Clean Tech: Visions for a New Pittsburgh Economy

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INTRODUCTION

Report Overview

The purpose of this report is to recommend actionable strategies to the City of Pittsburgh to strengthen and expand its clean tech sector. The report analyses the local clean tech landscape and examines strategies employed in other cities to form the basis for how the City can convene, coordinate, legislate, and invest to achieve clean tech sector growth.

The report begins by defining clean tech and discussing the mechanisms by which policy can influence clean tech activity. The next section analyzes the quality, composition, and size of Pittsburgh's clean tech sector and benchmarks these metrics to other regions.

The body of the report discusses three clean tech subsectors: (1) technologies and services that improve water use efficiency or quality, (2) energy-efficient building technologies, and (3) renewable energy generation and pollution control technologies. Each subsector overview contains information on market projections, local companies and institutions, relevant policies successfully pursued in other regions, potential sources of comparative advantages, and barriers to industry development. The purpose of the subsector analysis is to assess the strengths and weaknesses of Pittsburgh's existing clean tech sector and understand how economic opportunities can be created through better coordination, access to funding, and marketing and branding.

The report offers a detailed analysis of the clean tech strategies used in Portland, Milwaukee, and Cincinnati, discussing policies, programs, and organizations that could be adapted and implemented in Pittsburgh, as well as a review of some of the most relevant literature. Moreover, the group conducted over 30 interviews with leaders across the country from government, industry, nonprofits, universities, and foundations.

The comparative analysis, literature review, and interviews lead to the development of five actionable recommendations for the City of Pittsburgh that relate to:

1. Determining the scope of the cluster-based strategy
2. Creating a sector-based office Investment within the Mayor's Office
3. Organizing a nonprofit, cluster-based economic development organization
4. Increasing local demand for clean tech through a variety of mechanisms

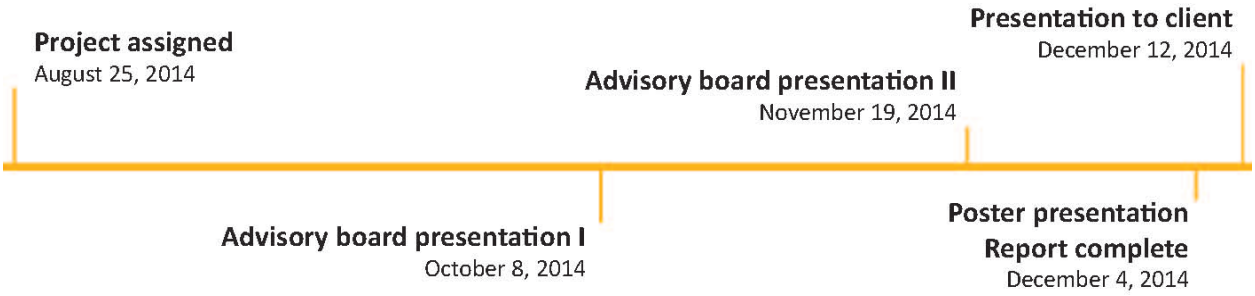
If implemented, these recommendations will positively influence the growth trajectory of the local clean tech industry and transform Pittsburgh into a clean tech hub.

Project Description

The project team had thirteen weeks to define the project scope, conduct research, collect data, interview experts, and propose recommendations (Figure 1). In total, the group conducted over 30 in-person and phone interviews and attended multiple workshops, conferences, and events related to clean tech.

The group presented twice to an advisory board comprised of experts from industry, academia, local government, and nonprofit organizations. The advisory board also volunteered for informational interviews, guided the scope of the research, and provided local institutional knowledge that heavily influenced the report recommendations. The group then presented the report recommendations to students and faculty at Carnegie Mellon University as well as the City of Pittsburgh's Office of Sustainability and Energy Efficiency.

Figure 1: Project Timeline



The report was completed as a degree requirement for the Master of Science in Public Policy and Management program. The group was not authorized to purchase services or data not available through Carnegie Mellon University.

Clean Tech Definition

The purpose of establishing a description definition of clean tech is to both clarify its meaning and provide a sufficiently narrow target for policy intervention. The clean tech definition used in this report draws upon several existing and widely used definitions (Figure 2).

Figure 2: Clean Tech Definitions

Source	Term	Definition
The U.S. Bureau of Labor Statistics (BLS)	Green jobs	Economic activities that "benefit the environment or conserve natural resources" or "make production processes more environmentally friendly or use fewer natural resources."[1]
The Brookings Institution	Clean economy	"The sector of the economy that produces goods and services with an environmental benefit or adds value to such products using skills or technologies that are uniquely applied to those products."[2]
Organization for Economic Cooperation and Development (OECD)	Clean technology	"Cleaner technologies, goods and services that prevent or minimize pollution and resource-efficient technologies, goods and services that minimize natural resource use."[3]

Each of these high-level definitions focuses on economic activities that minimize natural resource use or pollution. The clean tech definition used in this report integrates more narrowly defined sectors of clean tech that fit within this framework. Our clean tech definition focuses on three subsectors:

1. Energy-efficient building technologies
2. Renewable energy generation and pollution control technologies
3. Water technologies and services that improve efficiency or quality

[1] Bureau of Labor Statistics, 2010
[2] The Brookings Institution, *Sizing the Clean Economy*, p. 13-14, 2011
[3] OECD, *Green Growth Studies Green Growth Indicators*, p. 121, 2014

Though this definition does not contain an exhaustive list of all clean tech subsectors, Pittsburgh has the potential to develop a comparative advantage in each of these rapidly growing technologies.

Economic Development Policies

Public policy can influence both the supply of and demand for clean technologies (Figure 3). Incentives and subsidies can increase demand for clean tech goods and services, targeting the willingness or ability of local companies and residents to participate in a given market. For situations in which neither willingness nor ability are an issue, policies can educate target populations to induce demand. In addition, governments can use their purchasing power to create markets for clean tech goods and services at early stages when private markets lack both willingness and ability. Though not the primary goal of demand side clean tech strategies, local environmental and sustainability improvements are important co-benefits. Examples of demand side policies include requirements such as renewable portfolio standards, green building requirements, energy disclosure, and water-efficiency targets or incentives such as energy efficient procurement and energy efficient rebates.

The viability of clean tech economic activity can also be improved through supply side policies. These policies and programs are traditionally implemented by local development organizations with the goal of facilitating small business development, business retention and expansion, and business attraction. In general, supply side policies improve the competitiveness of local firms by reducing costs. This report delivers both demand side and supply side recommendations for the City of Pittsburgh.

Figure 3: Clean Tech Development Cause and Effect Diagram

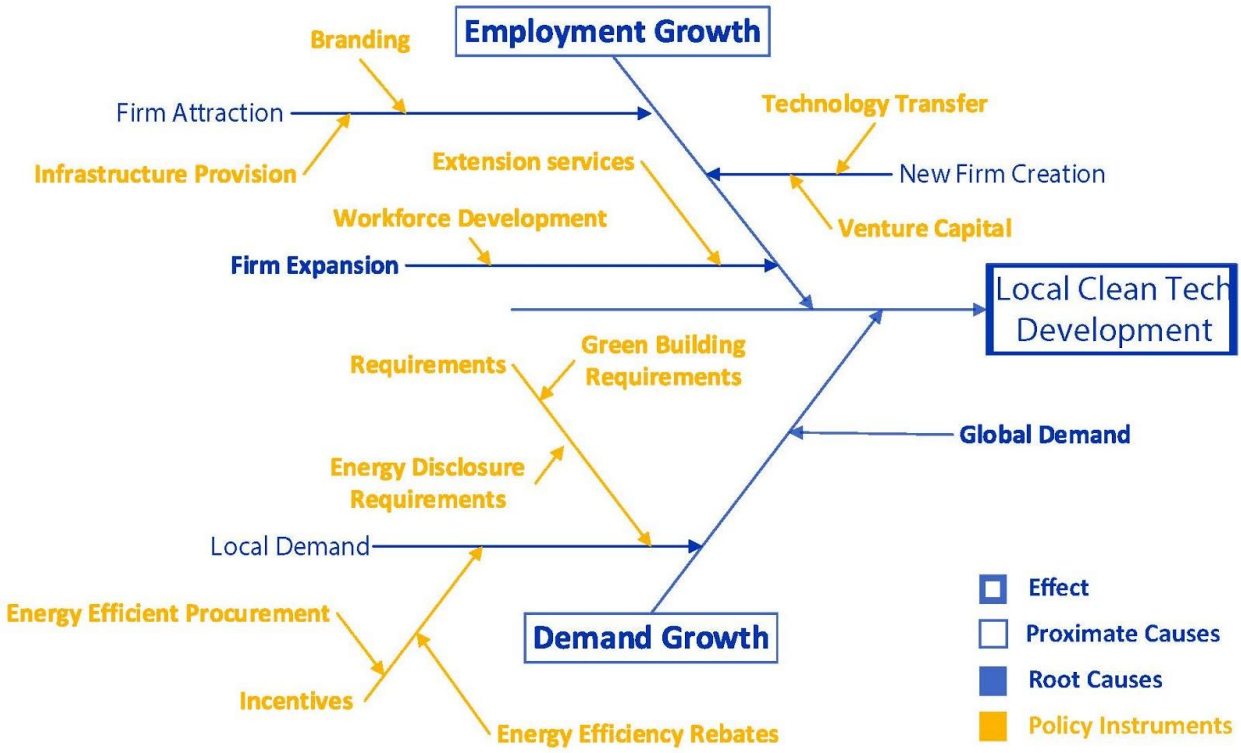


Diagram created by Kenny Barry & Molly Brennan

PITTSBURGH CLEAN TECH SECTOR

In 2011, the Brookings Institution completed *Sizing the Clean Economy* - a massive research project measuring the United States clean economy through an assessment of national and regional green jobs data between 2003 and 2010. The data Brookings collected and analyzed was the only source of quality data on the Pittsburgh clean tech sector publically available for use by our team. Though other studies have attempted to measure clean tech jobs and the clean tech economy, most of the metrics used have been aggregated to the national, state, or industry level (by combining NAICS or SIC industries into a uniquely defined clean tech sector). Notably, the Brookings Institution report gathered establishment-level data on the 100 largest U.S. metro regions and used many quality control measures to validate this data. This section summarizes the key findings from this report.

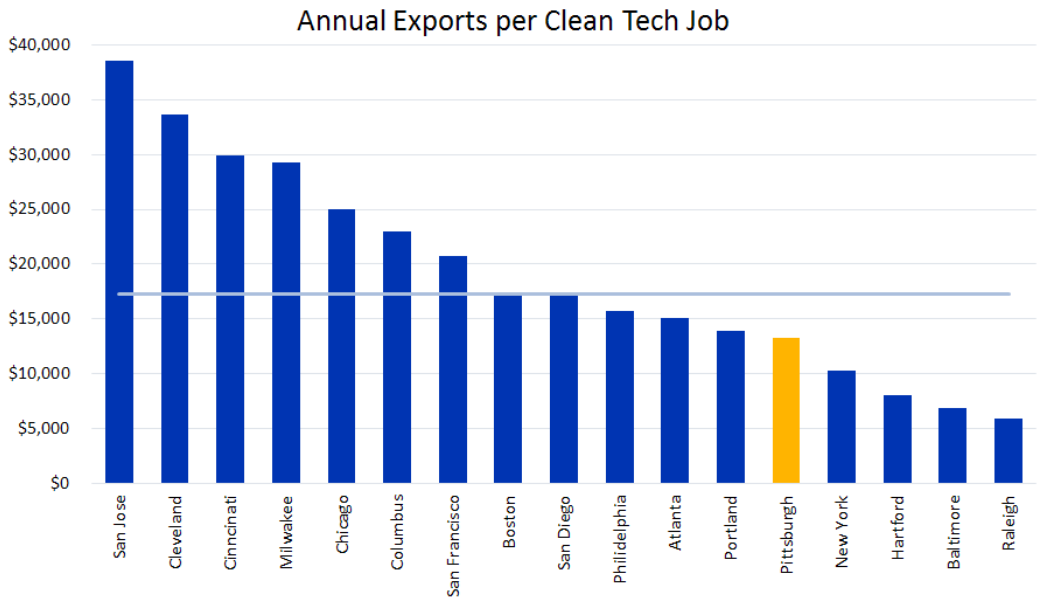
When considering the following statistics, it is important to keep in mind that Brookings defines the clean economy as, "economic activity—measured in terms of establishments and the jobs associated with them—that produces goods and services with an environmental benefit or adds value to such products using skills or technologies that are uniquely applied to those products."[4] In addition, establishments with fewer than five employees were excluded due to issues with collecting reliable data on small establishments.

[4] The Brookings Institution, *Sizing the Clean Economy*, 2011

In 2010, the Pittsburgh metro region had around 22,000 clean jobs and ranked 24th out of the 100 largest U.S. metro areas. These clean jobs account for about 2% of jobs in the region. Between 2003 and 2010, the clean tech sector in the Pittsburgh area grew by approximately 5,000 jobs.

Each clean job in the Pittsburgh region produces $13,257 in exports a year. The average for the 100 largest U.S. metro areas is $17,255. While Pittsburgh ranks below average, some of the other comparison cities have large ocean ports. Pittsburgh has the country's second busiest inland port, an advantage that could be used to expand the region's clean tech exports.

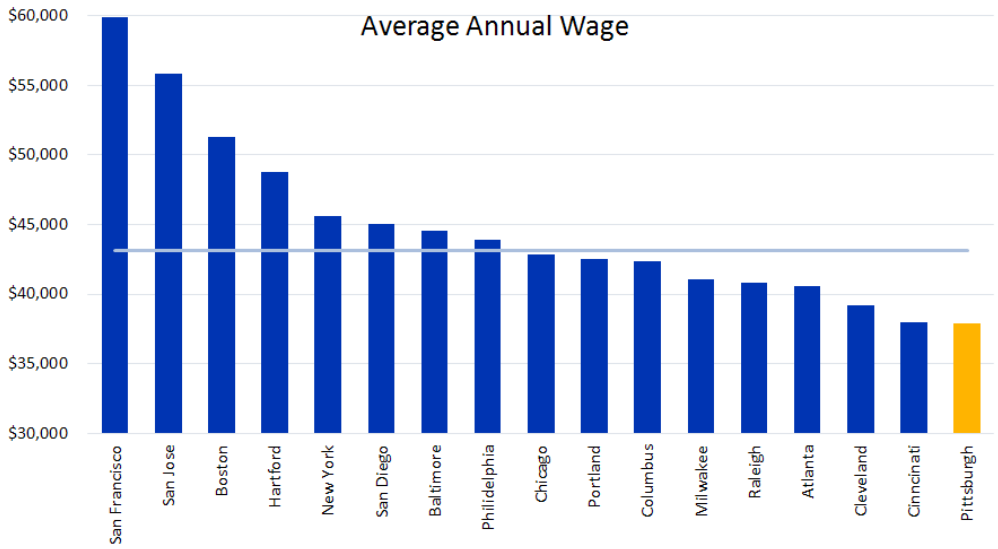
Figure 4: Annual Value of Exports per Clean Tech Job



Source: Brookings-Battelle Clean Economy Database, 2011

The median wage for a green job in Pittsburgh is $37,906 compared to the median of $36,153 for all jobs in the region. Although median wages for clean tech jobs in Pittsburgh is above median wages for other jobs here, it is significantly lower than median wages for clean tech jobs paid in other metro areas. Figure 5 below shows that Pittsburgh's clean tech workers are paid less than every benchmark city and less than the average of $43,133 for the largest 100 metro areas.

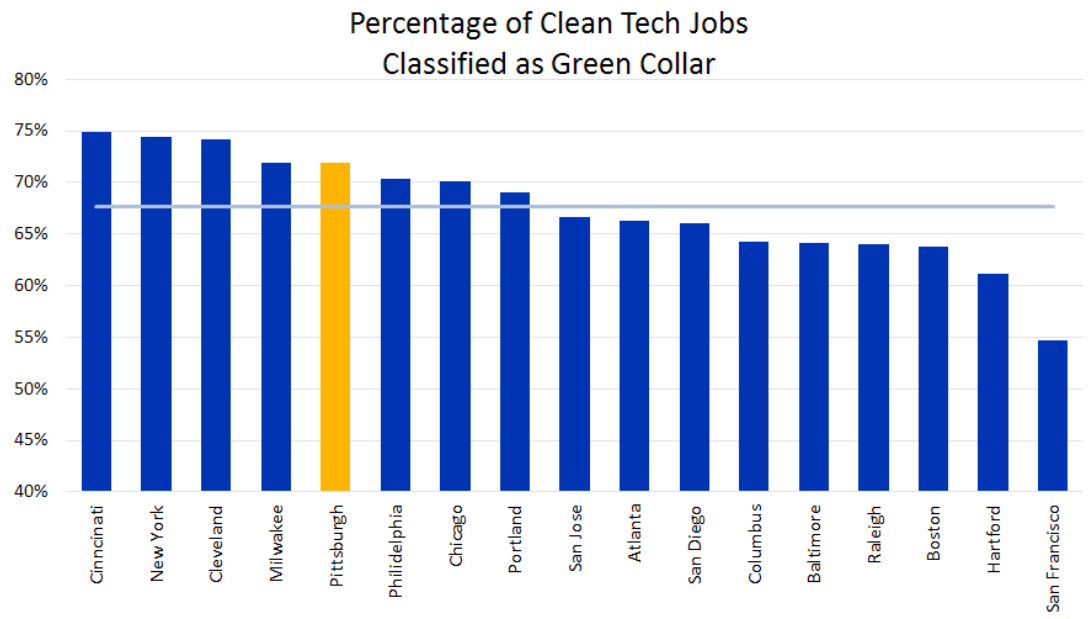
Figure 5: Average Annual Wages for Clean Tech Employment



Source: Brookings-Battelle Clean Economy Database, 2011

Clean tech jobs are a good source of middle-income jobs for workers with low levels of formal education. Approximately half of clean tech jobs are held by workers with relatively low levels of formal education, with 46.7% of clean jobs worked by an employee with a high school diploma or less. This is about average in comparison to the 100 largest U.S. metro areas. 71.9% of Pittsburgh's clean jobs are considered 'green collar,' meaning their median wage falls within 20 percentage points of the national median wage of $33,190. Figure 6 below shows that the portion of 'green collar' clean tech jobs in Pittsburgh is above the average of the 100 largest U.S. metro areas. This observation should be qualified by the fact that 'green collar' wages are defined by the national median wage, so some of the cities have lower portion of 'green collar' jobs because they have clean tech jobs that pay even more, such as San Francisco.

