Solar Products Manufacturing in Milwaukee

Prepared for:

Milwaukee Shines
Office of Environmental Sustainability

Prepared by:

CH2MHILL

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Preface

The purpose of this document is to assess the ability of the City of Milwaukee (the City or Milwaukee) to develop a solar manufacturing sector, to identify opportunities to capitalize on existing manufacturing assets, and to provide recommendations for the City. Much of the information that supports this document was obtained from existing research, information, and opinions from multiple sources within the Milwaukee area including the City of Milwaukee, local businesses, economic development groups, non profit organizations, and academic universities. While the information is believed to be true and accurately represented, CH2M HILL has not performed an independent verification of such data. Since the solar products industry is emerging and constantly changing, the forecasts included in the report may not be realized in the future. The recommendations included herein are based on the market understanding when the document was developed. If new information becomes available, this report should be reviewed to determine whether it should be revised.

Executive Summary

Project Background

In 2008, the City of Milwaukee (the City) was selected by the U.S. Department of Energy (DOE) to be one of 25 Solar America Cities (SAC). This designation is intended to accelerate adoption of solar energy technologies in U.S. cities by supporting innovative local efforts with both financial and technical assistance. CH2M HILL was retained by the DOE to provide technical assistance to Milwaukee as a part of the SAC program. This report presents the findings of a study which assesses Milwaukee's ability and opportunity to attract and grow solar products manufacturing. The report also provides suggestions on how the City should position itself to be successful in enabling solar industry growth, and creating local solar manufacturing jobs.

Solar Products Manufacturing Industry

The solar products manufacturing industry appears to be entering a long growth phase. This growth is being enabled by lower cost solar products and dramatically increased demand for solar products in the U.S. and abroad. The increasing cost of conventional electricity and the opportunities to reduce environmental pollutants associated with conventional power generation and distribution is creating manufacturing opportunities. These opportunities are not only for solar photovoltaic (PV) panels and solar hot water collectors, but also their associated system components like inverters, controllers & power electronics, racking and mounting hardware, valves, tanks, sensors, and pumps. Convergence, the point at which the cost of solar energy is equal to the cost of conventional energy, is beginning to reach select U.S. locations, and will reach a significant U.S. market in the next 5-8 years. The window of opportunity is now open for city and regional planning activities to encourage and create U.S. manufacturing capacity and build this industry.

The solar products manufacturing industry has specific requirements that are important for Milwaukee to understand in order to attract investment and create jobs in this sector. Large-scale integrated facilities have different requirements than assembly or supply chain components manufacturing facilities.

Large scale integrated PV facilities, which include multiple steps or even raw materials to finished product manufacturing processes in a single facility, are common targets for many regions pursuing solar economic development. These types of facilities require the following:

- Available sites of 25 acres or larger for facilities including at least cell manufacturing and module assembly processes.
- Electrical power connection requirements ranging from 5-50MW, and kWh prices ranging from 3-8 cents.
- Large incentives to reduce up-front capital expenses.
- Established technology or electronics companies and workforce.

PV module assembly, many solar hot water, and sub components manufacturing processes have different requirements than large scale integrated PV facilities, and are in many cases better suited to Milwaukee. Typical PV module assembly and solar hot water product manufacturing facilities have the following attributes:

- Can utilize smaller sites and existing buildings. Many companies need to get into production very quickly to capture market share in an increasingly competitive environment, and existing buildings can be part of this strategy.

- Generally require small electrical power connections. Power costs can still be an important factor.
- Require some incentives, but also typically have many low skill and lower pay jobs.
- Are less dependant on existing bases of experience and workforce.

PV product manufacturers in general seek out the following attributes or commitments from regions or cities:

- Off take commitments from city, state, or utility to purchase a set amount of production output over a period of time (1-3 years). These orders provide leverage for manufacturers to secure financing and lower risk.
- Good access to transportation networks for select products. Although transportation of raw goods and finished products is not currently a driving factor in locating all solar product manufacturing facilities, it will become more influential in the next 10 years.
- A strong public policy commitment to solar manufacturing and renewable energy. Many solar products manufacturing companies consider themselves to be "green" and want to be in places with a reputation for being sustainability focused, environmentally conscious, or ecologically progressive.

Assets and Challenges

Milwaukee has a number of assets that it can leverage to build a local solar products industry cluster, including a relatively strong general manufacturing history and work force, reasonable electricity costs, three or more university engineering programs, and active businesses promoting solar hot water products.

Milwaukee also has a number of challenges to overcome to build a local solar products industry cluster, including: a lack of focus and commitment to development of the solar industry, limited readily developable sites and buildings that meet the needs of the industry, limited visibility as a solar location, and limited incentives compared to areas currently winning solar investment.

Many other regions in the U.S. have been successful in attracting solar products manufacturing. These regions are using tools such as: large incentive packages that include cash and tax credits that can be monetized, shovel ready sites that meet the needs of the industry and are pre-permitted, commitment to renewables and solar power with requirements for renewables purchase agreements, active marketing programs targeted to solar manufacturers, and public/private/utility partnerships that encourage solar development.

Next Steps and Recommendations

Based on the needs of the solar products manufacturing industry, and assets and challenges identified in Milwaukee, the following are some next steps and recommendations. To successfully compete for investment from the solar products manufacturing industry, Milwaukee should consider the following recommendations:

Commit to Solar Products Manufacturing

- Make a commitment to growing solar products manufacturing through public policy and outreach activities.
- Establish a public/private group that will focus on growing solar manufacturing through education and advocacy for the industry. This group should include private industry, the public, university, and non-profit representatives with a focus on local businesses as well as the attraction of new investment.

- Commit necessary financial resources and select an experienced solar products industry champion dedicated to growing manufacturing in the City.

Improve Milwaukee as a Solar Products Manufacturing Location

- Develop an inventory of sites and building that could meet the needs of solar manufacturing industries, and an analysis of what each of these potential sites needs to be ready.
- Develop a solar specific incentive package focused on the creation of new jobs.
- Leverage existing strengths such as Milwaukee's manufacturing history and workforce. Existing strengths point to solar hot water product manufacturing, extensions from existing metal industry products, and installation applications as the most immediate opportunities.
- Leverage the three higher education institutions in the city. Promote their involvement as a critical part of the team.
- Develop a competitive and quantitative set of materials to present Milwaukee as a great place to manufacture solar products, leveraging Milwaukee's strengths, and addressing its challenges.

Create Showcase and Demonstration Projects

- Develop a high profile/visibility solar showcase application project to educate and show commitment to solar.
- Develop a set of regional best practices for solar products installations and implement them in the City on a real project. Use this project experience to guide manufacturing development efforts.
- Support existing groups in the development of their planned solar projects, such as Milwaukee utility We Energies' 12 MW PV commitment.
- Develop a showcase small scale manufacturing project to educate and show feasibility of manufacturing solar products in Milwaukee.

By following these steps Milwaukee has the potential to compete for investments with other states and regions in the U.S. for manufacturing development, and the economic and job growth that comes with it.

Project Background

In March 2008, the City of Milwaukee (City) was selected by the U.S. Department of Energy (DOE) to be one of 25 Solar America Cities (SAC). The primary goal for the SAC program is to achieve a nationwide sustainable solar infrastructure through a comprehensive, city-wide approach that facilitates mainstream adoption of solar and serves as a model for other cities to follow. This designation is intended to accelerate adoption of solar energy technologies in cities by supporting innovative local efforts with both financial and technical assistance through the DOE. The SAC program has engaged over 180 organizations including governmental agencies, universities, industry, and non-government organizations.

To implement this program, the City established the *Milwaukee Shines* program within the Office of Environmental Sustainability. The Milwaukee Shines team was established to, in part, encourage photovoltaic and domestic hot water solar product manufacturing businesses.

Project Overview

CH2M HILL was retained by the SAC program to provide technical assistance to the City. CH2M HILL is a global design, construction, and program management company with significant experience working for solar manufacturing companies seeking new production locations and facilities.

CH2M HILL was contracted to assist the City with the following tasks:

- Review solar products manufacturing and the critical elements of the supply chain
- Assess the City's ability and opportunity to attract and/or grow solar products manufacturing (this did not include an assessment of installation or battery capabilities, technology, or opportunities)
- Provide suggestions on how the City could position itself to be successful in attracting or growing solar products manufacturing industries

Section 1: Solar Products Manufacturing Overview

The purpose of this section is to present a basic overview of solar products manufacturing and its drivers.

Solar products manufacturing, as presented herein, is divided into two categories: non-concentrating solar photovoltaic (PV) system products, and domestic low temperature solar hot water (SHW) system products. These two types of solar systems are fundamentally different, but both have the potential to impact City and region-level economies in two important ways. First, increasing adoption displaces conventional energy demand and/or can provide sources of bulk power generation, essentially changing energy economics. Second, and more important, in the context of the City's objectives, manufacturing of solar products is a fast growing technology and job-intensive activity that can lead to flourishing local industrial and economic hubs around the U.S and the world.

Today, installed solar products generate only a small fraction of the primary global energy supply. However, solar energy demand and production is forecast to grow rapidly, driven primarily by the increasing costs of fossil fuels, concern about climate change and potential carbon cap and trade systems, reduction in solar generation costs, and general popular and political will in the form of incentives and renewable energy standards. Solar energy demand has grown at approximately 30% per annum since the early 1990s and is forecast to continue to grow as hydrocarbon fuel sources decline (hydrocarbon energy demand typically grows less than 2% per annum).

This rapid growth in demand for solar energy will have a profound effect on both PV and SHW products manufacturing industries and local economies. Demand for solar energy equates to demand for solar products, new and repurposed factories, research, training, and skilled workers. While growth in the solar products industry depends on new markets opened by cost reductions, these cost reductions appear to be reasonable. The main methods of these cost reductions are forecast to be economies of scale, and technology improvements (the first being the primary driver of cost reduction in SHW products, and both being drivers of cost reduction in solar PV products).

1.1 When and Where: Timing the PV and SHW Products Industry

Over the past few years, there has been dramatic growth in the solar products manufacturing industry which has resulted in the growth of many successful companies worldwide. This demand for manufacturing has been stimulated by recent incentives for end-use (installation), especially in Germany, and more recently in Spain, Italy, Portugal, and Greece. Japan has had a successful end-use incentive program and domestic manufacturing industry for years. The U.S., the former leader in developing solar technologies, is now behind in providing the end-use (and related manufacturing) incentives that would create a large domestic manufacturing base. Based on solar resources and recent focus on developing renewable energy resources, the U.S. is now the great hope in demand for solar products and solar products manufacturing capacity.

