New England's Cleantech Innovation Landscape

A Snapshot of a Growing Cluster

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Foreword

Since NECEC formed in late 2006, our core mission has included support to early-stage cleantech innovation across the region. The 2011 creation of the NECEC Institute and the awarding of a i6 Green grant from the US Department of Commerce allowed NECEC—for the first time in our short history—to carry out that mission in a meaningful way.

Over the past two years NECEC Institute has led a region-wide program, Cleantech Innovation New England, to accelerate the pace and scale of new cleantech ventures across all six New England states. As the NECEC Institute and its regional partners—including state agencies, incubators and other innovation accelerators—began carrying out activities of the i6 grant and evaluating businesses to provide direct financial support, it became clear that there was a need to understand the region's innovation resources and potential, and the gaps between start-ups and the critical resources they need to grow.

Over the past six months the NECEC Institute has led an analysis of how the region connects start-ups to critical resources, such as test sites, labs, development partners, and demonstration sites. The NECEC Institute collaborated with key partners from Northern Maine to Southern Connecticut as well as parts of New York to develop a snapshot of *New England's Cleantech Innovation Landscape,* showcasing the region's innovation resources and a handful of the many success stories.

I'm please to report that this research has identified more than 200 companies active in early-stage cleantech innovation as well as specific geographic areas where strong cleantech innovation clusters have formed. There is a budding water technology cluster in and around Boston, an energy generation and advanced chemical cluster in the "Pinecone Valley" along the southern border of Maine and a burgeoning electrochemical energy storage cluster in parts of Massachusetts, Connecticut and New York.

New England's Cleantech Innovation Landscape is by no means a comprehensive directory of all the cleantech innovative activity in our region, but it is an important step to characterize, measure, and expand the cleantech innovation ecosystem in New England and the Northeast. With this report, we have established a solid foundation. We look forward to working with regional stakeholders and partners to continue tracking cleantech companies, identifying and building innovation infrastructure, connecting entrepreneurs across the region and accelerating the growth of the regional innovation ecosystem.

Peter Rothstein
President, NECEC Institute

Executive Summary

Cleantech researchers, entrepreneurs, investors, corporate executives, and policy-makers across New England[1] are driving economic growth, stimulating creation of new jobs and businesses, and protecting the environment by enabling development of new and innovative clean technologies.

A series of recent studies have characterized the economic importance of cleantech at the state level,[2,3,4] but there has not been a regional analysis of the cleantech innovation cluster in New England. *New England's Cleantech Innovation Landscape* is the first New England-wide study of the cleantech innovation cluster. It establishes a foundation for measuring the progress of cleantech innovation, providing a snapshot of companies and supporting organizations *active in cleantech research and development (R&D) and commercialization activities*. It establishes benchmarks by which to gauge success of the regional cluster and also identifies areas where the region is – or could be – a leader in cleantech innovation.

New England's Cleantech Innovation Landscape identifies over 200 New England companies active in early-stage cleantech innovation. Between 2005 and 2013, these companies received over $100 million in Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) funding from the U.S. Department of Energy. They additionally raised over $1.1 billion in venture capital. Nine major cleantech sectors have been identified that make up the New England cleantech innovation cluster. Of these, the majority of cleantech innovation companies are primarily active in four sectors: energy efficiency, energy generation, energy storage and distribution, and chemicals and advanced materials. As described in Section 3.1, these four sectors show the greatest potential for cleantech in the region.

This analysis also identifies "innovation infrastructure" in the region, which includes governments, universities, non-profit institutions, and corporations that support cleantech technology research, innovation, and entrepreneurship. Innovation infrastructure is defined to include investment and capital providers; R&D laboratories, test-beds, and demonstration sites; business and marketing support services; and technical consultancies. In total, over 200 institutions were identified that provide innovation infrastructure for cleantech companies in New England (see Section 3.3).

Geographically, the majority of cleantech activity in New England – based on total investment, number of companies, and innovation infrastructure – is taking place in Massachusetts, specifically in or around the metro-Boston area. As described in Section 3.2, Massachusetts is home to a number of key resources and programs that drive cleantech activity, including world-class labs and universities, a robust financial services sector, and strong clean energy policies and programs.

Though Massachusetts is the hub of cleantech innovation in New England, there are also important pockets of cleantech innovation activity across the region (see Section 4). The "Pinecone Valley" along the southern border of Maine, for example, is home to a number of institutions that support cleantech,

[1] The New England region includes Massachusetts, Connecticut, Maine, New Hampshire, Rhode Island, and Vermont.

[2] **Massachusetts Clean Energy Center. (2013). Massachusetts Clean Energy Industry Report. Prepared by BW Research Partnership. Retrieved** from www.masscec.com.

[3] E2Tech. (2013). The Clean Technology Sector in Maine. Maine Technology Institute Cluster Initiative Program Award #144. Prepared by Innovation Policyworks and the University of Maine. Retrieved from www.e2tech.org.

[4] Navigant Consulting Inc. (2010). CCEF Technology Investment Strategy Study. Prepared for Connecticut Clean Energy Fund. Retrieved from www.ctcleanenergy.com.

especially within the chemicals and advanced materials sector. Similarly, Connecticut and Massachusetts are home to a number of electrochemical energy storage companies and supporting institutions, which drive development of hydrogen and fuel cell technologies, among others. Other states have also experienced recent cleantech successes – from the emergence of digital technology companies in Rhode Island that are solving energy transmission challenges to new ocean energy companies developing along the New England seaboard – all of which benefit from the region's culture of collaboration.

New England's Cleantech Innovation Landscape lays the foundation to measure and track the development of the regional cleantech innovation cluster in New England. Though additional work remains, this study shows that a robust cleantech innovation cluster has emerged in New England. By building strong networks, creating smart policy, and strengthening cleantech companies, regional leaders can transform New England's economy, moving it away from traditional fossil fuels and towards cleaner energy, thus driving innovation and achieving greater regional prosperity.

Acknowledgements

New England's Cleantech Innovation Landscape was commissioned by the NECEC Institute under the auspices of the U.S. Department of Commerce's i6 Green Partnership program. Kimberly Herb and Andrew Wilson of the NECEC Institute provided overall leadership to develop and implement this study.

The NECEC Institute is a leader in programs that support Innovation, Cluster Research, Economic Development and Workforce Development throughout New England. Its sister organization, the New England Clean Energy Council, is the lead voice for hundreds of clean energy companies across New England, influencing the energy policy agenda and growing the clean energy economy. Under the NECEC umbrella, both organizations share a common mission to accelerate New England's clean energy economy to global leadership by building an active community of stakeholders and a world-class cluster of clean energy companies.

NECEC Institute assembled a cluster analysis core team who contributed expertise and information to *New England's Cleantech Innovation Landscape* report. The core team includes:

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- *Alexander Barton*, Connecticut Center for Advanced Technology
- *Martha Bentley*, Maine Technology Institute
- *James Bowen*, Massachusetts Clean Energy Center
- *David Bradbury,* Vermont Center for Emerging Technologies
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- *Sally Griffith,* Massachusetts Clean Energy Center
- *Kim Herb,* NECEC Institute
- *Kenneth Jones,* Vermont Agency of Commerce and Community Development
- *Ryan Katofsky,* Advanced Energy Economy
- *Robert Kispert,* Mass Tech Collaborative
- Jeff Marks, E2Tech
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- *Andrew Wilson,* NECEC Institute

Neil Veilleux, Wilson Rickerson, Roland Devenyi, and Mary Stonaker of Meister Consultants Group (MCG) provided technical assistance and research services to complete this project. Neil Veilleux served as primary author of the report. MCG is a Boston-based consulting firm focusing on cleantech, sustainability, and climate issues in the United States and internationally. MCG specializes in market and policy analysis, program design and management, as well as stakeholder facilitation and dialogue.

This analysis builds on research from studies such as, *Measuring Regional Innovation: A Guidebook for Conducting Regional Innovation Assessments* by the Council on Competitiveness for the U.S. Department of Commerce as well as *Building a Successful Technology Cluster* by Maggie Theroux Fieldsteel of the U.S. Environmental Protection Agency. Additionally, a special thanks to Palmo Antonio Cavallo, Damir Gilyazov, Obiorah James Ike, and R. Aditya Raju, all graduate students at the Hult International Business School, who contributed additional research and analytical services to complete this project.

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1 Introduction: Innovative Capacity in New England's Cleantech Economy

The prosperity of a region hinges in large part on its "innovative capacity" – or the ability of a region to create and commercialize innovations.[5] Nationally, approximately 50 percent of GDP growth is attributed to advances in innovation, making it a necessary ingredient for regional economic competitiveness.[6] *New England's Cleantech Innovation Landscape* provides a snapshot of companies and supporting organizations that are engaged in clean technology research, development, and commercialization. These organizations – and the entrepreneurs, researchers, and policy-makers that support them – are drivers of cleantech innovation and economic competiveness in New England.

New England's Cleantech Innovation Landscape supports the following four objectives:

- Create a baseline of innovation output metrics – including the number of cleantech innovation companies, year of formation, and level of government and venture capital investment – in order to support analysis and evaluation of the New England cleantech innovation cluster over time;
- Identify the primary sectors and geographic distribution of cleantech innovation companies in New England;
- Characterize how innovation infrastructure – including regional assets like labs and testing facilities, strategic partners, and investors – support cleantech innovation in the region; and
- Explore the potential for cleantech organizations to work together and strengthen the long-term development of the cleantech cluster in the multi-state region.

This report represents the first step in a larger process to map, measure, and strengthen development of the New England cleantech innovation cluster. As described below, though New England is home to a vibrant cleantech innovation cluster, to date there has not been a comprehensive effort to measure its growth and development. *New England's Cleantech Innovation Landscape* is the first coordinated effort to characterize the cleantech innovation cluster across the region and is intended to support cluster leaders as they develop strategies that enhance regional economic competitiveness.

1.1 The Role of Clusters in Regional Economic Competitiveness

Clusters are defined as "geographically proximate groups of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities."[7] As described in Appendix C, the New England cleantech economy illustrates most, if not all, of the key traits of a cluster.

The cleantech innovation cluster is important for New England, because clusters enhance regional economic competitiveness. In particular, clusters provide the following benefits to regions:

- **Clusters improve productivity.** Companies located within a cluster have better access to specialized suppliers, skills, information, and training, all of which improve business productivity. Clusters also support development of specialized skills and relationships, providing special advantages to companies within the cluster. For example, firms may be able to access trained people and

[5] Porter, M. *Clusters of Innovation: Regional Foundations of U.S. Competitiveness.* Council on Competitiveness, Monitor Group.
[6] Council on Competitiveness. (2005). "Measuring Regional Innovation: A Guidebook for Conducting Regional Innovation Assessments." Prepared for U.S. Department of Commerce Economic Development Administration. ISBN-1-889866-26-1.
[7] Porter, M. *Clusters of Innovation: Regional Foundations of U.S. Competitiveness.* Council on Competitiveness, Monitor Group.

technology (from universities, consultants, etc.) within in the cluster at lower cost than they could if they had to develop the capacity internally.

- **Clusters foster innovation.** Interactions between cluster actors (e.g. entrepreneurs, scientists, engineers, market leaders, etc.) increase the ability to conceive of and develop new markets, products, or processes. Additionally, the presence of nearby suppliers and research institutions makes it easier for companies to engage in R&D, experimentation, and product innovation.
- **Clusters facilitate the commercialization of innovations.** Clusters support creation of start-ups, university spin-offs, as well as new business divisions at existing firms. Establishing new business ventures is easier in clusters because the inputs for success are more readily available. For example, universities and non-profits in the cluster provide licensing support, and investors (like banks, private equity, or venture capitalists) are actively looking for opportunities to invest in new products and businesses.[8]

Measuring, tracking and strengthening the cleantech innovation cluster will be important for future regional economic success. By characterizing New England's cleantech innovation cluster, this report aims to support policy-makers and cluster leaders improve productivity, foster innovation, and facilitate commercialization of new technologies in the region.

1.2 Report Structure

This report is structured as follows:

- **Section 2** describes the methodology used to conduct this analysis. This includes the definition of the cleantech innovation cluster, the company classification system, as well as an overview of the innovation infrastructure that supports technology development and commercialization in the region.
- **Section 3** describes the results of the *New England's Cleantech Innovation Landscape* assessment. It describes regional strengths of the cluster, focusing on the four sectors where the majority of New England companies are active. It additionally describes Massachusetts' role as the cleantech hub in region as well as the role of innovation infrastructure in driving that success.
- **Section 4** describes case studies of companies and innovation infrastructure, focusing primarily on promising areas that the core team and other stakeholders identified during workshops. In particular, it focuses on interactions between labs and testing facilities, strategic partners, and technology entrepreneurs.
- **Section 5** describes next steps for the cleantech cluster analysis. In particular, it lays out identified opportunities for continued collaboration across states.