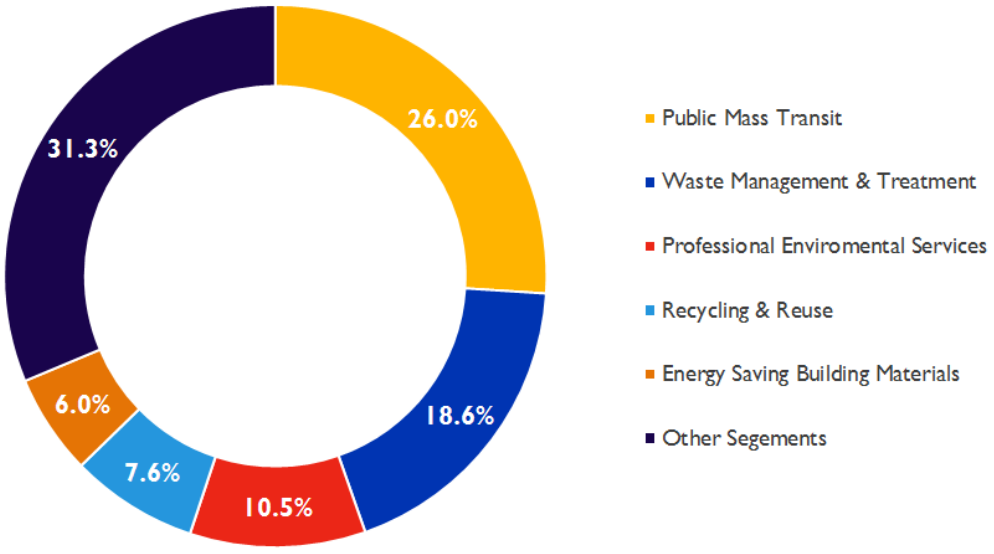
Figure 6: Percentage of Clean Tech Jobs within 20 Percent of the National Median Wage



Source: Brookings-Battelle Clean Economy Database, 2011

As illustrated in figure 7, the segments of the Pittsburgh clean economy that employ the most people are public mass transit, waste management & treatment, professional environmental services, recycling & reuse, and energy saving building materials.

Figure 7: Largest clean tech employers in Pittsburgh Metro Area



Source: Brookings-Battelle Clean Economy Database, 2011

The fastest growing segments of the Pittsburgh clean economy are solar energy, pollution reduction, recycled content production, HVAC/building control systems, and green architecture & construction services.

The clean tech sector is growing at a faster pace than all of Pittsburgh's major industries. The table below lists Pittsburgh's major industries and the job growth in that industry between 2003 and 2010. The industries are rank sequentially based on the percentage of job growth they experienced during this time period. Clean tech tops the list.

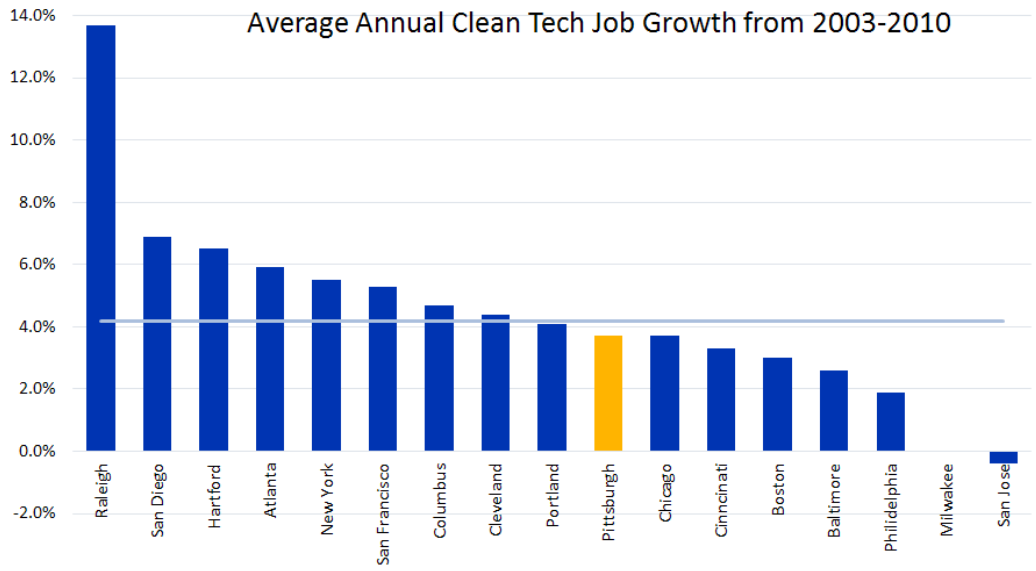
Figure 8: Change in Pittsburgh Metropolitan Area Employment, 2003-2010

	2003	2010	Change
Clean economy	**17,025**	**21,963**	**29.0%**
Educational services	50,395	60,601	20.3%
Real estate and rental and leasing	37,984	44,995	18.5%
Finance and insurance	72,014	83,399	15.8%
Arts, entertainment, and recreation	27,643	31,633	14.4%
Health care and social assistance	179,087	198,978	11.1%
Professional, scientific, and technical services	92,678	100,664	8.6%
Accommodation and food services	92,160	93,957	1.9%
Wholesale trade	49,591	50,029	0.9%
Administrative and waste management services	68,794	69,101	0.4%
Other services, except public administration	82,549	78,688	-4.7%
Construction	80,684	74,683	-7.4%
Retail trade	163,425	149,485	-8.5%
Transportation and warehousing	49,612	42,807	-13.7%
Manufacturing	110,346	91,172	-17.4%
Information	27,553	21,406	-22.3%
Utilities	7,619	5,916	-22.4%
All Sectors	1,134,000	1,125,300	-0.8%

Source: Brookings-Battelle Clean Economy Database (2011), BLS (2011)

Although clean tech is one of the fastest growing industries in the region, Pittsburgh's clean tech sector is growing more slowly than other U.S. metro areas. Between 2003 and 2010, the Pittsburgh clean tech sector grew by 3.7% a year, slightly below 4.2%, the average of the 100 largest U.S. metro areas.

Figure 9: Average Annual Clean Tech Job Growth, 2003-2010



Source: Brookings-Battelle Clean Economy Database, 2011

The Brookings report also found that metro areas with geographic clusters of companies in the same segment of the clean economy had higher job growth rates than areas without clusters. Segment clusters were identified if the establishment was located in a county with at least 1% of national jobs in the segment. For example, if more than 1% of U.S. jobs in wind energy were in Allegheny County, Pittsburgh would be considered a wind cluster. Pittsburgh has segment clusters in pollution reduction, professional environmental services, and recycled content products. Clustered establishments total 36% of the Pittsburgh clean economy and, Pittsburgh is one of the 13 metro areas with a 20% or greater share of establishments that are clustered. We do not agree with the Brookings definition of a cluster, but understand that they needed a consistent way to measure clusters across the country by using jobs data.

Conclusion

The benchmarking data and analysis highlights Pittsburgh's strengths and weaknesses when it comes to our regional clean tech sector. Most importantly, the clean tech economy is growing faster than other major Pittsburgh industries. Although the Pittsburgh clean tech sector is growing quickly, the sector growth is slower than clean tech sector growth in the majority of other U.S. cities.

Growth in the clean tech sector not only improves the regional economy, but is more beneficial to populations at risk then other types of industry growth because clean tech jobs are a good source of middle-income jobs for workers with low levels of formal education. However, clean economy jobs still only account for 2% of all regional jobs and have achieved below average annual exports per clean tech job even though Pittsburgh is home to the second busiest inland port.

As regional leaders work to grow the clean tech sector in Pittsburgh, the region will face fierce competition for business attraction and can no longer rely on having a competitive advantage in manufacturing. In addition, Pittsburgh clean tech jobs on average pay less than similar jobs in other cities, which may prevent the attraction of top quality employees to the area.

On the bright side, the region's high level of existing clusters of clean tech sub-sectors are predicted to grow faster in Pittsburgh than cities without such high levels of clustering. Ultimately, each step toward growth in clean tech will benefit both the economy and the environment.

PITTSBURGH CLEAN TECH SUBSECTOR ANALYSIS

Energy-Efficient Building Technologies

Introduction

Residential and commercial buildings account for 40% of total U.S. energy consumption, more than either the industrial or transportation sectors.[5] In major urban areas building energy use accounts for nearly 80% of the total energy consumption in the area.[6] The predominance of energy use in buildings reveals the significance of targeting the building sector to achieve any impactful sustainability. The energy-efficient building technologies subsector addresses these issues by optimizing energy use in both new and retrofitted buildings through technologies related to building automation, design, lighting, HVAC, and insulation.

Market Analysis

Energy-efficient construction is steadily becoming the standard in the U.S. According to McGraw-Hill Construction, approximately 40% of U.S. construction firms defined more than 60% of their building activity as green projects in 2012. U.S. companies are also evaluating energy-efficient building investments as an economic imperative, with 41% of them citing client demand as a trigger for planned green building projects – the most common motive identified.[7]

Although it is already a mature subsector of clean tech, energy-efficient building technologies are projected to continue expanding market share at a considerable rate. Navigant Research forecasts that the global market for green construction materials will grow from $116 billion in 2013 to $254 billion in 2020. This increase will be driven primarily by the growth in the adoption of certification programs and the increased awareness of the cost effectiveness of green building.[8] For example, while green buildings typically command a 2% cost premium, this investment is returned through higher rents, sale prices, and occupancy rates, in addition to 33% reductions in energy consumption.[9]

Energy efficiency commercial building retrofits are also projected to increase in relevance. The retrofit market is predicted to expand from $68.2 billion in 2014 to $127.5 billion in global revenue by 2023, led by continued decreases in payback periods and growing interest in corporate sustainability initiatives.[10] Also worth noting is the rapid growth anticipated in the building energy management systems (BEMS) market – a segment of green building technologies that focuses on software solutions to improve the operational

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[5] U.S. Energy Information Administration (EIA), 2013
[6] *High Performance Tenant Demonstration Project,* Natural Resources Defense Council
[7] *World Green Building Trends Smartmarket Report*, McGraw-Hill Construction, 2013
[8] *Materials in Green Buildings*, Navigant Research, 2013
[9] *Cleantech Redefined*, Kachan & Co, 2013
[10] *Energy Efficiency Retrofits for Commercial and Public Buildings*, Navigant Research, 2013

efficiency of buildings. The market for these emerging technologies is expected to more than triple between 2012 and 2020, from $1.8 billion to $5.6 billion.[11]

Venture capital markets have recognized this growth potential in the global energy-efficient technologies market. The efficiency component of clean tech – green buildings, smart grid, cogeneration, and data centers – was the leading clean tech subsector for venture capital investment in 2013, with 18.9% of the total, twice the share of any subsector.[12]

Pittsburgh Analysis

Research Universities

Research universities in Pittsburgh are an integral part of local energy efficient building technology development. Students in Duquesne University's top-ranked MBA Sustainability program complete multiple consulting engagements with private sector, government, and nonprofit clients that improve the economic viability of sustainability initiatives. The program produces actionable recommendations for participating organizations while increasing the supply of local workers qualified to profitably implement sustainable practices.

Carnegie Mellon University connects the Pittsburgh economy to technological breakthroughs in energy efficient building technologies. The School of Architecture's Center for Building Performance and Diagnostics "conducts research, demonstrations, and teaching in relation to the performance of advanced building systems and technologies" in collaboration with faculty from the College of Engineering.[13] Faculty are currently researching technologies such as smart facades; advanced combined heat and power (CHP) systems; HVAC systems that integrate indoor air quality management; and network infrastructures to monitor buildings and optimize energy use. Though much broader in scope, Carnegie Mellon's Scott Institute for Energy Innovation is similarly engaged in energy efficiency research. The School of Architecture also offers graduate degrees in Building Performance & Diagnostics and Sustainable Design.

Carnegie Mellon produces an average of 25 start-ups per year, including successful spinoffs in energy efficiency technologies like Energy Efficiency Me (EEme). Carnegie Mellon ranks first among American universities in the number of start-ups per research dollar spent, illustrating its role as a driver of local economic development.[14]

Nonprofit Sector

The Green Building Alliance (GBA) is a regional chapter of the U.S. Green Building Council, providing networking and educational programs focused on improving sustainability practices and processes for members and the community. A key initiative of the GBA is the Pittsburgh 2030 Districts. This program encourages property partners to commit to reducing energy use, water use, and transportation emissions by 50% by 2030. One of only seven districts in the U.S., the initiative is a powerful example of how formal recognition or certification can incentivize energy efficiency investments. The GBA is taking this concept to the next level by developing the national Database for Analyzing Sustainable and High Performance Buildings (DASH). DASH creates transparency for real-time, building performance data that can be used as a benchmarking tool, generating an additional source of market competition for energy efficiency.

The Energy Innovation Center is a model for equitable, employer-driven local workforce development. Located in a historically disadvantaged inner-city community, the $38 million LEED Platinum project will

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[11] *Building Energy Management Systems*, Navigant Research, 2013
[12] *Cleantech Redefined*, Kachan & Co, 2013
[13] Carnegie Mellon University School of Architecture
[14] Carnegie Mellon University Scott Institute for Energy Innovation

involve university-industry projects, technology demonstration laboratories, a business incubator, and workforce training programs.[15] While the building remains under construction, 2,500 students are expected to be trained per year through industry-driven credit and certification based programs such as energy modeling and energy auditing. The project is a partnership between local energy companies, research universities, economic development organizations, and the Department of Energy's National Energy Technology Laboratory (NETL).

Another example of nonprofit leadership is the Black and Gold City Goes Green campaign initiated in 2009 by Citizens for Pennsylvania's Future, an environmental advocacy organization. The organization deploys volunteers to engage and educate residents through "Neighborhood Blitzes" that provide free energy and water efficiency toolkits. The initiative has broad buy-in from over 117 regional partner organizations, demonstrating local interest in sustainability initiatives.

Public Sector

The City of Pittsburgh and Allegheny County government have each undertaken action plans and investments to demonstrate energy efficiency leadership. Allegheny Green is a county-level sustainability initiative that focuses on both internal practices and external leadership through demonstration projects and setting aggressive energy and water efficiency goals. The County Office Building green roof is intended to serve as a demonstration project at a cost of $621,000 that will yield $80,000 in energy cost savings annually. The County plans to invest a total of $32 million in energy efficiency upgrades across its major county facilities, resulting in $64 million in utility expense savings over 15 years.[16]

The City of Pittsburgh is currently implementing its 2008 Climate Action Plan to meet the local greenhouse gas reduction target of 20% below 2003 levels by 2023. This initiative has spawned several energy efficiency incentives and requirements. LEED Silver is now required for city projects that exceed 5,000 square feet or $2 million, or for projects that receive tax-increment financing. The Urban Redevelopment Authority of Pittsburgh (URA) operates the Pittsburgh Home Rehabilitation Program (PHRP) PLUS for energy efficiency. This program offers grants of up to $2,500, in addition to 0% fixed interest rate loans for up to 20 years for energy efficient home improvements. The URA also offers interest rates that are discounted based on the level of LEED certification achieved for its major business loan programs.

Other areas of local government are demonstrating leadership in energy efficient building technologies as well. In 2008, the Housing Authority of the City of Pittsburgh (HACP) invested $25.1 million in technologies, such as geothermal HVAC systems, lighting retrofits, and insulation, at City owned housing units. The Honeywell-led project is guaranteed to save the city $3.2 million in utility costs annually for at least 12 years, while showcasing the benefits of energy efficiency upgrades.[17]

Conclusion

Despite strong corporate leadership from companies such as Alcoa, PPG, and Bayer, our research unveiled few energy efficient building materials companies (Figure 10). This finding is reinforced by the "energy saving building materials" component of the 2010 Brookings-Battelle Clean Economy Database that shows below average employment in the subsector. Equally revealing is the significant emergence of companies located within the city that are involved in energy efficient consulting and software solutions – the fastest growing market within energy efficient building technologies (Figure 11). This industry composition provides insight into the types of demand side recommendations that might have the greatest impact on the development of this subsector.

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[15] Jones, Diana, *Renovation for Hill District 'green innovation' project moves ahead*, Pittsburgh Post-Gazette, 2012
[16] Allegheny County
[17] Lord, Rich, *Public housing goes geothermal*, Pittsburgh Post-Gazette, 2008

Figure 10: Regional Energy-Efficient Building Materials Companies

Company	Technology	Location
PPG Industries	Metal coatings, low-emissivity glass, no- and low-volatile organic compound (VOC) paints	Pittsburgh (HQ)
Bayer MaterialScience	Polyurethane insulation materials and coatings	Robinson Township (HQ)
Kawneer (Alcoa)	Highly-reflective aluminum building products	Cranberry Township
Forms+Surfaces	Durable, recycled and recyclable architectural materials with no- and low-VOC finishes	Etna
Extech	Cellular polycarbonate glazing, structural polycarbonate for windows, skylights adapted for translucent solar panels	Etna
ResponSave	Energy storing air conditioner	Pittsburgh
Insulastics	Recycled plastics for insulation products	Braddock

Figure 11: Regional Energy-Efficient Building Consulting and Software Companies

Company	Service	Location
EvolveEA	Sustainable architecture and consulting firm	Pittsburgh
EnergyChaser	Automated solution for continuous utility monitoring	Wexford
EEme	Software matches users with energy efficiency incentive programs	Pittsburgh
kWantera	Real time smart meter data to better manage power consumption	Pittsburgh
Encentiv Energy	Identifying energy efficiency incentives and financing opportunities	Forest Hills
Building Performance Architecture	Building energy consulting and architectural services	Pittsburgh
Conservation Consultants, Inc	Promote responsible building energy and resource use	Pittsburgh
eCap Network	Comprehensive energy management services	Pittsburgh
RCx Building Diagnostics	Commercial building owner education and data services	Charleroi
The Efficiency Network (TEN)	Developer, designer, engineer, financier and installer of energy saving retrofit projects	Pittsburgh

The second finding relates to subsector leadership. Though there have been several high-profile demonstration projects and sustainability initiatives launched by city and county governments, local government provides limited support for energy efficient buildings. Issues that surfaced in interviews included the City's limited zoning incentives for energy efficiency, a lack of building energy disclosure requirements, and an inadequate green infrastructure permitting process. Despite this, nonprofit leadership has filled much of that void. A strong network within the energy efficient building technologies subsector has already been cultivated by the Green Building Alliance as demonstrated by the widespread buy-in for the 2030 Districts that has occurred absent of any legislation. In addition, there already exists a strong university research & development ecosystem and interest in energy-efficient building technologies.

