LEED Certification

Introduction

As a voluntary certification program for buildings, homes and communities, Leadership in Energy and Environmental Design (LEED), provides third-party verification of green buildings. Beginning in March 2000, the goal of the LEED Certification program was to conserve energy and water, reduce landfill waste and greenhouse gas emissions and provide a healthier and safer indoor environment for occupants. The program is run through the U.S Green Building Council (USGBC), which is a 501(c)(3) nonprofit organization "committed to a prosperous and sustainable future for our nation through cost-efficient and energy-saving green buildings". To date USGBC has 77 chapters, 13,000 member companies and organizations, and more than 181,000 professionals who hold LEED credentials as of June 2014. [117]

According to USGBC, LEED is "the most widely recognized and widely used green building program across the globe". Today, there are more than 53,000 LEED projects, comprising more than 10.1 billion square feet of construction space. USCBC claims that by becoming LEED certified, buildings can experience lower operating costs and increased asset values, and can become qualified for tax rebates, zoning allowances, and other incentives. [118]

According to USGBC, LEED v4 will "open up LEED to a wider range of building types and manufacturing industries, delivering the benefits of green building up and down the supply chain. It will advance environmental footprint issues, like climate change, and encourage optimization of energy and water use."

LEED Certification can be pursued across a variety of industries and sectors, and through its implementation, can promote economic growth in the clean energy, biotechnology, nanotechnology, and green business sectors. Throughout the nation, tools such as zoning regulations, green building ordinances, and streamlined permitting have been used to promote LEED. This section examines the process of LEED Certification, as well as the barriers and opportunities associated with implementing LEED. Recommendations are also made on how to promote LEED in the Montachusett and Northern Middlesex Regions so as to encourage economic growth across the region through increased private investment, while also promoting a clean, healthy environment.

LEED Certification

LEED is continuously evolving and improving, and has gone through a variety of different versions over the years. The U.S. Green Building Council released the most recent version, LEED 4.0 (LEED v4), in November 2013. The new version reaches new market sectors, including data centers, warehouses and distribution centers, hospitality facilities (i.e. hotels), schools and retail, and includes a new category of LEED for Homes Mid-Rise. It also includes revisions to credit weights, new credit categories, and an

[117] http://www.usgbc.org/about/history
[118] http://www.usgbc.org/about

increased emphasis on measurement and performance. It also introduces tools to increase efficiency for the LEED documentation process.

There are five categories of LEED Certification for LEEDv4, which includes (1) Building Design and Construction, (2) Interior Design and Construction, (3) Building Operation and Maintenance, (4) Neighborhood Development (ND), and (5) Homes (Table 1).

Table 8: The Categories of LEEDv4 Certification

LEED Certification	Description
LEED Building Design and Construction	Applies to buildings that are being newly constructed or going through a major renovation including new construction, core and shell, schools, retail, healthcare, data centers, hospitality and warehouses and distribution.
Interior Design and Construction (ID+C)	Applies to projects that are a complete interior refurbishing including commercial interiors, retail and hospitality.
Building Operations and Maintenance (O+M)	Applies to existing buildings that are undergoing improvement work and little to no construction. Relevant to existing buildings, data centers, warehouses and Distribution Centers, Hospitality, Schools and Retail.
LEED for Homes	Applies to single family homes, low-rise multi-family (one to three stories), or mid-rise multi-family (four to six stories).
LEED for Neighborhood Development	Applies to new land development projects or redevelopment projects containing residential uses, nonresidential uses, or a mix. Projects can be at any stage of the development process, from conceptual planning to construction.
Source: http://www.usgbc.org/leed	

While the majority of LEED Certification projects deal with individual buildings, LEED ND (Neighborhood Development) promotes sustainability in design and development at the neighborhood scale. LEED ND certifies whole neighborhoods, or multi-building projects that contribute to neighborhoods. This certification prioritizes site location, urban design, transportation, housing affordability, pedestrian access, socio-economics, and neighborhood-wide green infrastructure. Projects can vary widely in size and type, but certification is most appropriate for projects that are smaller than 320 acres, larger than one building, developed by a single developer and constructed within a predictable timeframe.

LEED Certification Process

Each LEED project becomes certified through a rating system that consists of prerequisites and credits. Prerequisites must be met before a project can then be considered for LEED Certification. Examples of prerequisites include stipulations that a project must comply with environmental laws, be a complete, permanent building or space, use a reasonable site boundary, comply with minimum floor area requirements, and occupancy rates, and commit to sharing whole-building energy and water usage data. These are outlined on the LEED Project application form. Once prerequisites are met, a menu of

available credits is then available to the project Team, with the achieved Credits combined to meet the various certification levels.

Credits are earned during the certification process and seek to reduce the environmental consequences of the construction and operation of buildings and infrastructure (Table 9). They also promote walkable neighborhoods with efficient transportation options, open space, and connections to nearby communities. They encourage construction on previously developed or infill sites and are designed to provide home builders, real estate professionals, homeowners, tenants and building managers with the education and tools they need to understand and make the most of the green building features, while also promoting regional environmental priorities (Table 9).

Table 9: LEED Credit Categories

Credit Name	Description
Sustainable sites credits	Credits encourage strategies that minimize the impact on ecosystems and water resources .
Water efficiency credits	Credits promote smarter use of water, inside and out, to reduce potable water consumption.
Energy & atmosphere credits	Credits promote better building energy performance through innovative strategies.
Innovation	Credits address sustainable building expertise as well as design measures not covered under the five LEED credit categories.
Indoor environmental quality credits	Credits promote better indoor air quality and access to daylight and views.
Regional priority credits	Credits address regional environmental priorities for buildings in different geographic regions.
Additional LEED for Neighborhood Development Credit Categories	
Smart location & linkage credits	Credits promote walkable neighborhoods with efficient transportation options and open space.
Neighborhood pattern & design	Credits emphasize compact, walkable, vibrant, mixed-use neighborhoods with good connections to nearby communities.
Green infrastructure & buildings	Credits reduce the environmental consequences of the construction and operation of buildings and infrastructure.
Source: USGBC http://www.usgbc.org/leed	

The method of earning credits is complex, and varies with each different type of LEED certification. To assist with this process, USGBC has provided a credit library and credit scorecards, which contains a list of all the possible credits for each certification. Credits may be earned for a variety of actions, including water use reduction, use of renewable energy, recycling, and using low-emitting materials. Credits differ for each category and can change over time. As such, the LEED Credit Library contains the most comprehensive and up-to-date list of the credits available. It can be accessed at the following site: http://www.usgbc.org/credits.

Basic certification requires that a project earn a minimum of 40 credit points. Earning more than the 40 credit points allows a project to achieve a more prestigious level of certification. Projects earning

50 points achieve silver certification, 60 points receive gold certification, and 80 or more points receive platinum certification. The highest number of points that can be earned is 100.[119]

One of the primary goals of LEED is not only sustainable design, but also sustainable operation. The LEED for Existing Buildings Recertification Program is intended to either certify an existing building that was not previously certified under a LEED Design and Construction rating, or to recertify an existing building that was previously certified. This recertification can be done annually, but no less frequent than every five years, and ensures that the building's design remains compatible with LEED. The LEED for Existing Buildings: Operations and Maintenance Recertification Guidance is the first of several steps USGBC is taking to establish a clear LEED recertification program.[120]

LEED Implementation

For projects wishing to obtain LEED certification, a LEED project team should be developed as early as possible. This team, consisting of architects, landscape architects, urban planners, engineers, and other professionals, is responsible for integrating a broad range of sustainable design elements into the building project. The LEED Certification Process is typically divided into four phases that include registration, verification, review and certification (Table 10).

Table 10: Steps to LEED Certification

Phase	Description
Register	• Compile project team, discuss the approach, and outline a strategy for moving forward. • Register the project by selecting the team, completing key forms and submitting payment. • Registration will preserve the version of LEED used at the time of registration.[1]
Verify	• Verify project milestones and achievements through the on-site verification process.
Review	• Have USGBC conduct a Design Phase Review, so as to understand the degree to which the project team has fulfilled all design-based prerequisites and credits. • Submit the necessary information, calculations and documentation. • The LEED application is then reviewed by GBCI.
Certify	• Receive the certification decision. • If certification is not awarded, then the project team appeals credits, if necessary.
1. Rating systems are periodically updated, usually becoming more stringent, and if an update occurs while a project is in the design or construction phase and the project is not registered, eligibility for these credits can be lost if it fails to meet the newer LEED standards. Source: **http://www.usgbc.org/cert-guide/homes**	

LEED requirements should be integrated into a project early in the planning process. Postponing the discussion on LEED could overburden a project schedule and budget if the issue is discussed too late in the design process.

Project Fees

LEED registration and certification fees differ depending on the certifications system. Registration is a flat fee paid up front, and rates are based on the date of registration. The certification fee is based on a project's rating system and size and it is calculated and paid when the project team

[119] http://www.usgbc.org/certification
[120] http://www.usgbc.org/articles/recertification-guidance-existing-buildings

submits documentation for review in LEED Online. For previous versions of LEED, the fees for all single-building projects were the same. However, for LEEDv4, each category is subject to a different fee structure. The fees associated with Building Design and Construction are shown below to provide a general idea of project fees. All other fees can be found on the USGBC website at: http://www.usgbc.org/cert-guide/fees#bdc

Table 11: LEED Certification Fees

Building Design and Construction Fees	ORGANIZATIONAL LEVEL OR NON-MEMBERS	SILVER, GOLD AND PLATINUM LEVEL MEMBERS	MEMBER SAVINGS
REGISTRATION	$1,200	$900	$300
PRECERTIFICATION REVIEW (optional, LEED CS only)			
Flat fee (per building)	$4,250	$3,250	**$1,000**
Expedited review (reduce from 20-25 business days to 10-12, available based on GBCI review capacity)	$5,000		
COMBINED REVIEW: DESIGN & CONSTRUCTION			
Project gross floor area (excluding parking): less than 50,000 square feet	$2,750	$2,250	**$500**
Project gross floor area (excluding parking): 50,000-500,000 square feet	$0.055/sf	$0.045/sf	**$0.01/sf**
Project gross floor area (excluding parking): more than 500,000 square feet	$27,500	$22,500	**$5,000**
Expedited review (reduce from 20-25 business days to 10-12, available based on GBCI review capacity)	$10,000		
SPLIT REVIEW: DESIGN			
Project gross floor area (excluding parking): less than 50,000 square feet	$2,250	$2,000	**$250**
Project gross floor area (excluding parking): 50,000-500,000 square feet	$0.045/sf	$0.04/sf	**$0.005/sf**
Project gross floor area (excluding parking): more than 500,000 square feet	$22,500	$20,000	**$2,500**
Expedited review (reduce from 20-25 business days to 10-12, available based on GBCI review capacity)	$5,000		
SPLIT REVIEW: CONSTRUCTION			
Project gross floor area (excluding parking): less than 50,000 square feet	$750	$500	**$250**
Project gross floor area (excluding parking): 50,000-500,000 square feet	$0.015/sf	$0.01/sf	**$0.005/sf**
Project gross floor area (excluding parking): more than 500,000 square feet	$7,500	$5,000	**$2,500**
Expedited review (reduce from 20-25 business days to 10-12, available based on GBCI review capacity)	$5,000		
APPEALS			
Complex credits	$800/credit		
All other credits	$500/credit		
Expedited review (reduce from 20-25 business days to 10-12, available based on GBCI review capacity)	+ $500/credit		

The fee structure outlined above indicates there is a significant financial component for LEED Certification. In particular, LEED ND is the most expensive certification, with an $18,000 to $25,000 surcharge for the initial review. As a result, the fees associated with LEED, the cost of compliance, and the need to have a LEED accredited professional as part of the project team, all pose a significant barrier

to implementation for many developers and building owners – especially for small or mid-size projects. In addition to high project fees, many developers interested in pursuing green building projects hesitate to do so because they are unfamiliar with the standards and requirements for building green. For this reason many organizations use LEED certifications, such as LEED ND, as guidance for sustainable development, without actually pursuing formal certification. While fees are commonly sited as a barrier to LEED, the direct cost associated with seeking LEED certification have been estimated to be below 2% of the total project cost.[121]

Industrial and Commercial Economy

USGBC believes the economic impact from green building construction is significant and will continue to grow as the demand for green buildings rises. According to the USGB *Green Jobs Study*, LEED-related spending generated 15,000 jobs between 2000 and 2012, and by 2013 an additional 230,000 jobs have been created. In addition, estimates suggest that LEED related spending will generate an additional $12.5 billion dollars in Gross Domestic Product (GDP), and provide $10.7 billion in wage earnings. There are also indirect impacts as a result of LEED Certification – according to USGCB, LEED-based construction created more jobs in the manufacturing and service sectors, including lighting, HVAC, water heating, motors and drives, office equipment, environmental controls, and envelope improvements[122] (Table 12). *The Clean Energy Economy* report also indicates that programs such as LEED positively impact the economy by creating new jobs in the clean energy, energy efficiency and environmentally friendly production sectors. [123]

By promoting clean energy and energy efficiency, LEED encourages research and development, manufacturing and green businesses. LEED also will create jobs for chemists and engineers to develop technology, researchers and technicians to perfect and implement technologies, manufactures to create the products, and electricians, engineers and plumbers to install products in homes, businesses and government buildings. LEED promotes the transportation industry through the promotion of hybrid diesel buses, traffic monitoring software and liquid biofuels, as well as the manufacturing industry through the encouragement of environmentally sound packaging, equipment and surface cleaning and the construction industry through the promotion of green building material, green building design and construction services. The agricultural industry is also supported through smart irrigation systems, alternative pest controls, and agricultural sustainability planning. Energy production can be promoted through the encouragement of gasification, and carbon capture and sequestration (CCS).

[121] http://www.josre.org/wp-content/uploads/2012/09/Cost_of_LEED_Analysis_of_Construction_Costs-JOSRE_v3-131.pdf

[122] *A New Retrofit Industry: An analysis of the job creation potential of tax incentives for energy efficiency in commercial buildings and other components of the Better Buildings Initiative.*

[123] Pew 2009. *The Clean Energy Economy.*

Table 12: Indirect Impacts of USGBC LEED Certification

Direct Impacts	Industries indirectly impacted
Lighting	Wholesale trade, power equipment and transformer manufacturing, truck transportation, building services, machine shops
HVAC	Wholesale trade, truck transportation, services to buildings, machine shops, ferrous metal foundries, iron and steel mills
Water heating	Wholesale trade, machine shops, truck transportation, services to buildings, business support services, architecture and engineering
Motors and drives	Wholesale trade, truck transportation, services to buildings, copper rolling and drawing, crown and closure manufacturing, iron and steel mills
Office equipment	Wholesale trade, semiconductor manufacturing, software publishers, scientific R&D, advertising
Environmental controls	Wholesale trade, scientific R&D, software publishers, services to buildings, custom computer programming, semiconductor manufacturing
Envelope improvements	Wholesale trade, truck transportation, services to buildings, accounting, maintenance and repair construction, architecture and engineering
Source: Employment Estimates for Energy Efficiency Retrofits of Commercial Buildings, Heidi Garrett-Peltier, June 2011	

LEED promotes research and development and manufacturing in industries, such as biotechnology and nanotechnology. The biotechnology industry uses cellular and biomolecular processes to develop technologies and products that help improve health and the environment.[124] The nanotechnology industry involves the engineering of functional systems at the molecular scale to make complete, high performance products[125].

Additional Considerations

The International Organization for Standardization (ISO) is the world's largest developer of voluntary international standards for products and services, designed to make industry more efficient and effective. Developed through global consensus, these standards help to break down barriers to international trade. LEED and ISO standards can dovetail in an effort to promote the local/regional growth of environmentally sustainable businesses and business sectors (e.g., bio/nanotech, clean energy sector). While LEED standards address the sustainability of buildings and other infrastructure, ISO standards address the sustainability of the activity accommodated by that infrastructure. Specifically, the ISO 14000 family of standards provides practical tools for companies and organizations looking to identify and control their environmental impact and improve their performance.

Regulatory Barriers and Opportunities

Traditional zoning, which encourages the separation of land uses, may be incompatible with mixed-use development and can actually discourage, rather than encourage, green building. There are many tactics available for overcoming these barriers to promote economic development and to

[124] http://www.bio.org/articles/what-biotechnology
[125] http://crnano.org/whatis.htm

encourage a clean energy economy. Municipalities and state governments have promoted LEED through zoning codes, parking ratios, laws regarding the installation of green technology, and green building bylaws/ordinances. Additionally, these entities have also used policy statements, financial incentives, expedited review and technology assistance to encourage LEED. Each strategy is discussed below.