[8] Porter, M. *Clusters of Innovation: Regional Foundations of U.S. Competitiveness.* Council on Competitiveness, Monitor Group.

2 Methodology: Characterizing Companies and Innovation Infrastructure in New England

New England's Cleantech Innovation Landscape was developed in close partnership with policy-makers, industry experts, and academic leaders. Representatives from all six states in New England formed a "core team" to guide development of this study, providing input and expertise to define cluster sectors, identify regional cleantech companies, define and identify innovation infrastructure and assets, and create a set of common metrics to track progress of cleantech in the region.

New England's Cleantech Innovation Landscape represents the first effort to characterize early-stage clean technology companies and supporting innovation infrastructure in the New England region. In doing so, the project team had to address a number of key challenges. Chief among these is the lack of a commonly agreed upon definition for cleantech.

Unlike large, well-established sectors – like oil, gas, or biotech – cleantech has neither a standard definition nor large, government-maintained datasets to support economic analysis. Consequently, numerous definitions have been used across the country to characterize cleantech at the state level. To the greatest extent possible, this report seeks to build on definitions and methodologies utilized in previous cleantech studies.

In particular, this report draws upon recent state-level clean technology assessments, including:

- The Massachusetts Clean Energy Center's (MassCEC) *Massachusetts Clean Energy Industry Report,*[9]
- E2Tech's *The Clean Technology Sector in Maine 2013*[10] (an assessment that was also supported by the Maine Technology Institute),
- The Connecticut Clean Energy Fund's (CCEF) *Technology Investment Strategy Study,* and
- Research conducted by the Connecticut Center for Advanced Technology for the "Northeast Electrochemical Energy Storage Cluster."[11]

The following section describes the methodology used to complete this assessment. Additional detail is provided in Appendix D.

2.1 Cleantech Definition and Company Classification

The cleantech definition and methodology developed by the core team states:

> *The cleantech innovation economy encompasses economic activity – measured in terms of establishments and early-stage investments – that produces new, innovative, and sustainable technological goods by organizations actively engaged in the commercialization process.*

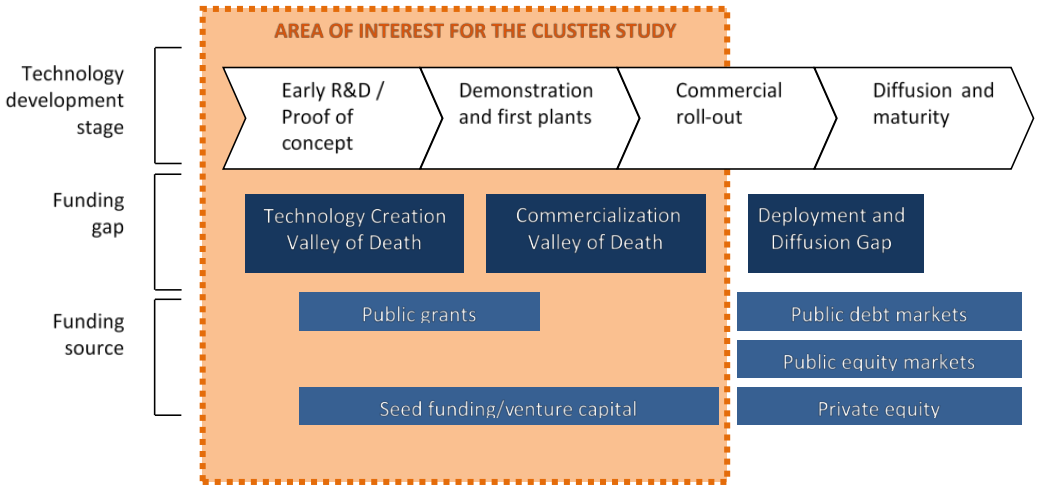
Practically speaking, to meet this definition, companies had to pass two tests. First, companies must be developing a product with value that is unique to a cleantech sector. For the purposes of this analysis,

[9] Massachusetts Clean Energy Center. (2013). Massachusetts Clean Energy Industry Report. Prepared by BW Research Partnership. Retrieved from www.masscec.com.
[10] E2Tech. (2013). The Clean Technology Sector in Maine. Maine Technology Institute Cluster Initiative Program Award #144. Prepared by Innovation Policyworks and the University of Maine. Retrieved from www.e2tech.org
[11] Northeast Electrochemical Energy Storage Cluster. (2014). Hydrogen and Fuel Cell Development Plans. Retrieved from http://neesc.ccat.us/publications/development_plans.

the project team used the approach taken by the Brookings Institute cleantech study (and adopted by Maine cluster researchers), in which companies are included in this study only if they "add value [to cleantech products] using skills or technologies that are uniquely applied to those products."[12] In other words, if a company manufactures ordinary screws, which are used in cleantech products just as they would be in any other product, then the screw manufacturer will not be included in the definition. On the other hand, if a company manufactures a product that is uniquely applied to cleantech, like wind turbine blades, then it will be included in the study (provided it meets other requirements below).[13]

Second, the core team emphasized the need to focus on companies engaged in technology research, development, proof of concept, and demonstration activities. As illustrated in Figure 1 below, this includes companies that are developing innovative technologies that are positioned within the technology and commercialization "valleys of death."

Figure 1: Clean Energy Technology Development Spectrum.
The cluster analysis focuses on companies engaged in, and the organizations supporting, early R&D, proof of concept and demonstration activities.



In addition, as illustrated in Figure 2 below, the core team also identified nine major sectors in the cleantech innovation cluster. This classification system is based primarily on the taxonomy developed by the Cleantech Open (see Appendix D).[14] Because cleantech companies often work across sectors, some companies are cross-listed in up to three sectors.

With this classification system in place, the project team developed a database that catalogues businesses engaged in early-stage technology development in New England. The database tracks the name and website of companies, year of incorporation, company location/geography, clean energy classification (industry sector and segments), as well as major public sector and venture capital investments made in each company.

[12] Rothwell, J. et al. (July 2011). Methodological Appendix for Sizing the Clean Economy: A National and Regional Green Jobs Assessment. Metropolitan Policy Program at Brookings.

[13] It is important to note that this definition applies primarily to companies in the supply chain – and not to facilities that provide important innovation infrastructure or assets (see Section 0). Facilities listed in the innovation infrastructure and assets inventory have been flagged by the core team as very important for the cleantech innovation ecosystem – especially with regard to R&D and demonstration. Such facilities may also add significant value to other (non-cleantech) sectors.

[14] The Cleantech Open. (2013). "Categories." Retrieved from www2.cleantechopen.org/categories/.

Figure 2: Cleantech classification system. *The cleantech classification system enables stakeholders to group companies engaged in similar activities. It is based primarily on the taxonomy developed by the Cleantech Open.*

The project team reviewed a variety of sources to identify cleantech innovation companies active in the region, including U.S. DOE SBIR/STTR databases, ARPA-E awardees, state grantees, industry trade lists, among others. In total, over 200 companies were included in the cleantech innovation company database. While researchers made every effort to include as many companies as possible, it is not an exhaustive list. The database and this analysis should be considered a starting point for tracking cleantech innovation companies active in the New England region.

2.2 Innovation Infrastructure

Companies in successful innovation clusters, like the New England cleantech cluster, require robust "innovation infrastructure" to support technology research and entrepreneurship. Innovation infrastructure is generally defined as the resources and assets that support cleantech innovation. The core team emphasized the following resources and assets as essential:

- Scientific resources, knowledge, and talent at universities and other major research institutions, which can be deployed to support technology R&D;
- A robust local value chain, including companies providing R&D, manufacturing, marketing and distribution, and other services that support cleantech innovation;
- Business and investment resources that support the creation of new companies and commercialization of technologies in new or emerging fields.[15]

While a full catalogue of regional innovation infrastructure is beyond the scope of this report, the project team did conduct a high level survey of the programs and organizations in the region. Major innovation infrastructure categories surveyed are described in Table 1.

Table 1. Innovation infrastructure. *Innovation infrastructure provides resources and assets to support cleantech innovation companies*

Innovation infrastructure category	Programs and services for researchers and entrepreneurs
Investment and Capital	Strategic partner and investor network formation, seed funding or early stage investments, later stage funding and investments, investment banking, project development
R&D Laboratories, Testbeds, and Demonstration Sites	Research labs, engineering modeling, industry-specific test beds, product validation services and testing
Business Support Services	Accounting and bookkeeping, business plan development, incubators, interim and executive management, IT, legal, market research, monitoring and compliance, training and education
Marketing Support Services	Advertising and new media, marketing and communications, press and media, public relations
Other Technical Consultancies	Energy, environmental management, policy, manufacturing, R&D , strategy development services and capabilities

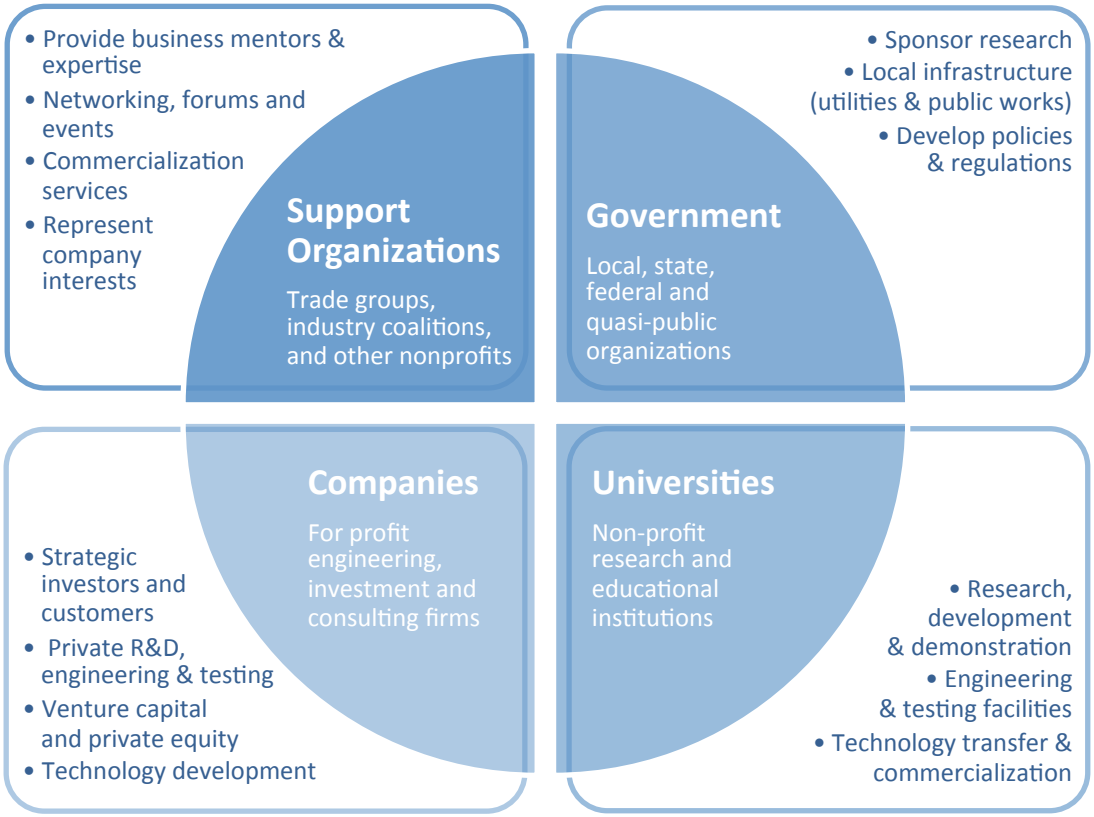
In addition, the core team emphasized the need not only to identify the programs, services, and assets that make up New England's innovation infrastructure, but also to identify the ways they are connected. Creating links between the public and private sectors is essential to fostering a strong cleantech cluster. It requires active collaboration between stakeholders across disciplines and organizations, and often depends upon the efforts of key influencers or champions.

The cluster wheel illustrated in Figure 3 below describes the typical roles and responsibilities of key types of organizations (support, government, companies, and universities), which provide innovation and commercialization infrastructure and also represent key stakeholders in technology

[15] Theroux Fieldsteel, M. (May 2013). Building A Successful Technology Cluster. U.S. Environmental Protection Agency. ORD/NRMRL/ETAV.

commercialization. This model, which was adopted from studies of other technology clusters,[16] was applied to the New England cleantech cluster. Section 4 includes case studies that illustrate some of the collaborative interactions between companies, universities, government agencies, and non-profit organizations. The core team believes that by exploring ways to strengthen the connections between these groups, cluster leaders will be able to develop strategies that further expand the cleantech innovation cluster.

