed to support advanced manufacturing for which Pittsburgh presently has substantial employment or a relative advantage over other regions.
This indicates a potential for short-term workforce availability challenges. For example, our analysis reveals less overlap between anticipated sector needs and short-term worker supply than in other sectors with similar numbers of training providers, including the circular economy and clean energy. Coupled with the general demographic pressures in the region, this is a concerning gap for the prospects of a robust advanced manufacturing sector.

Outdoor Recreation

Outdoor recreation includes a broad variety of activities that occur in an outdoor environment and for which well-preserved natural areas with unique or aesthetically pleasing features are generally highly valued. Outdoor activities appropriate to the region include biking, birdwatching, boating, fishing, hiking, landscape painting, photography, rock climbing, and cross-country and downhill skiing. The growth of this sector would directly leverage the benefits of regional environmental stewardship and, conversely, has the potential to increase awareness and appreciation of sustainability. An abundance of such recreational activities—well curated, branded, and publicized—would also bolster the quality of life for residents and enhance the region's reputation, thus indirectly supporting other economic sectors.

Strengths. Stakeholders across the board positively viewed the further development of this existing regional sector. There is already precedence in transforming parts of Southwestern Pennsylvania's numerous forests, wetlands, meadows, and rocky hills into accessible recreational spaces. As one interviewee put it, “Nature is right inside the City [of Pittsburgh] . . . [whereas] most cities are built in a way that excludes nature,” and Pittsburgh has natural assets “right at its fingertips.” In addition, almost every city and township in the region supports their own outdoor recreation systems, facilities, and related activities. Given the combination of successful examples, ample natural resources, and geographic location, leaning more into developing this sector could, as another interviewee put it, make Pittsburgh “the Boulder, Colorado, of the East.” More broadly, outdoor recreation can be kept from being “muddled” or wrapped up in controversies or backlash to green technology.

This sector already has strong nonprofit and educational opportunities in this region. Nonprofit leadership includes such organizations as Bike PGH, the Pennsylvania Environmental Council, and Riverlife. Two unique educational programs in parks and recreation management and conversation—at Butler County Community College and Slippery Rock University—could be leveraged for long-term workforce development.

Opportunities. In general, stakeholders saw this sector as one that could be readily expanded because, in the words of one interviewee, the region can “leverage a lot . . . with less money.” Economic benefits and workforce opportunities could be especially significant for residents of smaller towns that have lost industries in recent years. Creating facilities, expanding trail systems, and providing services to visitors were specific occupations noted by stakeholders. Strengthening outdoor recreation services and “trails-to-towns” programs can attract visitors to the region and offer adjacent small business opportunities, such as furniture making and sustainable agriculture. Many stakeholders asserted that a robust outdoor recreation sector is essential to attracting and retaining a larger general workforce. One interviewee noted that younger workers

Illustrative Outdoor Recreation Subsectors 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
- **Nonprofit**: 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: Authors’ analysis of information from Outdoor Recreation Roundtable, 2022.
Leadership, Success, and Opportunity in the Outdoor Recreation Sector: The Pennsylvania Wilds

The Pennsylvania Wilds (PA Wilds) initiative provides a relevant example and valuable lessons for the Southwestern Pennsylvania region. Many interviewees noted that this initiative was the result of the successful combination of state efforts with the unprecedented acquisition of federal funding. This innovative funding was made possible in part by cross-sector stakeholder collaboration and effective marketing and branding. Existing programs born out of this initiative include the Trail Town Program, which connects towns formerly reliant on extractive industries, and the Wilds Are Working remote work initiative to support outdoor recreation and the immigration of remote workers to the PA Wilds.

Within a six hour drive of 50 million people, the PA Wilds now draws visitors to a largely pristine natural area, roughly the size of Yellowstone Park, with rivers, mountains, trees, and elk. Interviewees noted that the PA Wilds’ proximity to Pittsburgh creates an opportunity for apprenticeship programs involving young people in trail development, renewed economic activity in towns formerly reliant on extractive industries, and other connected initiatives.

SOURCES: Features information from Trail Town Program, undated; Madera, 2023.

expect access to outdoor opportunities as part of their focus on quality of life and work-life balance. Several stakeholders noted that the potential exists to leverage trends in remote work, attracting new residents with jobs rooted elsewhere in the country to enjoy a reasonable cost of living and access to the outdoors in their leisure time. Additionally, for outdoor recreation workers, remote work can provide a broader variety of professional opportunities for family members not employed in the sector who want to live with or near them.

