Clean Energy Manufacturing in Michigan

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Apollo Alliance

Clean Energy Manufacturing Project

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1. Introduction

The purpose of this memorandum is to provide an overview of clean energy manufacturing activities in Michigan. Over the past decade, backed by significant state and federal initiatives and resources, Michigan has emerged as one of the premier centers of clean energy manufacturing (CEM) in the United States. As noted below, the substantial growth of Michigan's CEM industries has been built on the strengths of Michigan's powerful manufacturing sector (especially its automotive, metal fabrication, and machinery industries) and advanced technological capabilities, its highly skilled, experienced workforce, top-rated academic institutions, and rich natural resource endowment. Michigan excels in particular, in four major CEM sectors, which are featured in the review below—advanced energy storage (advanced batteries), wind energy, solar energy, and biofuels.

2. Michigan's Manufacturing Base

Efforts to grow a CEM sector in Michigan needs to be viewed against the backdrop of the erosion in Michigan's manufacturing base. This trend parallels the decline in overall manufacturing capacity in the United States, especially over the past decade—a trend made much worse by the major recession and financial crisis of 2008 and 2009. Some have touted CEM as a means to help revitalize Michigan's manufacturing industries, which is crucial to any long-term, sustainable recovery in the state's economy as a whole. At the same time, Michigan's substantial manufacturing capabilities, rooted in its automotive, fabricated metal products and machinery manufacturing industries, provides a foundation for building a strong, competitive CEM sector in the state.

As the center of America's automotive industry over the last century, Michigan has long been considered one the nation's most important manufacturing states. In 2009, it ranked ninth among the states in manufacturing real gross domestic product (GDP)[1]—i.e., manufacturing's real dollar contribution to a state's gross domestic (or gross state) product—and in 2010, it had the sixth largest manufacturing workforce in the country (473.8 thousand employees).[2]

However, because of the troubles in its automotive industry, the steady offshoring of production facilities, and recent economic crisis, Michigan's manufacturing sector shrank substantially over the last decade, in terms of real GDP contribution and employment. It ranked fourth among states in real manufacturing GDP in 1999—topped only by California, Texas and Ohio—but fell by a third, from $69.83 billion

[1] Source: Bureau of Ecoomic Analysis (BEA) (www.bea.gov). California, Texas, North Carolina, Ohio top the list, followed by Illinois, Pennsylvania, Indiana, and New York. Wisconsin rounds out the 10 ten.

[2] Source: U.S. Department of Labor, Bureau of Labor Statistics (BLS) (http://www.bls.gov/data/#employment).

(chained 2005 dollars) to $46,959 by 2009. However, the largest portion of this decline occurred between 2008 and 2009—Michigan's real manufacturing GDP fell by 26 percent in this period.[3]

Similarly, Michigan's manufacturing sector employed slightly under 900,000 workers in 1999—nearly twice the number of workers employed (474,400) in 2010. Its workforce shrank by a little over one-third between 1999 and 2008, and by another fifth between 2008-2009.[4] It also lost nearly 4,000 manufacturing facilities of all sizes between 2001 and 2010, ultimately losing one-fifth of its plants.[5]

Manufacturing nevertheless remains the largest sector in Michigan's economy, accounting for 14 percent of the state's overall GDP in 2009. Real estate and rental and leasing is the second largest industry(13.2 percent), government is third(13.5 percent), followed by health care and social assistance (9.1 percent) and professional and technical services (7.8 percent). The recession and financial crisis caused the state's overall real GDP to decline by 7.3 percent in 2009. Manufacturing, especially durable goods manufacturing led that decline—the latter fell by 29.2 percent, and was responsible for 4.3 percent of the state's overall real GDP loss, while professional and technical services fell by 10.3 percent, accounting for 0.8 percent of the overall decline.[6]

Michigan's durable goods industries. Durable goods account for three quarter of the state's real manufacturing GDP, while nondurable goods account for the remainder. Durable goods real GDP actually grew slightly, by 1.1 percent between 1998-2008, while non-durable goods real GDP fell by 17.3 percent. However, durable goods led the decline in overall manufacturing real GDP in 2009, dropping by 29.2 percent—nondurables also declined, by 14.1 percent.

Motor vehicle, body, trailer and parts manufacturing is by far the largest manufacturing industry, contributing $26.4 billion or 41.3 percent of real manufacturing GDP in Michigan in 2008. The fabricated metal product, machinery and food product manufacturing are the next largest sectors, accounting for 9.1 percent, 8.4 percent, and 7.9 percent respectively. Although the motor vehicles industry's real GDP grew by 6.3 percent between 1998-2008—and food production real GDP grew by 14.2 percent—the fabricated metal products and machinery manufacturing industries suffered substantial losses in this period; the former's real GDP fell by 12.5 percent and the latter's dropped by 23.1 percent.[7]

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[3] Source: BEA.

[4] Source: BLS.

[5] Source: Quarterly Census of Employment & Wages (QCEW), BLS.

[6] Source: BEA.

[7] Ibid.

Durable goods industries, in particular, transportation equipment, fabricated metal products and machinery manufacturing industries—and their largest subsectors—all suffered significant employment losses even before the recession and financial crisis took an additional toll. They remain the largest employing industries within Michigan's manufacturing sector—transportation equipment (primarily motor vehicle and motor vehicle parts manufacturing) accounted for 27.6 percent of manufacturing jobs in the state in 2010, fabricated metal product manufacturing (including machine shops, turned products, screw, nut and bolt manufacturing) accounted for 13.6 percent, and machinery manufacturing (including metalworking machinery) for 11.6 percent. They also are the industries that are most relevant to CEM, though the foundries, computer and electronic production, chemical manufacturing sectors also are important suppliers of materials, components, and equipment to CEM.