Figure 1: Solar PV Industry Outlook from Deutsche Bank SEMI Industry Strategy Symposium, January, 2008

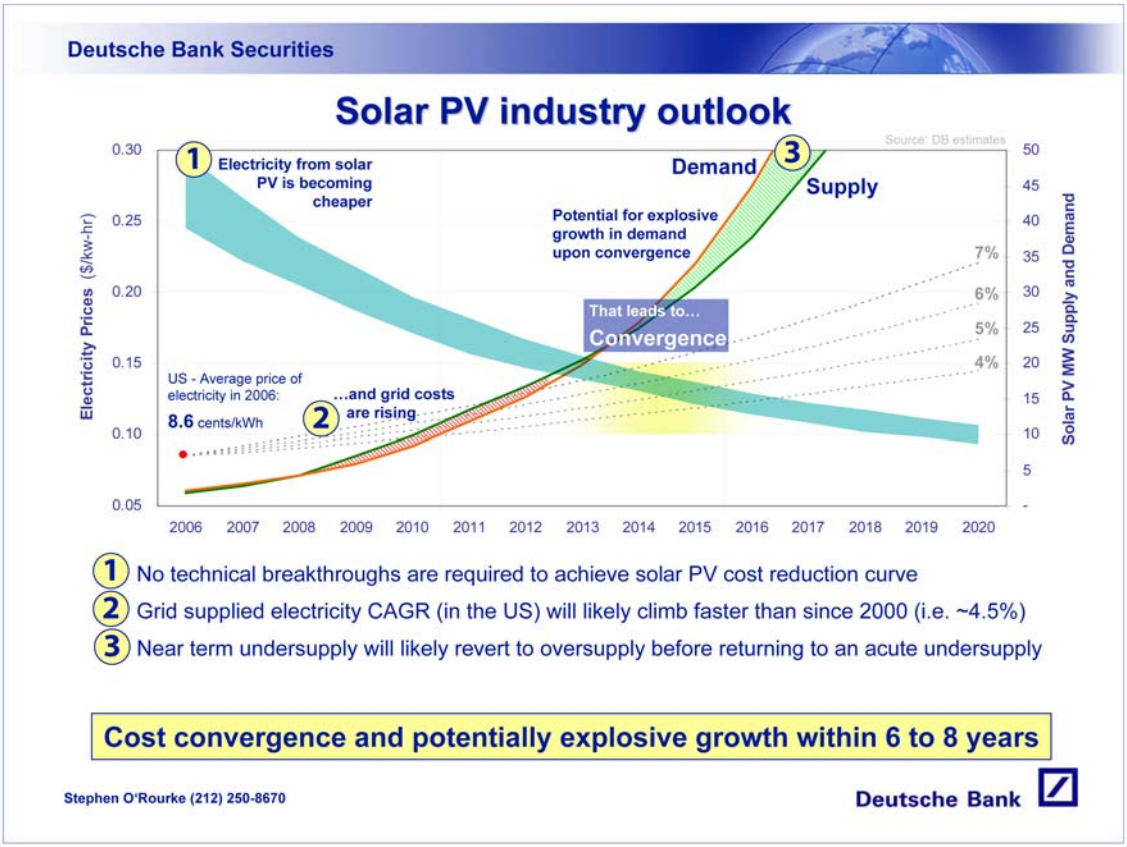


Figure 1 summarizes the cross-over point referred to as convergence (or grid parity), the point when the price of a kWh generated from solar energy is equal to or less than the price of a kWh from conventional sources. Grid parity is forecast to occur for some U.S. market segments in the next 3-5 years, and a large portion of U.S. markets in 5-8 years. Figure 1 also shows an increasing gap between PV product demand and supply, a positive outlook for solar products manufacturers.

Grid parity in Milwaukee will lag behind regions with better solar resources (the Southwest and Florida), and also behind some Northeast regions with more expensive conventional power. Grid parity in Milwaukee is not especially relevant to the short term viability of manufacturing solar products in Milwaukee, as the bulk of solar products end-use locations will be elsewhere (see Figure 4).

In the long term, the primary regional U.S. markets for both PV and SHW products produced in the United States and the world are defined by solar resources and conventional energy costs. Currently, installation incentives, a somewhat unpredictable driver, are extremely critical in creating regional demand, but will become less important over the next 5–10 years in the U.S. (see Figures 2, 3, 4, and 5).

Figure 2. PV Solar Radiation kWh/m2/day from NREL

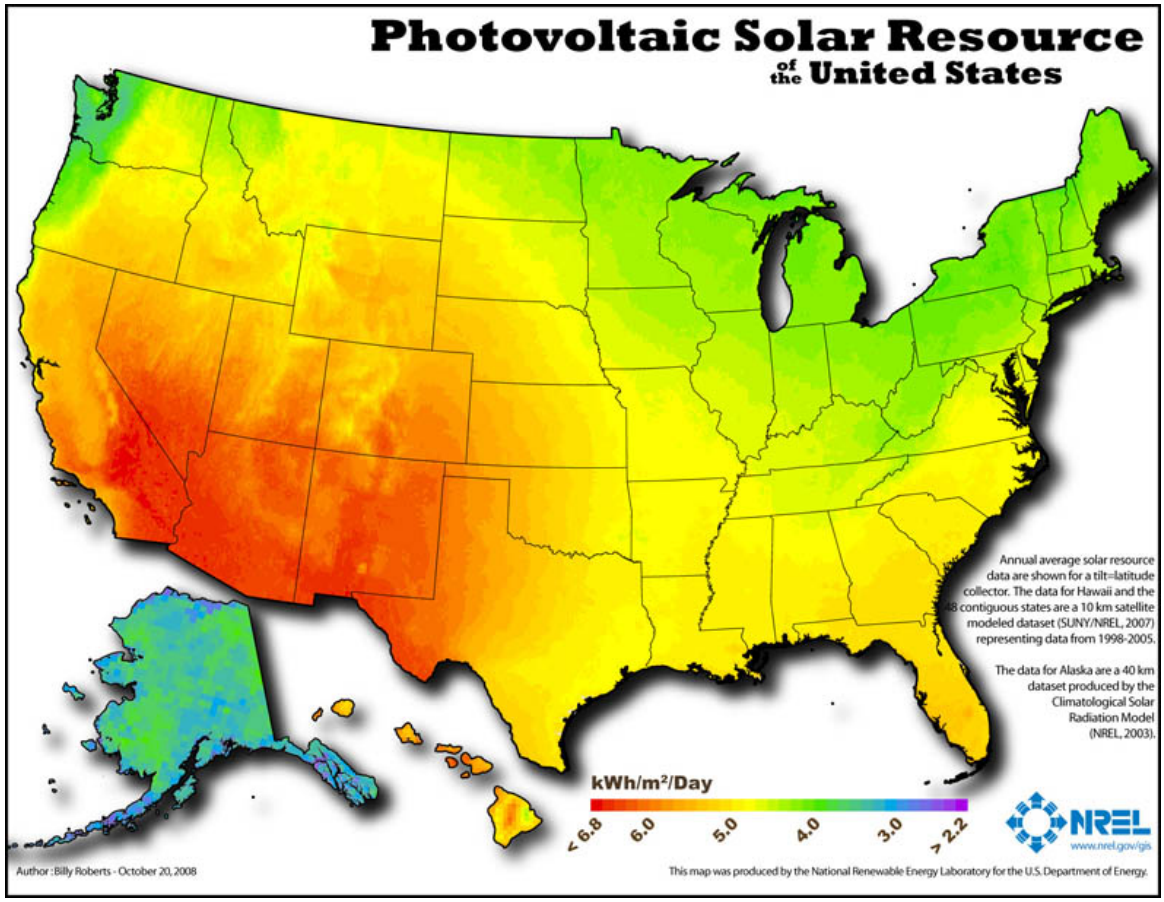
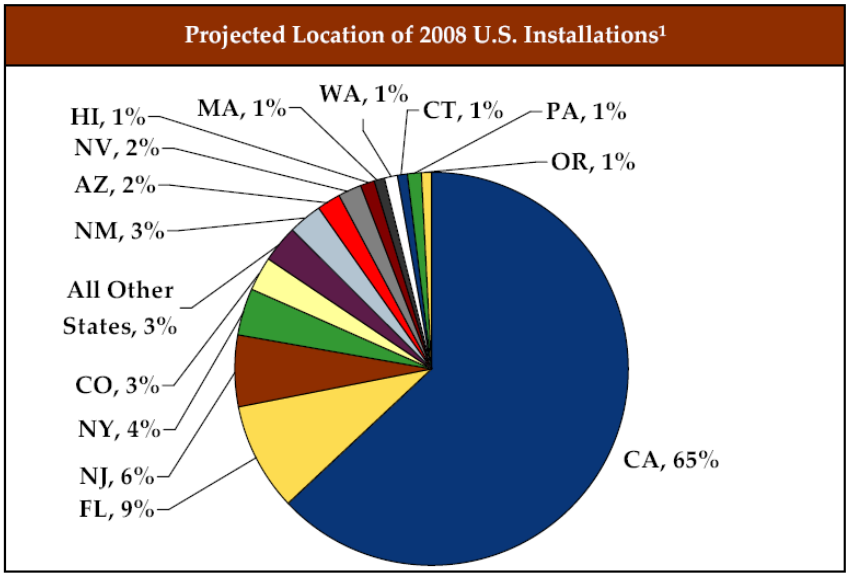


Figure 2 summarizes solar resources in the U.S., a strong economic driver for both PV and SHW products. Should Milwaukee develop a solar product manufacturing base, the areas with the best solar resources (the U.S. southwest) will be the primary shipping destinations in the long term. SHW products will have a slightly wider distribution than PV products (Figure 5). The regions best suited for manufacturing of solar products and their end-use are generally not overlapping.

Figure 3. Projected Location of 2008 U.S. PV Installations from Navigant Consulting –*Economic Impacts of Extending Federal Solar Tax Credits,* September, 2008

Navigant Consulting assumed future installations will be distributed the same as 2008's projected installations.



Source: Navigant Consulting PV Services Program, July, 2008

Figure 3 shows PV installations by state in 2008, and demonstrates that solar resources are a solid driver of PV product demand. However, certain states, like New Jersey, New York, Massachusetts, Washington, Connecticut, Pennsylvania, and Oregon show that solar resources are not the only important factor defining solar markets (see Figure 4). Existing electricity prices and end use incentives are also important factors. Manufacturing of PV and SHW products will seek out locations with low cost energy that are in proximity to regions with good solar resources and expensive conventional energy.

