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## Compiled Research & Materials, Appendix K: Economic Impact Potential of Solar Photovoltaics in Illinois

Illinois State University. Center for Renewable Energy

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# Economic Impact Potential of Solar Photovoltaics in Illinois

December 2013



CENTER FOR  
RENEWABLE ENERGY  
*Illinois State University*



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*Photo Source: NREL, Dennis Schroeder*

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# Center for Renewable Energy



Illinois State University established the Center for Renewable Energy, and it received Illinois Board of Higher Education approval in 2008. The Center was initially funded by a \$990,000 grant from the U.S. Department of Energy to research renewable energy, to establish a major in renewable energy at Illinois State and to administer the Illinois Wind Working Group (IWWG). The Center also received a grant from the Illinois Clean Energy Community Foundation to help complete its state-of-the-art renewable energy laboratory.

The Center has three major functional areas:

- Supporting the renewable energy major at Illinois State University
- Serving the Illinois renewable energy community by providing information to the public
- Encouraging applied research on renewable energy at Illinois State University and through collaborations with other universities

## Founding Members:

Founding members include EDP Renewables, Iberdrola Renewables, State Farm Insurance, and Suzlon Wind Energy Corp.

## Support of the Renewable Energy Major:

Many new workers will be needed in the renewable energy industry. To meet the growing demand for trained and educated workers, we have developed an interdisciplinary renewable energy major at Illinois State University. Graduates of the renewable energy program are well-positioned to compete for new and existing jobs.

The Center supports the renewable energy major through:

- Creation of an advisory board of outside experts
- Establishing a renewable energy internship program
- Bringing renewable energy experts to campus for seminars for faculty and students
- Funding scholarships to ensure high quality students in the major
- Providing ongoing financial support for the major

For more information about the Renewable Energy Undergraduate Major, please visit <http://tec.illinoisstate.edu/renewable-energy/>.

# Executive Summary

Illinois has great potential for job growth and economic impact from future solar installations. Currently ranked 24th in total installed solar PV capacity, Illinois has three utility-scale solar farms in operation: Exelon City Solar is a 10 MW installation on the south side of Chicago; Grand Ridge Solar Farm is a 20 MW installation near Streator, IL; and the Rockford Solar Farm is a 3 MW installation near the Chicago Rockford International Airport.

In a previous Center for Renewable Energy report titled, *Technical Potential for Solar Photovoltaics in Illinois* and a companion published paper (Jo et al., 2013), the authors examined three key research questions by examining hourly demand data supplied by the two transmission organizations (MISO and PJM) in the state. Depending on how technical potential is measured, we estimate the technical potential by 2030 for Illinois of 2,292 MW; 2,714 MW; or 11,265 MW.

In the present study, we seek to examine the jobs and total economic impact of the three technical potentials derived in the previous report. Table ES1 shows that the employment impacts during the construction period vary from 26,754 to 131,779 job years.

Table ES1 – Total Illinois Employment Impacts During Construction (job years)			
	Percentage Manufactured in Illinois		
Technical Potential	0%	5%	10%
2,292 MW	26,754	26,783	26,812
2,714 MW	31,680	31,714	31,749
11,265 MW	131,494	131,637	131,779

Table ES2 shows the ongoing operations and maintenance jobs that will result under each scenario. The employment impacts during the operating years vary from 1,223 to 6,010.

Table ES2 – Total Illinois Employment Impacts During Operating Years (job years)	
Technical Potential	
2,292 MW	1,223
2,714 MW	1,448
11,265 MW	6,010

In order to achieve these jobs impacts from these technical potential scenarios, Illinois must encourage the development of a robust PV supply chain within the state's borders and enact policies similar to other states that have experienced greater growth.



Photo Source: Illinois Department of Commerce and Economic Opportunity

# 1. Introduction

Solar energy in the form of photovoltaics (PV) has grown rapidly in the United States and in other countries. Both residential PV systems and utility-scale installations have experienced considerable growth. According to the National Renewable Energy Laboratory (NREL), as of April 2012, there were 42 utility-scale solar systems operating in the U.S. and another 161 systems under development (NREL, 2012). Including all types of photovoltaics, the U.S. installed approximately 2,320 MW of grid-connected solar PV capacity in 2012, a 33% increase over the 2,047 MW installed in Q1 2012 (SEIA, 2013), (SEIA, 2012). Between 2012 and 2013, the cumulative installed capacity grew from 5,161 MW to 7,962 MW (SEIA, 2013), (SEIA, 2012). Although this growth rate is impressive, the U.S. has begun to lag behind a number of other developed countries in newly installed capacity of solar PV.

New Jersey, Arizona, and California are the top three U.S. states for utility-scale solar PV installations. Illinois ranks 24th in total installed solar PV capacity as of the first quarter of 2013, dropping from 14th in fourth quarter 2012 (see Table 1.1 – Q1 2013 State PV Rankings). The reason Illinois has fallen behind is that no large solar installations have been brought online in the last year. As of November 2013, Illinois has three utility-scale solar farms in operation: Exelon City Solar is a 10 MW installation on the south side of Chicago; Grand Ridge Solar Farm is a 20 MW installation near Streator, IL; and the Rockford Solar Farm is a 3 MW installation near the Chicago Rockford International Airport.

In a previous Center for Renewable Energy report titled *Technical Potential for Solar Photovoltaics in Illinois* and a companion published paper (Jo et al., 2013), the authors examined three key research questions: First, given the current solar carve-out of 6% specified in the state's Renewable Portfolio Standards (RPS), how many megawatts of PV capacity must be installed by 2025 to meet the requirement? Second, can Illinois fully utilize all of the solar energy that will be produced as a result of the 6% carve-out without wasting a portion of the generated electrical energy? If so, then what is the maximum amount of PV capacity that could be installed in Illinois while maintaining 100% utilization of the energy that is produced by the systems? Third, how much of Illinois' electrical energy could PV supply if curtailment of the PV output is occasionally permitted? For this analysis, curtailment was allowed at a rate equal to the typical internal energy consumption at thermal generation facilities.