Figure 3: Technology Cluster Wheel.[17] *Collaboration across stakeholder groups is necessary to foster innovation and provide resources, knowledge, and assets needed to develop a strong cleantech cluster.*



Finally, the project team facilitated a series of roundtables across New England to gather qualitative information on the state of the region's cleantech innovation cluster. Roundtables were structured to identify companies and innovation infrastructure across cleantech sectors as well as the ways that cluster actors collaborate (or could collaborate in the future). These roundtables were the source of many of the case studies discussed in Section 4 as well as the recommendations made in Section 5.

[16] ibid

[17] This figure is based on the Key Cluster Sectors as described in "Building a Successful Technology Cluster," which is in turn inspired by the Technolopolis Wheel. See: Raymond W., Smilor, D. & Gibson, G. (1989). Creating the Technopolis: High-technology development in Austin, Texas. *Journal of Business Venturing*, 4:1, 49-67.

3 The State of Early-stage Cleantech Innovation in New England

This section presents the results of the effort to categorize and describe the cleantech innovation cluster across the six states in New England. It describes the four cleantech sectors in which the majority of identified New England cleantech innovation companies are active and also provides an overview of the innovation infrastructure that supports these companies. This section also describes the resources, programs, and assets that support cleantech innovation in Massachusetts – the hub of the New England cleantech innovation cluster.

3.1 Overview of the New England Cluster

Project research identified over 200 early-stage cleantech companies across the six New England states engaged in early-stage clean technology development activities. These companies attracted approximately $100 million in Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR)[18] funding from the U.S. Department of Energy between 2005 and 2013. They additionally received over $1.1 billion in venture capital during that same time period (see Appendix A for a state-by-state breakdown).[19]

Over 75 percent of the early-stage clean technology companies identified are active in four major sectors:

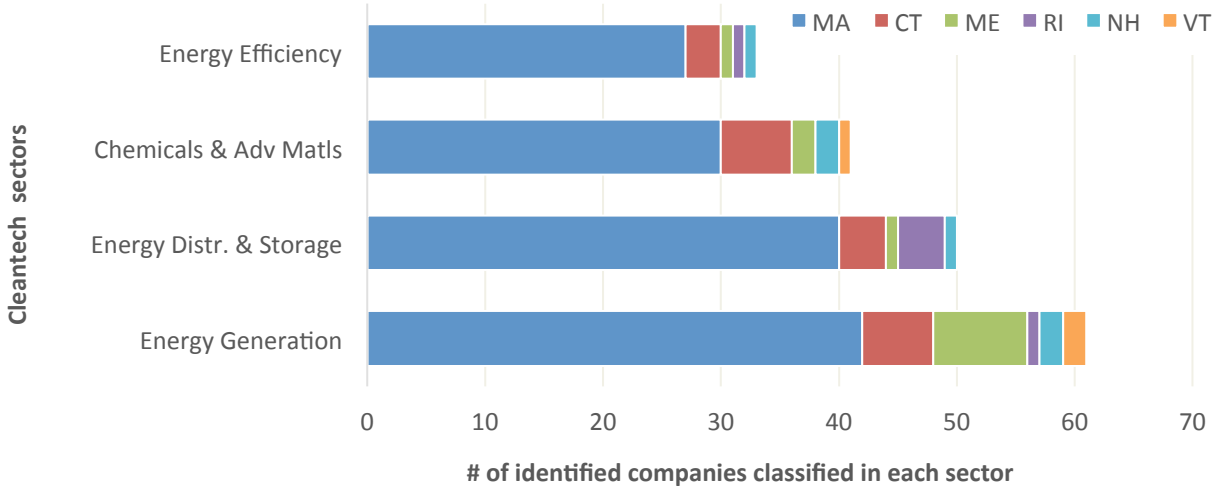
- energy generation,
- energy storage and distribution,
- chemicals and advanced materials, and
- energy efficiency.

Figure 4 shows the number of companies identified that are involved in each of these four sectors by state. The other cleantech sectors identified during the study – i.e. green buildings, agriculture and waste, information technology and communications, and water technology – are relatively small by comparison (under 15 firms each) by comparison, although there are signs that several of these sectors have promise for future growth.

[18] Through a competitive awards-based program, SBIR enables small businesses to explore their technological potential and provides the incentive to profit from its commercialization. See more at http://www.sbir.gov/about/about-sbir. Small Business Technology Transfer (STTR) is program that expands funding opportunities in the federal innovation research and development (R&D) arena. Central to the program is expansion of the public/private sector partnership to include the joint venture opportunities for small businesses and nonprofit research institutions.

[19] Due to the private nature of many venture capital deals, this estimate is likely lower than the actual number. Sources for this estimate include Crunchbase and PWC Moneytree.

Figure 4: Major sectors of New England companies engaged in early-stage cleantech
(see Appendix A for results in table format)



Of the four major sectors, **energy generation** is the largest, with 61 total companies identified. Key areas within the energy generation sector include solar, wind and bioenergy technology companies.

The **energy distribution and storage sector** is the second largest cleantech sector identified in the region. Within this sector 50 companies were identified that provide new technology solutions that support electricity delivery and/or provide residential, commercial, and industrial customers greater control over how or when energy is delivered. For example, this sector is primarily composed of electrochemical energy storage companies that develop batteries and fuel cells (most of these companies are part of the Northeast Electrochemical Energy Storage Cluster. See Electrochemical Energy Storage Case Study in Section 4). It additionally includes a number of companies that use compressed air or flywheels for energy storage as well as companies that develop technologies for electricity transmission and distribution. The latter group includes organizations like Utilidata (see Utilidata Case Study in Section 4), which is a digital technology company that provides grid management services.

The **chemicals and advanced materials sector** also has a large presence in the cleantech cluster, with 41 companies identified as being active in early-stage technology development. This includes companies that reduce or eliminate the use of hazardous substances in materials or chemical products. For example, a number of companies in this sector use nano- or bio-technology to develop cleaner, more environmentally sound products for use in energy or across the cleantech supply chain. It also includes a number of companies engaged in chemicals and manufacturing or creation of composites and other advanced structural materials (see Pinecone Valley Case Study in Section 4).

33 companies were identified in the **energy efficiency sector.** These are companies that develop technology to improve energy efficiency in residential, commercial, and industrial processes. Major areas of activity in this sector include building energy management and analytics, high efficiency lighting (especially LED lighting), and energy efficient HVAC systems. Due to the need to develop software and IT solutions to create building energy management solutions, a large number of energy efficiency companies are also cross-listed in the information technology and communications sector.

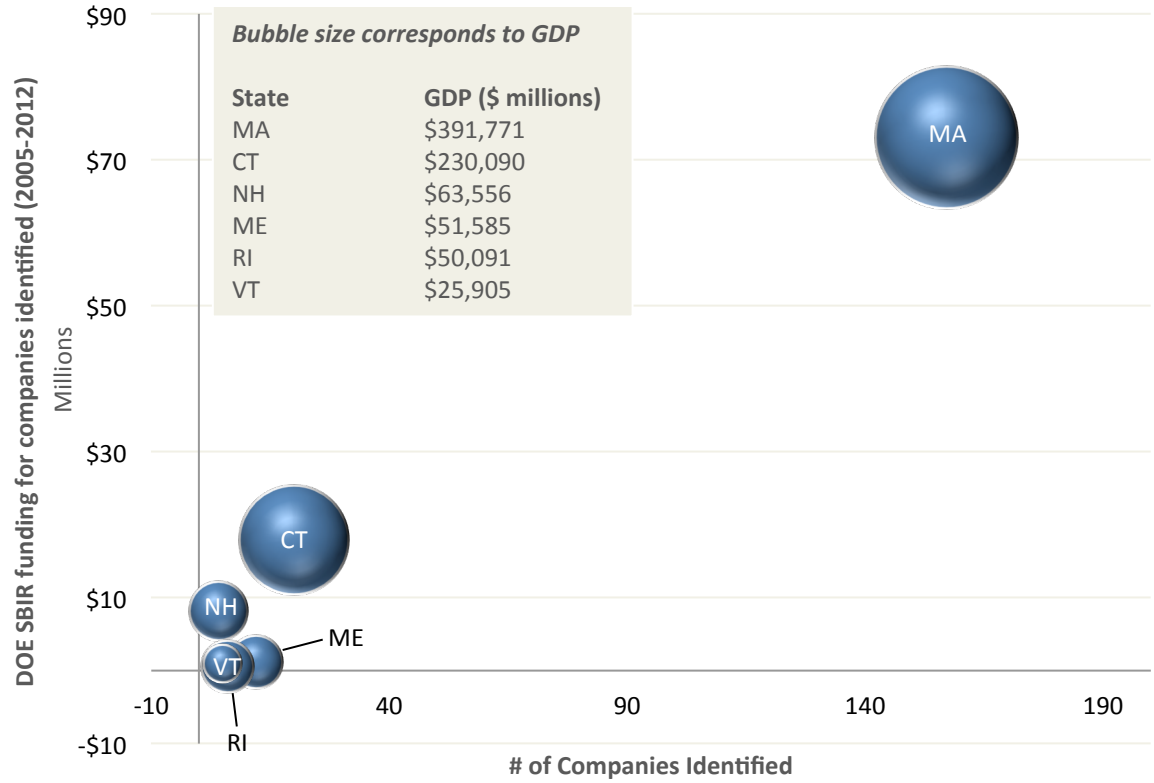
These four sectors have established a foothold in the New England economy and have potential to drive significant economic growth. Though a detailed analysis of these sectors is beyond the scope of this report, there are clear indications that they are closely interconnected, facing similar barriers and

requiring the support of financial, research, and strategic partners in the region. For example, the energy efficiency, energy generation, and energy distribution and storage sectors all face challenges establishing new customers, managing regulatory barriers, working within the constraints of conservative industries (utility, automotive, etc.), attracting sufficient financing for growth, and demonstrating the applicability of new technologies. Additionally, because many companies in the chemicals and advanced materials supply parts or technologies for the other three sectors (e.g. composite structures for wind energy generation or chemicals for biofuels companies), they also face many of the same challenges. Ensuring the robustness, resilience, and growth of these sectors will likely depend on the ability of companies to collectively address overarching barriers that inhibit cleantech market growth in New England and across the country.

3.2 New England's Cleantech Hub

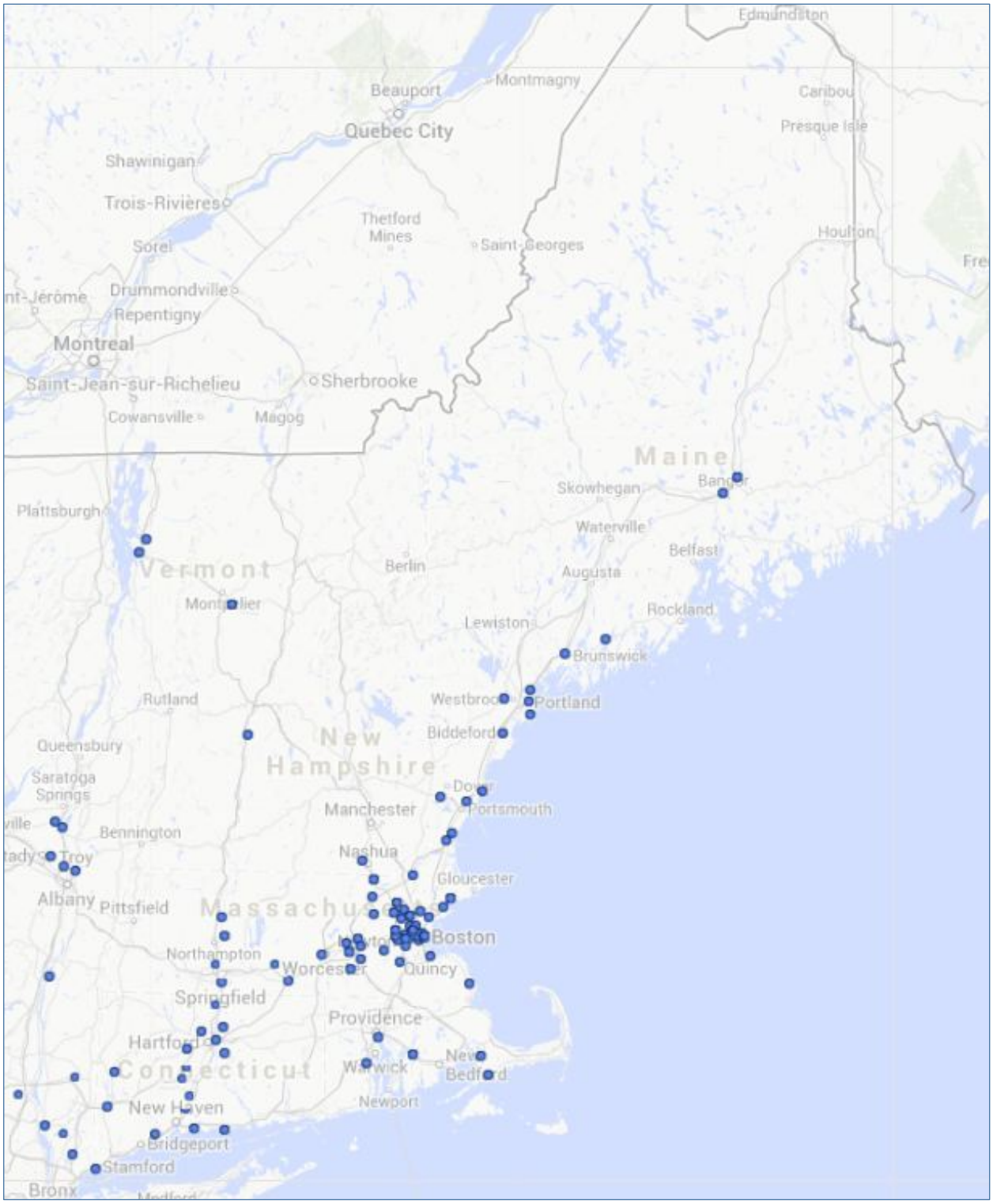
Geographically and economically, Massachusetts, specifically the metro-Boston area, is the hub of New England's early-stage cleantech cluster. As illustrated in Figure 5 and Figure 6 below, Massachusetts, and the metro-Boston area in particular, is home to the majority of the region's cleantech innovation companies (across all sectors analyzed in this report). Massachusetts companies have not only received the most SBIR funding in New England, but have also received the second most SBIR funding of any state in the country (second only to California).[20] Additionally, over 95 percent of the venture capital investments (by total dollar amount) identified in this assessment were made in Massachusetts companies.