Figure 4. PV and Conventional Electric Price Difference in the U.S. from NREL

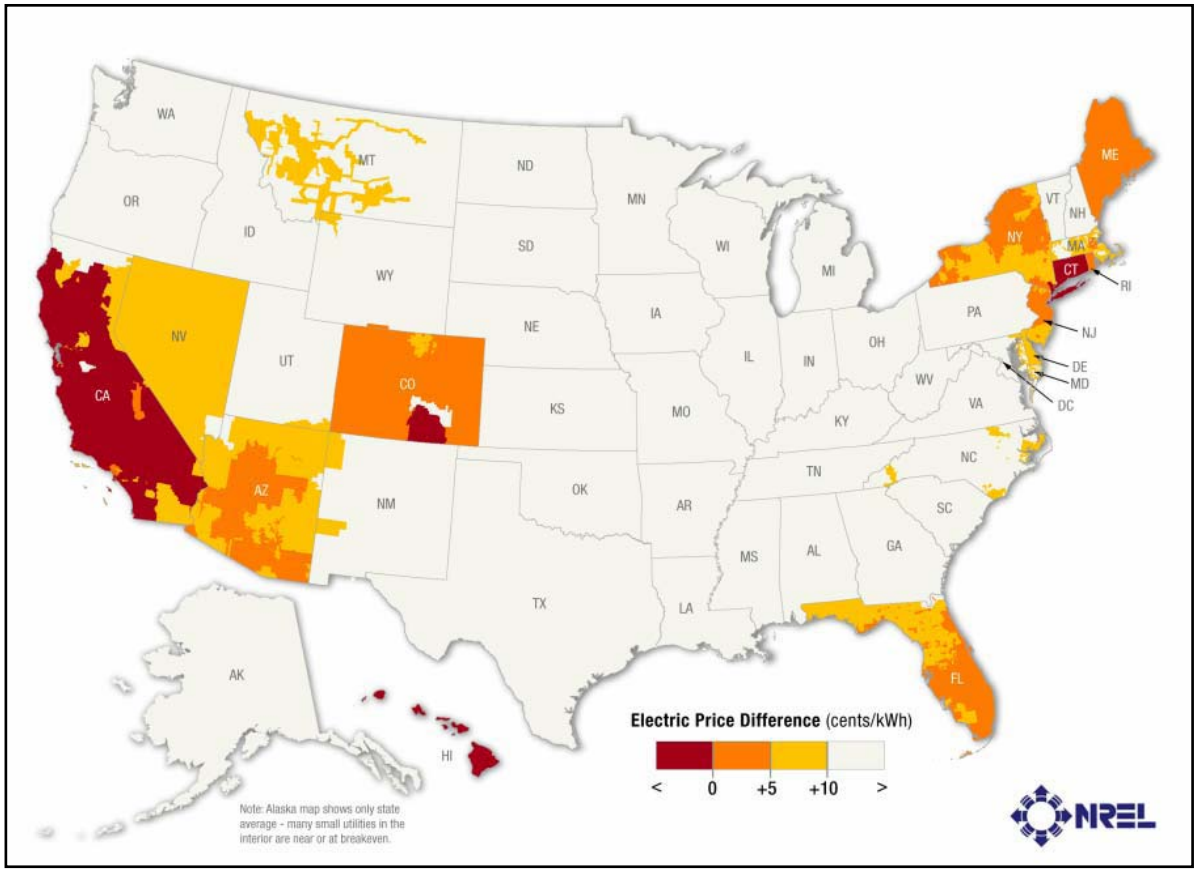
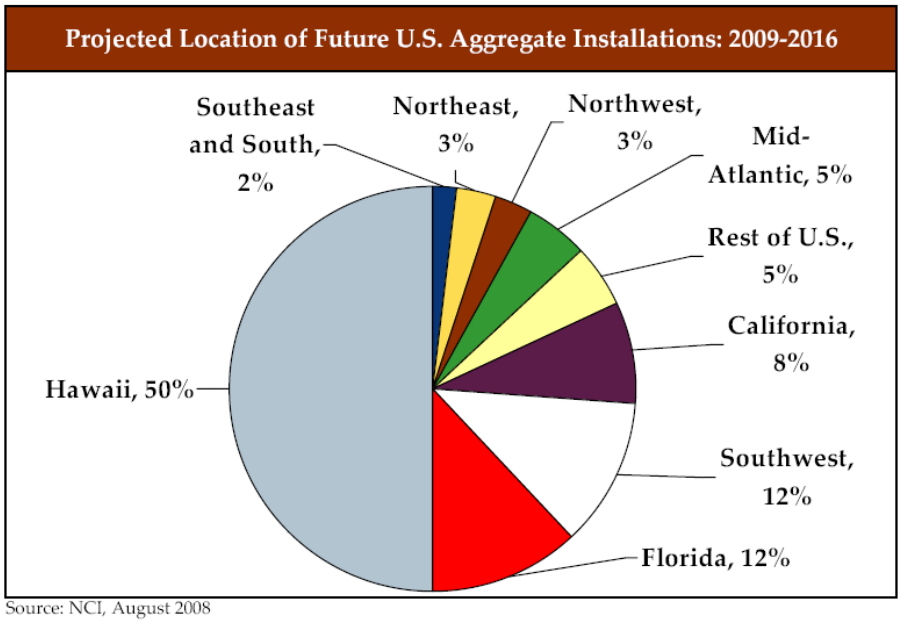


Figure 4 shows the influence of other factors on solar markets by comparing the price of solar PV energy including incentives compared to the price of conventional energy. The confluence of higher existing energy costs, good solar resources, and incentives for PV illustrate the regions of the U.S. that will be the first-stage volume consumers of PV solar products. These regions will be the primary markets for any solar products produced in Milwaukee. In the near term, international shipping destinations in Europe may also be important, but U.S. destinations will likely dominate future demand for U.S. manufactured solar products, especially for components.

Figure 5. Projected Future Solar Water Heating Installations from Navigant Consulting –*Economic Impacts of Extending Federal Solar Tax Credits,* September, 2008

Navigant Consulting projected future Solar Water Heating installations.



Solar hot water products are forecast to have somewhat different primary market locations than PV because SHW products are typically not used in larger power projects (see Figure 5). Transportation to these major markets will be through different routes than for PV applications. SHW products shipping locations will be slightly more distributed than PV products, and any products produced in Milwaukee will need transportation to end markets in Hawaii, but also throughout the U.S.

1.2 Solar PV

1.2.1 Manufacturing Markets and Supply Chain

Global PV generating capacity reached approximately 15 Gigawatts (10^9) at the end of 2008. While this is a small fraction of the tens of Terawatts (10^{12}) of global net electricity generation, it still represents close to 100 million installed PV panels, approximately one third of these installed in 2008. The global PV industry generated approximately $37 billion in 2008, not including many supply chain businesses beyond panel manufacturers.

Figure 6. Thin Film 2.0 Market Outlook through 2012 from the Prometheus Institute and Greentech InDetail

	2006	2007	2008	2009	2010	2011	2012
Total Silicon and Thin Film Modules	**2082**	**3151**	**5426**	**9383**	**14916**	**19702**	**26725**
Growth in Available Supply		*51%*	*72%*	*351%*	*59%*	*264%*	*20%*
Percent Thin Film Production	*9%*	*14%*	*19%*	*23%*	*29%*	*34%*	*41%*

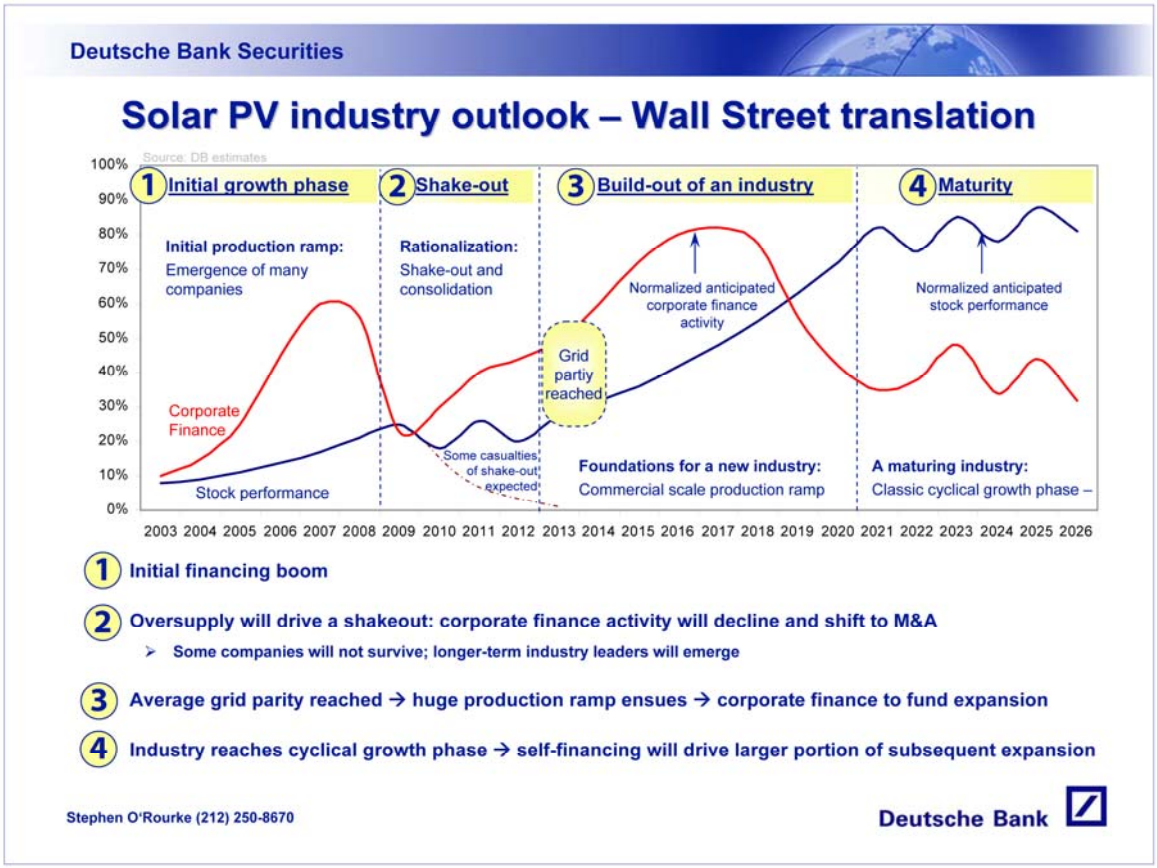
Figure 6 displays global PV module production in kW, and forecast production numbers through 2012. Based on these numbers, more than 330 million PV panels are estimated to be manufactured between 2009 and 2012. This growth in demand for PV panels require growth in demand for

accompanying products such as mounting hardware, wiring and connectors, and power distribution and regulation electronics.

1.2.2 PV Modules

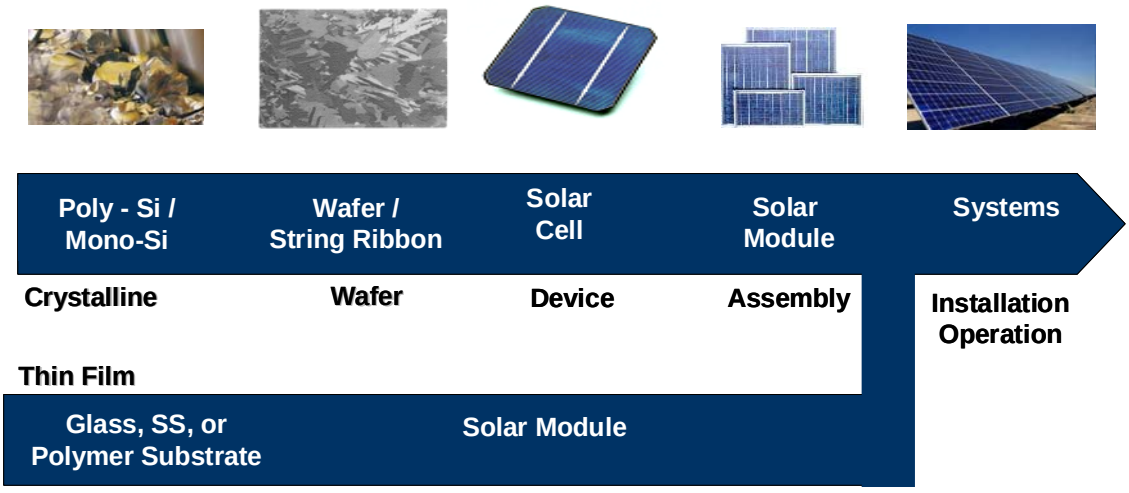
The primary component of a PV system is the PV panel or module, which represents 50-75% of the total installed system costs (percent contribution to total system costs increases with system size). Through the recent financial market and economic downturn, solar module manufacturing has remained strong. Over the last few years, this industry has continued to see strong growth with many multi-year contracts being pre-sold. The graph below shows the growth in the PV product market as the U.S. demand starts to impact global market numbers (PV only).

Figure 7. Solar PV Industry Outlook – Wall Street Translation from Deutsche Bank SEMI Industry Strategy Symposium, January, 2008



The Deutsche Bank forecast in Figure 7 (PV only) shows that 2009 is an ideal time to invest in solar products manufacturing, in preparation for a long growth period.

Figure 8. Solar PV Manufacturing Supply Chain



Photovoltaic panel manufacturing is divided into two major groups based on materials (Figure 8) and manufacturing process technologies: Crystalline Silicon (C-Si) and Thin Film (TF). C-Si processes currently dominate the marketplace with an estimated 90 percent market penetration. C-Si PV products are produced by manipulating the semiconductor properties of silicon wafers and materials and technology with a longer history and lower perceived risk. These panels are generally higher efficiency (12-20%) but higher cost. C-Si panels are the current standard for space-constrained applications but are also utilized on large scale solar farms.