Renewable Energy and Pollution Control

Global and National Market Analysis

Renewable energy generation is derived from natural sources that are constantly and sustainably replenished.[18] In 2012, renewables accounted for 19% of global final energy consumption, more than half of which is supplied by biomass, geothermal, hydropower, wind, solar, and biofuels. Notably, biomass, geothermal, and solar comprises only 4.2% of global final energy consumption, while hydropower alone accounts for 3.8%.[19]

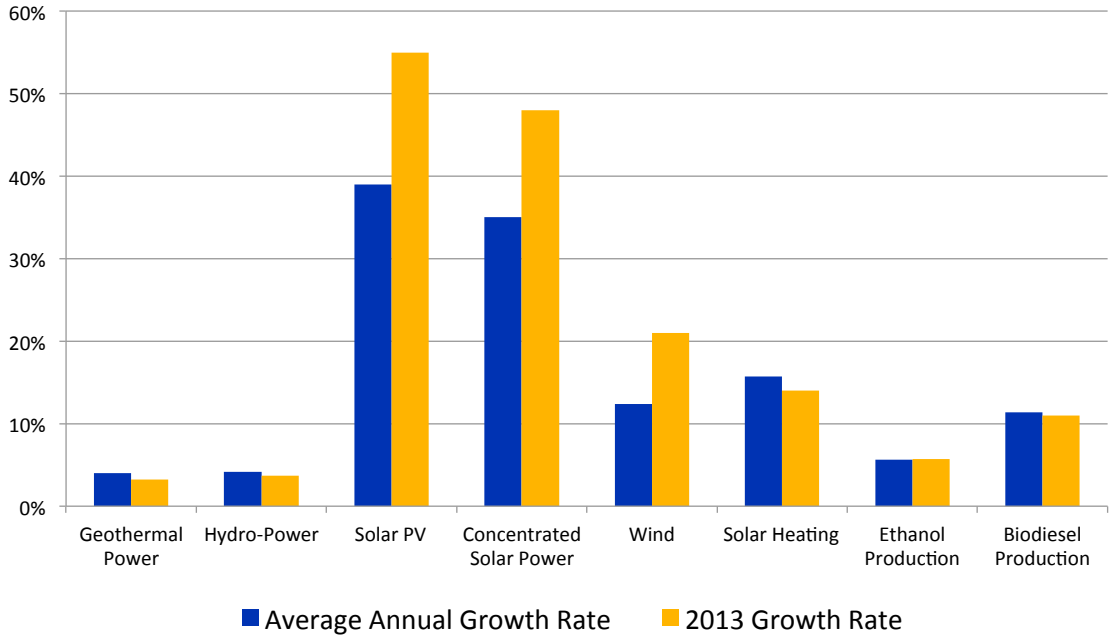
Despite the drop in hydropower output and increased competition from cheap natural gas, the share of renewable energy generation in the U.S. has edged upward from 12.2% in 2012 to 12.9% in 2013. In addition, the share of net electricity generation from coal declined 19% between 2008 and 2013, demonstrating the growing potential for displacement with renewable energy in the U.S.[20]

Power capacity is the maximum electric output a generator can produce under ideal conditions.[21] The renewable percent of global power capacity increased from 7.6% in 2007 to 13.7% in 2013. The change in renewable power capacity accounts for more than 40% of global power capacity change after 2011, indicating increasing investment in alternative forms of energy.[22]

Power generation is the amount of electricity a generator produces over a specific period of time.[23] Renewable power as a part of global power generation has increased from 5.2% in 2007 to 8.5% in 2013.

[18] Natural Resources Defense Council, 2014
[19] Renewable Energy Policy Network for the 21st Century (REN 21), *Renewables 2014 Global Status Report*, 2014
[20] Energy Information Administration, 2014
[21] Ibid
[22] Bloomberg New Energy Finance Report, 2013
[23] Ibid

Figure 12: Average Annual Growth Rates of Renewable Energy Capacity, 2008-2013



Source: Global Renewable Energy Market Report, 2014

Solar photovoltaic is the fastest growing renewable energy source with 39% average annual capacity growth between 2008 and 2013 (Figure 12). Concentrating solar power (CSP) had a similar 35% average annual growth rate over this period. Wind is the third fastest growth source of renewable energy with a 21% average annual increase. Each of these three renewable sources experienced even more significant growth rates in 2013.

Total global investment in renewable power and fuels was $249.4 billion in 2013. Clean energy investment has been declining for the past two years, largely due to uncertainty of renewable energy incentives in Europe and the U.S. and reductions in technology costs and efficiency improvements for renewable energies.[24]

Renewable Energy Policy in Pennsylvania

Pennsylvania's 2004 Alternative Energy Portfolio Standard (AEPS) promotes renewable energy development by requiring 18% of electricity to be provided by generation and distribution companies from renewable sources by 2021, with the added requirement that solar PV power generates at least 0.5%.[25] Retail energy suppliers would utilize Alternative Energy Credits (AEC) to comply with the standard. An AEC is created each time a qualified alternative energy facility produces 1000 kWh of electricity and can then be sold or traded separately from the power.

Pittsburgh Renewable Energy Initiatives

The City of Pittsburgh has made progress in its adoption of renewable energy. In 2007, the City and Allegheny County established the Western Pennsylvania Energy Consortium (WPEC) with the mission of purchasing renewable energy to drive market demand and achieving savings through energy investments. The

[24] Renewable Energy Policy Network for the 21st Century (REN 21), *Renewables 2014 Global Status Report*, 2014
[25] U.S. Energy Information Administration, 2014

Consortium is a purchasing authority for City authorities and municipalities, including Allegheny County and the Pittsburgh Water and Sewer Authority. In 2008, the Consortium purchased more than 11 million kWh of renewable energy, and increased the amount of renewable energy purchased by 5% in 2010 and 25% in 2013.[26]

The City has also supported several technology demonstration projects. In 2010, the Urban Redevelopment Authority of Pittsburgh provided funding for a wind study along the Allegheny River by the Carnegie Science Center to demonstrate future uses of renewable energy within the city. The study focused on the feasibility of installing smaller "urban turbines" that would be capable of running streetlights.[27] The City has also integrated B20 biodiesel into its fleet and, in 2013, retrofitted five diesel-powered trucks to use 100% biodiesel fuel using local technologies.[28]

Institutional Leadership

Energy Alliance of Greater Pittsburgh

The Energy Alliance of Greater Pittsburgh is a nonprofit organization that facilitates the innovation, education, and coordination of the broader energy economy in the Pittsburgh region. The Energy Alliance of Greater Pittsburgh is a network of more than 100 businesses, universities, and other entities.[29] In 2013, the Energy Alliance established the EnergyMatch database and portal that maps and provides information about energy related companies, investors, researchers, facilities, and technologies and connects solutions and technologies developed by researchers with private companies. Though solar and wind firms are represented in the Energy Alliance, the disproportionate influence of companies active in the Marcellus Shale has been noted in interviews with industry experts.

Energy Innovation Center

The Energy Innovation Center (EIC) is a nonprofit organization that advances the education, innovation, and collaboration of regional stakeholders, including companies, universities, community leaders, and small businesses. Developed in collaboration with the Pittsburgh Gateways Corporation, energy-related companies, research universities, economic development organizations, and the Department of Energy's National Energy Technology Laboratory, the EIC provides a broad array of energy sector workforce development services. The main programs within the EIC include co-located university-industry projects, proof-of-concept energy technology demonstration laboratories, early-stage business incubation, and workforce training. [30] Corporate partners are also able use the facilities to showcase new products and advanced energy management systems.

Pittsburgh Green Innovators

Pittsburgh Green Innovators (PGI) is a nonprofit organization that seeks to develop clean energy technologies and communities, particularly involving the Energy Innovation Center. PGI focuses on three strategies to facilitate clean energy growth: promoting high school STEM education; encouraging workforce development through apprenticeships, community college and four-year degree programs; and assisting with business start-up and development. In addition, PGI has developed actions around energy alternatives, green infrastructure, adaptive reuse, and social responsibility to further integrate clean energy into the

[26] U.S. Environmental Protection Agency, 2014
[27] Greener Pittsburgh, 2014
[28] The City of Pittsburgh, Office of Sustainability, 2014
[29] Energy Alliance of Greater Pittsburgh, 2014
[30] Energy Innovation Center, 2014

community.[31] PGI is funded in part by the Heinz Endowments, UPS Foundation, the Urban Redevelopment Authority of Pittsburgh, and the Redevelopment Authority of Allegheny County.

Community College of Allegheny County Renewable/Alternative Energy Technologies Program

The Community College of Allegheny County (CCAC) offers workforce training in solar, wind, and biofuel technologies through its Renewable Energy Lab. Founded in 2012, the Renewable/Alternative Energy Technologies program is applied in nature, with modules focused on the operation of wind, solar photovoltaic, and solar thermal systems.

Pittsburgh Renewable Energy Companies

Figure 13 provides an overview of clean energy and pollution control companies in the Pittsburgh region – several of which are located within the City of Pittsburgh. According to a 2009 report commissioned by the Green Building Alliance and GTECH, there were over 1,800 renewable energy jobs in the Pittsburgh region in 2007, a figure expected to increase to over 3,400 by 2015.[32]

Figure 13: Regional Renewable Energy and Pollution Control Companies by Technology

Category	Company
Biofuel	Optimus Technologies, Zero Fossil, Thar Energy, AE Resources, GE Ionics
Solar	Zero Fossil, Thar Energy, SolarCast, Industrial Learning Systems, Plextronics
Wind	GE Power Conversion, WindStax Wind Power Systems, Windurance, EverPower Wind Holdings, SolarCast, PPG, Ellwood Group
Pollution Control	Siemens Energy Inc., Extrel, Media and Process Technology Inc., Air Pollution Control Systems, Foster Wheeler, Process Combustion Corporation
Others	Aquion Energy, Emerson Process Management Power & Water Solutions, SolePower, Renewable Manufacturing Gateway

Conclusion

Any renewable energy development strategy in Pittsburgh is difficult to divorce from a broader energy strategy. Though the goals and desires of renewable energy firms are often disparate from those held by fossil energy producers, it is all but necessary for the subsector to leverage the resources and influence of these firms. The Energy Innovation Center is a powerful demonstration of this necessity. The EIC engages a spectrum of energy companies that enables the clean energy subsector to benefit from services and visibility that would not be feasible if pursued unilaterally. Similar consideration may need to be made for a cluster-based clean energy strategy, likely within the existing infrastructure of the Energy Alliance of Greater Pittsburgh. As a result of these complicated and unique clean energy issues in the Pittsburgh context, much of the recommendations within this report focus on the aforementioned clean energy subsectors.

Water Economy Products & Services

Overview

There is global demand for water products and services that improve efficiency and quality, and this demand is predicted to grow substantially in the near future. The water economy refers to both water products and

[31] Pittsburgh Green Innovators, 2014
[32] Litvak, Anya, "CCAC Offering Renewable Energy Lab," *Pittsburgh Business Times,* 2012

services, such as water purification or wastewater infrastructure, and to the direct use of water to create products and services in other industries, such as energy extraction and shipping transportation. A subset of the water economy businesses can also be classified as clean tech, specifically businesses that create and provide water products and services that improve efficiency and quality.

In some areas of the world, access to clean water remains a serious public health issue. Typically, a lack of clean water is due to a lack of expensive water infrastructure to treat and transport the water to those in need. The high capital costs of wastewater treatment plants, drinking water treatment plants, and underground water pipelines are an insurmountable barrier to many developing countries. Instead, demand for clean water has sparked demand for water technologies for treatment plants that are small, easy to operate, and affordable.

It is also predicted that the world will face severe water shortages in the near future if business as usual continues. Although the Earth's surface has more water than land, only 2.5% is fresh water and therefore available for human consumption. As population continues to increase and the amount of freshwater contaminated by improper waste disposal and industry pollution compounds over time, clean freshwater is becoming a scarcity. The impending water scarcity has created a global market demand for water efficiency and monitoring technologies, along with the demand for technologies that can improve water quality through innovative treatment processes.

Market Analysis

Fortunately, freshwater is an abundant natural resource in the Pittsburgh region. In fact, climate change models predict that average rainfall will increase in Southwestern Pennsylvania. While Pittsburgh has plenty of freshwater, decades of industrial manufacturing, coal mining, and combined sewer overflows have degraded its quality. Currently, the Environmental Protection Agency (EPA) is enforcing regional compliance with the Clean Water Act to improve local water quality. Compliance requires repairing and replacing much of the aging wastewater and stormwater systems. Within the City, the water infrastructure was built to serve a larger population, but it has not been maintained with necessary capital improvements. In addition, rain and flooding events are frequently pushing the sewer system over capacity, resulting in raw sewage running directly into the rivers. The EPA has yet to approve a specific plan of action, but estimates from potential wet weather plans put the cost of compliance between $1.6-3.6 billion.[33] In order to reduce this very high price tag, the region is actively seeking water products and services, creating local demand for innovative water technologies. As the region works to improve water quality, there is the opportunity to use the purchasing power to develop and demonstrate local clean tech water products and services.

Future compliance with the EPA Consent Decree will require large capital expenditures, but three factors have dis-incentivized local water innovations thus far due to a number of reasons. First, no clear wet weather plan has been approved by the EPA, which means there is no clear timeline for when the large capital expenditures will take place. Venture capital and funds for new innovations follow low risk opportunities created by real increases in demand. Although implementation of the wet weather plan will create demand, the uncertain timeline for adoption and implementation has not yet spurred a significant increase in demand for water product innovation in Pittsburgh today.[34]

Second, the EPA Consent Decree was given to the region in 2000[35] - 14 years ago – yet the Pittsburgh Water and Sewage Authority (PWSA) is not investing enough in capital improvements to keep pace with recommended capital improvement schedules, let alone invest on the scale needed to address the issues in

[33] Pittsburgh Post-Gazette, *EPA calls Alcosan's $2 billion sewer system proposal deficient*, 2014
[34] Ibid
[35] Pittsburgh Post-Gazette, *Consent decree 'best deal' possible Alcosan says*, 2007

the Consent Decree. For example, in the 2014 PWSA budget, only 1.8% was allocated for capital expenditures.[36] At this rate of capital investments, Pittsburgh will never catch-up with the backlog of ignored infrastructure needs. According to the U.S. Census Bureau's Survey of State and Local Government Finances, for the 53 year period between 1956 and 2008, local governments spent an average of 30.1% of public water and wastewater annual expenditures on capital investments.[37] At 1.8%, PWSA is far below average. Every year capital investment is put off; the more expensive it will be in the future.

Third, The PWSA budget choices do not signal to water tech innovators that investment in increasing efficiency and quality is important. In the 2014 PWSA budget, more money was allocated to pay for consultants than for capital infrastructure, $3.62 million versus $3 million.[38] This sends the message to the water products industry that Pittsburgh is not ready to prioritize and create a market for water efficiency and quality products.

The upside to these weaknesses is that Pittsburgh has not missed the opportunity to expand into the fast growing global water economy. There is still time to develop a regional competitive advantage in water technologies products and services that improve efficiency or quality. Market predictions of water products and services estimate potential for huge market growth.

Multiple respected organizations have estimated the cost of updating the U.S. drinking water infrastructure over the next few decades. Figure 14 lists the organizations and their estimates. Even though this amount of spending is what is needed, it may not be the amount of spending that actually occurs, as there is a limit to available funding. However, if even 50% of the estimated expenditures are made in the next 20-30 years, the demand for water products and services will significantly increase.

Figure 14: U.S. Water Infrastructure Needs in 2011 Dollars

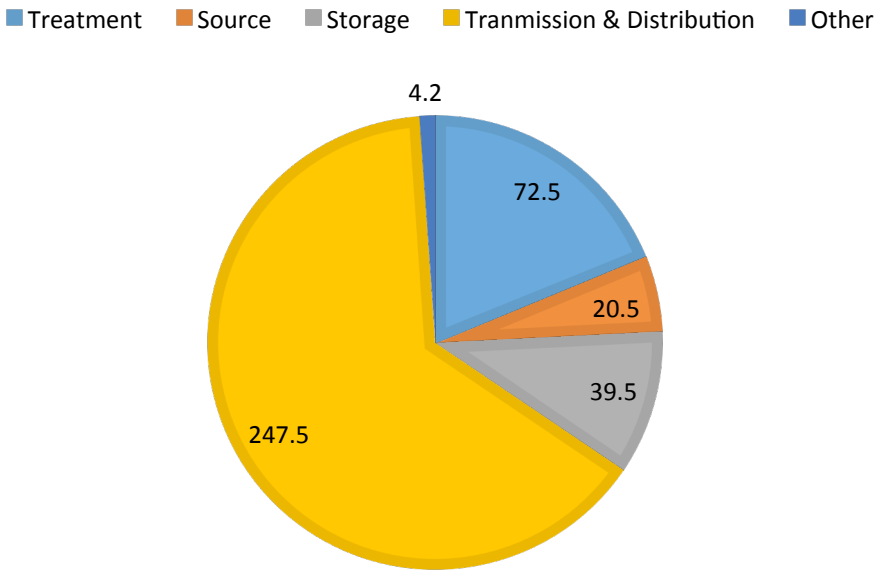
Organization	Estimate	Time Period	Type of Infrastructure
EPA	$384 billion	20 years	Drinking Water
Congressional Budget Office	$331.2-$571.7 billion	20 years	Drinking and Waste Water
Water Infrastructure Network	$570.4 billion	20 years	Drinking Water
American Water Works Association	$1 trillion	25 years	Drinking and Waste Water

Source: EPA, *Drinking Water Infrastructure Needs Survey and Assessment*, 2013

The EPA broke down the estimated needs calculation by project type, which gives insight into which areas of the water economy will likely have the greatest market growth. As illustrated in Figure 15, the majority of need is in transmission and distribution (i.e. pipes) and treatment.

