NREL National Renewable Energy Laboratory

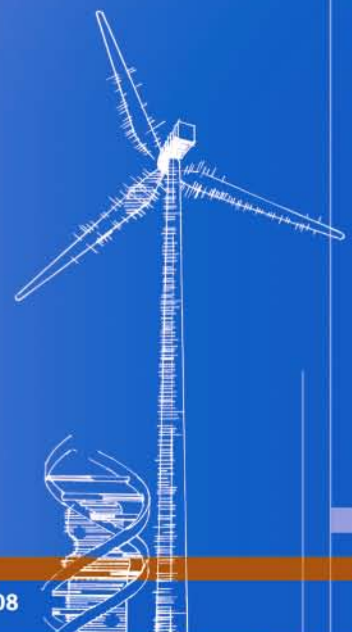
A national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy

Innovation for Our Energy Future

State Clean Energy Policies Analysis (SCEPA): State Policy and the Pursuit of Renewable Energy Manufacturing

Eric Lantz, Frank Oteri, Suzanne Tegen, and Elizabeth Doris

Technical Report
NREL/TP-6A2-46672
February 2010



NREL is operated for DOE by the Alliance for Sustainable Energy, LLC   Contract No. DE-AC36-08-GO28308

State Clean Energy Policies Analysis (SCEPA): State Policy and the Pursuit of Renewable Energy Manufacturing

Technical Report
NREL/TP-6A2-46672
February 2010

Eric Lantz, Frank Oteri, Suzanne Tegen, and Elizabeth Doris

Prepared under Task No. IGST.9000

National Renewable Energy Laboratory
1617 Cole Boulevard, Golden, Colorado 80401-3393
303-275-3000 • www.nrel.gov

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

Contract No. DE-AC36-08-GO28308

Available electronically at http://www.osti.gov/bridge

Available for a processing fee to U.S. Department of Energy
and its contractors, in paper, from:
U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
phone: 865.576.8401
fax: 865.576.5728
email: mailto:reports@adonis.osti.gov

Available for sale to the public, in paper, from:
U.S. Department of Commerce
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
phone: 800.553.6847
fax: 703.605.6900
email: orders@ntis.fedworld.gov
online ordering: http://www.ntis.gov/ordering.htm

Printed on paper containing at least 50% wastepaper, including 20% postconsumer waste

Acknowledgements

Many individuals contributed to this paper. Thanks go to each of the industry, NGO, and state economic development representatives who took time to relay their experiences and insights and review earlier versions of this paper. In addition, thanks go to Jessica Isaacs of the American Wind Energy Association (AWEA) and Justin Baca of the Solar Energy Industries Association (SEIA) for their reviews of earlier versions of this paper. Thanks also go to our NREL technical editor Mike Meshek. Finally, thanks to the Weatherization and Intergovernmental Program within the U.S. Department of Energy for funding this work. Of course, any remaining omissions or errors are the sole responsibility of the authors.

Executive Summary

Future manufacturing of renewable energy equipment in the United States provides economic development opportunities for state and local communities. Such opportunities are always valuable but become even more so in today's economy where unemployment is high. As such, many states are considering new policy measures to enable them to capitalize on opportunities in renewable energy manufacturing.

Effective policy development requires a broad understanding of the scale of the opportunity that renewable energy manufacturing offers and insights into the underlying factors that influence where new manufacturing facilities are located. This report uses existing deployment scenarios to estimate the potential scale of U.S. investment in renewable energy equipment through 2030 and highlights elements of successful recruitment strategies as elicited from interviews with state economic development officials, leading renewable energy equipment manufacturers, and NGOs engaged in bringing new business to state and local communities.

Assuming constant real-dollar, equipment costs and potential deployment as described in the U.S. Department of Energy's report *20% Wind Energy by 2030,* and under proposed national renewable energy standards (RES) debated in the U.S. Congress in the spring of 2009 U.S. demand for renewable energy equipment is estimated to drive annual investments of $14 billion-$20 billion in renewable energy equipment through 2030.[1] If the majority of this equipment comes from U.S. manufacturers, this level of direct investment would place the industry on par with the construction machinery, farm machinery, or household appliance industries.