Thin film PV panels are produced by applying semiconductor films directly to a typically glass, but potentially also metal or plastic substrate. TF panels are typically lower efficiency (6-11%) but lower cost making them a common choice for large commercial or utility projects.

PV panel manufacturers, especially C-Si cell processors and TF factories in general (Figure 8), will seek out inexpensive electricity and access to economic and talented engineering, technician, and operator labor. Low-technology processes like module manufacturing and integration (*Appendix A*) can more easily operate in existing buildings, in areas of economical and experienced labor, and near end markets. They require a mixture of flexible manufacturing space with varying utility requirements depending on the technology platform, and available office space. Access to local venture capital and financing, and supporting educational facilities are also important.

1.2.3 Other PV System Components

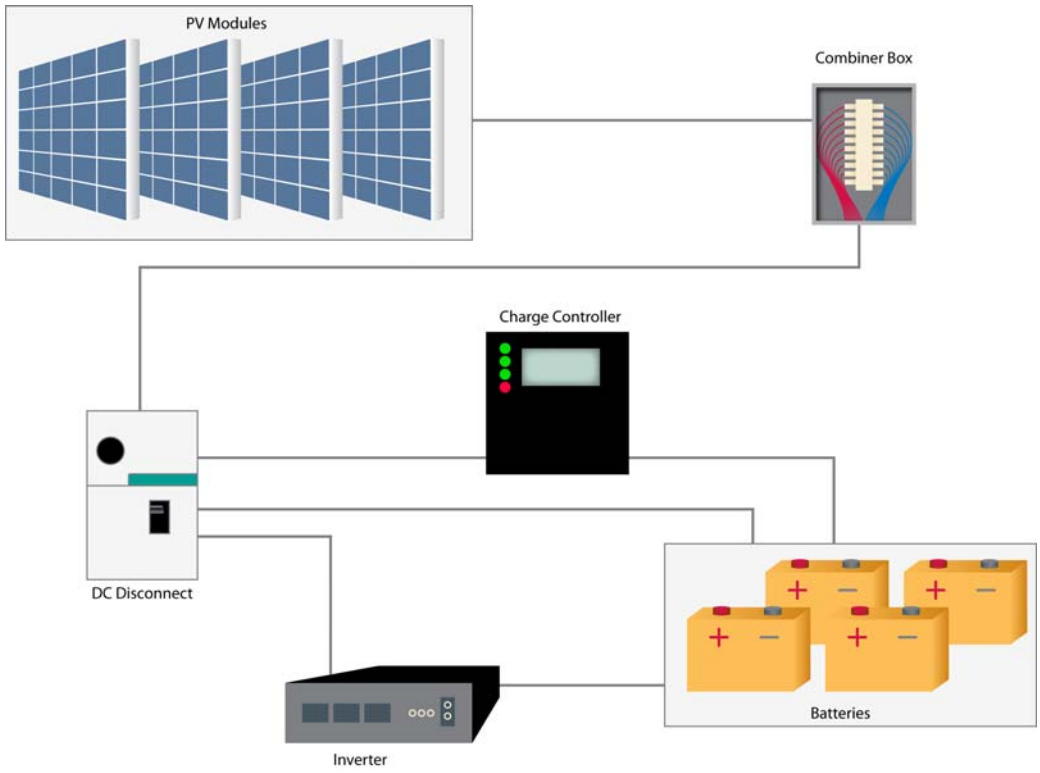
While the PV panel is the workhorse and the bulk of the cost of a PV system, many other components are required to convert sunlight into grid-ready electricity (Figure 9). Mechanical and electrical integration components remain an area of opportunity for manufacturing growth and cost reduction in installed PV systems:

- PV panels are mounted on rooftops or on stands requiring structural braces, brackets, and fasteners.
- In high-performance applications in larger PV arrays, PV systems can track the sun in 1 or 2 axes using complex tracking components.
- Mechanical integrators (Engineering Procurement and Construction (EPC) groups for solar systems) demand cheaper, improved parts that will reduce installation time, provide

installation flexibility and robust mounting (and sometimes tracking) systems with reduced part counts, weight, and system complexity.

- Current mechanical integration components can be overdesigned and overpriced due to lack of standardization for diverse applications.
- Many mounting system designs and components are shipped from overseas adding transportation costs, and can be mismatched to installation conditions in the U.S.

Figure 9. PV System Diagram



PV panels must be electrically connected with other components like inverters, batteries, regulating and monitoring systems (Figure 9).

- Electrical integrators demand high efficiency, cheap, robust, safe, and flexible plug-and-play components.
- Though components must meet certain standards, many are currently tested under unrealistic conditions, and can sometimes not perform to their nameplate capacities or efficiencies.
- There are opportunities to improve lifetimes on inverters, to reduce installation labor by reducing complexity, and to reduce costs of control, interconnection, and monitoring devices.

Mechanically and electrically-integrating solar PV modules into systems not only requires skilled contractors, but also many physical parts and components. These components are opportunities for industrial manufacturing economic development.

1.3 Solar Hot Water

1.3.1 Manufacturing Markets and Supply Chain

There are currently 300 million square meters of (low temperature) solar hot water collectors installed globally, and dozens of manufacturers of these products, especially in China and Europe (see *Appendix D*). Solar hot water systems are installed on about 10% of Chinese households, representing more than 60% of world-installed capacity. The solar hot water market is forecasted to increase in growing markets like the U.S., especially in locations where new, proposed building codes and policies require their use. Globally, solar water heaters reportedly have the energy capacity equal to more than 140 nuclear plants. Global energy from SHW systems far exceeds PV production by a factor of more than 20, competing with the energy capacity of wind, a renewable energy leader.

According to the Energy Information Administration (EIA), many foreign solar companies have been following U.S. solar market investment opportunities, specifically solar hot water. The EIA believes that the U.S. solar thermal market (including solar hot water products) is positioned to significantly expand, and notes that foreign SHW component manufacturers began seriously competing for the U.S. market in 2007, resulting in a more competitive environment for domestic producers.

Figure 10. Annual U.S. Shipments of Solar Hot Water Collectors 1998-2007 from *Solar Thermal Collector Manufacturing Activities 2007*

Annual Shipments of Low Temperature Solar Hot Water Collectors 1998-2007

Year	**Total Shipments** Square Feet	**Average per Manufacturer** Square Feet
1998	7,292,000	607,000
1999	8,152,000	627,000
2000	7,948,000	723,000
2001	10,919,000	1,092,000
2002	10,126,000	856,000
2003	10,877,000	906,000
2004	13,608,000	1,512,000
2005	15,224,000	1,522,000
2006	15,546,000	1,413,000
2007	13,323,000	1,025,000

Source: Energy Information Administration Form EIA-63A "Annual SOlar Thermal Collector Manufacturers Survey

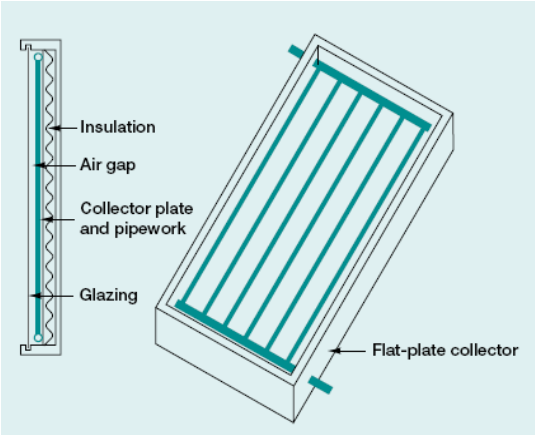
Figure 10 summarizes U.S. manufactured SHW collector shipments by year. There has been an increase in collector imports (see *Appendix D*) entering the markets, and the U.S. forecast for SHW products remains strong.

There are different types of SHW systems, the simplest and cheapest of which are thermo-siphon and batch systems, which are only appropriate for climates where temperatures rarely fall below freezing. These systems require no active components. More complex systems have active controls, pumps, tanks, and various other features to enable their interoperation with conventional hot water systems or space heating systems, and protect them from freezing or overheating. No standard system design has emerged, nor regional system best practices.

1.3.2 Solar Hot Water Collectors

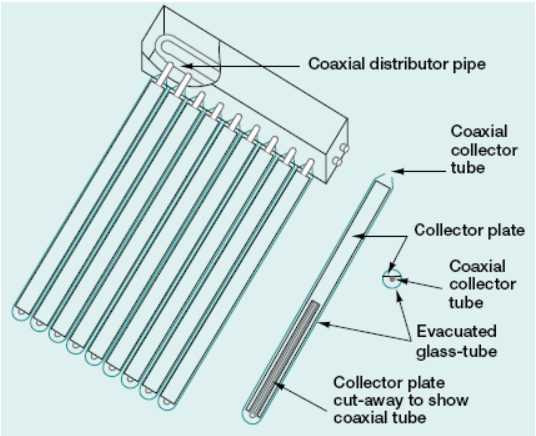
The primary component of a SHW system is the collector. Collectors are typically flat plate, or evacuated tube, each having some different minor and arguable application advantages, but neither providing a better universal solution.

Figure 11. Flat Plate Collector from ukcopperboard.com



Flat plate collectors consist of a metal heat-absorber plate (Figure 11), typically coated with antireflective surfaces for efficient energy absorption, and reduced energy losses through radiation. Heat transfer tubes are attached to the absorber plate, and typically covered by one or two layers of glass separated by an air space to trap heat energy. The air space reduces convective and conductive heat losses. Insulating the back and sides of the collector, as well as the pipes leading to and from the rest of the system, increases the system's efficiency. Efficiencies of flat plate collectors can be as high as 80-95% under ideal conditions.

Figure 12. Evacuated Tube Collector from ukcopperboard.com



Evacuated tube collectors (Figure 12) are constructed from a coaxial circulator tube (tube within a tube) attached to a collector plate inside of an outer glass tube. This outer glass tube is partially evacuated which reduces heat loss and makes tube collectors more efficient for higher temperature applications. Typical domestic hot water applications do not generally require these higher temperatures.

Figure 13. Typical Drain-Back Solar Hot Water System Diagram from www.energygridsolutions.com

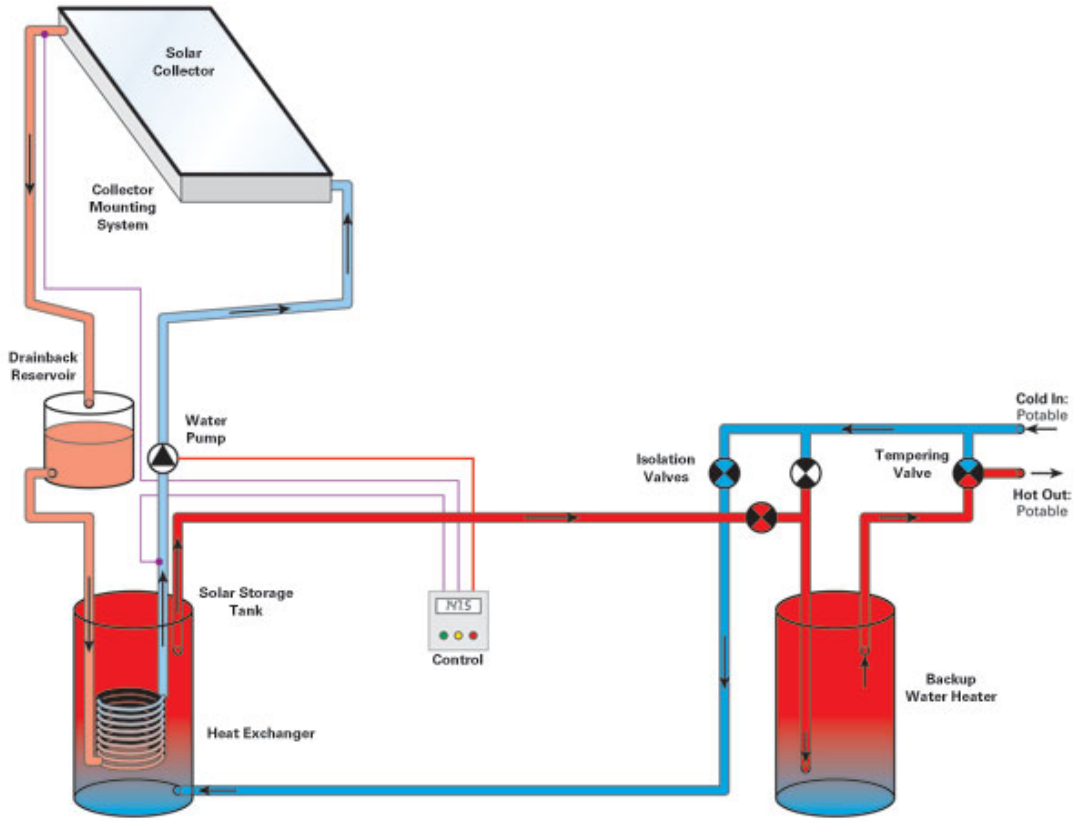


Figure 13 shows the various components and operation of a typical drain-back system, which potentially use either flat plate or tube collectors. The drain-back design is well-suited for Milwaukee and similar areas, but simpler designs are better suited for non-freezing climates. The highest single-value components are the collector and the controller, followed by more commodity products with a few special features like tanks, heat exchangers, valves, pumps, and finally products like fittings, pipes, wiring, fasteners, and connectors.

