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Approaches to Identifying the Emerging Innovative Water Technology Industry in the United States

ALLISON R. WOOD¹, TERESA HARTEN², and SALLY C. GUTIERREZ²

¹Oak Ridge Institute for Science and Education, Boston, Mass

²Environmental Technology Innovation Clusters Program, US Environmental Protection Agency, Office of Research and Development, Cincinnati, Ohio

Abstract

Clean water is vital to sustaining our natural environment, human health, and our economy. As infrastructure continues to deteriorate and water resources become increasingly threatened, new technologies will be needed to ensure safe and sustainable water in the future. Though the US water industry accounts for approximately 1% gross domestic product and regional “clusters” for water technology exist throughout the country, this emerging industry has not been captured by recent studies. As use of the term “cluster” becomes more prevalent, regional mapping efforts have revealed international differences in definition yet showcase this industry’s economic impact. In reality, institutional processes may inhibit altering industry coding to better describe water technology. Forgoing the benefits of national economic tracking, alternative data sets are available, which may support new ways of identifying these clusters. This work provides cluster definitions; summarizes current approaches to identifying industry activity using data, interviews, and literature; and sets a foundation for future research.

Keywords

technology transfer; water cluster; water industry; water technology innovation

Across the globe, nations are facing a variety of water challenges. These challenges include declining freshwater quality and availability. It is anticipated that by 2050, at least one in four people is likely to live in a country affected by chronic or recurring shortages of freshwater (United Nations 2017). It is estimated that each day, the United States loses 14–18% of treated drinking water as a result of aging, leaking infrastructure. Massive investments are needed to repair, rehabilitate, and update these systems to meet future demand and quality (ASCE 2017). Other water quality and quantity challenges facing the

To whom correspondence may be addressed is the director of USEPA’s Office of Research and Development, Environmental Technology Innovation Clusters Program, 26 West Martin Luther King Dr., G93, Cincinnati, OH 45220, USA; gutierrez.sally@epa.gov.

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United States include agricultural and industrial water use, urban stormwater pollution from growing cities, nutrient and energy recovery, and the need to revitalize ecosystems for the benefit of future generations and to ensure continued growth of the US economy.

New technologies will play a vital role in ensuring safe and sustainable water into the future. The US Environmental Protection Agency (USEPA) recognizes this enormous need and is committed to aiding the research and development required to generate new technologies. USEPA also works to aid programs that serve as vehicles for water technology innovation and dissemination, and encourages development and uptake of new technologies, which subsequently spurs greater amounts of water sector innovation.

When economic, social, and institutional groups pull together to support technology and innovation initiatives, they form a “regional innovation system.” In such systems, stakeholders support collaboration between entities, promoting the transformation of knowledge into innovation. These networks help encourage the development and adoption of new technologies to help solve pressing societal and environmental challenges (Cook 2016, Mercan & Goktas 2011).

One important aspect of an innovation system is the formation of industry “clusters.” In North America, clusters are considered to be “geographic concentrations of industries related by knowledge, skills, inputs, demand and/or other linkages,” a definition proposed by Harvard Business School researcher Michael Porter (Delgado et al. 2015). In the United States, certain industries have attempted to self-define their regional industry activities by forming what may be described as “cluster organizations.” These groups have been formed in regions with geographic concentrations of economic, social, and institutional players that operate in these industries. In most cases, a central entity composed of representatives from various sectors (industry, academia, and government) forms to facilitate activity. The resulting networks are similar to the model used by the European Union (EU), where a cluster is considered to be “an industrial network that is governed by a cluster management organization through specific activities following a common strategy agreed upon by participants” (Lämmer-Gamp 2014). However, because cluster knowledge is “highly fragmented, very descriptive, often qualitative, and inconclusive on many points,” there is no universally accepted definition of a cluster (Arthurs et al. 2009).

In the past decade, cluster organizations have developed significantly in the areas of both cleantech (an umbrella term for sustainable/green technology) and water technology. As cluster organizations are selfdefined, they may be formed to help facilitate regional development for industries not readily identifiable using traditional industry codes, which do not appear in examinations of national economic data. As a result, although a vibrant cluster organization may be present in a region, its industry of focus may not be easily tracked or validated by traditional cluster identification and mapping efforts. Such organizations must attempt to define themselves or find recognition through other arteries.

