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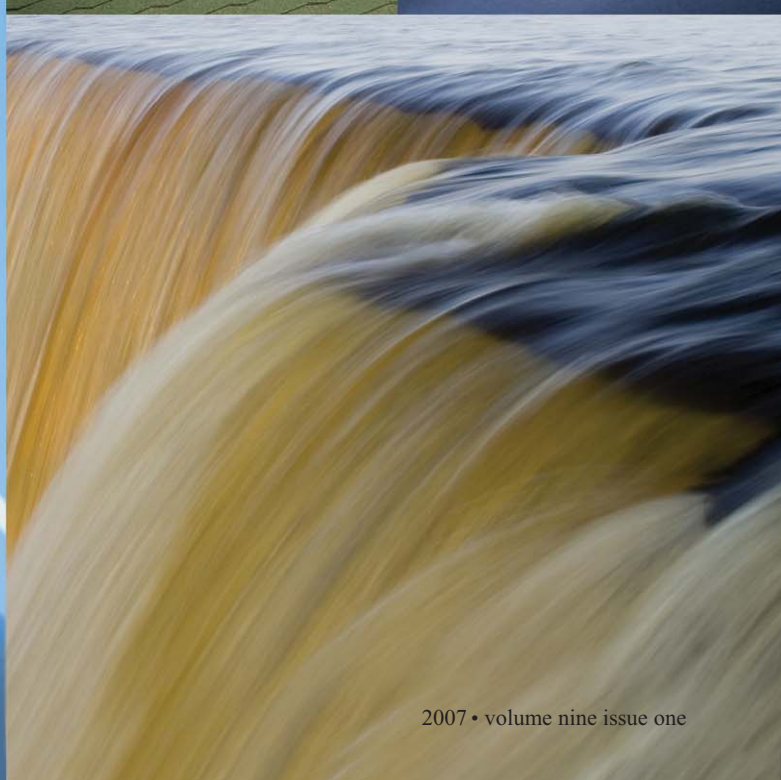


Clean Energy in Massachusetts

Already strong, this emerging sector is poised for greater growth

David L. Levy and David Terkla, University of Massachusetts Boston

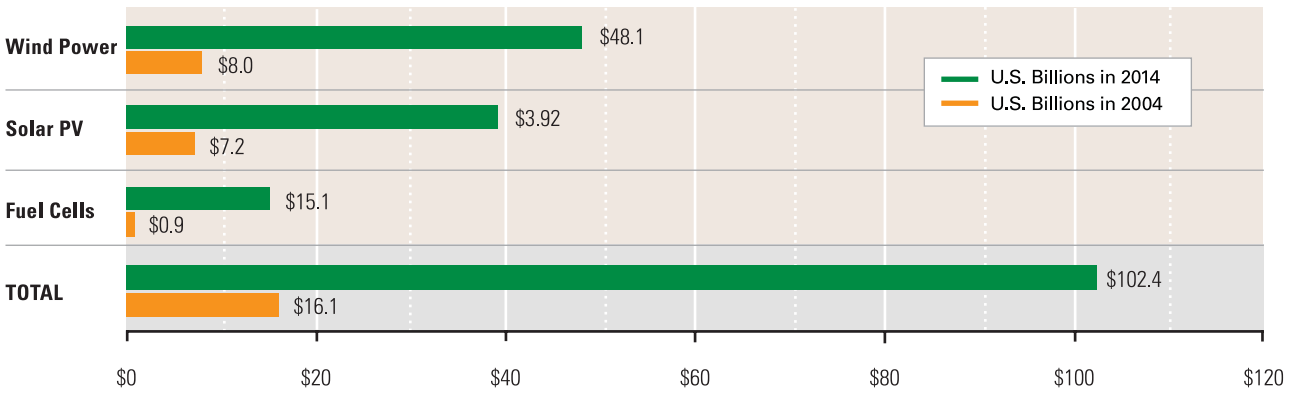
As renewable energy markets begin to develop rapidly around the world, few think about Massachusetts as a hub of such activity, except perhaps for the controversial proposal to develop a wind farm off Cape Cod. But in fact, Massachusetts has strengths in what we have identified as at least four sectors related to "clean energy" production, by which we mean the entire value chain of activities associated with clean energy. This chain runs from the raw inputs, such as photovoltaic (PV) cells and electronic control modules that are involved in the production of clean energy-related materials, to clean energy products themselves, such as solar panels and fuel cells, to the installation of these products[1]. The four major clean energy sectors in Massachusetts — renewable energy equipment and generation, power electronics, energy efficiency, and clean energy research — are in some way associated with the development, production, distribution or use of renewable and/or clean energy, or the reduction in use of "dirty" energy sources. Together, these sectors have a substantial impact on the Massachusetts economy, employing almost 11,000 people in approximately 400 firms (based on the most conservative estimates), while undergoing very rapid growth rates as the promotion of clean energy continues to expand nationally and worldwide.