Challenges. One concern raised by stakeholders about this sector was the perceived lack of diversity and inclusivity of many outdoor activities. One interviewee noted that skiing and rock climbing are sports that have historically lacked participants from diverse backgrounds and, thus, are perceived as being “very white.” Such activities can require substantial investments of time and resources; therefore, providing financial support and welcoming outreach will be required to ensure that opportunities for participation and for economic benefit are provided to everyone.

Workforce is another potential limitation for this sector. While the region has a significant number of existing workers who could transition into outdoor recreation fields, the Southwestern Pennsylvania region often does not have a relative workforce advantage compared with other regions of the country. The box above provides some examples of the types of occupations that are relevant to outdoor recreation subsectors. More generally, most park and recreational jobs offer positions with relatively low salaries, especially compared with jobs in the service industry, and often in remote locations. There is also the potential for unintended negative consequences with the success of outdoor recreation. A surge in population, either from people relocating from more-expensive areas of the country or even from nonresidents visiting for extended periods enabled by remote work, could potentially raise the cost of living, including housing costs, to the detriment of current residents.

Water Management

Water management entails the stewardship of water resources by both physical and regulatory means. Southwestern Pennsylvania has significant and distinct natural water assets that must be protected to maximize their associated economic benefits. Many municipalities in the greater Pittsburgh region have challenges related to water management and use, including insufficient infrastructure to support stormwater management and the resulting combined sewer overflows (CSOs) into the region’s rivers.

Strengths. Water has always played a significant role in the region. Historically and now, the
Allegheny and Monongahela rivers, which merge to form the Ohio River, serve as a source of drinking water for Pittsburgh and nearby communities. In addition, the rivers have played and continue to play an important role in transportation and, increasingly, for recreation, making them vital to the city’s infrastructure and identity. More than one stakeholder noted the two sides of the coin—“both an opportunity and a challenge”—of living somewhere with an abundance of water. Careful management of this asset will only grow in importance in a climate-constrained future where other regions of the country suffer from drought or sea-level rise. The workforce pipeline into occupations in the sector over the long term also has the potential to be robust. There are 20 distinct providers of certificates and degrees that span all training levels from multiple subbaccalaureate offerings to multiple advanced degrees, including CMU in the region and Penn State University just beyond the region.13

Opportunities. As noted by several stakeholders, the rivers and general abundance of water offer diverse green opportunities in the region. Everything built along the rivers is an opportunity to leverage those assets more fully and more sustainably. Stakeholders pointed out the clear links between water management and other sustainable sectors, such as outdoor recreation. There is an opportunity to increase positive branding for the region if water management–related activities can be sustainably expanded, offering both direct and indirect economic benefits. The potential to innovate in water management subsectors was also discussed. The strength of regional universities and engineering expertise, for example, was noted as a real opportunity that is not being fully leveraged.

In one example of collaborative success, the City of Pittsburgh now requires developers building or paving parcels of land of a minimum size to install green stormwater infrastructure, so that their projects will not contribute to stormwater runoff and CSO. This policy change was informed by analysis performed in collaboration with multiple regional entities and was highlighted in the 2023 National Climate Assessment (Hurdle, 2024). The green infrastructure investments by developers that will result provide an example of what is possible by combining the unique intellectual assets in the region with local policy and decisionmaking.

Challenges. Major investments in stormwater management will need to be made in the coming years to keep the region safe. Legacy water impairment is still a challenge, too, as many stakeholders pointed out. Managing these risks can offer economic and workforce opportunities, but doing so will require accessing state and federal funding and collaboration across municipalities where fragmentation has historically stymied cooperation and the ability to achieve economies of scale. An additional challenge is a relatively limited short-term workforce available to support this sector compared with workforces for other sectors that we considered, such as the circular economy and clean energy—strong both in absolute and relative terms—and outdoor recreation—with weaker relative strength but a significant number of workers nevertheless.