[36] Pittsburgh Water and Sewer Authority, 2014 Operating Budget, 2013
[37] U.S. Mayors Water Council, *Trends in Local Government Expenditures on Public Water and Wastewater Services and Infrastructure: Past, Present, and Future*, 2010
[38] Ibid, Pittsburgh Water and Sewer Authority

Figure 15: Total 20-Year Water Infrastructure Need by Project Type (Billions of 2011 Dollars)



Source: EPA, *Drinking Water Infrastructure Needs Survey and Assessment*, 2013

The American Society of Civil Engineers 2013 Report Card for America's Infrastructure provides estimates of necessary investments in water infrastructure on a state level. By extrapolating the data for Pennsylvania to the Pittsburgh Metro Area, we found the ASCE suggests spending approximately $2.9 billion for drinking water infrastructure and $5.8 billion for wastewater infrastructure over the next 20 years.[39]

Market research reports predict a similar water economy market growth. In 2013, BBC Research aggregated data on 15 products related to water quality and water treatment to predict market trends. According to its analysis, the global market for these water quality and treatment products is around $59.2 billion in 2014 and $96.3 billion by 2019, an annual growth rate of approximately 10%.[40] In 2014, BBC Research released a market forecast report on advanced municipal water treatment technologies, such as membrane filtration, ozone disinfection, UV irradiation, and oxidation processes. The researchers estimate the U.S. market for these types of treatment technologies will grow from approximately $2.4 billion in 2014 to $3.2 billion in 2019, with a compound annual growth rate of 7.4% over the next five years (2014-2019). One of the main drivers of expected growth is the improved reputation of treatment technologies "as proven, cost effective, green technologies with distinct advantages."[41]

McKinsey has analyzed the market drivers behind the water economy and it predicts that water technology innovations will play an essential role in closing the gap between the supply and demand of clean water around the world. Overall, McKinsey analysts estimate the total water market to grow by about 5% annually. The McKinsey analysis is mostly focused on high level information, but it did provide reference points on particular water technology markets to illustrate the massive growth potential, such as, "As the need for

[39] American Society of Civil Engineers, 2014 Report Card for Pennsylvania's Infrastructure, 2014
[40] BCC Research, Waste and Wastewater Treatment Technologies: Global Markets, 2013
[41] BCC Research, Advanced Technologies for Municipal Water Treatment, 2014

high-quality water treatment increases, specifically for potable or high-quality industrial use or re-use, low pressure membrane technology could develop a market potential of up to 85 billion m^3 by 2030, 56 times its volume in 2005."[42]

Thus, a variety of studies and economic indicators point to huge market potential in water products and services. Recent water economy growth supports the market forecasts. Over the last five years, S&P's Global Water Index, which tracks stock prices of 50 large water related businesses, reported a gain of 97%, as compared to general stock market growth of 51%.[43] Ideally, the large growth potential for water technologies will translate into increased private investments. Some may be opposed to using potential profitability of water technologies as a selling point because they believe water to be a human right rather than a commodity. Yet it is clear that potential for profit drives investment. According to an analysis done by Lux Research, "profit margins exceeding 10% are not uncommon in this field, and public services companies in localities that support privatized water treatment perform especially well at an average of 18% margins."[44] Hopefully continued water economy market growth will inspire private research and development and funding of socially beneficial water technologies.

Pittsburgh Water Economy

In 2010, Pittsburgh hosted the United Nations World Environment Day "Water Matters!" Conference. To supplement the conference's impact, local water economy businesses and the United Nations World Environment Day Partnership commissioned Fourth Economy Consulting to measure the nature of Southwestern Pennsylvania's water economy and identify future market trends the region could take advantage of. In the report, Pittsburgh's H2Opportunity, Fourth Economy estimates the water economy will growth at between 5-10% annually, a rate similar to the ASCE, BCC Research, and McKinsey estimates. A few key points from the report are valuable to keep in mind when considering how the City of Pittsburgh could move forward in this area. First, the region has the natural resources, universities, and existing business to create an active water cluster. Second, if Pittsburgh does develop a water cluster, it should be coordinated by an existing organization, rather than a new group. Third, we could explore partnerships with neighboring regions, such as Cleveland or Philadelphia. However, before moving ahead with the establishment of a water cluster, the City needs to find out if the relevant organizations have the time, resources, and interest in working together and developing this area. [45]

As an additional follow-up to the UN World Environment Day conference, a local Water Consortium Planning Committee was formed to "identify the water-infrastructure related assets and capabilities of the Southwestern Pennsylvania region that can be brought together to develop innovation solutions in the water sector." So far, the committee action has been limited to a 2010-2012 study led by Carnegie Mellon researchers titled the "Sustainable Water Innovation Initiative for Southwestern Pennsylvania." The study attempted to identify local water projects that could be public-private collaborations, which would foster water technology innovation. By examining the characteristics and content that made past projects successful, the report created a set of screening criteria it applied to options for future innovative demonstration projects. The committee recommended eight water related projects its authors believe are prime candidates for regional cooperation, but also acknowledged the need for an anchor organization to lead the regional efforts in water innovation.[46]

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[42] McKinsey Consulting & 2030 Water Resources Group, Charting our Water Future: Economic Frameworks to Inform Decision Making, 2009
[43] The Telegraph, Forget gold – invest in water, 2014
[44] Lux Populi, S&P Global Water Index Provides Further Evidence that Water is a Good Investment, 2014
[45] Fourth Economy Consulting, Pittsburgh's H2Opportunity: An Assessment of Southwestern Pennsylvania's Water Sector, 2011
[46] Water Consortium Planning Committee, Sustainable Water Innovation Initiative for Southwestern Pennsylvania, March 2012

Along with the Fourth Economy report, local businesses and organizations formally organized into the Pittsburgh Water Economy Network (WEN) in order to strengthen and grow the water economy in the Pittsburgh region. WEN is organized and staffed by Fourth Economy Consulting. WEN provides three main activities to fulfill its mission; (1) facilitate resource sharing, (2) generate news and marketing, and (3) advise and collaborate with both public and private stakeholders to identify specific market opportunities and spark new innovations to address those market opportunities.[47] In reality, since the 2011 report, the majority of WEN's work has been in marketing the Pittsburgh region's water economy opportunities through its website.

Fourth Economy has also registered WEN as a regional water cluster with the EPA's Environmental Technology Innovation Cluster Program. The EPA's cluster program "disseminates best practices in cluster development, connects clusters to relevant EPA programs and funding opportunities, and maintains an inventory of U.S. environmental technology clusters."[48]

Institutional Leadership

Research Universities

If Pittsburgh decides to organize an active water sector cluster, there are many regional water related assets to build on, including the universities that can serve as R&D hubs for water technology innovation. Carnegie Mellon University is already organized to support research in this field within the College of Engineering's Institute of Complex Engineering Systems (ICES). The goal of ICES is to develop research and relationships between the university, industry, and government. ICES is a member of the Pennsylvania Technology Alliance, which provides funding for specific technology research and development. The Institute is organized into topical research centers and clusters, a few of which apply to water technologies, including the Pennsylvania Smart Infrastructure Incubator (PSII), the Water Quality in Urban Environmental Systems (WaterQUEST), and the Steinbrenner Institute for Education and Research (SEER). Along with funding provided through the state's technology alliance, ICES also welcomes industry sponsored research projects.[49]

The University of Pittsburgh contributes to regional water technology innovation through a degree program and its innovation center. The Swanson School of Engineering at University of Pittsburgh offers a Bachelor's of Science and a Master's of Science degree program in environmental and water engineering. Students in these degree programs often produce R&D projects for industry and government partners. In the past few years, research projects have included research on ceramic membrane filtration systems and measuring the capability of a green roof to reduce stormwater in conjunction with 3 Rivers Wet Weather.[50] Also at the University of Pittsburgh students and faculty complete R&D on green building, green building materials, and green infrastructure through the Mascaro Center for Sustainable Innovation.[51]

Nonprofit Sector

The Pittsburgh region is home to a few water specific nonprofit organizations dedicated to improving local water quality. 3 Rivers Wet Weather works with the City and 82 other municipalities served by ALCOSAN to address wet weather overflow problem. With the end goal of improving water quality, their main activities include benchmarking green infrastructure technology, providing grants to municipalities, educating citizens and leaders about the combined overflow issues, and advocating the consolidation of the sewer system.[52]

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[47] Water Economy Network, 2014
[48] EPA, Environmental Technology Innovation Clusters, 2014
[49] Carnegie Mellon University, Institute for Complex Engineered Systems, 2014
[50] Swanson School of Engineering, Water Environment Research Foundation Grant, 2012
[51] University of Pittsburgh, Mascaro Center Research Webpage, 2014
[52] 3 Rivers Wet Weather, About Us Webpage, 2014

Another local water related nonprofit is the Nine Mile Run Watershed Association, created to restore and protect the Nine Mile Run Watershed, a 6.5 square mile area in Pittsburgh's East End. Its main activities include providing citizen training and supplies for urban ecological stewardship and educating local leaders about community greening best practices.[53]

The Clean Rivers Campaign works on advocacy efforts similar to 3 Rivers Wet Weather, but with a stronger focus on community engagement in order to make sure that the billions of dollars spent to comply with the EPA consent decree will truly benefit the community through green infrastructure and clean water.

A number of other local nonprofits work on a variety of environmental programs, some of which touch on the regional water economy. Among those is Idea Foundry, an accelerator that works to identify, accelerate, and commercialize innovative products in four key sectors, healthcare/life sciences, entertainment/education technology, social enterprise, and water. Within the water sector, Idea Foundry partnered with WEN to launch the Innovate H_2O Accelerator to focus on technologies to solve global water challenges including, energy production, manufacturing, drinking water, stormwater management, and navigation and monitoring. Individuals or organizations with innovation water solutions can apply to Innovate H_2O and if accepted will receive technical support, seed funding, and market connectivity.[54] The first round of applications was due in March, 2014.

The Pittsburgh 2030 Districts, a strategic initiative led by the Green Building Alliance, is generating greater local demand for water efficiency products. As of October 2014, about 70% of total real estate square footage in Downtown and Oakland has signed onto this advanced building performance challenge. In addition to the energy consumption goals previously mentioned in this report, businesses and organizations that have joined to challenge have agreed to significantly reduce their water consumption. Existing buildings will reduce their water use by a minimum of 10% below the District Average by 2015, with incremental targets reaching a 50% reduction by 2030. New buildings or new infrastructure will consume water at 50% below District Average levels of water consumption.[55]

Private Sector

Developing an active and successful regional water cluster is most dependent on the existence and interest of local water related businesses. Pittsburgh metro area benefits from being home to the global headquarters of multiple companies that are leaders in water products and services. However, these businesses need to be approached about their interest and availability to become a key partner in building a successful cluster. Figure 16 highlights local businesses who work in the clean tech side of the water industry. It is interesting to note that many of these companies have an international market presence, but maintain their headquarters in Pittsburgh. Despite the citing of central business operations in the region, the vast majority of these companies manufacture their products elsewhere.

[53] Nine Mile Run, About Us Webpage, 2014
[54] Idea Foundry, Water Sector Webpage, 2014
[55] 2030 Districts, Pittsburgh District Goals, 2014

Figure 16: Regional Water Technology Companies

Business	Description	Location
Alcoa	Natural Engineered Wastewater Treatment (NEWT™) system collects all sanitary and processes wastewater for treatment.	Pittsburgh
Aquatech	A global leader in water purification technology for industrial and infrastructure markets with a focus on desalination, water reuse, and zero liquid discharge.	Canonsburg (HQ)
BBJ Group	Water resource management services, wetland and stream restoration.	Pittsburgh
Calgon Carbon Corporation	Manufactures activated carbon and innovative treatment systems (ultraviolet light disinfection and oxidation). Pioneered cutting-edge purification systems for drinking water, wastewater, and other industrial applications.	Robinson (HQ)
Cardinal Resources	Developed Red Bird System, a solar powered water treatment system, to create simple, reliable, and sustainable method of producing clean drinking water	Pittsburgh
Consol Energy: Water Division	Develop water-related services and evaluate emerging treatment technologies for water used in energy production, including the reuse of treated mine water.	South Park
Emerson Process Management Power & Water Solutions	Control and oversight technology for large water and wastewater systems	Pittsburgh (HQ)
Epiphany Solar Water Systems	Simple, inexpensive, modular method of distilling water with solar energy, including seawater. Original R&D funding from Innovation Works, and now looking for funds to expand to full scale production and market launch.	Pittsburgh
Evoqua Water Technologies	Previously Siemens Water Technologies. Advanced water and wastewater treatment technologies, mobile and emergency water supply solutions, and services for industrial and municipal customers.	Warrendale (HQ)
Hedin Environmental/Iron Oxide Recovery, Inc.	Production of pigment-grade iron oxide from abandoned coal mine drainage. Technology applicable to water pollution problems wherever coal mining has contaminated water.	Pittsburgh
LANXESS	Production of water treatment technologies, including ion exchangers, absorbers, and functional polymers.	Robinson (HQ)
Red Valve	Valves and infrastructure products for wastewater treatment and stormwater systems.	Carnegie
Red Zone Robotics	Wastewater and sewer asset management, including using robots to assess pipe infrastructure.	Pittsburgh
Xylem's Leopold	Rapid gravity media filtration and clarification solutions for the water and wastewater industry.	Zelienople

Figure 17: SWOT Analysis of the Regional Water Products and Services Subsector

Figure created by Molly Brennan

Conclusion

Although Pittsburgh is water rich, other water rich cities have been unsuccessful at using this strength to attract businesses that require large amounts of water in their processes. There is more economic value to be had by focusing on technologies related to water, than the water itself.

The Pittsburgh region has a solid base of private sector businesses that provide water products and services. There is a wide variety of industry type and experience, from multinational corporations such as LANXESS, to startups still in the commercialization stages, such as Epiphany Solar Water Systems. It is interesting to note that many of these companies have an international market presence, but choose to maintain their headquarters in Pittsburgh. Despite the siting of operations functions in the region, the vast majority of these companies manufacture their products elsewhere. Local businesses have already expressed some level of interest in collaboration and coordination, as evidenced by the creation of the Water Economy Network in 2009. The City could use this group to kick-start efforts to create a more active cluster. There are many innovative water projects located in the Pittsburgh region, but most of them have relied on one time funding sources. If there is a desire to create an active water cluster, City officials will need to provide leadership in identifying sustainable funding sources.

In conclusion, universities are one Pittsburgh's strongest assets that can serve as research and development hubs for water technology innovation and improve the human capital available to work in the water economy. The solid base of businesses and organizations already working within the water economy would

allow Pittsburgh to create an organized cluster for water products and services that improve efficiency and quality. Projected market growth for water efficiency and quality products is between 5-10% annually. While Pittsburgh has not missed this opportunity, the City should act now to capitalize on this booming market.

CASE STUDY CITIES

The following case studies analyze cluster-based economic development strategies used in Milwaukee, WI; Portland, OR; and Cincinnati, OH. These cities are competitors to Pittsburgh in many respects and their clean tech development transferrable strategies provide context for the policy recommendations that follow.

The Water Council: A Public-Private Partnership for a Water Technologies Cluster in Milwaukee

Introduction

Milwaukee is the largest city in Wisconsin, with a population of roughly 600,000. Once a manufacturing hub, Milwaukee shed nearly 100,000 manufacturing jobs between 1979 and 2008.[56] The erosion of the City's manufacturing base coincided with a 20% drop in population and a decline in the proportion of families that are middle class from 37% in 1970 to 24% in 2007.[57]

The Milwaukee 7 (M7), a regional economic development organization launched in 2005, responded to the city's economic decline with a cluster-based economic development strategy focused on three emerging industries: food and beverage, power and controls, and water technologies. The water technologies cluster - the focus of this case study - is an industry-driven strategy that capitalizes on Milwaukee's location at the confluence of three rivers along the shore of Lake Michigan.

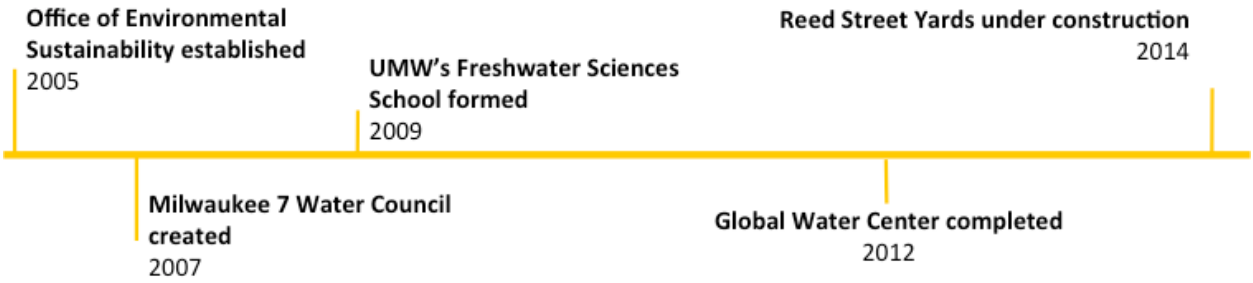
The water technologies cluster was wholly initiated by water industry leaders Badger Meter and A.O. Smith. The CEOs of both firms communicated the potential for water industry collaboration on a tour of a research facility before engaging the M7 and The Greater Milwaukee Committee, a private-led organization that invests in economic and cultural assets across the region, in creating The Milwaukee 7 Water Council in 2007.[58] The committee formed organically from the regional presence of five of the eleven largest global water companies: Siemens, ITT, Veolia, Pentair, and GE. During its inceptive year, the committee hosted a water summit to publicize the cluster and gain broader support from industry.

