




2011 Massachusetts Clean Energy Industry Report

MASSACHUSETTS CLEAN ENERGY CENTER

JOIN THE INNOVATION REVOLUTION

Prepared for the
Massachusetts Clean Energy Center
by BW Research Partnership and
the New England Clean Energy Council

[bw] RESEARCH PARTNERSHIP

new england clean energy council

Table of Contents

Letter from Patrick Cloney, Executive Director ii

Ackowledgements iii

Introduction 1

Research Findings 5

- Massachusetts' Clean Energy Sector is Large, Diverse and Growing 5
- Massachusetts Clean Energy Employers are Growing Rapidly 7
- Clean Energy Provides an Important Revenue Stream to Many Businesses 9
- Small Businesses Play a Key Role in the Clean Energy Cluster 10
- Clean Energy Workers are Distributed Throughout the Commonwealth 11
- Clean Energy Supports Numerous Industry Segments in Massachusetts 11
- Massachusetts is Strong In Multiple Technology Areas 13
- Massachusetts Competes For Talent 20

Conclusions 25

Research Methodology 26

About the Research Team 29

Letter from MassCEC Executive Director Patrick Cloney

Massachusetts is committed to a clean energy future not only to ensure clean air and water and a stable climate for the next generation, but also because the clean energy sector represents an economic engine with so much untapped potential that it can truly transform our economy.

The Massachusetts Legislature saw this opportunity in 2008 when it passed and Governor Deval L. Patrick signed the ground breaking Green Jobs Act to create the Massachusetts Clean Energy Center (MassCEC), the first sole purpose state authority of its kind in the nation working to comprehensively develop the clean energy sector. Since then we have been working hard to accelerate the success of clean energy technologies, companies, and projects in the Commonwealth—while creating high-quality jobs and long-term economic growth for the people of Massachusetts.

From our inception, we here at MassCEC have believed that Massachusetts is a smart place to grow, start, and scale a clean energy business. This industry—comprising a vibrant community of visionary people and world-class institutions working together to propel clean energy technologies from the drawing board to the global marketplace—provides one of the best opportunities for major economic and job benefits in the Commonwealth.

This report finds that at least 64,310 employees are working in clean energy from the Berkshires to the tip of Cape Cod, and that employment in the last year alone grew 6.7 percent. Not only is it is clear that clean energy is one of our Commonwealth's marquee industries, but this report affirms that this sector has played a key role in helping the Commonwealth fare the recession better than many other states.

We are pleased to provide this report, which captures the full extent of the clean energy community in Massachusetts. We look forward to continuing our work to nurture the growth of this industry, which is creating revolutionary change that will benefit our economy, environment, and society for generations to come.

Patrick Cloney
Executive Director, Massachusetts Clean Energy Center (MassCEC)

Acknowledgements

The 2011 Massachusetts Clean Energy Industry Report was developed out of a year-long research process that involved thousands of contributors. The Massachusetts Clean Energy Center (MassCEC) would like to sincerely thank all of the survey respondents for taking time out of their busy schedules to participate in this important research effort. Without the information companies shared, this report would not have been possible.

2011 Massachusetts Clean Energy Industry Report Advisory Committee

- Anita Worden, Solectria Renewables
- Donald Gilligan, National Association of Energy Services Companies
- Edward Londergan, Northeast Energy Efficiency Partnerships
- Erin Travassos, NSTAR
- Jack Healy, MassMEP
- Kane Osmars, Brookfield Power
- Larry Martin, Regional Employment Board of Hampden County
- Lars Humblebak, Siemens USA
- Loh-Sze Leung and Patricia Maguire, Skillworks
- Navjeet Singh, Commonwealth Corporation
- Paul Gromer, Peregrine Energy Group
- Paul Wolff, Bunker Hill Community College
- Steve Falvey, New England Carpenters Regional Council
- Tom Pincince, Digital Lumens
- Wanda Reindorf, Conservation Services Group

Research Team

The publication of this report would not have been possible without the hard work and dedication of the research team at BW Research Partnership, IHR Research Group, and the New England Clean Energy Council.

- Phillip Jordan, BW Research Partnership
- Kevin Doyle, New England Clean Energy Council
- Jamie Barrah, BW Research Partnership
- Veronica Williams, BW Research Partnership
- Josh Williams, BW Research Partnership
- B.J. Richards, BW Research Partnership
- Lynn Stallone, IHR Research Group

MassCEC Staff

- Alexandra Adler
- James Bowen
- Marybeth Campbell
- Jennifer Gorke
- Kate Plourd

MassCEC would also like to acknowledge the industry associations that made a concerted effort to encourage their members to respond to the survey: Environmental Business Council of New England; Marine Renewable Energy Center (MREC); Massachusetts Association for Community Action (MassCAP); Mass Hydrogen Coalition; Massachusetts Manufacturing Extension Partnership (MassMEP); National Association of Energy Services Companies; New England Carpenters Regional Council; New England Clean Energy Council; New England Geothermal Professional Association (NEGPA); New Fuels Alliance; Northeast Energy Efficiency Council; Northeast Sustainable Energy Association (NESEA); and Solar Energy Business Association of New England (SEBANE).

Introduction

Massachusetts has a long history of innovation. From computers and information technology to life sciences and defense, the Commonwealth has spawned numerous companies and industries focused on developing game-changing technologies that have altered the way people throughout the world live. Given this track record, the state's world-class colleges and universities, and its vibrant venture capital community, it is not surprising that Massachusetts has been at the forefront of clean energy research and development for decades.

For the purpose of this report, a clean energy firm is defined as an employer engaged in whole, or in part, in providing goods and services related to renewable energy, energy efficiency, alternative transportation, and carbon management. Renewable energy is defined as solar photovoltaic, solar thermal or concentrated solar power, wind power, fuel cell, bioenergy, hydropower or hydrokinetic, geothermal, hydrogen generation, or thermal to energy conversion, or renewable energy combined heat and power. Energy efficiency is defined as lighting, HVAC and building controls, energy efficient appliances , energy efficient processes and machinery, energy storage, demand response services, smart grid (smart computing/software), weatherization services and energy efficient building materials. Other technologies include electric vehicles and systems, electric rail and carbon management, including carbon capture and storage, coal gasification and the secondary carbon market. The report defines clean energy workers as employees which spend at least a portion of their time supporting the clean energy aspects of their businesses.

Market demand for clean energy technologies has increased dramatically in recent years, due to both consumer preferences and new government incentives and regulations. Massachusetts' leading academic institutions, active network of technologists, entrepreneurs, investors, highly skilled workforce, market-building public policy, and engaged government leaders have positioned the state to take advantage of this demand. The strong clean energy community has led to significant recognition from leading

clean energy research firms as well as the federal government. **MASSACHUSETTS RANKED FIRST IN THE NATION IN CLEAN ENERGY POLICY LEADERSHIP AND INVESTMENT CLIMATE, AND THIRD IN THE NATION OVERALL IN THE 2011 CLEANEDGE U.S. CLEAN ENERGY LEADERSHIP INDEX.** In addition, Massachusetts-based companies and research institutions have received 17 percent—or $62.8 million—of the federal dollars awarded through the first year of the U.S. Department of Energy's Advanced Research Projects Agency-Energy (ARPA-E) program. Progress has also been made in the production of renewable energy in the Bay State. **BY THE END OF 2011 THERE WILL BE A NEARLY 30-FOLD INCREASE IN SOLAR ENERGY INSTALLED OR IN CONSTRUCTION SINCE 2007. MASSACHUSETTS ALSO CONTAINS SIGNIFICANT WIND ENERGY POTENTIAL, INCLUDING AT LEAST 6,000 MW OF OFFSHORE WIND, AND THE GOVERNOR HAS TARGETED PRODUCTION OF 2,000 MW OF WIND POWER BY 2020.** These clean energy achievements have helped create jobs throughout the state and kept the Massachusetts' innovation engine running.

As the clean energy industry grows, states and regions across the nation are working to examine the impact that clean energy companies have on their workforce and economy. The Massachusetts Clean Energy Center (MassCEC) is responsible for conducting an annual accounting of the Commonwealth's clean energy sector.

> *Being in Massachusetts affords us access to technical talent in clean energy and renewable energy project development resources that are difficult to match anywhere else in the country. While our growth market is worldwide, we see Boston and Massachusetts as having all of the business resources to build the most competitive clean energy technology and development cluster."*
>
> **Henry Dormitzer, President & CFO**
> **Free Flow Power, Boston, MA**

Most studies of the clean energy economy, including MassCEC's previous employment surveys and the recently released report on green jobs by the Brookings Institution, rely solely on databases of known employers - organizations that are members of industry associations, have signed up for various clean energy incentives or programs, or have been otherwise identified as conducting clean energy work. Though these lists are important in researching the clean energy economy, analyses based solely on known employers can undercount clean energy work-

2011 Massachusetts Clean Energy Industry Study Key Findings

- *4,909 clean energy firms*
- *64,310 clean energy workers*
- *1.5 percent of total workers in the Commonwealth*
- *6.7 percent growth rate from July 2010 to July 2011*

ers because they miss large numbers of companies that are engaged in clean energy work but have not yet been identified as part of the industry. Other studies have also often relied on assumptions and economic models or are based on incomplete or unverified employment counts from secondary sources.

In addition to surveying known clean energy employers in Massachusetts, the research for the *2011 Massachusetts Clean Energy Industry Report* included a survey of randomly-selected Commonwealth employers from industries identified as being potentially related to clean energy. To capture the breadth of the cluster, surveys were administered online and by telephone to a list of known clean energy employers, as well as to a representative, clustered sample of companies across the entire Commonwealth, including companies across the clean energy value chain, representing manufacturing, service, research and development, and construction firms.

The findings in this report are highly reliable because they come straight from the source: the clean energy employers of Massachusetts. **THE RESEARCH TEAM ATTEMPTED MORE THAN 31,000 TELEPHONE CALLS AND SENT OVER 4,800 EMAILS TO EMPLOYERS.** This thorough survey effort, with a combined margin of error of approximately +/-2.5 percent at a 95 percent confidence interval, yielded 1,401 survey responses. The research effort identified more than 3,500 previously unknown employers that reported working in the Massachusetts clean energy sector.