Cross-Sector Considerations and Implications for Priority Sectors

There are several regional attributes and factors that span some or all of the most promising sustainable sectors that our analysis identified. Leveraging these strengths and coordinating on challenges could support sustainable economic development and promote a more equitable distribution of benefits and risks in the region. Considering pros and cons for the seven sectors described above in aggregate, we assessed the overall favorability of each sector across the following dimensions: historical relevance and leadership, broad stakeholder support, near-term workforce supply, education and training availability, and potential impact of local and regional support (shown as column headers in Figure 2). All seven sectors look quite promising across several important dimensions—including the fact that all have synergies with one or more other sectors and all have near- and long-term workforce opportunities that span skill levels. Therefore, Figure 2 focuses on the attributes that most distinguished each sector. Although all sectors are generally favorable across these distinguishing dimensions—and thus they were all assessed as promising for the region—we identi-
<table>
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<tr>
<th><strong>Sustainable Sector</strong></th>
<th><strong>Strengths</strong></th>
<th><strong>Opportunities</strong></th>
<th><strong>Challenges</strong></th>
<th><strong>Illustrative Nonprofits</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustainable agriculture</td>
<td>Broad geographic distribution</td>
<td>Synergies with other sectors (e.g., outdoor recreation)</td>
<td>Limited economic potential relative to other sectors</td>
<td>Grow Pittsburgh</td>
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<td></td>
<td>Favorable climate (e.g., water resources), even with future climate change</td>
<td>Co-benefits, such as more-equitable food access</td>
<td>Short- and long-term workforce limitations</td>
<td>Phipps Conservatory</td>
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<td>Proximity to East Coast markets</td>
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<td>Circular economy</td>
<td>Alignment with the region's “thrifty” culture</td>
<td>A focus on the buildings subsector leverages other strengths (e.g., green buildings)</td>
<td>Insufficient policy and market signals</td>
<td>Construction Junction</td>
</tr>
<tr>
<td></td>
<td>Strong short-term workforce supply in absolute and relative terms</td>
<td>A variety of needed skills and training could support equitable job creation</td>
<td>Inherently decentralized, requiring coordination</td>
<td>Landforce</td>
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<tr>
<td></td>
<td>Strong ecosystem of training and education providers for long-term workforce pipeline across all skill levels</td>
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<td></td>
<td>Sustainable Pittsburgh</td>
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<tr>
<td>Clean energy</td>
<td>Workforce, infrastructure, and natural resources in fossil fuel energy, especially natural gas</td>
<td>Multiple promising subsectors, from blue hydrogen to nuclear energy to solar power</td>
<td>Stakeholder disagreement on the definition of “clean”</td>
<td>Keystone Energy Efficiency Alliance</td>
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<td></td>
<td>Very strong short-term workforce supply in absolute and relative terms</td>
<td>Synergies with many other sustainable sectors, including the circular economy, green building, and advanced manufacturing</td>
<td>Risk of lock-in for technologies that are transitional and not future-proof</td>
<td>Pennsylvania Solar Center</td>
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<td>Less potential for local and regional influence (e.g., philanthropic investments)</td>
<td>Energy Innovation Center</td>
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<tr>
<td>Green building</td>
<td>National and international leadership and recognition in sector</td>
<td>Large potential for economic growth and positive climate impact</td>
<td>Limited (explicitly) training in green building occupations by traditional educational institutions</td>
<td>Construction Junction</td>
</tr>
<tr>
<td></td>
<td>Strong short-term workforce supply in absolute and relative terms</td>
<td>Strong co-benefits for equity</td>
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<td>GBA</td>
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<td></td>
<td></td>
<td>Synergies with the circular economy (e.g., building deconstruction and materials reuse) and advanced manufacturing (e.g., modular housing)</td>
<td></td>
<td>Rebuilding Together Pittsburgh</td>
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<tr>
<td>Advanced manufacturing</td>
<td>Strong regional history and culture in manufacturing</td>
<td>Synergies with other sectors (e.g., clean energy and related opportunities, such as a cracker plant and a blue hydrogen hub and associated CCS)</td>
<td>Stakeholder disagreement on the direction of the sector in the long term</td>
<td>Catalyst Connection</td>
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<td></td>
<td>Significant number of educational providers for long-term workforce supply</td>
<td></td>
<td>Relatively few occupations with large numbers to support growth in the short term</td>
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</table>
fied two sectors that might be best suited for focused support by local and regional governments, nonprofits, and philanthropic entities: circular economy and outdoor recreation. In the next sections, we discuss cross-sector and subsector strengths, opportunities, and weaknesses, especially those relevant to these two priority sectors.