This article reviews Massachusetts' clean energy sector in the context of the industry nationally and worldwide. We also suggest policy options to enhance the sector's potential for the Massachusetts economy.

Global markets for renewable energy are growing rapidly, creating opportunities not just for individual firms, but for regions with the appropriate resources and capabilities to develop sectoral clusters. Global markets for wind and solar photovoltaic power are growing at an annual rate of around 20 percent, and markets for associated electronics, materials, construction, and services will also experience rapid growth. The global market for energy efficiency products, currently estimated at $115 billion, is projected to grow more than $150 billion by the end of this decade (Makower, Pernick, & Wilder, 2005). Figure 1 offers one estimate of the expected market growth of three clean power technologies.

However, these markets are being driven more by public policy than by fundamental economics. Though the cost of wind energy is approaching that of conventional gas or

Figure 1. Clean Energy Projected Growth, 2004 – 2014
Global markets



Source: Makower et al., 2005

coal-fired power generation, other renewable energy sources are still significantly more expensive. Authorities at national and regional levels are encouraging these markets with substantial subsidies, incentives, and mandates in an effort to stimulate research and development as well as final demand (Center for Clean Air Policy, 2002; Loiter & Norberg-Bohm, 1999). Public policy is responding primarily to concerns about climate change due to emissions of greenhouse gases, local air quality issues, and the prospect of scarce and unreliable sources for fossil fuels. A growing awareness of the economic implications of attracting investment and employment in these rapidly growing sectors is also apparent in several individual U.S. states, which are seeking to position themselves as strong centers of activity in this area. Successful development of regional clean energy industrial clusters requires the presence of a critical mass of firms, suppliers, customers, labor skills, and research institutions. Policy makers have increasingly adopted an understanding of "regional competitiveness," in which local prosperity is linked to the ability to attract clusters of related high-value-added activities in sectors with rapid growth. Policy makers sometimes recognize that early action can yield long-term benefits due to the momentum of sectoral clusters (Bolinger & Wiser, 2001). A recent report on climate policies for California, for example, highlighted that a series of measures could achieve substantial reductions in greenhouse gas emissions while "increasing Gross State Product by about $60 billion and creating over 20,000 new jobs" (Farrell, Hanemann, & Roland-Holst, 2006).

Components of the clean energy cluster

Massachusetts is well positioned to participate in the growing global market for clean energy technologies, as it is host to the prerequisite cluster of specialized firms, skilled labor, research universities, sources of venture capital, and an enthusiastic community of environmental activists and entrepreneurs. Our study identified four clean energy sectors in which Massachusetts currently has a substantial presence. The first is the set of core renewable energy technologies, including wind power, solar photovoltaics, fuel cells, and biomass. Massachusetts also possesses significant strength and growth potential in the related though much less recognized clean energy sector of power electronics, which comprises a range of hardware and software technologies used to control, store, switch, and monitor power production and energy usage. A third major clean energy sector is the energy efficiency industry, which includes a broad range of goods and services, from architects and developers who help construct green buildings or retrofit existing ones to enhance energy efficiency, to the producers of components and materials required for energy efficiency enhancements. A final substantial component is "research enterprise" in Massachusetts, including universities, businesses, and non-profits that engage in energy research and consulting, which attract substantial grants and private capital.