Since 2013, water innovation has been a key theme for AWWA. AWWA recognizes the importance of nextgeneration technologies in addressing the urgent water problems facing the country and the need for effective partnerships to successfully overcome the many

complexities related to their deployment (AWWA 2015). Aligning with the goals of the AWWA innovation initiative, water clusters offer an important platform to bridge the many relationships and players in innovation at the local and regional levels (Moore 2017). This article explores current approaches being used to identify and track the water industry and how newer approaches can help clusters better identify their innovation capability.

The first step toward this process will be to establish sound methods to define water technology industry activity. Any definitions generated will need to be modern and holistic to promote innovation across various subsectors of the water technology industry. The ability of cluster organizations and/or regions to evaluate, quantify, and map their water technology industry activity will offer recognition and continue to push this vital emerging industry forward.

This article begins by exploring successful attempts to define and track industry clusters while pointing out institutional and other barriers that prevent the recognition of innovative industries and highlighting recent efforts by cluster organizations. It goes on to explore alternative data sources for innovative water technologies and emerging mapping tools that may help experts develop new methods for quantifying and mapping activity in the water technology industry. This article does not aim to suggest any single method, but to provide an overview of potential methods and data sources in the hope that each region will continue to grow and define itself using this cumulative knowledge.

BACKGROUND

The US water industry

In 2007, it was estimated that on the national scale, the US water industry accounted for \$120 billion, or about 1% gross domestic product (Grigg 2007). In 2015, Environmental Business International estimated US water industry revenues grew 3% that year, generating \$160 billion.

(WaterWorld 2016). In a report evaluating the future of Massachusetts' water technology industry, one research firm stated: "While still nascent, the water technology industry has progressed to the point that it is now an increasingly organized sector ready to be counted and tracked" (Mass CEC & Battelle 2015).

The way humans interact with water involves trade and production by traditional water utilities; however, services and technologies associated with water span traditional industry definitions and have strong footing in various sectors of the economy. The US water industry is often described as the "water utility industry" or the "water and sewage treatment" industry, when in fact the water sector is far more complex (Picou 2014, Grigg 2007). Updated definitions have been put forth in recent years by state or regional analysts, as well as a few academics, but there is still no agreement within the United States or internationally as to which groups should be included in the term "water industry." The EU recently decided to name water as an "emerging industry category" inclusive of both ocean and freshwater technologies, services, and research (Ketels & Prostiv 2014). In this article, the term "water industry" is used broadly to describe those who affect and/or participate in water

management, processing, and trading within the water sector. This group includes utilities, private companies, supporting organizations, the academic community, and regulators.

Industry classification

In the United States, most national economic data are collected using North American Industry Classification System (NAICS) codes. The codes may be presented at any level from two through six digits, as the categories become more specific. Even at the six-digit level, NAICS codes are typically not specific enough to capture emerging industries (Monnard et al. 2014). In an ideal world, industries would be tracked at every stage of their development, from infancy to maturity. This is not the case with the current NAICS, meaning emerging industries do not benefit from the same long-term, uniform national method of tracking as established industries. NAICS data are used by both private industry and government for purposes such as contracts, state and federal regulations, tax purposes, legislative issues, and various applications of economic data analysis. In addition, the US NAICS is only open for review every five years, meaning any changes to the system require extensive planning.

The Bureau of Labor Statistics (BLS) attempted to address this challenge in its work on “green” NAICS codes, which includes entities that produce “green” goods and services and/or provide services that benefit the environment or conserve natural resources. After collaborating with industry groups, government agencies, stakeholders, and the public, BLS released a list of “green goods and services” (BLS-GGS), which specifies that 30% of NAICS codes (325 industries) may be associated with “green jobs.” Beyond this, BLS used a complex sampling method to survey entities and generate a “green percent” of employment in each of the 325 industries. BLS was then able to calculate employment estimates of “green jobs” at the national and state levels for 2010 and 2011 (BLS 2013).

Even within the broad area of green/clean technologies, water technologies are not as easily distinguishable as in other industries. For example, in the energy sector, renewable energy technologies are easily separable from fossil fuel and nuclear technologies, while in the water sector, there has yet to be a precise widespread definition agreed upon by experts distinguishing innovative water technology (Partzsch 2009).

The BLS method brings to light an important complexity to using NAICS codes to describe activity in highly specific industries. For innovative clusters focusing on cleantech or water technology, generating a list of codes that capture regional industry activity is not enough. Accurate estimates of employment and other economic activity using NAICS data will require more specific breakdowns within these codes.