3. Clean Energy Manufacturing in Michigan

Recent evidence, however, suggests a potentially more optimistic future for Michigan's economy. A Reuters article reports that a recent Gallup survey of state job markets shows that Michigan ranks first in the nation for job creation improvement. It also cites a University of Michigan report that projects job gains and significantly reduced unemployment. It currently anticipates that Michigan will add 64,600 jobs in 2011 and 61,500 more in 2012, which in part reflects a bounce in manufacturing.[8]

Expansion of the CEM sector and renewable energy generation in the state is thought to be a driver of this growth. Some claim clean energy manufacturing and technology is the fastest growing segments of Michigan's economy.[9] According to a 2009 Michigan Department of Energy, Labor & Economic Growth (DELEG) report, Michigan already has nearly 110,000 total "green" jobs, both direct and support positions, in the private sector. Although this only represents 3 percent of the state's overall private sector employment, the report argues that it shows the potential for growth of the green economy.[10]

This number includes jobs associated with renewable energy production, energy efficiency, pollution prevention and environmental cleanup, and agriculture and natural resource conservation, as well as jobs tied to the manufacture of clean energy products and equipment. According to the report, production occupations account for 28 percent of the green jobs and engineering occupations for 24 percent.

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[8] Maria Gallucci, "Job Boom in Michigan, as Clean Energy Manufacturing Drives Economic Recovery." Reuters (www.reutersreprints.com). 6 April, 2011.

[9] Skip Pruss, "Clean Energy: The Business Case." Lansing, MI: 5 Lakes Energy. Unpublished paper.

[10] Michigan Department of Energy, Labor & Economic Growth (DELEG), Bureau of Labor Market Information & Strategic Initiatives. *Michigan Green Jobs Report 2009, Occupations & Employment in the New Green Economy.* Detroit, MI, May 2009, 4.

This includes transportation equipment manufacturing with 25,700 jobs and professional, scientific and technical services, with 22,178 jobs.[11]

As these job numbers suggest, CEM growth is tied to the demand for clean energy sources (i.e., clean energy production), including electricity generated by clean energy products (solar, wind). Although Michigan has adopted a number of policies aimed at ramping up both clean energy production and CEM in the state, renewable energy still supplies only a small fraction of the state's energy consumption. For example, renewables account for only 3.4 percent of net electricity generation in the state (2008). Of this, hydroelectric provides a 1.2 percent of net generation, wood/wood waste provides 1.5 percent, municipal solid waste biogenic/landfill gas supplies 0.6 percent, wind supplies 0.1 percent, and solar generation is miniscule in the state.[12]

Given the current political environment and the failure of Congress to pass a comprehensive cap-and-trade bill in the last Congress, the potential for greatly expanding clean energy production in the state remains uncertain. Nevertheless, supporters of clean energy believe that Michigan has an opportunity to become a leader in clean energy manufacturing building on its considerable manufacturing and technological capacity, especially in its transportation equipment manufacturing sector.

Michigan's Manufacturing Strengths. Clean energy manufacturing entails the utilization of advanced materials and machining capabilities, which require a high level of education and technical skills. Advanced batteries, wind turbines and solar panels together require thousands of components, which need to be designed, manufactured, distributed, sold, deployed, installed and serviced by a skilled, well-trained workforce. [13]

Michigan's industries have world-class capabilities employing advanced and cost-competitive manufacturing practices, integrated supply chains and a workforce that is one of the most highly-trained skilled in the world. It also has very substantial engineering and technology innovation capabilities. Aside from established strengths in advanced manufacturing, robotics, engineering, and materials science, Michigan leads the nation in industrial R&D investment, has more than 65,000 engineers, specialists, and technicians, and is home to more than 330 automotive R&D facilities. It also has top-notch academic research and educational institutions—the University of Michigan ranks 2nd in the nation for R&D spending, and the state is 4th in the number of engineering graduates.[14]

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[11] DELEG, *Michigan Green Jobs Report,* 5.

[12] Source: U.S. Department of Energy (DOE), Energy Information Administration (EIA). *State Renewable Electricity Profiles 2008*, release date August 2011. (http://www.eia.doe.gov/state).

[13] Pruss, "Clean Energy: Business Case."

[14] Michigan.Gov Energy (http://www.michigan.gov/energy#).

As a result, Michigan appears well-poised to build upon and extend its existing manufacturing and technological prowess to grow a large, competitive clean energy manufacturing sector to provide next generation energy technologies for domestic and international markets.[15] According to an assessment by Clean Edge, Inc., a research and advisory firm devoted to the clean-tech sector, Michigan is among the states leading "the charge in driving clean-energy innovation and advancing the clean-energy economy."[16] For example, although Michigan ranks seventh overall in the number of patents awarded, it is first in clean-energy patents, which in part reflects its focus on electric vehicle and automotive battery technologies.[17]

Investment and Policy Support. Recognizing this potential, and the opportunities, that clean energy presents to help revive the state's eroding manufacturing capacity, Michigan's political leaders had begun initiatives earlier in the last decade to encourage and support investments in clean energy production and manufacturing. Former Governor Jennifer M. Granholm, whose second term ended in January 2011, began clean energy initiatives early in her administration with a $2 billion 21st Century Jobs Fund, setting up a 10-year program starting in 2005 to encourage venture capital investments and R&D funding for 1,500 startups or existing firms seeking to transfer their skills to the emerging "cleantech" industry.

Two years later, Granholm signed the state's renewable portfolio standard that requires utilities to get 10 percent of their electricity supply from clean energy generation, renewable energy credits and energy efficiency programs by 2015.[18] This is one of several pieces of legislation that was passed and signed during Granholm's administration, aimed at promoting clean energy production and manufacturing. For example, Michigan has undertaken a wide array of clean energy programs, including tax-exempt zones for R&D and manufacturing facilities, business accelerators for cleantech startups, clean energy training grants, and business tax credits for alternative energy businesses.[19] In 2008, SB 1380/PA 175 was signed into law, authorizing the Centers of Energy Excellence (COEE) program, a $45 million grant program to help deliver, grow and sustain alternative energy clusters, involving partnerships between the private sector, universities, and government to commercialize innovative energy technologies, with the potential for significant economic impact, and to leverage federal dollars.[20]

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[15] Pruss, "Clean Energy: Business Case."

[16] Clean Edge, "California, Oregon, and Massachusetts Lead List of Top 10 Clean-Energy States." *BusinessWire*. 7 December, 2010. (http://www.businesswire.com/news/home/20101207005888/en/California-Oregon-Massachusetts-Lead-List-Top-10).

[17] Ibid.

[18] Galluci, "Job Boom in Michigan."

[19] Galluci, "Job Boom in Michigan."

[20] Michigan Economic Development Corporation (MEDC). *Michigan New Market Development Overview, Centers of Energy Excellence.* PowerPoint Slide Show. February 10, 2010. (MichiganAdvantage.org.). Six centers received awards in 2008.