In the present study, we seek to examine the jobs and total economic impact of the three technical potentials derived in the previous report. Further, we seek to examine the existing and potential PV supply chain in the state of Illinois. Finally, we seek to examine the state policies in Illinois and other states to see what policies Illinois can adopt in order to increase the impact of PV on Illinois jobs.

The remainder of this report is organized as follows: Section 2 reviews the existing literature of jobs and economic impacts from solar energy. Section 3 briefly describes the main results from our previous study



that will be the basis for the economic impact analysis presented in this report. Section 4 will review the methodology and the Jobs and Economic Development Impacts (JEDI) software developed by NREL. Section 5 will show the main results of the analysis and Section 6 will describe the existing PV supply chain. Section 7 will provide an overview of existing solar policies in Illinois and other states and provide policy recommendations for the state of Illinois. Appendix A lists a comparison of solar energy projects in Illinois versus leading solar states. Appendix B reports the Illinois manufacturers in the solar energy supply chain.

**Table 1.1 – Q1 2013 State PV Rankings**

State	Rank (Q1 2013)	Rank (2012)
California	1	1
New Jersey	2	3
Hawaii	3	7
Arizona	4	2
North Carolina	5	6
Massachusetts	6	5
Tennessee	7	15
Colorado	8	13
Pennsylvania	9	11
Florida	10	18
Ohio	11	17
Missouri	12	24
New York	13	10
Vermont	14	21
Minnesota	15	25
Georgia	16	23
Maryland	17	8
Texas	18	12
Oregon	19	16
Connecticut	20	22
Washington	21	26
New Mexico	22	19
Wisconsin	23	28
Nevada	24	4
Delaware	25	20
Illinois	26	14
Washington D.C.	27	27

Source: SELA (2012, 2013)



Photo Source: NREL, Jamie L. Keller



## 2. Review of Existing Literature on the Economic Impacts of PV

The examination of the economic impacts of solar energy has a long history. As far back as 1980, Edward Hudson (1980) published an article in *The Energy Journal* claiming increased solar energy production expected by the year 2020 would have a negative economic impact. He assumed the costs of PV would stay relatively high and would displace cheaper energy alternatives. More recently, Matt Croucher (2012) published an article with the clever name, “Which State is Yoda?” which shows that if we judge by size, Pennsylvania appears to be the Yoda of solar deployment. Croucher uses the same JEDI model used in this present study except that he uses the project-specific modeling tool rather than the scenario tool. Using the default values from NREL, Croucher tries to determine which state receives the greatest economic impact from installing one hundred 2.5 kW systems. Under these assumptions, Pennsylvania is ranked first with 28.98 jobs during the installation period and 0.20 jobs during the operation period. Interestingly, Illinois is ranked second with 27.65 jobs during the installation period and 0.18 jobs during the operation period.

In addition, several studies have been performed on the statewide economic impacts of PV. In 2006, Bezdek (2007) estimated the PV market in Ohio to be \$25 million, with 200 direct jobs and 460 total jobs (direct plus indirect). Citing an NREL study, the Center for Competitive Florida (2009) states that if Florida installed 1,500 MW, up to 45,000 direct jobs and 50,000 indirect jobs would be created. Very recently, the Solar Foundation (2013) released a report titled, “An Assessment of the Economic, Revenue, and Societal Impacts of Colorado’s Solar Industry.” This report, which used the JEDI modeling methodology, found the solar photovoltaic (PV) development in Colorado to date has resulted in direct, indirect, and induced employment impacts of approximately 10,790 job-years (or full-time equivalents), leading to employee earnings of over \$534.1 million and total economic output of \$1.42 billion. Furthermore, the project examines what would happen if the State of Colorado attains its Million Solar Roofs Goal through the installation of 2,750 MW of solar PV from the remainder of 2013 through the end of 2030. This would result in almost 32,500 job-years, over \$1.9 billion in employee earnings (present value; 3% discount rate) and over \$3.85 billion in total output.



Photo Source: Center for Renewable Energy, Illinois State University

### 3. Solar Energy Market Potential in Illinois

Jo et al. (2013) examined several scenarios to determine an optimum penetration level of PV in the state of Illinois. In order to perform this analysis, a model was created to ascertain the impacts of varying levels of PV penetration. To create a model that accurately reflects the impact of increased PV electricity generation, historical weather data and electrical load data for both of Illinois' two regional transmission organizations – PJM and MISO – were obtained. The PV capacity and electrical generation potential were then modeled to answer each of the three research questions described above in Section 1. To reflect differences in the solar radiation levels between the PJM and MISO regions of Illinois, the simulation models were performed individually based on geographical weather information for each of the two regions. Table 3.1 presents the three scenarios and their results from the analysis.

**Table 3.1 – Technical Potential of PV in Illinois**

		6% Carve-out	100% Utilization (None Wasted)	94.4% Utilization (Thermal Plant Use Match)
PJM Region	System Capacity (MW)	1,577	1,314	7,665
	Electricity Delivered (MWh)	1,800,190	1,500,158	8,750,924
	Load Demand Met in PJM (%)	1.5	1.3	6.9
MISO Region	System Capacity (MW)	715	1,400	3,600
	Electricity Delivered (MWh)	885,573	1,733,989	4,458,830
	Load Demand Met in PJM (%)	1.5	3.0	7.2
Total	System Capacity (MW)	2,292	2,714	11,265
	Electricity Delivered (MWh)	2,685,763	3,234,147	13,209,754
	Load Demand Met in PJM (%)	1.5	1.8	7.5
	RPS Met in IL	6.0	7.3	29.8

For the first research question, the third column of Table 3.1 shows that in order to achieve the solar carve-out at the rate of 6% of the state's RPS, a total of 2,281 MW of PV need to be installed by the year 2025. If allocated proportionally based on electric load, this equates to approximately 1,577 MW for the PJM region and 715 MW for the MISO region. This will generate a combined 2,686 GWh of electricity per year, and will meet 1.5% of the electrical load demand in Illinois from PV sources, thus satisfying the state's solar carve-out requirement.