Industry clusters

In 2014, The Harvard Business School Institute for Strategy and Competitiveness, in partnership with the US Department of Commerce and US Economic Development Administration, launched the US Cluster Mapping Project, an online national cluster mapping tool intended to “provide rigorous and relevant cluster definitions for policymakers, practitioners, and academics” (HBS 2014). The tool identifies clusters quantitatively, using

various national economic data including input/output tables, NAICS codes, county business patterns, and employment statistics.

As part of its study, Harvard released a set of 51 “US Benchmark Cluster Definitions”. On the US Cluster Mapping website (www.clustermapping.us/), the definitions can be exported into an Excel file that lists cluster and subcluster definitions. There are two clusters relating to water: (1) environmental services, which includes waste collection, waste processing, and other waste management services, and (2) water transportation, which includes water passenger transportation, marine transportation services, and boat building and repairing (Delgado et al. 2013). The subclusters related to water are generally limited to the areas of waste services, water transportation, and construction of water and sewer lines. There are no obvious categories that could capture innovation in drinking water, wastewater reuse, storm water pollution, tidal energy, advanced monitoring, or other water-related technology.

In Canada and Mexico, efforts are well underway to complete respective counterparts of the US Cluster Mapping tool. Notably, Canada is also exploring alternative cluster analysis methods at the provincial/territorial level. Ontario’s Ministry of Economic Development and Growth is currently working to facilitate an indepth cleantech study throughout Ontario (an industry not included in the 51 Harvard Benchmark Cluster Definitions), which will ideally include a breakdown of the water technology industry within cleantech. This aligns well with the efforts of the province’s active Water Technology Acceleration Project, WaterTAP (Shirey 2016).

As a result of the difficulties of classifying water technologies, early stage or developing clusters encouraging the development of innovative water technologies struggle to gain recognition by quantitative projects such as the US Cluster Mapping Project. Even recent methodologies developed to better evaluate regional innovation systems often do not capture significant amounts of innovative activity based on the limited metrics available (Dempwolf 2012). To address this difficulty, water cluster organizations throughout the country have attempted to conduct small-scale regional economic impact studies, most using location-quotient-based methods like those used by the US Cluster Mapping Project. Location quotients are used to quantify the strength of regional economies, industries, or professions compared with the national average. Through these attempts to evaluate their cluster organization’s membership, several groups have aggregated lists of NAICS codes specific to their region. Unfortunately, none are comparable with each other because of the variety of definitions used (Accelerate H2O 2016, Baireuther et al. 2015, Minnesota DEED & Collaborative Economics 2015).

In contrast to the quantitative approach taken by the US Cluster Mapping Project and greater North America, the EU typically identifies and ranks clusters in a more qualitative manner. According to the European Secretariat for Cluster Analysis, clusters are individuals and may be qualitatively analyzed and subsequently ranked according to quality of management. European clusters have been benchmarked not according to economic impact, but by their importance to overall regional or national economic/industrial development strategy. Overall, the EU’s focus is on perfecting its cluster program and policies, allowing for the growth and development of innovative technology industries.

METHODS

A preliminary literature review was conducted to explore efforts to identify, map, and track clusters, efforts to define innovative industries, and national and international efforts to define and track the water sector. Various lists of industry and employment codes were gathered and examined as part of this literature review, including USEPA's list of Small Business Innovation Research (SBIR) awards specific to water technology across eight federal agencies. A brief analysis of this list was conducted for this report, using a combination of online searches and the website.¹ In addition, eight water technology cluster organizations of a certain level of maturity were interviewed to gather firsthand perspective. A set of five identical questions was sent to each group ahead of a phone interview, and a summary of the responses is included in this report.

FINDINGS

Recent efforts to capture the water sector

In 2014, the European Cluster Observatory (ECO) took Harvard's 51 cluster definitions and either combined or expanded the definitions to better suit the EU. Instead of using NAICS codes, the report uses the European NAICS code equivalent: NACE (Nomenclature des Activités Économiques dans la Communauté Européenne) codes. NACE codes track economic activity by industry throughout the EU and can be easily translated to or from NAICS codes for comparison using the ISIC system (International Standard Industrial Classification of all economic activities) as an intermediate. In the 2014 ECO definitions, the water sector is scattered across multiple European clusters. For example, the code for water collection, treatment, and supply lies in "environmental services," along with two codes relating to hazardous waste collection and disposal and one code for recycling. Other water-related codes, such as engineering and technical testing, fall under "business services," while the code for construction of water projects falls in "construction products and services." The codes for research and development in biotechnology and in natural sciences and engineering both fall in "education and knowledge creation."