The state policy initiatives, as well as targeted support for clean energy by the federal American Recovery and Reinvestment Act (ARRA), appear to have had a real measure of success in spurring significant investment in clean energy in the state, including for CEM. In an interview, Granholm stated that she expects Michigan businesses to create more than 150,000 clean energy jobs in the next decade from $14 billion of projects in the pipeline. In particular, jobs will be created from the 17 advanced battery companies and nearly 50 solar, wind, and biofuels companies that have come to Michigan from August 2009 to December 2010, lured by state tax credits and federal stimulus grants.[21]

Federal stimulus investments have helped to amplify the state efforts begun under Granholm to grow a clean energy sector in Michigan. The ARRA has given out over 5,000 awards, worth 33.4 billion, to a very large array of clean energy projects in every state in the nation, the District of Columbia, Puerto Rico, and the U.S. territories.[22] Michigan has been awarded $1.5 billion from these funds, for a total of 138 clean energy projects. Nearly 60 percent of these awards, $0.87 billion, have been awarded to a total of 27 CEM-related and CEM-related R&D projects. The CEM awards went to battery, biofuels, transportation electrification, and PV systems development projects. In addition, Michigan firms received a minimum of $237.4 million in ARRA Section 48C advanced manufacturing tax credits, primarily for clean energy manufacturing (batteries, solar and wind) projects. A total of $2.3 billion of 48C tax credits went to over 180 companies around the nation for CEM.[23]

Michigan's CEM Industries. As 5 Lakes Energy principal Skip Pruss summarizes, there has been a total of $10 billion in capital investment in production infrastructure for new wind energy production ($270 million), solar ($4.1 billion) and advanced energy storage systems ($6 billion). This is "creating whole new sectors in Michigan's economy and establishing Michigan as a leader in clean energy technology manufacturing."[24] Others similarly claim that Michigan becoming a "global hub" for clean energy technologies, based on a " new manufacturing base" built on the expertise of state's auto industry, thereby generating thousands of clean energy jobs.[25]

The evidence in fact does indicate that extensive state and federal efforts to stimulate clean energy growth appear to have generated substantial manufacturing activity in the state devoted to electric vehicles and advanced battery development

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[21] Galluci, "Job Boom in Michigan."

[22] Of this, $13.7 billion or 41 percent of the grants so far have actually spent by the awardees. However, all $33.4 billion has been awarded to private sector firms, local and state governments, universities and other entities. U.S. Department of Energy (DOE). *Energy.gov/List of Awardees*. Excel database. April 15, 2011.

[23] Source: U.S. Department of Energy (DOE). *Selection for Section 48C Manufacturing Tax Credit.* Excel database. January 13, 2011. Michigan had 11 known projects, accounting for one in ten contracts that are known to have gone to Michigan firms. A total of 183 projects have received these tax credit, but only 140, receiving three-quarters of the total tax credits granted, had information about the grantees' location.

[24] Pruss, "Clean Energy: Business Case."

[25] Galluci, "Job Boom in Michigan."

and biofuel technologies—both tied to automotive industries—as well as windpower parts and solar panels. Whether this growth is sustainable in the face of little or no new federal support—which currently appears likely—remains to be seen. What state policies and new legislation might help strengthen and maintain the growth of these four key CEM sector is beyond the scope of this paper. But as these industries are still in early stages of development, some state and federal support is likely to be needed to bring these them into maturity.

- **Michigan's Advanced Energy Storage Industry—**Advanced energy storage (AES), in particular, lithium-ion batteries, is a key technology that the United States will need to be a major player in if it is to compete in the future auto industry, according to a Duke University study (2010).[26] The shift to hybrid-electric (HEVs), plug-in hybrid electric (PHEVs) and all-electric vehicles (EVs) will eventually depend on cost-competitive, advanced lithium-ion batteries, requiring additional technological advances before they can be applied widely to future electric vehicles. Today, almost all hybrids in the world market run on nickel metal hydride batteries. But within 10 years, 70 percent of hybrids and 100 percent of PHEVs and EVs will be expected to run on lithium-ion batteries, according Duke. [27]

The ARRA is credited for jumpstarting the U.S. industry from only two battery pack plants to 30 planned sites, all key parts of the value chain, including materials, components, and the production of cells and battery packs. As a result, the United States appears to be on track to achieve a 40 percent share of global capacity to produce lithium-ion batteries for vehicles by 2015.[28]

Michigan's manufacturing activity in AES. The Duke study identifies several advantages that U.S. firms have in lithium-ion batteries, that apply especially well to Michigan manufacturers. These include research capacity, a well-established domestic automotive industry, a large market for vehicles, and the support of government policies. To date, the Duke study reports, there are 50 U.S.-based firms, with 119 locations in 27 states, performing manufacturing and R&D on lithium-ion batteries. California and Michigan have the greatest activity, with 28 and 13 sites respectively.[29]

With the help of both federal and state programs, Michigan, in particular, has become the North American center for the development and commercialization of AES systems with 16 companies establishing research and production facilities in the state. These companies are developing the next generation of energy storage technologies for electric drivetrains and commercial and stationary energy storage

[26] Marcy Lowe, Saori Tokuoka, Tali Trigg and Gary Gereffi. Lithium-ion Batteries for Electric Vehicles: The U.S. Value Chain. Center on Globalization, Governance & Competitiveness, Duke University. October 5, 2010 (Rev. Nov. 4, 2010).

[27] Ibid.

[28] Ibid.

[29] Ibid. Other geographic areas of concentration include the Northeast Atlantic (9 sites), Greater Chicago area (8 sites) and the Carolinas (7 site).

applications.[30] In addition, nine of the top ten automotive OEMS developing HEVs, PHEVs, and EVs are located in Michigan. It has been estimated that the production of electric vehicles and AES systems will create more than 60,000 new jobs in Michigan over next decade.[31]

According to the Michigan Economic Development Corporation (MEDC), Michigan's AES ecosystem includes:

- six firms involved in powertrain integration and vehicle assembly;
- two companies making electric motors/power electronics/subsystems;
- eleven companies involved in cell/pack manufacturing, four producing battery materials and components, one charging station/infrastructure firm;
- nine engineering, R&D and testing companies;
- six companies making automation, manufacturing, and text equipment; and
- one recycling outfit.