The fourth column in Table 3.1 represents the maximum PV penetration level that avoids wasting any of the electricity generated by the installed PV. This is the maximum installed PV capacity where all of the energy generated from PV sources will be utilized 100% of the time. This is a very stringent requirement because it means that rare instances during the year (e.g. mid-morning on a particularly bright but cool day), when the PV could produce more than the allowed replaceable load, will be the limiting factor for the system's size. As shown in Table 1, the maximum PV capacity that could be installed without wasting any electricity is 2,714 MW across the



*Photo Source: Illinois Department of Commerce and Economic Opportunity*

state of Illinois, which will generate 3,234 GWh of electricity per year, thus meeting 7.3% of the state's RPS and 1.8% of the state's total electrical load demand.

These output potentials show the state can indeed utilize 100% of the energy generated by the 6% carve-out for solar energy in the RPS. In the PJM region the 6% solar carve-out is slightly more than the level at which 100% of the power generation can be utilized, but in the MISO region there is room to nearly double the solar carve-out and still fully utilize all the electricity generated. On a statewide level, the solar carve-out could be increased from 6% to 7.3%, and the state could still utilize 100% of the PV electricity generated.

As mentioned earlier, the requirement that none of the energy generated by PV be wasted is a very stringent requirement. Instead of limiting the installed PV capacity by requiring that no energy be wasted, it may be preferable to allow some small amount of electricity to be wasted, because the PV systems still offer significant benefits during times of high electricity demand. This is called curtailment, and it is a common mechanism for controlling the flow of energy onto the electric grid. However, the question of how much electricity is allowed to be curtailed is somewhat arbitrary in this analysis. For the purpose of comparison, we will allow electricity generated from the PV systems to be curtailed at the same rate as what is typically used by thermal generation plants for their own internal use, which is approximately 5.58% according to the U.S. Energy Information Administration (EIA, 2012). As shown in the fifth and final column of Table 3.1, the installed PV capacity at which 5.58% of the generated electricity is expected to be curtailed is a state-wide total of 11,265 MW. This level of installed PV capacity will produce approximately 13,210 GWh of electricity annually. This is equivalent to 29.8% of the state's RPS and 7.5% of the state's total electrical load.

In summary, the conclusions of the technical potential study are as follows:

- 1) The level of installed PV capacity corresponding to the current 6% RPS carve-out is slightly less than the level at which 100% of the electricity produced by PV can be fully utilized.
- 2) If the optimal level of solar PV penetration is defined as the point at which 100% of the electricity produced by PV is utilized, then the state's solar carve-out could be increased to 7.3%, which would meet approximately 1.8% of Illinois' total electric load.
- 3) If we allow some of the electricity produced by solar PV to be curtailed, the installed PV capacity could increase even more. If solar PV is allowed to be curtailed at the same rate that conventional thermal plants typically use electricity for their own internal operation (approximately 5.58%), then the solar carve-out could be increased to 29.8%, and PV could produce approximately 7.5% of Illinois' total electric load.



## 4. Study Methodology

The economic analysis of PV development presented here uses the NREL's latest Jobs and Economic Development Impacts (JEDI) Scenario PV Model (PVS4.5.13). The JEDI PV Model is an input-output model that measures the spending patterns and location-specific economic structures that reflect expenditures supporting varying levels of employment, income, and output. That is, the JEDI Model takes into account that the output of one industry can be used as an input for another. For example, when a PV system is installed, there are both soft costs consisting of permitting, installation and customer acquisition costs, and hardware costs, of which the PV module is the largest component. The purchase of a module not only increases demand for manufactured components and raw materials, but also supports labor. When an installer/developer purchases a module from a manufacturing facility, the manufacturer uses some of that money to pay employees. The employees use a portion of their compensation to purchase goods and services within their community.

The first Jobs and Economic Development Impacts (JEDI) Model was developed in 2002 to demonstrate the economic benefits associated with developing wind farms in the United States. Since then, JEDI models have been developed for biofuels, natural gas, coal, transmission lines and many other forms of energy. These models were developed by Marshall Goldberg of MRG & Associates, under contract with the National Renewable Energy Laboratory. The JEDI model utilizes state-specific industry multipliers obtained from IMPLAN (IMpact analysis for PLANning). IMPLAN software and data are managed and updated by the Minnesota IMPLAN Group, Inc., using data collected at federal, state, and local levels.

The total economic impact can be broken down into three distinct types: direct impacts; indirect impacts and induced impacts. Direct impacts during the construction period refer to the changes that occur in the onsite construction industries in which the direct final demand (i.e., spending on construction labor and services) change is made. Onsite construction-related services include installation labor, engineering, design, and other professional services. Direct impacts during operating years refer to the final demand changes that occur in the onsite spending for the solar workers. The initial spending on the construction and operation of the PV installation creates a second layer of impacts, referred to as "supply chain impacts" or "indirect impacts."

Indirect impacts during construction period consist of the changes in inter-industry purchases resulting from the direct final demand changes, and include construction spending on materials and PV equipment and other purchases of goods and offsite services.

Induced impacts during construction refer to the changes that occur in household spending as household income increases or decreases as a result of the direct and indirect effects of final demand changes. Local spending by employees working directly or indirectly on the PV project who receive their paychecks and then spend money in the community is included. Additional local jobs and economic activity are supported by these purchases of goods and services.