Zoning Codes

As implemented in many communities today, building setbacks may not be compatible with compact development, and parking ratios may also be incompatible with certain LEED certification categories. To overcome this barrier, zoning regulations can be revised to align with, and encourage, LEED principles, even if LEED certification is not mandated. Simple modifications in zoning permitting and review processes can encourage developers and building owners to follow green building and development standards. For example, communities can revise zoning pavement regulations, and pavement widths in new subdivisions can be revised to allow for less pavement. Off street parking could also be revised to require less pavement based on new definitions of floor space. Porous pavers could be encouraged and communities could establish strict impervious lot area maximums in all zones.

While municipalities across the state and the nation have promoted LEED through zoning in a variety of ways, only one town in the Montachusett and Northern Middlesex Regions mentions LEED in their zoning regulations: the Town of Westford Zoning Regulations encourage LEED by stating that "Compliance with the Leadership in Energy and Environmental Design (LEED) certification standards and other evolving environmental efficiency standards shall be encouraged" for major commercial or retail projects (§9.3A p. 104). Lowell requires the submission of a "Green Checklist" for special permit development projects. While the Planning Board encourages the implementation of green building methods in development projects, implementation of performance standards based on the LEED checklist is still voluntary.

Outside of the Region, the Town of Bedford's Zoning Bylaw states that new projects should incorporate LEED criteria where practicable (§ 16.6.8), while the Town of Pembroke's Zoning Bylaw states that all new construction and major renovations on town-owned land and buildings must meet the Massachusetts LEED Plus Standards (Article XII-A). The City of Boston Zoning Code requires LEED certification or proof of a comparable level of measurable accountability for all public and private development projects over 50,000 square feet. Permits and certificates of occupancy can be denied for noncompliant projects. The Boston Redevelopment Authority requires a LEED checklist to be submitted for all projects (Article 37 Green Buildings). The Town of Arlington requires all new buildings, major renovation projects, and additions to achieve a minimum of LEED Silver Certification (Title 1, Article 16, § 4). In Cambridge, the City Council adopted a green building zoning amendment which requires that all new construction and major renovations of municipal buildings, including public schools, follow LEED guidelines (Article 22 of the Zoning Ordinance).

Modifications in zoning, such as a shift to form-based code, may help communities align with LEED-based principles, sustainability and green building. While conventional zoning neglects an "integrated built form", form-based code:

[Uses] physical form (rather than separation of uses) as the organizing principle for the code…Form-based codes address ….the form and mass of buildings in relation to one another, and the scale and types of streets and blocks….Form-based codes are regulatory, not advisory. They are drafted to implement a community plan. They try to achieve a community vision based on time-tested forms of urbanism. Ultimately, a form-based code is a tool; the quality of development outcomes depends on the quality and objectives of the community plan that a code implements.[126]

Some municipalities have begun switching from traditional zoning to form-based code in order to encourage smart growth, as well as LEED development. Within the Northern Middlesex Region, the City of Lowell has established form based codes in the Hamilton Canal Overlay District[127]. Outside of the Region the Ashland Zoning Bylaw states that consideration should be given to LEED criteria in the construction of new buildings in the Pond Street Mixed-Use Overlay District (§ 8.9.1-7). In Grand Rapids, Michigan, a new zoning code follows a form- and performance-based model and strongly encourages sustainable development. Grand Rapids planning staff consulted LEED for Neighborhood Development standards as they were creating the new code ensuring that new projects that meet the code's site and design requirements are likely eligible to score enough points to become LEED ND certified. [128] Both the Northern Middlesex Council of Governments and the Montachusett Regional Planning Commission can encourage LEED throughout the Regions by promoting the integration of LEED into the zoning code.

Laws and policy regarding the installation of Green Technology

Another opportunity for encouraging LEED at the local level is to adopt a municipal policy regarding green technology. Currently, none of the municipalities in the Northern Middlesex or Montachusett Regions have a formal policy regarding the installation of green technology. However, outside of the Regions, the Boston Redevelopment Authority Columbia Point Master Plan requires all new buildings to be certified at a LEED silver level and that all multiple building developments include at least one LEED silver building. The Plan also highlights all policies and implementation actions that relate to LEED for Neighborhood Development. On April 13, 2007, Boston Mayor Thomas Menino issued an Executive Order requiring LEED silver certification for all city-owned new construction and major renovation projects and LEED certification for all city-supported development projects. [129] Similarly, in 2005, the City of Medford issued the Energy and Resource Efficiency Policy, requiring that all new municipal construction achieve LEED certification. [130] At the statewide level, in 2007 Governor Deval Patrick signed Executive Order 484, "Leading by Example – Clean Energy and Efficient Buildings", which instructed all Executive agencies to adhere to the Massachusetts LEED Plus standard for new construction and major renovation projects that are 20,000 square feet or larger and are designed for use by a public entity. For projects smaller than 20,000 square feet, there is an option of either adhering to the Massachusetts LEED Plus standard or other green building standards.[131]

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[126] http://www.formbasedcodes.org/what-are-form-based-codes
[127] http://www.hamiltoncanal.com/Default.aspx
[128] http://www.mml.org/green/pdf/GrandRapids_Zoning_Case.pdf
[129] http://www.cityofboston.gov/Images_Documents/Clim_Action_Exec_Or_tcm3-3890.pdf
[130] http://www.medford.org/pages/medfordma_energy/Energy_Efficiency_Policy.pdf
[131] http://www.mass.gov/anf/docs/dcam/dlforms/energy/energy-eo484-final.pdf

Public transit and housing authorities can also influence LEED-based development through their policies. Public housing authorities, in particular, can make optimal use of the LEED for Homes rating system. For example, in New York City, the Blue Ribbon Commission on Sustainability and the Metropolitan Transportation Authority (MTA) analyzed the existing operational structure of the MTA and issued a report outlining practices that would make the agency and region more sustainable. Among other policies, the report encouraged policies that provide incentives to developers who design and construct LEED for Neighborhood Development gold-level projects.[132] In Chattanooga, Tennessee the Chattanooga Housing Authority recently initiated two LEED for Homes projects to replace existing dilapidated multi-family housing. The first project received 50% of its funding as an incentive grant to pursue platinum certification. The second project was developed by a for-profit affordable housing developer with no incentive funding. [133] Throughout our regions, the Regional Planning Agencies can help municipalities adopt municipal policies regarding that promote green technology and LEED certification.

Green Building Bylaws/Ordinance Models

Green building ordinances and Green Communities are becoming increasingly popular throughout the country and are often a highly effective opportunity for promoting LEED. While some municipalities require certification for projects receiving a certain level of financial support from the municipality, many require projects to meet specific LEED standards without obtaining certification.

In Massachusetts, one of the premier ways to promote LEED Green Building Ordinances is through the Green Communities Program. The Green Communities Designation and Grant Program helps a municipality become designated as a "Green Community" and provides funding to qualified municipalities for energy efficiency and renewable energy initiatives. The Program is open to all communities served by investor-owned utilities and those served by municipal light plants that adopt the renewable energy charge.

According to the Department of Energy Resources (DOER), to achieve "Green Community" designation, a municipality must meet five clean energy benchmarks:

- Provide as-of-right siting: A city or town must zone designated locations for as-of-right siting for one of the following: renewable/alternative energy-generating facilities, renewable/alternative energy research and development facilities, or renewable/alternative energy manufacturing facilities. As-of-right siting means the development may proceed without the need for a special permit, variance, amendment or other discretionary approval.

- Expedited Permitting: The municipality must adopt an expedited application and permitting process, not to exceed one year, for the siting of facilities outlined in the first criterion.

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[132] http://mta.info/environment/pdf/draft_final3.pdf
[133] http://www.chahousing.org/s/

- Establish an Energy Baseline/20 Percent Energy Reduction Plan: The municipality must establish an energy use baseline inventory for all municipal buildings, vehicles, and street and traffic lights, and it must put in place a comprehensive program designed to reduce this baseline by 20 percent within five years.

- Purchase Only Fuel Efficient Vehicles: All municipal departments must purchase only fuel-efficient vehicles when they are commercially available and practical.

- Minimize Life-Cycle Costs: The municipality must require all new residential construction over 3,000 square feet and all new commercial and industrial construction to minimize life-cycle costs of the facility with energy efficiency and other renewable or alternative energy technologies. This requirement is met by adopting the state's "stretch code", an energy building code that requires construction practices and building materials that are 20% more efficient than the baseline state energy building code.

Green Communities and LEED

To comply with Green Communities Criterion 5, municipalities must adopt the Massachusetts Stretch Energy Code, which is 20% more stringent than the state's building code. According to DOER, the stretch energy code, as it applies to homes and businesses, is synonymous with LEED Silver certification. DOER feels that "because LEED for Homes and the stretch code share the same Home Energy Rating System (HERS) and Energy Star underpinnings they are fully compatible". (A description of HERS is provided in the inset to the right.) NMCOG and MRPC can assist municipalities with the Green Communities application process to encourage LEED throughout the region.

Permitting and Regulations

Many local government have turned to financial and development incentives in order to promote green building and construction. These have been found to be the most effective strategies for encouraging LEED, as well as green building and development. Rewarding developers and builders who choose to build green is a crucial way to encourage the adoption of best practices in design, construction, and operations while spurring innovation and demand for green building technologies. Financial incentives, such as tax credits or fee reductions, are a highly successful means of encouraging developers to follow green building and

HERS stands for 'Home Energy Rating System,' and is a national standard that uses information on the design of the energy systems in a home to calculate, via computer modeling, the average energy needs of that home and give it a rating score…

On the HERS 2006 index scale smaller numbers are better, with 0 representing a net zero energy home, and 100 representing a home built to meet the national model energy code in 2006 (the IECC 2004 with 2005 amendments). A HERS rating of 65 means that the home uses about 35% less energy than the same size home built to the 2004/2005 IECC code requirements. The Residential Stretch code is based on the nationally successful 'Energy Star for Homes' program requirements, which utilize HERS ratings.

neighborhood practices.

Density Bonus

While there are no municipalities in our region who have promoted LEED through density bonuses, there are municipalities outside of our region who have done so. In Massachusetts, the Town of Acton adopted a zoning bylaw allowing a density bonus for buildings achieving a LEED certification in the East Acton Village District (§ 5.5B.2.2.d). Outside of Massachusetts, Arlington County, Virginia allows commercial projects and private developments earning LEED certification to develop sites at a higher density than conventional projects with bonuses varying depending on the level of LEED certification. Bar Harbor, Maine awards a density bonus of an additional market-rate dwelling unit for construction projects for which all dwelling units meet LEED standards. This bonus applies to projects within a Planned Unit Development (PUD) and compliance is determined by either application or by affidavit for adherence during construction. Cranford, New Jersey offers a green building density incentive program through which redevelopers who achieve LEED certification and comply with the specific program requirements may earn a development density bonus. Portsmouth, New Hampshire offers a density bonus for private projects that use LEED. Seattle, Washington offers a height or density bonus to commercial or residential projects that achieve at least LEED silver certification and contribute to affordable housing. Sunnyvale, California offers density and building height bonuses for certain types of LEED certification.[134]

Expedited Permitting and Fee Reduction

Expedited permitting processes can provide extra incentive for a developer to pursue LEED certification, and while there are no examples from our region, there are many examples from across the country where expedited permitting has been used to encourage LEED certification. The State of Hawaii requires priority processing for all construction and development permits for projects that achieve LEED silver or equivalent. Alachua County, Florida provides a fast-track building permit incentive and a 50% reduction in the cost of building permit fees for private contractors who use LEED. Hillsborough County, Florida offers expedited permitting to home builders with a completed scorecard from either the LEED for Homes program or the Florida Green Home Standard Checklist. Miami Lakes allows for expedited permitting for private developers who build to minimal LEED requirements. Sarasota County provides fast-track permitting for residential and commercial green developments.

Costa Mesa, California offers expedited permitting processes for green buildings, including LEED certified buildings. The City of Los Angeles expedites processing through all departments if LEED silver designation is met. In San Diego commercial projects achieving LEED silver certification benefit from expedited discretionary processes. In San Francisco there is a priority permit review for all new and renovated buildings that achieve a LEED gold certification or higher. In Santa Monica, LEED registered projects receive expedited permitting. In Issaquah, Washington, projects achieving LEED certification are placed at the head of the building permit review line. [18]

[134] http://www.slocounty.ca.gov/Assets/PL/Green+Building/USGBC+Public+Policy+Database.pdf

Another way LEED is encouraged through permitting is by waiving the permitting fee. Mecklenburg County in North Carolina offers permit fee rebates to projects with proof of LEED certification. Rebates increase proportionate to the level of certification achieved: 10% reduction for LEED certified, 15% for LEED silver, 20% for LEED gold, and 25% for LEED platinum. Babylon, New York requires LEED certification for any new construction of commercial, office, and industrial buildings, as well as multiple residences and senior citizen multiple residences over 4,000 square feet. The town refunds all certification fees paid to USGBC by the developer. Gainesville, Miami Lakes and Sarasota County, Florida offer a 50% reduction in the cost of building permit fees to private contractors who use LEED. San Antonio, Texas provides an administrative waiver or a reduction of certain development fees for projects achieving certain LEED standards. [18]

Tax Credits

At the state level, Maryland, New Mexico, New York, and Oregon provide tax credits to businesses that construct or rehabilitate a building that conforms to certain LEED and other sustainability standards.

In Baltimore County, Maryland, tax credits are offered to incentivize LEED certified residential and commercial buildings while Howard County, Maryland offers a five-year property tax credit for projects that achieve LEED new construction or core and shell. Chatham County, Georgia offers full property state and county tax abatement for commercial buildings achieving LEED gold certification for the first five years and then decreasing by 20% each year until the tenth year. Harris County, Texas offers partial tax abatement for costs incurred by developers to certify buildings with the USGBC. Cincinnati, Ohio offers an automatic 100% real property tax exemption of the assessed property value for newly-constructed or rehabilitated commercial or residential properties that earn LEED certification. [18]

Grants

Grants are also a way to help address the cost issue. The Commonwealth of Pennsylvania provides several hundred dollars of funding per pupil for public schools that achieve LEED silver or higher. The State of Illinois issues grants to school projects using LEED for schools. King County, Washington offers $15,000 to $25,000 in grant funding to building owners who meet a minimum of LEED silver for certain rating systems. El Paso, Texas awards grants at increasing amounts based on LEED certification level. Pasadena, California awards grants at increasing amounts based on LEED certification level ($15,000 for certified, $20,000 for silver, $25,000 for gold, and $30,000 for platinum) and Santa Monica, California awards grants at increasing amounts based on LEED certification level. [18]

Marketing Assistance

Developers and owners of green buildings and neighborhoods, as well as municipalities and other jurisdictions, have much to gain from the increased marketability of third-party certified, high-performance green real estate. Toward this end, some municipalities and counties offer free marketing assistance to help green builders rent and sell properties more effectively. Charlotte County, Florida provides free marketing, including signage, promotional mailings, press releases, newsletters, websites,

and awards for LEED certified projects. Oakland, California offers free public promotion for LEED and other green building projects. San Diego, California sponsors a public recognition program for innovative LEED and other green building projects designed to encourage and recognize outstanding environmental protection and energy conservation projects. [18]

Technical Assistance

Developers interested in pursuing green building projects often hesitate to do so because they are unfamiliar with the standards and requirements for building green. There are opportunities for bridging this gap through technical assistance, public-private partnerships, and numerous educational initiatives. The State of Minnesota requires utilities to provide technical assistance for commercial and residential projects that incorporate LEED and other green building strategies into the construction process. Oakland and Pasadena, California, as well as Washington, D.C., offer free technical assistance for LEED and other green building projects. San Diego, California provides green building training, support, and education for private sector building projects registering for LEED certification. West Hollywood, California provides a resource center at City Hall, which serves as a source of information to developers and homeowners interested in incorporating LEED and other green building strategies into their projects. [18]

Public Private Partnerships

A public-private partnership – where the local entity sells or issues a ground lease for the land, or serves as an active member of the development team – can facilitate LEED-based development, especially if the development program includes new public infrastructure or multiple facilities dedicated to public use. A variety of municipal departments can be involved at different levels or may simply establish policies that support such an initiative. For example, in Rockville, Maryland, the Washington Metropolitan Area Transit Authority (WMATA) acted as a co-developer with the JBG Companies on a project to transform 26 acres of a WMATA-owned commuter parking lot around a transit station into a mixed-use development. The Twinbrook Station project earned gold-level certification for its plan under the LEED for Neighborhood Development pilot program. [18]

Revolving Loan Funds

Revolving Loan Funds can also be used to create incentives for LEED. While the funds described below are not officially LEED-based, they all can be used as incentives for LEED certification. Babylon, New York's Long Island Green Homes (LIGH) program offers energy efficiency upgrades to residents at little or no out-of-pocket cost. For already efficient homes, LIGH may finance on-site renewable energy projects. All expenses are repaid by residents on a schedule that allows residents to take advantage of savings and repay retrofit costs. The Berkeley FIRST program in Berkley, California enables residents to make long-term investments in residential photovoltaics with little up-front cost. Projects are repaid through a property tax on individual program participants over a period of 20 years. The solar-electric system and the tax obligation remain with the property, allowing initial program participants to transfer their obligations to future homeowners. The Milwaukee Energy Efficiency (Me2) program in Milwaukee, Wisconsin, offers financing of home energy retrofits for building owners and occupants with immediate savings and no upfront costs. Using both public funds and private capital, Me2 offers longer-term repayment for retrofits through simple additions to municipal services or utility bills at less than the

value of energy saved. In California, the Sonoma County Energy Independence Program gives commercial and residential property owners the opportunity to borrow funds to increase their property's energy efficiency. The money is paid back as an assessment on the property, due at the same time as property taxes. Five-, ten-, and twenty-year terms are available at 7% interest. Technical assistance, public-private partnerships and revolving loan funds are all tools that can be used to overcome the lack of familiarity with the standards and requirements for building green. [18]

Another financing option is Property Assessed Clean Energy (PACE) financing, which provides property owners access to low-cost financing repaid as a property tax assessment for up to 20 years. This method has been used nationwide for decades to finance improvements to private property that meet a public purpose. PACE programs can result in consumer savings on utility bills, as well as local job promotion. Today, 31 states and the District of Columbia have adopted (or already had) legislation that enables local governments to offer PACE benefits to building owners.[135]

In July 2014 the Massachusetts senate passed proposed bill (S.2225), which according to the US Green Building Council (USGBC), will make necessary improvements to the Commonwealth's current PACE program, creating a streamlined, centrally administered PACE program that is capable of achieving economies of scale and will be easily adopted by municipalities. The new program will require lender consent and will focus on the demand for energy efficiency and disaster-resilience financing in the commercial and industrial sector. Passage of S. 2255 will fuel job creation and spur private investment. The legislation also will allow property owners to upgrade buildings with resiliency improvements, to reduce or eliminate damage caused by extreme weather events.[136]

By assisting municipalities with these incentives discussed above, we can work to encourage LEED throughout the region.