As a result of this intensive research effort, the *2011 Massachusetts Clean Energy Industry Report* provides more comprehensive and reliable data on the number of clean energy firms and employees in the Commonwealth than has ever been available before. **THIS REPORT FINDS THAT MASSACHUSETTS HAS A ROBUST CLEAN ENERGY CLUSTER WITH 4,909 CLEAN ENERGY FIRMS EMPLOYING 64,310 CLEAN ENERGY WORKERS.** For the purpose of this report, a clean energy firm is defined as an employer engaged in whole or in part in providing goods and services related to renewable energy, energy efficiency, alternative transportation, and carbon management. Clean energy workers are defined as employees which spend at least a portion of their time supporting the clean energy aspects of their businesses.

The *2011 Massachusetts Clean Energy Industry Report* offers several significant findings related to the growing importance of this sector to the

Commonwealth's overall economy. First, the more than 64,000 **CLEAN ENERGY WORKERS IN MASSACHUSETTS REPRESENT 1.5 PERCENT OF THE TOTAL EMPLOYMENT IN THE COMMONWEALTH**, a percentage large enough to warrant clean energy to be recognized as a key sector in Massachusetts. In addition, the Massachusetts clean energy sector has breadth and depth across multiple industries and technology areas, and, while research and development are key contributors to the sector's success here, there is also significant clean energy employment in manufacturing, sales, and the installation of renewable energy.

The research also finds that clean energy employment is growing faster than other sectors in Massachusetts. **FROM JULY 2010 TO JULY 2011, CLEAN ENERGY EMPLOYMENT GREW BY 6.7 PERCENT, MUCH FASTER THAN THE OVERALL 1 PERCENT GROWTH RATE AMONG ALL INDUSTRIES IN THE COMMONWEALTH.**[1] Employers are also optimistic about their future prospects, anticipating 15.2 percent growth from July 2011 to July 2012.

Employment in the Massachusetts clean energy sector is diverse. The research finds that there are numerous growing occupations throughout the value chain of activities, such as research and development, manufacturing, and sales.

According to employers surveyed, talent development and supporting the pipeline of educated workers is critical to the success of clean energy companies in Massachusetts.

The following pages include detailed findings of the research, including a review of the size, growth, distribution, and workforce needs of clean energy employers in Massachusetts.

1. Economic Modeling Specialists, Inc. 2011 Complete Employment, 2011.3

Research Findings

Massachusetts' Clean Energy Sector is Large, Diverse and Growing

Since 2007, Massachusetts has made growing its clean energy sector a clear economic development priority, supported by the passage of various legislative and policy initiatives, including the Green Communities Act, the Green Jobs Act, and the Global Warming Solutions Act.[2] An independent report by CleanEdge in April 2010 noted that these initiatives, together with expanded incentive and training programs, have "cemented the state's position as a national leader in smart, proactive policies promoting clean-energy development."[3]

Indeed, investments in clean energy have clearly paid off. **MASSACHUSETTS IS CURRENTLY HOME TO 4,909 CLEAN ENERGY EMPLOYERS AND 64,310 CLEAN ENERGY WORKERS.** Prior to this research effort, MassCEC had identified 1,351 known clean energy firms—this year's research found these known firms to employ more than 25,000 clean energy workers. Further research conducted for this report uncovered more than 3,500 additional clean energy firms with 39,135 clean energy employees.

CLEAN ENERGY WORKERS MAKE UP 1.5 PERCENT OF THE COMMONWEALTH'S WORKFORCE AND ARE FOUND IN NUMEROUS INDUSTRIES ACROSS THE STATE. Of these 64,310 workers, 20,709 work primarily with installation and maintenance firms; 18,686 work in sales and distribution; 11,019 work for engineering and research firms; and 8,173 work for manufacturers.

From a technology perspective, clean energy firms work in many areas, led by energy efficiency and renewable energy. Specifically,

2. "A Future of Clean Energy and Growth: Advancing Massachusetts' Clean Energy Leadership," CleanEdge, April 2010.
3. Id., at p.8.

Portrait of a growing clean energy employer:
Next Step Living, Boston, MA

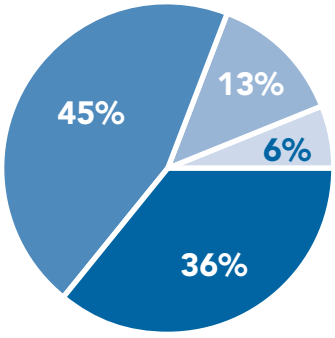
Next Step Living was founded in 2008 with the goal of making it easy for New England residents to make energy efficiency improvements in their homes. Since then, the company has grown dramatically – to more than 185 people now employed throughout the state helping homeowners achieve greater energy savings.

Founder Geoff Chapin saw a bright future for Next Step Living in Massachusetts from the start, and he deliberately located it to capture the greatest opportunity for success. "I knew that people in Massachusetts were like me – they were ready to make a difference," he says, "that fact, in combination with the abundance of old houses and long winters, led me to believe that the Massachusetts market was ready for the services we planned to provide."

The unique assets of Massachusetts' clean energy community were a bolster to Next Step Living's growth. With the passage in 2008 of Massachusetts' leading energy efficiency policy requiring utilities to use low-cost energy efficient resources, Chapin and his team at Next Step Living realized that utility partnerships offered an opportunity to bring its programs to a broad base of customers, while also helping the utilities meet their efficiency goals. "When the state's aggressive energy and environmental policy framework was passed, it sealed the deal," says Chapin.

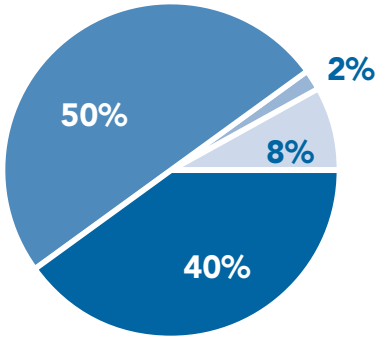
The company has also worked with state workforce development programs and received a grant from the Massachusetts Clean Energy Center. The strong financial community in Massachusetts also saw a bright future for Next Step Living. Rob Day of Boston-based Black Coral Capital, an investor in Next Step Living, says "It was a no-brainer to see their growth potential. By locating in Massachusetts, they clearly had access to a sizeable market and could apply lessons learned here in scaling up to additional locations."

MA Clean Energy Employment Growth from July 2010 to July 2011



- Positive growth over past 12 months
- Same number of clean energy employees
- Fewer clean energy employees
- Don't Know/No Answer

Projected Clean Energy Employment Growth, July 2011 to July 2012



- More
- Same number of clean energy employees
- Less
- Refused

2,687 employers in Massachusetts produce goods or services related to energy efficiency, while 2,027 employers produce goods or services related to renewable energy.[4]

The size of the cluster is impressive, demonstrating Massachusetts' position as a national leader in clean energy. Given the Commonwealth's strong employer base, leading policies, and clear commitment to growing the cluster, the potential for employment growth in the clean energy sector is significant.

"Conservation Services Group has seen tremendous growth in the past three years. The staff in our New England Energy Efficiency programs in Massachusetts has grown from 83 people in January 2009 to 185 today. The biggest growth has been in our field positions: energy auditors, project managers, and inspectors. And, we've seen Massachusetts job growth in other areas as well. The total number of staff in our Westborough and Fall River locations went from 162 at the beginning of 2009 to over 300 today – and still increasing."

Maureen Huffam,
Vice President of Human Resources
Conservation Services Group
Westborough, MA

Massachusetts Clean Energy Employers are Growing Rapidly

OVERALL, CLEAN ENERGY FIRMS IN MASSACHUSETTS EXPERIENCED IMPRESSIVE GROWTH FROM JULY 2010 TO JULY 2011, ADDING 4,036 NEW JOBS AT A 6.7 PERCENT GROWTH RATE. While overall job growth in Massachusetts during that period was less than one percent,[5] more than one-third of all clean energy companies grew, while only 13 percent cut their workforce. This finding highlights clean energy as a bright spot in economic recovery in the Bay State.

4. Note that this includes overlap. Many of the firms report working with renewable energy and energy efficiency technologies.
5. EMSI Complete Employment, 2011.3.

Portrait of a small business: *Digital Lumens, Boston, MA*

Against the backdrop of a sagging economy, Digital Lumens is bucking the trend, serving a growing list of industrial customers for its trademark Intelligent Lighting Systems. The systems have been proven to reduce lighting energy bills by up to 90 percent over conventional alternatives, and the company has quickly become a leader in the market for smart, LED-based lighting solutions.

After its founding in 2008, the company moved rapidly through the process of developing and testing product prototypes and raising first round investments from Flybridge Capital, Stata Ventures, and Black Coral Capital. The firm shipped its first systems to customers early in 2010.

Customer growth means job creation. The company now has 40 employees, primarily in engineering fields with the balance in sales, marketing, and support. The rapidly expanding application engineering team has found a particularly strong pool of talent among former military personnel.

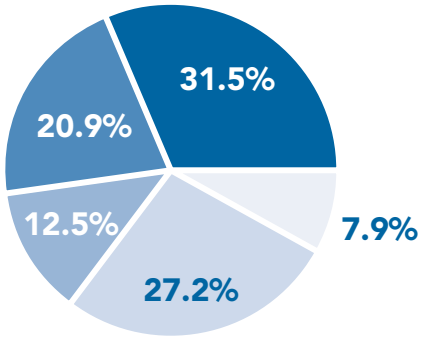
With products in demand and a growing customer base, Digital Lumens CEO Tom Pincince is bullish on the future, and on Massachusetts. Pincince easily reels off a list of Massachusetts advantages:

- A vibrant startup ecosystem, comprising people who are eager to work for a startup that wants to affect positive change;
- A terrific venture community that is willing to fund new companies;
- State government that prioritizes both the clean energy and technology sectors, and works to support innovation and customer adoption;
- Numerous organizations that support the clean energy ecosystem, including MassCEC, New England Clean Energy Council, and Mass Technology Leadership Council, and:
- A talented labor pool developed in the state's colleges and universities and through programs like MassCEC's new Clean Energy Summer Internship Opportunity Program.