## 5. Study Results

Using the JEDI model, we assess the economic impact of the three technical solar potentials that were developed from the companion technical potential report. Depending on how technical potential is measured, we estimate the technical potential by 2030 for Illinois of 2,292 MW, 2,714 MW, or 11,265 MW. A key driver of the economic impact of these different potentials is the percentage of materials and equipment that is manufactured locally. Illinois does not have a significant competitive advantage relative to other areas in the United States or overseas. Nevertheless, we detail many Illinois-based companies in the solar supply chain in Section 6. To show the possible jobs impact of growing the solar supply chain, we assume that 0%, 5% or 10% of the materials and equipment that are used in Illinois installations are manufactured in Illinois. Thus, we perform nine different model runs as shown in Table 5.1 below:

Table 5.1 – Nine Models Using Different Input Assumptions			
	Percentage Manufactured in Illinois		
Technical Potential	0%	5%	10%
2,292 MW	Model 1	Model 2	Model 3
2,714 MW	Model 4	Model 5	Model 6
11,265 MW	Model 7	Model 8	Model 9

In addition to the technical potential and percentage manufactured in Illinois, there are several assumptions built into the model that do not change between the model runs. We assume that 10% of the capacity of the systems are residential with 80% retrofits and 20% new construction. Small commercial makes up 10% of the market; large commercial 20% and utility-scale solar is 60% (all based on capacity measured in megawatts). Furthermore, all labor and other soft costs (such as permitting and business overhead) are assumed to be purchased 100% locally. Materials and equipment are assumed to be purchased 100% locally for residential and small commercial but 0% locally purchased for large commercial and utility-scale systems (note that purchasing location is different from manufacturing location).

Table 5.2 shows the jobs impacts for the nine different scenarios that were run for the construction phase of the projects. The jobs are reported in job-years and based on full time equivalents. This type of measurement of the jobs impacts enables us to do an apples-to-apples comparison. By this measurement, one full-time construction job lasting for one year is equivalent to 2 full-time jobs lasting six months or 4 full-time jobs lasting three months. As shown in Table 5.2, the total employment impacts vary from 26,754 to 131,779 job years. These results are in line with the Colorado study cited in Section 2 which showed that 2,750 MW of PV installations would result in 32,500 job years. This is very close to the 2,714 MW scenario for Illinois that results in 31,749 job years.

Table 5.2 – Total Illinois Employment Impacts During Construction (job years)			
	Percentage Manufactured in Illinois		
Technical Potential	0%	5%	10%
2,292 MW	26,754	26,783	26,812
2,714 MW	31,680	31,714	31,749
11,265 MW	131,494	131,637	131,779

Table 5.3 shows the ongoing operations and maintenance jobs that will result under each scenario. The operations and maintenance jobs are not dependent on where the original equipment was manufactured, so the jobs impact only varies by the assumed installed capacity. Although some replacement parts will be required from time to time, the supply chain impacts from this small amount of equipment is overshadowed by the direct labor involved in operations and maintenance. The employment impacts during the operating years vary from 1,223 to 6,010.

Table 5.3 – Total Illinois Employment Impacts During Operating Years (job years)	
Technical Potential	
2,292 MW	1,223
2,714 MW	1,448
11,265 MW	6,010

The employment impacts in Tables 5.2 and 5.3 are the total impacts including direct, indirect and induced impacts. Table 5.4 provides a more detailed breakdown of the employment effects for the 2,292 MW scenario. The direct impacts of employment are the same, 7,775 job years, no matter what percentage of the equipment is manufactured in Illinois. The indirect and induced employment impacts, however, increase as higher percentages are assumed to come from within Illinois. The indirect impacts range from 9,639 to 9,676 and induced impacts range from 9,340 to 9,361.



*Photo Source: NREL, Dennis Schroeder*





Photo Source: NREL, Dennis Schroeder

Table 5.4 – Breakdown of Construction Employment Under the 2,292 MW Scenarios (job years)			
	0%	5%	10%
Direct Impact	13,994	13,994	13,994
Indirect Impact	3,420	3,439	3,457
Induced Impact	9,340	9,350	9,361
Total Impact	26,754	26,783	26,812

Similarly, the total employment result during operating years of 1,223 job years can be broken into its component parts of direct, indirect and induced employment effects. Table 5.5 shows the breakdown as 701 direct jobs; 164 indirect jobs; and 309 induced jobs cumulatively.

Table 5.5 – Breakdown of O&M Employment Under the 2,292 MW Scenarios (job years)	
Direct Impact	750
Indirect Impact	164
Induced Impact	309
Total Impact	1,223

When measuring the economic impact, one is concerned with the earnings of these workers as well as the total number of jobs created. Table 5.6 shows the total Illinois earnings impacts for the nine different scenarios that were run for the construction phase. The earnings are reported in millions of 2012 dollars so that they are adjusted for the fact that jobs created in future years may have higher earnings due to inflation alone. As shown in Table 5.6, the total earnings impacts vary from \$1.6 billion to \$7.9 billion. Once again, these results are in line with the Colorado study cited in Section 2 which showed that 2,750 MW of PV installations would result in \$1.9 billion in earnings, which is the same amount of earnings as the 2,714 MW scenario for Illinois. Thus, the overall average salary of workers under these scenarios is approximately \$60,000 per year.

Table 5.6 – Total Illinois Earnings Impacts During Construction (\$ millions 2012)			
	Percentage Manufactured in Illinois		
Technical Potential	0%	5%	10%
2,292 MW	\$1,606	\$1,607	\$1,608
2,714 MW	\$1,902	\$1,902	\$1,903
11,265 MW	\$7,893	\$7,897	\$7,901

Table 5.7 shows the earnings from ongoing operations and maintenance jobs that will result under each scenario. Once again, the operations and maintenance earnings are not dependent on where the original equipment was manufactured, so the jobs impact only varies by the assumed installed capacity. The earnings impacts during the operating years vary from \$115 million to \$567 million.