Figure 5: Companies engaged in early-stage clean technology development activities, DOE SBIR/STTR funding, and GDP per state



[20] SBIR/STTR. "Awards." Retrieved from www.sbir.gov/past-awards.

Figure 6: Cleantech innovation companies active in New England

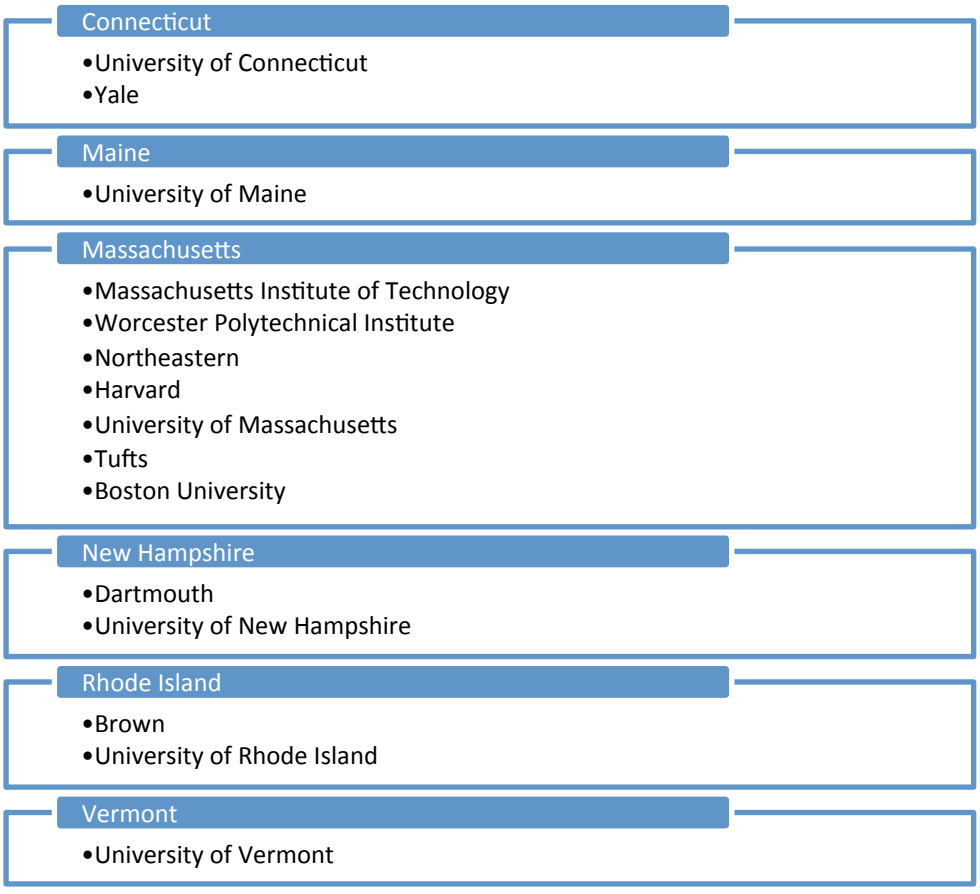


Massachusetts' leadership in cleantech innovation is attributed to several factors. Massachusetts has the largest economy in the region: its GDP is over 1.5 times the size of the next biggest economy (Connecticut) in New England, giving it a strong economic base on which to grow the cleantech economy. Massachusetts also has a long history of technological innovation and well-established infrastructure to support cleantech entrepreneurs. Regional stakeholders and experts highlighted Massachusetts' research labs and universities, robust financial services sector, and commitment to strong public policy as contributors to the state's strong cleantech innovation economy.[21,22] Each of these factors are described below.

3.2.1 Research Labs and Universities

Massachusetts cleantech research infrastructure includes seven of the 15 premier R&D universities identified in the region (see Figure 7), as well as non-academic research institutions such as the Massachusetts Wind Technology Testing Center and the Fraunhofer Center for Sustainable Energy Systems. Facilities such as these provide research, technology, or testing services for regional cleantech entrepreneurs.

Figure 7: New England Research Universities



[21] Massachusetts Clean Energy Center. (2013). Massachusetts Clean Energy Industry Report. Prepared by BW Research Partnership. Retrieved from www.masscec.com.
[22] Clean Edge. (2013). U.S. Clean Tech Leadership Index. Retrieved from www.cleanedge.com/.

During regional workshops, cleantech stakeholders reported that the entrepreneurial resources provided by MIT, in particular, best illustrate how R&D institutions in Massachusetts support cleantech innovation. In addition to world-class research labs, MIT has developed a number of programs to assist researchers with the commercialization of new technologies. This includes programs such as:

- **The MIT Enterprise Forum,** which builds connections between technology entrepreneurs and the communities where they reside and has produced extensive educational programs about entrepreneurship through a network of twenty-four chapters in Massachusetts and across the world.[23]
- **MIT Clean Energy Prize,**[24] which assists students to compete for prize money and to develop, evaluate, and refine entrepreneurial ideas – often in partnership with faculty team members.[25]
- **The MIT Technology Licensing Office (TLO),** which has consistently led the nation's universities in licensing technology to startup firms. The TLO is credited with pioneering a strategy of leveraging intellectual property from MIT to form companies based on the long-term roles and contributions of those companies as opposed to their short-term licensing value.[26]

According to a recent report, MIT's support for entrepreneurship among its students, scientists, and engineers has emerged as an important driver of the innovation economy in Massachusetts. Approximately 6,900 MIT alumni companies with worldwide sales of $164 billion are located in Massachusetts.[27] While not all of these companies are engaged in early stage cleantech innovation, it is clear that R&D universities with strong entrepreneurial programs like MIT can have a significant impact on cleantech growth and economic prosperity.[28] Regional stakeholders report that MIT's approach to technology commercialization could offer a promising model for cultivating cleantech innovation across New England and that enabling greater access to these types of resources could drive growth for new technology companies in the region.

3.2.2 Financial Services Sector

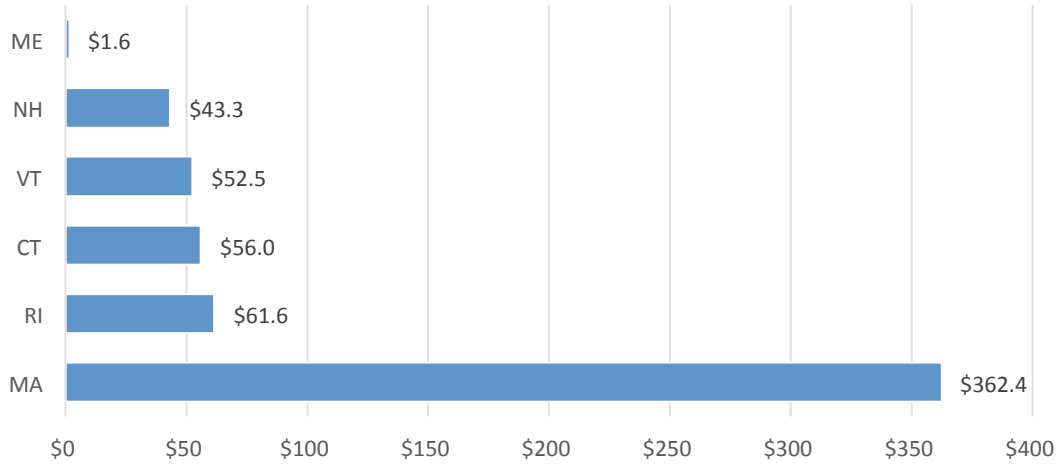
Massachusetts also benefits from a robust financial services sector, with a large geographic cluster of early-stage investment and capital providers working with clean energy and other technology companies. This includes venture capital investors such as Braemar Energy Ventures and Rockport Capital, among others.

As illustrated in Figure 8 below, venture capital investment in Massachusetts is significantly higher than in neighboring New England states (on a per capita basis across all economic sectors).[29] This is a trend reflected across the early-stage cleantech companies identified in this analysis as well. Over 95 percent of the venture capital deals tracked in this analysis occurred in Massachusetts companies. Stakeholders note this is due in large part to the geographical clustering of venture capital in the greater Boston region, which affords easier access to venture funding for Massachusetts companies (relative to other New England states). Participants at the roundtables across New England (including in Western

[23] For more, see www.mitef.org/.
[24] Also known as the US DOE National Clean Energy Business Competition – Northeast Regional Lead. For more, see http://cep.mit.edu/
[25] For more, see www.mit100k.org/.
[26] Kauffman Foundation. (2009). Entrepreneurial Impact: The Role of MIT. Retrieved from www.kauffman.org.
[27] ibid.
[28] ibid.
[29] State Science & Technology Institute. (2011). U.S. Venture Capital Dollars Invested Per Capita by State, 2005-2010. SSTI Weekly Digest. Retrieved from www.ssti.org/Digest/Tables/042711t.htm.

Massachusetts) suggested the need to implement strategies to increase access to financial resources present in the Boston area to support development of companies across the region.

Figure 8: Venture Capital investment per capita *(State Science & Technology Institute, 2010)*



3.2.3 Clean Energy Policies and Programs

Finally, strong public investment and sound cleantech policies create a fertile marketplace and improves opportunities for cleantech firms in Massachusetts,[30] a sentiment echoed by stakeholders across the region. In particular, cleantech leaders reported that the Massachusetts Clean Energy Center (MassCEC) is responsible for many policies and programs that encourage innovation and entrepreneurial development across the state and the region.

MassCEC is a quasi-public agency created in 2008 by the Massachusetts legislature and operating since 2009. It receives funding from the Renewable Energy Trust Fund, a systems benefit charge paid by electric ratepayers in Massachusetts.[31] In 2012, MassCEC invested over $33.5 million in clean energy projects.[32]

MassCEC is "dedicated to growing the clean energy sector from the ground up" by assisting companies with funding for research, targeting investments at companies that create local jobs, and fostering development of the clean energy workforce.[33] It supports cleantech innovators through a variety of programs. Several notable programs and policies that support cleantech innovation in the state include:

[30] Massachusetts Clean Energy Center. (2013). Massachusetts Clean Energy Industry Report. Prepared by BW Research Partnership. Retrieved from www.masscec.com.

[31] By contrast, **Rhode Island, New Hampshire, and Vermont** do not have a well-funded organization dedicated to cleantech innovation investment at the state level. **Maine** is served by the Maine Technology Institute, a publicly funded non-profit corporation that offers early-stage capital and commercialization assistance in the form of competitive grants, loans and equity investment for new R&D and technology applications across a broad spectrum of economic sectors (of which cleantech is one). **Connecticut** is served by the Clean Energy Finance and Investment Authority (CEFIA), a quasi-public agency, which invests resources in an array of enterprises, initiatives and projects aimed to attract and deploy capital to finance the clean energy goals of Connecticut.