1.4 A Window of Opportunity

As this sections indicates, the solar industry is expected to grow dramatically in the next 5-8 years as the costs of solar energy becomes competitive with conventional sources in the U.S. (grid parity). This growth in solar products demand will:

- Occur primarily in regions that have high existing energy costs, good solar resources, and good end-use incentives
- Create more need for solar products and manufacturing capacity
- Open new opportunities for Milwaukee to attract new manufacturers and encourage local supply chain participation

To take advantage of this opportunity, the City should invest now in strategic planning and development efforts.

Section 2: Milwaukee Solar Manufacturing Assessment

This section of the document summarizes an assessment of the City's assets and challenges relative to the needs of the solar manufacturing industry. The evaluation factors analyzed have been identified based on CH2M HILL's professional experience working with solar products companies.

2.1 Milwaukee's Manufacturing Base

Milwaukee has a long history of manufacturing beginning with steel production and the industrialization of the United States. Milwaukee entrepreneurs built some of the first foundry, machinery and metal working businesses. Early Milwaukee manufacturing included iron rails for railroads, iron pipe for water systems in Milwaukee and Chicago, and heavy machinery for capital-intensive industries such as mining, transportation, and power generation. The Milwaukee manufacturing base focused on skilled labor to turn raw materials into high quality finished products. This allowed the City's businesses to be early leaders in manufacturing.

Like many other cities in the Midwest, Milwaukee has not maintained high growth in its conventional manufacturing base. Facing these losses, Milwaukee is now pushing for growth into engineering, technology-based manufacturing, and research and development. A few examples of large Milwaukee-area manufacturing companies can be found in *Appendix M*.

The Milwaukee area is also home to several large manufacturing and technology companies that could be valuable resources for research, development, and partnerships for economic growth, including companies with specialties in welding, assembly, and fabrication. These companies have the potential to be involved in production of solar product hardware, frames, mounting systems, tracking systems, and plumbing fixtures and fittings. Additionally, there are Milwaukee manufacturers that produce control systems, inverters, and electronics. These companies may have only small changes to make to target solar products. Cardinal Glass is located in Wisconsin and has already started up a solar technology spin off that intends to provide glass for either PV or solar hot water panels, and in the future, begin to offer high-value specialty PV coatings on their glass. Numerous plastic injection molding companies in the area also have the potential to create improved, lower cost solar products.

Milwaukee's historical manufacturing base is very similar to the requirements to build many solar products. The City can leverage its history to attract and grow solar products companies by understanding the following solar products manufacturing issues, comparing Milwaukee's attributes and manufacturing capabilities, and making the necessary adjustments.

2.2 Solar Products Manufacturing Requirements

The following sub sections review some of the critical location factors for solar products manufacturing, including a brief comparison of Milwaukee to areas that have been successful in attracting or developing these facilities. These competitor areas have not been identified to preserve confidentiality between some competing interests in the various cities and regions in the SAC program receiving technical assistance through CH2M HILL.

2.2.1 Solar Products Manufacturing Initiatives

The most successful regions in solar products manufacturing have strong supporting policies and strategic initiatives specifically to attract or grow solar manufacturing facilities. They proactively

market to companies and are heavily invested in creating an overall solar industry-friendly environment. The solar industry is looking for this type of comprehensive commitment as a critical location factor.

The Milwaukee area is in the early stages of developing a strategy to encourage development of solar products manufacturing. It is not one of Milwaukee 7's target industries or currently a focus of the City of Milwaukee for economic development. While the efforts of the Milwaukee Shines program could provide the basis for an expanded commitment and initiative for solar products manufacturing, extended, visible and proactive support for solar manufacturing will be required for Milwaukee to successfully participate in the growth of this industry.

2.2.2 Base of Similar Technology Businesses

The initial rounds of solar products manufacturing investments have gone to areas that have a concentration of companies using similar technologies (for PV, semiconductors). Advanced manufacturers of solar products will look for an environment with existing research and development programs and facilities, technology workers, and existing technology manufacturers. Technology driven manufacturer's pilot and first large scale facilities will continue to locate in areas with an existing and similar base of technology. However, as they add production with subsequent facilities, lower costs and process maturity will allow them to find new locations.

Milwaukee has a core group of technology-based companies relevant to SHW products and PV system components. Milwaukee does not have a core history in semiconductors, which is a disadvantage for growing or attracting integrated PV panel manufacturing.

2.2.3 Solar Products Research and Development

Companies that are searching for locations look for proximity to research and an innovation culture. Although much of the relevant PV research is occurring in California, manufacturing investment is limited there due to high costs. Several companies have located in the West and Southwest U.S. to be near research and innovation centers.

Milwaukee is not in close proximity to research centers in California or the West and this study did not reveal any relevant local public or private solar research projects. The proposed expansion of solar research activity by the three Milwaukee area universities could be an important step in overcoming this disadvantage.

2.2.4 Electricity Availability and Costs

Energy costs and availability are primary drivers for the solar products industry supply chain for essential materials such as glass, copper, aluminum, and polysilicon. They are also primary drivers for PV wafering and cell processes for C-Si and for most TF processes, and for any integrated solar PV manufacturing facility. Integrated PV factories require 5-50MW and sometimes up to 150 MW. Certain areas of North America that are aggressively pursuing large integrated PV factories have offered power as low as $0.03 per kWh with many locations offering between $0.06-0.08 per kWh.

Energy costs and availability are not driving factors in many other solar product process steps, like PV module assembly, inverter and power distribution and regulation electronics, SHW collector manufacturing, SHW controls, other SHW products, or in system packaging, connector, and mounting systems.

Electric power in the Milwaukee area is provided by WE Energies. With new capacity coming online, WE Energies appears to be capable of supporting the development of most solar products manufacturing facilities. Blended peak and off-peak power rates were reported in the $0.07-$0.08 per kWh range, which should be acceptable for most solar products manufacturing. This low cost of electricity, however, means that Milwaukee is not a primary location for PV installation. Low cost

natural gas, often used to heat water and for space heating, can be cheaper than electricity, and even more difficult competition for solar products adoption.

WE Energies is planning on developing at least 12MW of solar generation capacity in the near future. While WE Energies' intention is to finance and own these plants, it may look to developers to construct and guarantee the price of delivered power. This 12MW demand could provide the opportunity for an "off-take" program with a local solar panel manufacturer (a commitment from a state, city, utility or other entity to guarantee purchase of a certain number of solar panels over time, typically 1-3 years). Some PV module assemblers or integrated manufacturers are asking for these commitments as part of the incentive package to locate a facility in a state or municipality. San Antonio, for example, reported that PV manufacturers were seeking agreements of 20 MW per year for at least three years as incentives.

2.2.5 Proximity to Markets and Transportation

Proximity to end-user markets and transportation costs are not currently critical factors in the location of solar products manufacturing facilities, but they are important and anticipated to become more important with the growing uncertainty of transportation costs.

Local demand can be an important consideration in locating a solar products factory, and local off take agreements and Renewable Portfolio Standards (RPS) are encouraging to manufacturers. Wisconsin has a state Renewable Portfolio Standard goal of 10% by 2015, and surrounding states such as Michigan, Minnesota and Ohio have similar goals (see *Appendix R*).

The reported cost of transportation for SHW collectors, which for shipping purposes should be more significant than PV panels, was a less than 0.05% of wholesale costs. Other higher value components like inverters and power electronics or control systems are not required in the same volume as panels or collectors, and their higher value per unit, per weight, and per volume, makes transportation an equally minor concern. Bulkier, lower added value components, however, like metal mounting systems, tanks, specialty valves, sensors, or specialty glass, may derive some benefit from being close to an excellent transportation infrastructure.

For the City of Milwaukee, other factors will likely dominate decisions to invest in solar manufacturing. Milwaukee's Port provides good access to interstate truck and rail routes and is in close proximity to the industrial prowess and consumer base of the Midwest and eastern U.S. However, as discussed previously, this access is not currently a primary driver for many solar products industries. The benefit of this infrastructure will be seen by some discrete supply chain products that are heavier, required in very large quantities, and relatively inexpensive. The benefit of this transportation infrastructure and proximity to markets will likely become more significant in the near future.

2.2.6 Sites – Land and Facilities Overview

Ideal sites for integrated PV manufacturing are at least 20-25 acres and are "shovel ready". Successful areas have multiple sites up to 200 acres that are certified, and are often pre-permitted and planned specifically for PV manufacturing with appropriate infrastructure and utilities in place or immediately available. Most other solar PV and SHW product components are more flexible in their ability to use existing buildings and smaller sites.

While multiple, large, shovel ready sites may not be immediately available in the City of Milwaukee, many smaller sites and existing buildings are available or could become available, and could be appropriate for smaller supply chain PV manufacturers. For cost reasons, redevelopment opportunities for existing buildings can be attractive options for PV module assemblers and SHW collector manufacturers if the City can help make the properties suitable and available. Other components manufacturing can take advantage of existing building redevelopment opportunities or small parcels because they can operate at small economies of scale, and are not resource intensive.

Currently, the City is a developed urban area with limited vacant industrial land and a mix of older, multi-storied buildings and more modern warehouse/manufacturing facilities. A detailed study of industrial real estate would help to determine suitable redevelopment opportunities for land or buildings, and it would also identify steps needed to prepare the sites for solar products manufacturing.