Table 5.7 – Total Illinois Employment Impacts During Operating Years (\$ millions 2012)	
Technical Potential	
2,292 MW	\$115
2,714 MW	\$137
11,265 MW	\$567

The final and largest measure of economic impact is total output impacts. Table 5.8 shows the total Illinois output impacts for the nine different scenarios that were run for the construction phase. Output is reported in millions of 2012 dollars so that they are adjusted for the fact that output in future years may be higher due to inflation alone. The Illinois output impact of \$4.578 billion under the middle scenario is slightly larger than the \$3.85 billion result from the Colorado study. As shown in Table 5.6, the total earnings impacts vary from \$3.8 billion to \$19 billion.

Table 5.8 – Total Illinois Output Impacts During Construction (\$ millions 2012)			
	Percentage Manufactured in Illinois		
Technical Potential	0%	5%	10%
2,292 MW	\$3,843	\$3,854	\$3,866
2,714 MW	\$4,550	\$4,564	\$4,578
11,265 MW	\$18,886	\$18,943	\$19,000

Table 5.9 shows the total output from ongoing operations and maintenance that will result from each scenario. The earnings impacts during the operating years vary from \$166 million to \$815 million.

Table 5.9 – Total Illinois Output Impacts During Operating Years (\$ millions 2012)	
Technical Potential	
2,292 MW	\$166
2,714 MW	\$196
11,265 MW	\$815



*Photo Source: Illinois Department of Commerce and Economic Opportunity*

## 6. Potential Supply Chain Impacts of Solar Energy in Illinois

Like many other supply chains, the solar supply chain begins with the excavation of raw materials and proceeds through refining and processing, the creation of sub-assemblies, and final assembly into a finished product. In the case of a crystalline silicon PV module, this supply chain includes the excavation of raw materials such as silicon, upgrading raw silicon into purer forms suitable for manufacturing, silicon ingot and wafer manufacturing, cell sub-assembly, and final solar module assembly. The solar supply chain also includes a variety of thin-film photovoltaic technologies as well as ancillary balance-of-system devices such as inverters, junctions, disconnects, wire, conduit, and installation hardware.

According to Stone (2011), a crystalline structure (mono- or polycrystalline) is used in 80-90% of photovoltaic installations. This material is the majority of the installation because it offers high light-to-electricity conversion efficiency and is widely available worldwide. However, the same foundation states that Thin-film photovoltaic modules are available as an economical alternative in many cases. Thin-film modules are less efficient and make up only 0-20% of the market, but their market share is growing.

The production of crystalline silicon ingots and wafers is typically located in or near plants manufacturing the individual photovoltaic cells in order to ensure a consistent supply. Because of the energy demands of the silicon purification and wafer production processes, these plants are usually sited where there is a plentiful source of reliable, cost-effective energy. These crystalline wafer and PV cell plants do not need to be sited close to solar module assembly plants because transportation at this stage is economical and accessible. Many plants are located close to one another because PV manufacturers invest in secure wafer supply to their cell plants.

Solar cell manufacturing plants are large, capital-intensive projects. Stone (2011) also found that a solar cell plant typically holds a yearly capacity of 10-50 MW and has an average area of 50,000 square feet. Millions of dollars of capital investment are required for building one solar cell plant. Because this is a highly capital-intensive part of the supply chain, most manufacturers prefer to centralize this activity at selected locations and meet global market demands from this central location.



Solar cells are relatively inexpensive to transport, so the manufacturing of the solar PV module (which may consist of anywhere from a few to nearly 100 solar cells wired together) may be performed in the cell plant or in smaller plants closer to the end market. The capital cost of assembling and laminating solar cells into solar modules is low, so the economics of smaller capacity plants can be justified. The final piece of the PV supply chain is the installation of the modules along with mounting hardware and other balance-of-plant system components. Installation of the PV system requires comparatively low overhead costs, and is thus suitable for smaller providers located near the point of installation.

In the state of Illinois, there is one solar module manufacturer (Wanxiang New Energy LLC in Rockford, IL) and many more companies that are involved in the production of balance-of-system equipment. A list of Illinois companies in the PV supply chain is provided in Appendix B. While the PV supply chain base in Illinois is small, the solar demand in Illinois is growing. The Illinois Solar Energy Association provided data of the Illinois solar industry stating that in 2012 Illinois consumers and businesses spent \$27 million to install PV on commercial and residential properties. This represented a 259% increase from the previous year according to the ISEA 2012 data. This growing industry will require a supply chain and a workforce that is capable of supporting it. With increasing demand and supportive policies – which are discussed in the following section – the Illinois PV supply chain is poised for rapid growth in the coming years.



*Photo Source: NREL, Dennis Schroeder*



*Photo Source: Illinois Department of Commerce and Economic Opportunity*

## 7. Solar Energy Policies in Illinois and Other States

In this section, we will first review the current Illinois solar energy policies. This will help provide a context for comparing Illinois' policies to others states. Finally, after reviewing the solar policies of other states, we will give policy recommendations for what Illinois can do to increase the penetration of solar energy with a particular focus on those policies that will maximize the economic impact.