The Milwaukee 7 Water Council became a nonprofit called simply The Water Council in 2009. The Water Council is responsible for both facilitating connections between members and increasing the national and international visibility of the region's water technology cluster. The public-private partnership model attracted the attention of the Economic Development Administration (EDA) which infused the organization with $172,500 in grants in 2009. The same year, Milwaukee was recognized as a United Nations Global Compact City for its concentrated expertise in freshwater technologies - one of only two U.S. cities to have

[56] Berg, Ryan, *A Fresh Take on an Old Reliable: Milwaukee and Manufacturing*, 2013
[57] Rohde, David, *Free-Falling in Milwaukee: A Close-Up on One City's Middle-Class Decline*, 2011. & City of Milwaukee, *Demographics and Data*
[58] Milwaukee 7, *Milwaukee Region: Southeast Wisconsin's Food Industry*, 2012

ever received this designation.[59] The Water Council continues to sustain its $1,000,000 budget through a balance of funding sources, including fees that are scaled to the size of its 184 member organizations that span industry, universities and research centers, government agencies, and municipal government.[60] The following section describes economic development initiatives in the Milwaukee region that have emerged since the formation of the Water Council.

Figure 18: Timeline of Milwaukee Water Cluster Milestones



Key Programs and Initiatives

Global Water Center

A key component of the Water Council is the Global Water Center. In 2012, the organization led a LEED Silver project to renovate an abandoned warehouse to accommodate a water technology accelerator, a business park, and research center. The $22 million project was financed through a combination of private and government sources.[61] The seven-story Global Water Center opened in 2013 and houses an array of tenants including large corporations, start-ups, regional and state economic development organizations, the University of Wisconsin-Milwaukee School of Freshwater Sciences, and spaces for seed funded accelerators.[62]

Another significant Water Council milestone occurred with the redevelopment of the Reed Street Yards, a 17-acre, derelict rail yard adjacent to the Global Water Center. The new development, also called the Global Water Technology Park, 70% of which is dedicated to water technology tenants, is intended to provide start-up space for companies graduating from the Global Water Center's accelerator program.[63] The Reed Street Yards is a public-private venture and includes over $7 million in public investments for off-site infrastructure.[64]

BREW Accelerator

Created through a partnership between Wisconsin Economic Development Corporation (WEDC) and the Water Council, the BREW (Business Research Entrepreneurship in Wisconsin) is the first global freshwater seed accelerator program.[65] Located inside the Global Water Center, the BREW holds an annual start-up contest with applications in the spring, a round of judging and pitching, and final decisions in August. The

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[59] The Water Council, *United Nations Global Compact*
[60] The Water Council, *Water Council Members*
[61] Schmind, John. "Efforts to brand Milwaukee as water technology hub reach milestone." 2013.
[62] Shaker, Dan. *Milwaukee Opens: The Global Water Center*, 2013 & The Water Council, *Moving Forward…Rather, Westward: Reed Street Yards,* 2013
[63] Ibid Shafer, Dan
[64] Ibid
[65] In Wisconsin, *The Water Council, WEDC Announce Second Phase of Seed Accelerator Program*, 2014

winners move into the Global Water Center in September with a six-month, subsidized lease. Participating companies receive additional benefits such as low cost housing through a local developer, mentoring from industry experts, the opportunity for pilot projects with the Milwaukee Metropolitan Sewerage District, and a $50,000 grant from WEDC.[66] The state economic development agency also provided an initial contribution of $750,000 for the development, while Badger Meter contributed $500,000 in funding for lab space.[67] In 2011, the Economic Development Administration (EDA) seeded the program with a $500,000 grant through its Jobs and Innovation Accelerator Challenge to support communal lab equipment purchases and research commercialization initiatives.[68] Applications to the BREW doubled after the program's inaugural year in 2013 in which six start-ups were selected, demonstrating the embrace of the program by the region's start-up community.

University Partnerships

Local universities are also central to the Water Council's objective to catalyze homegrown water technology development. The School of Freshwater Sciences opened in 2014 and is the only such program in the U.S. offering undergraduate and graduate degrees, supplying the regional water cluster with a pipeline of specialized talent. The Water Council provided the political capital necessary for the state-funded $53 million facility that includes teaching labs, quarantine and pathogen-testing facilities, and the Great Lakes Genomics Center.[69] Another $525,000 was secured from the National Oceanic and Atmospheric Administration (NOAA) to attract top talent through five graduate research fellowships.[70]

Similarly, the University of Wisconsin-Whitewater Institute for Water Business, launched in 2009 through a partnership with the Water Council, produces graduates with an understanding of water management while also supplying business modeling and operations training services for start-ups in the BREW program.[71] A water law program was also created through an industry-academia partnership at Marquette University in 2009, providing opportunities for students to specialize in legal issues in the water industry that are growing in significance.[72]

Water Equipment and Policy Research Center

The Water Equipment and Policy Research Center (WEP) is a research partnership between industry, the University of Milwaukee, Marquette University, and the National Science Foundation (NSF). Established in 2011, the program is funded through scalable membership fees from companies and research organizations that support industry-driven, university-based water technology projects.[73] Member companies benefit from royalty-free licensing of technologies generated through the national program.[74] Though the NSF provides limited financial support for administrative costs, the WEP is expected to be entirely self-sustaining within ten years of its creation.

Milwaukee E3 (Economy, Energy Environment)

The Milwaukee E3 (ME3) program helps small- to medium-sized manufacturers (fewer than 500 employees) reduce their environmental impacts while also minimizing costs through sustainable manufacturing

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[66] Ibid
[67] Schmind, John, *Efforts to brand Milwaukee as water technology hub reach milestone*," 2013, & Water World, *WI opens first-of-its-kind water business, research facility addressing world water challenges*
[68] BizTimes Newsletter, *Milwaukee Water Council lands $500,000 Grant*, 2013
[69] Bauter, Alison, *First Look: Inside UWM's new School of Freshwater Sciences*, 2014
[70] Webster, Amanda, *NOAA funding to support UMW water science*, 2010
[71] Bauter, Alison, *Water technology accelerator embarks on second round*, 2014
[72] Marquette University Law School, *Water Law*
[73] The Water Council, *Annual Report 2013*
[74] University of Wisconsin – Milwaukee, Water Equipment and Policy Research Center

processes.[75] The ME3 program covers up to $3,600 in diagnostic costs through the Wisconsin Manufacturing Extension Partnership (WMEP) and 50 percent or up to $5,000 of the cost the follow-up assessment. Along with the financial benefits, ME3 manufacturers gain access to network of "statewide service providers" that can offer a broad range of services that are essential in manufacturing.[76] Originally funded by the U.S. Department of Energy, the ME3 program is now financed through a partnership between the city and the Milwaukee Economic Development Corporation (MEDC).

Conclusion

Political collaboration and community consultation were vital components in the creation of the Water Council. The community was engaged throughout the process via town hall meetings, round tables, and surveys to not only educate the public, but also to understand and manage expectations. Political support at the city and state levels was also critical. Despite opposing political agendas, the Water Council used the economic benefits of clustering initiatives to bridge these divisions. Though still in its early stages, the Water Council public-private partnership model illustrates the importance of industry leadership in identifying value-added economic development programs and building support for cluster-based initiatives.

We Build Green Cities: A Comprehensive, City-Driven Clean Energy Development Strategy in Portland

Timeline of Clean Tech Development in Portland

The development of clean tech in the city of Portland dates back to 1970s, when Oregon state enacted the country's first refundable bottle deposit and land use bill, which stimulated the recycling industry in Portland. In the 1990s, Portland became the first city to adopt a Global Warming Action Plan, with a goal of reducing greenhouse gas emissions to 10% below 1990 levels.[77]

Since the 1990s, the city took a few major steps to increase local demand for clean tech. First, the city adopted a green building policy that requires new construction and major renovations of all City facilities to be LEED certified. The Portland Development Commission (PDC) later required similar green building metrics for all developments built through public-private partnerships. At the same time, Portland became the first city in the U.S. to adopt a local Renewable Fuels Standard for all motor vehicle fuels sold inside the city limits, which requires all diesel fuel sold in the city to contain a minimum of 5% biodiesel and all gasoline must contain a minimum of 10% ethanol.[78]

In 2007, Oregon passed one of the most ambitious renewable energy laws in the nation, the "Renewable Portfolio Standard," requiring large utilities to provide at least 25% of their electricity from renewable energy sources by 2025. At the same time, Portland initiated a more aggressive Climate Action Plan to reduce greenhouse gas emissions by 80% by 2050. The city also created a framework for the next 15 years of economic growth and adopted its first Economic Development Strategy, which included clean tech as a crucial sector of the Portland economy.[79]

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[75] City of Milwaukee, *ME3: Milwaukee Economy, Energy, and Environment Program*
[76] Ibid
[77] Portland Development Commission, *Advancing Portland's Clean Tech Economy: We Build Green Cities*, 2013
[78] Ibid
[79] Ibid

The motivation for developing the clean tech sector in Portland can be divided into six components:[80]

(1) Reacting to increasing concern about the condition of the local environment
(2) Improving energy efficiency
(3) Exploiting potential of clean tech market in Portland
(4) Capitalizing on export opportunities to Asia
(5) Building upon strengths in renewable energy generation technologies
(6) Leveraging progressive image of Portland

Key Initiatives

The State Energy Loan Program (SELP) was established in 1981 to improve energy conservation and renewable energy development. The program offers low-interest loans to various individuals, businesses, nonprofits, schools, etc. The loans usually range from $20,000 to $20 million, with a repayment period of 5-15 years. Eligible projects should be able to save energy, promote renewable resources, develop alternative fuels, and use recycled materials. In 2011, SELP issued a $20 million loan to SoloPower, a solar energy manufacturer, to help finance their facilities in North Portland, which created hundreds of job for the city.[81]

In April 2010, a nonprofit program called **Clean Energy Works Oregon (CEWO)** was established in Portland with $20 million from the U.S. Department of Energy. The goal of this program is to retrofit commercial buildings and homes in order to save energy and reduce CO_2. Through the program, qualified homeowners have access to free energy audits, loans of up to $30,000 for energy efficiency upgrades, and can repay the loans directly with their heating bills. There are a number of partners involved in this program, including the City of Portland, Energy Trust of Oregon, Enterprise Cascadia, PGE, Pacific Power, and NW Natural. Among these partners, the Energy Trust of Oregon provides the financing, offering up to $100 million annually to Oregon residents and businesses to improve energy efficiency.[82]

The region has been aggressive in pursuing a transition to all-electric and plug-in vehicles, as well as developing electric vehicle manufacturing industries. In 2011, Portland State University, Portland General Electric, and the City of Portland collaborated on **Electric Avenue**, a two-year project aimed at providing more places for electric vehicle owners to park and charge and to collect data from charging stations for research purposes. The Electric Avenue is located in downtown Portland, offering eight parking spaces with charging stations.[83]

Portland Development Commission (PDC) is a city agency responsible for economic development and urban renewal created in 1985 by the Portland residents through popular vote. Its mission is, "to create one of the world's most desirable and equitable cities by investing in job creation, innovation and economic opportunity throughout Portland."[84] The Commission is governed by five board members who are local citizens appointed by the Mayor and approved by the City Council. PDC has an Executive Director who reports to the Commission, rather than directly to the Mayor or other elected officials. The major initiatives and programs of PDC have to be reviewed and approved by City Council. PDC's structure is beneficial for its coordination of activities related to urban renewal, economic development, and redevelopment.

PDC's funding is mainly supported by tax increment financing debt proceeds (90%), while the remainder of revenues are derived from federal grants, asset management, City of Portland General Fund Allocations, and

[80] Synthesized from interviews with clean tech experts in Portland
[81] Clean Edge, Oregon's Clean Energy Economy, 2011
[82] Ibid
[83] Portland State University, *Electric Avenue FAQ*, 2014
[84] Portland Development Commission

lending agreements.[85] Their fiscal year 2014-15 total budget was $246 million, with $190 million in expenditures.[86] Based on robust economic data analysis and predictions, PDC invests public resources wisely to bring about the largest economic impact.[87] The PDC's strategic plan from 2010 to 2014, focuses on clean tech, athletic & outdoor equipment, software, and advanced manufacturing industry clusters.

One notable program of PDC is the **Green Features Grant Program**, which offers grants for up to $25,000 to small business and building owners for installing clean technology that improves energy efficiency, promotes renewable energy, reduces water consumption, or mitigates stormwater. The proposed project must be related to green and sustainable practices that reduce operational costs. This program assisted eleven businesses from 2012-2013 with $185,000 financial assistance.[88]

We Build Green Cities (WBGC) is a project launched by the Portland Sustainability Institute in partnership with Business Oregon, the City of Portland, and the Portland Development Commission. Its mission is to, "better connect Portland's green innovations, intellectual capital and products with the rest of the world."[89] Their website is a showcase of Portland initiatives, programs, and achievements, with the goal of connecting regional businesses, sustainability advocacy, and attracting investment to Portland.

WBGC developed a network of hundreds of local companies, including green buildings, clean energy, water, green transportation, investment and financing, and waste and recycling.[90] WBGC dispatched some local firm representatives to trade meetings with foreign investors and government economic developers in order to market Portland firms overseas. Partner countries include Japan, China, and Mexico.

We Build Green Cities functions as the branding and marketing organization for clean tech in Portland. The WBGC has unified all the policies and initiatives in the Portland region, helps the City use consistent language to describe clean tech strategies, and creates a unique image in the media. The marketing has been especially beneficial for Portland's clean tech exports and foreign investment attractions. The organization produced a short video showcasing Portland's strengths in clean tech, which has been shown at various Portland trade meetings and posted on green economy related government websites, in order to create an appealing and consistent image of Portland.

Portland State University Clean Tech Challenge was started by Portland State University in 2013. Sponsored by Wells Fargo, Ecoworks Foundation, Oregon Built Environment and Sustainable Technologies Center, Portland State University, and PSU Business Accelerator, this clean tech challenge is held annually to encourage undergraduates, graduate students, and faculty from diverse disciplines to come up with innovative clean tech innovations and sustainable solutions.[91]

During the 2013 challenge, among the 15 teams who competed, seven semifinalists were selected to receive a $2,500 grant to develop their prototypes over the summer. Innovations touched on a variety of clean tech topics, including building materials, clean energy, and water consumption. The competition consists of an elevator pitch and a prototype showcase, and finalists are selected by expert judges. Team presentations are open to the public as a conference event.

A $10,000 grand prize was awarded to the winning team to further develop their product model, which was an alternative car battery that can eliminate environmental and health risks associated with lead-acid

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[85] Ibid
[86] Portland Development Commission, *Adopted Budget, FY 2014-15*
[87] Portland Development Commission, *Annual Report, FY 2012-13*
[88] Portland Development Commission, *Green Features Grant Program*, 2014
[89] The City of Portland, *We Build Green Cities*, 2014
[90] Ibid
[91] Oregon BEST, 2014

batteries. In addition, this team also received a business services and support package from the PSU Business Accelerator, a university entity that provides resources, connections, and expertize to local startups and entrepreneurs. Currently, the PSU Clean Tech Challenge team is moving toward opening the competition to all Oregon students and creating a dedicated clean tech business incubator with the support of PSU Business Accelerator.

Portland Clean Tech Cluster Strategy

The Portland Development Commission (PDC) chose clean tech as one of the city's main clusters because the solar, wind, and energy efficiency subsectors have been proactively developing their supply chain and market base in Portland, creating opportunities for Portland's green economy growth. Additionally, Portland has a solid industry base in semiconductor manufacturing and metals manufacturing, which are beneficial for solar and wind energy industries and the PDC identified that Portland regional architects, builders, and related firms have competitive advantages in green development practices.[92] Figure 19 details key components of this cluster strategy.[93]

Figure 19: Cluster-Based Strategies Employed by the Portland Development Commission

Strategy	Actions
Analyze subsectors and develop action plan	• Convene thought leaders from each subsector • Identify opportunities and barriers • Develop plans to explore opportunities and remove barriers
Create local markets	• Set up green buildings requirement, energy consumption standards, and clean technology grants
Brand sector and engage community	• Build clean tech websites and send clean tech information materials to citizens and industries • Survey citizens about ideas on green city development and clean tech
Connect local business to international markets	• Match local firms with foreign market and investors • Help small and midsize firms market overseas • Host events and conferences to establish business networks and attract investment

Outcomes

Portland has great strengths in policy leadership and a high-skilled workforce supply. Being an early adopter of clean tech enabled the city to have a solid base for clean tech infrastructure (organizations, networks, clean tech awareness of customers, etc.). However, the volume of investments in the city has been going down. According to the Clean Edge Index, Portland's performance in capital attraction has declined in recent years.[94] Portland can use its strength in renewable energy installation, green buildings, and waste-to-resource technology to meet the rising demand of both local and global markets. Competition in capital and business attraction from other West Coast cities is posing a threat to continue growth of Portland's clean tech sector.

[92] Portland Economic Development Strategy, Clean Tech Webpage, 2014
[93] Portland Development Commission, City of Portland Clean Tech Update Presentation, 2010
[94] Clean Edge, 2014 U.S. Clean Tech Leadership Index, 2014

Regional and city led efforts to grow clean tech in Portland have achieved notable levels of success that have been nationally recognized. According to the U.S. Clean Tech Index in 2014, Portland ranked fourth among the 50 largest metro areas across the country. Portland has been a national leader in LEED-certified design and construction, with the third highest number of LEED certified projects in 2014 (118.6 projects per million people in the metro area). Additionally, Portland is the top metro area in regards to electric vehicle charging stations, with 102.2 per million residents.

Conclusion

Above all, Portland established strong public-private-partnerships to facilitate clean tech growth. The collaboration and constant communication among nonprofits, local governments, research institutes, and companies has bridged the information and technology gap in the clean tech market. In addition, Portland is supporting clean tech incubators, which transfer technology from universities to the market through commercialization and business model building. Tax incentive programs are encouraging higher local demand for renewable energy and green buildings, thus growing the local market for related clean tech companies. The numerous sustainability campaigns in the city are raising the community's awareness of clean tech products, thus promoting clean tech consumption. Lastly, Portland is taking advantage of the rising demand for clean tech in Asian markets, such as China and Japan, to increase their clean tech exports.