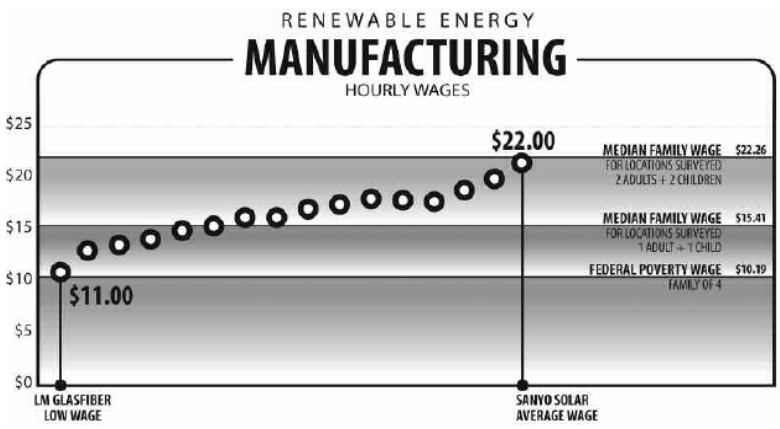
In a cursory review of available vacant sites within the City conducted through the Milwaukee 7's site and building inventory, it was noted that there were very few properties larger than ten acres that were also ready for development. The City is considering the acquisition of large sites but they will require public acquisition, demolition and/or clean up. To successfully compete for certain solar products manufacturing businesses, the City should create and promote sites in this and larger categories, as well as pursue redevelopment opportunities in existing buildings.

2.2.7 Workforce

Both solar PV and SHW manufacturing have similar general workforce requirements as shown in Figure 17. They do, however, differ in the experience requirements for engineers and scientists. Integrated solar PV manufacturing facilities require some portion of their workforce to have high technology experience. Solar hot water can utilize workers that have a more general manufacturing background.

The City has an experienced general manufacturing workforce and there are multiple local training facilities that could train staff for a solar product manufacturing facility. Additional training would likely be necessary to create a pool of high tech workers for there to be a good opportunity in integrated PV manufacturing, but the existing workforce would be very appropriate for other solar products manufacturing operations.

Figure 14. Renewable Energy Manufacturing Hourly Wages from *Component Manufacturing: Wisconsin's Future in the Renewable Energy Industry*



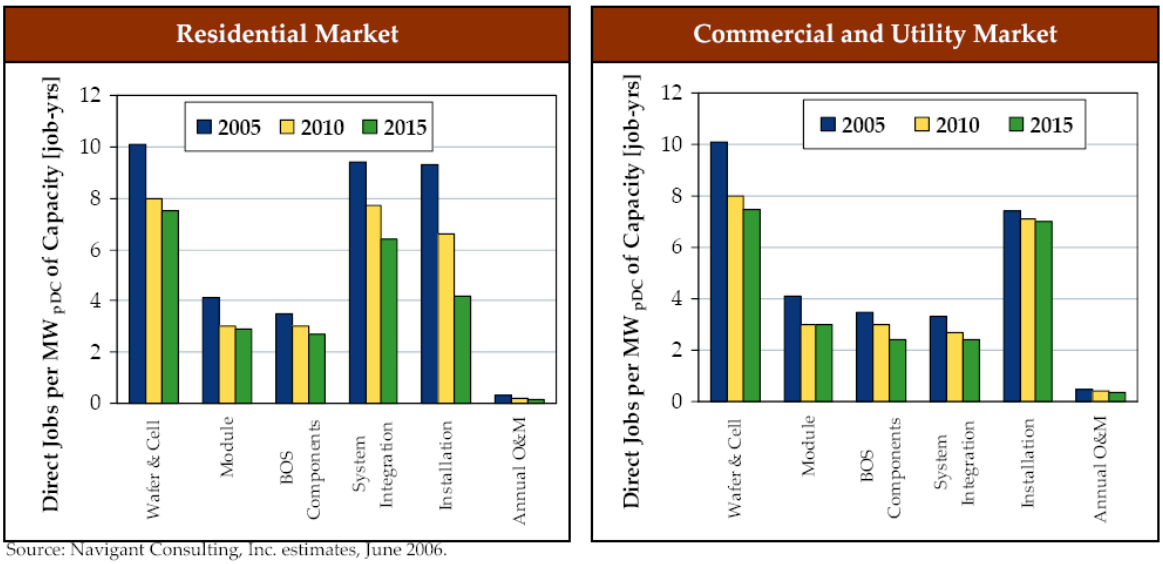
The chart shows how average hourly wages at wind and solar energy manufacturing facilities profiled in this report measure up against two benchmarks: the hourly pay of a full-time worker with a family of four with an income at the federal poverty level; and the median wage required for a full-time worker to meet basic family needs among the renewable manufacturing locations cited in the report. Estimates of basic family needs budgets were provided by the Economic Policy Institute.

Figure 14 shows the range of hourly wages associated with wind and solar manufacturing. Integrated PV manufacturing, while offering the highest average wages, is the most difficult to recruit or grow.

The City has three universities with engineering programs. They have initiated a consortium with the National Energy Technology Lab (NETL) to create the Southeastern Wisconsin Energy Technology Research Center that is reported to have a focus on energy and advanced manufacturing. The University of Wisconsin Milwaukee (UWM) and Marquette University both have plans to build new engineering school facilities and labs in the near future, including the addition of engineering faculty. UWM seems especially interested in pursuing solar research projects and the development of workers

under the energy initiative of its new long term goals. Milwaukee Area Technical Colleges (MATC) is also nearby and is more than capable of training technician-level manufacturing workers.

Figure 15. Direct Jobs per MW Installed PV from Navigant Consulting –*Economic Impacts of Extending Federal Solar Tax Credits* September, 2008



Source: Navigant Consulting, Inc. estimates, June 2006.

Figure 16. Job Multipliers from Navigant Consulting –*Economic Impacts of Extending Federal Solar Tax Credits* September, 2008

PV Employment Economic Multipliers			
Construction and Manufacturin		Operations and Maintenance	
Ratio of Indirect to Direct	Ratio of Indirect to Direct	Ratio of Indirect to Direct	Ratio of Indirect to Direct
1.4	*2.1*	*0.5*	*0.8*

PV Investment Economic Multipliers			
Construction and Manufacturin		Operations and Maintenance	
Indirect to Direct	Indirect to Direct	Indirect to Direct	Indirect to Direct
1.1	*1.3*	*0.7*	*0.9*

Source: S. Grover, "Energy, Economic and Envinronemntal Benefits of the Solar America Initiative" August 2007 NREL/SR-640-41998 Navigant Consulting calculations using IMPLAN regional economic modeling software.

Figures 15 and 16 show that for direct employment and employment multipliers, the greatest number of manufacturing jobs in the solar industry comes from wafer, cell, and module manufacturing activities. These activities also have the highest average wages. The easiest manufacturing industry

segments to grow and attract – i.e., commodity components, have a higher percentage of lower wage and lower skill jobs.

Figure 17.Solar Manufacturing Industry Job Descriptions from Navigant Consulting –*Economic Impacts of Extending Federal Solar Tax Credits* September, 2008

Solar Industry Jobs Titles, Skillsets, and Educational Backgrounds	
PV MFG Jobs	**SHW MFG Jobs**
Manufacturing	**Manufacturing**
Factory Worker	Sheet Metal Worker
Technitian	Technician
Material Handler	Material Handler
Factory Supervisor	Factory Supervisor
MFG Engineer	MFG Engineer
MFG Manager	MFG Manager
Quality Assurance	**Design**
Chemical / Process Engineer	Material Science
Design	Mechanical Engineer
Material Science	**Admin / Support**
Electrical Engineer	Purchasing
Admin / Support	Quality Assurance
Purchasing	Health and Safety
Director	Accounting
Health and Safety	Assistant
Accounting	IT Professional
Assistant	
IT Professional	

As seen in Figure 17, the workforce requirements for PV and SHW manufacturing operations are very similar. This suggests that workforce training programs can be developed with both markets in mind.

2.2.8 Incentives for Manufacturing

Incentive programs are major criteria for the attraction of solar manufacturing facilities. Incentives will continue to be important as prices are driven down, costs of operations are reduced, and margins are squeezed. Successful areas have aggressive programs with many of the following features:

- Cash grants and low cost loans
- Investment tax credits that can be monetized to provide investment capital
- Multi-year property and other tax abatements
- Other programs that provide cash or cash equivalents
- Funding for research programs and partnerships in solar product development and improvement

Existing Manufacturing Incentives Available in Milwaukee

The State of Wisconsin and the City of Milwaukee have incentive programs that can be used to attract or grow industrial businesses. Many of the incentives are targeted to specific areas but the City seems flexible in working with job creating companies to accommodate their needs. Incentives identified that appear to have the most benefit for solar products industrial users are described below.

City of Milwaukee Manufacturing Incentives

- *Tax Increment Financing (TIF).*TIF districts can be formed around the site of a proposed new business. Districts generally provide funding for public improvements, environmental remediation, site improvements, and grants for fixed assets acquisition or construction. Funding is provided up front and paid back by the incremental property tax increase on the property created by the new development. Proceeds are made available to the business through a forgivable loan.
- *Renewal Community Incentives.* Federal designation of Renewal Community Area in some sections of the City can provides federal tax benefits. $1,500 annual federal income tax credit on wages for new and existing employees that live in the designated area. Accelerated depreciation on real estate from 39 years to 10 years. Enhanced capital gains treatment.
- *New Markets Tax Credits.* Two methods are used for eligible projects: the Rate Reduction Method, with a contribution to the project using credits to reduce conventional financing rates by up to 4 percentage points for a period of 7 years, and the Equity Method, where the sale of credits to raise approximately 25-27% of the cost of a project is lent to the project at a rate of 0.5-1% interest only for a 7 year term. At the end of the term a substantial portion of the debt can be forgiven.
- *Local Demand Side Incentives Indirectly Encourage Manufacturing Investment.* Local installation incentives and financing mechanisms, like those available from and encouraged by Focus On Energy, are indirectly beneficial to local manufacturing, specifically those that reduce upfront costs to end-users. While local markets do not appear to be substantial enough to fully support large scale local manufacturing in the short term, they can be politically and emotionally important.

State of Wisconsin Incentives

- *Property Tax Exemptions.* Machinery and equipment used in manufacturing, computer hardware and software, and inventories are exempt from property taxes.
- *Sales and Use Tax Exemptions.* Manufacturing equipment and consumables, pollution control equipment and electricity, and other fuels used in production are exempt.
- *Development Zone Tax Credits.* For projects creating new jobs, income tax credits are provided for income over $30,000 and can be used over 10 years. These credits are refundable within an Enterprise Zone.
- *Brownfield Remediation Grants.* Grants of up to $1,250,000 for acquisition, demolition, and environmental remediation of brownfield properties are available and require a 50% private match.
- *Wisconsin Energy Independence Fund*. $150 million, 10-year loan and grant program to support cutting edge research and development (R&D), manufacture of new clean energy products, and ways to make clean energy use widespread and cost effective.

Incentives focused on assistance in job training and infrastructure improvements to make sites shovel ready are expected, and not a differentiator.

Although Milwaukee and Wisconsin offer incentives including grants, low cost loans, and tax credits, they do not appear to be on the scale of other areas that are successfully attracting the best integrated PV manufacturing facilities. Other areas are more aggressive in providing grants, tax exemptions, and tax holidays, and are highlighted in Figure 18.