The research also found that respondents are optimistic about future growth. Overall, clean energy employers expected to have 9,769 more clean energy jobs over the 12 months from July 2011 to July 2012, a 15.2 percent growth rate among clean energy workers. Forty percent of employers expect to have more clean energy workers in the coming year, while only two percent expect fewer. In comparison, overall Massachusetts employment is projected to grow by 1.4 percent from July 2011 to July 2012.[6]

6. Id.

Revenue related to clean energy products or services

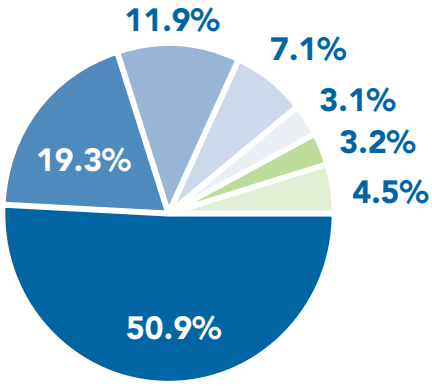


Clean Energy Provides an Important Revenue Stream to Many Businesses

Surveyed employers were also asked about the percentage of their overall revenues that are attributable to clean energy activities. **THE LARGEST SEGMENT OF SURVEYED EMPLOYERS ATTRIBUTE 100 PERCENT OF THEIR REVENUES TO CLEAN ENERGY ACTIVITIES, AND MORE THAN HALF OF EMPLOYERS REPORT THAT 50 PERCENT OR MORE OF THEIR REVENUES ARE RELATED TO THEIR BUSINESS ACTIVITIES IN THE CLEAN ENERGY INDUSTRY.** These findings show that clean energy touches a breadth of companies across the Commonwealth's industries and provides an important revenue stream to companies that have primary functions outside the clean energy cluster.

The revenue stream findings are clearly important to a state in recovery. Though Massachusetts has fared better overall in the recent economic recession than other states, there are still industries—such as construction—that are tens of thousands of jobs below pre-recession levels. **THE FINDINGS IN THIS REPORT SUGGEST THAT CLEAN ENERGY IS PROVIDING A MUCH-NEEDED SHOT IN THE ARM TO THESE RECOVERING INDUSTRIES.**

Number of Clean Energy Employees at MA Firms



> *"Our company has grown from five employees in March 2011 to 25 today. We expect to hire at least 10 more employees in the next few months and be near 50 by the end of 2012. We're taking HVAC and construction workers out of the unemployment line and putting them to work. Massachusetts has been very supportive and involved with the well being of its start-up and renewable energy focused companies, and we're thankful to be part of a progressive and visionary government at both the state and local levels."*
>
> **Ed Malloy, President and CEO**
> **New England Renewable Energy Systems, Sherborn, MA**

Small Businesses Play a Key Role in Massachusetts' Clean Energy Cluster

THE MAJORITY OF THE COMMONWEALTH'S CLEAN ENERGY EMPLOYERS ARE SMALL BUSINESSES, WITH NEARLY 40 PERCENT HAVING FIVE OR FEWER PERMANENT EMPLOYEES. According to the Small Business Association's *2010 Small Business Profile for Massachusetts,* small businesses account for nearly 50 percent of all employment in the Commonwealth, and the fastest growing segment is companies with one to four employees.

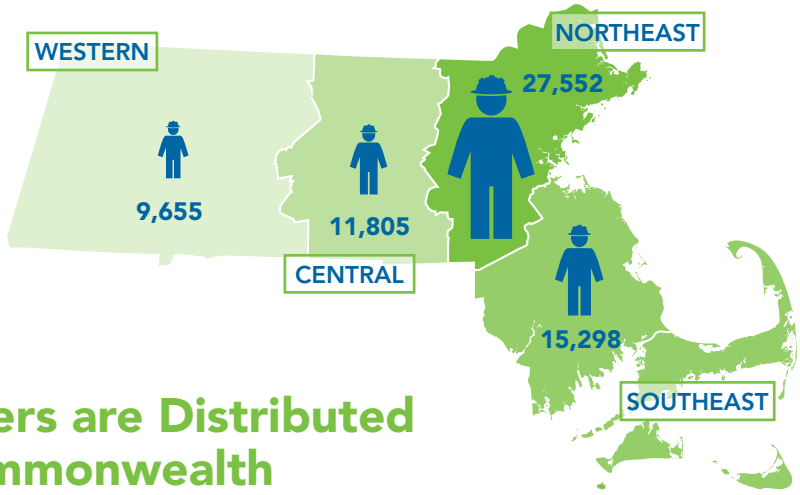
Historically, small businesses have driven job growth in the United States. In fact, according to Ying Lowry, an economist at the Small Business Association, small businesses created 3.5 million new jobs nationwide annually between 1997 and 2008.

The most recent economic recession has impacted small businesses in many ways. On the one hand, layoffs have led many to start their own companies, fueling new small business growth. At the same time, existing smaller employers have been hiring at a slower pace than before the recession.

The data collected for this report, however, demonstrate solid small business representation in the clean energy sector and strong employment growth at small clean energy businesses. **WHILE SMALL BUSINESSES NATIONWIDE HAVE EXPERIENCED A SLOWDOWN IN HIRING OVER THE PAST SEVERAL MONTHS,[7] MASSACHUSETTS BUSINESSES WITH FEWER THAN 50 CLEAN ENERGY EMPLOYEES GREW THIS EMPLOYMENT SECTOR BY 9.6 PERCENT FROM JULY 2010 TO JULY 2011.**

7. See generally; "CBIZ Small Business Employment Index Shows Pause in Hiring Trend," available at: http://eon.businesswire.com/news/eon/20110708005088/en/employment-data/employment-news/small-business; Reuters, "Small business hiring slows in August, wages dip," available at: http://www.reuters.com/article/2011/08/29/us-usa-economy-jobs-idUSTRE77S00320110829

Total Clean Energy Workers by Region



Clean Energy Workers are Distributed Throughout the Commonwealth

Clean energy employment exists throughout the Bay State. The map above illustrates the clean energy employment concentrations of the four regions in Massachusetts. The Northeast has the greatest concentration of workers, followed by the Southeast, Central, and West. All areas, however, show significant employment, ranging from 9,655 clean energy workers in the West to 27,552 clean energy workers in the Northeast.

In the period from July 2010 to July 2011, clean energy employment in Southeastern Massachusetts grew the fastest at 7.6 percent. Western Massachusetts grew by 7.2 percent, Northeast Massachusetts by 6.7 percent, and Central Massachusetts by 5.1 percent. Going forward, clean energy employers expected to expand their clean energy employment by 23.5 percent in the Southeast, 14.3 percent in the Northeast, 10.7 percent in the Central region, and 10 percent in the West from July 2011 to July 2012.

Clean Energy Supports Numerous Industry Segments in Massachusetts

In addition to the impressive size of the cluster, the research shows that employers' involvement in clean energy activities is much broader and deeper than previously believed. Many—particularly those outside of the Commonwealth—have viewed Massachusetts' clean energy cluster predominantly as a hub for research and development (R&D) and finance. While these are vital industry segments in the Massachusetts clean energy industry cluster, the entire value chain of activities—including manufacturing—is well represented in Massachusetts, as illustrated by Table 1 on page 12, and the "Clean Energy Firms Activities" graph on page 15.

While there are many firms engaged in more than one activity, **INSTALLATION AND MAINTENANCE OF RENEWABLE ENERGY PROJECTS IS THE LARGEST VALUE CHAIN ACTIVITY IN THE COMMONWEALTH.** More than one in three clean energy firms in Massachusetts are primarily engaged in installation and maintenance of clean energy technologies, while nearly one in five are primarily engineering or R&D firms. Sales and distribution and manufacturing are also clearly important segments of the cluster, making up 29 percent and 17 percent, respectively.

Portrait of a Massachusetts Manufacturer:
Diamond-Roltran, Littleton, MA

As Massachusetts' clean energy sector has grown in recent years so have opportunities for companies such as Littleton, MA-based Diamond-Roltran to utilize their expertise in precision manufacturing in the clean energy manufacturing market.

Diamond-Roltran was founded in 2007 as a spin-off of 50-year old company Diamond Antenna, which historically designed and manufactured microwave rotary couplers used in radar systems such as air traffic control (ATC) shipboards and Satcom-On-The-Move (SOTM) pedestals.

Diamond-Roltran started designing and manufactures its Roll-Ring® technology, which offers an alternative to the slip rings used for rotary electrical transfer in applications that require high power, low noise, and long life. In 2010, it adapted the technology to be used in wind turbines, creating the Roll-Ring® Wind Collector to replace the traditional slip ring at the connection point between the rotor and generator in a utility scale wind turbine.

"It was a logical progression for the development of the Roll-Ring® technology," says Jeff Gilling, Chief Executive Officer of Diamond-Roltran. "As a growing small business with an existing product line, we had the capacity to make the transition."

While traditional slip rings need maintenance about every six months, Diamond's Roll-Ring® technology lasts ten times longer helping turbine owners realize savings in reduced maintenance costs and improved up-time.

With 25,000 operational utility scale wind turbines in the United States – 90 percent of which can benefit from the Roll-Ring® Wind Collector – Diamond Roltran sees a significant market for their innovative technology, and with the help of the local precision manufacturing sector, the potential for job growth in Massachusetts.

"It's all local," says Matt Edison, Chief Operating Officer of Diamond-Roltran. "In Massachusetts, we are in close proximity to many precision machine shops, mold shops, metal finishers, and value added distributors, and that helps us to be competitive."