**Strengths.** As one interviewee phrased it, Pittsburgh “punches above its weight” in innovation and skilled workforce, with a strong combination of reputation, culture, and substantive capacity. Robotics and autonomous systems are well-known examples of such cross-sector strengths and were specifically called out by many interviewees. Although aging, inefficient infrastructure is not an asset per se, energy efficiency and conservation were both seen as foundational concepts for sustainable industries and societies, and both were noted to have cultural resonance. The pressing need for improvement in, for example, residential energy and water efficiency is an opportunity for economic growth, and the variety of opportunities for improving infrastructure could best leverage unprecedented federal funding opportunities if considered at scale and coordinated across relevant stakeholders.

**Opportunities.** Some of the key opportunities for the region lay at the intersection of defining regional strengths and clusters of complementary sustainable sectors. For example, building on Pittsburgh’s success and reputation in green building to (1) expand successful programs to the greater Pittsburgh region; (2) extend programming and lessons learned to residential buildings, including affordable housing; and (3) link to opportunities in both innovation and practice in the circular economy of building materials seems particularly promising. There is

<table>
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<th>Challenges</th>
<th>Illustrative Nonprofits</th>
</tr>
</thead>
</table>
| Outdoor recreation | • Leading educational institutions (i.e., Butler County Community College and Slippery Rock) offer relevant programs  
• Ability to leverage lesser strengths of other sectors (e.g., sustainable agriculture and water management) | • Direct and indirect synergies with other sectors  
• Proximity to population centers | • Historic lack of participant diversity  
• No relative advantage in existing workforce numbers compared with other regions of the country | • Landforce  
• Pennsylvania Environmental Council  
• Riverlife  
• Venture Outdoors |
| Water management | • Distinctive and increasingly important resource  
• Leadership in water management practice and potential for more innovation | • Synergies with outdoor recreation and a relevant resource for virtually all other sectors considered  
• A relatively less robust near-term workforce supply  
• Funding and collaboration complexities (i.e., government-funded work that spans municipalities) | • UpstreamPgh  
• Western Pennsylvania Conservancy |
| Across sectors | • Relative strengths in numerous cross-sector occupations | • General skills required for these sectors contribute to a more future-proof workforce  
• General demographics will require recruiting non-traditional workers—which is also an opportunity to increase diversity, equity, and inclusion. | | • Southwestern Pennsylvania New Economy Collaborative  
• Sustainable Pittsburgh |

NOTE: Short-term labor supply was deemed to be relatively limited if a sector had few directly relevant occupations that exceeded 1,000 workers and for which the region did not have a relative advantage in numbers compared with other regions in the country—a LQ >1. Conversely, a sector with a significant number of occupations with a high number of workers in both absolute (i.e., more than 1,000) and relative (i.e., LQ >1) senses was deemed to be an area of relative strength for the region.

This is not meant to be a comprehensive list of relevant organizations.
ample raw material—in the form of aging buildings, strong unions, world-class educational institutions, and national and international private-sector firms with headquarters in the region—for a building materials subsector of a circular economy to emerge.

Similarly, the ingredients are all here for a robust outdoor recreation sector that provides direct and indirect economic growth and burnishes the region’s green credentials. Both examples have the advantage of scalability and the potential for the whole to be greater than the sum of its parts: Meaningful investments could be made in small businesses and localized initiatives, yet greater success will come with more growth as economies of scale can be realized.

In contrast, while some subsectors of clean energy could grow with relatively modest and incremental investments, such as the deployment of rooftop or community solar power, a blue hydrogen hub would require substantially larger capital investments. Thus, the color-coding in Figure 2 is split for the associated assessment of impact for this sector.