[32] Massachusetts Housing and Economic Development. (2013). "Annual Reports, Massachusetts Clean Energy Center, FY2012." Retrieved from www.mass.gov/hed/economic/eohed/opmo/annual-reports/.

[33] Massachusetts Clean Energy Center. (2013). Massachusetts Clean Energy Industry Report. Prepared by BW Research Partnership. Retrieved from www.masscec.com.

- **IncubateMass**, a program that funds incubators in order to catalyze and support start-up companies;[34]
- **InnovateMass**, a competitive program that awards funding to teams that can prove out new technologies that are scalable, have strong commercialization potential, and create local jobs;[35]
- **MassCEC's Catalyst program,** which awards up to $40,000 to early-stage researchers and companies to help them demonstrate the commercial viability of their clean energy technology;[36]
- **Clean Energy Internship program,** which helps prepare the next generation of clean energy workers by connecting students and recent graduates with Massachusetts clean energy companies in need of interns;[37]
- **Investments in the Advancement of Technology program**, which makes venture capital equity investments in promising early-stage Massachusetts clean energy companies developing and commercializing technologies that contribute to the advancement of clean energy sectors.[38]

MassCEC additionally provides funding for major facilities, such as the Wind Technology Testing Center – a facility that offers the full suite of certification tests for turbine blades in order to maintain high levels of blade reliability and evaluate the latest technology development in airfoils and materials. MassCEC also invests in technology, cluster and innovation partnerships, such as the annual Global Cleantech Meetup,[39] the Massachusetts-Israel Innovation Partnership,[40] the NECEC Institute regional cluster development programs,[41] and the Massachusetts Technology Transfer Center.[42]

Finally, it is clear that Massachusetts – and the metro-Boston area in particular – serves as a hub for the New England cleantech innovation cluster. While there are a number of other cluster "nodes" that support innovation and accelerate commercialization across New England – several of which are described in Section 3 – it is clear that the Boston area exercises enormous influence on the direction of the cleantech cluster. Looking ahead, there is the potential to extend the culture of innovation seen in the metro-Boston area across the New England region. Leveraging lessons learned from Massachusetts, extending access to Boston-based resources, and supporting collaboration across the region will be an important task for New England's cleantech cluster leaders in the future.

3.3 New England's Innovation Infrastructure

Together, the ecosystem of cleantech companies, universities, policymakers, regulators, end-users, and support organizations in Massachusetts has successfully propelled development of early-stage cleantech innovation. A key question for the region is how to leverage strong innovation hubs, such as the Boston area, to support the *regional* cleantech innovation cluster. Innovation and cluster research suggest that increasing awareness of – and accessibility to – innovation infrastructure, while nurturing a culture of

[34] For more, see www.masscec.com/programs/incubatemass.
[35] For more, see www.masscec.com/programs/innovatemass.
[36] For more, see www.masscec.com/programs/catalyst-program.
[37] For more, see www.masscec.com/programs/massachusetts-clean-energy-internship-program.
[38] For more, see www.masscec.com/programs/investments-advancement-technology.
[39] For more, see http://globalcleantechmeetup.com/
[40] For more, see www.masscec.com/miip.
[41] For more, see http://nececinstitute.org/.
[42] For more, see www.mattcenter.org/.

innovation, and helping regional entrepreneurs extend their networks can help spur continuous innovation.[43, 44]

As a result, in addition to building a database of cleantech innovation companies in New England, this study also created a database of cleantech innovation infrastructure across the six New England states, including investment and capital providers; R&D labs, testbeds, and demonstration facilities; business support providers; and technical consultancies, among others. Although the database should be viewed as a first step in characterizing regional cleantech infrastructure, it clearly demonstrates that the region has a strong foundation upon which it can build. In total, the initial compilation revealed over 200 cleantech support institutions across all six New England states.

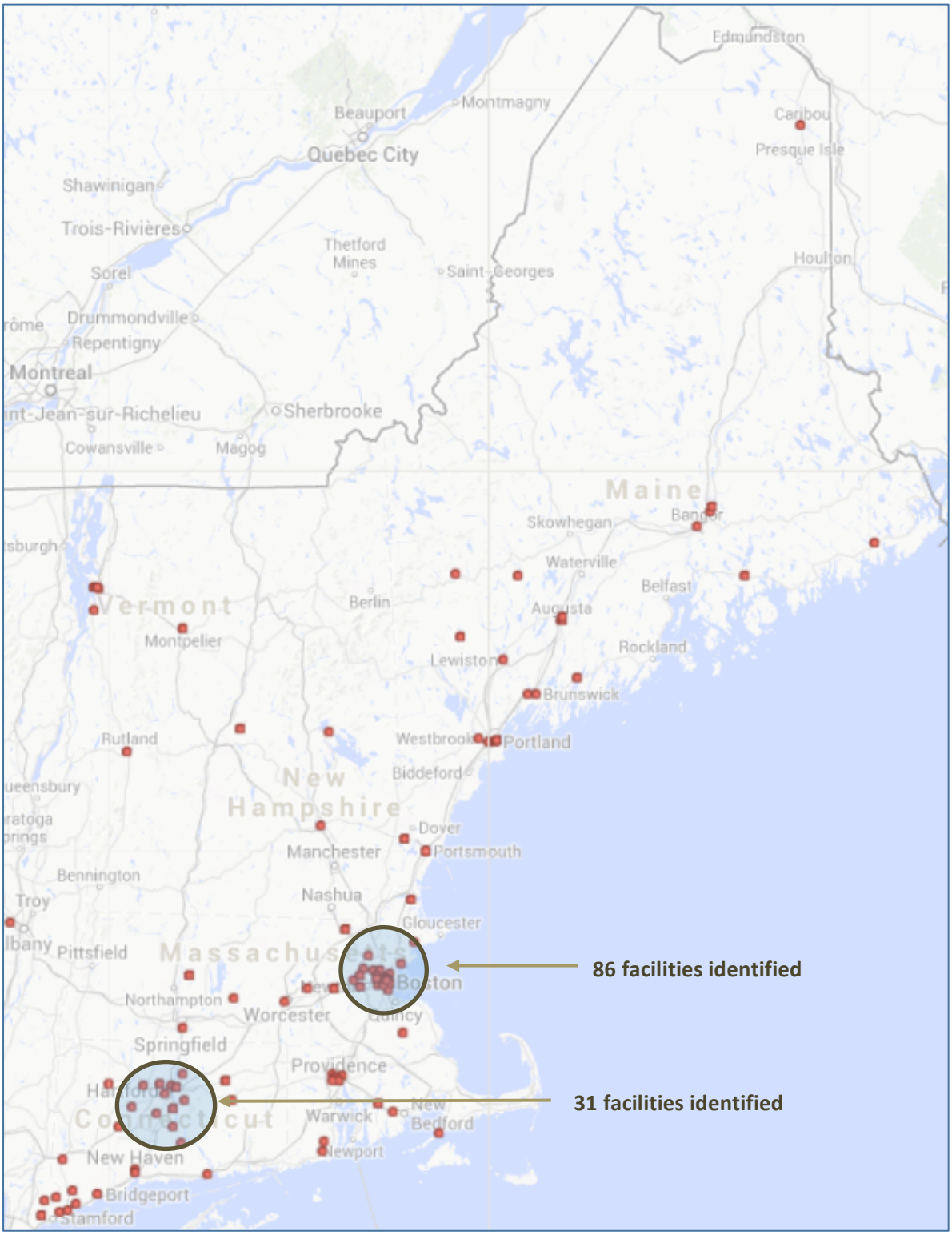
The map below provides a high-level snapshot of the geographic distribution of cleantech institutions available to support companies in the region (see Figure 9). In particular, it illustrates the density of innovation infrastructure clustered around the metro-Boston (86) and Hartford, Connecticut (31) regions. Similarly, it is evident that smaller clusters of innovation infrastructure are emerging in or around Providence, Rhode Island, Portland, Maine and Stamford, Connecticut. A summary of the types of innovation infrastructure identified in each state is provided in Appendix B.

New England stakeholders identified potential to drive forward regional cleantech innovation by increasing connectivity between these cleantech support organizations across the states. By doing so, cleantech leaders could help entrepreneurs leverage important cleantech assets and resources available in the region. For example, stakeholders in Maine pointed out that though the state is home to a number of world-class labs and research facilities, entrepreneurs often lack access to venture capital or other investment resources, making it challenging for them to raise funds needed for growth. Boston, on the other hand, is home to the majority of venture capital institutions identified in this survey. Thus, by creating linkages across the states and strengthening networks between the facilities that make up New England's cleantech innovation infrastructure – e.g. by connecting researchers and entrepreneurs from Maine's labs and research facilities with venture capitalists operating out of Boston – New England cleantech leaders can grow the regional cleantech innovation economy.

These concepts are also discussed in Section **Error! Reference source not found.**, which provides case studies describing how cleantech companies are leveraging innovation infrastructure to drive growth of cleantech across New England.

[43] Council on Competitiveness. (2005). "Measuring Regional Innovation: A Guidebook for Conducting Regional Innovation Assessments." Prepared for U.S. Department of Commerce Economic Development Administration. ISBN-1-889866-26-1.
[44] Saxenian, A. (1996). Regional Advantage: Culture and Competition. Harvard University Press.

Figure 9: Cleantech Innovation Infrastructure in New England



4 Case Studies: Cleantech Innovation Companies and Infrastructure

As referenced in previous sections, early-stage cleantech innovation activities are taking place in all six states in the region. In some cases, states or organizations are leveraging local innovation infrastructure to support cleantech in ways similar to that seen in Massachusetts. In other cases, cluster initiatives are emerging across state lines, supported by state authorities or other industry and research networks. In almost all cases, clean technology innovation occurs where entrepreneurs and researchers have access to key assets and infrastructure.

This section describes a series of case studies to illustrate how individual organizations are accessing assets, collaborating within a supportive innovation culture, and uncovering new and valuable ways to make needed connections. Each case study describes how companies, labs and testing facilities, and strategic partners collaborate to address cleantech opportunities. In particular, they explore (i) Maine's "Pinecone Valley," (ii) the electrochemical energy storage cluster extending across Connecticut and Massachusetts, (iii) a digital technology and voltage optimization company in Rhode Island, and (iv) the water technology cluster emerging across New England.

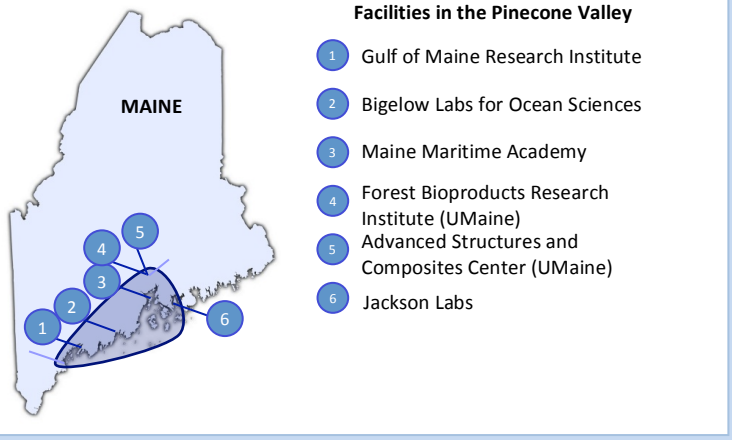
Case Study 1. Innovation and Entrepreneurship in Maine's "Pinecone Valley"

World-class research facilities supporting cleantech research and development

Location: Maine

NECEC Cleantech Sector Classification:
- Energy Generation
- Chemicals and Advanced Materials

Key Collaborators:
- Gulf of Maine Research Institute
- Bigelow Laboratories
- University of Maine Advance Structures and Composites Center
- University of Maine Forest Bioproducts Research Institute
- Maine Maritime Academy
- Jackson Labs



Background: Maine's technology and innovation activities are clustered across research institutions in the "Pinecone Valley." Likened to North Carolina's Research Triangle Park or California's Silicon Valley, the Pinecone Valley is a region along Maine's southern border that is home to labs and testing facilities engaged in technology research and development.[45] R&D and commercialization activities in the Pinecone Valley focus on aquaculture and marine technology research, biotechnology, composites and advanced materials,

[45] Martin, R. (January 2013). "Pinecone Valley: Maine's Hidden Asset." MTI Blog. Retrieved from www.mainetechnology.org/news-events/mti-blog/post/pinecone-valley-maine-s-hidden-asset.

environmental technology, forest products & agriculture, information technology, and precision manufacturing. Research in the Pinecone Valley is increasingly focusing on cleantech – specifically on advanced materials, bioenergy, offshore wind energy development, and hydrokinetic energy. Selected labs, testbeds, and demonstration sites supporting this work in the Pinecone Valley are described below.