In 1997, Illinois established the Renewable Energy Resources Trust Fund to provide funding for support of renewable energy sources. To establish the fund, a surcharge was placed on residential and non-residential gas and electricity bills. Originally set to last ten years, in 2007 the program was extended through the year 2015. This fund provides \$3-5 million annually for rebates and grants but it is due to sunset in December 2015. This program provides rebates for residential, commercial, non-profit, and public sector applicants. For solar PV, residential systems are eligible for the lesser of \$1.50/watt or 25% of project costs, commercial systems are eligible for the lesser of \$1.25/watt or 25% of project costs, and non-profit and public sector systems are eligible for the lesser of \$2.50/watt or 40% of project costs. The PV systems must be at least 1 kW and be listed by Underwriter's Laboratory or field tested for one year (United States Department of Energy, 2013). In 2011, the Illinois Department of Commerce and Economic Opportunity began offering grants for large distributed solar and wind projects. Businesses can receive the lesser of \$1.25/watt or 25% of project cost and government and non-profit agencies can receive the lesser of \$2.60/watt or 40% of project cost (Illinois Department of Commerce and Economic Opportunity, 2013). As a final incentive, for property tax purposes, Illinois allows solar energy equipment to be assessed at the same value as a conventional energy system (United States Department of Energy, 2013).

In 1999, the Illinois Clean Energy Community Foundation was created. The goals of the Foundation are to improve the environment, create jobs, reduce energy costs, and boost the renewable energy sector through support of renewable energy sources. To achieve these goals, the foundation supplies grants to projects for energy efficiency and renewable energy. The Foundation also administers the Illinois Solar Schools program, established in 2006, which promotes installation of 1 kW solar PV systems on school buildings to allow students to see how sunlight is converted to electricity (Illinois Clean Energy Community Foundation, 2013).

In 2007, Illinois created the Illinois Power Agency (IPA) to develop electricity procurement plans for investor-owned utilities (IOUs). The Act that created the IPA also created a renewable portfolio standard (RPS) requiring increasing amounts of renewable energy as a percentage of the electric load for IOUs. The current RPS is set at 25% by year 2025, with a 6% solar carve-out starting in the year 2015. This means 1.5% of IOU load is to be procured from solar by the year 2025. The IPA can procure the required solar energy under long-term contracts or by purchasing Solar Renewable Energy Credits (SRECs) to meet the solar carve-out (Illinois Power Agency, 2013). The IPA has been hindered in its procurement of renewables for two reasons. First, customers have shifted away from the default service provided by ComEd and Ameren in favor of municipal

aggregation where cities solicit suppliers on behalf of its residents. Thus, the IPA has procured more energy, including more renewable energy, than its needs at the current time. Alternative suppliers, called Alternative Retail Electric Suppliers (ARES), purchase renewable energy credits and also pay into an Alternative Compliance Payment (ACP) fund to meet their RPS mandates. The fund currently has \$15 million and could reach as much as \$130 million in the next two years. However, the IPA Act says the ACP money can only be used when the Illinois Power Agency is buying renewable energy or credits on behalf of ComEd and Ameren. But since ComEd's and Ameren's customer bases have shrunk so drastically due to aggregation, they have already purchased more than enough renewable energy to meet their RPS needs and the ACP fund sits idle. Even worse, the fund can be swept by the state for other budgetary needs. Efforts are underway to "fix" this problem. In 2010, a separate program managed by the Illinois Solar Energy Association called the Renewable Energy Credit Aggregation Program (RECAP) was implemented, allowing producers of solar energy to sell their earned SRECs to utility companies.

Legislation requiring investor-owned utilities to offer net metering by April 1, 2008 was enacted in 2007. Traditional net metering is allowed for systems up to 40 kW and dual metering is allowed for systems greater than 40 kW but not larger than 2 MW. This service must be provided until it reaches 5% of peak demand supplied the previous year. Those participating in the program earn credits for energy generated. At the end of the month, any excess generation rolls forward, expiring at the end of the annual period. With net metering, this amount is found by taking kWh produced and subtracting kWh consumed. With dual metering, a special meter separately measures the amount of energy consumed from the electric grid and the energy exported onto the electric grid from the PV system. The producer then typically receives a credit for costs avoided by the utility company (United States Department of Energy, 2013).

In 2007 with the creation of net metering, the state also developed interconnection standards for systems under 10 MW. These standards were based on IEEE 1547, a nation-wide set of interconnections standards of the Institute of Electrical and Electronics Engineers. The systems are divided into four levels to determine level of review required before allowing grid connection. Levels 1, 2, and 3 are considered expedited review levels. Level 1 systems are certified systems with a capacity of 10 kW or less. The review ensures certain aspects such as the system qualifying at Level 1, the total capacity connected to a network not exceeding set limits, and that no facilities need to be constructed by the electricity distribution company to accommodate the connection. Level 2 are certified, inverter-based systems of 2 MW or less connected to a spot network serving only one customer. This review is similar to Level 1 reviews, with additional concerns for generator connections. Level 3 are either certified systems of 50 kW or less, connected to an area network with no exportation or non-exporting systems, connected to a spot network that are 10 MW or less and certified. Reviews for Level 3 follow a similar set-up as Levels 1 and 2. Level 4 systems are held to a more in-depth review. These systems are any system 10 MW or less that do not fit the requirements for lower tiers. The review for Level 4 cannot be expedited and may include an interconnection feasibility study, an



*Photo Source: NREL, Jim Yost*





*Photo Source: Center for Renewable Energy, Illinois State University*

interconnection system impact study, or an interconnection facilities study (Ill. Admin. Code tit. 83, pt 466). For systems larger than 10 MW, a separate process exists. Evaluations of capacity levels, review of facilities, and multiple studies must be completed before a decision about allowing the interconnection can be made (Ill. Admin. Code tit. 83, pt 467).

Even with these advances in solar policies and programs, Illinois is not a leader in solar PV installation. It is helpful to examine other states that have higher penetrations of PV to see what policies may have led to their success. We will examine the policies of Hawaii, California, Arizona, Nevada, and New Jersey, which all have high levels of installed solar PV capacity and high per capita installation rates, to find what policies lie behind this growth in PV.