Confluence: A Public-Private Partnership for Water Technology Innovation in Greater Cincinnati

Introduction to Cincinnati

The City of Cincinnati is located on the border between Ohio and Kentucky at the confluence of the Ohio and the Licking Rivers and has a population of 297,000 people.[95] The Greater Cincinnati region is a 15-county, three-state area located at the intersection of Ohio, Kentucky, and Indiana with a population of 2.13 million people.[96] By leveraging Greater Cincinnati's assets within the three states, the region has achieved gains in economic development that surpass what individual cities could have achieved independently.

Cincinnati has an economy based on key sectors, such as aerospace, automotive, chemistry and plastics, and financial services. Trending recently however, are emerging sectors that will diversify Cincinnati's economy. Advanced energy, consumer products and creative services, information technology, and life science industries have grown to become key components in the continuing evolution of Cincinnati's economy.[97]

The development of a clean tech sector in Cincinnati currently relies on the strengths of the region's water technology innovation and manufacturing clusters. Coordinated efforts within the region and leadership from economic development organizations to align stakeholders with public funds and initiatives have strengthened the possibilities for the clean tech sector's growth.

The Water Cluster and Confluence

The water technology innovation cluster (WTIC) is a major contributor to the clean tech sector in Cincinnati. Formed in 2011, Confluence is a nonprofit organization that leads the water technology innovation cluster in the Ohio River Valley. Composed of federal water laboratories and agencies, major research universities, large and small water related businesses, innovative water utilities, and regional development agencies, the

[95] U.S. Census Bureau Population Estimate, 2013
[96] U.S. Census Bureau Population, 2010
[97] City of Cincinnati Office of Trade and Development, 2014

groups work together under Confluence's umbrella to expedite the commercialization of water technologies. To achieve these goals Confluence utilizes a suite of natural, unique water assets, identifying the barriers that encumber the commercialization process, and organizing to break down those barriers.[98] Confluence builds on existing firms, intellectual capacity and expertise in the region to advance economic development and technology innovation in a strategic and coordinated manner.

In 2010, the EPA established that one of its goals was to support regional economic development efforts, preferably in regions with an EPA office. As a result, EPA regional offices around the country were tasked with developing public-private partnerships focused on environmental technology innovation and commercialization. Ultimately, the EPA Cincinnati office was selected to develop a private-public partnership focused on water technology innovation and commercialization because of its rich research and development infrastructure to anchor the water technology cluster technically.[99]

A Joint Effort between the EPA and Greater Cincinnati

There was initiative and interest from both the EPA and Greater Cincinnati leaders to improve the drinking water system and address issues related to contaminants in wastewater treatment effluents. In 2010, EPA Cincinnati staff initiated studies and organized briefings with regional leaders to investigate the potential for forming a technology innovation cluster in the Greater Cincinnati area focused on water. The response the EPA received during the briefings was overwhelmingly positive and the region quickly formed a steering committee to spearhead the effort. This committee drafted an initial vision and mission for the cluster and developed agendas for two EPA hosted stakeholder meetings.[100]

Throughout the process, EPA Cincinnati kept local government and elected officials informed. Local government was broadly supportive of Confluence as well as Cincinnati's key utilities including Greater Cincinnati Water Works (GCWW) and the Metropolitan Sewer District (MSD).[101]

Prior to the EPA's initiative, GCWW was conducting research on technologies available to address the growing concerns over microbial and viral contamination from microorganisms resistant to chlorine disinfection. GCWW wanted to implement preventive measures to avoid waterborne disease outbreaks like the one in Milwaukee, Wisconsin in 1993 when nearly 400,000 people became ill from Cryptosporidium and more than 100 deaths were reported.[102] With the mandate to produce safer drinking water and the possibility of enhancing the development of water technologies, Cincinnati and GCWW were early supporters of forming a water technology innovation cluster.

Greater Cincinnati possesses unique strengths in the area of water technology including the EPA's

Environmental Research Center which offers direct access to national water regulations, policy development initiatives, and oversight. The EPA laboratory, regional utilities, and a vast array of natural hydrologic test beds in the region formed by thousands of miles of flowing rivers and streams provided multiple research settings for companies to test their technology. Indiana, Ohio, and Kentucky have more than 700 water technology patents as of 2013, the highest concentration per capita in the United States. [103] The intellectual capacity of 100 years of water research in the region and access to research and development at the EPA and local universities gave the Greater Cincinnati region an advantage over other water clusters.[104]

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[98] Confluence, 2014
[99] Ibid
[100] Ibid
[101] Environmental Protection Agency Cincinnati, 2014
[102] Pure Water Gazette, 2013
[103] WVXU Cincinnati, 2013
[104] Ibid

Approximately 160 stakeholders from regional universities, large corporations, emerging companies, federal government, state government, local government, and economic development agencies attended stakeholder meetings prior to the formation of Confluence. Water utilities, including GCWW and MSD, had stakes in the formation of Confluence. With over four decades of presence in Cincinnati, the EPA office used its government and private industry contacts to bring together these stakeholders.

Funding and Implementation of Confluence

Confluence is a paid scaled membership organization, currently with 25 different members paying $500 to $5,000 for the services provided by Confluence. When Confluence was formed, the EPA Office of Research and Development's Science to Achieve Results (STAR) program dedicated $5 million over the first 3 to 5 years to support water technology businesses. STAR funds were intended for research grants and graduate fellowships in various environmental science and engineering disciplines through a competitive process. The funds were allocated to conduct key studies of the environmental technology market place for drinking water, acquire the services of a cluster consultant, conduct technology and knowledge mapping of the region to gauge its strengths, and develop, test, and market innovative processes and technologies.

In addition, the EPA announced the availability of up to $1.5 million through the Small Business Innovation Research (SBIR) program to fund innovative water treatment technologies developed by the private sector. The Small Business Administration (SBA) collaborated with the EPA to provide federal backing and program oversight to help ensure success of Confluence's efforts.

Confluence was responsible for identifying, testing, developing, and commercializing innovative technologies to solve environmental challenges and spur sustainable economic development and job creation. A Board of Directors formed with various members of communities across the region, with an EPA representative as a non-voting member of the board. EPA advises the Board of Directors, offers EPA participation in working groups, and coordinates joint activities, including meetings, workshops, and test events. The EPA provides detailed knowledge on the technical resources and agency regulations and does not advise on topics outside their expertise, such as commercialization efforts.[105]

When Confluence began, the plan was to activate a number of working groups to develop strategies to achieve its organizational goals. Table X summarizes these working groups.

Table 20: Confluence Working Groups

Working Group	Purpose
State Testing Protocol*	To facilitate the development of protocols for test and approval of water devices in partnership with organizations across the three-state cluster region.
Network of Test Beds*	To coordinate the development of and access to a network of test bed sites to evaluate local, national, and international water technologies.
Water Policy Forum*	To identify issues or questions within the water industry, facilitate dialog with EPA or other regulatory agencies on those questions, and report key knowledge back to the water community.
Seminars, Conferences, Workshops*	To develop a premier series of water-related educational programming, including technology workshops, industry or technology seminars, and water

[105] Environmental Protection Agency, 2011

	conferences.
Business Advisory Council	To establish a business advisory council of businesses and inventors/entrepreneurs with water-related products that reduce pollution, manage and regulate known and emerging chemicals of concern, and support sustainable water infrastructure.
Top Three to Five Technology Problems Identification	To define the top three to five technology problems to be addressed to better serve the water community and to improve the competitive advantage of businesses within Confluence's region.
Partnerships With Other Technology/Research Entities*	To use Confluence as a hub for developing partnerships with other technology, cluster, and research organizations.
Establish Success/Impacts Metrics	To establish the metrics that will be used to measure the success and impact of Confluence overall.
Communications & Marketing	To develop a top-notch communications and marketing plan capable of communicating cluster impacts worldwide.

* EPA Cincinnati participation indicated with an asterisk.

Source: Environmental Protection Agency

Even with this framework in mind, Confluence's Board of Directors decided to hold off initiating all the working groups listed in Table X and instead focused on two areas that would directly impact indigenous businesses. First, the Board focused on identifying the existing barriers to develop water technologies. The Board felt that they would be more effective as an organization by understanding the barriers that led to an average development timeline of 10-15 years from idea to commercialization.

The Board also created a committee focused on improving relations with new businesses that came to Confluence with technologies for development. Informally named a "triage committee," it developed a standardized form to be given to companies in order to assess how developed the technology was, what the businesses needed for further development, and what they wanted from Confluence and the government. Several dozen companies were interested in the assistance of Confluence whether it was for finding a manufacturer for a component part, connections to cooperating businesses, or investment capital. Confluence also designed a program where Confluence staff members serve as "business champions" to help guide local businesses to resources within the region. This committee evolved organically after realizing there was a need for these services.[106]

Impacts of Confluence

The development, testing, and potential for future commercialization of water technologies in the Greater Cincinnati region by Confluence has brought more visibility to the WTIC.

- In January 2013, two years after the establishment of Confluence, a multi-state memorandum of understanding (MOU) was signed allowing Confluence to work with companies to complete testing that can be approved by all three states at once, speeding up time to market.[107] The MOU was "a

[106] Alan Vicory, 2014
[107] Confluence, 2013

direct attack on an organizationally bureaucratic problem."[108] Confluence made Greater Cincinnati a more attractive location for water technology companies to work, by reducing the barriers to entry and streamlining the process for testing approvals with the MOU.

- In March 2013, Cincinnati announced a collaborative partnership with regional stakeholders and utilities in Israel and Canada to establish a utility-based "water technology innovation hub" that will bring water technologies from idea to market.[109] The announcement of the new innovation hub seemed to duplicate the role of Confluence and caused confusion. The city eventually clarified that their intention was not to create something to compete directly with Confluence, but to investigate water technologies that would help Cincinnati's utilities.[110]

- In April 2013, Cincinnati began a nationwide marketing effort leveraging the abundance and quality of their water to attract the interest of water intensive industries to a developable 18-acre industrial site, MetroWest Commerce Park.[111] Efforts to attract food, beverage, and technology businesses that need water for cooling, have not been successful in Greater Cincinnati despite a water abundant aquifer because scarcity of water in other places is not the only reason businesses make site selection choices.[112] As the demand for water in manufacturing and industrial processes increases, Greater Cincinnati will benefit from its abundance of water.

- In June 2013, after 10 years of development and $30 million, GCWW announced the adoption of UV disinfection for treating water in Cincinnati. The EPA identified the technology as one of the best to inactivate pathogenic microorganisms, such as Cryptosporidium in drinking water. GCWW pioneered advances in water treatment including rapid-sand filtration, the use of chlorine and granular activated carbon (GAC). Although not a direct recipient of Confluence funding for the UV disinfection technology, GCWW's latest development strengthened the role of Cincinnati's water, wastewater, and stormwater utilities as test beds for water technologies in the nation.

- In September 2014, GE Intelligent Platforms announced the use of the Procify Software platform by MSD for optimizing its wet weather facilities, equipment, and operations. Procify solutions will assist city management in bringing together disparate pieces of information about their wastewater system from remote locations to provide a system-wide view of what is happening across their watersheds.[113] By procuring and applying innovations to improve its own regional water utility systems, Cincinnati is demonstrating to businesses and investors that they are a leader in water technology.

- In October 2014, Confluence held a summit to address ways to keep harmful algae blooms out of the local water supply. After a toxic algal bloom occurred in August in Lake Erie near Toledo prevented nearly 500,000 residents access to drinking water, Confluence brought together stakeholders to discuss prevention strategies. Having an organization that is nimble and can react to a problem that demands water technology and/or advice reinforces the strength of the water cluster in Greater Cincinnati.[114]

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[108] Ibid
[109] Metropolitan Sewer District Greater Cincinnati, 2013
[110] Ibid
[111] City of Cincinnati, 2013
[112] Journal-News, 2013
[113] General Electric, 2014
[114] WVXU Cincinnati, 2014

Lessons for Pittsburgh

Although Pittsburgh may not benefit from having a local EPA office or the benefits of federal funding for a local water cluster, the focus of Confluence on developing local businesses and the engagement of progressive city utilities is a model from which Pittsburgh can learn.

The Pittsburgh Water Economy Network (WEN), an existing water innovation cluster, could work with the City, first to align interests and then to identify problems with environmental impacts that need innovative solutions. However, because of the differences between WEN and Confluence (private organization vs. P3), it may be difficult to achieve significant change through Pittsburgh's existing water cluster. Without the support of federal funding, a dedicated nonprofit organization to facilitate working groups or the presence of progressive water utilities, WEN lacks the overall "buy in" and technology strategy that Confluence provided for Greater Cincinnati. However, the City of Pittsburgh could bring together existing economic development organizations, utility representatives, industries, and water technology stakeholders to determine which water problems are most pressing and determine practical clean tech solutions.

The Manufacturing Cluster and Investing in Manufacturing Communities Partnership

In May 2014, the Cincinnati-Dayton region was designated a "manufacturing community," only one of twelve in the nation, as part of the Investing in Manufacturing Communities Partnership (IMCP). Also known as the Southwestern Ohio Aerospace Region (SOAR), the designation gives preferential status to the region on a number of federal grants, a point of contact within the federal government to help navigate grant opportunities, and the ability to brand the Greater Cincinnati/Dayton region as center of U.S. Aerospace Manufacturing.[115] The U.S. Economic Development Administration chose SOAR based on its regional economic development strategy, public-private partnerships, and support for the manufacturing industry.[116] The designation lasts for two years, after which the region can reapply for it.

The Role of Manufacturing in Cincinnati

Manufacturing is Ohio's single largest industry -out of 20 industries identified by state government researchers- based on the value of goods produced. Manufacturing represented nearly 17.7% of the state's total economic output of $565.3 billion in 2013, according to the Ohio Research Office, a state affiliate of the U.S. Census Bureau. Manufacturers in Ohio produced $99.8 billion worth of goods in 2013, a 14.5% increase from $87.2 billion produced in 2012.[117]

Nearly 110,000 people worked in manufacturing in the Greater Cincinnati region in September 2014 and they represent approximately 10% of the region's employment base. Employment in this key sector of the Greater Cincinnati's economy is down 9% from the 120,800 manufacturing jobs on payrolls in September 2007.[118] IMCP allows Greater Cincinnati to strengthen a key industry that produces not only aerospace, automotive, and plastic products, but also clean energy products, such as components for wind and solar technologies. Key to the region's manufacturing sector are small to mid-sized manufacturers who are re-tooling to make renewable energy equipment for growing markets.[119]

The regional collaboration between Cincinnati and Dayton for IMCP followed the trend of cities working together to form multi-city partnerships to attract industry from around the world. Economic development groups in the region, REDI Cincinnati and Dayton Development Coalition (DDC), and the newly elected mayors pursued IMCP to become eligible for federal funding targeted for manufacturing.

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[115] REDI Cincinnati, 2014
[116] Dayton Business Journal, 2014
[117] Journal-News, 2014
[118] Ibid
[119] Environmental Law and Policy Center, 2012

A Joint Effort between Cincinnati and Dayton

Partners in the effort included the City of Cincinnati, the City of Dayton, and their respective regional economic development organizations (REDI and DDC). For the IMCP application, REDI and DDC requested letters of recommendation from the local industries that support manufacturing to demonstrate the impact of manufacturing on the region. Letters of support came from other stakeholders including workforce training programs, energy companies, and the manufacturing companies themselves. The strongest advocate in the application was GE Aviation, an aerospace company based in Cincinnati.[120]

Funding and Implementation of Investing in Manufacturing Communities Partnership

The general IMCP program allocated federal funding of $300 million to develop advanced materials and new technology for sensors and digital manufacturing, $100 million for apprenticeship programs aimed at advanced manufacturing, and $130 million over five years in 10 states to help small manufacturers adopt and market new technologies. The federal government made a substantial investment in manufacturing research and technology to boost the advanced manufacturing sector.[121]

Businesses and organizations that are part of the SOAR designation, by being in the Dayton and Cincinnati are encouraged to apply for government funding for activities related to aerospace and advanced manufacturing. Funds are available from different federal government agencies such as the Departments of Agriculture, Commerce, Energy, and Labor. REDI and DDC provide guidance to companies and organizations applying for funding through IMCP and the government agencies prioritize manufacturing companies in SOAR during the review process. Because the manufacturing community designation expires after two years, the region is motivated to act on its economic development plans before their benefits end.

Results in Investing in Manufacturing Communities Partnership

Since the SOAR designation in May 2014, three community colleges have secured funding to support workforce training and development programs, thus attempting to fill the need for skilled workers to support manufacturing in the region:

- Sinclair Community College - $1,000,000 for machining certification program
- Cincinnati State Community College - $1,000,000 for welding certification program
- Cincinnati State Community College - $2,498,888 for logistics program[122]

Lessons for Pittsburgh

The IMCP program funds regional economic development strategies for manufacturing. During the application process, regions identify which counties to include as part of a manufacturing region, build strong and durable industrial ecosystems, and align industry needs for worker training, research, supply chains, capital access, infrastructure and site development, and trade.[123] Although 70 regions applied for the manufacturing communities designation and only 12 received it in the first round, those who completed the application process said the coordination and comprehensive planning effort the initiative spurred in their region will help strengthen local public-private partnerships that can lead to job creation and economic growth.[124]

The City of Pittsburgh should work with regional economic development organizations to determine its manufacturing strengths and apply for IMCP designation. A regional approach to manufacturing is necessary

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[120] Ibid
[121] Ibid
[122] Ibid
[123] U.S. Economic Development Administration, 2014
[124] Ibid

because clean tech companies based in Pittsburgh choose manufacturing sites outside of the city limits due to limitations in manufacturing space and qualified workers. For example, Aquion Energy is building a full-scale manufacturing facility for their battery technology in Westmoreland, PA, and chose to move there because of the combination of state incentives and qualified workforce. By aligning with regional economic development organizations, the City of Pittsburgh could use its convening power to lead the assessment and development of a manufacturing strategy that supports clean tech manufacturing.