The trend toward remote work opportunities is likely to have different impacts across the sectors that we have discussed. For example, remote work could support demand for outdoor recreation goods and services in the region and, at the same time, support

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### FIGURE 2
Overall Favorability of Seven Promising Sustainable Sectors for the Southwestern Pennsylvania Region

<table>
<thead>
<tr>
<th>Sustainable Sector</th>
<th>Historical Relevance and Leadership</th>
<th>Broad Stakeholder Support</th>
<th>Near-Term Workforce Supply</th>
<th>Education and Training Availability</th>
<th>Potential Impact of Local and Regional Support</th>
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</thead>
<tbody>
<tr>
<td>Sustainable agricultures</td>
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<td>Circular economy</td>
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<td>Clean energy</td>
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<td>Green building</td>
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<td>Advanced manufacturing</td>
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<td>Outdoor recreation</td>
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<td>Water management</td>
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**NOTES:** “Historical relevance and leadership” refers to a sector’s substantive strengths and reputation. “Broad stakeholder support” refers to existing or potential backing and/or cultural resonance with stakeholders from diverse geographic, socioeconomic, racial, and political groups. A split between two colors indicates an existing or potential lack of stakeholder consensus in support of a sector. “Near-term workforce supply” indicates existing regional workforce in the most directly relevant jobs, in terms of total numbers of workers and in terms of relative advantage of these numbers compared with other regions. “Education and training availability” in the region indicates the existence of multiple and/or distinctive providers and a potential for long-term workforce supply. “Potential impact of local and regional support” was based on our assessment of whether small or incremental investment and/or policy support by local and regional governmental, philanthropic, and nonprofit organizations could be relatively impactful. A split here indicates mixed impact, depending on the scale of associated subsectors or projects.
Our quantitative analysis shows that more than half of existing jobs in needed green occupations typically do not require education past high school for entry, making green sectors open to workers with a variety of educational and skill levels.

outdoor recreation worker supply by enabling friends and family to live in relatively remote locations. In other cases, such as the circular economy, an interest in remote work may undermine interest in jobs that require hands-on, in-person work. On balance, remote work trends need to be considered and leveraged for the potential benefits offered.

Another general opportunity of green sectors is that, despite some distinctions of required workforce for different sustainable industries, the skills and training that are desirable for sustainable industries are in many instances general skills. In the other words, in many ways green jobs are “just jobs.” Our quantitative analysis shows that more than half of existing jobs in needed green occupations typically do not require education past high school for entry, making green sectors open to workers with a variety of educational and skill levels. And, in addition to the sector-specific overlaps discussed above, our analysis indicates that the region has strengths in many areas with cross-sector relevance, both in absolute and relative terms, such as in occupations that could support research and development across sectors. Moreover, our analysis of the potential medium-term labor supply to sustainable sectors—current workers with adjacent skills—revealed 43 close occupations with more than 1,000 workers, including more than 30 in which the greater Pittsburgh region has a relative advantage over other regions in the country (Curtright et al., 2024).

**Challenges.** There are several common potential challenges, some unique to the region, that could affect the growth of promising sustainable sectors. One issue raised by stakeholders was the importance of branding and messaging. For example, 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 perceive a green economy as a threat to their way of life. Appealing to the practical attributes of a green economy—cost savings, job creation, health co-benefits—is a good strategy across worker demographic and locale. In the case of clean energy, for example, blue hydrogen and solar energy both lack universal enthusiasm across stakeholder groups; many stakeholders indicated a strong positive or negative assessment of one or the other. Figure 2 shows this divergence in opinion by the split color-coding for the associated assessment. On the other hand, outdoor recreation and the circular economy both seem to be promising sectors for developing broad appeal if cultural nuances are understood and respected.

Although not unique to sustainable sectors, communication, coordination, and collaboration in the region could be improved. Stakeholders noted that there are perennial problems with the make up of Pennsylvania’s many municipalities and the associated fragmentation of state-wide decisionmaking. Working in silos and “talking past” each other will hinder growth and success. Some stakeholders talked about disconnects specific to green sectors, such as a “misalignment” of academic institutions with non-
profits and businesses. This can lead to a duplication of efforts and a failure to scale up concepts that work. For example, innovative educational programming that only serves several dozen people could potentially be scaled up to serve hundreds, and if scaling up is not practical or useful, investing in already existing programming might be a more efficient use of time and resources. Relatedly, there is a 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 often too late for them to change their career trajectories.