Due to Hawaii's location and excellent solar resources, solar PV is becoming increasingly popular in the state. Currently the state has an RPS of 40% by year 2030. Already, 15% of their energy comes from solar PV. Net metering is allowed in the state, and energy credits are forwarded through a one year period. While there is no compensation for net metering credits remaining at the end of the year, a feed-in tariff program has recently been initiated for some customers. A feed-in tariff provides above-market rates for the electricity that is generated from the PV system. Hawaii has streamlined the interconnection process for small-scale generation systems and given large-scale systems a different, more complex set of standards. A public benefit fee has also been established. The fee was originally set to fund energy efficiency projects and was amended in 2013 to include renewable energy projects in order to help achieve RPS goals. To encourage unit installation, Hawaii has a solar and wind energy tax credit of up to 35% of actual cost for solar at both corporate and personal levels. The state also has financing available to fund loans for various solar projects (United States Department of Energy, 2013).

California is one of the top states in solar PV installation. The state's net metering policy allows full retail value compensation of earned credits. Those not participating in net metering are eligible for a feed-in tariff. The state's interconnection standards include "fast track" eligibility for non-exporting systems, while exporting systems may apply for a "detailed study" eligibility. A Public Benefits Fund exists to support renewable energy research, development, and projects. California has the Homebuyer Solar Option and Solar Offset Program, which requires builders to provide a solar energy option to homebuyers or to install a system elsewhere with 20% of the capacity that would have been installed. To ease installation costs, California has restrictions on pricing of solar system permits. The California Solar Initiative Program's main purpose is to provide rebates or financing for solar energy systems, as well as providing assistance to homeowners. Paired with this, the California Energy Commission New Solar Homes Project works towards encouraging homebuilders to produce solar efficient homes. Low interest rate loans are also available. The state also offers a property tax exclusion for solar energy systems and a sales and use tax exemption for any property used solely for design, manufacture, production, or assembly of alternative energy source product components. The state has also implemented a Solar Shade Control Act which

encourages the use of natural shading, except where it blocks sun from solar energy systems (United States Department of Energy, 2013).

With high solar resource levels, Arizona is also a leading state in solar PV installation. Currently the RPS is 15% by year 2025. Net metering is allowed with excess energy credits rolling over from month to month. Any credits left at the end of the billing year must be paid for by the utility. Currently each utility has set up its own interconnection guidelines based on system size, but the state has passed legislation for statewide standards. It is expected that the utility companies will comply with the standards once they are in effect. New buildings over 6,000 square feet are required by law to be designed for solar efficiency. Arizona also offers several significant tax incentives for solar PV installation. A tax credit of 10% of installed costs of systems is granted for personal and corporate non-residential solar and wind energy systems. For residential systems, an income tax credit equal to 25% of the cost of the wind or solar energy device is applied. Additionally, a renewable energy production tax credit is granted on a per-kWh produced basis. Solar and wind energy systems are also exempt from state sales tax. The state has two policies regarding property taxes, dependent on reason for electricity generation from the system. For renewable energy systems that generate electricity not for use by the generator, the system is assessed at 20% of its depreciated cost to determine property taxes. For renewable energy systems that generate electricity that is used on-site, the systems are exempt from property tax assessment. Finally, to encourage new businesses in the state, qualifying ones can receive an income tax credit of 10%. If initial investments are high enough, they can be classified differently for property taxes, allowing reductions of 75% (United States Department of Energy, 2013).

Similar to Arizona, Nevada's solar resource levels allow it to excel in solar PV installation. Their RPS is set at 25% by year 2025. Through year 2015, solar is to comprise 5% of the RPS, then 6% in the year 2016 and thereafter. Paired with this, state law requires Nevada Electric to retire 800 MW of coal-fired electric generating plants and to replace these plants with 900 MW of cleaner facilities, 350 MW of which must be from new renewable sources. Nevada's net metering policy allows indefinite rollover of any excess credits. Interconnection standards in the state are similar to those of California and consistent with IEEE 1547. Those that produce their own electricity earn portfolio energy credits; utility companies can then buy these to reach their RPS. The state has a loan program set up for renewable energy and energy efficiency projects. Additionally, a rebate program is in effect for renewable energy systems based on kW of capacity installed. For tax incentives, Nevada offers a tax abatement for renewable energy systems in the form of a reduction on sales and use taxes. There is also a 100% property tax exemption for systems serving residential, commercial, or industrial buildings and a property tax abatement for large-scale renewable energy producers (United States Department of Energy, 2013).



*Photo Source: Illinois Department of Commerce and Economic Opportunity*



*Photo Source: Illinois Department of Commerce and Economic Opportunity*

New Jersey is ranked near the top in solar PV installations. Their RPS is 20.38% by the year 2020 with an additional 4.1% of all electric sales to come from solar by the year 2027. Net metering in the state allows compensation for any excess generation. For interconnection standards, the state has varying levels of difficulty depending on the size of the system, allowing smaller, on-site use systems easier access. The state also applies a social benefits charge to utility bills; some of the funding collected goes towards the New Jersey Clean Energy Program which promotes renewable energy sources. Similar to Nevada, New Jersey has established a Solar Renewable Energy Credit (SREC) earned by those that generate electricity from solar power. These credits may be sold on the SREC marketplace to help utilities meet RPS goals. Several loan programs are also available to fund solar PV and other renewable energy projects. Solar energy systems are also exempt from sales tax and renewable energy systems generating electricity for on-site use are exempt from property taxes (USDOE, 2013).