University Clean Energy Alliance of Ohio (UCEAO)

In 2007, the University Clean Energy Alliance of Ohio (UCEAO) set out to create a network of academic professionals engaged in research and education on advanced and renewable energy issues, to facilitate collaboration and communication among them, and to promote the environmentally responsible development and deployment of advanced and renewable energy technologies in Ohio. UCEAO was the first energy advocacy organization in Ohio where universities played a prominent role.

UCEAO had the participation and support of the founding member research institutions, as well as affiliates representing independent colleges and universities, community colleges, government agencies, private sector businesses, and statewide advocacy groups who shared the organization's mission.

Of the 15 universities involved, the University of Cincinnati (UC) was the founding member of the UCEAO. Paul Bishop, Associate Vice President for Research at UC acknowledged the challenges, but was optimistic about the alliance's possibilities from the beginning; "These problems are very complex and will require the collaboration of researchers from various Ohio universities. We at UC have major strengths in this area and plan to be a significant component of this new endeavor."[125]

Rakesh Govind, professor of Chemical & Materials Engineering at UC was confident that the intellectual capacity that exists within the Alliance would lead to innovative solutions, "UC has a diversity of faculty who have investigated various facets of the energy and environment issue over the past two decades, who bring this wealth of experience to this consortium. This faculty stands ready to propose and develop real solutions for Ohio in conjunction with the State's industry, federal labs, and other Ohioan universities."[126]

Over the next seven years, UCEAO worked to accomplish these goals through a variety of educational programs and partnerships, including six annual conferences and two Clean Energy Challenges that empowered Ohio's student entrepreneurs. The Challenges were part of the Department of Energy's National Clean Energy Business Plan Competition designed to create a network of student-focused clean energy business competitions. The competitions allowed student teams to present their investor pitches in front of an expert panel of judges that included venture capital and private equity professionals and entrepreneurs, and a live audience.

Change in UCEAO Mission

In 2012, while still maintaining its role as an energy advocacy organization in Ohio, UCEAO's mission evolved to become representative of their economic development work. The revised mission of UCEAO focused on "the development and deployment of advanced and renewable energy technologies in Ohio by promoting and enhancing connections among Ohio institutions of higher education, government entities, the private sector, and other strategic partners."[127]

Two years later in June 2014, the UCEAO Board of Governors decided to dissolve the organization due to changes in programmatic focus and financial resources – both on campuses and in the external environment,

[125] Green Energy Ohio, n.d.
[126] Ibid
[127] University Clean Energy Alliance of Ohio, 2012

while maintaining a commitment to carry forward UCEAO's mission and goals at their institutions and through other avenues.[128] The scale of UCEAO in aligning 15 separate universities while trying to achieve multiple program goals made it difficult to coordinate.

Lessons for Pittsburgh

UCEAO goals aligned well with Ohio's plans for economic development in clean energy, but its collaboration model between institutions throughout the state did not meet the needs of its members. Lack of funding aside, the trend in industry-university collaboration with local and regional innovation clusters has increased, and replaced the statewide connections that UCEAO provided.

For Pittsburgh, the university institutions are assets and sources of clean tech innovations. There exist opportunities to foster collaboration between the university innovators and industry. In the absence of a university consortium for clean tech, the City of Pittsburgh could encourage the development of one with the intention of bringing clean tech innovations and products to market.

Conclusion

The three Cincinnati initiatives evaluated above reinforce certain themes in the development of any industrial cluster including clean tech. Regional collaboration is essential to make an impact in a global economy. Confluence depends on the Greater Cincinnati region and IMCP depends on the Cincinnati-Dayton partnership in order to bring attention and funding dollars to water technology and manufacturing clusters. Although clean tech is an emerging sector, its success will rely on existing assets. For Cincinnati, the spillover effects from the aerospace, automotive, and plastics manufacturing industries allowed for small to mid-sized manufacturers to re-tool their operations for emerging clean energy needs in wind and solar. Finally, engaging with public or private economic development organizations to apply to programs that build on the strengths of a region is necessary to generate interest and secure funding. Through the process of applying, cities stand to learn more about what assets they have, problems they need to address, and opportunities for implementing clean tech solutions.

RECOMMENDATIONS

Recommendation 1: Narrow the Scope of the Clean Tech Development Strategy

The City of Pittsburgh should evaluate the relative importance of a clean tech economic development strategy. If local clean tech development is a priority, then the City should also evaluate the degree to which political capital and resources need to be invested in the strategy. Throughout the implementation phase the City should reevaluate which clean tech subsectors are central to the strategy and how this strategy can be paired with ongoing economic, social, and environmental initiatives. Though cities are rarely a driver of cluster-based movements, they provide important, ongoing leadership and advocacy and can serve as a bully pulpit for industry and source of legitimacy for clean tech efforts.

Local clean tech sectors are disparate with varying needs and objectives. Successful strategies in other cities have, at least initially, focused on a small subset of local clean businesses and organizations. By choosing subsectors the City already has advantages in; Pittsburgh is more likely to reap the benefits of clustering.

[128] Ibid

Creating an entirely new cluster is not only difficult, but research suggests that "cluster upgrading" leads to greater economic impacts.[129]

The report suggests three clean tech subsectors as potential foci of a Pittsburgh strategy: (1) water economy products and services, (2) energy-efficient building technologies, and (3) clean energy and pollution control technologies. Further refining of the scope should consider subsectors that have business leaders interested in collaboration and that are closely aligned with the City's other strategic goals.

The City should also ensure that clean tech initiatives are reflected in municipal operations. An important component of this is educating municipal employees on the importance of clean tech and how equivalent departments in other cities have supported these initiatives. The city can also shift the objectives of otherwise unrelated projects to support clean tech development, such as:

- **Discussing** the use of infrastructure investments as opportunities to demonstrate new, local clean technologies with organizations such as the Allegheny County Sanitary Authority (ALCOSAN) and the Pittsburgh Water and Sewer Authority (PWSA)
- **Matching** local accelerators and incubators with stakeholders interested in supporting clean tech specific programs
- **Creating** symbiotic partnerships with universities on specific clean tech research and development projects to use the city as a learning lab

In order to become a competitive clean tech cluster, Pittsburgh must also take a regional perspective. Both Cincinnati and Milwaukee have successfully employed regional approaches (working with the bordering 15 and 7 counties respectively), on business and human capital attraction and formation, accomplishing what no city could have achieved unilaterally. These cities have also focused finite cluster-based economic development resources on water technologies – a single, narrowly defined subsector that leveraged regional comparative advantages.

Chicago was successful in investing in goal setting and prioritization prior to implementation. In September 2012, Mayor Emanuel unveiled the Sustainable Chicago 2015 Action Agenda, which offers concrete initiatives, strategies, and metrics to advance Chicago's goal of becoming the most sustainable U.S. city. Sustainable Chicago identifies twenty-four specific goals that are critical to the sustainability of the city including economic development and job creation, energy efficiency and clean energy, water and wastewater, and climate change, as well as key actions necessary to reach those goals by 2015.[130]

Recommendation 2: Create or Support a Cluster-Based Economic Development Organization

The following recommendation contains two alternative approaches to a cluster-based economic development organization. The Office of Strategic Investment recommendation is a two-phase, scalable, sector-based strategy housed in the Mayor's office that addresses broader gaps in economic development functions at the city-level. The Pittsburgh Clean Tech Greenhouse recommendation is a distinct, member-

[129] Porter, Michael, *Location, Competition, and Economic Development: Local Clusters in a Global Economy*, 2000
[130] Sustainable Chicago, 2015

based organization that is coordinated by the City and operates at the regional level to organize and strengthen specific subsectors of clean tech.

Alternative 1: Establish an Office of Strategic Investment

Summary

The City of Pittsburgh should establish an Office of Strategic Investment (OSI) to convene stakeholders, such as business executives, developers, city officials, and nonprofit leaders to identify strategic industries with high growth potential. The purpose of the OSI is to provide the City with the capacity to identify cluster-based economic development strategies and link them with broader economic or environmental goals. The OSI ensures that relevant city agencies are committed to implementing these goals and that these cluster-based strategies are connected to funding opportunities.

The Pittsburgh region and Allegheny County each have economic development organizations responsible for promoting and securing investment in their jurisdictions. The City of Pittsburgh, however, is limited in its ability to pitch itself to outside investors. Responsibilities such as branding and communicating with investors are deferred to regional actors that have limited incentive to connect opportunities to the City. The current administration has already recognized this need by creating a liaison to the County and the Allegheny Conference, but more needs to be done to resolve these issues that cannot be solved at the county or regional level.

As part of Mayor Bill Peduto's transition to office, an Economic Development Transition Team offered recommendations intended to strengthen the City's role as the economic engine of the region. The proposal for a separate OSI was not explicitly stated in the transition team's recommendations, but the need for more coordination between the City and its customers was identified. The proposal for an OSI is closely related to the Planning and Development Process recommendations proposed by the Economic Development Transition Team in January 2014.[131] The majority of cities analyzed in this report have economic development offices within city government.

Organizational Structure

The OSI should be modeled as a start-up "delivery unit" to distinguish itself from the typical city office. A delivery unit "drives and coordinates start-up activities and helps cities progress much more rapidly than they otherwise might. The unit should mirror as much as possible the ad hoc way start-ups do business and provide a credible focal point for immediate problem resolution, stakeholder engagement, and response."[132] Delivery units are scalable in their ability to focus on multiple sectors and the first applied delivery unit in Pittsburgh could be to advance the clean tech sector. The concept of delivery units is relatively new and used in London, New York, and Berlin to develop their start-up sectors.

The OSI would differ from other city offices in terms of leadership and staff. To be effective, it is important to retain a flat organizational chart to improve communication and create a clear chain of command. Hiring talent with a mix of entrepreneurial, private sector, and public sector experience is essential to coordinate organizations that are necessary to implementing the city's clean tech business development goals. The organization must be comfortable with uncertain, project-based work with limited processes and finite deadlines, while also understanding the pace of public administration. OSI staff would focus on a specific area or share responsibilities with the following business development and cluster-based strategy tasks:

[131] City of Pittsburgh, 2014
[132] McKinsey & Company, 2014

1. Assess industry interests in an active regional cluster, in coordination with the Mayor
2. Conducting delivery labs to identify focus sectors
3. Educating outside investors and local firms about Pittsburgh's business development goals
4. Liaising with local economic development organizations, including the Urban Redevelopment Authority (URA), Allegheny County Economic Development, and the Allegheny Conference
5. Lobbying and soliciting state and federal funding opportunities
6. Communicating and marketing OSI initiatives

A desired director is one who is an established entrepreneur or someone from the private sector with knowledge of local government, but not a career government employee. The City should design an incentive structure that attracts a sufficiently qualified OSI director. Evaluating the director based on the number of initiatives implemented, deals finalized, and positive publicity may incentivize strong performance and willingness to stay within local government. The OSI director would serve both as a dealmaker and connector and be responsible for developing and maintaining relationships with the County and the Allegheny Conference. The director would develop connections with site selectors, venture capitalists, and organizations such as SelectUSA to attract business and pitch the City's comparative advantages for key industries.

If the City does not have the resources to complete a search for an OSI director, the City could "outsource the vetting of agency directors and assistant directors to foundations and search firms."[133] The City has a history of fruitful partnerships with Pittsburgh foundations. For instance, the foundations provided a portion of the salaries for the directors of the Bureau of Neighborhood Empowerment and could be leveraged to either fund OSI salaries or specific initiatives.[134]

Creating an OSI is an immediate recommendation. Establishing an office with the capacity to identify business development goals for the City would leverage the momentum developed in Mayor Peduto's first year in office. In order to develop a clean tech sector in Pittsburgh that achieves economic or environmental goals, an OSI should lead the City in implementing growth strategies.

Role of the City

The role of the City would be to provide a working space for OSI. It is suggested that the OSI be located in a building with business interests in one of the active regional clusters (Water Economy Network, Sustainable Pittsburgh, Green Building Alliance), outside of the City-County building. This proximity would facilitate interactions between the City and business community.

The mayor and other regional political leaders need to support the OSI by articulating the potential benefits of clean tech through civic campaigns and press releases. Support from existing Offices of Sustainability and Energy Efficiency, Innovation and Performance, and Management and Budget would also be essential to aligning interests with business development initiatives related to clean tech, building on existing relationships with universities, and sharing knowledge on government funding opportunities.

Other cities have led similar structure-based strategies. In October 2012, the City of Chicago announced ChicagoNEXT, a platform created by Mayor Rahm Emanuel and led by a council of technology business leaders who promote new opportunities in three critical sectors: digital, life sciences, and clean technology.[135] ChicagoNEXT has a straightforward mission: to foster economic development and job growth in these sectors and to attract investment needed to build technology companies.

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[133] Greenblatt, 2014
[134] Pittsburgh Post-Gazette, *Pittsburgh City council moves ahead on approving bureau salaries*, 2014
[135] World Business Chicago

Obstacles to Implementation

The potential obstacles to creating a new City office are many, but we have identified three specific challenges that will require special attention. First, gaining the support of the Mayor and the City Council for the formation of a unique government unit and justifying the expense of paying additional City employees need to be overcome. Second, convincing the business community that the City is prepared to be the leader for regional growth strategies would require hiring the right talent. Third, it is essential that the OSI director and staff forge working relationships with existing local organizations to further City-led business initiatives. Among these organizations are the Urban Redevelopment Authority, Allegheny County, and the Allegheny Conference.

Example Programs and Initiatives

Conduct "delivery labs"

Led by a clean tech delivery unit within the OSI, a delivery lab would bring together 20-40 key stakeholders to solve a problem associated with the development of clean tech. Labs may consist of workshops over several days and build upon ideas from forums like the Mayor's roundtables. Delivery labs inject ideas and translate high-level strategies into detailed implementation plans. For instance, the lab should focus on the barriers to clean tech innovation that exist in Pittsburgh and develop solutions to address identified challenges. If the OSI implements an initiative but faces setbacks, it (functioning as a delivery unit) should mimic the approach taken by most start-ups: launch the initiative, analyze the launch, learn what went wrong – and then adjust it and re-launch. Rapid prototyping allows policy makers to maximize the utility of an initiative by repeatedly and quickly adjusting to the needs of start-ups and sustaining momentum through prompt action by the delivery unit, while running at minimum cost.[136]

Coordinate funding for clean tech regional clusters

The OSI would have either a dedicated person or shared responsibilities among staff to seek, attract, and create funding opportunities for clean tech initiatives. The OSI would be instrumental in aligning funding needs, identified through assessments of industry interests or through delivery labs, with funding opportunities. For example, the OSI would provide local government support to connect the private sector and universities with available federal and state funding. Though traditional venture capitalists are more likely to invest in products nearing the commercialization phase of development, government can be critically important and add significant value by facilitating early seed funding.[137]

Among the OSI's functions would be to attract funding for clean tech start-up ideas by forming partnerships with local accelerators like Innovation Works, Idea Foundry, Alpha Labs, and Thrill Mill. Pittsburgh's foundations are assets that could be used to support clean tech initiatives in ways that align with the foundation's goals. For instance, to attract venture capital funding for clean tech to Pittsburgh, the City could develop a program that matches funds dollar-for-dollar. The foundations should find the program particularly attractive in its ability to achieve both economic and environmental goals. The OSI would also create opportunities for businesses and university innovators to pitch their ideas for addressing a City problem where winning pitches receive seed funding for further research and development to develop marketable solutions.

Establishing a clean tech brand

The Urban Redevelopment Authority (URA) of Pittsburgh, through the Center for Innovation and Entrepreneurship, manages a job creation strategy in collaboration with government, businesses, entrepreneurs, and universities. Power-Up Pittsburgh, the vehicle for this strategy, includes the LaunchPGH

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[136] McKinsey Center for Government, 2014
[137] Socio-Economic Review, 2009

small business resource website as well as a YouTube channel highlighting the success stories of local tech businesses.[138] Though these videos offer valuable publicity for participating firms, there exists an opportunity to feature these videos as part of a cluster-based marketing strategy. In addition, companies that discuss the strategic advantages of operating in the Pittsburgh region could be featured. A clean tech focused website could also include the following resources:

- Highlights of regional clean tech advantages
- Relevant business resources, such as venture capital funds, government loans and grants, nonprofit grants, and statewide tax incentives
- Ongoing clean tech research at local universities
- Events related to clean tech, such as university competitions or accelerator application rounds
- Public investment opportunities for industry
- City-led clean tech efforts, promoted through social media

The OSI would play an important role in convening regional economic development stakeholders to create consistent branding language for similar cluster-based economic development strategies. In Cleveland, branding the local economy has been successfully spearheaded by the Mayor's office in combination with a regional business advocacy organization. The city's sustainability initiative, Sustainable Cleveland 2019, was launched in 2009 and is intended to engage the community in key areas fundamental to a sustainable economy. For instance, in 2013 the city focused on the key area of Advanced and Renewable Energy, creating awareness at the annual Sustainable Cleveland summit and publishing a primer highlighting emerging and existing advanced and renewable energy technologies in Northeast Ohio. The Office of Sustainability has echoed the thinking of the leading economic development organizations in promoting advanced and renewable energy, a move that suggests the public and private sectors are coordinated with each other.[139]

Alternative 2: Initiate and Support the Creation of a Clean Tech Greenhouse

The Pittsburgh Clean Tech Greenhouse (PCTG) will be a distinct, member-based organization with only limited operational involvement from the City. The organization would implement strategies at the regional level focused on organizing stakeholders from specific clean tech subsectors. Due to the inherent indivisibility of clean energy from a broader, regional energy sector strategy, the PCTG would focus on repurposing the Water Economy Network or creating a new energy-efficient building technologies cluster.

Purpose

Sector-based clean tech development organizations assume various forms, but are most successful as member-based, public-private partnerships that are regional in scale. Only with a sufficiently broad base and balanced revenue sources will the PCTG have the capacity to implement value-added activities for specific clean tech subsectors with similar needs and objectives. Several thematic organizational functions have appeared in our research, including:

- **Advocating** for clean tech priorities at the local, regional, and state levels, especially to strengthen local demand for clean tech.
- **Connecting** members with one another, outside markets, and government to improve knowledge transfer, market opportunities, and policy awareness.