Potential Locations in the Montachusett and Northern Middlesex Regions

Both LEED Registered and LEED Certified Projects are present throughout the Montachusett and Northern Middlesex Regions. LEED Registered projects are those that are still in the process of Certification, while LEED Certified projects refer to those that have completed construction and are fully certified. In the Montachusett region, there are seven (7) fully certified projects, which are located in Devens, Leominster, and Townsend and nine (9) registered projects, which are located in Athol, Ayer, Fitchburg, Gardner, Harvard and Townsend. In the Northern Middlesex region there are ten (10) fully certified projects, which are found in Billerica, Chelmsford, and Lowell, and nine (9) registered projects located in Billerica, Chelmsford, Lowell and Westford (Table 13 and Table 14 follow). Also see map in Appendix I.1.

[135] http://pacenow.org/about-pace/what-is-pace/
[136] http://usgbcma.blogspot.com/2014/07/progress-on-pace-legislation.html

Table 13: LEED Certified and Registered Buildings in the Northern Middlesex Region

Project Name	Certification date	City	Rating system	Version	Certification level
EMD Project Bridgeway	--	Billerica	Commercial Interiors	v2009	--
300 Apollo Recert	--	Chelmsford	Existing Buildings	v2009	--
Chelmsford, MA	7-Oct-13	Chelmsford	Retail - New Construction	v1.0 pilot	Certified
LeBlanc Residence	--	Westford	Homes	v2008	--
U.S. EPA, New England Regional Laboratory	2-Feb-03	Chelmsford	New Construction	v1.0 pilot	Gold
UMass Lowell - University Crossing	--	Lowell	New Construction	v2009	--
UMASS-ETIC	1-Aug-13	Lowell	New Construction	v2.2	Gold
Parexel	15-Dec-09	Billerica	Commercial Interiors	v2.0	Certified
Nobis Engineering Merrimack Valley HQ	20-Jan-10	Lowell	New Construction	v2.2	Gold
United Teen Equality Center (UTEC)	12-Nov-12	Lowell	New Construction	v2.2	Platinum
SDM0801-DC1 Billerica BLDG U3 Expansion	--	Billerica	New Construction	v2009	--
UMass Lowell New South Academic Building	--	Lowell	New Construction	v2009	--
Chelmsford Relocation	28-Feb-12	Chelmsford	Commercial Interiors	v2009	Silver
DYouville Transitional Care Unit	--	Lowell	New Construction	v2009	--
Brookside Mill Re-Development	--	Westford	New Construction	v2.1	--
Concord Road Corporate Center	--	Billerica	Existing Buildings	v2009	--
EMD Serono Research Institute	7-Mar-11	Billerica	New Construction	v2.2	Gold
One Main Financial, Chelmsford MA	13-Apr-09	Chelmsford	Retail - Commercial Interiors	v1.0 pilot	Certified
Concord Road Corporate Center	20-Aug-09	Billerica	Existing Buildings	v2008	Certified

-- indicates project is registered, but not yet certified
Source: USGBC LEED Project Database, Downloaded June 20, 2014

Table 14: LEED Certified and Registered Buildings in the Montachusett Region

Project Name	Certification Date	City	Rating system	Version	Certification level
North Middlesex Regional High School	--	Townsend	Schools - New Construction	v2009	--
"Townsend Woods, HUD 202 Senior Housing"	4-May-12	Townsend	Homes	v2008	Silver
Kohl's Leominster	19-Apr-12	Leominster	Existing Buildings	v2009	Certified
5 Penny Lane	24-Jan-11	Townsend	Homes	v2008	Gold
Ayer Shirley Regional High School	--	Ayer	Schools - New Construction	v2009	--
Preservation Mill	--	Fitchburg	New Construction	v2.2	--
Harvard UU Fellowship Building	--	Harvard	New Construction	v2.2	--
LSCC - MFG	1-Apr-10	Devens	New Construction	v2.2	Silver
Fitchburg State College - Science Bldg.	--	Fitchburg	New Construction	v2.2	--
Athol Public Library Renovation/Addition	--	Athol	New Construction	v2.2	--
LSCC-LOC	15-Dec-09	Devens	New Construction	v2.2	Gold
Devens Public Safety Building	--	Devens	New Construction	v2009	--
Devens Transitional Housing	19-Aug-10	Devens	Homes	v2008	Gold
Modified Record Fire Range	--	Devens	New Construction	v2.2	--
Hammond Student Center Fitchburg State	--	Fitchburg	Commercial Interiors	v2009	--
Doyle Conservation Center	26-Jun-06	Leominster	New Construction	v2.0	Gold

-- indicates project is registered, but not yet certified
Source: USGBC LEED Project Database, Downloaded June 20, 2014

Suggested Locations

In the Montachusett and Northern Middlesex regions, LEED can be promoted using a variety of strategies including zoning, policy statements, green building ordinances, and financial incentives. In addition, specific locations for LEED implementation could be selected based on factors such as proximity to transit, public water and wastewater infrastructure, community services, previously developed land, wetlands, and water bodies, soil characteristics and proximity to floodplains. While all these tools have proven successful across the country, the tool in Massachusetts that has proven the most successful is the use of green building ordinances through the Green Communities program. The Green Communities Designation Program encourages green building through the adoption of the

"stretch energy code", which is currently synonymous with LEED Silver Certification, and is implemented at the community level.

Green communities in the Northern Middlesex region include Chelmsford, Lowell, Tewksbury and Tyngsborough and Westford. Those in the Montachusett region include Ashby, Athol, Ayer, Gardner, Harvard, Lancaster, Leominster, Petersham, Shirley, Townsend and Westminster. In these Green Communities, any building built since the date of designation will be synonymous with LEED Silver criteria. However, it is important to note that these building are not required to register as LEED certified buildings. A map of green communities is included in Appendix I.1.

Promotion of the Green Communities Program across the Northern Middlesex and Montachusett communities would promote job growth across the clean energy, biotechnology, nanotechnology, and green business sectors. Encouraging green building ordinances through the Green Communities Program will also allow developers to create a building that is synonymous with LEED Silver, without having to pay the cost of certification and will provide communities with access to technical support and grant funding.

Toward that end, MRPC should focus its efforts on promoting the Green Communities program in the communities of Ashburnham, Clinton, Fitchburg, Groton, Hubbardston, Lunenburg, Phillipston, Royalston, Sterling, Templeton, and Winchendon. NMCOG should focus its efforts on Billerica, Dracut, Dunstable and Pepperell.

Recommendations for NMCOG and MRPC

NMCOG and MRPC can work with the DOER regional representatives to promote Green Communities across the regions. Specifically, NMCOG and MRPC can provide education to municipalities who are not yet designated as Green Communities, and can provide technical assistance to help these communities through the application process.

The agencies can also work to promote and initiate Green Building Commissions and Sustainable Councils throughout the region. Municipal commissions and private organizations can be a vital component of a city or town's sustainable planning effort. Lowell has a city-manager appointed Green Building Commission which promotes and advocates for "green" design, construction, and development practices in the City of Lowell through identification and implementation of policies and programs that will increase environmental sustainability. Westford has a private group - Sustainable Westford - whose mission is to serve as a venue for raising awareness and providing education and inspiration on issues of sustainability. Working with the community and related organizations to advance our mutual missions, Sustainable Westford provides access to local sustainable foods; recycling programs; renewable energy options; conservation of natural resources; and health and wellness programs.

In terms of education, MRPC and NMCOG should conduct workshops and seminars in target communities to encourage municipalities to apply for the Green Communities Program. The agencies could also conduct outreach to energy committees, municipal staff and administrators to promote the Green Communities Program and can assist communities with the application process, especially with the adoption of the state's "stretch energy code".

NMCOG and MRPC should also assist with the following:

- Encourage municipalities to transition from traditional zoning to form-based code;
- Encourage municipalities to promote LEED by incorporating it into their zoning code;
- Encourage municipalities to adopt a municipal policy regarding green technology;
- Encourage local government to use financial and development incentives to promote green building and construction through density bonuses, expedited permitting, fee reduction and tax credits;
- Provide technical assistance to developers seeking LEED certification; and
- Provide education on LEED certification programs to planners and engineers throughout the region.

By helping communities to promote LEED, NMCOG and MRPC will be promoting the clean energy economy. In particular, if all communities in the Montachusett and Northern Middlesex regions become green communities, then every new building built will be synonymous with LEED silver, and builders would not have to pay certification costs. In addition, communities would receive grant funding and technical assistance. This method would promote LEED and the clean energy economy while also addressing some of the barriers to LEED Development (e.g. cost of certification).

Promoting LEED across the region will encourage growth in the areas of research and development, biotechnology, nanotechnology, manufacturing and green businesses. It will promote a clean economy, and healthy communities, and could serve as a model for other regions and states who also want to promote energy efficiency in the commercial and industrial sectors.

RENEWABLE ENERGY MANUFACTURING & LABOR FORCE ASSESSMENT

Introduction

Historically, manufacturing has been at the heart of the American economy, representing nearly 12 percent of the nation's gross domestic product and providing good quality, high-paying jobs. With the passage of the Energy Independence and Security Act[137] (which contains the Green Jobs Act) and the American Recovery and Reinvestment Act of 2009[138] (ARRA) at the federal level, billions of dollars were made available to jump start the renewable energy industry. As the United States transitions to a clean energy economy, Massachusetts is well positioned to capture its fair share of this rapidly growing market and its associated manufacturing sector. The Patrick Administration has focused on growing the State's clean energy sector as a way to create local jobs and retain more energy dollars in the state economy. Therefore, promoting the deployment, production and development of renewable energy

[137] http://energy.gov/eere/femp/energy-independence-and-security-act
[138] http://www.irs.gov/uac/The-American-Recovery-and-Reinvestment-Act-of-2009:-Information-Center

facilities in the region represents a significant economic development opportunity. As explained by the Organization for Economic Co-operation and Development (OECD), "sustainability within the energy sector increases efficiency and security, encouraging prosperity and growth through energy access, industry development, job creation and competitive technological innovation"[139]. Regional growth in the number of renewable energy firms and associated jobs also has the potential to replace many of the lost manufacturing jobs and to capitalize on the rich manufacturing legacy of the Montachusett and Northern Middlesex regions.

This section of the Renewable Energy Facilities Siting Plan focuses on the role played by existing renewable energy facilities in Massachusetts and the Northern Middlesex and Montachusett regions, the potential demand for additional renewable energy facilities statewide and regionally and the identification of the barriers facing these industries in providing additional employment opportunities for the region. An overall labor force assessment by energy sector has been included, as well as the potential employment opportunities in the future. In addition, location and siting considerations are addressed, specific industrial and commercial sites are identified and the regional potential for an expanded renewable energy sector, particularly in terms of manufacturing firms, is discussed. Through this overall assessment, specific recommendations have been made regarding how the region can become more welcoming to renewable energy manufacturing firms and capitalize on the rising demand for renewable energy across the region, state and nation.

Background

For the purposes of this report, 'renewable energy' includes the following categories and segments: wind, solar, LEED, hydropower, biomass and geothermal energy manufacturing. The renewable energy manufacturing industry is also defined as firms that focus on the manufacturing of renewable energy materials, components and systems.

Since most of the available information focuses on 'clean energy', the data is limited in regard to specifically capturing renewable energy manufacturing in some instances. In addition to the energy sectors identified above, 'clean energy' also includes biofuels, carbon management, energy efficiency, and alternative transportation, such as clean cars. Regional-level and company-level data is also not consistently available for the renewable energy sector, which creates some consistency problems.

In addition, the North American Industry Classification System (NAICS), the standard used by federal statistical agencies in classifying business establishments and tracking jobs, does not account very well for green industries and their numerous distinctions. The NAICS, for instance, currently lumps items like solar, wind, and tidal into a single "Other Electric Power Generation" category and does not specify categories for hybrid electric vehicles, green buildings, recycling, and many other key sectors.

The renewable energy manufacturing industry has undergone significant growth in Massachusetts over recent years. The 2013 Massachusetts Clean Energy Industry Report found that

[139] OECD, *Green growth and energy,* http://www.oecd.org/greengrowth/greening-energy/greengrowthandenergy.htm (accessed May 23, 2014).

there are 564 firms in Massachusetts involved in the manufacturing and assembly of clean energy[140]. According to the Massachusetts Clean Energy Center (MassCEC), more than 13,458 people were employed statewide in the manufacturing and assembly of renewable energy in the state in 2013.[141]

Within the Northern Middlesex and Montachusett regions, manufacturing has historically driven growth and development. The industrialization of the Northern Middlesex region began in 1811, with the introduction of wool manufacturing in North Billerica. Subsequently, the first planned industrial city in America was created in Lowell, utilizing the hydraulic power of the Merrimack River at Pawtucket Falls. By 1836 the City of Lowell had eight major textile firms employing approximately 7,000 people. The region surrounding Lowell was also impacted by industrialization, as small industrial settlements grew into extensive textile mill villages. Additional industrialization in the region occurred between 1850 and 1890 with the introduction of the railroad.

While the Montachusett region's earliest settlements were founded as trading outposts for the Massachusetts Bay Colony, manufacturing soon became the region's driving economic force. Montachusett communities utilized local streams and rivers to power manufacturing facilities. The first mills were allied with agricultural production, followed by the establishment of other industries, including paper, textile and woodworking industries in the mid-19th Century. Similar the Greater Lowell region, industrial growth was accelerated by railroads, which enabled the easy transport of raw materials, finished goods and people.[142]

By the 20th Century, both regions experienced economic decline as a result of the Great Depression and the migration of manufacturing industries to the southern United States. While manufacturing has continued to decline due to the national transition to a more serviced-based economy, new and innovative industries, including renewable energy development, have begun to establish themselves in the Northern Middlesex and Montachusett regions. Many of the communities within both regions are experiencing growth in renewable energy and are evolving from their formally specialized manufacturing industries to more diverse enterprises. The role of renewable energy in the Commonwealth of Massachusetts and the Northern Middlesex and Montachusett regions is described in the next few sections.

Renewable Energy in the Commonwealth of Massachusetts

Massachusetts consistently ranks high as a renewable energy leader among other states. According to the American Council for an Energy-Efficient Economy (ACEEE), Massachusetts was ranked number one for implementing energy efficiency programs and policies in 2013.[143] The State was ranked second in clean energy technology, according to the 2013 U.S. Clean Tech Leadership Index. Massachusetts has taken extremely proactive measures to reduce the greenhouse gas emissions and

[140] A clean energy firm is defined by the MassCEC 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.
[141] MassCEC, *Massachusetts Clean Energy Industry Report, 2013*, http://www.masscec.com/content/2013-clean-energy-industry-report (accessed May 20, 2014)
[142] Montachusett Regional Planning Commission, *Montachusett Regional Strategic Framework Plan*, April 2011.
[143] http://www.aceee.org/sector/state-policy/massachusetts

diversify the composition of energy consumption. These measures have helped spur growth in the "green economy".