These AES facilities are clustered in a half dozen areas of the state. The largest concentrations are in Wayne, Macomb and Oakland counties.[32]

State and federal investments. Both state and federal programs have been key to Michigan's growth and potential to become a world leader in AES technologies. Stimulated by these programs, since November 2008, Michigan businesses have announced $6 billion in investments in the advanced battery industry.[33] A MEDC review of the new market opportunities for clean energy products, summarizes the federal and state investments in Michigan's AES industry:

- The Michigan Advanced Battery Credits program (created by HB 6611/PA 580 and signed into law in 2009), provided a total of $1 billion in refundable credits on the Michigan Business Tax—this includes $255 million of credits for pack manufacturing, $135 million for vehicle engineering, $30 million for advanced battery technologies engineering, and $600 million for cell manufacturing, which supports up to a 50 percent capital investment for a cell manufacturing facility. Recipients of these credits include companies such as GM, Ford, Chrysler, JCS, A123 Systems, Xtreme Power, fortu Power, and LGCHem, among others.[34]
- Michigan's Centers of Energy Excellence (COEE) program has provided $10 million to A123 Systems, Inc. to establish a center focused on the manufacture of rechargeable lithium batteries and $3 million to Sakti3 for developing thin film

[30] "Michigan Energy Storage & Advanced Energy Systems." The Michigan Advantage. Michigan Economic Development Corporation. http://michiganadvantage.org/Targeted-Initiatives/Advanced-energy-Storage/Default.aspx]

[31] MichiganAdvantage.org. "Growth Industries, Advanced Energy Storage Systems."

[32] MEDC. *Advanced Energy Storage Ecosystem.* (www.MichiganAdvantage.org). January 2011.

[33] MichiganAdvantage.org. "Growth Industries, Advanced Energy Storage Systems."

[34] MEDC. *Michigan New Market Development.*

battery technology for next generation electric vehicles, using an advanced manufacturing process with the aim to manufacture batteries in Michigan.[35]

- In 2009, the DOE gave $2.4 billion in ARRA grants to spur domestic development of new battery technology, advanced power trains and vehicle platforms around the United States. Michigan received $1.36 billion in Aug 2010, for 12 Michigan projects on advanced-battery and EV manufacturing and development—this is more than every other state combined. MEDC has estimated that these initiatives will create 6,800 jobs by 2011 and up to 40,000 jobs by 2020.[36] Major examples of ARRA Advanced Battery Manufacturing awards in Michigan include:[37]
  - Johnson Controls, Inc. Holland—$299.2 million to build domestic manufacturing capacity for advanced batteries for hybrid and electric vehicles.
  - A123 Systems, Inc. Romulus—$249.1 million to expand the company's global final cell assembly capacity to over 360 MW hours.
  - KD ABG MI, LLC, Midland—$161 million to establish manufacturing operations and to produce affordable advanced superior lithium polymer battery (SLPB) technology for the hybrid and electric vehicle markets.
  - Compact Power, Inc. (on behalf of LG Chem, Ltd.), St. Clare—$151.4 million for production of lithium-ion polymer batter cells for the GM volt.
  - General Motors, Brownstown—$105.7 million for its Battery Pack Assembly Plant, which will become the first high-volume advanced-batter manufacturing facility of its kind in the nation.
  - Ford Motor Company, Dearborn—$62.7 million to support their manufacturing facility for integrated EDV transaxle.

- **Michigan's Wind Energy Technology Industry—**U.S. firms have capabilities in each sector of the wind power value chain, from materials production and component manufacturing to project development and construction.[38] With its engineering expertise and modern machining capacity, Michigan in particular has the potential to become a regional and global powerhouse in wind turbine manufacturing.[39]

There are over 8,000 precision parts in a single wind turbine, ranging from the steel tower and high-tech composites for blades, to gearboxes, bearings, electrical wiring,

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[35] Ibid.

[36] Michigan.Gov Energy (http://www.michigan.gov/energy#).

[37] Department of Energy, Recovery Act State Memos, Michigan. Washington, DCm, June 1, 2010. (www.energypowers.gov/Michigan).

[38] Gloria Ayee, Marcy Lowe and Gary Gereffi. *Wind Power: Generating Electricity and Employment.* In *Manufacturing Climate Solutions, Carbon-Reducing Technologies and U.S. Jobs.* Chapter 11. Center on Globalization, Governance & Competitiveness, Duke University. September 22, 2009: 10.

[39] DELEG, *Michigan Green Jobs Report.*

and power electronics.[40] Depending on the size of the turbine, each windmill consists of between 10 and 20 tons of ductile iron castings.[41] The supply needs of the wind industry include gearboxes, bearings, turbine generators, fabricated parts, power transmission devices, and electrical equipment.

The components and manufacturing needs for producing wind turbines plays especially well to Michigan's manufacturing strengths. These include industries such as fabricated metal products, machinery manufacturing, and foundries, among others. Many of Michigan's auto parts companies, in particular, are capable of converting to wind component manufacturing, though primarily for small-scale wind projects.[42]

So far, however, European companies have dominated wind turbine and component manufacturing, as the technology is mature in Europe. But as competition in the wind industry has increased globally, the United States, which in 2008 became the world leader in total wind power installed capacity, has begun to develop a niche in wind turbine manufacturing. According to a Duke University study of wind power, several leading OEMS, the main finished turbine firms, have established, or plan to open, manufacturing facilities in the United States.[43] Although European and Asian firms supply the majority of wind turbines currently installed in the United States, the share of wind turbine parts being manufactured domestically grew from less than 30% in 2005 to 50% in 2008, by value.[44]

Michigan's manufacturing activity in wind energy. According to the Environmental Law and Policy Center (ELPC), Michigan is home to 120 wind industry supply chain companies employing more than 4,000 workers. Although all the companies are part of a wind supply chain, not all of them are manufacturers. The study identifies 63 wind turbine components manufacturers and 5 turbine manufacturers. Of the remainder, 37 companies are involved in wind turbine installation and 16 are in services associated with wind energy. Most of these firms tend to be clustered in the southern end and middle of the state, especially in Saginaw, Grand Rapids, and around Detroit and Ann Arbor.[45]

Whether this capacity continues to grow, will largely depend on the expansion of wind energy generation within the state, throughout the United States, and globally. Michigan has substantial available wind generation capacity along its coastline—reportedly over 530 square miles of potential offshore wind energy construction for current technologies.[46] MEDC emphasizes that developing this capacity and

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[40] Ayee et al, *Wind Power,* 5.