Though the water sector remains divided in ECO's list of existing European clusters, the group made a notable effort to look toward the future by including a section on emerging industry clusters. Using employment data, ECO identified 10 new European clusters predicted to become emerging industries. The report includes a method and appendix of these emerging industry group definitions, one of which is termed "blue growth industries." The category includes a variety of fishing, tourism, manufacturing, water transportation, electricity generation, and construction codes. There are also a few codes for research and development in engineering, technical testing and analysis, and technical consulting, as well as water collection, treatment, and supply (Ketels & Prostiv 2014). The group of codes associated with blue growth is arguably somewhat broad; however, ECO has taken an important step in recognizing anticipated industry growth across the EU in the areas relating to both marine and freshwater technologies. Interestingly, the blue growth category definitively includes electricity production and transmission, thus recognizing the

¹LexisNexis®, New York City, N.Y.

importance of water technology in the future of clean energy production and advancing the concept of the energy–water nexus.

In the United States, efforts to define the water sector nationally have been limited, but it has been recognized at the community and regional levels by various groups as an emerging sector. Several regions have gone a step further and have organized notable efforts to take advantage of their assets through both NAICS code and other types of regional industry analyses.

In 2014, Michigan’s University Research Corridor (comprising Michigan State University, University of Michigan, and Wayne State University) commissioned a report detailing the value of higher education research institutions to water-related research and innovation. The report classified Michigan’s economy into two major sectors related to water: (1) core water products and services (i.e., water technology producers and service providers), and (2) water-enabled industries, which include entities affected by changes in the quantity and quality of available water. A list of seven four-digit NAICS codes is identified in the report, which together describe the industries that make up Michigan’s Core Water Products and Services economic sector (Rosaen 2014).

In 2009, Milwaukee, Wis., established a regional water technology cluster called The Water Council. In the development process, Milwaukee learned it has an interesting regional concentration of water solution manufacturers as well as a concentration of academics with water interests. Sammis White, a professor of urban planning from the University of Wisconsin– Milwaukee, has been working for 10 years to define local water technology companies using NAICS codes. Using a refined list of 34 six-digit NAICS codes, White and his graduate students have performed in-depth analyses of companies by performing individual research, conducting phone calls, and so on, to generate a continuously updated list of water technology companies in the region. The Water Council’s definition of the water technology industry differs from that of Michigan and others in that it excludes water users, water and wastewater utilities, and service providers, focusing instead on water technology producers (White 2016).

In 2013, as part of an effort to boost the workforce in the water technology sector, the Nevada Governor’s Office of Economic Development (GOED) analyzed the state’s growing water technology industry sector. Using a method similar to that used by The Water Council, industries were classified as either low, medium, or high priority, which, in Nevada’s case, was to focus on efficiency and innovation. From this analysis, a final list of 44 NAICS codes was compiled to not only identify water-related companies in the areas of aridity and water supply and efficiency, but also the occupation codes of workforces staffed by these companies. These “in-demand” occupations are reviewed by employers on the Governor’s Workforce Investment Board Natural Resources Sector Council. This work led to the development of the current Nevada water technology cluster organization, WaterStart. The organization identifies technology development projects that meet Nevada’s priorities and needs, with end-user goals in mind. Each year, WaterStart reports growth metrics to GOED based on the number and types of projects completed (Potts 2017).

The Texas water cluster, Accelerate H2O, has been working to gather information on the impact of the water sector on regional employment for several years. In a 2015 report, it used methods from the US Cluster Mapping Project, including applying a location quotient analysis to statistics such as employment, job concentration, and wages to compare the water sector in Texas with other states and regions. The report also included an examination of subsectors within water, such as construction, manufacturing, and services, and identified a primary list of NAICS codes associated with these sectors (Accelerate H2O 2015). In a subsequent 2016 report, a full list of NAICS codes is included and is used for analysis of the Texas water sector workforce. The list includes a variety of codes within agriculture, fishing, hydroelectric power, water supply, engineering services, water transportation, research and development, consulting, manufacturing, beverage production, conservation, construction, and more (Accelerate H2O 2016).