Table 1: Clean Energy Firms and Employment By Value Chain Activity[8]

Primary Value Chain Activity	Number of Clean Energy Employers	Number of Clean Energy Workers
Manufacturing and assembly	462	8,173
Research and development	868	11,019
Sales and distribution	881	18,686
Installation	2,052	20,709
Other	645	5,722

8. Note that the total in each category is rounded to the nearest worker, which explains the difference with the totals reported previously.

Municipal Government Employees are Part of the Clean Energy Workforce

Profile: The City of Worcester

The City of Worcester is the second largest city in Massachusetts, with a growing population of more than 180,000 people. It is also a clean energy leader in the Commonwealth with a deep commitment to energy policies that save taxpayer dollars, reduce greenhouse gas emissions, improve environmental health, and create new jobs for city residents.

Even before the passage of the city's first Climate Action Plan in 2006, Worcester's city government understood that pursuing clean energy would touch workers in many of the city's ten departments and their component divisions. Among those most involved are the Departments of Economic Development, Inspectional Services, Public Works, Parks, Administration and Finance, and the Office of the City Manager.

To provide structure and coordination to clean energy initiatives in city government, the city formed an Energy Efficiency and Conservation Program within its Division of Planning and Regulatory Services. John Odell was named manager of this unit in 2009. Working with oversight from the City Manager's Energy Task Force, staff from this division are leading the creation of a new Climate Action Plan.

Odell points out that clean energy activities in city government do not create very many additional jobs, but they add to and change the responsibilities of many existing employees; from planners and civil engineers to building inspectors, clerks, procurement officers, facilities managers and more. "This work touches on so many things in Worcester," Odell reports. "Building energy, municipal operations, waste, transportation, green infrastructure, and outreach to the community are all involved. Even food consumption activity is affected."

Worcester's planners are quick to point out that, while some clean energy initiatives are clearly led by city government, many efforts involve collaboration and coordination with different levels of government, the business community, community groups, and other stakeholders. "City government and city government workers can't do this work alone," says Odell.

Worcester's clean energy efforts also require contracting for expert assistance, which supports jobs at companies such as Honeywell International, the city's primary energy service company (ESCO) partner. From 2009 to 2011, the city worked with Honeywell on an energy audit of all public facilities as a precursor to signing a $26.6 million agreement designed to reduce energy consumption by 20 percent and slash over $1 million from the energy bill of Worcester taxpayers.

Massachusetts is Strong In Multiple Technology Areas

The research shows that the Massachusetts clean energy cluster includes a wide spectrum of technology areas. Survey participants were first asked to list the major technology areas with which their employers are most closely associated. Because researchers anticipated that many employers would be active in a number of technology areas, multiple responses were permitted.

Individual employers in the Commonwealth tend to work with multiple clean energy technologies. **IN FACT, 28 PERCENT OF EMPLOYERS SURVEYED REPORTED WORKING**

As is true in cities across Massachusetts, adoption of clean energy policies created new responsibilities and training needs throughout the city government. This impact is clearly seen in the commitments that Worcester made to earn its designation by the Department of Energy Resources as a "Green Community" under the Massachusetts Green Communities Act. These commitments include:

- Zoning ordinance changes related to siting renewable energy research and development or manufacturing facilities;
- Zoning ordinance changes to ensure expedited application and permitting for clean energy facilities;
- Completion of an energy use baseline inventory for municipal buildings, vehicles, and street and traffic lighting;
- Development of a comprehensive plan to reduce energy use by 20 percent in five years in those municipal facilities;
- Approval of a policy for purchasing only fuel-efficient vehicles for municipal use; and
- Adoption of the Stretch Code, an energy code which exceeds the baseline energy code requirements by approximately 20 percent for residential and commercial construction.

Assuring that municipal employees have the information and training they need to carry out these "Green Community" responsibilities is not a hypothetical matter. For example, a growing number of renewable energy facilities and installations have been recently completed in Worcester, and many more are planned.

Some of the most notable projects include the installation of a 59 kilowatt (kW) solar array on the roof of the city's water filtration plant, a project made possible by federal funds from the Energy Efficiency Community Block Grant (EECBG) program of the American Recovery and Reinvestment Act of 2009 (ARRA). The filtration plant's solar installation was performed by Nexamp, a Massachusetts-based company whose rapid growth epitomizes the recent expansion of the state's solar industry.

A 250 kW roof-mounted solar array is planned for Worcester Technical High School using funds from the EECBG, and an additional solar array is in the works for Sullivan Middle School.

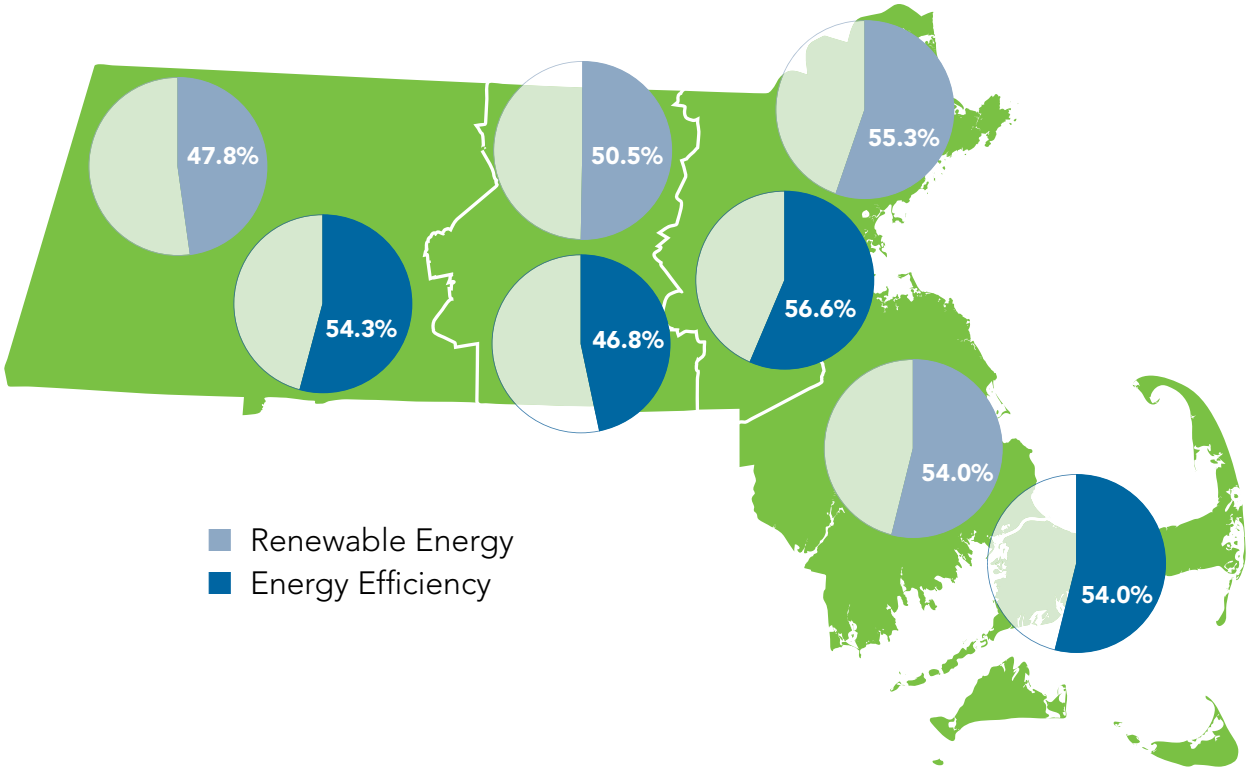
The City of Worcester is clearly a clean energy leader among Massachusetts municipal governments. Happily, it is not alone. Municipal governments in Salem, Lowell, Springfield, Boston, New Bedford, and many other towns and cities are using and training existing employees to achieve their clean energy goals and hiring new professionals as needed. These local government change agents are a critical part of the Commonwealth's growing clean energy workforce.

IN MORE THAN ONE MAJOR AREA, SUCH AS RENEWABLE ENERGY OR ENERGY EFFICIENCY.

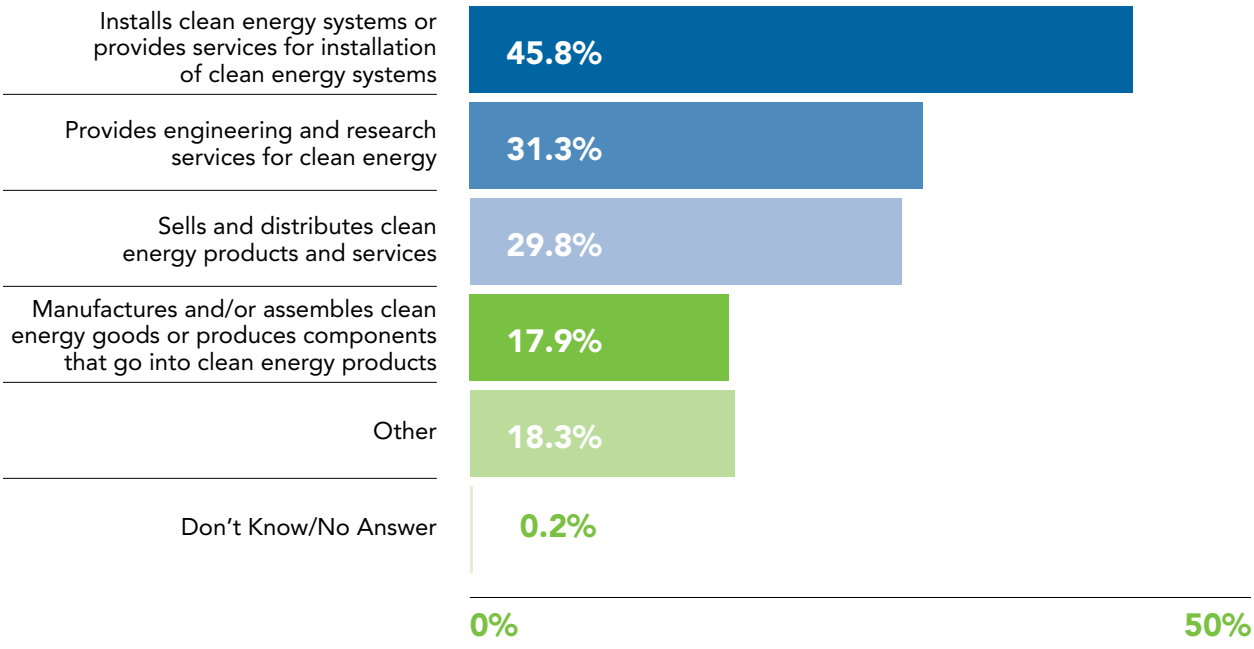
The survey answers demonstrate that energy efficiency and renewable energy are the most prevalent technology areas in Massachusetts' clean energy cluster. (see "Massachusetts Clean Energy Technology Strengths" graph on page 17).