[41] Shannon Kruse, "Supporting Wind's Power," *Engineered Casting Solutions,* May/April 2006: 16-22.

[42] Ayee et al, *Wind Power.*

[43] Ibid.

[44] Ibid. 5.

[45] Ashley Craig, Howard Learner, and Peter Gray. *The Solar and Wind Energy Supply Chain in Michigan.* Chicago, IL: Environmental Law & Policy Center (ELPC), March 2011.

[46] Michigan.Gov Energy (http://www.michigan.gov/energy#).

building up manufacturing capability in wind turbines must co-exist to maximize opportunities for the state's wind power sector. Therefore, to grow MI wind power generation capacity is important to stimulate and support a robust, competitive wind turbine manufacturing supply chain in the state. At the same time, the overall U.S. and global market for wind turbines has grown over the past decade. The U.S. market for wind turbines broke $3 billion in 2005 and was estimated to grow to $7.5 billion by 2010.[47]

Demand for wind turbines would be greatly amplified if the U.S. adopted an ambitious goal to increase the share of wind energy of overall energy production. For example, the DOE claims that to achieve a goal of 20 percent wind energy, the number of turbine installations in the United States would need to increase from approximately 2,000 per year in 2006 to almost 7,000 per year in 2017. This in turn would require manufacturing of at least 21,000 each year—compared to current U.S. production capacity of 10,000 blades per year.[48] Meanwhile, the global wind turbine component market totaled $37 billion in 2008, and is anticipated to reach $56 billion by 2015. The total wind turbine blade market value is anticipated to grow from $4.7 billion to around $7.9 billion between 2008 and 2015.[49]

State and federal investments. At this point in time, it is not clear that U.S., much less Michigan manufacturers, has the capacity to meet this growing and future demand, or whether these markets would be captured by foreign producers. As in the case of advanced batteries, federal and state policies could play a critical role in enabling Michigan to grow its wind turbine manufacturing capacity. The evidence indicates that Michigan wind turbine producers have been helped both by state programs initiated by Governor Granholm and federal stimulus grants. For example, the MEDC notes that a federal investment of $39.3 million in the state supporting wind turbine manufacturing has leveraged a total new business investment of $132.1 million.[50]

The state's renewable portfolio standard creates the conditions for expanding wind power generation, which in turn creates more demand for wind turbines manufactured in the state. The Center for Energy Excellence (COEE) designations and grants have been given to wind turbine manufacturers, and several ARRA awards have been given to support wind turbine manufacturing. Some examples of wind energy manufacturers assisted by government programs in Michigan include the following:

- The State of Michigan gave a COEE designation plus $7.5 million in grants to URV USA in Eaton Rapids, to build a 80,000 ton foundry to produce heavy castings for wind turbine OEMs and develop the next generation of casting materials in

[47] MEDC. *Michigan New Market Development.*

[48] Ibid.

[49] Ibid.

[50] Ibid.

collaboration with Oak Ridge National Laboratory and Michigan Technological University.[51]

- ➢ In December, 2010, Michigan DELEG awarded $15 million in ARRA grants to four small Michigan companies who are diversifying into wind turbine manufacturing, including:
  - o Astraeus Wind Energy, Eaton Rapids—$7 million for manufacturing large wind turbines and advanced composite wind turbine blades, which will create 100 jobs;
  - o Energetx Composites, Holland—$3.5 million to enable diversification into the manufacture of large, advanced, composite wind turbine blades, creating 280 jobs in the project's first phase;
  - o Merrill Technologies Group, Saginaw—$3 million for partnering with Vermont-based Northern Power to manufacture a next generation utility scale wind turbine in Saginaw, creating 113 jobs;
  - o LOC Performance Products, Plymouth—$1.5 million for diversifying into the manufacture of planetary gears and gearboxes for utility scale wind turbines, creating 118 new jobs. [52]
- ➢ ARRA Section 48C energy manufacturing tax credits have been granted to four Michigan wind energy manufacturing companies including:[53]
  - o Merrill Technologies Group, Saginaw ($22.02 million), for investing in advanced manufacturing equipment to support the production of nacelles used in Northern Power's new 2.2 MW-utility-scale wind turbine.
  - o Flame Metals Processing, Rogers ($1.35 million) for purchasing equipment used in the heat treatment of gears used in wind turbine gear assemblies;
  - o Great Lakes Industry, Inc. Jackson ($1.30 million), for manufacturing component precision gears for multi-megawatt and wind turbine gearboxes.
  - o Vela Gear Systems, Inc., Indianapolis, MI ($11.60 million), to build a plant to produce advanced wind turbine parts with improved technology.

● **Michigan's Solar Energy Technology Industry—**Michigan has become a leading center for solar energy in the nation. The Solar Foundation's National Solar Jobs Census in 2010, ranked Michigan 4th in the number of jobs in the solar industry. According to this survey, approximately 6,300 workers in 76 firms are employed in the solar industry in the state, which includes installation, manufacturing, wholesale trade, and utilities.[54] Nationally, as of August 2010, the Census estimates that the U.S. solar industry employed 93,000 solar workers, defined as those workers who spend 50 percent of their time supporting solar-related activities. Moreover, solar

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[51] Craig et al. *The Solar and Wind Energy Supply Chain*, 9.
[52] www.michigan.gov
[53] DOE, *Selection for Section 48C.*
[54] The Solar Foundation, *National Solar Jobs Census, 2010.* Washington, DC. October 2010: 63.

employers said they expected to increase their workforces by 50 percent 12 months after the survey was released.[55]

The optimistic results reflect the dramatic growth in solar energy in the United States over the previous few years, because of new technology, favorable legislative policies, and increased consumer demand for clean, renewable sources of energy. The Census sites a GTM Research estimate that solar photovoltaic installations grew at a Compound Annual Growth Rate *(CAGR)* of 61 percent between 2006 and 2009.[56] U.S. solar products manufactures employed nearly 25,000 solar workers in 2010 and expect strong growth in 2011. About 65 percent of the manufacturers in the survey produce photovoltaic systems, 28 percent manufacture products for solar water heating (not including pool heating), 21 percent make solar space or cooling systems, 18 percent produce concentrating solar power (CSP) systems, and 15 percent make products used in solar pool heating. [57]