Figure 18. Examples of State Subsidies to Attract Solar Products Manufacturers from *High Road or Low Road? Job Quality in the New Green Economy* and CH2M HILL

Company	State	Workers	Investment	Subsidies	Subsidy per Investment	Subsidy per Job
AE Polysilicon	PA	145	$ 70,000,000	$ 8,200,000	12%	$ 56,552
Evergreen Solar	MA	700	$ 165,000,000	$ 44,000,000	27%	$ 62,857
Evergreen Solar	MI	100	$ 55,000,000	$ 5,700,000	10%	$ 57,000
First Solar	OH	834	$ 71,500,000	$ 20,960,000	29%	$ 25,132
Flabeg Solar	PA	300	$ 30,000,000	$ 9,000,000	30%	$ 30,000
OptiSolar	CA	1000	$ 600,000,000	$ 20,000,000	3%	$ 20,000
Sanyo Solar	OR	200	$ 80,000,000	$ 26,985,000	34%	$ 134,925
Schott Solar	NM	360	$ 105,000,000	$ 17,000,000	16%	$ 47,222
Solaicx	OR	66	$ 56,000,000	$ 21,500,000	38%	$ 325,758
Solar World	OR	1000	$ 440,000,000	$ 41,000,000	9%	$ 41,000
Suniva	GA	100	$ 75,000,000	$ 10,000,000	13%	$ 100,000
United Solar Ovonic	MI	350	$ 260,000,000	$ 96,900,000	37%	$ 276,857
United Solar Ovonic	MI	400	$ 126,000,000	$ 37,000,000	29%	$ 92,500
Xunlight	OH	160	$ 52,000,000	$ 14,900,000	29%	$ 93,125

2.2.9 Other Factors

Overall Cost of Operations

In general, solar products manufacturing is dominated by the cost of raw materials. For PV panel products, this includes primarily raw silicon (subject to boom and bust commodity pricing) and its derivatives, and depreciation of up front capital for manufacturing equipment and facilities. Other significant PV panel manufacturing cost variables include glass, labor, and electricity. Selecting an automation scheme in PV panel production can shift costs between capital costs and labor. For PV products other than panels, mounting systems are dominated by metals costs, while inverters and electrical gear are dominated by the cost of materials in the form of electrical components and some assembly labor or automation systems. Power distribution and regulation electronics manufacturing must also recoup R&D costs, which can be considerable for a new product.

Solar hot water product manufacturing is much less technology intensive than PV products, as SHW systems are based on lower tolerance and lower purity materials. Solar hot water collector manufacturing costs are dominated by raw materials including copper, aluminum, steel, glass, and their forming and joining processes. Historically, typical SHW collector manufacturing has been performed on smaller scales using a considerable amount of manual labor. In the future, as demand justifies larger facilities, the industry has an opportunity to leverage economies of scale in materials and processes, including increased automation.

Solar hot water system controller production costs are dominated by the cost of components and recouping any R&D expense in product designs. Other components like pumps, valves, mounting systems, fittings, and tanks are typically manufactured similar to their counterpart commodity products, sometimes with a few specific SHW system features. These components are usually produced in high volume for multiple industries.

The City of Milwaukee's cost of operations for solar product manufacturing seems to be reasonable in the U.S. For solar manufacturers driven by inexpensive energy, extremely high volume production, or low cost labor, the City will have to invest to be competitive. For other products or manufacturing processes with business drivers or scales of operation where these drivers do not dominate decisions, Milwaukee should be competitive within the U.S.

Water Infrastructure

Water is not a critical factor for most solar products manufacturing facilities, as most regions can supply water and wastewater requirements for the solar products manufacturing industry. However, water costs can provide some minor regional advantages depending on manufacturing technology.

The City of Milwaukee operates two drinking water plants through the Milwaukee Water Works that provide water for residential, industrial, commercial, and public utility users. Both treatment plants use Lake Michigan as their source water. The combined treatment capacity of multiple plants is 380 mgd. In 2006, the average water demand was 115 mgd and the maximum water demand was about 230 mgd. With the demand being significantly less than the combined capacity of the treatment plants, it appears that Milwaukee has capacity to support the development of solar products industries.

The Milwaukee Water Works provides retail and wholesale water service to 15 communities in southeast Wisconsin, and to many large commercial customers. Due to water conservation and decreased manufacturing in Milwaukee, industrial water use has dropped by approximately 34 percent between 2002 and 2006 and the total water demand (including residential and commercial) has dropped by approximately 11 percent.

The Milwaukee Water Works rates are lower than the national average. According to the EPA, the average price for 1,000 gallons of water is slightly more than $2 (USEPA 2004). In 2006, the average price for 1,000 gallons of Milwaukee water was approximately $1.63.

Water availability and rates should not constrain any solar products manufacturing growth in the Milwaukee area. Solar products manufacturing water requirements vary widely, but only a large-scale, fully integrated PV facility or primary materials fabrication facility have significant water demands.

2.3 Comparison Matrix

Figure 19. Milwaukee Comparison Matrix for Selected Variables

MILWAUKEE COMPARISON MATRIX

CRITERIA	Milwaukee	State A	State B	State C
Solar Manufacturing Initiatives				
Base of Tech Businesses				
Solar Products R&D				
Electricity Availability & Costs				
Proximity to Markets				
Sites - Land and Facilities				
Workforce				
Incentives for Manufacturing				
		Good	Fair	Poor

Figure 19 is a comparative matrix that summarizes the City's competitive position on critical factors compared with other areas that have been successful in attracting solar manufacturing facilities. The criteria used are not a comprehensive site selection list but include key factors that are currently considered important for investment. These criteria are discussed in Section 2.2 above. Competing areas have not been identified to preserve confidentiality among cities and regions receiving assistance from the SAC program and CH2M HILL.

As shown in Figure 19, Milwaukee has several challenges to overcome to compete in attracting new solar products businesses, but these challenges are not insurmountable. Some investment and effort is required by the City to shift Poor (red) grades to Fair (yellow), and Good (green), to effectively compete with other successful solar products manufacturing regions. Poor, Fair, and Good ratings in Figure 19 are relative to a theoretical best case based on a combination of ideal programs from multiple states, and not based on thorough quantitative analysis.

Section 3: Milwaukee Local Interviews

In evaluating Milwaukee's options for developing a solar products manufacturing cluster, CH2M HILL studied existing research and market reports, and conducted a series of interviews with City officials, economic development professionals (shown in no particular order in Figure 20), the local power utility, two universities, and various local businesses. The information gathered from these sources was then measured and balanced with our experience in solar manufacturing planning, siting, and design. Interview participants were selected by the City based on their relevant experience and market involvement.

Figure 20. Interviewed Milwaukee Stakeholders

Johnson Controls
• William T Guiney, Program Manager, Renewable Energy Solutions – Building Efficiency
RES Manufacturing Company
• John Wittmann, Vice President – Sales and Marketing • Scott Budnowski, Market Development Manager • Steve Pankowski, Manufacturing Manager
Caleffi Hydronic Solutions
• Rex Gillespi, Director of Marketing
A.O. Smith Corporate Technology Center
• Stephen Memory, Director, Thermal and Mechanical Technology • Janice Fitzgerald, Principal Engineer, Thermal and Mechanical Technology • Dennis Hughes, Engineering Fellow, Thermal and Mechanical Technology
WE Energies
• Carl Siegrist, Solar Programs Manager, Renewable Energy Strategy • Jessica Thibodo-Johnson, Renewable Energy Specialist, Advocacy and Energy Options
Hot Water Products
• Gregory Daniels, Vice President, Kurt Koepp & Aaron Adler
University of Wisconsin Milwaukee
• Michael R Lovell, Dean, College of Engineering and Applied Science • David Yu, Associate Dean, Graduate Programs, Electrical Engineering and Computer Science
Marquette University
• Stanley Jaskolski, OPUS Dean of Engineering • George Corliss, Professor Computer Engineering
City of Milwaukee & State of Wisconsin Representatives
• Ann Beier, Director, Environmental Sustainability, Department of Administration • Andrea Luecke, Project Manager, Milwaukee Shines, Office of Environmental Sustainability • David Misky, Assistant Executive Director, Department of City Developemtn • Dan Casanova, Senior Economic Development Specialist, Redevelopment Authority • Mathew Haessly, Reas Estate Specialist, Department of City Devlopment • Mary Perry, Area Development Manager, State of Wisconsin Department of Commerce
Focus On Energies
• Niels Wolter, Program Manager, Renewable Energy Program
Milwaukee 7
• Jim Paetsch, Director Corporate Relocation, Expansion, and Attraction

3.1 Interview Themes

The following themes appeared in our interviews:

- SHW collector manufacturing in Milwaukee is a good opportunity. Current best practices for collector design and assembly are from Europe. Only a few companies exist in the U.S. and their quality and competitiveness is good, but could still be improved.
- There is general interest in a regional group around solar products manufacturing. No single leader or champion was identified, but it was recognized that one is needed.
- University participation in solar manufacturing and installation projects would be a great asset. A solar products testing and analysis lab could be valuable, but it would need to be differentiated from other existing, similar labs.
- Wisconsin is better suited to pursue SHW products and installations over PV, based on existing local businesses, local materials expertise, and easier cultural acceptance.
- A successful solar products cluster should consider regional southeast Wisconsin development efforts, such as those coordinated by Milwaukee 7.

3.2 Other Important Milwaukee Area Stakeholders

Many other relevant groups exist in and around the Milwaukee area. Identification and continued collaboration with these groups will be important, and their input should not be overlooked, however, schedules and time constraints prohibited formal interviews over the course of this study.

Section 4: Solar Manufacturing in Milwaukee: Conclusions, Opportunities, and Suggestions

This section is a summary of the findings from the analysis which are compiled from interviews, review of published data and information, and CH2M HILL knowledge and experience in the solar industry. These findings are not listed in any order of importance.

4.1 Milwaukee Analysis

- There appears to be significant interest in development of solar manufacturing by Wisconsin and Milwaukee-area business and government entities. However, at this point, there is not a consolidated focus.
- Transportation and access to markets for manufactured product in Milwaukee is good with port facilities and good highway and air service. Although transportation costs are not a critical factor today, it is expected that the importance will increase as transportation costs increase in the future.
- Wisconsin and neighboring states have Renewable Portfolio Standards that will positively influence local demand.
- Electric power costs and availability are important to integrated large scale PV facilities. WE Energies appears to have sufficient present and future capacity for these developments. Rates are in the mid to low-range compared to many competing locations if a facility can take advantage of local off-peak or blended rates. However, rates appear to be higher than the least expensive areas that have been successful in attracting large scale integrated solar PV products manufacturing.
- The commitment by WE Energies to purchase and install at least 12 MW of solar generation is positive as it will raise the visibility and potentially create a market for locally produced modules.
- Although water is not a significant factor for most solar manufacturing, it is an area where the City is in a good competitive position.
- The cost of operations for a solar products company should be generally good compared to competing locations in the U.S. However, Milwaukee will have challenges competing for or growing solar products manufacturing at scales or in specific processes that are driven heavily by energy or low cost labor. A more detailed investigation should be completed for specific cases.
- There is good potential to build on university and technical college resources in the City and focus these resources on the solar products industry for product development, testing, and worker training. The planned collaboration between local area universities could be advantageous if there is focus on solar products.
- Availability of ready-to-develop land and buildings is a critical requirement. This will become more important as the economy recovers and companies look to establish facilities to capture the expected growth in the solar products market. Through interviews with the City and a review of the published inventory at the time of this report, CH2M HILL identified:
  - Few (16) sites available over 10 acres with many appearing to need significant investment before they are suitable for industry needs (from Milwaukee 7).
  - Three large sites up to 60 acres (from discussions with the City) that could be redeveloped to accommodate a large user. These sites appear to require heavy investment and extended development time to be suitable.

  - Developable sites in the Menomonee Valley industrial area under 10 acres appear to be good opportunities. There are other smaller sites scattered throughout the city but more specific research will be required to determine if these sites are suitable and how much investment would be required to make them ready.
  - Multiple available buildings, some single story and appearing suitable, and many multi-story that are not an ideal fit for many solar products manufacturing are available and opportunities for redevelopment.

- With the lack of available development capital in the market today, incentives are increasingly important. The City of Milwaukee has grants, low cost loans, and tax credits available that might be specifically targeted at solar products industries. However these incentives are lower in dollar values than many states and regions aggressively attracting these industries and jobs

4.2 Milwaukee Strengths and Challenges

As a result of our analysis, strengths and challenges for expanding the City's opportunity to participate in the solar products industry have been developed. The evaluation is based on comparing the basic requirements of manufacturers in the industry with the attributes of the City.