In 2002 the Massachusetts Department of Energy Resources (DOER) adopted the Renewable Energy Portfolio Standard (RPS) and Alternative Energy Portfolio Standard (APS). The RPS and APS are statutory obligations that align with the Commonwealth's energy goals of increasing energy efficiencies and reducing the need for conventional fossil-fuel based power generation. The RPS mandates that energy suppliers obtain a percentage of all electricity from qualifying renewable energy producers. The APS is an opportunity for Massachusetts businesses, institutions, and governments to receive incentives for installing eligible alternative systems that are not renewable, including Combined Heat and Power (CHP), where the heat emitted from electricity production is collected and used to heat buildings.[144]

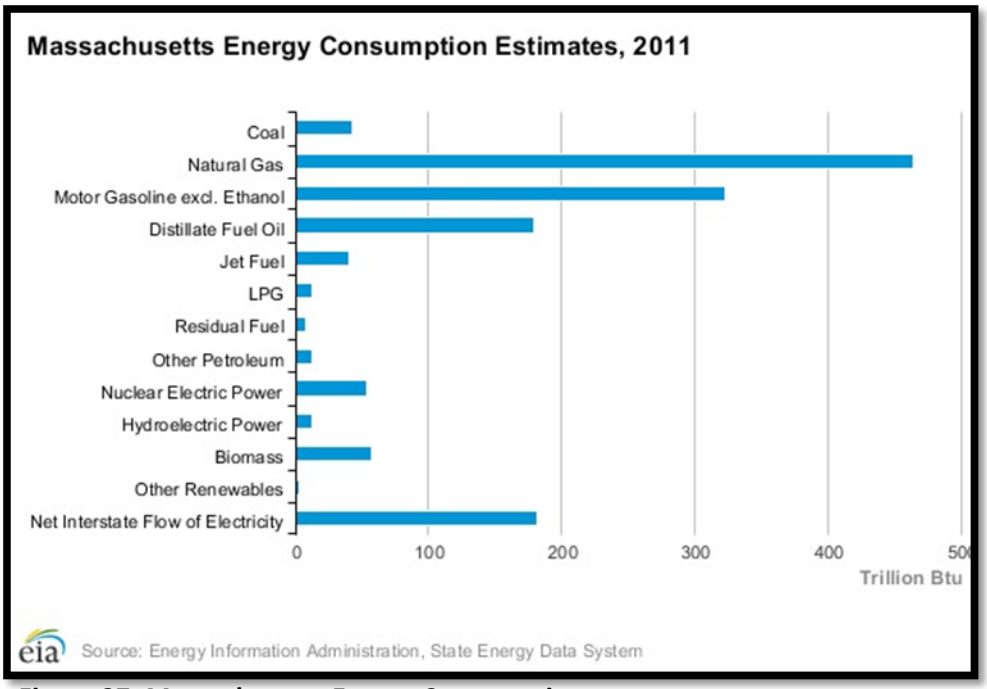


Figure 27: Massachusetts Energy Consumption

In 2011 the Energy Information Administration, State Energy Data System reported that the Commonwealth consumed very little renewable energy and had a high dependency on natural gas, ethanol, and fuel oil. The chart above shows that the State consumes a relatively small amount of energy generated from renewable resources. In response, the Commonwealth of Massachusetts has established a number of goals and incentives to increase the efficiency of buildings, increase the consumption of energy generated from renewable resources, decrease the Commonwealth's reliance on fossil fuels, and decrease the emissions of greenhouse gases.

[144] http://www.mass.gov/eea/energy-utilities-clean-tech/renewable-energy/rps-aps/

The RPS and APS, in addition to other state and federal funding incentives for renewable energies, have significantly increased the number of renewable energy installations within the Commonwealth over the past fifteen years. The image below shows all of the sites in Massachusetts that were generating energy from renewable resources in 2006.

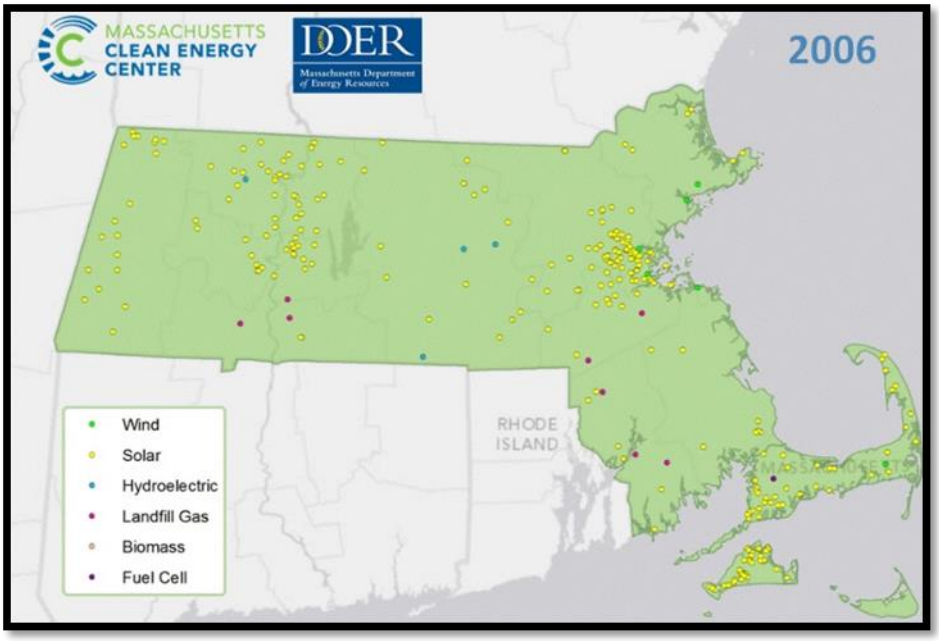


Figure 28: Sites Generating Energy from Renewable Sources in 2006

In 2006 there were few sites generating energy from energy renewable sources. The 2013 image below shows the number of sites that were generating renewable energy in 2013. While renewable energy has been growing in Massachusetts, there is still a high dependence on fossil fuels and there is room for growth within the renewable energy sector.

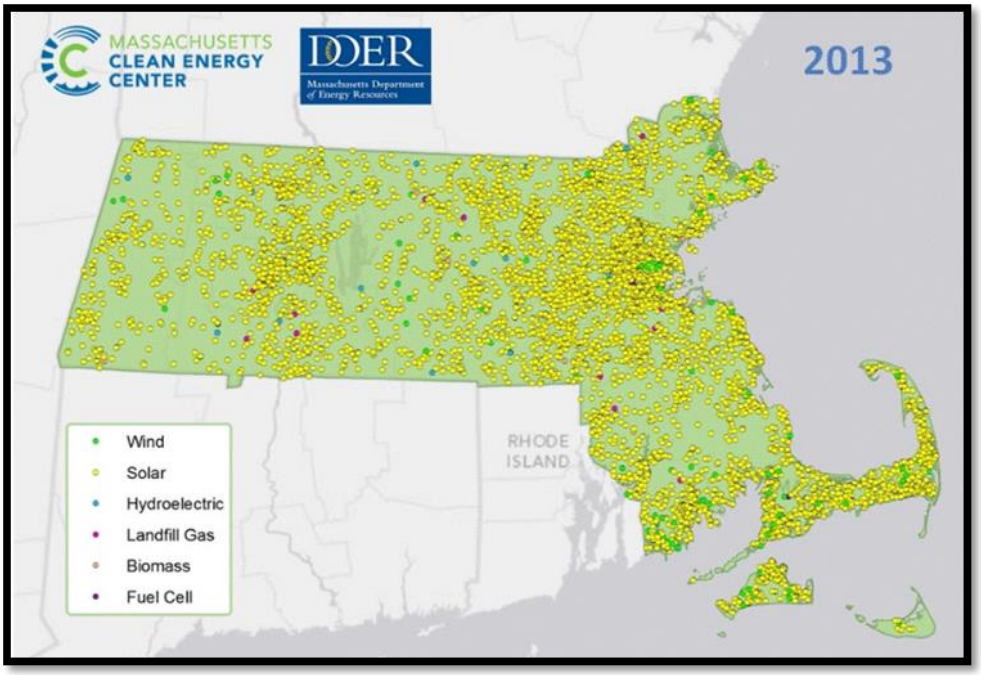


Figure 29: Sites Producing Electricity from Renewable Source in 2013

As indicated in the previous maps, there has been a large increase in the number of sites producing energy from renewable resources between 2006 and 2013.[145] In particular, there has been a large increase in the production of photovoltaic energy. The reason for the substantial jump in the generation of solar energy within Massachusetts is because of the current solar incentive policy called the Solar Carve-Out Program. The original goal of the program was to expand solar energy capacity to 400 MW. This goal was attained in 2013 when the Solar Energy Industry Association reported that Massachusetts had a total installed solar capacity of 464 MW. In 2013 Massachusetts ranked fifth in the country for installed solar capacity and fourth in the country for installing 237 MW of solar energy from 2012 to 2013.[146] The new Solar Carve-Out Goal expands the solar energy capacity from 400 MW to 800 MW by 2017.

As tax incentives and state regulations make renewable energy more affordable, additional businesses, municipalities, and individuals have invested in renewable energy. The increase in renewable energy sites expands the renewable energy labor force. In Massachusetts there are more than 286 companies supporting the solar industry, which employ more than 6,400 workers. The solar industry in Massachusetts has roughly 59 manufacturers, 27 manufacturing facilities, 119 contractors/installers, 26 project developers, 12 distributors, and 70 other support companies (such as finance and law).[147] Based on the Commonwealth's established goal to increase the percentage of energy produced from renewable resources, the renewable energy labor force will certainly expand.

[145] Image 2: http://www.masscec.com/content/clean-energy-progress-animation
[146] http://www.seia.org/state-solar-policy/massachusetts
[147] http://www.seia.org/state-solar-policy/massachusetts

Existing renewable energy manufacturing facilities in the region

According to the MassCEC, there are 5,577 clean energy firms in Massachusetts with 2,312 of these firms specifically involved in the renewable energy industry. Of the renewable energy firms, 564 are associated with manufacturing. In the Montachusett and Northern Middlesex regions, a relatively modest number of renewable energy manufacturing facilities have been identified. Eighteen (18) establishments, including two firms that work across both wind and solar, have been identified through a review of a variety of federal, state and local sources and databases[148]. The results of this analysis show that there is a cluster of solar manufacturing companies in the Northern Middlesex region, particularly in Billerica, while the Montachusett region has a number of hydropower-related and wind-energy related supply chain manufacturing facilities.

It is also important to note that a number of the identified establishments are involved in the manufacture and supply of renewable energy materials, components and parts, rather than the systems themselves. In terms of the manufacturing supply chain, these firms are known as Tier 1 and Tier 2 suppliers, while firms that make, assemble and sell renewable energy systems are defined as Original Equipment Manufacturers (OEMs)[149]. In addition, some establishments are part of global companies so it is unclear what is specifically manufactured by those establishments within the Montachusett and Northern Middlesex regions.

Wind energy manufacturing facilities

America's wind-energy industry supports an increasing domestic industrial base. The American Wind Energy Association (AWEA) has determined that the wind industry in the United States has more than 550 manufacturing facilities producing products ranging from blade, tower and turbine assembly facilities to raw component suppliers, such as fiberglass and steel. While there is a growing cluster of wind-energy research establishments in Massachusetts, including the recently developed Wind Technology Testing Center in Charlestown and UMass Lowell's Wind Energy Research Group, the number of firms that focus on wind-energy manufacturing is limited to component and equipment manufacturing in the region. Through research of the National Renewable

Figure 30: American Superconductor 354,000 ft^2 facility in Devens

Source: Cutler Associates
http://cutlerdb.com/portfolio/corporations-industry/american-superconductor

[148] The following databases were examined: http://energy.sourceguides.com/businesses/byB/manufacturers/manufacturers.shtml,, State Wind Energy Statistics: Massachusetts, http://www.awea.org/Resources/state.aspx?ItemNumber=5218, Solar Companies in Massachusetts, http://www.seia.org/state-solar-policy/Massachusetts; National Hydropower Association, U.S. Hydropower Industryhttps://fortress.maptive.com/ver3/ushydropowerindustry

[149] For example, wind-energy OEMs purchase or make components, then assemble and sell completed turbines to wind farm developers. Tier 1 suppliers support OEMs through production of large components such as towers and blades. Tier 2 suppliers support the supply chain by manufacturing machined parts, motors, fiberglass, electrical parts, etc.

Energy Laboratory's (NREL) online database and other relevant wind energy databases, the following local firms have been identified:

Table 15: Wind Energy Manufacturing Facilities

Company Name	Address	Products and Services
American Superconductor	64 Jackson Rd, Devens	Megawatt-scale wind turbine designs and electrical control systems.
Assembly Guidance Systems	27 Industrial Ave #5, Chelmsford	Large laser projection systems used in producing wind turbine blades and tooling.
BJA Magnetics	7 Moore St, Leominster	Engineered permanent magnets used in wind turbines.
Ranor Inc,	1 Bella Dr, Westminster	Larger scale machining and fabrication of wind housings, turbine shafts, mounting rings and generators.

Solar Manufacturing Facilities

According to The Solar Foundation, the solar industry employs nearly 30,000 people in the manufacturing sector across 1,484 solar manufacturing establishments in the nation. Over a quarter of these establishments serve as U.S. headquarters for manufacturing that is conducted abroad[150]. Within Massachusetts the Solar Energy Industry Association (SEIA) has identified 60 solar manufacturers and 26 solar manufacturing facilities.[151] The following ten manufacturers and facilities have been identified within the Montachusett and Northern Middlesex regions:

Table 16: Solar Manufacturing Facilities

Company Name	Address	Products and Services
American Super Conductor	64 Jackson Rd, Devens	Smart Grid technologies for power grid operators, including superconductor power cable systems, grid-level surge protectors and stabilization systems.
Anderson Power Products	13 Pratts Junction Rd, Sterling	High current, quick-disconnect power connectors and interconnect solutions for the solar industry.
Beacon Power LLC	65 Middlesex Rd, Tyngsborough	Flywheel energy storage systems.
Bruce Technologies Inc	18 Esquire Rd, North Billerica	Solar cell manufacturing equipment.
Bruker Corp	40 Manning Rd, Manning Park, Billerica,	Manufacturer and developer of advanced materials for applications in energy, including superconductors.
BTU International	23 Esquire Rd, North Billerica	Solar cell manufacturing equipment, diffusion furnaces, doping, cell coating equipment, drying furnace, firing furnace.
Entegris, Inc.	129 Concord Rd, Billerica	Delivers technology, product and service solutions that purify, protect and transport critical materials used in the semiconductor and high-tech industries.
Epoxy Technology	14 Fortune Dr, Billerica	Specialty adhesives for advanced industries
Ranor Inc	1 Bella Dr, Westminster	Large-scale component fabrication and machining services, including the manufacturing of vacuum chambers used in the

[150] The Solar Foundation, *National Solar Jobs Census 2013: The Annual Review of the U.S. Solar Workforce*, 2014

[151] SEIA, *State Solar Policy – Massachusetts*, http://www.seia.org/state-solar-policy/Massachusetts (accessed June 30, 2014)

		creation of poly-silicon (poly-Si) based technology, amorphous-silicon (a-Si) and CIGs based technologies, and HEM Sapphire technologies.
Semilab USA LLC	47 Manning Rd, Billerica	Front-end electrical characterization of the solar cell manufacturing process in the silicon-based PV market.

While not located within the study area, there are a number of solar manufacturing and design firms located nearby in Lawrence, Methuen and North Andover.

Although there is a cluster of solar manufacturing firms in both regions, there have been a number of recent factory closings. Konarka Technologies Inc, formerly located in Lowell, filed for bankruptcy in 2012, despite securing $20 million in government grants and more than $150 million in venture capital investment. The company manufactured thin, flexible, organic solar panels. Evergreen Solar also closed down its $430 million Devens factory in 2011 and relocated its operations to China. The company cited competition from manufacturers that are subsidized by the Chinese government, which have brought prices for solar panels far below previous forecasts, as their principal reason for closing. The experience of these two companies is similar to other solar firms across the state.

Michael El-Hillow, Konarka's chief executive, said in a statement that his company had decided to close the Massachusetts factory in response to plunging prices for solar panels. World prices have fallen as much as two-thirds in the last three years — including a drop of 10 percent during last year's fourth quarter alone.

Chinese manufacturers, Mr. El-Hillow said in the statement, have been able to push prices down sharply because they receive considerable help from the Chinese government and state-owned banks, and because manufacturing costs are generally lower in China.

Hydropower manufacturing facilities

Figure 31 ***Water control gates manufactured by Steel-Fab Inc.***

Source: http://www.steel-fab-inc.com/

Hydropower transformed New England into a center of industrial activity by the mid 19th Century with mill towns dotted across the region. According to the National Hydropower Association (NHA), New England is also home to some of the nation's leading hydro-manufacturing and engineering firms. The following manufacturing establishments are located in the Montachusett region.