Michigan's manufacturing activity in solar energy. Michigan's advanced manufacturing infrastructure, high-tech workforce, and strong scientific community, are significant strengths that have enabled Michigan to play a leading role in solar technology manufacturing. According to the MEDC, heat transfer, power and control electronics, CAD/CAM and logistics are some of the broad spectrum of engineering capacities found in the state, that have helped stimulate the growth of Michigan's solar energy sector. As automobile R&D capital of the world, Michigan has spawned a large number of independent solar research, development and manufacturing entities focused on new technologies derived from the automotive industry.[58]

The Environmental Law & Policy Center has identified 121 solar industry supply chain companies in Michigan, of which 48 are involved in components manufacturing, 59 are installation firms, and 13 are involved in solar-related services. [59] Most of Michigan's solar industry is devoted to photovoltaics. However, a Duke University analysis of the U.S. solar industry notes that a concentrated solar dish system, called the Infinia Solar System, which can be mass manufactured by Tier 1 and Tier 2 auto manufacturers in the United States, has the potential of generating a large number of jobs in Washington, Michigan, and the upper Midwest.[60]

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[55] Ibid., 4.

[56] SEIA/GTM Research, U.S. Solar Insight, 2nd Quarter 2010. Cited in Solar Foundation, *National Solar Jobs Census,* 6.

[57] Ibid., 20

[58] MEDC, *Solar Energy*. Brochure. (MichiganAdvantage.org/solar).

[59] Craig et al. *The Solar and Wind Energy Supply Chain*.

[60] Gary Gereffi and Kristen Dubay. *Concentrating Solar Power, Clean Energy for the Electric Grid*. In *Manufacturing Climate Solutions, Carbon-Reducing Technologies and U.S. Jobs.* Chapter 4. Center on Globalization, Governance & Competitiveness, Duke University. September 22, 2009. 52-64: 60. According to the Infinia Corporation's CEO J.D. Siton, his company has developed a technology product that can be "stamped out like a Chevy and installed like a Maytag." It can be manufactured on existing auto production lines and shipped as a kit that can be installed by the most basic construction crew. Siton notes that currently idle production capacity could produce 40 million units of the new technology each year. This would equate

Because of its strong manufacturing capabilities—and helped along by government support—Michigan has been able to attract global solar powerhouses to set up major facilities in the state. These include:

- Hemlock Semiconductor Group, the world's largest manufacturer of polycrystalline solar cells and modules for panels, based in Saginaw—close to the largest silicon deposit in North America—in 2009 commenced operation of a new 8,500 metric tons polycrystalline silicon production facility at its Hemlock facility, representing the completion of the first phase of a $1 billion expansion announced in May of 2007. A second phase of this expansion was to come online in 2010, increasing the facility's total annual capacity to approximately 36,000 metric tons.
- United Solar Ovonic, a subsidiary of Auburn Hills-based Energy Conversion Devices, operates four of the largest thin-film photovoltaic laminate plants in the world in Michigan, and is planning a fifth.
- Evergreen Solar manufactures solar panels using unique String Ribbon water technology, is building a $55.2 million plant in Midland's Eastwick Industrial Park.
- Dow Corning Solar Solutions, whose Solar Application Center is located in Freeland, is working to develop solutions for the solar market including the first commercially available solar feedstock material derived from metallurgical-grade purification.[61]
- KUKA, headquartered in Michigan for 27 years, is a systems integrator for automated assembly processes, with expertise in automotive, aerospace, distribution/bottling and PV modules.[62]
- Patriot Solar Group has developed one of Michigan's premier state-of-the-art manufacturing facilities for the solar industry.[63]
- Dow Chemical recently announced plans to manufacture its new PowerHouse solar shingle in Midland.

Ford Motor Co. announced in September 2009 an agreement in principle with another large solar manufacturer Clairvoyant Energy of Santa Barbara, California, along with Xtreme Power of Austin, Texas, who would to come to Michigan to help redevelop Ford's former Wixom Assembly plant into one of the nation's largest renewable energy manufacturing parks. Clairvoyant would manufacture energy storage systems and high-efficiency solar panels at the site. If all goes as planned,

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to 120,000 MW of solar capacity and as many as 500,000 manufacturing jobs. However, although Infinia initially planned for nearly 100 percent of manufacturing to be in the United States, legislative uncertainty—Congressional delay in extending the renewable energy investment tax credits and the federal government's lack of an effective renewable energy policy—have driven Infinia to invest some of its manufacturing abroad (about 40 percent), where markets are more economically attractive.

[61] MEDC, *Solar Energy*. Brochure.

[62] Ibid.

[63] Ibid.

the park is expected to create more than 4,000 jobs on site and the surrounding area, as well as support thousands of indirect jobs.[64]

State and federal investments. Both state and federal programs have played a major role in spurring and encouraging the growth of solar products manufacturers in Michigan, including those mentioned above. As a result of aggressive tax incentives to attract solar-energy manufacturers, Michigan's Great Lakes Bay Region (Bay, Midland, and Saginaw counties), have been called an emerging "Silicon Valley" of the clean energy industry.[65] The state's first photovoltaic tax credit was signed into law by the Governor Granholm in October, raising the total solar energy manufacturing investment by the state to more than $3.5 billion over the previous five years. [66]

Several major Michigan solar manufacturers were selected as recipients under the Advanced Energy Manufacturing Tax Credit (Sec. 48C) program in ARRA including:[67]

- Hemlock Semiconductor: received a $141.9 million tax credit for expanding its Michigan polycrystalline silicon operations in Hemlock;
- The Dow Chemical Company in Midland: received a $17.8 million to produce photovoltaic cells built into residential and commercial roofing and siding products;
- Dow Chemical-Solar Silane, Hemlock: received a $27.3 million credit for a monosilane plant Dow is building;
- United Solar Ovonic, Auburn Hills: received a $13.3 million credit to support its plan to invest $42 million in its Auburn Hills 1 facility to upgrade equipment used in its commercial solar deposition process.
- Other tax credit recipients in Michigan for producers of solar energy PV technologies, include Stirling Energy Systems, Inc. Livonia ($9.83 million) and Guardian Industries Corp., Carleton ($2.71 million).