Also in Texas in 2015, the CleanTX organization used a replicable method to evaluate the regional economic impact of the clean technology sector in the greater Austin area. Its report includes a list of four-digit NAICS codes along with employment statistics and gross regional product contributions to generate evidence of economic impact of the sector. Notably, CleanTX also used a method from BLS. This method attributed specific percentages of each industry code to clean technology sector activity (Baireuther et al. 2015). While the BLS-GGS list exists for clean technologies, a similar list has yet to be developed for the water sector.

Innovation in the water sector

Innovation in the water industry cannot be easily tracked using NAICS codes; therefore, clusters are using various methods and data sets to identify water innovation activity. This section provides a brief analysis of the types of innovation taking place in the water sector using data from the SBIR program. This US Small Business Administration program is designed to stimulate the development and commercialization of high-tech innovation by providing federal research and development funding to small businesses in the United States on a competitive basis (SBA 2017). SBIR award data have been used previously in studies as a proxy for locating innovation (Dempwolf 2012). USEPA's Environmental Technology Innovation Clusters (ETIC) Program began tracking SBIR award activity specific to water technology in 2006 and has continued adding projects to a database annually.

The companies included in the following analysis were awarded SBIR funding between 2006 and 2015 for innovations in water technology. NAICS codes were available for 385 of 387 companies that received awards. In total, the 385 companies were distributed among 97 six-digit NAICS codes. The top 10 codes captured 54.7% of the companies, with the top two codes accounting for 32% of the list (Figure 1).

The “engineering services” code captures a significant amount of small businesses working on innovations in the realm of water technology, yet this code is rarely listed in regional efforts to capture water sector activity. The “custom computer programming services” and “computer systems design services” codes also appear in the top 10, yet would not typically be associated with water technology. The 45% of companies that fell into “other” categories

were spread across a wide variety of industry codes, which may suggest NAICS codes are not an accurate data source for tracking activity in innovative industries like water.

Next-generation mapping techniques

Knowledge maps are an emerging method of capturing the regional industry potential of innovators and researchers. Knowledge mapping is a tool that may be used to enable collective learning, forge relationships between regional actors, and aid in the decision-making process for regional policy. The design of regional knowledge maps "...requires capturing all the information about the regional competencies composed by infrastructures, structures, resources, actors, knowledge, and social capital. The collection and the representation of these elements present a number of challenges that must be resolved" (Garcia-Alsina et al. 2013). One of the challenges in creating knowledge maps is accurately defining the actors involved. This creates a barrier to developing knowledge maps for water technology, as regional definitions vary greatly.

Elsevier and the Council for State Governments produced a 2015 report that was intended to stimulate discussion within states regarding the prioritization of higher education research funding and how a state's policies align with its research goals and expertise. The report suggests that by creating a state or regional knowledge map, states or regions can better strategize the way they fund research to maximize return on investment. The study uses a metric called a "fieldweighted citation impact" that compares two states or regions on the basis of the number of citations for articles published within an academic topic in the same year. The report includes a graph that compares a state's publication output by percentile with its overall field-weighted citation impact, which helps display that quality research is taking place across the country, while vast quantities of research are coming from a few states (Elsevier & CSG 2015). This is possible evidence that measuring the number of patents or journal articles published in a state or region is not enough, and fieldweighted citation impacts may serve as a more accurate metric to display a state or region's research strength in an industry. Depending on the data and search techniques, this metric may be of use moving forward for innovative water technology. However, it should be noted that technology transfer and/or licensing is not addressed via this metric.

There are many companies in the economic development space with capabilities in knowledge mapping that could be resources for regions with interest in assessing and further developing their capacity in the water technology sector. A variety of data and software from government and private sources is also available.

Social network analysis is another avenue for looking at locational innovation activity down to the county and even zip code. Social network analysis studies the patterns of relationships that connect actors, such as authors of patents and publications, licensees, and manufacturing firms in this case. According to Scott Dempwolf, a practitioner and developer of social network models for economic development at the University of Maryland, College Park, these tools can "identify specific clusters of firms with high potential for manufacturing job growth" (Dempwolf 2012).