Renewable energy firms often work across technologies as well. **MORE THAN TWO IN THREE RENEWABLE ENERGY EMPLOYERS, HOWEVER, REPORT WORKING WITH SOLAR ENERGY TECHNOLOGIES**—clearly the

Percentage of Clean Energy Firms Working in Renewable Energy and Energy Efficiency, by Region



Clean Energy Firm Activities



most prevalent renewable technology in the Bay State. Solar is a fast-growing sector, with national estimates indicating growth rates of nearly seven percent annually, which bodes well for Massachusetts. **NEARLY A THIRD OF COMPANIES REPORT WORKING WITH WIND TECHNOLOGY**, followed by geothermal and bioenergy.

Equally important to the cluster, energy efficiency firms seem to be supporting the otherwise distressed construction industry in Massachusetts.[9] **THE RESEARCH FINDS THAT OVER HALF OF ALL ENERGY EFFICIENCY FIRMS WORK IN HEATING, VENTILATION, AND AIR CONDITIONING (HVAC), OR BUILDING CONTROLS, FOLLOWED BY LIGHTING AND BUILDING MATERIALS.** Like renewable energy, the energy efficiency sub-sector contains activities related to goods, such as appliances and machinery, as well as services, such as weatherization and energy efficient processes. Supporting energy efficiency measures clearly benefits these important Massachusetts employers.

Though not as large as renewable energy or energy efficiency, **ALTERNATIVE TRANSPORTATION MAKES UP A SIGNIFICANT PART OF THE CLEAN ENERGY SECTOR IN MASSACHUSETTS.** Surveyed alternative transportation employers overwhelmingly report being involved in electric vehicle technologies.

Clean Energy Industry Technologies

Renewable Energy

- Solar (PV or photovoltaic, thermal or concentrated or CSP)
- Wind power
- Fuel cell
- Bioenergy
- Hydropower or hydrokinetic (river, wave, tidal)
- Geothermal
- Hydrogen generation
- Thermal to energy conversion
- Renewable combined heat and power

Energy Efficiency

- Lighting
- HVAC and building controls
- Energy efficient appliances
- Energy efficient processes and machinery
- Energy storage
- Demand response services
- Smart grid (smart computing/software)
- Weatherization services
- Energy efficient building materials

Transportation

- Electric vehicles and systems
- Electric rail

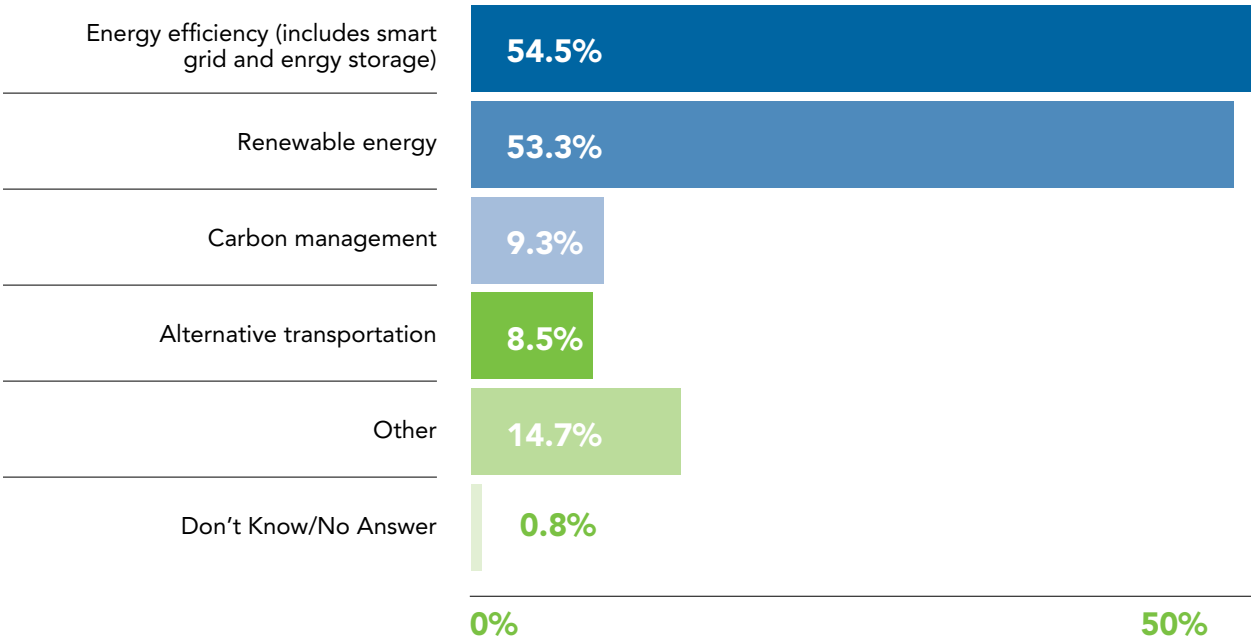
Carbon Management

- Carbon capture and storage
- Secondary carbon market
- Coal gasification

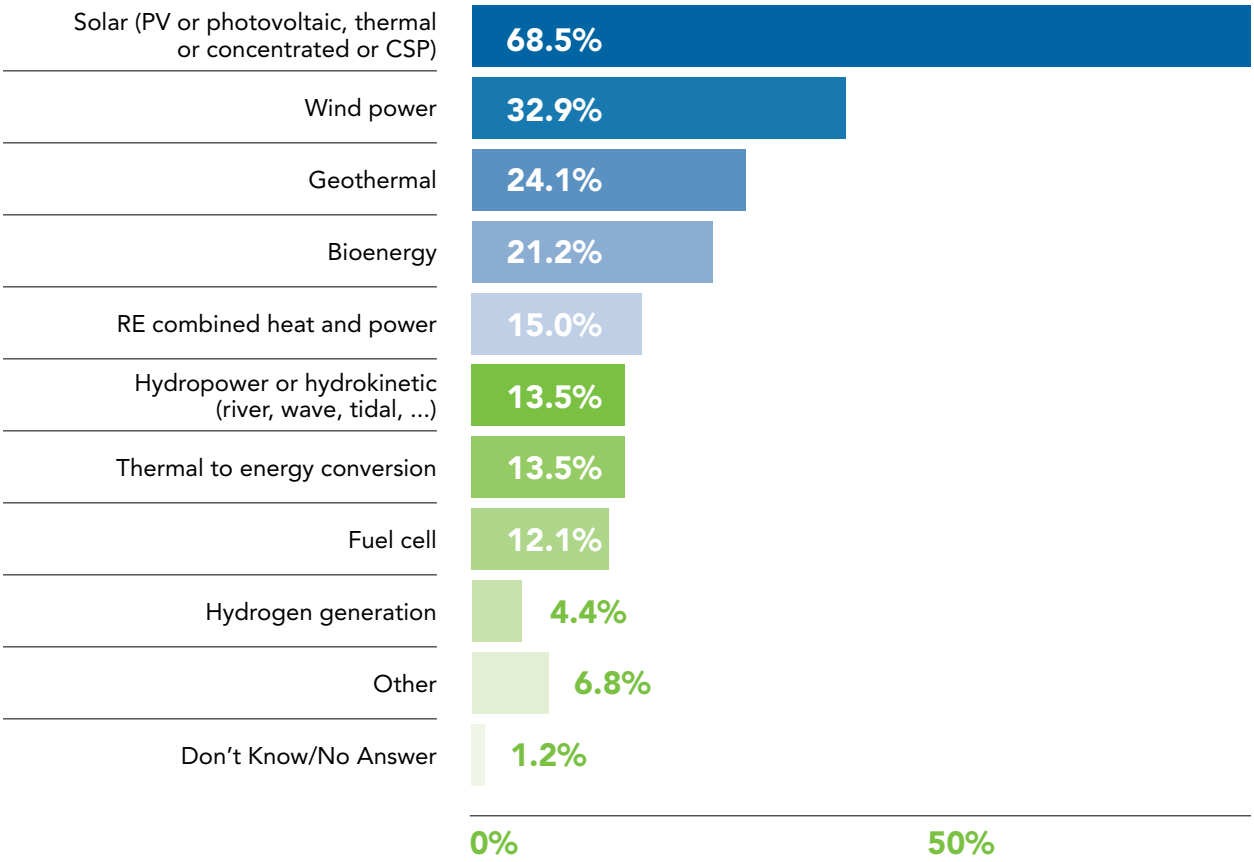
Massachusetts is funding the purchase and supporting the installation of 142 public electric vehicle charging stations in more than 25 communities to help reduce the "range anxiety" that may slow down the penetration of electric