Massachusetts already has developed a presence in the clean energy sector that is far greater than its relative share of the overall national population and/or economy. This is partially due to its early adoption of a set of policies that favor renewable energy and energy efficiency, but it is also due to the nature of the state's economy as one that specializes in cutting-edge technologies. But without a coordinated approach of supportive policies, regulatory initiatives, and investments and subsidies, Massachusetts risks falling behind other states and countries that also recognize the economic opportunities in clean energy.

Core renewable energy technologies

Massachusetts has a vibrant cluster of renewable energy companies, with many research-intensive companies, as well as some smaller manufacturing firms. Though the state's most substantial presence is in PV, Massachusetts is also home to significant manufacturing capacity for solar

cells, modules, and related industrial machinery. Many smaller companies specialize in sub-segments, such as solar battery combinations for off-grid power, research into low-cost and high-efficiency solar cells, and design and installation services. The development of PV is, however, constrained by the lack of a substantial local market.

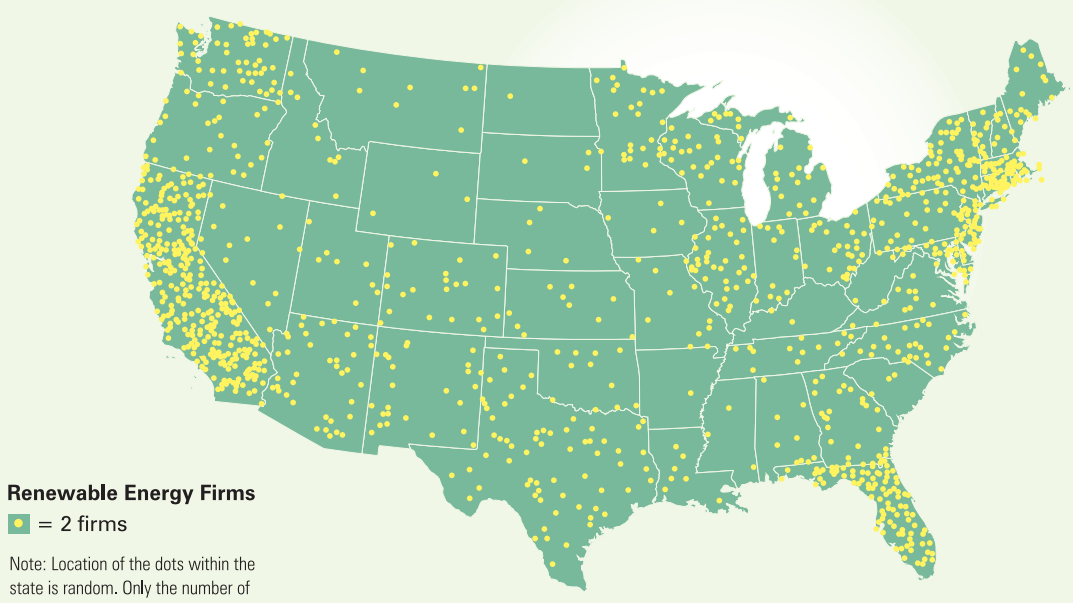
Massachusetts has little commercial presence in wind turbines, even though wind is currently the only cost-competitive renewable source of power for the grid and the fastest-growing source of electric power. The state does, however, have substantial offshore wind resources, which could stimulate elements of a local industry, and Massachusetts universities have significant and relevant research expertise. In fuel cells, Massachusetts is home to some smaller, research-oriented firms, though three of the top-tier fuel cell manufacturers are located in Connecticut and New York. Commercial activity in biomass and biofuels tends to be small and fragmented. Though Massachusetts has some research presence, there is little prospect for dramatic growth on the agricultural or processing side.