- **Michigan's Biofuels Industry—**Biofuels is one of the three sectors that comprise what a Michigan State University (MSU) study call the "bioeconomy." Biofuels production turns organic materials such as corn and sugar cane (to make grain ethanol), agricultural cellulosic feedstocks (to make cellulosic ethanol), or vegetable oils such as soy or palm, wast greases/oils/fats, or algae (to make biodiesel) into substitutes for gasoline or diesel fuel used in transportation. "Bioenergy" is comprised of biobased fuels that can replace coal, natural gas, and (possibly) nuclear energy in electricity generation. "Biomaterials" are biobased

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[64] "Ford Wixom vehicle assembly plant gains new lease on life as renewable energy park." Monday, October 18, 2010. (www.media.ford.com).

[65] Michigan.Gov Energy (http://www.michigan.gov/energy#).

[66] Galluci, "Job Boom in Michigan."

[67] DOE, *Selection for Section 48C.*

replacements for petroleum and synthetic inputs in making chemicals, plastics, polymers, and other materials.[68]

There have been promising advancements in all three sectors in Michigan, and promoting the bioeconomy has been an important part of the state's efforts to grow its clean energy market and manufacturing capacity. As in the case of the other clean energy technologies, Michigan's automotive manufacturing history and strengths offer competitive advantages for bioeconomy industries. In addition, Michigan has access to vast water resources and significant forestry resources that a robust bioeconomy requires.[69]

At the same time, Michigan has prioritized growing its bioeconomy to support its own energy needs as well as be a global supplier. Michigan imports almost all of its energy inputs and fuel. As the MSU study states, "Advancing the bioeconomy in Michigan not only increases the state's share of the global bioeconomy market, it addresses the need for cost-competitive, Michigan-based energy feedstocks so the percentage of gross state product spent on imported energy can be reduced."[70]

Michigan's manufacturing activity in biofuels. The recent major economic downturn and tightened credit markets in 2008 and 2009 hit the emerging biofuels, bioenergy, and biomaterials sectors hard. Low oil prices, the high costs of biobased products relative to fossil fuel counterparts, and lack of consumer readiness to adopt these products, also limited the growth of these sectors in Michigan over the past few years. Nevertheless, Michigan has continued to make some progress in growing its bioeconomy.

The MSU study identifies more than 100 companies operating directly in the bioeconomy, with dozens more (engineering, research, and consulting firms) supporting it. These range in size from entrepreneurial startups to billion-dollar corporations such as Dow Chemical and Dow Corning. There are nearly 30 operational biofuel-related companies in Michigan, including five operating ethanol plants. Two new ethanol plants are also under development, including its first commercial-scale cellulosic ethanol plant, one of only seven in the country. The MSU list also includes 8 anaerobic digester facilities, 24 bioenergy companies, and 37 biomaterials companies—the latter includes Michigan-based Dow Chemical (Midland) and KTM Industries (Lansing).[71]

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[68] Michigan State University Product Center for Agriculture and Natural Resources (MSU) and Shepherd Advisors, *Advancing the Bioeconomy: Overview of Michigan's Recent Progress.* East Lansing and Ann Arbor, MI, September 2010.

[69] Ibid.

[70] Ibid., 5. Michigan imports 97 percent of its petroleum, 80 percent of its natural gas, and 100 percent of coal and nuclear fuel from other states and nations. These imports account for 70 cents of every dollar spent on energy by Michigan's citizens and businesses.

[71] Ibid., 8, esp. Table 1. The five operating ethanol facilities, all using food feedstock, include The Andersons Albion Ethanol plant, Albion (55 mgy), Marysville Ethanol, Marysville (50 mgy), Global Ethanol/Midwest Grain, Riga (57 mgy), POET Ethanol, Caro (53 mgy), and Carbon Green Bioenergy (50 mgy). The two

Between 2005 and 2010, Michigan's biofuels industry had mixed market success. Through 2008, the high price of crude oil fueled more demand for biofuels, which in turn lead to the continued operation, expansion and construction of ethanol and biodiesel production facilities. Falling oil prices and the economic crisis in 2008 and 2009 substantially slowed growth and investment in the bioeconomy sectors. Unprecedented volatility of the commodity markets, reduced profit markets, and poor management practices put substantial strain on ethanol producers in particular. In one case, VeraSun, among the largest ethanol producers in Michigan and the nation, filed for Chapter 11 bankruptcy and closed its Woodbury facility, along with other plants in the Midwest. Biodiesel producers were also hard hit from 2007 to 2009 as the price of soybeans soared, and several are currently out of production or operating at partial capacity.[72]

Other biofuels producers have fared better, such as the POET Ethanol, LLC, plant in Caro, which produces ethanol at a rate of 53 million gallons per year (mgy) at its Caro plant. Three other ethanol plants in Michigan, in The Andersons Albion Ethanol plant, Albion, Marysville Ethanol, Marysville Global Ethanol/Midwest Grain, Riga also have been successful due to factors such as technological improvements in their production.[73]

State and federal investments. State and federal policies and programs have played a critical role in driving the development and growth of the bioeconomy sector in Michigan. Governor Granholm prioritized growing Michigan's alternative fuel industry and significant resources have been focused on the biofuel industry to locate or expand within the state.[74] On the demand side, Governor Granholm's administration supported the expanded use of alternatives to gasoline and diesel, in part through developing infrastructure of these fuels for end-use. In 2006, the Michigan Renewable Fuels Commissions (RFC) was established and charged with making recommendation to enable the state to become a leader in alternative fuel production and use. Meanwhile, Granholmset an initial target to establish 1,000 ethanol or biodiesel pumps across the state by 2008. The state also passed a Renewable Portfolio Standard in 2008, which includes electricity generated from biomass resources.[75]

Granholm's initiatives, following some of the RFC's recommendations, included policy supports; investments in bioeconomy-related R&D; investments in private

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underway include Mascoma-Frontier Renewable, Kinross (40 mgy), which would use cellulose and wood feedstock, and a pilot scale cellulosic ethanol plants being built by American Process Inc. Biorefinery, Alpena.

[72] MSU, *Advancing the Bioeconomy*, 7; The Michigan Renewable Fuels Commission (RFC), *Renewable Fuels Commission, 2008 Annual Report,* 2. Prepared for Governor Jennifer M. Granholm and the Michigan Legislature. Lansing, MI, February 2009. As a result, biodiesel firms like Michigan Biodiesel, Bangor MI have diversified their output from biodiesel fuel into "green" chemicals, while others pursue alternative feedstock.