Table 17: Hydropower Manufacturing Facilities

Company Name	Address	Products and Services
Capacitec	87 Fitchburg Road, Ayer	Design and manufacture of non-contact capacitive displacement sensors, gap sensors, hole probes and parallelism sensing systems.
Steel Fab Inc.	430 Crawford Street, Fitchburg	Design and manufacture water control gates and valves for hydroelectric plants.
Universal Machine & Design Corp.	323 Princeton Road, Fitchburg	Metal production and prototypes.

Biomass manufacturing facilities

Based on the Source Guides Renewable Energy Directory (http://energy.sourceguides.com), there are no firms or facilities associated with the development and/or manufacturing of commercial-scale biomass systems and components in the Montachusett and Northern Middlesex regions. The nearest manufacturing facility, Biomass Combustion Systems, Inc., is located in Princeton, Massachusetts.

Geothermal energy manufacturing facilities

There are a number of geothermal energy installers in the Montachusett and Northern Middlesex regions, according to the New England Geothermal Professionals Association's (NEGPA) database. However, there are no known manufacturing facilities or firms associated with the geothermal energy manufacturing supply chain. The nearest firm, Watts Water Technologies, is located in North Andover and manufacturers pipes, valves, fittings and safety devices for the plumbing, HVAC, irrigation and backflow prevention industries.

Demand for Renewable Energy Manufacturing

In 2013 the global market for clean, renewable energies reached a record estimated $260 billion – and is expected to grow into the trillions over the next twenty years. In the United States alone, $36 billion was invested in renewable energy in 2013. This capital has, in part, been invested to create domestic supply chains that support both the domestic and global renewable energy market[152]. Recently, there has been major growth in wind and solar photovoltaic (PV) technologies across the nation. Other renewable technologies, such as hydropower, geothermal and biomass, have also continued to grow due to a strong established base. The success in the solar and wind energy industries has been driven by energy policy changes at the federal and state levels, which has helped these industries grow considerably over the last decade. Utility-scale and rooftop solar PV generation has experienced major growth in the past few years, resulting from both energy policy changes and the decline in the cost of PV modules.

[152] U.S Partnership for Renewable Energy Finance (US PREF), *Renewable Energy Finance, Market & Policy Overview,* April 2014

Future renewable energy generation is expected to be driven, in part, by federal incentives and renewable portfolio standards mandated in many states. The *Emergency Economic Stabilization Act of 2008 (EESA)* and the *American Recovery and Reinvestment Act of 2009 (ARRA),* created a favorable long-term policy environment for renewable energy. Investment in the renewable energy industry was an important component of both laws, which were aimed at economic recovery and encouraging future growth in the U.S. economy. Among the policy developments created in these two pieces of legislation, manufacturing and investment tax credits were key measures that supported the renewable energy manufacturing industry. Furthermore, the U.S. Congress continues to deliberate on long-term policy, such as a National Renewable Energy Standard and carbon emissions caps that will impact future renewable energy markets. Much of the debate is focused on how to increase U.S. economic competitiveness and create jobs growth, which often results in a focus on revitalizing the nation's manufacturing sector. Due to this policy setting, the long-term outlook for renewable energy is considered positive, and in particular, the wind and solar energy markets are expected to see significant investment from renewable energy manufacturers[153]. However, the federal incentives for the renewable energy industry largely expired last year.

New England start-ups will need to come up with truly breakthrough technologies to make solar materials much more efficient at converting sunlight into electricity or new manufacturing processes perhaps using automated assembly lines that don't rely as much on workers. "I absolutely think that the panel that winds up on your roof or your business in the next decade could be made in the US, instead of China,'' says Taneja, a venture capitalist at Cambridge-based General Catalyst Partners. "But the key is making giant leaps, not small incremental improvements.'' Boston Globe by Scott Kirsner Globe Correspondent / November 7, 2010

Consumer desires for higher levels of renewable energy electricity and "green" lifestyles, as well as growing climate change concerns, are also anticipated to drive demand. Fortunately, the United States has diverse and abundant renewable energy resources that are available to contribute higher levels of electricity generation over the next decades and meet this growing demand[154]. While this is likely to lead to increased deployment of renewable energy facilities across the nation, domestic manufacturing is also likely to grow.

To evaluate the future potential of renewable energy manufacturing in the Montachusett and Northern Middlesex regions, each of the sectors will be examined in terms of their short- and long-term forecasts. While the data specific to each region may be limited, generalizations will need to be made based on available industry data and forecasts for the nation and state.

Solar energy manufacturing

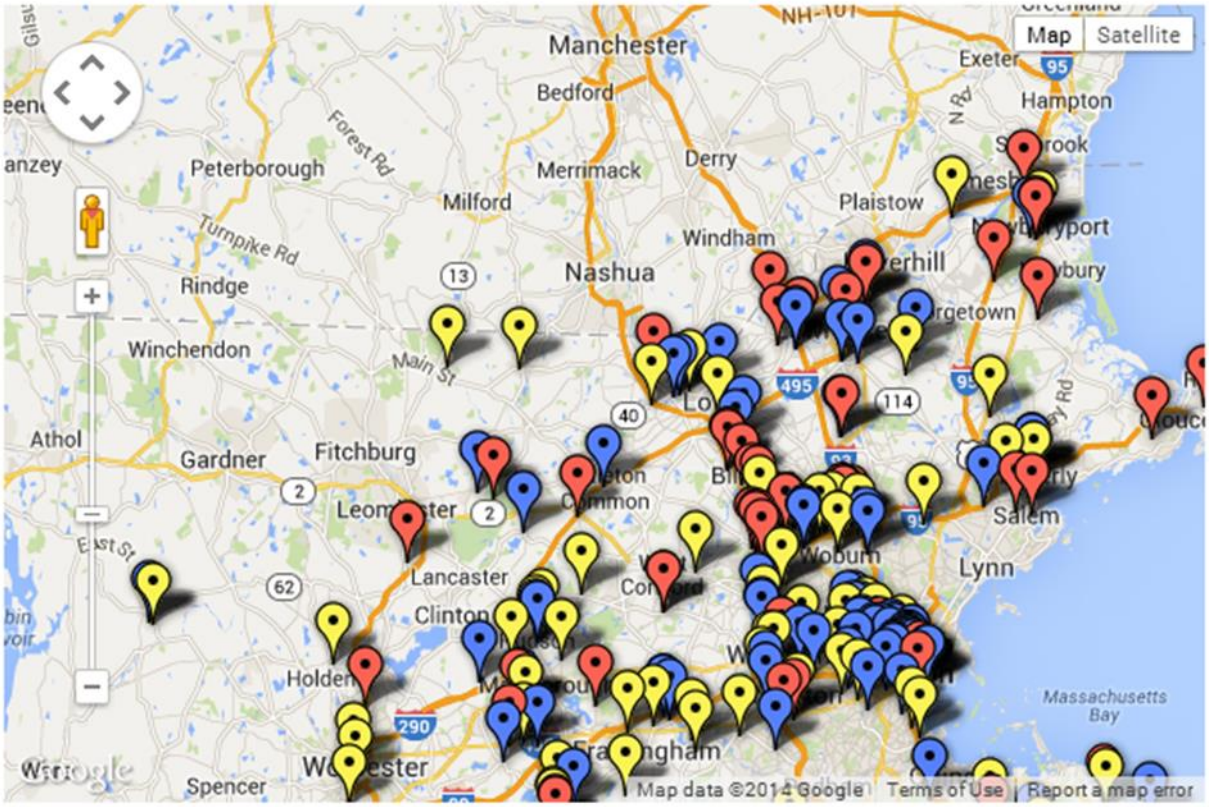
The solar energy industry is growing dramatically in the United States. In 2013 solar installations proliferated by increasing 41% since 2012 to reach 4,751 MW of new solar energy capacity. By the end of 2013, there was a total 13,000 MW of solar energy capacity installed nationwide. Therefore, the total installed utility-scale electrical generating capacity in the U.S. is 1,158 GW; thereby accounting for 1.1%

[153] National Renewable Energy Laboratory (NREL), *State Clean Energy Policies Analysis (SCEPA): State Policy and the Pursuit of Renewable Energy Manufacturing, Technical Report,* February 2010.
[154] National Renewable Energy Laboratory (NREL), *Renewable Electricity Futures Study,* 2014.

of the nation's electrical generating capacity. The increasing number of solar installations has also bolstered the national economy. In 2013 solar electric installations were valued at $13.7 billion, compared to $11.5 billion in 2012 and $8.6 billion in 2011. The U.S. Solar Market Insight Report forecasts a 26% overall growth in the U.S. solar market in 2014 with new installations projected to reach nearly 6,000 MW.

In Massachusetts the solar energy market is booming. As described in Chapter X, the combination of strong government policies, consumer demand, local community support, PV cost reductions, improved financing terms, tax breaks and public incentives has influenced the high growth in the State's solar energy-generating capacity. Massachusetts had 465 MW of solar energy installed by the end of 2013 and $789 million was invested to install solar for home.

Figure 32: Snapshot of Solar firms in north east Massachusetts



Key: Manufacturer Installer Other

Source: SEIA National Solar Database, 2014

There are currently more than 290 firms operating within the solar value chain in Massachusetts. These firms provide solar products and services ranging from the primary business and utility use in 2013. This represents a 50% increase over the previous year and is expected to grow again in 2014.

These firms provide solar products and services ranging from the primary components of a solar PV system, such as solar-grade polysilicon, wafers, cells, solar modules, and inverters, to the glass and steel components used in utility-scale solar power plants. As mentioned previously, 60 of the solar firms operating in Massachusetts are manufacturers and 26 are manufacturing facilities (Refer to Figure 3 below for a snapshot of the regions' solar firms).

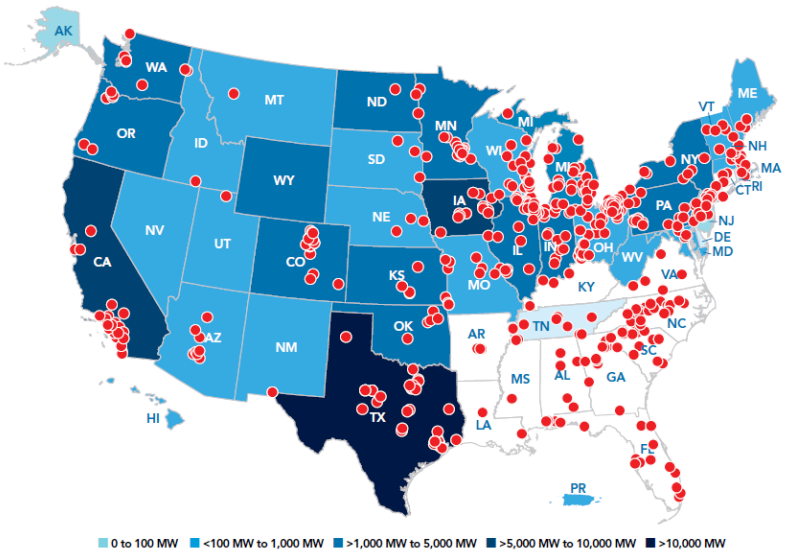
After meeting the State goal of 250 MW of solar power installations four years ahead of schedule, Governor Patrick set a new goal of 1,600 MW by 2020. Similar goals and incentives are in place or are being considered in most states across the United States. Such broad scale policy directions are likely to ensure that solar energy continues to be in demand and that the solar manufacturing base in Massachusetts continues to expand. Given the recent closing of solar firms in the Northern Middlesex and Montachusett regions, industry experts have suggested that solar manufacturing in Massachusetts will need to evolve and grow in order to compete with low-cost Chinese manufacturers and declining PV costs.

Wind Energy manufacturing

The wind industry achieved 61 GW of cumulative wind energy capacity in the United States in 2012 with more than 45,000 wind turbines installed across the nation. According to the AWEA, there are 560 wind-related manufacturing facilities in the United States producing more than 8,000 components that comprise a typical wind turbine (Refer to Figure 33).

Prior to 2005, only one wind turbine original equipment manufacturer (OEM) assembled utility-scale turbines in the United States. By the end of 2012, a total of twelve assembly facilities were online. This growth in wind-related manufacturing has occurred across the entire value chain – there are currently thirteen facilities producing blades and twelve tower manufacturing facilities.

Figure 33: Online Wind-Related Manufacturing Facilities as of 2013



Source: American Wind Energy Association

Recently, new wind power project installations have grown at an average rate of 36% per year, creating new opportunities throughout the wind energy supply chain. A relatively stable policy environment attracted major wind manufacturers to invest in U.S.-based facilities, often bringing their supply chain with them. This has helped bring down wind turbine costs and has boosted domestic content from less than 25% in 2005 to more than 67% in 2013. However, in 2014 the industry

lacks the long-term policy support needed to guarantee a stable market, and manufacturing levels in the U.S. are anticipated to exceed domestic demand for select parts of the supply chain in the short term, partially due to this policy uncertainty. Yet, the fundamentals of the industry remain strong with the expectation that the market will create new opportunities as current and new manufacturers develop domestic supply chains, and other states establish wind energy generation targets.

As of March 2014, there was 106 MW of installed wind energy capacity in Massachusetts, providing 0.6% of the state's electricity. Governor Patrick has set a goal of installing 2,000 MW of wind capacity by 2020. Since only 5% of that capacity was in place by mid-2013, the demand for wind energy is likely to continue based upon this policy goal. In addition, federal studies rank Massachusetts' wind resources as excellent around Cape Cod, Martha's Vineyard and Nantucket. Some ridge crests in the Berkshire Mountains in western Massachusetts have also been found to have good potential. In total, NREL data shows that there is 1,028 MW of onshore wind potential in Massachusetts. However, the state's offshore regions have the highest wind resource potential with 199,987 MW of technical capacity. In fact, these locations are currently being considered for offshore wind projects. Cape Wind, which is the nation's first-ever offshore wind project proposed for ocean waters off Cape Cod, is progressing in its financing by also securing U.S. Department of Energy loan guarantees. Massachusetts is also planning the construction of the New Bedford Marine Commerce Terminal, the first facility in the nation built specifically to support the assembly, construction, and deployment of offshore wind projects.

In 2011 Massachusetts opened the first U.S. facility capable of testing large-scale wind turbine blades up to 90 meters in length. The MassCEC's Wind Technology Testing Center (WTTC) in Charlestown serves as a critical element in the wind energy industry, speeding deployment of the next generation of wind blades, attracting companies to design, manufacture and test their blades in the U.S. and catalyzing growth in the American wind turbine supply chain.

Growth of offshore wind turbines is anticipated to drive larger component sizes and make it increasingly difficult to move turbine components over land. Coastal manufacturing for blades and nacelle assembly, as well as tower, foundation, and substructure fabrication, may therefore be an industry requirement in the near future. It may be for these reasons that many blade and tower manufacturers have recently sought locations in southeastern Massachusetts.

As described in the Wind Energy section, there is a lack of wind in the range required to produce utility scale wind power, at a useful capacity, in the Montachusett and Northern Middlesex regions. However, smaller industrial or mid-sized turbines, as well as residential and community-scale turbines that can be applied to the electrical grid, may be feasible. As a result, there may potentially be more regional demand for smaller scale wind turbine production or components to be manufactured.

Hydro-energy related manufacturing

According to the NHA, there are 2,200 hydropower plants in the United States, which provide 100,000 MW of hydro-energy capacity[155]. Hydropower plants are by far the largest supplier of renewable energy in the nation. The industry is supported by more than 2,500 supply chain companies. In Massachusetts there are approximately 78 firms involved in the hydro-energy industry. These companies range from project developers to construction firms; architecture and engineering firms to electricians; and component manufacturers. Figure 40 below shows a snapshot of the hydropower industry in the region.

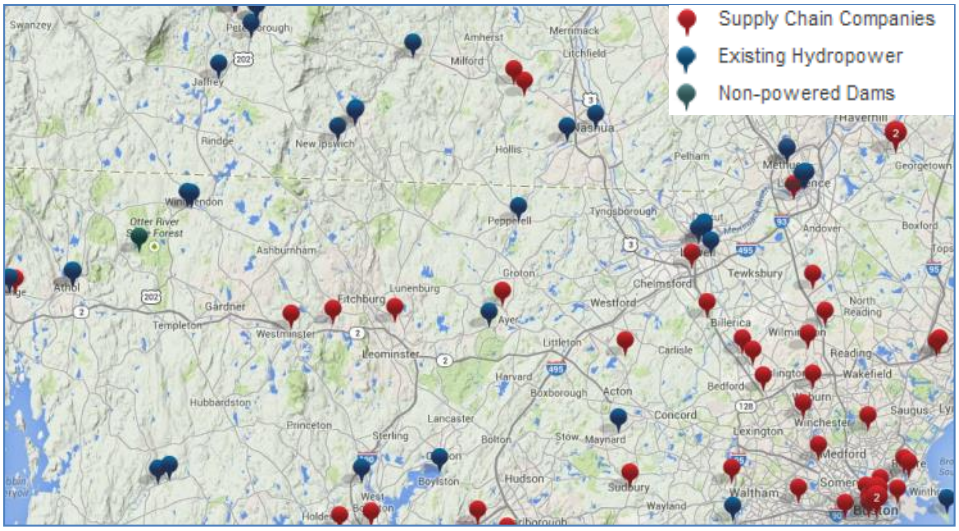


Figure 34: Snapshot of the Hydropower Industry

Source: NHA, http://www.hydro.org/why-hydro/available/industrysnapshot/

In 2012 the U.S. Department of Energy determined that there are approximately 54,000 existing non-powered dams across the country that could be powered and add 12,000 MW of new hydropower capacity to the nation's electricity grid. In Massachusetts, existing non-powered dams have 67 MW of potential capacity[156]. Additionally, Navigant Consulting, on behalf of the NHA, identified several tens of thousands of additional megawatts from other forms of development, such as expanding and upgrading existing hydropower plants and building new pumped storage. Recently, the Oak Ridge National Laboratory undertook an assessment of undeveloped stream-reaches to determine further hydropower energy potential in the U.S. The estimated technical resource capacity for new stream-reach development across the nation was found to be 65.5 GW, with 194 MW of potential in Massachusetts[157].