Figure 2, which shows the national distribution of renewable energy companies, demonstrates that Massachusetts is clearly in a strong position relative to its size[2]. The state ranks sixth in terms of number of companies and is part of a very strong regional cluster in the northeastern United States. The Commonwealth ranks sixth among the continental states in terms of renewable energy production, although most of this is hydroelectric power.

Power electronics technology sector

This sector encompasses a number of different industries, from firms that specialize in computer sensors and controls for building temperature environments to the components of renewable energy systems that control power and connect it to the grid or other applications. It includes electronics hardware and software firms that specialize in power switching equipment, inverters, advanced energy storage systems, and devices to modify, control, monitor, and connect power output from renewable energy sources. Power electronics, which constitutes an estimated 20 to 30 percent of the total value of renewable energy and energy efficiency systems, will benefit from the growth of clean energy usage around the world[3]. Massachusetts has traditionally been strong in these types of technologies —software, hardware, instrumentation, inverters and associated electronics — and can therefore expect to be a major supplier for national and global markets. With five small-to-medium size companies focusing on power electronics for clean energy, Massachusetts may already have the largest such concentration in the country. The state is also home to many power electronic companies for which clean energy applications represent only a small portion of their total sales. Many of these firms are producing products that could have much wider applications in the clean energy industry. However, these are currently escaping their attention because of lack of business linkages with firms in the clean energy sector.

Figure 2. Distribution of Renewable Energy Companies in the United States



Source: UMass Donahue Institute with data from: http://www.sourceguides.com/index.html

Energy efficiency sector

This sector covers firms involved in the construction of materials to enhance energy efficiency, installers of energy efficient components, and developers that coordinate the retrofitting of existing buildings to increase their energy efficiency or manage the "greening" of new buildings. It includes firms classified under construction, such as installers of environmental controls and building insulation, as well as manufacturers that produce insulating glass for windows. It also includes wholesalers and/or retailers who specialize in materials designed to increase energy efficiency. A final major component is the many engineering and consulting firms that specialize in energy conservation.

Although Massachusetts is not home to major suppliers of passive insulating materials, it has significant activity in design and installation, driven in part by various state programs to promote energy efficiency and green buildings. The state's strong presence in specialized electronics and devices, though classified for this study as power electronics, clearly benefits from more active energy efficiency systems that monitor and control lighting, heating, and cooling. Energy efficiency accounts for the lion's share of current employment in clean energy in Massachusetts, but is growing more slowly than core renewables.

Clean energy research

Massachusetts is very active in research that supports innovation in the clean energy sector, reflecting its broader position in industrial and university research. The state's research sector attracts substantial federal research and development funds, helps develop and refine technologies, provides a trained workforce, and engages in technology licensing and start-up activity. The research sector includes consulting and engineering firms that devote significant research to clean energy, major university research centers in fuel cells, solar energy and wind turbines, and contract research and development firms. MIT, for example, has a very substantial energy research program and UMass Lowell has a more specialized research program on wind energy. Many of the research and development firms are DOD, DOE and NASA contract winners and some are leading major technical consortia.

How big is the clean energy sector?

Because it comprises a range of new technologies and diverse firms in different industries, this is a very difficult sector to track through standard industrial classifications. Moreover, many of the sector's firms are either start-ups or in the process of merging, changing names or location, or in some cases failing. In addition, many firms become involved in the clean energy sector while still carrying on business in other more traditional sectors. All of this makes it difficult, if not impossible, to use existing datasets to identify firms that are in or are likely to become involved in clean energy.