One possible path forward is to combine traditional cluster mapping with knowledge mapping and other mapping tools to identify geographic concentrations of water technology invention, employment, and commercialization. Some regional studies of this type already exist. As mentioned previously, Accelerate H2O evaluated the water sector in Texas using a combination of techniques and data sets. The Massachusetts Clean Energy Center also published the 2015 Massachusetts Water Technology Roadmap, which estimated economic activity of the water technology industry in the state. The study involved the use of analytic software from the IMPLAN Group and Battelle, which relied on data from BLS. The report estimated and projected water technology industry employment, using primarily company survey data and the Hoover's Inc. database.² Measures of water technology innovation, patents and associated supportive infrastructure, SBIR grants, and business incubators and accelerators in the state were also tracked (Mass CEC & Battelle 2015).

Potential foundations for future methods

Identifying the emerging innovative water technology industry in the United States may include tracking various economic, research-based, and knowledge-based factors. Depending on the characteristics of a region's water technology industry, there are various ways this may be approached.

By building on the US Cluster Mapping Project, it may be possible to create a method to capture innovative industries similar to the algorithm by Delgado et al. (2015) by incorporating economic data unrelated to NAICS codes and emphasizing knowledge mapping elements. The methods already include evaluating knowledge clusters, or groupings of industries that have a common science/technology base, by examining the relevance of academic disciplines and using US Patent and Trademark Office data (Delgado et al. 2015).

Drawing further ideas from the realm of knowledge mapping, the use of data such as field-weighted citation impacts, overall research outputs, academic patent citations (formal citations of academic publications in industry patents used as a proxy of measuring academic impact on research and innovation), and interstate research collaboration potential, or "Salton's measure of collaboration strength," may hold value for identifying innovative industry activity (Elsevier & CSG 2015).

Potential new methods include examining concentrations of federal research funding through SBIR for water-related innovation to identify startups, using a novel approach to identify large water technology firms, examining other professional and trade organization memberships (e.g., AWWA), tracking changes in water utility governance and procurement policies that place greater focus on innovation, and tracking licensing agreements to see what percentage of water technology patents are actually moving from the research and development phase into the marketplace.

There are also several potential new data sets, including examining North American Product Classification codes, which are under development by the United States, Canada, and

²Dun & Bradstreet, Short Hills, N.J.

Mexico. This system may serve as a way to introduce flexibility into new codes detailing water technology products (Jones 2017). In addition, US trade is monitored using harmonized system codes. The World Customs organization has created a list of 16 harmonized system codes relating to environmental trade; however, since these are not technically product codes, they have not been used historically to study specifically water sector-related activity (Sugathan 2013).

If new regional methods are developed to help define and track the US water technology sector, the goal would be to share techniques and move forward in the direction of collaboration. A good example is the national program Manufacturing USA. The program brings together nearly 1,200 organizations to encourage collaborative approaches to research and development for advanced manufacturing, with the goal to “strengthen regional economic clusters by boosting innovation and collaboration through increased connectivity.” More than eight organizing institutes centralize research facilities and resources, sharing results and funding throughout the program to encourage networking and collaboration between stakeholders. Manufacturing USA addresses the “valley of death” between research and commercialization by convening members that conduct work along different parts of the research and development spectrum. “Institutes deliver greater return on research and development spending for members than they could each achieve on their own. Co-development of technology results in cross-industry and cross-company sharing of information that accelerates technology transition and advancement” (Deloitte 2017). The Manufacturing USA model serves as one example of a successful collaborative technology development program based on specific industries.

US water technology cluster organizations

USEPA’s ETIC program works with 18 recognized clusters and helps support cluster organizations by sharing best practices, connecting the organizations to one another to encourage collaboration between them, and maintaining an updated inventory of them on its website (USEPA 2016). In addition to reviewing reports and studies performed in Europe and the United States, the authors interviewed eight US water cluster organizations (simply termed “clusters” in this section) recognized by the USEPA ETIC program (Table 1).

These organized clusters have significant differences including funding sources, geographic focus, and whether they are member-based. Because of the conversational nature of the responses, the information gathered is summarized below in paragraph format. The five interview questions were as follows:

1. Has your cluster organization performed any selfassessment to characterize assets for water technology innovation (such as patents, research and development, private companies, utilities, startup assistance, funding, and/or other assets)? If so, please elaborate.
2. Does your cluster organization measure its impact in the local community or region? If so, what metrics are used? (e.g., job creation, dollars invested)
3. Harvard’s US Cluster Mapping Project relies on NAICS codes and other national economic data, including employment statistics, to compare local industry

activity to national levels of activity and pinpoint regions of industry strength. Has your cluster ever considered performing an inventory of your membership using economic data to generate evidence of a water technology cluster in your region? If a methodology were developed, might you consider doing this in the future?