4.2.1 Strengths

- Existing manufacturing and engineering base
- Skilled manufacturing work force
- Applied research focus of universities
- Engineering programs within the cities three universities
- Abundant, high quality water supply
- Competitive electricity rates
- Transportation and distribution channels and facilities
- Public and private entities appear to be enthusiastic and supportive of creating solar product manufacturing jobs
- A few existing Milwaukee area companies already involved in parts of solar product supply chains
- WE Energies commitment to developing solar generation

4.2.2 Challenges

- A focused solar initiative and visible commitment will be needed to be successful in both the attraction of new investment and growth of existing companies.
- Historically, the Milwaukee area has not been visible in the solar industry as a place committed to solar energy.
- The Milwaukee area should invest to create and promote available sites and buildings that meet the requirements of the industry. Certifying the sites will also provide a competitive advantage when manufacturers are comparing multiple locations.
- The City of Milwaukee should develop a larger incentive program that meets the needs and expectations of the industry.

4.3 Solar Product Manufacturing Opportunities

- Milwaukee has existing companies that are already participating in the distribution, packaging, and installation of solar products, but not directly in manufacturing. Milwaukee has large companies headquartered in the City manufacturing solar products elsewhere. These small and large companies provide opportunity to expand participation throughout sectors in the supply chain or help to attract new companies.
- With the City's strength and expertise in metals manufacturing and a skilled work force, it appears that the most immediate opportunities are in the areas of:
  - Manufacturing of fittings and valves for solar hot water systems
  - Forming and assembly of frames for both PV and SHW
  - Manufacturing of mounting systems for both PV and SHW
  - Manufacturing of tracking systems for PV
  - Manufacturing of tanks for SHW systems for specialty and high performance applications
- The City's strength and experience in electronics creates related opportunities that include:
  - Controllers for SHW systems
  - Inverter and charge controllers for PV systems
- Although the City is not ideally suited for integrated large scale PV panel manufacturing, smaller scale manufacturing operations for these products or SHW products are feasible, are highly visible commitments to the solar industry, and should be considered to raise awareness of opportunity within the community.

4.3.1 The Most Immediate Opportunities and Methods

Based on the local profile of manufacturing capabilities, SHW products manufacturing—specifically collectors or controllers—are likely the most immediate opportunity for the City. This opportunity could be explored through multiple pathways:

- Growth of an existing local company (possibly a SHW product distribution or packaging operation) into SHW products manufacturing
- Introduction of a new local SHW products factory by a company not currently located in the City
- Forming of a new SHW products manufacturing company

These options could apply to multiple SHW products, including, but not limited to collectors, control systems, mounting systems, tanks, fittings and connectors, sensors, and metering equipment.

Additionally, some parts of the PV supply chain might be a good fit for the City. The fastest actionable PV opportunity is likely module assembly. Beyond module assembly, power distribution and regulation electronics, and mounting systems/trackers are good candidate opportunities for the City to encourage.

To enable and encourage these developments, the City should act quickly, as competing locations are also looking to capitalize on recent and forecasted growth patterns and trends in demand for solar products.

Section 5: Next Steps

5.1 Commit to the Solar Products Industry

Before any outreach or marketing activities begins, the City should make a solid, public commitment to developing a local solar products industry backed by real programs and funding. If the City creates a focus on the solar products manufacturing industry it should consider the following actions:

5.1.1 Commit Resources and an Outreach and Marketing Program

The City should make the commitment to contract a solar products manufacturing industry expert, program manager, or champion dedicated to the Milwaukee area. The role of this person should be to oversee the following activities:

- Create a working group of Milwaukee businesses and stakeholders in solar products manufacturing, taking cues from the successful organization of the M7 Water Council. Organize, educate, support, and assist the group to promote the solar products industry.
  - This group should consist of industry, governmental, non profit and education leaders that have an interest in growing the solar products industry and can guide this process.
  - Each member should have real investment in the potential success of the initiative. The working group should be focused on real results, and willing to commit resources and time, not just go to meetings, and include regional interests
  - This group should be business-led and business-focused
- Assemble this working group to discuss and create a list of opportunities, and prioritize them. The working group should then develop initial plans for the best potential opportunities and give feedback to the City, economic development entities, and local businesses on how they can best contribute
- Develop a good information kit about the existing and desired commitment to solar and how this commitment contributes to the local business opportunities. This kit can address solar product company's needs and the qualities that make Milwaukee attractive
- Interact and assist various City departments, economic development entities, and local businesses in the promotion and development of solar manufacturing for the region

5.1.2 Take Actions to Improve the Milwaukee Product

The City needs to take certain steps to improve its offering to the solar product industry. The primary steps needed are the following:

- Develop sites and or buildings specific to the needs of solar products manufacturers. A study of available buildings of appropriate size, infrastructure, and with resolved development challenges would demonstrate a commitment and focus to develop solar industries
- Develop a specific incentive program targeted directly to solar products companies and their needs (an off-take program, tax holiday, etc)
- Develop training, higher education, research, and partnering programs focused through local universities and technical colleges
- Develop a competitive and quantitative set of materials to present Milwaukee as a great place to manufacture solar products, leveraging Milwaukee's strengths, and addressing its challenges
- Improve the City's image as a "green" location. Develop best practices for solar product and systems and work to reduce up-front costs of solar systems in the city through innovative financing or leveraging of existing installation incentives.

If the City can commit to these types of activities, and devote the necessary effort to enact these programs and activities as, well as build a local solar products industry, then it should continue with outreach, specific projects, and marketing plans outlined below.

5.1.3 Showcase Projects

Focusing efforts on a few projects that highlight the City's interest in becoming a solar manufacturing center should be coordinated through the working group.

- Although Milwaukee is not an immediately ideal location for large scale PV manufacturing, the City should identify a select few companies and interests and promote a new small scale solar PV or SHW module or collector manufacturing operation within the City. This showcase-type project could focus on the immediate opportunity to produce PV and SHW panels in Milwaukee, and provide a high visibility manufacturing operation.
  - Successful startup of this operation could demonstrate a winning perception of the Milwaukee Shines program and a lower perceived risk for other new solar product manufacturers
- Milwaukee should also assist in the establishment of a high visibility solar installation in the city that will generate discussion and focus attention on solar products. This project or projects is also an opportunity to showcase any developed best practices for the region, and could tie into the opportunity to develop solar generation or a large solar hot water project on an industrial or commercial building.

5.1.4 Marketing to Solar Products Companies

A marketing program targeted at solar manufacturing should begin once the City's solar focus has been established, resources have been committed and necessary steps in improvement have been completed.

1. A first step could be to develop a comprehensive list of potential companies. Appendix O has a list of Solar Rating and Certification Corporation (SRCC) approved SHW collector manufacturers. Appendices P and Q have lists of PV panel manufacturing companies and related PV system components by product types and geographies. These lists are not comprehensive, but are fairly detailed sources that could provide a starting point for recruitment activities. The Solar Energy Industries Association (SEIA) also has additional information, and a wide ranging membership that might be a useful resource in developing local efforts
2. Develop and execute a marketing plan, including:

- Direct company contact with the best prospects. This is the most effective marketing outreach method but also the most time consuming to develop the right contacts
- Attendance at targeted trade shows and solar industry events. This is a generally effective method to meet and interact with companies face to face. Solar Power International is one of the largest and best attended tradeshows in the U.S. and will be held October 27-29th 2009 in Anaheim, California. InterSolar is also an excellent solar industry event held July 14-16th 2009 in San Francisco, California. While 2009's show has already passed, Photon International hosts an excellent trade show in Europe
- Mailings to target companies. Mailings have a very low success rate, but tailored, specific messages followed up with a phone call can make messages effective

In parallel, the City and the working group mentioned under 5.1.1 should:

- Define networking opportunities and presentation opportunities to spread the solar products manufacturing message and goals, and build support at:
  - Local public meetings
  - Community events

  - Local industry groups

- Develop and refine marketing materials, specifically presentation materials, to help working group participants and targeted industries understand the value and their potential return on the investment
  - Fact sheets directed to specific audiences to show the value proposition, the benefit, and the outcomes available
  - Frequently asked questions like “What is next?” and “Where do I go for help?” with a single point of contact for supplying these answers
  - Centralized location for all marketing materials

Milwaukee faces challenges in becoming a solar products manufacturing center. However, if the City decides to commit to developing this industry cluster, leverage its local assets, and invest in building opportunity for solar products manufacturing through the activities suggested in this report, these challenges are manageable, and Milwaukee can compete to create solar products industrial jobs and further solar products manufacturing opportunities.

The solar products manufacturing industry is about to enter a long growth phase and the City has a window of opportunity to begin planning activities, and position itself successfully. If the City can work to get an early win, and establish itself as a solar products manufacturing location, this reputation can grow, and a cluster can start to develop, bringing jobs and expertise to the area. Many cities and regions will compete for these opportunities, and to get this early win, the City will need to be prepared to recruit the right people, commit the necessary funding, and work together for a common goal.

Appendices and Sources

Appendix A: PV Manufacturing Plants and Processes

http://www.solarbuzz.com/Plants.htm

Appendix B: Greening Wisconsin's Workforce

http://www.cows.org/pdf/rp-GreeningWisconsin.pdf

Appendix C: Component Manufacturing: Wisconsin's Future in the Renewable Energy Industry

http://www.repp.org/articles/static/1/binaries/Wisconsin%20Report_Short_2.pdf

Appendix D: Solar Thermal Collector Manufacturing Activities 2007

http://www.eia.doe.gov/cneaf/solar.renewables/page/solarreport/solar.html

Appendix E: Solar Photovoltaic Cell/Module Manufacturing Activities 2007

http://www.eia.doe.gov/cneaf/solar.renewables/page/solarreport/solarpv.html

Appendix F: Economic Impacts of Extending Federal Solar Tax Credits

http://seia.org/galleries/pdf/Navigant%20Consulting%20Report%209.15.08.pdf

Appendix G: Various U.S. Solar Resource Maps

http://www.nrel.gov/gis/solar.html

Appendix H: Various U.S. Incentive Maps

http://www.dsireusa.org/library/includes/topic.cfm?TopicCategoryID=6&CurrentPageID=10&EE=0&RE=1

Appendix I: Solar America Cities Market Evolution

http://www1.eere.energy.gov/solar/solar_america/pdfs/solar_market_evolution.pdf

Appendix J: CH2M HILL Solar PV and SHW Value Chain Discussion

http://www.city.milwaukee.gov/milwaukeeshines/Links.htm

Appendix K: High Road or Low Road? Job Quality in the New Green Economy

http://apolloalliance.org/downloads/gjfgreenjobsrpt.pdf

Appendix L: Milwaukee 7's Next Generation Manufacturing Initiative

http://www.choosemilwaukee.com/upload/documents/NGM%20Initiative%20Apr%2008.pdf

Appendix M: Milwaukee 7's Large Local Manufacturing and Other Businesses

http://www.choosemilwaukee.com/leading_businesses.aspx

Appendix N: M7 Manufacturing Survey Results 2006

http://www.mmac.org/ImageLibrary/M7_Manufacturing_report_8_23_06.pdf

Appendix O: Solar Ratings and Certification Corporation Companies with Certified Products (SHW Collectors only)

http://www.solar-rating.org/participants/participants.htm#acr

Appendix P: ENF Solar PV Panel Companies by Geography and Technology

http://www.enf.cn/database/panels.html

Appendix Q: ENF Solar PV Components Companies by Product Type and Geography

http://www.enf.cn/database/components.html

Appendix R: State Renewable Portfolio Standards

http://www.dsireusa.org/documents/SummaryMaps/RPS_map.ppt