Another cross-sector concern was insufficient funding for translating innovation from regional research institutions—including CMU, Pitt, and the National Energy Technology Laboratory—into commercialization. Previous analysis has noted this long-standing issue: “[P]re-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). The lack of “upfront bridge funding for projects eligible for IRA [individual retirement account] tax credits” was described as “in some ways the largest single barrier facing Pennsylvania” to leverage historic federal funding in order to address infrastructure and climate change (Freedman Consulting, undated). Relatedly, stakeholders lamented the inability to retain significant numbers of the highly trained talent coming out of regional universities and asserted that local companies need to have stronger connections to schools and offer direct pipelines through internships and other mechanisms.

Finally, many stakeholders noted shortfalls in existing workforce size and expected insufficient numbers of future workers. This is a demographic issue because of an aging workforce and declining population in some parts of the region and is not specific to growing green sectors. As with other economic sectors, to fill these gaps, traditionally underrepresented workers will be needed. Our analysis indicated that the existing workforce with the most directly applicable training and skills is, not surprisingly, not racially or ethnically diverse and is even less diverse than the general population of the region. Women are also underrepresented in these sectors. Stakeholders reiterated the need to work toward culturally sensitive communications to attract workers to fields in which they may have historically been underrepresented—such as people of color and women—and to retain traditional workers who may negatively associate “green” as being an urban or elite trend.

**Recommendations**

Although not without challenges and not all equal in the magnitude of their potential economic impacts, the seven promising sustainable sectors identified in our assessment offer the greater Pittsburgh region a potential foundation on which to build a green economy. We present several recommendations below to foster a more sustainable and equitable future in the region, along with specific steps for the consideration of regional stakeholders, such as training and education providers; research entities (e.g., universities and the National Energy Technology Laboratory); city, county, and state governments; nonprofits; philanthropic organizations; small businesses; national and international corporations; and venture capital investors.

**Recommendation 1. Focus on sustainable sectors that support regionally distinct opportunities, have broad stakeholder support, and that can do the most with modest or incremental investments, such as a circular economy (centered on a potential building materials subsector) and outdoor recreation.**

It makes sense for local and regional governments and philanthropic organizations to lean into opportunities that are unique to the area, can be championed by diverse stakeholders, and can grow substantially with small- to medium-sized investments. Short- and long-term workforce supply—both the absolute number of workers and the number of workers in occupations for which the region has a relative advantage—will be key to success. Long-term workforce supply will require strong regional training and educational opportunities. Ideally, the areas of focus will have natural synergies with other exist-
focus on the circular economy for the green 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 in training or specific projects, provide opportunity for branding, and potentially help attract and retain students specifically interested in emerging concepts in sustainability. The private sector has a clear role to play in supporting these ecosystems, too.

Recommendation 3. Develop and build support for policies that create appropriate regulatory or market signals at local and regional levels when possible.

Stakeholders did not always agree on which policies would be acceptable or most effective (e.g., is it better to mandate or incentivize?), but all acknowledged that new policies will likely be needed to support industries that provide benefits not directly reflected in market prices. More-concerted efforts in developing proactive policies at the state level would be beneficial, but there are opportunities to better align incentives at the regional and local levels, too. To lay the groundwork for a truly circular economy, local governments should work to improve education and standardize 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 green building sector broadly; and increase coordination across municipalities to achieve economies of scale. Such a foundation could foster the creation of more-robust related policies and signal the importance of the growing circular economy sector in the greater Pittsburgh region. Nonprofits and private-sector companies could signal their support for local government initiatives or, at the very least, not stand in the way of them—and this support could usefully be extended to state-level policy, such as support for low-carbon portfolio standards for electricity production in the commonwealth. For a circular economy example, regional nonprofit Sustainable Pittsburgh and Covestro, an international supplier of high-tech polymer materials, both recognize the potential of this sector in the region and could encourage local,
The training gap is in the “coordination of technical [mid-skill] training programs with industry . . . as companies pivot to more green lines of business or green applications.”  
— Environmental nonprofit stakeholder

There “hasn’t been a clear articulation of what industry needs.”  
— Educational institution stakeholder

Recommendation 4. Ensure that educational opportunities, jobs, and projects in sustainability have proactive and appropriate outreach and education to support cultural shifts and inclusion.