The Northern Middlesex and Montachusett regions have the potential to develop a number of existing dams (Refer to Hydropower Chapter). Powering these facilities is a way to increase the state's supply of renewable energy by maximizing existing infrastructure and avoiding the need to build new dams. Consequently, the potential to support additional hydro-related supply chain manufacturing could expand in both regions based upon the potential state demand.

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[155] NHA, Hydropower Industry Snapshot, http://www.hydro.org/why-hydro/available/industrysnapshot/ (accessed July 25, 2014)

[156] ORNL, *An Assessment of Energy Potential at Non-Powered Dams in the United States*, 2012

[157] ORNL, *New Stream-reach Development: A Comprehensive Assessment of Hydropower Energy Potential in the United States*, 2014

Geothermal manufacturing

Since the 1960s the United States has been a world leader in the geothermal industry. Installed geothermal power capacity in 2012 grew by 5% or 147 MW to a total of 3,386 MW of geothermal power[158]. This represents the highest installed geothermal capacity in the world. The majority of geothermal installed capacity in the nation is concentrated in California and Nevada where geothermal resources are abundant. Several geothermal power plants are also operating or under construction in Alaska, Hawaii, Idaho, Oregon, Utah, Washington and Wyoming. It is forecast that emerging technologies, including enhanced geothermal systems, engineered hydrothermal reservoirs, geo-pressured resources, low temperature resources, and co-production from oil and gas wells, could expand the geothermal resource potential in the nation by more than 500 GW[159].

The Geothermal energy chapter found limited potential in the Montachusett and Northern Middlesex regions to generate large-scale geothermal electricity due to temperatures at the low end of binary cycle capability, as well as the high cost of implementing geothermal systems. Given the limited application in both regions and the absence of an existing supply chain, there may be limited opportunities for geothermal manufacturing to be established in the region. However, geothermal components, equipment and devices could still be manufactured in the Northern Middlesex and Montachusett regions and shipped to western states or overseas, where more geothermal capacity is generated. In addition, the analysis in Chapter X found that ground source heating has major potential for growth in Massachusetts and the Montachusett and Northern Middlesex regions. Therefore, manufacturing and installing small-scale, geothermal systems, such as heat pumps, may be a potential niche sector servicing this growing local residential market.

Biomass manufacturing

While biomass represents a very interesting renewable energy source, it is often considered controversial due to environmental impacts from greenhouse gas emissions, high water use, low energy efficiency and forest harvesting associated with woody biomass. However, the use of biomass energy is growing and will likely continue in the future as the nation seeks to increase use of renewable energy and decrease carbon emissions associated with fossil fuel use. According to a Pike Research study, "Biopower Markets and Technologies", global biomass power capacity will reach at least 86 GW globally by 2021, increasing by almost 50% from 58 GW in 2011. This growth in capacity will be the result of a total investment of $104 billion in the biomass sector between 2008 and 2021

The U.S. Department of Energy projects an estimates 696 to 1,184 million annual dry tons of biomass inventory potential by 2030[160]. The estimated biomass feedstock corresponds to roughly 100 GW of dedicated biopower capacity in the nation. In Massachusetts the NREL estimates that between 150,000 and 250,000 annual dry tons of biomass resources is technically available in Middlesex and Worcester counties[161]. While demand for biomass production is expected to increase, environmental

[158] Geothermal Energy Association, *2013 Annual US Geothermal Power Production and Development Report, April 2014*

[159] NREL, *Renewable Electricity Futures Study,* 2012

[160] Department of Energy, *U.S. Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry,* 2011.

[161] NREL, *Biomass Maps, 2009*, http://www.nrel.gov/gis/biomass.html (accessed July 24, 2014).

concerns with this energy source, combined with limited application and supply chain activities in the region, may mean that biomass manufacturing is not an industry sector that is directly targeted by communities in the region. However, similar to geothermal manufacturing, there are no constraints to the manufacturing of biomass components, equipment or machinery in the Northern Middlesex and Montachusett regions.

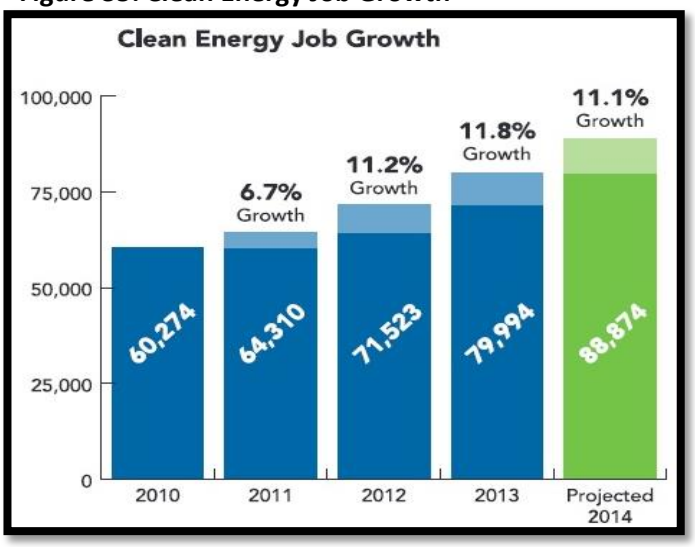
As summarized in this section, the renewable energy manufacturing industry currently has a modest presence in the Montachusett and Northern Middlesex regions. Solar supply chain activities, particularly those of Tier 2 manufactures, are clustered in the Northern Middlesex region. In the Montachusett region, there are a number of hydropower-related and wind-energy related supply chain manufacturing facilities, including several Tier 1 suppliers. Furthermore, the renewable energy industry, primarily solar and wind, is a growing sector in the nation and the state. Given the relatively recent emergence of this industry, forecasts about future growth must be tempered with a degree of caution as the long term performance of the industry in the United States remains unknown due to the uncertainty about as federal incentives and tax breaks. Yet, the outlook for renewable energy manufacturing is fairly positive due to growing customer demand and overall concerns about the environment.

While deployment of certain renewable energies may have limited potential in the region, this does not preclude the manufacturing of components, machinery and equipment associated with these sectors. However, transportation costs will be an important factor, depending on where the equipment is ultimately deployed. As described in further detail in the following sections, the region is well served by rail and road networks making transportation of most large scale machinery, components and equipment relatively easy. There are also many other manufacturing, workforce and locational strengths that make the Montachusett and Northern Middlesex regions attractive locations for renewable energy manufacturers.

Demand for Renewable Energy Manufacturing Employment

According to the U.S. Bureau of Labor Statistics, renewable energy, such as solar power and wind power, is expected to be a key piece of the growing "green economy," and jobs in these industries show great potential for growth. As growth and interest in renewable energy continues, demand for more trained workers, including those involved in the manufacturing supply chain, will also increase. Renewable energy manufacturing is also typically more labor intensive than current fossil fuel energy. Both the solar-related and wind energy sectors have more than two-thirds of their jobs in manufacturing, with the remaining third consisting of research and development, construction and operation,

Figure 35: Clean Energy Job Growth

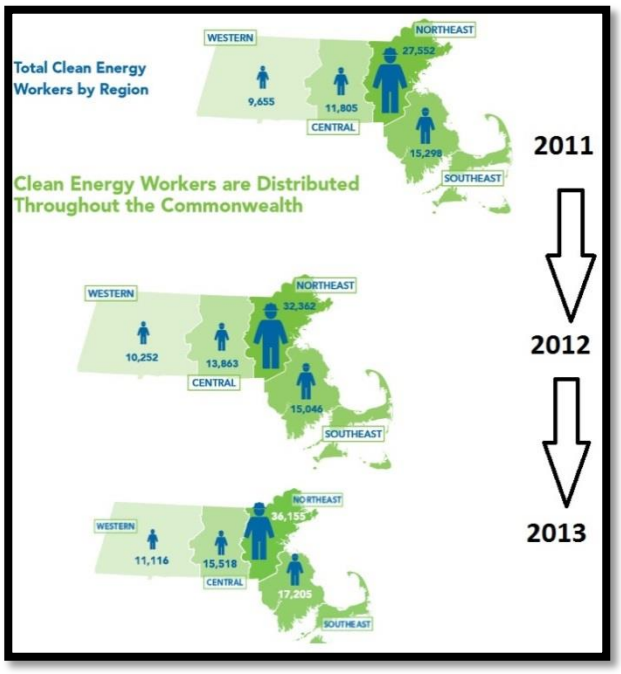


and installation and maintenance.[162]. Thus, the number of manufacturing jobs is expected to increase proportionately with the amount of renewable energy created. Peripheral jobs are also likely to be created in related sectors that develop and maintain associated systems, technology and equipment.

In its most recent report, the MassCEC found that there were 79,994 workers employed in the clean energy industry at the end of 2013[163]. Approximately 30,537 workers are associated with the renewable energy sector and it is estimated that 13,458, or 44.1%, of these workers were employed in manufacturing. The 2013 Massachusetts Clean Energy Industry Report also shows that all clean energy jobs grew by 11.8% from 2012 to 2013, following an 11.2% growth the year before and a 6.7% increase in 2011. Between 2012 and 2013, clean energy manufacturing employment in Massachusetts grew by 20.6%. The Clean Energy Job Growth is summarized in the chart below. It is expected that there will be an 11.1% growth between 2013 and 2014. The future for clean energy jobs in Massachusetts is quite positive based upon the figures from MassCEC.

The image to the left shows the Massachusetts map and depicts the regional changes in the labor force; it augments the data from the table above. Clean energy employs the highest amount of people in the northeastern region of Massachusetts. This is to be expected considering that Boston and the majority of its suburbs fall within this region. Since 2011 the number of clean energy jobs within the northeast region of Massachusetts increased by 9,000 or 31.2%. Central Massachusetts experienced a 31.5% increase in clean energy jobs with a total of 3,713 new jobs between 2011 and 2013. There has been a resilient upward trend of workforce expansion for all clean energy jobs throughout the Commonwealth since 2011.

Figure 36: Total Green Energy Workers By Region



To reduce greenhouse gas emissions at the state level, Executive Order No. 484[164] is an environmental initiative titled Leading by Example Program, which mandates that state agencies reduce their environmental impact by aggressively setting energy use goals and by targeting reductions in greenhouse gas emissions. The Executive Order dictates numerical percentages and years by which state-owned buildings must reduce their energy consumption and reduce their level of greenhouse gas emissions. In a further effort to facilitate renewable energy production, and reduce fossil fuel emissions

[162] The Brookings Institution - Metropolitan Policy Program, *Sizing the Clean Economy a National and Regional Green Jobs Assessment*, 2011

[163] The study's definition of a clean energy worker is any worker that spends *any* portion of his or her time supporting their firm's clean energy business.

[164] http://www.mass.gov/governor/legislationeexecorder/executiveorder/executive-order-no-484.html

of greenhouse gases - the Commonwealth has enacted the Green Communities Act, Global Warming Solutions Act, Clean Energy Biofuels Act, and the Green Jobs Act[165].

Massachusetts has been successful in stimulating the clean energy economy throughout the past seven years. Moreover, this economy has been booming in the past three years – as seen in the table on the next page. This table illustrates the increases in various sectors of the economy's clean energy labor force over the past three years. Installations and maintenance firms are the only sector of the economy where job growth was not consistently increasing. The reason for this is that installation jobs are seasonal and part-time; once the installation is complete the installers are no longer required. Since 2011, the clean energy sales and distribution labor force has increased by 3,000 or 15.79%. Engineering and research jobs grew by 58.44% and manufacturing jobs grew by 64.66%. Massachusetts has 13.2% more clean energy firms in 2013 compared with 2011.

Table 18: Growth in Energy Sectors

Work Force Sector	**2011**	**2012**	**2013**	**% Growth**
Installations and Maintenance Firms	20,709	18,280	19,031	↓ 8.10 %
Sales and Distribution	18,686	20,671	21,637	↑ 15.79 %
Engineering and Research	11,019	13,182	17,458	↑ 58.44 %
Manufacturers	8,173	11,162	13,458	↑ 64.66 %
Other (legal, policy making, finance, etc.	5,723	8,229	8,409	↑ 46.93 %
Total	64,310	71,524	79,993	↑ 24.39 %
Employers/ Firms	4,909	4,995	5,557	↑ 13.20 %
Locational Division of Workforce				
Northeast	27,552	32,362	36,155	↑ 31.23 %
Southeast	15,298	15,046	17,205	↑ 12.47 %
Central	11,805	13,863	15,518	↑ 31.45 %
Western	9,655	10,252	11,116	↑ 15.13 %
Total	64,310	71,523	79,994	↑ 24.39 %

Determining the exact number of employees working to support the clean energy economy is difficult because different data sources use slightly different parameters to define the green economy or green goods and services. It is important to note that the positive trend of more jobs relating to the green economy is consistent across an array of sources. The U.S. Bureau of Labor Statistics shows the number of employees supporting green goods and services within Massachusetts private sector. Data from BLS indicates that in 2010 there were roughly 70,000 people employed in Massachusetts who spend at least a part of their time supporting the green goods and services industry. In 2011 this number grew to 75,000. According to the Massachusetts Clean Energy Center, in 2010 there were about 60,000 clean energy workers. This inconsistency is due to the varying definition of clean energy worker or green

[165] http://www.mass.gov/governor/legislationeexecorder/executiveorder/executive-order-no-515.html
Table 2: 2011-2013 Massachusetts Clean Energy Industry Report - http://www.masscec.com/content/2013-clean-energy-industry-report

goods and service used to collect data; there is no one definition for this and therefore variations in statistical data do occur.

Table 19: Green Goods and Services (GGS) private sector employment by state and industry sector with over-the-year change and annual averages

		2010			2011			change	
	Industry	GGS Employed	Total Employed	GGS %	GGS Employed	Total Employed	GGS %	GGS Employed	GGS %
Massachusetts	Total	70,720	2,733,361	2.6	75,071	2,778,429	2.7	4,351	0.1
	Natural resources and mining	-	7,783	-	-	7,877	-	-	-
	Utilities	1,263	10,434	11.1	958	10,453	9.2	-305	-2.9
	Construction	8,029	107,103	7.4	8,582	110,752	7.7	553	0.2
	Manufacturing	9,457	256,493	5.8	9,299	253,948	3.7	-158	0.0
	Trade	3,074	462,054	1.0	3,048	466,636	0.7	-26	0.0
	Transportation and warehousing	10,782	68,840	9.1	11,067	69,667	15.9	285	0.2
	Information	-	85,118	-	3,674	84,251	4.4	-	-
	Financial Activities	-	207,883	-	-	207,409	-	-	-
	Professional, scientific, and technical services	11,840	248,546	5.7	14,736	256,923	5.7	2,896	0.9
	Management of companies and enterprises	-	57,442	-	-	58,628	-	-	-
	Administrative and waste services	9,538	156,279	5.6	8,917	161,564	5.5	-621	-0.6
	Education and health services	8,112	626,851	-	7,351	638,878	1.2	-761	-0.1
	Leisure and hospitality	-	307,011	-	708	314,883	0.2	-	-
	Other services, except public administration	2,052	113,528	0.9	2,426	136,559	1.8	374	0.3

Source: U.S. Bureau of Labor Statistics; http://www.bls.gov/web/ggqcew/ggqcew_supple_table6.pdf
[Note: Data is missing when statistics do not meet BLS disclosure standards.]

Solar energy jobs

According to the Solar Energy Industry Association, America's solar industry now employs more than 142,000 workers – more than doubling since 2009, of which 8,400 are

Figure 37: Worker in Solar Factory
Source: www.seia.org

located in Massachusetts[166]. This growth in the solar power industry is evidenced by the rapid increase in solar capacity over the past several years, leading to the increased demand for skilled workers. The U.S. Bureau of Labor Statistics anticipates that as solar technology evolves and new uses for solar power are discovered, occupations in the industry will continue to grow and develop. The Solar Foundation, in its Annual Review of the U.S. Solar Workforce, found that there are 29,851 workers employed in solar manufacturing in the U.S. in 2013[167]. This is expected to rise by 8.9% in 2014 to approximately 32,429 workers[168].