Comparing solar PV policy in Illinois with policy in high solar PV capacity states allows for recognizing needed policy changes in Illinois. Given New Jersey and Illinois' similar solar radiation levels, the discrepancy between the two in amount of installed capacity is likely due to differences in policy. First and most obvious, New Jersey's RPS solar carve-out is much larger than Illinois'. This higher requirement is also likely easier to achieve given the sales tax exemption and on-site use property tax exemption. Illinois should consider increasing the solar carve-out in order to create a greater need for solar PV installation. To encourage this installation, the state should consider a sales tax exemption (found in California, Arizona, Nevada, and New Jersey) to lessen the burden on potential producers. The state should reconsider its current property tax assessment. Instead of assessing at the value of a conventional system, the state should consider a complete exclusion, especially for systems designed for on-site use. Alternatively, the state could consider an abatement to provide a greater reduction than the current assessment.

Illinois should also reconsider its current net metering standards. Offering a feed-in tariff or some form of compensation for all excess energy credits, even at the end of the billing year, may encourage more solar PV installation.

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# Appendix A

## Comparison of Renewable Policies for Illinois and Other States

Policies	Illinois	Hawaii	California	Arizona	Nevada	New Jersey
RPS	x	x	x	x	x	x
Solar Carve-Out	x				x	x
Net Metering	x	x	x	x	x	x
Feed-in Tariff		x	x			
Public Benefits Fund	x	x	x			x
Sales Tax Exemption/Abatement			x	x	x	x
Property Tax Exemption/Exclusion			x	x	x	x
Property Tax Special Assessment/Abatement	x			x	x	
Rebate Program			x		x	
Tax Credit		x		x		
Loan Program	x	x	x		x	x
Grant Program	x	x	x			
Other Financing Program		x				
Renewable Energy Credit Sales	x				x	x
Solar Rights	x	x	x	x	x	x
Solar Easements			x		x	x

# Appendix B

## Illinois Manufacturers in the Solar Energy Supply Chain

Company	City	Raw Material	Wafer Mfg	Solar Cell	Solar Module	Solar Panel	Install	Developer
Able Distributors Inc.	Chicago						x	
Advanced Energy Solutions	Pomona				x			
Aerotecture International	Chicago			x	x	x	x	x
Aldridge Electric	Libertyville	x	x	x	x	x		x
All Suburban Electric	Arlington Heights				x			
American Renewable Energy	Evanston			x			x	
Angel Wind Energy	Onarga	x	x	x	x	x		
APT Solar Div	Rochester					x		
Atlas Tube	Chicago							x
Building Energy Experts	Crystal Lake				x	x	x	x
Chart House Energy	Chicago				x			
Chicago Wind and Solar	Chicago					x		x
CIC Energy Consulting	Chicago						x	x
Day & Night Solar	Collinsville					x	x	
Earth Wind and Solar Energy	Chicago		x	x	x	x	x	x
EcoLogical Products Company	Oak Park					x		
Energy Independence Corporation	Galena					x	x	x
Energy360 Solutions	Wood Dale				x			
Fabricating and Welding Corp.	Chicago	x						
Fluitechnik	Elk Grove			x	x	x		
Gabriel Environmental	Chicago						x	x
General Energy Corp	Oak Park					x		x
Gere Marie	Lake Zurich	x	x					
Good Electric	Chicago					x	x	x
Green Power Solutions	Palos Heights				x	x	x	
Guarantee Electric	Granite City	x	x	x	x	x	x	x
Haenig Electric Company	Springfield					x	x	x
Hardt Electric Inc.	Chicago				x		x	x
Homestead Specialties	St. Charles				x		x	x
Huen Electric	Broadview				x			
Illinois Renewable Energy Assoc.	Oregon					x		
Imperial Crane	Bridgeview							
Invenergy	Chicago			x	x	x		x
Invensys Controls	Carol Stream			x	x	x	x	x
Johnson Bros Metal Forming Co.	Berkley	x	x					
Jon Haeme	Kempton						x	
Lincoln Renewable Energy	Chicago				x	x		x

Company	City	Raw Material	Wafer Mfg	Solar Cell	Solar Module	Solar Panel	Install	Developer
MAAPS	Swansea					x	x	
MicroLink Devices	Niles			x	x	x		x
Midstate Renewable Energy Services	Champaign						x	
Midwest Green Energy	Peoria					x	x	x
Millenium Electric	Park Forest					x	x	
New Generation Power	Chicago				x	x		
New Grid Energy Solutions	Chicago				x	x		
PVPower	Chicago				x	x		
RICK Electrical Contractors Inc	Sugar Grove		x		x		x	
S&C Electric	Chicago	x	x	x	x	x		
Sargent & Lundry	Chicago							x
Shamrock Electric	Elk Grove	x		x	x			
SoCore Energy	Chicago						x	
SolAir	Chicago						x	
Solar Energy International	Chicago						x	x
Solar Energy Of Illinois	Elmwood Park					x	x	x
Solar Service	Niles					x	x	
Solar Xorce	Northbrook	x	x	x	x	x	x	x
Solargenix Energy	Chicago	x	x	x	x	x		x
SolarWerks	Chicago					x	x	x
Solergy	Rockford				x	x	x	
Sun Air Systems	Byron						x	x
Sun Heat Solar	Addison					x	x	x
Tecta America Corp.	Rosemont				x	x		x
Tesla Solar Technologies	Chicago			x		x	x	
Tick Tock Energy	Effingham				x	x	x	x
UPC Solar	Chicago	x		x	x	x	x	x
US Solar Power Corporation	Chicago							x
Velux America, Inc.	Aurora						x	
Wanxiang New Energy	Rockford		x	x	x	x	x	x
WCP Solar Services	Naperville					x	x	x
Wilhelm Engineering	Stelle					x	x	x
Wiliam Lyons	Evanston				x	x	x	
Wind and Solar by Blackshor	Peoria				x	x	x	x
WindSolarUSA	Owaneco			x	x	x	x	
WinSol Power Company	Glenview					x	x	





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