Therefore, we cast a very wide net to identify firms in the clean energy sector. We then fine-tuned the selection process as we narrowed the relevant categories, using interviews with core firms in each sector, a written survey of firms in the industry, and two proprietary databases (D&B MarketPlace and Corptech). The end result of this process — details of which are available from the authors — is a list of 25 eight-digit sectors from the D&B MarketPlace database, which yielded 321 firms with total employment of 7,428. The Corptech database revealed an additional 70 firms employing 3,400, which we added to the D&B MarketPlace data to get our conservative estimate of total employment and total firms for the clean energy industry in Massachusetts. However, the Corptech data did not allow us to determine the disaggregated eight-digit sector codes of these additional firms.

The 25 industry sectors chosen from the D&B MarketPlace database to represent the clean energy industry in Massachusetts range from construction (e.g., solar energy contractors and energy management controls) to manufacturers of rubber and plastic (e.g., insulation materials), glass (e.g., insulating glass), fabricated metals (e.g., solar heaters and collectors), electronics (e.g., power switching equipment, inverters, fuel cells, and PV devices), and instruments (e.g., monitoring controls) to wholesalers and retail distributors (e.g., of energy conservation products), and engineers and consultants.

When combined with the Corptech data, almost 400 firms were in these sectors in 2003, employing almost 11,000 people and generating more than $3 billion in sales. We believe this estimate is quite conservative. We are unable to include some employment in power electronics that relates to clean energy because existing databases do not allow us to separate out employment that can be definitively identified as being largely devoted to clean energy. However, if just 10 percent of employment in this sector were involved in clean energy, that would represent an additional 2,300 jobs. Likewise, in some cases, we are unable to separate firms engaged in energy research and development from those involved in electrochemical research and development services. If 10 percent of those employed in this category were involved in clean energy research it would mean another 1,400 jobs, bringing total clean energy employment in the state to almost 15,000.

Table 1 shows the employment breakdown by sector using the data we were able to delineate in this fashion (only data from D&B MarketPlace allowed for this level of disaggregation). This accounts for a little less than 70 percent of the 11,000 jobs we identified in this sector.

Table 1. Number of Firms and Employment in the Clean Energy Sector, Massachusetts, 2003

Sector	Number of Firms	Employment
Renewable Energy Sector	51	899
Power Electronics	33	2,879
Energy Efficiency	225	2,098
Energy Research	12	1,552
TOTAL	321	7,428

Source: D&B MarketPlace and authors' calculations

Though Table I shows that most of the firms are in the energy efficiency sector, we believe this is a conservative estimate. For example, many small contractors that install and maintain energy efficiency-related materials are not included in this count because it is not possible to identify them. Though it has fewer firms, the power electronics sector is the largest sector in terms of employment. This is not surprising since this sector is made up of firms which, while involved to varying degrees with the clean energy industry, are also involved in the production of other products and services that are not necessarily clean energy-related.

To further check our findings on the sector's size, we developed a "top down" approach that relies on measures in the literature that associate spending on energy efficiency with job creation and that associate installation, maintenance, and manufacturing of clean energy equipment (as measured by megawatts of output) with the number of workers required to generate this output. We estimated total employment in the clean energy sector in Massachusetts using a spreadsheet model that projects employment for each sector based on current installed generation capacity, new installations, and the level of manufacturing and sales activity. This generated estimates of employment in 2003 and 2004 in the 10,000 to 11,000 range, which helps to validate our conservative estimates derived strictly from the proprietary databases (Levy & Terkla, 2004).

Massachusetts is home to a large group of firms in this sector relative to its size nationally. Table 2 shows that Massachusetts ranks eleventh nationally in terms of the number of businesses involved in the clean energy sector and third when weighted by state population[4]. More impressively, Table 3 shows that Massachusetts ranks seventh nationally in total employment in the clean energy industry.