Many interviewees noted the not-always-positive cultural connotations of “green” in the context of sustainability efforts. Social, cultural, and ideological barriers may inhibit the full participation of the labor force in green opportunities. For example, historically marginalized people of color residing in urban areas may perceive the clean energy sector as unwelcoming because of historical racial/ethnic minority underrepresentation in the trades. Rural workers may view green practices as an urban elite trend that threaten their culture and way of life. Women may worry that traditionally male-dominated fields, such as engineering, will remain so even as sectors become increasingly green. Therefore, it may be useful to emphasize the practicality and health and economic benefits of a green economy or make connections between green and positive regional assets, such as local sports teams that support sustainability initiatives. And an early introduction to the opportunities of sustainable industries to students—starting in kindergarten through grade 12—will be essential. Communication that is crafted for specific populations may help bridge gaps and bring more talent into a growing green economy. Philanthropic organizations, local governments, and employers should work with education and training providers to bring awareness to students at all levels of education and across locales, which might include programs hosted in schools or external programming, such as field trips and site visits.

Recommendation 5. Support existing education and training providers that seek to bridge gaps rather than 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. Fortunately, the region is already strong in training and education providers that can support both the existing and the future green workforce. Important skills vary from general soft skills, such as adaptability and communication, to basic digital skills to more advanced learning in data analytics, automation, and cybersecurity. Our analysis found that, while there are relative strengths and weaknesses in existing and potential future workforce supply for different sustainable sectors, in many ways green jobs are “just jobs.” This means that a robust system of general educational opportunities can support green sectors if providers focus on future-proofing workers with general technical literacy and soft skills.

For training and education providers, this would entail *fundraising and marketing for distinctive existing programs* that support the most promising regional green sectors—such as Butler County Community College’s program for future workers in outdoor recreation or Pitt’s program for circularity in engineering. For other providers, *adjusting existing programs* to ensure the relevance of their curricula by increasing emphasis on sustainability or bolstering recruiting in gap areas, such as construction managers who could support the circular economy, are more appropriate. Both private-sector and nonprofit employers may wish to engage with these providers to ensure that their curricula are relevant and to financially support programs (e.g., provide scholarships for students from underrepresented groups to pursue relevant training, endow funding for outstanding faculty, and offer internships and employment opportunities to students).
Fostering a green economy in the region is a once-in-a-generation economic opportunity. It is also an opportunity to provide funding and support thoughtfully to increase diversity, equity, and inclusion in new and positive ways—the substantial federal funding available to support infrastructure investments and drive economic development require such an approach. However, this outcome can only be realized if stakeholders are, in the words of one 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, U.S. citizens in the region from all demographic groups have a chance to gain from new and lucrative career opportunities. Additionally, stakeholders should be mindful of unintended adverse impacts of emerging sectors, especially for historically disadvantaged communities. Related to the general idea of outreach and communication, outreach programs that are developed and run by members of relevant communities and connected directly with employers could be impactful investments for philanthropic organizations. Traditional training programs at all levels of skill and education need to be intentional about inclusion, including raising awareness of implicit bias and providing clear and specific guidance for their employees.

On balance, the region is in a strong position to capitalize on new and expanding markets for sustainable goods and services but is at risk of missing opportunities. Many of these challenges are not new or unique to sustainable sectors—a lack of coordination and communication between local stakeholders and decisionmakers has long stymied the full realization of the region’s potential, and an inability to translate innovation to market opportunities has hampered growth across various technologies—but sustainable sectors have the potential to bring equitable and geographically well distributed economic development and workforce benefits to the region if a shared vision can be developed and implemented. As one stakeholder cautioned, the region should not get “wrapped up” in debating sectors without unanimous stakeholder support but allow “all of the above” to happen organically with general policies that support innovation and decarbonization. At the same time, the effective branding and marketing of sustainability requires a coordinated focus on win-win sectors with broad stakeholder support—such as the circular economy for green building and outdoor recreation—to ensure that everyone in the region benefits.
Notes

1 We are referring to the seven-county Pittsburgh metropolitan statistical area—more commonly known as the “greater Pittsburgh region” or the “Southwestern Pennsylvania region.”

2 We also noted an expanding development of frameworks and metrics to hold governments and other entities, such as private companies, accountable and to assess progress—both of which are beyond the scope of this work.

3 Pittsburgh’s proximity to East Coast markets was noted with respect to several sectors, including the circular economy and outdoor recreation. We call it out specifically in this report for cases where it seemed to be a key advantage, was mentioned by more than one stakeholder, or was specifically noted in the literature.