[138] Urban Redevelopment Authority of Pittsburgh
[139] Sustainable Cleveland, 2019

- **Identifying** specific clean tech investment and partnership opportunities through a working group comprised of stakeholders such as the City of Pittsburgh, Pittsburgh Water and Sewer Authority, Duquesne Light, university researchers, and industry leaders. Regional impediments, such as combined sewer outflows and shale gas wastewater management, can be used opportunities for clean tech solutions.
- **Marketing** the clean tech cluster to improve its relevance in policymaking decisions and to attract outside business and venture capital investment interest through initiatives such as brand marketing and patent partnerships with local universities and businesses.
- **Measuring** the magnitude and progress of regional clean tech activity through an industry database.
- **Supporting** start-up and member companies with consulting and accelerator services, potentially engaging universities, foundations, or the state in creating an accelerator spaces or an innovation challenge.

Role of the City

As stated, the role of the City is critical but limited. City resources need to be focused on convening relevant stakeholders, conveying support for the cluster, and lobbying other stakeholders. Typical stakeholders, partners, sponsors, and members involved in these clean tech organizations include:

- Industry
- Research universities
- Local, regional, and state economic development organizations
- Foundations
- Local, regional, and state regulatory agencies and authorities
- Community colleges
- Local advocacy groups

Implementation Obstacles

A key obstacle is for the PCTG is funding. Our research did not return any clean tech specific organizations that are fully or even majority funded by their membership base. At full scale, many of these standalone organizations have annual budgets exceeding $1,000,000, requiring a diverse pool of revenue from both public and private sources. For example, a significant portion of the $1.5 million in 2013 revenue for the Milwaukee Water Council is derived from leases within their Global Water Center, as well as federal and state grants.[140] The PCTG may be difficult to launch in the short-term as its timeline depends entirely on its ability to secure funding. The Water Council, for example, did not launch a formal organization until two years after creating a water committee within the regional economic development organization. The PCTG may need a similar incubation period as a key sector of the Allegheny Conference or industry network within the Pittsburgh Technology Council, but might quickly evolve into a standalone after strengthening industry connections and securing sufficient outside funding.

Similar Organizations

Successful subsector-level clean tech development organizations have been implemented at the regional-level, including the Water Council (Milwaukee), Confluence Water Technology Innovation Center (Cincinnati), the Research Triangle Cleantech Cluster (Raleigh-Durham), Cleantech San Diego, the Massachusetts Clean Energy Center, and NorTech (Cleveland). Initiatives in Milwaukee and Cincinnati are detailed in earlier case studies, while two additional organizations are briefly discussed below.

[140] The Water Council, *2013 Annual Report*

Massachusetts Clean Energy Center

The Massachusetts Clean Energy Center (MASSCEC) was created with the help of city and state government leadership.[141] MASSCEC provides incentives to residents, commercial businesses, nonprofits and start-ups through a charge on residents' electric bills.[142] This funding has allowed MASSCEC to run 28 programs that support clean tech research and development, incubators, accelerators, solar penetration, internships, and job training.[143]

NorTech (Cleveland)

Years after the 1969 fire on the Cuyahoga River, a water innovation cluster emerged in Cleveland focused on developing technologies to address environmental risks from water contaminants. Northeast Ohio's expertise in water remediation and control continues to spur new technologies, businesses, and jobs that drive growth in the region's economy while also protecting water assets. The Great Lakes Institute houses the Cleveland Water Alliance whose purpose is to share knowledge and spur innovative solutions to freshwater issues. The alliance brings together different sectors of business, academia and research, government, and nonprofit to develop collaborative solutions for freshwater issues.[144]

NorTech is also active in the water technology cluster. The regional technology council focuses on accelerating the growth of innovation clusters in advanced energy, flexible electronics, and water technologies, choosing these subsectors based upon existing supply chains and the research interests of nearby universities. NorTech assessed the region's water technologies cluster and targeted specific subsectors for growth and job creation, identifying the most promising technologies as automation and control, sorbents, and water system corrosion protection. Currently, Northeast Ohio has 54 organizations with core technologies in these three sectors. They accounted for approximately 338 employees and $72 million in revenue in 2011.[145]

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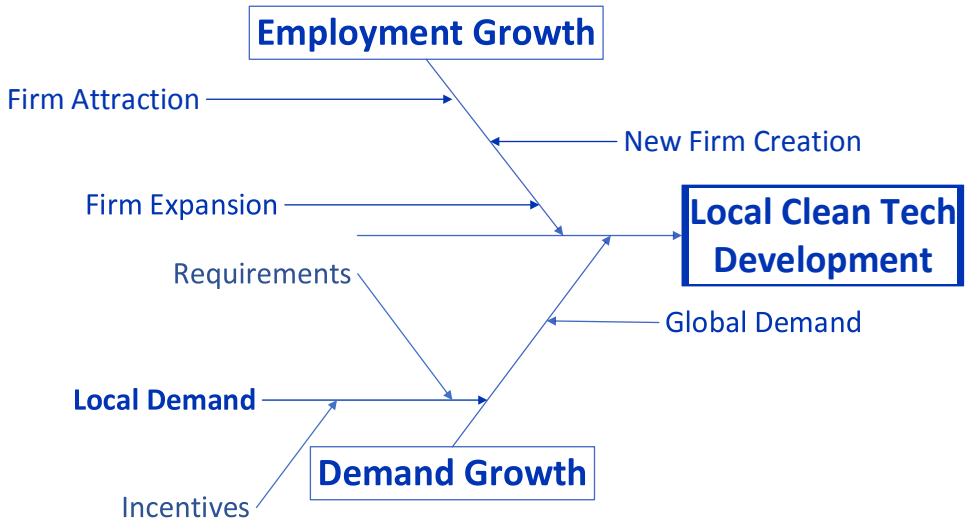
[141] Greentown Labs
[142] LaMonica, Martin. Xconomy, *How States Can Build a Cleantech Funding Pipeline*, 2014
[143] Massachusetts Clean Energy Center
[144] Cleveland Water Alliance
[145] NorTech

Recommendation 3: Create Local Markets to Enable, Educate, and Incentivize Clean Tech Development

Summary

The two prior organizational alternatives involve activities that improve the ability of local clean tech firms to meet demand through traditional economic development functions that influence business attraction, creation, and expansion. The following series of alternatives shifts to the other half of the clean tech development framework, proposing actions the City of Pittsburgh can take to incentivize local demand for clean tech products and services (Figure 1). Through legislative requirements or incentives the City can generate local demand, a portion of which will be met by local firms. These policies also have the capacity to pilot new clean tech inventions, enabling investors to see emerging technologies in action by using the city as a lab.[146]

Figure 21: Local Clean Tech Development Framework



Demand side policies have several advantages over traditional economic development strategies related to implementation, impact measurement, and targeting to clean tech exclusively. Demand side initiatives tested in other U.S. cities also provide evidence of increased awareness and community support for clean tech, building support for more resource-intensive supply side initiatives.

Once the City determines the scope of its clean tech development strategy, demand side incentives could be implemented to support cluster-based growth strategies developed by the Office of Strategic Investment or the Clean Tech Greenhouse. The funding and leadership for demand side incentives for clean tech may originate from the Offices of Sustainability and Energy Efficiency or Innovation and Performance, in combination with local foundations and state and federal grant opportunities related to environmental goals.

[146] Greentown Labs

Alternative 1: Offer expedited permitting or recognition program for achieving a designated level of green infrastructure

Purpose

The purpose of this alternative is twofold:

1. Increase the amount of green infrastructure within the City, which would not only increase local demand for clean tech, but also contribute to the regional efforts to mitigate stormwater overflow to improve the quality of water in our rivers and streams. Green infrastructure includes products or building practices that reduced stormwater runoff from a property, such as rain barrels, green roofs, rain gardens, porous sidewalks, and bioswales.
2. Reward innovation and increase awareness of green infrastructure projects by the public and decision-makers. Interviews with key players in other cities who have attempted to grow clean tech highlighted the need for residents to be informed, involved, and enthused. Behavioral research has shown that people will work to achieve recognition, even when there is no direct financial benefit in doing so.

Impact

Since green infrastructure practices increase property values, this will raise City property values. According to the University of Louisville, trees alone increase home values by 5% to 20%.[147] In the long run, higher property values will translate into higher levels of real estate tax revenue.

Implementation

The City should evaluate if the Department of Permits, Licenses and Inspections has the ability to expedite permitting. If they do not, expedited permitting cannot be offered as an incentive for developing properties with green infrastructure. Instead, the City could decide to offer a different type of development incentive, such as decreased fees or density bonuses.

The City should also investigate the price of the BLUE certification program through Tethys Environmental for watershed friendly homes, and compare costs to the City's ability to start a similar program internally.[148] The BLUE certification program sends evaluators to residential properties to work through a behavioral and physical checklist of actions required to become certified as watershed friendly. Homeowners who meet the requirements are audited every three years for continued compliance and are given a lawn sign to advertise their dedication to stormwater mitigation and water quality. Whichever program the City chooses a pilot version should be installed in select neighborhoods prior to full-scale implementation.

In 2008, the City of San Jose implemented a green building checklist for building planning applications that requires applicable construction projects to achieve minimum green building performance levels using the Build It Green (BIG), GreenPoint Rated (GPR), and the U.S. Green Building Council's LEED green building rating systems.[149] A similar green infrastructure checklist could be implemented in Pittsburgh to make development incentives transparent and predictable.

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[147] University of Louisville, *Green Infrastructure Report*, 2010
[148] Tethys Environmental, 2014
[149] City of San Jose, Webpage, 2014

Alternative 2: Revamp the City procurement process and RFP score sheets

Purpose

Too often the winner of a city contract is the company that is best at navigating the contracting-compliance maze. If the City wants to increase their procurement of clean tech, the request for proposal (RFP) process could be revised to create opportunities for newer, innovative companies to win contracts and spur creative clean tech solutions to issues the City is facing.

Implementation

There are two ways to revise the RFP process to achieve these results. First, release an improvement RFP similar to Philadelphia's FastFWD program. An improvement RFP recognizes that government may not know the best solutions available to tackle City issues, instead communicating to potential business partners which issues are a priority to the City and inviting entrepreneurs to explore the best possible solution.

The City of Philadelphia focused its first cycle of FastFWD in late 2013 on using technology to improve public safety, and attracted 82 applications from around the world. In early 2014, ten companies were selected to participate in a 12-week accelerator program aimed at refining their ideas. The finalists each got a $10,000 stipend and access to municipal officials, which allowed them to tailor their ideas to the Philadelphia context. At the end of the accelerator program, three public safety technology solutions were chosen to contract with the City. City representatives have acknowledged that these three solutions are unlikely to have developed contracts with the City through the traditional RFP process.[150]

The City of Pittsburgh can recreate the success of Philadelphia. First, the City would need to decide which urban challenge is a City priority that could be improved with technology solutions. Next, the City could approach the local foundations about funding a pilot program to test out an improvement RFP in Pittsburgh.

A second method to increase City procurement of clean tech is to reconsider which business characteristics are considered when making award decisions and what level of importance is given to those characteristics. Though the City needs to limit its exposure to risk of failure, heavily weighting the importance of company experience disqualifies potentially innovative solutions.

Supporting Evidence

A sizable amount of research has focused on measuring the impact of public procurement as a policy tool for growing local demand. Overall, the evidence shows that although the choice can be risky, the government can have a significant impact on local innovation by leveraging procurements as investments and publicity for up and coming clean tech solutions.

Local and regional governments are becoming more involved in procuring innovative solutions, but there is a lack of awareness among city officials about the connection between procurement and innovation, and local authorities tend not to be willing to take risks when promoting innovation through public procurement. Public procurement for innovation involves procuring products that need additional R&D work and thereby might influence the innovative capacity of providers. In this respect, public procurement can be taken as an additional tool in the innovation policy mix (such as R&D grants, tax support, and infrastructure investments) that also affects national, regional, and urban competitiveness.[151]

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[150] Governing, *Turning the RFP Upside Down*, 2014

[151] Lember, V, *Urban Competitiveness and Public Procurement for Innovation*, 2011

Public procurement for innovation can create local demand for new products or technologies, enhance providers' creativeness, create and protect infant industries, and increase diversification of economic activities and average wages. The public sector can act as a technologically demanding first buyer by absorbing financial and development risks of socially and ecologically conscious products, as well as by introducing strong elements of learning and upgrading into public intervention processes.[152]

A study of municipal policies requiring governments to construct green buildings on private-sector adoption of the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) standard found that procurement policies could break deadlocks that emerged when coordinated investments were required to adopt the LEED standard. Procurement policies produced spillover effects that stimulated both private-sector adoption of the LEED standard by developers and investments in green building expertise by local suppliers; which all reinforced the underlying policy goal.[153]

Impacts of Public Procurement for Innovation

There are three fundamental mechanisms by which public procurement can impact innovation:

- Market initiation: developmental technology is procured by the public sector (technology comes into existence only because of public demand)
- Market escalation: public procurement is employed to diffuse the existing new technology into the market
- Market consolidation: occurs via bundled demand that leads to a harmonization of fragmented markets. The government can be the party demanding the innovation, bear higher entry costs, create critical mass, signal the market, and link innovation to production.[154]

These innovation mechanisms can be targeted by any of three public procurement processes:

- Direct public procurement: the public organization is the primary end-user of the purchased product or service
- Co-operative procurement: the public authorities buy the products and services together with private organizations and both also use the bought products or services
- Catalytic procurement**:** the government initiates or is involved in the procurement process, but the purchased products or services are used by private end-users

Simcoe's study of municipal policies for green buildings characterized the effects of direct procurement for market initiation and escalation. Simcoe proposed three mechanisms by which municipal procurement policies could promote the diffusion of LEED standards within the private sector. First, government procurement policies might stimulate local demand for green buildings by raising awareness of buildings' impact on the environment or legitimating a particular standard for measuring green building performance. Second, government procurement policies might lead to lower prices for green building inputs through some combination of increased entry by new suppliers, economies of scale, and learning effects. Third, government procurement policies might solve a coordination problem in the market for green buildings. Specifically, if developers are waiting for key suppliers to invest in green building expertise, while those same suppliers are waiting for evidence of ample demand, municipal government procurement policies might jump-start the

[152] ibid
[153] Simcoe, T. and Toffel M.W., *Government green procurement spillovers: Evidence from municipal building policies in California*, 2014
[154] Ibid, Lember

development of specialized input markets by providing a guaranteed source of demand for LEED-accredited professionals and other suppliers.[155]

Although Pittsburgh has a relatively small market when compared to procurement by the state or federal government, the city has some strategic advantages. Cities are more attractive as testing grounds through their ability to build and create competencies and networks essential to the successful procurement of innovation where cooperation, networking, and learning-by-doing are cornerstones of success. City procurement also involves concrete and short-term demand – for example, procurement for a new system to pay for parking via mobile phones – that is relatively easy to handle, in terms of management capacities, finance, accountability, and transparency, than long-term R&D ventures.[156]

Existing public procurement for innovation cases are mainly triggered by specific public needs or policies, such as an environmental policy, which can be regarded as a good platform for future activities. The challenge the cities face is to know how to bind together different field policies and innovation policies when procuring goods and services. Cities also require a shift in their current public procurement culture, moving away from risk-averse behavior and becoming risk managers.

Alternative 3: Coordinate local contractor training on best green technologies

Purpose

There exist several efforts within the city to target energy efficiency with building audits, property owner education campaigns, and goal setting (such as Pittsburgh 2030 districts). A significant opportunity exists, however, in connecting these initiatives with the local energy efficiency supply chain. To close this gap in the local clean tech supply chain, the City can coordinate stakeholders to create trainings that inform contractors about the latest green innovations.

Implementation

Most contractors lack the incentive to complete a green building professional accreditation, so the City could partner with the Green Building Alliance to coordinate a training program on green building technologies and best practices. It remains unclear whether local contractors would be willing to attend this type of training, so the City should survey contractors to determine and whether incentives would be necessary to encourage attendance. In addition, the City should engage local clean tech firms to sponsor trainings at which their products or services would be featured.

Supporting Evidence

Energy efficiency stakeholders in Pittsburgh argue that their work would be more impactful if local contractors were better informed of the benefits of new technologies and supportive of energy efficiency programs. Currently, LEED or Energy Star professional certification programs are the only option for contractor training, both of which require significant investments. Green building product trainings that are advertised to local contractors and only require an hour or two of time are much more likely to reach a larger audience of contractors that can impact regional energy efficiency.

[155] Ibid, Simcoe
[156] Ibid, Lember

Alternative 4: Develop green infrastructure guidelines within Department of Permits, Licenses and Inspections

Purpose

With no structured process to permit green infrastructure projects, developers interesting in using the latest innovations are faced with prohibitive permitting timeframes. Developing clear guidelines for permitting green infrastructure will expedite construction timelines for developers interested in using green infrastructure.

Implementation

The Department of Permits, Licenses and Inspections should seek guidance from industry experts, such as the Green Building Alliance, Riverlife, and 3 Rivers Wet Weather, in the creation of these guidelines.

Supporting Evidence

Interviews with local stakeholders identified that developments are deterred from including green infrastructure in their plans due to lengthy permitting timelines.

Alternative 5: Require utilities to publish aggregate neighborhood-level data on energy and water usage on a regular basis

Purpose

Data on energy and water use is valuable for two reasons. First, the City could initiate a neighborhood level energy and/or water efficiency competition and use the utility data as a measure of each neighborhood's success. Pittsburgh could use its strong neighborhood identities to create a friendly competition to raise awareness and encourage responsible usage.

Second, the data could be used to target the energy efficiency programs and resources that are already in place. For example, PennFuture's "Black and Gold Makes Green Program" already operates programs that raise awareness and encourage residents, businesses, government, and universities to take concrete action to reduce greenhouse gas emissions.[157] Requiring utilities to publish data could help PennFuture target its awareness campaigns to specific neighborhoods where the program will have the greatest impact.

Both uses of the data will ultimately grow local demand for clean tech products and services and improve energy efficiency within the City.

Implementation

The Mayor's office should lobby for City Council support to lead competition between neighborhoods in their districts. Councilmembers could even use the improved status of energy and/or water consumption within their district as a measure of their success. If the data is not made public but shared with the City, the City should then set-up a communication plan to efficiently share the data with local energy efficiency businesses.

[157] Penn Future, 2014

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