It is also important to note that solar manufacturers are the most diverse of all solar sectors. Firms in this category are an important employer of U.S. veterans and Latino/Hispanic workers. Additionally, manufacturers on the whole have the largest proportion of female workers of all of the solar industry sectors.[169]

Wind energy jobs

As of the end of 2013, the U.S. wind energy industry supported 50,500 full-time equivalent jobs directly associated with wind energy project planning, siting, development, construction, manufacturing and supply chain, and operations[170]. Wind energy development supports long-term, high-paying jobs in fields such as wind turbine component manufacturing, construction and installation, maintenance and operations, legal and marketing services, transportation and logistical services.

Historically, the wind industry's manufacturing sector has grown significantly in the U.S. Employment in the manufacturing sector increased from 2,500 jobs in 2004 to 20,000 in 2010.[171] However, in recent years, the wind energy industry has declined due to uncertainties associated with the federal Production Tax Credit and Investment Tax Credit extension. Manufacturing and supply-chain-related employment dropped from 30,000 jobs to 25,500 jobs in 2012, according to the AWEA. Furthermore, in 2013 there was a 92 percent drop in wind installations across the nation and 30,000 wind energy jobs were lost.

Hydropower jobs

Being the largest supplier of renewable energy in the United States, the national hydropower industry employs approximately 300,000 workers. In 2009 the National Hydropower Association commissioned a study examining the hydropower industry's job-creation and growth potential. The results demonstrate that with the right policies in place, hydropower could create 1.4 million cumulative jobs and add 60,000 MW of affordable, domestic, renewable energy by 2025[172].

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[166] SEIA, *Solar Energy Facts: 2013 Year in Review*, March 2014, http://www.seia.org/research-resources/solar-industry-data (accessed May 22, 2014)

[167] http://www.thesolarfoundation.org/sites/thesolarfoundation.org/files/TSF%20Solar%20Jobs%20Census%202013.pdf (Accessed May 21, 2014)

[168] Ibid.

[169] Ibid.

[170] AWEA, *Wind Energy Facts at a Glance*, http://www.awea.org/Resources/Content.aspx?ItemNumber=5059

[171] NREL, *Renewable Electricity Futures Study,* 2012

[172] Navigant Consulting, *U.S. Offshore Wind Manufacturing and Supply Chain Development,* 2009

Location and Siting Considerations

Attracting renewable energy manufacturers to a region requires an understanding of the decision-making process and variables that determine where new manufacturing facilities are located. Facility location is a strategic decision that firms make based on the whole environment in which they operate. This section examines the location and siting considerations of renewable energy manufacturing facilities and the typical siting strategy that guides private sector decision-makers.

In general, much of the background material focuses on locations that are supportive of the renewable energy manufacturing in terms of Renewable Portfolio Standards (RPS) and incentives, site and building readiness, transportation, and the presence of existing supply chains and suppliers. However, it is important to note that location and siting needs vary for renewable energy manufacturers. For example, wind-energy manufacturing facilities have more specific transportation requirements and are generally located near valuable wind resources in comparison to the other energy sectors. Many other variables may guide a firm's decision-making process, as outlined in the summary list included in this section.

Economics

The economic development tools used to attract renewable energy manufacturers have historically focused on financial incentives.[173] Many states have sought to influence siting decisions with property tax rebates, income tax credits, grants, loans, and sales tax exemptions. The success of these financial incentives is often debated and, as a result, other approaches are often recommended by economists, including investing in human capital, workforce development and modernizing infrastructure[174]. This section briefly summarizes some of the key national and state manufacturing incentives and initiatives available in the Northern Middlesex and Montachusett regions.

Federal incentives and initiatives

Manufacturing Tax Credits (48C)

In order to foster investment and job creation in clean energy manufacturing, the *American Recovery* and *Reinvestment Act of 2009* included a tax credit for investments in manufacturing facilities for renewable energy technologies. The Section 48C Advanced Manufacturing Tax Credit originally provided a 30% investment tax credit to 183 domestic clean energy manufacturing facilities valued at $2.3 billion. On February 7, 2013, the IRS announced the availability of additional 48C allocations, releasing $150 million remaining tax credits that were never fully utilized by previous awardees.

Production Tax Credit for Renewable Energy

The Production Tax Credit (PTC) is a federal incentive that provides financial support for the development of renewable energy facilities. Companies that generate electricity from wind, geothermal, and "closed-loop" bioenergy (using dedicated energy crops) are eligible for a federal PTC, which provides a 2.3-cent per kilowatt-hour (kWh) incentive for the first ten years of a renewable energy facility's operation.

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[173] NREL, *State Clean Energy Policies Analysis (SCEPA)*:February 2010.

[174] Ibid.

The PTC for renewable energy technologies expired at the end of 2013. A new provision was included in the American Taxpayer Relief Act of 2012 (enacted in January 2014) permitting only projects that were under construction before January 1, 2014 to qualify for the PTC.

Clean Energy Manufacturing Initiative

The Clean Energy Manufacturing Initiative strategically focuses the Office of Energy Efficiency & Renewable Energy's (EERE) clean energy technology offices and its Advanced Manufacturing Office around the competitive opportunity for the United States to be the leader in the clean energy manufacturing industries and jobs of today and tomorrow. The objectives of this initiative are to:

- Increase U.S. competitiveness in the production of clean energy products.
- Increase U.S. manufacturing competitiveness across the board by increasing energy productivity.

State incentives and initiatives

Massachusetts consistently ranks high as a renewable energy leader among other states. Growth of the renewable energy industry is a clear economic development priority, with strong results to date in leading-edge policies, industry expansion, job creation, and increased investment and deployment.[175]

Advanced Manufacturing Collaborative

On November 28, 2011, Governor Patrick announced the launch of the Massachusetts Advanced Manufacturing Collaborative (AMC) – a group comprised of leaders from industry, academia and government that has come together to enhance the competitiveness of Massachusetts manufacturing and lead the national effort to revitalize the U.S. as a manufacturing center. The industry-led AMC is focused on improving the competitive conditions in which our manufacturers can compete and thrive.

MassCEC's IncubateMass program

The MassCEC's IncubateMass program was recently announced and provides funding to incubators that catalyze and support startup companies to create jobs and promote the commercialization of new clean energy technology. By providing their client companies with targeted business support services and resources, such as mentors, specialized equipment, educational series and networks, these incubators work to accelerate the development of clean energy startups and increase the success rate of member companies.

Commonwealth Solar II

Commonwealth Solar II provides rebates for homeowners and businesses in Massachusetts, who install solar PV at residential, commercial, industrial, institutional and public facilities. In addition to the base incentive, additional incentives are available for installations using components manufactured in Massachusetts, for individuals with moderate income or home values, and for those who are rebuilding as a result of a natural disaster.

[175] Clean Edge, *A Future of Innovation and Growth: Advancing Massachusetts' Clean Energy Leadership,* April 2010

Working Capital Loan Guaranty for Manufacturers

MassDevelopment's newest loan guaranty product allows banks to make larger working capital loans to manufacturing companies than they would normally make under their existing advance rates. Eligible borrowers are manufacturers that conduct their primary operations in Massachusetts. A fixed guaranty to the lender of up to $1 million will cover advances up to 25% above the lender's maximum allowable advance rate under its current formula. The guaranty terminates with the maturity of the line of credit and will be considered for renewal on the same cycle as the bank, but no less frequently than every three years.

Some firms assert that incentives are temporary "band-aids" and that the success of the solar market depends on its ability to function without them. The temporary nature of incentives is aggravated by the fact that many state and local incentives are constantly in flux. One respondent noted that if incentives were guaranteed for four or five years, solar companies (particularly manufacturers) could plan investment with much more certainty (IEDC).

Local government

While states normally establish industry wide programs and incentives for renewable energy, local governments can also play a role in attracting renewable energy investment to their municipalities. Local governments unable to finance programs specifically for the renewable energy manufacturing industry can prioritize the industry as one of the targeted sectors of its economic development efforts. Miami-Dade County, Florida, for example, provides financial incentives for specific industries, including renewable energy, looking to relocate or expand within the county. Specifically, the County provides qualifying companies a property tax credit up to 1.7% of total real property capital investment or 1.15% of the tangible personal property capital investment. Additional incentive opportunities for eligible real property and tangible personal property include:

- 17.5% of capital investment bonus for each new job if the company is located in a Designated Priority Area.
- 17.5% of capital investment bonus for each new job if the company is a "Green Certified" business in Miami-Dade County.
- 5% of capital investment bonus for companies that operate their businesses out of buildings or facilities that qualify as "green construction" or that incorporate an alternative energy system.
- 5% of capital investment bonus, if the company manufactures, installs or repairs solar thermal or PV systems.

Municipalities can also commit to purchasing a specified amount of renewable energy (solar) equipment from manufacturers locating in a community as a recruitment tool. Municipalities that operate their own local electric utilities have additional options to attract solar firms to the area. For example, Columbia, Missouri, established a solar portfolio goal as a target to generate or procure a portion of the municipal utility's electrical load with PV generation. Austin Energy, in Texas, and the Los Angeles Department of Water & Power offer higher incentives for installing locally-manufactured solar equipment as part of their solar incentive programs.

Within the Northern Middlesex and Montachusett regions there are no known local incentives or initiatives that specifically target renewable energy manufacturing at the municipal level. However, the traditional economic development tools available for other manufacturers, such as the Economic Development Incentive Program (EDIP), can be used for renewable energy firms as a means to reduce their property taxes for a specific period of time, as well as their personal property taxes.

While traditional economic development activities have focused on providing various forms of financial and other incentives to attract new renewable energy facilities, there appears to be a move away from these costly tools. A growing national trend focuses on maintaining, retooling and diversifying the existing manufacturing base to support emerging industries. This is evidenced in the recent development of several national and state collaboratives and partnerships, as well as workforce development grants (discussed in Section 7). Coupling incentives with broad-based programs will ultimately support long-term economic development[176].

Zoning and Permitting

"Building" or "site-readiness" is also identified as key site determining factors. A fundamental aspect of 'site readiness' is related to zoning. Zoning has the potential to either facilitate economic development or prohibit it. In general, zoning should encourage the specific uses a municipality is seeking to attract in specific locations. This means that sites are readily available for economic development, and that a developer or end user has one less regulatory step to go through. As such, this section examines the zoning of each community within the Northern Middlesex and Montachusett regions.

Zoning

Generally, renewable energy manufacturing would fall under the definition of light manufacturing, manufacturing, laboratory/office park, and research & development when combined with these other uses as an accessory use, rather than 'heavy' manufacturing. Locations that either allow manufacturing by right, or with a special permit are considered most supportive of renewable energy manufacturing. The tables in Appendices J.1 and J.2 identify the Northern Middlesex and Montachusett communities that currently facilitate renewable energy manufacturing through their bylaws.

Permitting

The ease and speed of permitting is also very important to the renewable energy sector and assists with site readiness. The faster a community signs off on permitting, the quicker a manufacturing facility can be built or retrofitted. According to the International Economic Development Council (IEDC), based on a survey of solar industry firms, the most important local asset for growing renewable energy is the permitting process. Studies comparing the U.S. and German solar markets have shown that "soft costs", such as permitting, are 80% lower in Germany. Similarly, wind farm developers have identified the State's complicated permitting process, which involves multiples agencies and levels of government, as a barrier to wind energy development.

[176] NREL, *State Clean Energy Policies Analysis (SCEPA):*February 2010

Massachusetts Chapter 43D - Expedited Local Permitting

In August 2006 Chapter 43D Permitting was enacted into Massachusetts law, establishing an inventory of Priority Development Sites (PDS) on which municipalities offer a maximum of 180 day local permitting process. Cities and towns that opt into the Chapter 43D Program are able to target and promote specific areas, through a streamlined local permitting process, for economic development and housing production. As of February 2014, the Chapter 43D Program has been adopted by sixteen (16) municipalities for thirty (30) sites within the Northern Middlesex and Montachusett regions.

Table 19: Expedited Permitting – Chapter 43D

Municipality	# of Sites	IPB Approval Date	Site(s)	Municipal Contact
Athol	3	9/13/2007	North Quabbin Business Park District; Mohawk Plaza EOA; 134 Chestnut Hill Street	Shaun Suhoski, Town Manager, (978) 249-2496
Ayer	1	1/9/2008	40 Groton School Road	Robert Pontbriand, Town Administrator, (978)-772-8210
Billerica	1	12/13/2007	45 Middlesex Turnpike	Stephanie Cronin, Economic Development Coordinator, (978) 808-5281
Chelmsford	1	12/17/2008	25 Katrina Road	Evan Belansky, Community Dev. Director,(978) 244-3341
Clinton	1	3/11/2009	460-530R Main St.	Philip M. Duffy, Director Community and Economic Development, (978) 365-4113 pduffy@clintonma.gov
Fitchburg	2	3/13/2008	0 Airport Road and 135 Intervale Road; 0 Princeton Road	Michael J O'Hara, Principle Planner,(978) 345-1018 x18
Gardner	3	9/24/2008	Rear Main St.;Mill St.; Summit Industrial Park	Trevor Beauregard, Dir. Dept. of Comm. Dev. & Planning, (978) 630-4014
Groton	2	12/13/2007	Station Avenue Overlay District; 134 Main Street (6/21/11)	Michelle Collette, Town Planner, (978-448-1105
Lancaster	4	3/11/2009	Lancaster Technology Park; Ascetic Hill Park; Chisholm Property; Hill Property	Noreen Piazza, Planning Director, (978) 368-4007
Leominster	1	4/11/2007	Southgate Business Park	Lisa Vallee, Economic Development Coordinator, (978) 534-7525 ext. 257
Lowell	2	5/24/2007	Hamilton Canal District; 38 Prince Avenue	Diane Tradd, Asst City Manager, (978) 446-7200
Lunenburg	1	8/12/2009	100 Summer Street	Planning Director, (978) 582-4147
Orange	3	5/14/2008	Putnam Hall Block; South Main Street Block; West River Street Block	Richard Kwiatkowski, Town Administrator, (978) 544-1100 x107

Municipality	# of Sites	IPB Approval Date	Site(s)	Municipal Contact
Pepperell	1	12/17/2008	128 Main Street	Ken Kalinowski, DPW Director/Town Engineer, (978) 433-0327
Tewksbury	1	9/24/2008	Simon Properties/RJ Kelly	Steven J. Sadwick, Dir. of Comm. Dev., (978) 640-4370
Westminster	3	3/11/2009	Fitchburg Road; Simplex Drive; Westminster Business Park	Steven Wallace, 978-874-7414

Barriers

There are several planning barriers to locating renewable energy manufacturing facilities in the Montachusett and Northern Middlesex regions. Most notably, there is a lack of 'as-of-right' zoning in many communities, which may reduce the attractiveness of the region when manufacturers are making location decisions. Lengthy and costly siting processes can also be barriers to the siting of renewable energy manufacturing facilities. The process for securing permits and community approvals for renewable projects can be both costly and time-consuming without municipal support.

Infrastructure

Like any manufacturing industry, renewable energy manufacturing facilities require land to be fully serviced with infrastructure and services. Firms, especially those serving regional markets, will evaluate the infrastructure available within a region. Water and sewer is usually required. While energy use in the manufacturing sector has declined over recent years[177], the industry has high electricity consumption rates, therefore power supply and gas requirements are essential factors. Given today's high-tech workplace, telecommunications are also essential. Within the Northern Middlesex and Montachusett regions, there are some industrial districts with limited access to sewerage, which would limit their consideration as viable sites.

Access and Transportation

The efficient movement of goods, machinery, people and finished products is a key component of any manufacturing activity. Easy access to development sites can be vital when it comes to executing business strategies, saving time and money, and creating an attractive environment for both employees and customers. The same can be said for the specific renewable energy segment, however, some additional parameters must be considered as large components, machinery and devices are manufactured in the wind and hydro sectors. Notably, transportation of wind turbine equipment, such as blades and towers, requires specific local and regional infrastructure. (Attached in Appendix J.3 and J.4 are the analyses of the access and transportation issues in the Montachusett and Northern Middlesex regions completed by the MRPC and NMCOG staff. These analyses were completed to help identify those potential locations for renewable energy facilities within each region, taking into

[177] Total energy consumption in the manufacturing sector decreased by 17 percent from 2002 to 2010 (US EIA, http://www.eia.gov/consumption/manufacturing/reports/2010/decrease_use.cfm?src=%E2%80%B9%20Consumption%20%20%20%20%20%20Manufacturing%20Energy%20Consumption%20Survey%20(MECS)-f2)

consideration the barriers that need to be addressed for each site. The maps for each region reflect the conclusions reached by each RPA staff as a result of the analyses.)