4 These are referred to as “green occupations” in the detailed analyses described in the companion report (Curtright et al., 2024).

5 We caution that standard occupational data do not capture some portions of the agriculture sector, and thus, our statements with respect to near-term workforce supply in this section are less definitive than in some other sectors that we consider. Relevant to our analysis across all sectors, the relative strength of the workforce in the region is assessed, in part, by considering the location quotient (LQ) of a given occupation. An LQ of 1 would indicate that the greater Pittsburgh region has an average number of workers in this occupation per capita, an LQ >1 indicates a relative per capita advantage compared with other regions in the country, and LQ <1 indicates a relative disadvantage. The Occupational Employment and Wage Statistics data from the Bureau of Labor Statistics that we used for our analysis is limited to workers at non-farm establishments.

6 Downcycling refers to the production of a product of lower value than the original product, such as burning trash as fuel to produce heat or electricity. Upcycling creates a product of higher value, such as turning trash into art. Recycling reprocesses the raw materials of one product into a new product.

7 This result considers all occupations with an LQ of 1 or greater and with 1,000 or more workers in the region. For comparison, clean energy and green buildings had overlap with 13 and 11 occupations, respectively, and thus were also strong. The remaining sectors in our short list have the following number of relevant occupations: outdoor recreation (5), advanced manufacturing (4), water management (2), and sustainable agriculture (1). We caution overinterpreting this finding for the circular economy: The high concentration of 1,000+ workers/LQ ≥1 suitable for circular economy jobs is likely also related to the large number of circular economy–relevant occupations overall, and there are also many circular economy jobs with a low presence and a low LQ in the region. See Appendix E in the companion report and the illustrative example of how one looks for “close green” jobs (Curtright et al., 2024).

8 See Appendix E in the companion report (Curtright et al., 2024) for details on which occupations are needed to expand the circular economy and examples of “close green” occupations that could help workers transition to green occupations to support it.

9 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. This report defines clean energy generation as “carbon-free electricity generating technologies” and “alternative transportation” includes “plug-in hybrid, electric, natural gas, hydrogen, and fuel cell vehicles” (BW Research Partnership, 2022a, pp. 19, 22).

10 A cracker plant converts liquid hydrocarbon products—often those extracted as co-products of natural gas—into plastic and, thus, has similarities with a facility that converts natural gas into hydrogen. Commonalities may include ownership by and the involvement of the petrochemical industry, the use of industrial processes that produce pollution, and reliance on fossil fuel use over many decades to achieve the profits needed to make initial capital investments worthwhile.

11 However, in terms of its current manufacturing workforce, the region is no longer a national leader in absolute or relative numbers of manufacturing workers.

12 As previously noted with respect to the circular economy—which boasted 14 of 28 occupations with substantial employment numbers and a strong competitive advantage in numbers relative to other regions—this was only the case for four occupations in the region. Across those top overlapping occupations, the circular economy had nearly 50,000 regional potential workers; clean energy had more than 74,000. In contrast, advanced manufacturing could expect to draw from an existing workforce of about 13,000.

13 Although 20 is a substantial number of program providers, we note that this is the second lowest number of providers among the sectors that we considered. Only sustainable agriculture, with a single relevant educational and training provider, had fewer options.

14 Workers in close occupations have shared occupational characteristics with those needed in the sector but may require some training. Thus, they are likely part of a medium-term labor supply.
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About This Report

This report summarizes an assessment of the economic development potential of sustainable sectors in the seven-county greater Pittsburgh region. Through qualitative and quantitative analyses, we identify the most promising sectors based on their relative strengths, opportunities, and challenges for success. Our findings and recommendations are intended to support decisionmaking by local and regional stakeholders in education and training institutions and in workforce boards and economic development organizations; nonprofit, public-, and private-sector employers; policymakers; public and private funders; and residents of the greater Pittsburgh region. Specifically, the report highlights potential areas of focus for regional philanthropic organizations, including the study’s funder, the Richard King Mellon Foundation.

This short report provides key insights derived from a longer companion report, available at www.rand.org/t/rra2563-1. There, the interested reader will find additional information on our study methods, analysis, and findings.

RAND Education and Labor

This study was undertaken by RAND Education and Labor, a division of RAND 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 RAND 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 environments, technology, and community organizations and institutions that affect well-being. For more information, email chep@rand.org.

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