9. The Solar Jobs Census 2010; The Solar Jobs Census 2011 (forthcoming), available at http://thesolarfoundation.org.

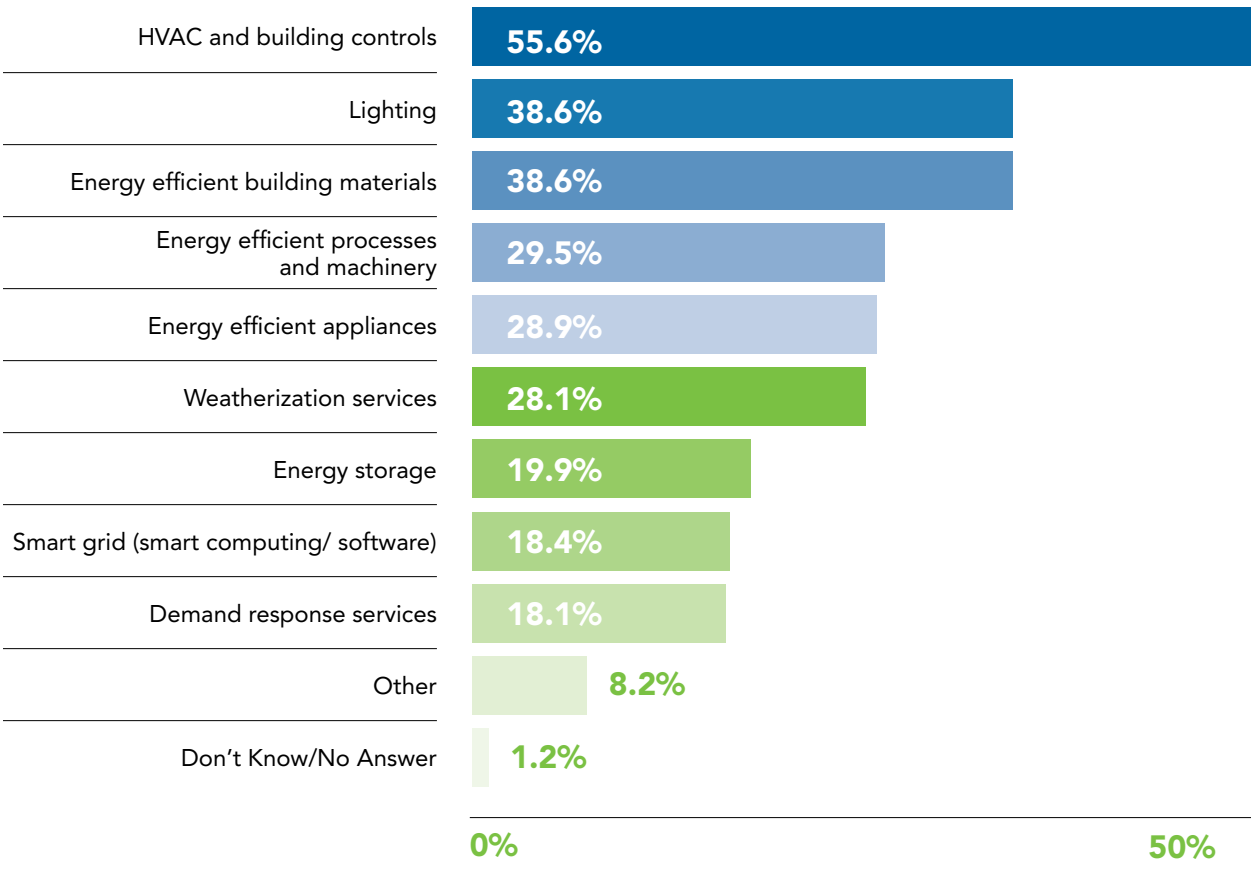
Massachusetts Clean Energy Technology Strengths



Renewable Energy Firms' Technology Focus



Energy Efficiency Firms' Technology Focus

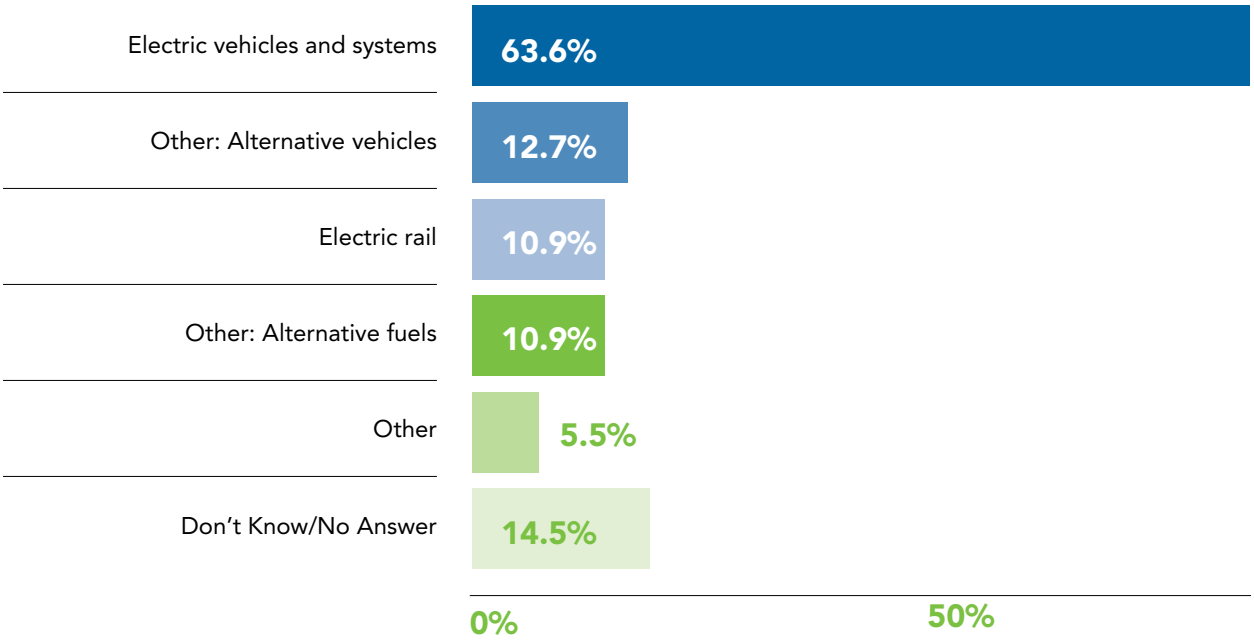


vehicles beyond the "early adopters." A coalition of organizations in the Northeastern states, led by the Massachusetts Clean Cities program, has received a nearly $1 million federal grant to jump start planning for an interstate network of electrical vehicle charging stations, an initiative that will spur job creation and use of electric vehicles throughout the region.

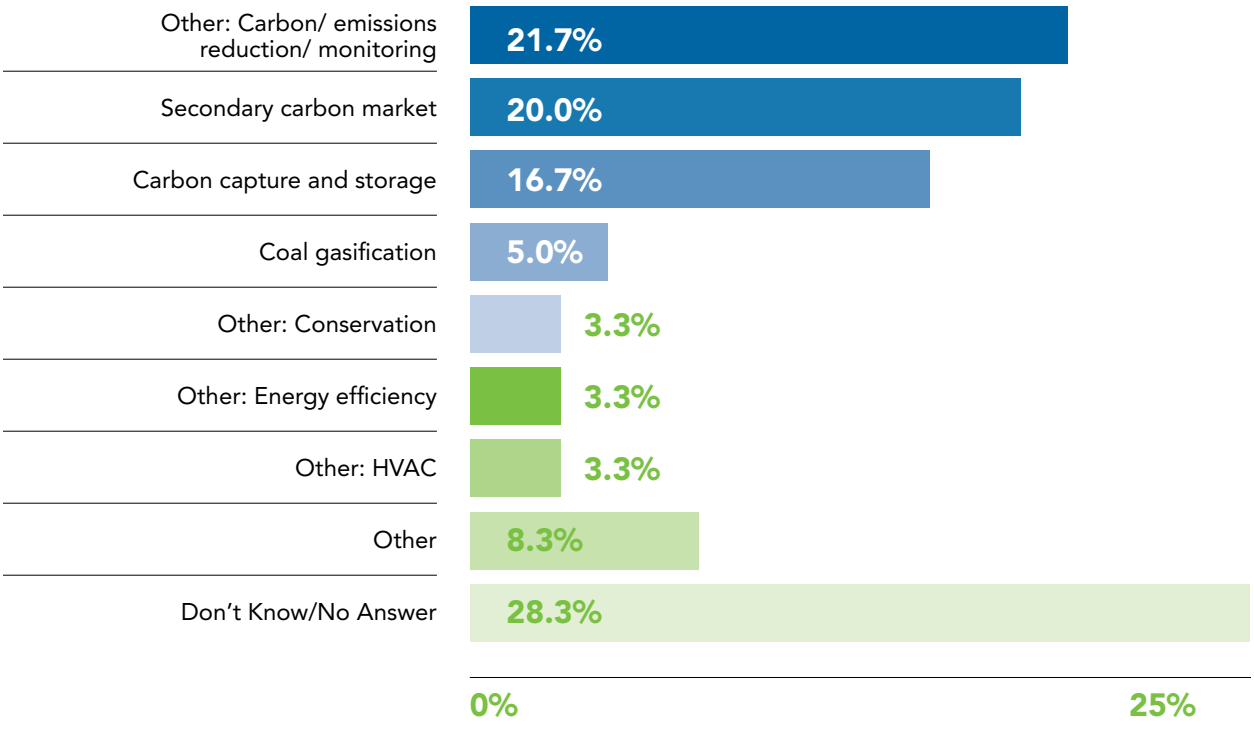
Currently, the Commonwealth is transitioning its bus fleet to cleaner fuels through agencies such as the Massachusetts Bay Transit Authority, MassPort, Massachusetts Department of Transportation and other transit authorities, private fleets and municipalities. The state has provided guidance to facilities planning to make biodiesel from waste products, is simplifying rules to encourage aerobic digestion of wastes to energy or fuel, and provides a tax exemption to producers of cellulosic ethanol.

FINALLY, MANY ENERGY EFFICIENCY EMPLOYERS REPORT CARBON MANAGEMENT AS A BUSINESS ACTIVITY. Carbon management employers were most likely to report involvement with carbon emission management or monitoring, secondary carbon markets, or carbon capture. Most of these employers, however, were referring to traditional energy efficiency activities and not carbon management as defined by the survey options. This finding potentially illustrates the role of carbon reduction in the marketing and branding of energy efficiency technologies in the Commonwealth, just as it demonstrates the importance of carbon reduction to clean energy firms in the state.