[73] RFC, *Renewable Fuels Commission,* 2. MSU, *Advancing the Bioeconomy*, 8.

[74] MSU, *Advancing the Bioeconomy*, 7. RFC, *Renewable Fuels Commission.*

[75] MSU, *Advancing the Bioeconomy* 7; RFC, *Renewable Fuels Commission,* 6.

sector efforts to build biofuel, bioenergy, and biomaterial facilities; partnerships with major bioeconomy companies; support for entrepreneurial and pilot-scale efforts; and support for technology commercialization.[76] In 2008, Granholm signed 11 bills aimed at expanding the use of and development of Michigan's renewable fuels industry. For example, one bill (Public Act 329 of 2008) added 5 additional renewable fuel renaissance zones in Michigan, bringing the total to fifteen, The renaissance zones designate a specific geographic area as tax exempt to encourage economic development. The bill also requires that five of these zones be designated for facilities focused primarily on the production of cellulosic biofuel. Other legislation (Public Acts 321 and 322 of 2008) created a new Renewable Fuels Fund to promote the production and use of alternative fuels in Michigan.[77]

These efforts bore fruit, resulting in the successful expansion of bioeconomy activities in state, starting with the construction of Michigan's first production-scale cellulosic ethanol plant and development of two cellulosic ethanol pilot plants. Some important examples include:

- Frontier Renewable Energy, a partnership between the Mascoma Corporation and J.M. Longyear to develop a commercial-scale cellulosic ethanol plant in Kinross in the Eastern Upper Peninsula, to be completed in 2013. It is expected to produce up to 40 million gallons of low-cost, low-carbon cellulosic ethanol, and employ more than 150 people and 50 full-time employees when operational. This project was one of the state's initial Center for Energy Excellence (COEE) awards. The U.S. DOE, MSU, and Michigan Technological University are also partners in the project. Funding includes $23 million from the state, $26 million from DOE, and $300 million from Frontier.[78]
- Aside from the Frontier Renewable Energy project, Michigan's COEE Program has supported other cutting edge companies in the state working with Michigan University researchers to commercialize clean energy solutions:[79]
    - A COEE award was given to American Process, Inc. to establish a pilot scale biorefinery at its Decorative Panels International (DPI) hardwood plant in Alpena, taking the waste stream the wood panel manufacturing facility and turning it into cellulosic ethanol.
    - A COEE award was given to Working Bugs LLC from East Lansing, Webberville and Sweden, to establish a biorefinery to produce high-value specialty and fine biochemicals and bioefuels from natural feedstocks. Technology developed a this center can be applied to existing biomaterial processing facilities across the state, such as corn ethanol plants, beet sugar refineries, and pulp mills.

[76] MSU, *Advancing the Bioeconomy*, 5.

[77] RFC, *Renewable Fuels Commission*, 12.

[78] MSU, *Advancing the Bioeconomy*, 7.

[79] Ibid. 4.

- The Michigan Department of Agriculture (MDA) has been working with Renewafuel, LLC, subsidiary of Cleveland Cliffs, Inc to build their first commercial plant near Marquette, MI to make biomass dense fuel cubes as a substitute for coal. MDA also has helped Renewafuel upgrade their R&D facility in Battle Creek, into a production-scale facility. Both plants will aggregate and process agricultural and forestry residues as biomass materials, including corn stove, wood residues, switchgrass, or others.[80]

Federal support, primarily through ARRA, was less common in support of bioefuels (or bioenergy or biomaterials) projects. Aside from the grant given to the Frontier Renewables project mentioned above, an ARRA grant of $18 million was given in support of the COEE award provided to American Process, Inc. in Alpena, to accelerate biofuel production and construct a new plant on a nearly 29 acre site adjacent to DPI's Alpena Facility, creating 160 jobs.

4. The Future of CEM in Michigan

Michigan experienced substantial growth in clean energy manufacturing over the last decade, emerging as a leader in the nation in the four alternative energy technology areas discussed above—advanced energy storage, wind energy, solar energy, and biofuels. State and federal policies and programs were instrumental in this growth. At the same time, Michigan enjoys considerable manufacturing and technological strengths, a large high-skilled, well-trained workforce, top-flight academic institutions, and a substantial natural resource endowment, which provide an excellent foundation for building strong CEM capabilities in the state.

The future health of Michigan's CEM sector, however, is unclear. Former Governor Granholm deserves a great deal of credit for initiating a large number of government programs that proved effective in stimulating the growth of CEM in the state while she was in office. ARRA, the federal stimulus program, enhanced and amplified the state's efforts. But the new Congress and the new administration in Michigan, may not be as supportive of clean energy initiatives needed to help Michigan maintain its momentum in building up competitive CEM industries.

Nevertheless, the evidence is clear that Michigan could enjoy large economic gains with significant new investments in clean energy and clean energy manufacturing. Proponents especially tout the potential for helping revitalize Michigan's ailing manufacturing industries, especially its automotive industry, which has direct tie-ins to CEM-based industries such as advanced energy storage and biofuels. It has been estimated that the clean energy economy has already created over 100,000 jobs in Michigan. But this is still far from replacing the more than half-million jobs lost in the state's manufacturing sector since 2000 or satisfactorily keeping up with the growing number of young people entering the workforce in the state and nation.

[80] RFC, *Renewable Fuels Commission*, 10.

One thing is clear, though. Realizing the potential of clean energy manufacturing to create new jobs will require ramping up the demand for clean energy technologies, not only in Michigan—which only has a very tiny clean energy generation sector—but nationally. At the same time, investments in CEM can help build up the manufacturing capacity in Michigan, indeed, in the United States as a whole, so it can remain competitive in the rapidly growing global clean energy markets. In short we need policies that support the demand for and use of clean energy while also building up the manufacturing capabilities needed to make the products used to supply clean energy throughout the economy.

There is a danger, though, that in the coming years, the United States—and Michigan in particular—will greatly diminish its support for clean energy production and manufacturing, while European countries, China, and Japan continue to rapidly more ahead in these areas, backed by substantial government programs. As Skip Pruss warns, "While much of the rest of the world is moving strategically to capture the economic benefits accruing from clean energy technology manufacturing, the US seems to be moving backwards."[81]

[81] Pruss, "Clean Energy: Business Case."