Labs and Testing Facilities:

- The University of Maine's (UMaine) Advanced Structures and Composites Center has capabilities to design, manufacture, and test large high-performance hybrid composite structures. It houses laboratories for composite materials manufacturing science, resin infusion, polymer/interface science, environmental-durability testing, and mechanical testing, among others. Researchers at the lab are applying this knowledge to demonstrate a deep-water floating offshore wind platform under the first stage of a potentially $93.2 million U.S. Department of Energy award. The project is a collaboration between the University of Maine, industry leaders, and national laboratories.
- Scientists at Bigelow Laboratories work on projects to enhance the productivity of the world's ocean ecosystems at the molecular level. They have recently applied their research to support to algal biofuel companies, identifying methods and designs for capturing and sending light to algae in larger volumes under varying conditions in order to support next generation, commercial production of algae biofuels. This work has been completed in collaboration with companies like Bodega Algae, a Boston-based developer of scalable algae photobioreactors for the production of biodiesel, among others.[46]
- The Forest Bioproducts Research Institute (FBRI) Technology Research Center (TRC) at the University of Maine validates, demonstrates, and provides commercialization assistance for forest bioproduct companies active for fuel, chemical, and advanced material technologies. FBRI assists wood suppliers and wood users develop successful collaborations with other companies as well as researchers at the University of Maine. The Center focuses on demonstrating products at industrial scale.[47]
- The Maine Maritime Academy is a public college of engineering, management, transportation, and ocean science. The Academy has recently supported research in hydrokinetic energy (within the Center for Engineering and Applied Research), having won a $500,000 investment from MTI. The Academy is additionally creating a Tidal Energy Demonstration and Evaluation Center (TEDEC), which is expected to support economic development for Maine's companies.[48]

Outlook: Maine's Pinecone Valley has a strong foundation of research and testing facilities, which can be used to further build Maine's cleantech cluster and create linkages with the rest of the region. Stakeholders in the region report that there is significant potential to build out cleantech activity in the Pinecone Valley, especially in key areas including advanced materials, bioenergy (using forest products), offshore wind energy development, and hydrokinetic (ocean) energy.

[46] Hill, S. and Brailovskaya, T. (January 2010). "Growing Green: Bodega Alga and Bigelow Laboratory collaborate to develop algal biofuel technology in New England. Retrieved from www.bigelow.org/.

[47] E2Tech. (2013). The Clean Technology Sector in Maine. Maine Technology Institute Cluster Initiative Program Award #144. Prepared by Innovation Policyworks and the University of Maine. Retrieved from www.e2tech.org.

[48] Maine Maritime Academy. (n.d.) "MTI funds MMA research in Hydrokinetic Energy." Retrieved from www.mainemaritime.edu/.

Case Study 2. Sustainable Innovations and Electrochemical Energy Storage

Fostering the electrochemical energy storage cluster

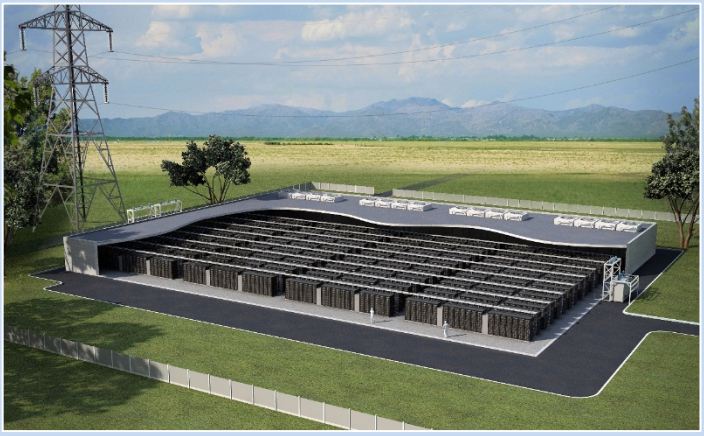
Location: Connecticut and Massachusetts

NECEC Cleantech Sector Classification:

- Energy Distribution & Storage

Key Collaborators:

- Sustainable Innovations
- Northeast Electrochemical Energy Storage Cluster
- Harvard University
- ARPA-E
- ICL Industrial Products



Background: A number of early-stage electrochemical energy storage companies are active in New England due in part to their ability to leverage the resources and services from universities, supply chain companies and strategic partners. They are supported by the Northeast Electrochemical Energy Storage Cluster (NEESC), a network of industry, academic, government and non-governmental leaders that work together to help businesses create energy storage solutions.[49] This case study describes the experience of Sustainable Innovations,[50] a Connecticut-based company founded in 2007, which has developed electrochemical cell stack architecture for energy efficient hydrogen compression in proton exchange membrane (PEM) technology. The technology can be applied to products that generate and compress hydrogen, store renewable energy, and sequester carbon dioxide. Sustainable Innovations works closely with labs, government agencies, and strategic partners to develop its technology for commercial applications.

Labs and Testing Facilities: Sustainable Innovations has supported its operations primarily through federal and state research grants, often in close collaboration with university labs and researchers. In partnership with researchers at Harvard's material, energy, and chemistry labs, Sustainable Innovations won a U.S. Department of Energy ARPA-E grant to develop a new type of flow battery. The collaboration supports the efforts of Harvard researchers to identify and synthesize molecules and protective coatings for the flow-battery designs. Sustainable Innovations conducts technical and economic assessments for these new technologies and integrates promising innovations into its commercial electrochemical systems.

Strategic Partnerships: Sustainable Innovations has also entered into a strategic partnership with ICL Industrial Products, a multinational chemical company with facilities in the northeast. Sustainable Innovations and ICL Industrial Products are working together to develop a regenerative fuel cell for energy storage. According to ICL executives, they have invested time and money in Sustainable Innovations because the founders have a successful track record of taking a technology from concept to commercialization.

Outlook: Sustainable Innovations joins a large number of companies active in electrochemical energy storage supported by NEESC. Stakeholders note that NEESC and other cluster development efforts that connect cleantech companies with supply chain resources is essential to the success of the industry.

[49] For more, see http://neesc.ccat.us/.
[50] For more, see www.sustainableinnov.com/.

Case Study 3. Utilidata, Digital Technologies, and Voltage Optimization

Leveraging local and regional resources to drive growth in Rhode Island's cleantech economy

Location: Rhode Island

NECEC Cleantech Sector Classification:

- Information & Communication Technologies
- Energy Storage & Distribution

Key Collaborators:

- Utilidata
- Renewable Energy Fund
- RI Economic Development Corporation
- American Electric Power
- Braemar Energy Ventures

Background: Rhode Island cleantech leaders describe significant opportunities to drive growth in cleantech, especially by leveraging regional assets and providing "nimble, targeted services" to support key sectors like electricity transmission and distribution (part of the energy storage and distribution sector). Stakeholders point to Rhode Island's recent recruitment of Utilidata – a company with a digital technology platform that provides Volt/VAR optimization services to improve energy efficiencies for utilities – as an important success story. By working with the RI Economic Development Corporation to secure a half million-dollar loan, and with close access to regional venture capital providers like Braemar Energy Ventures in Boston, Utilidata was able to access the start-up resources necessary to launch its operations in New England.[51]

Labs and Testing Facilities: Utilidata set up a smart grid simulation and research center in Rhode Island. The facility supports the testing of digital control technologies designed to deliver superior Volt/VAR optimization, peak demand reduction and other services. The lab can simulate real-world conditions to explore how new Volt/VAR technologies operate in the electric grid. It is a valuable resource for Utilidata's efforts to create strategic partnerships both within and beyond Rhode Island. According to Scott DePasquale, Chairman and CEO of Utilidata, the company gains access to valuable human capital and thought leadership by offering university researchers and customers access to its testing facility.

Strategic Partnerships: Utilidata has entered into strategic partnerships with customers such as American Electric Power (AEP), an electric utility serving customers across 11 states. As part of the R&D collaboration, AEP supports product development at Utilidata's smart grid simulation and research center. The project will explore new areas where digital signal processing (DSP) could improve utility operations, including fault indication and the integration of distributed generation and electric vehicles on the distribution system.

Outlook: Utilidata joins a number of other companies active in clean technology development in Rhode Island, including VoltServer, Yardney Technical Services, and VCharge to name a few. Looking ahead, cleantech leaders at Utilidata and across the state note that Rhode Island has potential to build a strong cleantech market. To do this, stakeholders report that state policy leadership is essential. By providing targeted support to cleantech entrepreneurs, increasing access to financial and technical resources (located both in Rhode Island and in nearby Massachusetts), and assisting entrepreneurs' access local talent at nearby universities, policy-makers can build up Rhode Island's role in the cleantech cluster.

[51] Wilson, J. (June 2012). Utilidata launches operations in Rhode Island. Retrieved from http://utilidata.com/news/press_releases/utilidata_launches_operations_in_rhode_island.

Case Study 4. Massachusetts Water Innovation Cluster

Attracting ideas, innovation, and capital for the global water industry

Location: Massachusetts and New England states

NECEC Cleantech Sector Classification:

- Water

Key Collaborators:

- Symposium on Water Innovation in Massachusetts (SWIM)
- UMass Amherst
- Northeastern University
- MIT
- Environmental Protection Agency
- CDM Smith
- AECOM
- Woodward & Curran
- Xylem
- Bowditch & Dewey
- Cambrian Innovations
- Oasys
- Liberation Capital

Background: The global water industry – including those companies that develop innovative technological solutions to address water distribution, usage or treatment, as well as purification, water-saving, and monitoring systems – is expected to double in the next several years with a market worth over $961 billion by 2020. Despite the growing need for new water technologies, there is no "center" for water innovation in the world.[52] Recognizing the potential for market growth and the need for new, innovative technologies to meet future market needs, a number of investors, companies, and policy-makers have launched an initiative to improve communication and collaboration for industry players in the Massachusetts water industry. The Massachusetts Innovation Waster Cluster is an emerging group of organizations that strives to make Massachusetts a premier global water innovation cluster.[53]

Labs and Testing Facilities: A number of labs and testing facilities are already active in water technology and research in Massachusetts. This includes facilities at MIT, University of Massachusetts, Cambrian Innovation Systems, Oasys, and the Massachusetts Alternative Septic Testing Center, among others. Together, Massachusetts research institutions are responsible for developing more water technology patents (on a per capita basis) than any other state in the nation, developing new technologies to address drinking, waste, storm, coastal, and industrial water management needs.

Strategic Partnerships: The innovation infrastructure for water technology in Massachusetts extends to a number of strategic partners. For example, engineering companies, like CDM Smith headquartered in Cambridge, MA, design and build water treatment facilities across the world. Similarly, AECOM, another water engineering company with a significant presence in Massachusetts, designed and built the Deer Island Water Treatment Facility – a world class water treatment facility.

Outlook: Looking ahead, Massachusetts has the potential to become a global hub of water innovation and piloting technologies. Massachusetts potential is even greater if it were to leverage resources available in surrounding New England states. To date, at least 14 water companies, engaged in early-stage technology research, have been identified in Vermont, Maine, Connecticut, and Massachusetts.

[52] Goodtree, D. (2012). "The Other Side of Water." TED[X]Boston. Retrieved from www.youtube.com/watch?v=NBWd36D1hqU.

[53] Symposium on Water Innovation (SWIM). (2013). "Massachusetts is on the way to becoming a global leader in water innovation." Retrieved from www.swim-ma.com/.

5 Next Steps for New England's Cleantech Innovation Economy

From the outset, this study was implemented to support New England-wide strategic efforts to strengthen the cleantech economy. The project established a common methodology to categorize and assess the regional cleantech innovation cluster. It established a regional definition of cleantech and developed a system to categorize cleantech companies, which can be used to characterize and measure development of the cleantech innovation cluster over time. It applied these definitions and categories to both the companies active in early-stage cleantech commercialization activities as well as the innovation infrastructure supporting those companies to better show what resources are available to help cleantech companies commercialize.

However, this assessment represents only one step in a broader process to drive development of the New England cleantech innovation cluster. Building on the information captured in this report, regional stakeholders, including core team members and workshop participants, identified a number of recommendations, structured around three key areas, which will support future development of the cluster:

- Increase access to information on cleantech companies and innovation infrastructure;
- Assess innovation barriers and expand best practices across the region; and
- Develop or strengthen networks in the regional innovation economy.

Each of these recommendations is briefly described below.