Alternative Transportation Firms' Technology Focus



Carbon Management Firms' Technology Focus



"We made the strategic decision to locate EnerNOC in downtown Boston because of its rich talent pool and alignment with EnerNOC's corporate mission. In the past four years, we have added over 200 jobs located here in Boston. We have been able to scale our organization globally in large part because of the rich talent we have locally."

Tim Healy, Chairman and CEO
EnerNOC, Boston MA

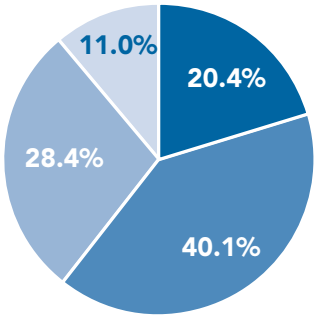
Massachusetts Competes For Talent

Employers report that the strength of the Massachusetts clean energy cluster is in its talent, and that recruiting and retaining top talent is critical to continued industry success. Massachusetts is home to world-class universities and colleges, has a high standard of living, and is recognized as the most educated state in the nation.[10] According to a recent report by the Massachusetts Business Roundtable,[11] the Commonwealth's talent and quality-of-life assets allow it to compete with other states at the highest levels of innovation.

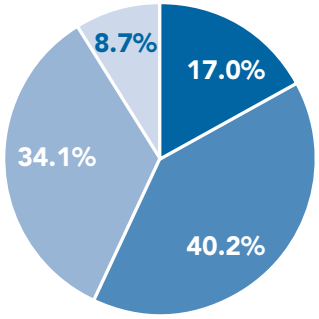
Clean energy employers in Massachusetts surveyed for this study prefer or require more education and training of their employees than clean energy employers across the country. **THE MASSACHUSETTS EMPLOYERS WHO RESPONDED TO THE SURVEY VALUE BACCALAUREATE, MASTER, DOCTORAL, AND PROFES-SIONAL DEGREES FROM THEIR CLEAN ENERGY WORKERS INVOLVED IN R&D, SALES, AND MANAGEMENT TO A MUCH HIGHER DEGREE THAN THE NATIONAL AVERAGE.**[12] At the same time, the

10. U.S. Census Bureau.
11. Massachusetts Business Roundtable, Strengthening Massachusetts' Long-Term Vitality, available at: maroundtable.com/doc.../MBR_2011CompetitivenessAgenda.pdf.
12. See Generally, The Solar Foundation, National Solar Jobs Census 2010, October 2010; The Solar Foundation, National Solar Jobs Census 2011 (forthcoming, October 2011); BW Research Partnership, Silicon Valley in Transition: Economic and Workforce Implications in the Age of iPads, Android Apps, and the Social Web, July 2011; Cuyamaca College and the San Diego Workforce Partnership, Green Construction Outlook, April 2011; Green LMI Consulting, Renewable Energy in Imperial Valley, March 2011.

Finding qualified applicants with adequate experience in the clean energy industry



Recruiting employees with the technical skills required for their position



Great Difficulty Some Difficulty No Difficulty Don't Know/No Answer

nation is experiencing critical shortages of workers who are highly educated in science and math, such as engineers, research scientists, and technical managers.[13]

The majority of Massachusetts clean energy employers report little to no difficulty in finding and recruiting employees. Talent acquisition difficulty rises as positions require greater education and experience, again suggesting employers are competing for the highest-level talent.

Clean energy employers report that their positions are less likely to be entry level and more likely to require advanced skills and education. Employers note that for many of the occupations, experience in a related field—whether in sales, research, or installation and maintenance—is important for successful employment, indicating that short-term training is valuable for already-skilled workers but is not sufficient training for new entrants to the field.

Clean energy employers continue to report that talent is vital to their long-term success. The highly skilled fields in which survey respondents report the most difficulty finding qualified applicants require training in science, technology, engineering, math (collectively known as the STEM fields), and/or management. Shortages in these skilled areas would be detrimental to growing the Massachusetts clean energy clus-ter, suggesting that the state should continue to strengthen its pre-K–12 pipeline in STEM.

Given the national shortages of educated workers and their importance to the Com-monwealth, retention of university graduates is important to employers (currently 40 percent of Massachusetts Institute of Technology (MIT) graduates remain in Massachusetts)[14], as is attracting graduates from outside of the region.

According to employers interviewed for this report, recruiting and retaining top talent and competing with other clean energy regions will require maintaining the Bay State's high quality of life and active commitment to recruiting companies and people to the Commonwealth.

13. See Generally, Manpower, Talent Shortage 2011 Survey Results, available at: http://us.manpower.com/us/en/multimedia/2011-Talent-Shortage-Survey.pdf
14. CleanEdge, April 2010.

Universities are key clean energy employers in Massachusetts

A closer look at university employment

Massachusetts is home to some of the best universities in the world, and many of them are deeply engaged in clean energy education and research. While the benefits that Massachusetts receives from these institutions in terms of new knowledge, technological innovation, and the training of talented professionals are well understood, the Commonwealth also benefits in another way: clean energy jobs.

Just how extensive is the clean energy research, education, and training community in Massachusetts? One measure is found in the more than 125 programs identified and described in the Massachusetts Clean Energy Education and Training Online Directory at www.cleanenergyeducation.org. The directory lists dozens of institutions of higher learning in Massachusetts, which provide jobs at all levels of the clean energy industry.

To capture a snapshot of clean energy research employment at universities in Massachusetts, the research team engaged the help of research deans and other managers at four leading institutions. This process identified 1,326 employees involved in clean energy related research activities. The selected institutions were:

University	Number of Clean Energy Jobs
University of Massachusetts, Amherst	234
University of Massachusetts, Boston	37
University of Massachusetts, Lowell	55
Massachusetts Institute of Technology	1,000

The clean energy workforce in the higher education sector includes professors, adjunct professors, lecturers, researchers, research assistants, staff, doctoral and postdoctoral fellows, graduate students, and paid undergraduate assistants.

UNIVERSITY OF MASSACHUSETTS, AMHERST

The University of Massachusetts, Amherst is both a leader in clean energy education and research and a major employer. The UMass Amherst clean energy job count survey identified 57 professors or faculty members, 160 postdoctoral, doctoral, and graduate students, and 17 additional staff at:

- Energy Frontiers Research Center
- Enhanced Geothermal Research Group
- The Institute for Massachusetts Biofuels Research (TIMBR)
- Wind Energy Center
- Center for Renewable Energy Science and Technology
- Northeast Combined Heat and Power Application Center
- Geobacter Project (involves microbial fuel cells)
- Green Building Program
- Political Economy Research Center (Green Economy Project)

UNIVERSITY OF MASSACHUSETTS, LOWELL

Clean energy employment at the University of Massachusetts Lowell is already significant and is on the rise as the university's leadership deepens its commitment to the clean energy sector. The UMass Lowell job count survey found employment in many places, with research being conducted in engineering (plastics, me-

chanical, civil, electrical) and in the economics, physics, and chemistry departments. Clean energy employment included at least 24 faculty members, three postdoctoral fellows, 21 graduate students, and seven additional staff associated with a number of centers and projects:

Centers and Programs

- Center for Electric Car and Energy Conversion
- Center for Sustainable Energy
- Climate Change Initiative
- Wind Energy Research Group
- Clean Energy Workforce Development Program

Selected Research Projects

- Molecular and Polymeric Photovoltaics
- Organic Photovoltaics from Nano-Patterned Fullerenes and Semi-Conducting Polymers
- Binder-Free Silver Links for Electrode Materials in Organic Photovoltaics
- Biobased Surfactants
- Novel Halogen-Free Flame Retardants
- Enzymatically Synthesized Conjugated Polymers
- Using Fossil Energy in a Cleaner Way

UNIVERSITY OF MASSACHUSETTS, BOSTON

Clean energy related employment and research is found throughout the University of Massachusetts, Boston community, including the departments of accounting, finance, chemistry, computer science, economics, engineering, management, marketing, physics, political science, and environmental, earth and ocean sciences.

Additional employment is found at the Urban Harbors Institute and the Department of Conflict Resolution, Human Security, and Global Governance.

Taken together, UMass Boston clean energy employment includes 18 professors, two research associates, one institute director, and at least 16 postdoctoral, doctoral, and graduate students.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY (MIT)

MIT is by far the largest employer of clean energy-related faculty, researchers, graduate students, and staff in Massachusetts, with at least 1,000 people involved in clean energy related research and other work. Much of this work is organized and described through The MIT Energy Initiative (MITEI). Some of MIT's laboratories, centers, and programs that involve clean energy include:

- Alliance for Global Sustainability
- Building Technology Program
- Cambridge-MIT Institute
- Center for Energy and Environmental Policy Research
- Center for Global Change Science
- Center for Materials Science and Engineering

- Center for Ocean Engineering
- Center for Technology, Policy, and Industrial Development
- Center for Transportation and Logistics
- Center for 21st Century Energy
- Computer Science and Artificial Intelligence Laboratory
- Cryogenic Engineering Laboratory
- Deshpande Center for Technological Innovation
- Earth Resources Laboratory
- Earth System Initiative
- Electrochemical Energy Laboratory
- Fuel Cell Laboratory
- Gas Turbine Laboratory
- Industrial Performance Center
- Joint Program on the Science and Policy of Global Change
- Laboratory for Electromagnetic and Electronic Systems
- Laboratory for Energy and the Environment
- Laboratory for Manufacturing and Productivity
- Laboratory for Ship and Platform Flows
- Materials Processing Laboratory
- Microsystems Technology Laboratory
- Reacting Gas Dynamics Laboratory
- Research Laboratory of Electronics
- W.M. Rohsenow Heat and Mass Transfer Laboratory
- Sloan Automotive Laboratory
- Solar Frontiers Center
- System Dynamics Group

In addition to these special units, MIT faculty, students and staff and are employed in clean energy-related work in the following departments: aeronautics and astronautics; architecture; biological engineering division; biology; chemical engineering; earth, atmospheric and planetary sciences; economics; electrical engineering and computer science; engineering systems division; history section; materials science and engineering; physics; political science; program in science; technology and society; Sloan School of Management; and urban studies and planning.