A sector poised for growth — with need of cultivation

Total employment of between 10,000 to 15,000 in the Massachusetts clean energy cluster has the potential to grow to more than 20,000 within six years — if Massachusetts remains at the forefront in terms of both policy and technology in clean energy development (Levy & Terkla, 2004). Massachusetts is already a significant player nationally in the clean energy industry, ranking in the top ten in terms of total employment, despite the fact that the state has relatively few clean energy-producing installations. Clearly, Massachusetts has been able to use its comparative advantage in being on the cutting edge of new technologies through university and private sector collaborations to position itself as a key exporter of

Table 2. Top 15 states by Number of Businesses in the Clean Energy Sector

State	Number of Firms	State	Firms per one million people
California	1,064	Colorado	58
Texas	900	Wisconsin	46
Florida	563	Massachusetts	44
New York	447	Texas	41
Michigan	361	Washington	40
Pennsylvania	357	North Carolina	40
Ohio	353	Georgia	38
North Carolina	337	Michigan	36
Georgia	332	Florida	33
Illinois	328	New Jersey	32
Massachusetts	282	Ohio	31
New Jersey	275	California	30
Colorado	268	Pennsylvania	29
Wisconsin	253	Illinois	26
Washington	247	New York	23

Source: D&B MarketPlace; authors' calculations

Table 3. Top 15 States Ranked by Employment in the Clean Energy Sector

State	Total Employment
Texas	14,825
California	11,406
Illinois	10,618
New York	6,678
Tennessee	6,473
North Carolina	6,282
Massachusetts	6,277
Florida	6,021
Ohio	4,156
Wisconsin	3,947
Michigan	3,410
Georgia	3,312
New Jersey	3,176
Virginia	3,175
Minnesota	3,098

Source: D&B MarketPlace; authors' calculations

clean energy materials as well as moving forward in terms of advancement of energy-efficient buildings and technologies.

Despite this strength, there is little reason for complacency. Many research-intensive companies, as well as some smaller manufacturing companies, are located in the state, but Massachusetts is not currently home for any of the top four or five largest manufacturers in any clean energy sector. And other states and countries are investing substantial resources to build the demand for renewable energy and to develop business infrastructures. If Massachusetts wants to sustain and expand its presence in the rapidly growing clean energy industry and to reap the benefits of growing employment and investment, it must also invest in the industry as it continues its transition toward full commercialization.

Growing the Clean Energy Cluster

No single clean energy sector is likely to produce both large quantities of new energy grid power and significant additional employment for the state, at least over the next decade. Wind power is likely to generate most of the power, while fuel cells and solar PV have the potential to generate more employment. As a result, assistance cannot be focused on a single sector, but needs to be directed toward encouraging the clean energy cluster, recognizing cross-sectoral linkages and existing strengths, and providing:

- equity funding for clean energy firms
- targeted installation subsidies
- regulatory reform to smooth approval processes in order to encourage distributed generation
- pricing mechanisms that monetize benefits of avoided pollution from the use of clean energy
- support for sector-level organizations in power electronics and clean energy research in order to encourage greater product linkages and innovative joint ventures
- a broader state renewable portfolio standard to include a wider array of clean energy sources and more stringent standards
- venues for bringing together university energy researchers, renewable energy firms, and supporting supply chain firms (such as power electronics) to accelerate the development of this renewable energy cluster in Massachusetts.

David L. Levy is a professor of management and marketing at the University of Massachusetts Boston.

David Terkla is a professor of economics, and environmental, earth and ocean sciences at the University of Massachusetts Boston.

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ENDNOTES

1. Fuel cells are clean and highly efficient, but are not strictly 'renewable', since they require fuels, such as natural gas or hydrogen. However, these fuels can be derived from renewable sources, such as landfills.

2. Data for the map and this ranking are from the University of Massachusetts Donahue Institute and are based on the Sourceguides database (www.sourceguides.com), a reasonably comprehensive list of vendors that includes smaller retail, service, and consulting firms. The dots represent the number of firms listed in each state and are distributed randomly within the state, rather than representing the actual location of each firm.

3. Information from personal interview.

4. These numbers are derived from D&B MarketPlace using twenty-five industry codes identified.