5.1 Increase Access to Information on Cleantech Companies and Innovation Infrastructure

Over the course of this analysis, the core team members identified a number of additional areas of research areas that need further analysis to support development of the region-wide cluster. These include the need to (i) regularly update the *New England's Cleantech Innovation Landscape* assessment, (ii) expand the analysis to incorporate new services and supply chain providers, (iii) and enable regional stakeholders to access databases supporting this study in order to conduct primary research of their own. Each of these recommendations is described below.

First, the status of cleantech activities across the region is constantly shifting. In order to keep policy-makers and cluster leaders apprised of the current status of the New England cleantech innovation cluster, there is a need to regularly update the company and innovation infrastructure databases developed in this assessment. In addition, it is clear that there are more cleantech innovation infrastructure facilities and companies in the region than were identified in this report. In particular, the core team has emphasized a critical need to conduct a detailed assessment of the labs and testing facilities that support cleantech R&D in New England.

Next, as discussed earlier in this report, cleantech spans across many sectors and industries, and this study has focused on companies and organizations engaged in early-stage clean technology development. Noting this, several core team members have advocated for expanding the analysis to also incorporate companies providing innovative technology "services." This would, for example, enable

assessment of a broader range of companies, including those developing innovative financial models or cleantech service delivery models. By doing so, the assessment would evaluate not just companies engaged in early-stage technology development, but also those enabling widespread deployment.

Similarly, regional stakeholders also emphasized the need to track and evaluate the supply chain companies that support cleantech. This includes the machine shops, fabrication shops, and welders, among many other service companies. Moreover, stakeholders suggested creating the equivalent of an "Angie's List" for cleantech, enabling entrepreneurs to find, learn about, and evaluate the quality of services provided by supply chain providers. This could build on other regional databases and efforts, including the Maine Ocean and Wind Energy Supply Chain Initiative, which enables companies in the offshore wind industry update profiles in an online database describing services, certifications, and other information. Additionally, the Northeast Electrochemical Energy Storage Cluster has developed a searchable database of resources in the Northeast, including suppliers, incubators, academic institutions, legal, manufacturing, and export advisory services. These resources could be leveraged to incorporate other "green" technologies such as wind and solar, in the future.

Finally, the core team expressed interest in expanding access to the databases developed in this assessment, developing an interactive, online tool that enables stakeholders to review, update, or download information from an online portal in order to conduct their own analyses. In such a manner, companies and organizations engaged in clean technology innovation across the region could regularly update key metrics – and also provide stakeholders across the region a clear sense of what technologies or services their respective organizations or companies provide.

5.2 Assess Innovation Barriers and Expand Best Practices Across the Region.

This study has dealt primarily with cataloging cleantech innovation companies and supporting facilities in order to develop concrete metrics to track regional cluster performance. However, in the course of this work, stakeholders have engaged in robust discussion regarding the barriers and opportunities for growing the regional cleantech barriers. A detailed, regional assessment of innovation barriers and best practices should be conducted to support cluster development efforts.

A number of barriers are commonly cited that impact entrepreneurs engaged in early-stage cleantech. These include poor access to financing, inadequate business experience, lack of access to (early adoption) customers or strategies, as well as poor access to technical resources like lab space or testing services. While these barriers are generally well-recognized, it is less clear how effective state policy-makers and local support organizations are at addressing these barriers across the region. New England is home to a patchwork of innovation policies and programs, resulting in uneven access to innovation funding and technical support. This in turn creates resource gaps that inhibit development of the multi-state cleantech innovation cluster.

Though a detailed assessment of innovation barriers and best practices is beyond the scope of this report, the text box below describes initial findings and recommendations for addressing key barriers. By conducting a comprehensive barrier assessment *across the region,* and disseminating best practices to address barriers in local innovation communities, regional leaders and policy-makers can overcome challenges that inhibit regional cleantech market growth and cultivate a strong regional market.

Barriers & Opportunities: Implementing Best Practices to Support Regional Cleantech Market Growth in New England

As a first step to addressing barriers to innovation in New England, it will be important to hone in on regional resource gaps and disseminate innovation policy and program best practices across the region. For example, creating (or expanding access to) the best practices that address the following barriers is essential to the development of the regional cleantech innovation cluster.

- **Access to Capital.** Venture capital has become increasingly cautious about leading early rounds in financing start-ups, and entrepreneurs across New England continue to face challenges overcoming the technology and commercialization valley of death. Additionally, stakeholders across the region report that venture capital providers are clustered in and around Boston, making it challenging for entrepreneurs outside of Boston to access early-stage capital. To address these challenges, it will be important to reduce investment risk in early-stage ventures across the states through development of new policies and programs. Additionally, regional investment forums could be developed to increase access to capital for stakeholders outside of Boston. While a comprehensive discussion of policy options is beyond the scope of this report, it is recommended as a first step that cluster leaders convene key stakeholders – including venture capital providers, entrepreneurs, and policy-makers across the region – to identify opportunities for piloting new investment strategies that reduce risk and increase access to capital for entrepreneurs across the region.
- **Access to Business and Executive Expertise.** As entrepreneurs confront challenges in scaling up new ventures or technologies, they benefit from the support of mentors or experienced executives who can provide important insights as well as connections to technical, business, and market resources. A number of organizations across New England provide support to entrepreneurs via mentor or executive-in-residence (EIR) programs; however, as noted above, depending upon the location in New England, access to such support is uneven or unavailable. Resources providers across the region should share best practices and facilitate expansion of EIR programs, increasing access for entrepreneurs to the network of business advisors.
- **Access to Key Business Services.** Entrepreneurs require access to experienced service providers that can provide pro bono or discounted business services, including accounting, business plan development, marketing, human resources, legal, IT, and other services. Ensuring access to such services is necessary to the success of new venture development. Increasing access by developing local programs across the region is an important next step for the development of the New England-wide cleantech innovation cluster.
- **Access to Technology Development Resources.** Entrepreneurs need product development and technology testing resources, including access to the laboratories, prototyping resources, technology testing facilities, and capabilities of New England's universities and government-supported research facilities. Regional entrepreneurs and experts note that there is a lack of transparency regarding what labs and testing facilities are available and what services they provide. Cataloguing regional technology development resources by specialties and capabilities is needed in order to assist entrepreneurs address product development challenges.

5.3 Develop or Strengthen Networks in the Regional Innovation Economy

In addition to implementing the best practices described above, it will be important for cluster leaders to strengthen New England's innovation networks by creating linkages across the region's entrepreneurial support programs and to maintain formal connections with national organization supporting the cleantech economy. Existing entrepreneurial support programs – like Cleantech Open Northeast, the Association of Cleantech Incubators of New England (ACTION), university tech transfer programs, as well as regional or state proof of concept centers – all serve as on-ramps for cleantech entrepreneurs, providing them access to investors, business mentors, corporate partners, as well as technical resources. However, as noted earlier, there is not necessarily strong access to these networks and resources across the region. By creating a strong regional network that connects entrepreneurial support activities across New England, and by maintaining connections to national networks, the region can create more opportunities for entrepreneurs and foster a region-wide culture of innovation.

At workshops across New England, especially those outside of the metro-Boston region, stakeholders repeatedly noted the challenge of accessing key innovation networks. For example, entrepreneurs in Maine, New Hampshire, Rhode Island, and Western Massachusetts reported that they found it challenging to connect with strategic investors as well as early-adopter (corporate) customers. This represents a clear gap in the regional innovation network, which could be filled by strengthening regional connections (as described in the text box below).

Innovation Networks: Addressing Cleantech Barriers through Robust Network Development

Successful innovation networks bring together key stakeholders with diverse perspectives and afford them the opportunity to collaborate in order to solve targeted challenges. Many innovation networks are structured around conferences, forums, competitions, or other events that enable robust and meaningful engagement. Within New England, significant potential exists to drive forward the cleantech economy by creating networks that connect entrepreneurs with strategic partner, investors, and early-adopters.

- **Strategic Partner and Investor Networks.** Entrepreneurs require access to a community of corporate investors and partners, who can support development and demonstration of new clean technologies. Increasing access to strategics across the region by implementing regional forums benefits both corporate companies looking for new technologies and entrepreneurs looking for new markets and investors. Cluster leaders should develop a series of annual events, hosted across the New England region, convening strategic partners and investors and connecting them with local investors. These events should be structured to share best practices and enabling entrepreneurs and strategics to explore potential for bringing new technologies and products to market.
- **Early Adoption Customers and Demonstration Sites.** Identifying early adopter businesses and facilities, which will provide demonstration sites to run technology pilots and provide performance data for innovative clean technologies, is essential to the success of new technology ventures. To address these needs, regional cluster leaders should create opportunities for corporate customers to learn about new technologies. Such forums should provide customer feedback and advice to entrepreneurs, enabling robust discussion of best practices, research, and tools for demonstration and adoption new technologies.

Looking ahead, by creating strong networks that address key needs of entrepreneurs in the New England cleantech innovation cluster, the region can expand access to resources for entrepreneurs, especially those outside of the metro-Boston, and drive development of the regional cluster. Following up by channeling regional cleantech innovation policy needs through national organizations, such as the American Council on Renewable Energy (ACORE) and the Advanced Energy Economy (AEE), helps national leaders understand and consider the positive and negative implications of policies affecting cleantech innovation.

6 Conclusion: The Outlook for New England's Cleantech Innovation Cluster

Over the past several years, the NECEC Institute and its sister organization the New England Clean Energy Council have made significant progress in expanding the cleantech innovation cluster. By now focusing attention on development of concrete metrics to track development of companies and the development of innovation infrastructure across New England, regional cluster leaders can better evaluate progress, providing benchmarks by which to gauge success of regional cluster development.

It is clear that the cluster faces many challenges. However, it has tremendous potential to emerge as the global center for cleantech innovation. States like Massachusetts already attract a significant amount of federal and private innovation funding and have developed robust innovation infrastructure with which it supports cleantech entrepreneurs. Similarly, other New England states have created a strong foothold in cleantech. For example, Maine has tremendous potential for growth in its Pinecone Valley. Additionally, as a result of the Small Business Administration's Regional Innovations Cluster (RIC) initiative, the Northeast Electrochemical Energy Storage Cluster has been strengthened in New England and across the Northeast. Rhode Island, New Hampshire, and Vermont have all also shared in cleantech successes. And new cleantech areas are emerging in the region – like the water technology and ocean energy clusters.

Looking ahead, the region will benefit from additional cluster development initiatives – focusing on opportunities to identify and break down cleantech innovation barriers and disseminate best practices across the region. New England is poised to be a global leader in cleantech innovation. By building strong networks, creating smart policy, and implementing transformative projects, regional leaders can transform New England's economy, moving it away from fossil fuels and towards clean energy in order to achieve regional economic growth goals protect the environment, and stimulate creation of new jobs and businesses.

Appendix A: Snapshot of Cleantech Sectors & Investment by State

	# companies*					Dollars ($)			Million people
	Energy Generation	Energy Distr. & Storage	Chemicals & Adv. Matls.	Energy Efficiency	Other Sectors	GDP	DOE SBIR	VC	Population
MA	42	40	30	27	45	$ 391,771,000,000	$ 73,027,131	$ 1,126,460,000	6.65
CT	6	4	6	3	1	$ 230,090,000,000	$ 17,947,118	$ 8,250,000	3.59
ME	8	1	2	1	4	$ 51,585,000,000	$ 1,199,772	$ 10,000,000	1.33
RI	1	4	0	1	1	$ 50,091,000,000	$ 498,131	$ 2,250,000	1.05
NH	2	1	2	1	0	$ 63,556,000,000	$ 8,196,087	$ 24,000,000	1.32
VT	2	0	1	0	3	$ 25,905,000,000	$ 985,638	$ -	0.63

* Companies may be cross-listed in one or more cleantech sectors

Appendix B: Snapshot of Innovation Infrastructure by State

	# of facilities *						
	Business Support Services	Investment & Capital	Laboratory / Testing Facilities	Marketing Support Services	Other	Product Development Services	Technical Consultancy
CT	33	19	5	11	0	4	1
MA	63	24	19	4	2	8	11
ME	33	11	6	11	0	3	2
NH	8	3	0	0	0	0	0
RI	9	5	3	2	0	2	3
VT	6	5	1	0	0	1	2

* Facilities may be cross-listed in one or more “innovation infrastructure” categories

Appendix C: Defining New England's Cleantech Innovation Cluster

Michael Porter, an authority on cluster theory and regional competitiveness, defines clusters as "geographically proximate groups of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities."[54] According to Porter, clusters are normally contained within a common geographic area, which makes possible communication, logistical support, and personal interaction between cluster actors.[55]

Although clusters can take on various forms depending upon their state of development, they usually cut across traditional industry classifications. Well-developed clusters, for example, include end product or service companies, suppliers of specialized inputs (e.g. components, machinery, and specialized services), financial institutions, and firms in related industries. Additionally, clusters also typically include firms in downstream or customer industries; specialized infrastructure providers; as well as government, universities, and other institutions that provide specialized training, education, information, or research and technical support, among other services. Many successful clusters also include trade associations or other organization that support cluster members.[56]

The New England cleantech economy illustrates the key traits of a cluster described by Porter. New England is home to many interconnected companies and associated intuitions, which have a long history of economic cooperation. In addition, the region is connected by a number of key institutions that encourage or enable cleantech innovation.