To arrive at an accurate clean energy employment count for the sprawling MIT energy-related job community, the researchers communicated with leaders at MITEI. These conversations resulted in agreement that at least 1,000 faculty, students, and staff at MIT are employed in clean energy research and related work at MITEI related programs and departments.

Other Massachusetts Universities with Significant Clean Energy Employment

In a state with more than 100 exceptional colleges and universities, it is clear that a close look at just four leaders can account for only a fraction of the total clean energy research and academic workforce. There is also significant clean energy employment at University of Massachusetts Dartmouth, Worcester Polytechnic Institute, Harvard University, Boston University, Boston College, Clark University, and many others.

Conclusions

THE DATA UNCOVERED BY THIS RESEARCH REPORT MAKES IT CLEARER THAN EVER BEFORE THAT THE CLEAN ENERGY SECTOR IS A LARGE, GROWING, AND IMPORTANT PART OF THE MASSACHUSETTS ECONOMY. THIS REPORT SHOWS THAT THE MASSACHUSETTS CLEAN ENERGY CLUSTER IS SIGNIFICANTLY LARGER THAN PREVIOUSLY BELIEVED, WITH 4,909 FIRMS EMPLOYING 64,310 WORKERS—THEREFORE ENCOMPASSING 1.5 PERCENT OF ALL EMPLOYMENT IN THE COMMONWEALTH. THE CLUSTER IS ALSO GROWING , WITH 6.7 PERCENT GROWTH FROM JULY 2010 TO JULY 2011 AND AN ANTICIPATED 15.2 PERCENT GROWTH FROM JULY 2011 TO JULY 2012. WITH SUCH IMPRESSIVE NUMBERS AND ROBUST GROWTH, CLEAN ENERGY IS A MAJOR ECONOMIC FORCE IN MASSACHU-SETTS AND SHOULD BE CONSIDERED A CRITICAL DRIVER OF THE STATE ECONOMY.

In addition to its size, the clean energy cluster proves to be diverse, encompassing the entire value chain—from research and development to manufacturing and installation—and with a variety of technologies represented. This research shows that companies engaged in renewable energy and energy efficiency are by far the most prevalent in the Commonwealth, though alternative transportation is also well-represented. And while the clean energy cluster itself is large, the firms that comprise it tend to be small, with 40 percent having five or fewer permanent employees, showing that small businesses are critically important to the sector.

There are a number of important steps Massachusetts can and should take to support this important cluster. As a start, policymakers should continue efforts to support the small businesses that make up the majority of clean energy employers. Likewise, a continued commitment to education and maintaining the Commonwealth's high standard of living will ensure that the state is able to develop and retain the top-tier talent that the cluster requires. Initiatives promoting renewable energy and energy efficiency are and will continue to be important, and these efforts should extend to developing all parts of the value chain, including manufacturing and installation.

Massachusetts has long been a hotbed of technological innovation, and by working to support and further develop its flourishing clean energy cluster, the Commonwealth can guarantee its position well into the 21st century.

Research Methodology

In June and July 2011, BW Research worked closely with the Massachusetts Clean Energy Center to conduct a survey of clean energy companies in the Commonwealth. For the purposes of the survey, a clean energy firm is defined as a company involved with an activity related to the clean energy industry. The Clean Energy Industry is defined as being directly involved with researching, developing, producing, manufacturing, distributing, or implementing components, goods, or services related to renewable energy, energy efficiency or conservation, smart grid, energy storage, carbon management, and/or electric or hybrid vehicles. Clean energy employees are defined as full-time and part-time permanent employees who support the clean energy portion of their businesses, including administrative staff.

In order to accurately capture data from the cluster, surveys were administered online and by telephone to a list of known employers as well as to a representative, clustered sample of companies from the NAICS industries identified by the Bureau of Labor Statistics as being potentially related to the renewable energy, energy efficiency, and alternative transportation sectors.[15] NAICS codes that were identified to have fewers than ten establishments or fewer than 500 employees in Massachusetts were excluded from the sample.

The research team attempted over 31,000 telephone calls and sent over 4,800 emails to employers. The survey effort, with a combined margin of error of approximately +/- 2.5 percent at a 95 percent confidence interval, yielded 1,401 survey responses from the samples (660 surveys from clean energy companies and 741 "short" surveys from firms not currently in clean energy to assess whether they expect to be next year). The survey was fielded from June 30 to July 29, 2011 and averaged 15 minutes in length.

Known Universe

The original list of employers, developed from previous work efforts and databases from the Massachusetts Clean Energy Center and partner organizations, contains the companies that are known to be to be active in the clean energy

15. See BLS Green Jobs Initiative - http://www.bls.gov/green/, list of NAICS codes at http://www.bls.gov/green/final_green_def_8242010_pub.xls

economy. After duplicate cleaning and applying estimates from the survey data to account for companies that are no longer in business, do not have at least one Massachusetts location, or do not identify as in the clean energy industry, the known universe of firms is estimated at 1,351 companies.

All firms in the database with email information were sent multiple online invitations and the survey link was also distributed to the membership of the following partner organizations: Environmental Business Council of New England, Massachusetts Manufacturing Extension Partnership, Marine Renewable Energy Center, Massachusetts Association for Community Action, Massachusetts Hydrogen Coalition, New England Geothermal Professional Association, New Fuels Alliance, and Northeast Sustainable Energy Association.

Firms in the database that did not complete an online survey and those without email information were called up to six times and asked to complete the telephone version.

Of the estimated 1,351 firms in the known universe, 455 completed a survey (34 percent). The surveyed firms report clean energy employment of 8,053 workers (university employment was collected separately and is reflected in the total).

The resulting calculation yields a mean of 18.6 clean energy workers per clean energy firm in the known database. This calculates to 25,175 clean energy workers in the known universe of 1,351 firms, including the major research institutions in the Commonwealth. Due to the high participation rate, the margin of error is low at

a confidence level of 95 percent (approximately +/- 3.74 percent).

Unknown Universe

The database for the unknown universe was drawn from BLS NAICS industries and InfoUSA company listings. The list contains 17,245 firms, which were clustered by industry (agriculture, manufacturing, sales/trade, services/R&D, construction, and repair) and by size (small, medium, large). Firms were randomly called within the clusters and the known firms were removed from the sample. In total, calls were made to 16,237 of the 17,245 firms in the database and up to four attempts were made per firm.

The overall incidence rate was nearly 26 percent across industries, indicating a large number of firms in varied industries that report activity and employment in the clean energy sector which are not on any existing databases used for this study. The highest incidence rates were found among wholesale trade firms, manufacturing firms, and construction firms.

In total, 848 firms completed surveys in this sample (204 surveys from firms identifying as clean energy and 644 "short" surveys from firms not currently in clean energy), yielding a margin of error of approximately +/- 3.28 percent.

As part of the analysis, the 17,245 database number was reconciled against Economic Modeling Specialists Inc.'s (EMSI)[16] employment data for the NAICS codes studied, resulting in a base firm count of 14,308 to which churn rates and incidence rates were applied by industry cluster and size.

The level of clean energy employment at "unknown" firms is lower by a significant margin, with a mean of 11 (compared to 18.6 in the known sample). After adjusting for firms no longer in business, the incidence sampling indicates an estimate of 3,558 firms with 39,138 clean energy employees, again defined as workers from all occupational areas who spend at least some of their time supporting the clean energy portion of the business.

16. EMSI combines covered employment data from Quarterly Census of Employment and Wages (QCEW) produced by the Department of Labor with total employment data in Regional Economic Information System (REIS) published by the Bureau of Economic Analysis (BEA), augmented with County Business Patterns (CBP) and Nonemployer Statistics (NES) published by the U.S. Census Bureau.

About the Research Team

BW Research (Green LMI)

The Massachusetts Clean Energy Center commissioned Green LMI Consulting, a division of BW Research Partnership, together with the New England Clean Energy Council, to complete a comprehensive assessment of the Commonwealth's clean energy economy. Green LMI was selected for its proven track record of providing accurate, real-time economic and workforce information to workforce investment boards, colleges, universities, and training providers, government agencies, and nonprofit organizations. Its detailed sector reporting, occupational forecasts, and economic impact studies have been recognized as pioneering in sectors ranging from solar energy to information technology to healthcare. Some of Green LMI's recent projects include the National Solar Installer Labor Market Analysis for the National Renewable Energy Laboratory (2010), The Solar Foundation's National Solar Jobs Census (2010 and 2011), the California Information and Communications Technologies Environmental Scans, the Silicon Valley Emerging Green Industry Study, a comprehensive review of the Silicon Valley ICT economy for NOVA, and the San Diego Green Building and Design report, to name a few.

New England Clean Energy Council

The New England Clean Energy Council's mission is 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. The Council represents close to 400 member and affiliate member organizations, including clean energy companies, venture investors, major financial institutions, universities, industry associations, utilities, labor, and large commercial end-users. The Council's ranks now include clean energy CEOs, representatives from most of the region's top ten law firms, and partners from most of the top New England venture capital firms (with a total of over $8 billion under management). Working with its stakeholders, the Council develops and executes a wide array of programs in six key focus areas: Innovation, Growth, Education & Workforce Development, Adoption, Policy & Advocacy, and Research.

About MassCEC

Created by the Green Jobs Act of 2008, the Massachusetts Clean Energy Center (MassCEC) is dedicated to accelerating the success of clean energy technologies, companies, and projects in the Commonwealth—while creating high-quality jobs and long-term economic growth for the people of Massachusetts. MassCEC is a partner, clearinghouse, and connector for people in the clean energy sector, making direct investments in clean energy companies, building a strong clean energy workforce, and supporting responsibly sited renewable energy projects across the Commonwealth. MassCEC works with the entire clean energy community in Massachusetts to propel promising technologies from the drawing board to the global marketplace. Join the Innovation Revolution at http://www.masscec.com.

55 Summer Street, 9th Floor Boston, MA 02110

Phone: 617-315-9355 | Fax: 617-315-9356

Info@masscec.com | www.masscec.com