4. On the basis of your experience, how would you define the US “water technology industry”?
5. New NAICS codes are proposed and published every five years. As this industry continues to develop and expand, do you think that a US industry code (e.g., able to track employment) describing water technologies and/or cleantech would be beneficial to your cluster organization?

US water clusters continue to grow rapidly, but according to many, the water industry is perceived to be highly fragmented, and regional economic impact is hard to measure. The national industry classification system in its current state is considered by most to be too broad, which makes it difficult to tease out a specific sector for special attention, particularly an innovative industry (Zoldoske & Petersen 2017). Many clusters remain doubtful of the value of NAICS codes for defining innovative industries, and it is questionable whether it may be possible to find a purpose for them within new mapping methods.

Certain clusters have worked either internally or with third-party consulting firms to conduct an accounting of cluster assets (e.g., companies, research institutions, startup resources, testing facilities, patents). Several clusters found the results of asset mapping efforts, combined with employment data, produced regional themes, or cluster strengths, with a focus on technology segments. For some of these clusters, self-definition has come by emphasizing these regional industry specialties, such as agriculture, maritime, information technology, and infrastructure (Gay & Murphy 2017, Jones 2017). Other clusters have found self-definition through an eco-region approach, which designs the cluster around a regional water resource, including using the cycle of water use to link regional players into the cluster effort (Baunach & Stubbs 2017).

Several of the cluster organizations had received state or local funding that helped determine what types of companies and organizations were counted and prioritized. In Nevada, GOED first analyzed the regional water industry, creating a list of relevant NAICS codes and regional priorities. WaterStart receives funding from GOED, and it continues to work closely on water innovation programming (Allen & Shanahan 2017, Potts 2017).

Cluster organizations also often had a client focus, which led to further growth. Clusters in Nevada, greater Cincinnati, and Colorado solicited their membership to provide technology challenges that needed to be addressed. Challenges were published in venues such as a “reverse pitch” event in which a regional network of utilities, in the case of Cincinnati, presented their technology needs to an audience of vendors and developers. These challenges prompted companies already within the region, as well as some from outside, to participate with technology solutions, presumably further enlarging the cluster membership (Krueyer 2017). Some clusters ignored NAICS codes altogether in identifying assets and recruiting participants. For example, the Colorado clusters used memberships from regional

chapters of water technology-related trade organizations as a starting point to identify and contact potential member companies and organizations (DeCoursey 2017).

Many clusters shy away from using traditional economic metrics to measure impact and growth. They often place more value on community engagement and awareness, as well as tracking technologies tested, the value of those technologies, attendance and engagement at annual cluster events and meetings (networking), and membership growth (Crisp & Silk 2017, Gay & Murphy 2017, Jones 2017). Still others measure growth and success on the basis of requirements from grants and other funding sources. The BlueTech Valley cluster has leveraged grants to support incubation and acceleration of new water technologies, which it has found to be a mutually beneficial way to attract companies while also targeting regional challenges related to water use efficiency and water quality (Zoldoske & Petersen 2017).

To foster collaboration and growth, certain clusters are already active internationally. A number of clusters are pushing for a stronger national platform that will connect clusters into one large “cluster of clusters” (DeCoursey 2017). Other clusters are pushing closer collaboration with the clean energy sector and emerging cleantech clusters (Gay & Murphy 2017). While many similarities exist between these emerging clusters, each region is currently working individually to grow existing companies and develop and attract additional water technology companies. In total, the clusters have amassed a vast amount of data that, if combined, could lend itself to enhanced collaboration and continued growth.

CONCLUSION AND RECOMMENDATIONS

The definition of the term “cluster” continues to differ greatly both nationally and internationally. As water technology cluster organizations continue to form, no clear agreement has been reached regarding what entities “belong” in the water technology industry. There have been notable efforts to group NAICS codes that apply to cleantech and green entities, but efforts to group NAICS codes relating to water technology have been relatively small, and in the United States, primarily region-specific. Water technology continues to evade national economic analyses, specifically the US Cluster Mapping Project. Europe has taken some steps to recognize water as an emerging industry worthy of attention, and Canada has taken several steps to analyze its cleantech sector. In the United States, cluster organizations have used various techniques to find entities related to water technology, some using NAICS codes and some choosing other data sources. Innovation in the water sector can be equally difficult to pinpoint, as SBIR data shows water-related research spread across many NAICS codes. New methods such as knowledge mapping, using academic and patent-based data, and social network mapping may lead to advances in cluster identification techniques for emerging industries.