For example, New England energy companies are connected by the Regional Greenhouse Gas Initiative (RGGI), the first mandatory carbon cap-and-trade program in the nation. Similarly, New England states have collaborated for years as part of the Northeast States for Coordinated Air Use Management (NESCAUM), an initiative that addresses issues and policies affecting the common regional air-shed. Other regional economic initiatives include the New England Independent System Operator (NE-ISO) and the New England Power Pool, which manages the region's interconnected electricity system, providing reliability, market, and electricity transmission benefits. All of these initiatives provide a foundation of collaboration on which to further develop the New England cleantech cluster.

Next, the New England cleantech innovation cluster cuts across multiple sectors and industries. For example, it leverages strengths and resources from information and communication (IT), digital, plastics, chemicals, biotechnology, and other high-tech industries. Nine major cleantech sectors have been identified that make up the New England cleantech innovation cluster. Additionally, the New England cleantech innovation cluster also brings together companies across the value chain, including manufacturing, engineering, service, and countless supply chain companies.

The New England cleantech innovation cluster also includes participation of governments, universities, non-profit institutions, and private sector entities that provide "specialized training, education, information, research and technical support."[57] This includes a number of organizations that provide

[54] Porter, M. *Clusters of Innovation: Regional Foundations of U.S. Competitiveness.* Council on Competitiveness, Monitor Group.
[55] Ibid.
[56] Ibid.
[57] Ibid.

important "innovation infrastructure" in the region. For example, many of the world's top research universities are located in New England, most of which are actively engaged in R&D supporting the development of new cleantech products. The region is also home to a number of labs and testing facilities, investment and capital providers, business service providers, and technical consultancies.

Finally, the New England cleantech innovation cluster is served by the New England Clean Energy Council, a regional trade organization that seeks to accelerate New England's clean energy economy to global leadership by building an active community of stakeholders and a world-class cluster of clean energy companies.[58] It is also supported by a number of other organizations that represent cleantech business interests. This includes the Northeast Electrochemical Energy Storage Cluster (NEESC), a Regional Innovation Cluster (RIC) initiative funded by the Small Business Administration (SBA), which supports companies and institutions commercializing hydrogen and fuel cell technologies in New England.[59]

Ultimately, it is clear that New England is home to a vibrant cleantech innovation cluster. Measuring, tracking and strengthening the cleantech innovation cluster will be important for future regional economic success.

[58] New England Clean Energy Council. (2012). Mission. Retrieved from http://www.cleanenergycouncil.org/about/mission.

[59] NEESC is one of ten cluster initiatives funded by SBA in September 2010, as part of a 2-year pilot initiative. It continues to support small businesses in the Northeast Region.

Appendix D: Cleantech Sector and Segment Classification System

The following categories have been established to categorize clean tech companies. Companies that meet the definitional requirements established in the methodology will be catalogued in the clean energy innovation cluster analysis using this classification system. The classification system is primarily based on the system developed by the Clean Tech Open.[60] It additionally takes into account cluster analyses and company classifications developed by E2Tech, Maine Technology Institute, the Massachusetts Clean Energy Center, and the New England Clean Energy Council.

The following nine categories are used to classify clean energy companies:

1. Energy Generation
2. Energy Distribution & Storage
3. Energy Efficiency
4. Chemicals & Advanced Materials
5. Green Building
6. Transportation
7. Agriculture & Waste
8. Water
9. Information & Communication Technologies

Detailed descriptions of each category are given below. This includes a category definition, category segments and sub-segments, and where relevant a description of how companies should be classified across categories. It is expected that this classification system will continue to be updated and refined over time.

1. Energy Generation

Definition: The energy generation category includes innovations that use, enable and accelerate the usage of renewable energy resources as well as energy generation from alternative sources like waste heat, sewage and materials. This category comprises technologies that include low-emission power sources, such as solar, geothermal, biofuels, wind, wave and tidal energy and hydropower. Renewables also encompass technologies that use waste streams to directly produce energy, like biogas from manure or landfills.

[60] The Clean Tech Open. (2013). "Categories." Retrieved from http://www2.cleantechopen.org/categories/.

Segment	Sub-segment (if relevant)
Bioenergy	Anaerobic digestion
	Biogas/land-fill gas
	Biofuels-Non Transportation
	Biomass-thermal
	Pellets
	Other
Gensets	
Geothermal	
Gasification	
Hydrogen Generation	
Hydrokinetics	Wave
	Tidal
	Current
	Other

Segment	Sub-segment (if relevant)
Hydropower	Small/Mini
	Large
	Other
Solar	PV
	Thermal
	CSP
	Other
Waste	Power
	Thermal
Wind	Land
	Offshore
	Other
Thermal-to-Energy	
Other	

Energy Generation vs. Transportation: If the company produces biofuels like liquid biodiesel for transportation, then it is classified in the "Transportation" category. If it produces biofuels, like biogas for heating or cooking, then it may be classified in the "Energy Generation" category.

2. Energy Distribution & Storage

Definition: Energy Distribution & Storage includes technologies that enable electricity delivery and give industrial, commercial and residential consumers greater control over when and how energy is delivered and used. It includes improvements in all forms of energy storage, from battery technology for consumer-scale products to large chemical, metal, biological or other approaches to storage of utility-scale energy, as well as methods for controlling or increasing the efficiency of energy storage or energy transmission.

Segment	Sub-segment (if relevant)
Demand Response	
Battery	Flow Battery
	Liquid Metal Battery
	Lithium
	Other
Energy Storage	Hybrid
	Hydrogen
	Other
	Flywheels
	Fuel Cells
	Super / Ultra-capacitors
Transmission and Distribution	Volt/VAR
	Advanced Metering
	Automation / Control Systems
	Interconnection technologies
	Other
Other	

3. Energy Efficiency

Definition: The Energy Efficiency category includes technologies that enable energy savings in industrial processes as well as at home. Saving energy reduces greenhouse gas emissions and has also a positive impact on expenditures on energy. Examples include advanced light sources and controls, smart / user-friendly energy management systems, energy-efficient water heaters and other appliances, high-efficiency industrial process systems, energy efficient technologies for construction, motors, pumps, and advanced space heating and cooling systems.

Segment	Sub-segment (if relevant)
Appliances	
Building Energy Management / Analytics	
Lighting	
HVAC	High Efficiency Heat Pump
	Air Exchange/Air Quality
	Other
Combined Heat & Power	From renewable sources
	From non-renewable sources
Energy Services	

Energy Efficiency vs. Energy Generation: If a company uses waste to create energy, like biogas from landfills, then it is Energy Generation category. If a company uses integrated systems for waste heat recovery, then it is Energy Efficiency category.

Energy Efficiency vs. Information & Communications Technologies (ICT): If a company develops software for integrated energy or resource planning to reduce the usage of energy and greenhouse gas emissions, then it belongs to the Information & Communications Technologies category. If a company develops a technology, which requires less energy per product than other similar technologies, then it should be categorized in the Energy Efficiency category company.

4. Chemicals & Advanced Materials

Definition: Chemicals and Advanced Materials comprise companies and technologies that reduce or eliminate the use or generation of hazardous substances in materials or chemical products. These chemicals and advanced materials include novel detergents, pharmaceuticals, cosmetics, household products, lubricants, surface and finishing materials, packaging materials and fabric. In addition, it may include companies using nanotechnology or biotechnology to achieve more efficient or environmentally sound products that are used broadly in the industrial supply chain. This could include cleantech companies engaged in chemicals or the creation of composition or other advanced structural materials.

Segments	Sub-segments (if relevant)
Chemical	
Materials / Components	Bio-products
	Nanotechnology

Chemicals and Advanced Materials vs. Energy Generation: If a company produces energy from biodegradable waste, then it is classified as an Energy Generation company. However, if the company produces raw product for chemicals from bio-waste, then it is classified in the Chemicals & Advanced Materials category.

If a company produces innovative solar panels with advanced materials, then it is classified in the Energy Generation category. If it develops novel materials, which are more environmentally friendly and are sold to renewable technology companies as part of the supply chain, then it is classified in the Chemicals & Advanced Materials category.

Chemicals and Advanced Materials vs. Transportation: If a company produces biofuels for transportation, then it is classified in the Transportation category. If, on the other hand, the company's main production articles are novel chemicals or household products from raw biofuels, then it is classified in the Chemicals and Advanced Materials category.

5. Green Building

Definition: Green Building focuses on reducing the environmental impact of construction by producing innovative, energy- and material efficient building materials. This category also encompasses improved design or construction practices. Examples include improved site planning, water management systems, reduction of hazardous materials in building construction or operation, use of new environmentally friendly or recycled materials, systems to improve indoor environmental quality and systems for improved waste reduction or disposal.

Segments	Sub-segments (if relevant)
Architecture and Design	n/a
Thermal Envelope	
Materials	
Other	

Green Building vs. Energy Efficiency: If a company produces pavers and bricks that require less energy to produce and thus generate less greenhouse gas emissions in their manufacturing, then it is classified in the Energy Efficiency category. If the company produces pavers that are made of recycled waste, then it is a Green Building category.

6. Transportation

Definition: The Transportation category covers innovative technologies that not only improve the means and ways of mobility, but also reduces environmental impact of mobility markets. Start-ups that are focused on electric vehicles, motorbikes, aviation, trains and fleet logistics are classified in this category. Transportation encompasses transportation and mobile technology applications that improve fuel efficiency, produce biofuels for transportation, reduce air pollution, reduce oil consumption or reduce vehicle travel (not limited to automobiles). Technologies are applied directly to transportation systems or vehicles. Examples include new vehicles and new types of transport services and infrastructure, efficient and portable batteries, fuel cells and bio-based transportation fuels and use of information technologies.

Segments	Sub-segments (if relevant)
Alternative Fuels-Transportation	Cellulosic ethanol
	Biodiesel
	Drop-in Fuels
	Other
Alternative Vehicles	Electric
	Hybrid
	PHEV
	CNG
	Other
Infrastructure (charging)	
Other	

7. Agriculture & Waste

Definition: Applications in the Agriculture & Waste category focus on improving food security, resource availability, conservation, and pollution control.

Agriculture encompasses innovative farming technologies that reduce the need for resources needed to produce food, improves supply chain and ensures sustainable food security. Agriculture examples include technologies and solutions that increase yield size, soil fertility, harvesting efficiency or decrease the need for resources (like water and fertilizers), land use, reduce energy use for machinery, agricultural leftovers, nutrients runoff and degradation of biodiversity and habitats.

Waste focuses on cradle-to-cradle approaches to reduction, reuse and recycling technologies, as well as innovative business models and approaches to materials usage. Waste examples include: waste management equipment; sorting; resource recovery processes; pollution prevention, control, and treatment technology; as well as waste reduction through innovative recycling processes and new recyclable materials, such as bio-based plastics.

This category also includes companies that are focused on air quality improvement. Air examples include services, instruments and equipment related to emission control, treatment or reduction technologies, creative approaches to greenhouse gas reduction, including carbon conversion and sequestration.

Segments	Sub-segments (if relevant)
Carbon Capture & Sequestration	n/a
Emission Controls	
Emissions & Waste Mgmt.	
Recycling	
Waste Treatment	

8. Water

Definition: Applications in the Water category focus on improving resource availability, conservation and pollution control. Water refers to innovative technological solutions which address drinking water distribution, usage or treatment. Solutions can include purification-, water saving and monitoring systems.

Segments	Sub-segments (if relevant)
Other	
Water Pollution	Remediation
	Wastewater Treatment
Water Treatment & Purification	Desalination
Water Use & Efficiency	Storage & Distribution
	Appliances
	Conservation

9. Information & Communication Technologies

Definition: The Information & Communication Technologies category includes companies whose primary business is built around computing hardware or software design improvements or the application of information technology, web, mobile or social applications (including emerging "clean web" applications) to reduce resource consumption and environmental impacts.

There are many potential overlaps with other categories. The distinction made on classification is that if the primary business value is built upon the data or application, then the company belongs in ICT. If the business value includes specific hardware, controls or other technology specifically targeted at the market that is complemented by data or applications, then the companies belongs in other sectors (Green Building, Transportation, etc.).

At this time, no segments have been identified for this sector.

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