Goods and Freight Movement

Ensuring that the regional transportation network is capable of transporting equipment is an important consideration in renewable energy development. Locations near major transportation facilities that enable the efficient movement of freight, and movement and storage of goods are fundamental to a region's economy and also very important to the renewable energy manufacturing industry.

Clean Energy executives recognized the cost to their businesses caused by inefficient transportation. One employer said, "Improving public transit would allow us to connect regionally, and would prevent wasting money on travel and transportation …traffic kills our productivity but we need better and more options for people to reliably get to and from work." MassCEC 2013

Figure 38: Transporting a Wind Turbine Blade over Highway

Transporting wind turbine components, due to their physical dimensions and weight, from the factory floor to the project site is a significant challenge for the wind industry. It involves handling sensitive and valuable components that can weigh up to 80 tons and be up to 145 feet in length. Such dimensions exceed standard truck trailer parameters, which carry 28 tons and are 53 feet long, and require closure to traffic of one side of an Interstate highway while it passes. Blade lengths are also expected to grow in the future, particularly for offshore wind projects, which further complicates road transportation.

As a result of these logistical issues and transportation costs, original equipment manufacturers (OEMs) often seek locations close to regions with valuable wind resources. In contrast, renewable energy component suppliers may be less constrained by resource areas or transportation infrastructure, but often require more engineering and machining production expertise. These suppliers are likely to be more interested in workforce characteristics, local government dynamics, overall operations costs, and incentive packages (NREL, 2010).

Transportation costs and issues have been a lesser concern for the solar energy manufacturing industry. This may change as the industry develops. Moving large volumes of glass can be challenging and manufacturers may ultimately decide to locate close to high-value markets to overcome this barrier. Nevertheless, the solar energy manufacturing industry, like the wind energy manufacturing sector, involves many component and material suppliers for which proximity to demand is less important. The solar energy industry prioritizes the ability to leverage existing assets, including R&D capabilities, as well as a skilled labor force and infrastructure with pre-existing silicon refining and production capacity[178] .

[178] NREL, Assessment of Offshore Wind Energy Resources for the United States, 2010

Public transit

While the highway and road network is highly important for large scale goods, freight and machinery movement to and from renewable energy manufacturing facilities, the MassCEC 2013 Clean Energy report emphasized that employers want more public transit options to make it easier for employees to travel to work without driving. One key reason cited in the report is that an effective transportation system can help to mitigate Greater Boston's high real estate prices in two key ways. First, it enables additional, lower-cost alternatives by providing access for people and goods to be connected to the marketplace. It also permits workers to commute from farther, lower cost areas, which allows for wage-growth containment as it less frequently needs to be linked to cost of living standards of Greater Boston[179].

Transportation Barriers

In the wind energy manufacturing sector, the blade and turbine transportation challenge is associated with the difficulty of transporting long wide loads around turns, through narrow passages, and beneath overhead obstructions on roads and railways. Thus, road weight limits and clearances, as well as bridge clearances and weight capacities, have the potential to limit the easy and efficient transportation of large-scale wind energy (and to a certain extent hydro energy) components and machinery.

Clustering

According to the Brookings Institution, clusters are a key organizational unit for understanding and improving the performance of regional economies. Firms cluster together within a region because each firm benefits from being located near other similar firms. The firms in a cluster have common competitive strengths and needs, and draw an advantage from their mutual proximity and connections. Consequentially, renewable energy manufacturers may look at the existing supply chain and ascertain which suppliers are present or absent in a region. These locational attributes are an important consideration for renewable energy firms looking to invest capital in a new location and are considered fundamental building blocks to establishing a successful enterprise.[180]

More detailed considerations

The National Renewable Energy Laboratory (NREL) has identified the following specific attributes that may also be attractive to renewable energy manufacturers when determining facility location:

- **Immediate local infrastructure:** A well-designed industrial park or existing facility may help finalize an individual firm's siting decision.

- **Business and government relations:** Courteous and transparent relations between government and business create a stable and clearly defined future, which is a vital business interest.

[179] MassCEC, *Massachusetts Clean Energy Industry Report*, 2013

[180] NREL, *State Clean Energy Policies Analysis (SCEPA): State Policy and the Pursuit of Renewable Energy Manufacturing*, Technical Report, February 2010

- **Quality of life variables:** Companies are often concerned with local public services (e.g., primary and secondary school systems), culture, and recreational opportunities. Such attributes are important when executives, management, staff, and families are expected to relocate.

- **Public investment in the broader community:** Public support for parks, recreation, and public spaces may be viewed as indicators of community values or local government values.

- **Community enthusiasm:** Company representatives sometimes mention community support for projects as drivers in the decision-making process. In addition, supportive communities may help simplify the permitting and approval processes, thereby reducing costs.

Potential Land Supply

Based on the location and siting considerations described above, locations suitable for renewable energy manufacturing have been defined as industrial and commercial districts that allow manufacturing by right or special permit. These districts have been mapped in the Northern Middlesex and Montachusett regions to determine the preferred locations for the siting of renewable energy manufacturing facilities. In addition, major transportation infrastructure, industrial parks, and road and bridge capacity restrictions are also mapped.

A more detailed analysis of potential sites at the local level would involve identifying several other factors associated with providing a realistic opportunity to construct a renewable energy manufacturing facility, site readiness, as well as the more specific transportation requirements. The analysis might include:

- Within the zoning districts, identification of zones that allow manufacturing by right.

- Identification of available vacant and developable land that can accommodate a facility or facilities of 50,000 square feet or larger in the aggregate. Due to the scale of products being manufactured, renewable energy manufacturers often require large floor space areas and high ceilings. As was seen at American Superconductor in Devens, the facility has a floor area of 345,000 square feet. A rule of thumb that could be used for this assessment is the Green Communities Criterion 1 guidance, which includes determining if there is enough available land or vacant space in existing buildings to provide for a facility at least 50,000 square feet or larger. To undertake this assessment basic yield calculations considering height, floor area ratio, setback, parking, and other limits on building size can be undertaken to determine available land for new renewable energy manufacturing facilities.

- Locations within 2.5 miles of entries, exits or stations associated with major transportation routes (major roadways, highways and active freight and rail lines).

a. Available land in the Northern Middlesex Region

See map in Appendix J.5.a

b. Available land in the Montachusett Region

See map in Appendix J.5.b

Education and Workforce Development

Many renewable energy manufacturers also seek out locations with a highly educated and skilled workforce. As renewable energy manufacturing is a relatively new industry, a highly trained workforce with renewable energy technology-specific knowledge and skills is required. This workforce is needed to support innovative, large-scale manufacturing facilities that can produce renewable energy products that are required now and into the future. As such, some regions may be overlooked because of workforce skill deficiencies.[181] States and regions with a highly skilled manufacturing workforce are likely to have an advantage in attracting new renewable energy manufacturing investment. Available training programs at public and private universities, colleges, and other educational facilities throughout the region, coupled with the ability to develop new training programs, as the need arises, are key considerations.

In the Montachusett and Northern Middlesex regions, energy-related training is provided at a number of universities, colleges, technical schools and organizations, including UMass Lowell, Fitchburg State University, and Middlesex and Mount Wachusett Community Colleges. These programs are summarized in Appendix J.6. In order to capitalize on the growth of renewable energy, the Montachusett and Northern Middlesex regions need to ensure that the existing manufacturing workforce is ready to adapt to this industry. This will be possible through enhanced communication and partnerships with educational institutions and the Workforce Development Boards.

In addition, MassCEC's Workforce Capacity Building program provides funding for renewable energy-centered science, technology, engineering and math (STEM) for students throughout the state. The initiative targets Massachusetts vocational-technical high schools, colleges, universities and community-based non-profit groups to help train students for careers in the rapidly-growing clean energy sector. Programs funded under this program aim to boost the number of high school graduates pursuing STEM majors in college and include curriculum and course development, professional development, internship and apprenticeship programs, hands-on instruction training and dual enrollment programs, in which high school students are able to take college courses.

Additional information on the workforce development and training programs in the Northern Middlesex and Montachusett regions are included in Appendix J.6. Potential careers in renewable energy are highlighted in Appendices J.7.a – J.7.e.

[181] Ibid.

Regional Potential

The renewable energy industry provides economic development opportunities for regions and local communities. The direct economic benefits of renewable energy include the creation of jobs in construction and operation of new facilities, payments to the state and localities, payments for fuel and land leases, and in-state purchase of materials and services.

In order to gain an understanding of the potential in the Northern Middlesex and Montachusett regions to attract renewable energy manufacturing, a self-assessment of the regions' strengths, weaknesses, opportunities, and threats (SWOT) has been undertaken. There is benefit from evaluating the region's strengths and examining its abilities to meet the needs of renewable energy industries.

a. Strengths

- Both the Northern Middlesex and Montachusett regions possess a highly educated workforce.
- High-tech manufacturing expertise, which can meet the needs for engineers, manufacturing technicians, and design professionals, that are required in the renewable energy manufacturing sector (Northeast Energy Sector Partnership)
- There is a relatively large cluster of solar energy manufacturing firms in both regions, a small cluster of hydro manufacturing industries in each region and a small cluster associated with the wind energy industry in the Montachusett region.
- Both regions have a history of manufacturing and an existing manufacturing base that could be diversified to support emerging renewable energy industries.
- The Montachusett and Northern Middlesex regions have good quality road and rail infrastructure.
- The Northern Middlesex region is home to the UMass Lowell Wind Energy Research Group and is close to the MassCEC Wind Technology Testing Center (WTTC) in Charlestown.
- Both regions are recognized for their high quality of life and attractiveness.

Several state workforce training grants have been awarded to firms in the Montachusett and Northern Middlesex Region. In 2013, the Executive Office of Labor and Workforce Development's Workforce Training Fund awarded grants to two renewable energy manufacturers in the region. Entegris Inc., of Billerica, was a recipient of a $128,000 to train 55 employees (in collaboration with Middlesex Community College) and hire five new workers. Ranor, Inc Westminster was awarded $73,692 to train 140 employees and create five additional jobs.

- Both regions have four-year and two-year colleges (UMass Lowell, Fitchburg State University, Middlesex and Mount Wachusett Community Colleges), as well as technical and vocational schools (Montachusett Regional Vocational Technical School, Nashoba Valley Technical High School, Greater Lowell Technical High School, and Shawsheen Valley Technical High School).

- UMass Lowell has clean energy technical assets and expertise. The university provides 120 degree and certificate programs in a wide variety of fields, and works closely with employers engaged in manufacturing, plastics engineering, design and quality control through its Corporate Training Department. In addition, UMass Lowell has a growing wind energy research group and thus potential synergies, clustering and business development opportunities are possible[182].

- Fitchburg State University offers more than 30 undergraduate and 22 graduate programs, including an industrial technology program, with concentrations in energy management and manufacturing technology.

b. Weaknesses

- There is a lack of skilled workers in certain manufacturing sectors and in certain locations within the region.

- New industry with unknown future in region.

- Some towns have infrastructure limitations, such as lack of sewer, while other communities do not actively support manufacturing initiatives.

c. Opportunities

- Renewable energy manufacturing is a growing sector in the State, which builds upon the emphasis on green communities and sustainability in the region.

- Expanding renewable energy production in the region can broaden and diversify the regions' existing industrial base.

- Manufacturing jobs in the renewable energy industry are often well paid jobs. According to the Brookings Institution, the clean economy offers more opportunities and better pay for low- and middle-skilled workers than the national economy as a whole.

[182] The UMass Lowell Wind Energy Research Group (WERG) has expertise and capabilities to conduct research in the advancement of wind turbine science and systems. The group consists of thirteen interdisciplinary faculty members whose research focuses on wind turbine manufacturing, reliability, energy storage, and design.

- Partnerships with UMass Lowell, Fitchburg State University, Middlesex and Mount Wachusett Community Colleges and regional technical schools are readily available.

d. Threats (or Barriers)

- Loss of incentives and subsidies for renewable energy, and changing policies and programs at the federal and state levels may limit future renewable energy development opportunities.
- Market demand for renewable energy manufacturing is unknown over long term and manufacturing has cyclical history.
- Expanding and cheaper industrial markets in China and other foreign countries.

1. Recommendations

The Northern Middlesex Council of Governments and the Montachusett Regional Planning Commission are committed to facilitating the growth and expansion of the renewable energy manufacturing sector in their region. Having the right siting and planning policies in place, as well as economic and workforce development actions that support renewable energy manufacturing, will ensure the region is well positioned to capitalize on the potential of this emerging industry and attract and grow jobs associated with the renewable energy supply chain. The following recommendations are steps that NMCOG and MRPC can take to create the right conditions that make the region attractive for renewable energy manufacturers.

Siting and Planning

- Encourage local communities in the region to review their zoning bylaws and ordinances to consider introducing laboratory R&D, light manufacturing and manufacturing zones by right, in appropriate locations.
- For those communities without expedited permitting, encourage the introduction of expedited and streamlined permitting process for renewable energy manufacturing faculties. Cutting the timeline and paperwork for permitting at the municipal level would remove a barrier to renewable energy manufacturing growth.
- Encourage local communities in the region to consider waiving or reducing permit fees for renewable energy manufacturing as part of an incentives package.
- Work with local communities in the region to investigate the potential of establishing a comprehensive inventory of development-ready large industrial sites that could be utilized by renewable energy manufacturing facilities.

- Undertake a comprehensive assessment of road and bridge infrastructure to determine where limitations exist and what mitigation is needed to establish large scale renewable energy manufacturing in the region.

- Better understand the regional strengths through a detailed cluster analysis of the renewable energy industry, including the range of other industries associated with the energy sector, such as manufacturing, R&D, installation and maintenance. Identify ways to support the entire industry by attracting suppliers and manufacturers to locate in the region.

Attracting renewable energy manufacturers

- Ensure that the Northern Middlesex and Montachusett Comprehensive Economic Development Strategies (CEDS) prioritize renewable energy manufacturing.

- Assist municipalities through economic development activities and strategies to help determine if engaging in the renewable energy manufacturing supply chain is a good fit for their community, and if so, through which avenues.[183]

- Encourage municipalities to address renewable energy manufacturing in their comprehensive master plans.

- Work with economic development stakeholders and organizations to promote the Montachusett and Northern Middlesex regions as a friendly place for renewable energy manufacturing.

- Recognize the need to educate existing manufacturers and suppliers on the opportunities available in the renewable energy manufacturing supply chain and provide assistance to enter these markets.

- Work with economic development stakeholders to develop and grow the cluster of solar firms in the region seeking synergies with other nearby firms and research facilities.

- Assist interested communities to meet with renewable energy manufacturers in the region in order to establish a comprehensive understanding of their needs and to entice suppliers to locate in the region.

- Encourage interested communities to adopt incentive programs such as property tax credits for renewable energy manufacturers, like the Miami-Dade County, Florida example cited in Section 5(a) or offer other incentives to renewable energy facilities utilizing equipment and components made in the regions.

[183] U.S. Department of Energy, Spurring Local Economic Development with Clean Energy Investments: Lessons from the Field, November 2013

Education and workforce development

In order to capitalize on growth of the renewable energy sector locally, it is important to ensure the local workforce has the right skills to engage in this sector. As such, the Northern Middlesex Council of Governments and the Montachusett Regional Planning Commission should assist the Greater Lowell and North Central Workforce Investment Boards to:

- Enhance the amount and quality of science and math taken at the secondary level so that students are able to take advantage of both current and future employment in areas of occupational growth.
- Increase the amount of hands-on instruction related to renewable energy in the regions' vocational schools through closer partnerships with businesses and suppliers in the industry.
- The regions' community colleges should explore the development of manufacturing technician Associate Degree programs that meet the needs of companies and those workers seeking middle skill positions in the industry.
- Work with local education providers to ensure that renewable energy training curricula aligns with the workforce needs of the industry.
- Identify ways to market the regions' labor force, particularly in advanced manufacturing, to clean energy companies looking for a U.S.-based location to establish and conduct their manufacturing operations.
- Consider the development of on-the-job (OJT) training programs at the regions' critical Clean Energy manufacturing businesses to give potential workers the sector-specific work experience necessary to gaining employment in these growing middle-skill occupations.
- Work closely with companies in the sector to develop short-term training and OJT opportunities to transition experienced manufacturing workers to new opportunities in the Clean Energy industry.
- Continue to advocate for policies that support the development of a skilled regional workforce, particularly in the areas of engineering and manufacturing technicians.
- Work with unions providing training and apprenticeships in the critical Clean Energy trades to ensure that workers have the skills required in the fastest growing sectors of the Clean Energy economy.
- Work with economic development stakeholders to enhance connections between the region's small and medium sized manufacturing firms and emerging Clean Energy companies that will require manufacturing expertise as they come to scale.

(The above education and workforce development recommendations are from the Northeast Energy Sector Partnership's *Clean Energy Labor Market Blueprint*, 2012)