To protect the environment and public health from ever-increasing water quantity and quality challenges, continued development of innovative technologies in the water sector will be crucial. USEPA has realized this need through its work helping communities comply with the national Clean Water and Safe Drinking Water Acts and has taken steps to support water technology development and commercialization through its ETIC program and other

initiatives. The efforts of the USEPA, along with other agencies and researchers, and efforts around the globe, will be necessary to move this industry forward.

Recognizing emergent industry clusters may be as important as identifying current clusters. The EU has already taken steps to identify and support future clusters that exist outside of traditional definitions, including the water sector. Moving forward, it will be critical for the United States to bring national attention to emerging industries such as water technology and cleantech.

New efforts to define water technology clusters should be guided by a mission to achieve national and global competitiveness through collaboration. Several countries, including Israel, the Netherlands, and Singapore have national approaches to water technology management and export, while the US industry is not yet as cohesive. As stated by Deborah L. WinceSmith, president, Council on Competitiveness, “In a knowledge-based economy, economic growth is inextricably linked to the capacity for innovation—the ability to transform knowledge and ideas into new products, processes or services. Healthy and innovative regional economies are the foundation of US competitiveness” (Council on Competitiveness 2005).

Future research should investigate methods to capture water innovation activity nationally, in conjunction with methods for identifying, defining, and strengthening possible clusters of water technology activity. Methods that take into account the diversity of water cluster values and targeting efforts, while lending validity to cluster strength by using metrics beyond national economic data, need to be developed. Additional research will ideally bring a national focus to the economic area of water technology innovation. The recognition of community and regional water cluster efforts is a vital step toward encouraging continued growth in this sector and ensuring effective technologies will be available to solve the water challenges of tomorrow.

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Biography

Allison R. Wood graduated cum laude in 2016 with a BS degree in environmental engineering from the University of New Hampshire, Durham, N.H. She has firsthand

experience in drinking water technology development, and specifically the removal of harmful disinfection byproducts. Upon graduation she accepted a research position with Oak Ridge Institute for Science and Education (ORISE) as a fellow assigned to US Environmental Protection Agency's (USEPA's) Office of Research and Development, Environmental Technology Innovation Clusters Program. As of July 2017, she left ORISE and USEPA to pursue graduate studies. Teresa Harten is a senior cluster development specialist (retired) and Sally C. Gutierrez.

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FIGURE 1.

Top 10 North American Industry Classification System (NASICS) codes for companies awarded Small Business Innovation Research (SBIR) grants in water treatment between 2006 and 2015

TABLE 1

Us water cluster organizations selected for interviews

US Water Cluster Organization	Location	Technology Emphasis	Representative(s) Interviewed	Website
Akron Global Water Alliance	Akron, Ohio	Drinking water, wastewater, infrastructure, algal blooms, and toxin monitoring and control	Ken Crisp, David Silk, and Jessica Glowczewski	akronglobalwateralliance.com
BlueTech Valley	Fresno, Calif.	Agriculture waterenergy-food nexus	David Zoldoske and Helle Petersen	bluetechvalley.org
Cleveland Water Alliance	Cleveland, Ohio	Smart water, biomimicry, freshwater lake system monitoring and modeling	Dorothy Baunach and Bryan Stubbs	clevelandwateralliance.org
Colorado Water Innovation Cluster	Colo.	Water efficiency, water reuse, water-energy-food nexus, drinking water treatment	Louann DeCoursey	co-waterinnovation.com
Confluence	SW Ohio, N. Ky., SE Ind.	Drinking water, wastewater treatment, combined sewer overflows, monitoring, and modeling	Melinda Kruyer	watercluster.org
Maritime Alliance	San Diego, Calif.	Ocean, maritime, and freshwater	Michael Jones	themaritimealliance.org
North East Water Innovation Network (NEWIN)	Boston, Mass.	Drinking water and wastewater treatment, monitoring, on-site sewage disposal	Marcus Gay (NEWIN) and Michael Murphy (Massachusetts Clean Energy Center)	newin.org
WaterStart	Las Vegas, Nev.	Water efficiency, drinking water treatment, water reuse, smart water, mining, commercial buildings	Bob Potts (Nevada Governor's Office), Nathan Allen, and Rebecca Shanahan	waterstart.com