The current distribution of renewable energy equipment manufacturers suggests that state recruitment strategies are most successful when they are a part of a robust, broad-based, economic development strategy. Such strategies often rely on existing resources and economic development programs to develop and maintain a skilled workforce, ensure adequate transportation infrastructure, attract a diverse set of potential raw material and component suppliers, and generally reduce the cost of manufacturing operations. However, successful recruitment strategies also include financial and economic incentive packages that are competitive with those offered in other states and in line with public value of a new manufacturing facility. Under some circumstances, geography and transportation costs may place specific states at a distinct advantage. In addition, some

[1] The figure of $14 billion-$20 billion represent the authors' estimate of equipment purchases based on the U.S. DOE (2008) study noted in the text and four domestic deployment scenarios outlined in Sullivan et al. (2009). None of these scenarios are based on explicit mandates or goals, nor do they consider the impact of any carbon or climate mitigation strategy. Equipment costs may actually decline in real dollar terms, which would reduce the average annual investment value noted here. However, significant cost declines may stimulate deployment at levels greater than estimated in the scenarios analyzed here. As well, to the extent that U.S.-based manufacturing capacity can serve export markets, global demand may increase the level of investment noted here. In spite of these caveats, the authors believe this value roughly reflects the order of magnitude level of direct investment in renewable energy equipment that could potentially flow to U.S. based manufacturers.

manufacturers seek out large renewable energy markets and states with progressive renewable energy policies.

These findings concur with broader academic literature, which indicates that the states and regions that are most able to attract direct investment and promote sustained economic development are able to leverage both durable assets—like highly trained human capital and a diverse economic base—and low barriers to entry (i.e., low costs to start up or establish a new facility) (Bobonis and Shatz 2007, Buch et al. 2005, Coughlin and Segev 2000, and Oman 2000).

In this context, state marketing strategies for attracting renewable energy manufacturers are likely best served by an approach that (1) is multi-faceted and long-term (i.e., decadal), (2) fits within existing broad-based economic development strategies, (3) includes industry-specific components (e.g., support for renewable energy markets and the ability to address specific renewable energy manufacturing needs), and (4) highlights existing assets to demonstrate critical location specific differences when applicable. Such an approach might include:[2]

- State and local infrastructure development
- Education and workforce training
- Direct outreach and marketing
- Community development and quality of life programs
- A predictable regulatory and governing environment
- Provision of fiscal and financial incentives
- Detailed market and resource analysis
- Advancement of renewable energy markets.

[2] Policy best practices outlined in this report represent information elicited through the personal interviews conducted for this report (see the Appendix for details) as well as the results of published work by Bobonis and Shatz (2007), Buch et al. (2005), Coughlin and Segev (2000), and Oman (2000).

Table of Contents

List of Figures

List of Tables

1 SCEPA Project Background

The State Clean Energy Policies Analysis (SCEPA) project seeks to quantify the impacts of existing state policies and identify crucial policy attributes and their potential applicability to other states. The project goal is to assist states in determining which clean energy policies or policy portfolios will best accomplish their environmental, economic, and security goals. Analysts from the National Renewable Energy Laboratory (NREL) are implementing the project. State officials and policy experts are providing input and review. For more information on the SCEPA project or to see additional reports from the SCEPA project, access NREL's Applying Technologies Web site at http://www.nrel.gov/analysis/scepa.html. The SCEPA project is supported by the Weatherization and Intergovernmental Program within the Department of Energy's Office of Energy Efficiency and Renewable Energy.

This report diverges slightly from other SCEPA analyses. Rather than evaluating impacts across the array of state clean energy goals, this report focuses on renewable energy manufacturing's role in economic development and discusses policy best practices for pursuing renewable energy manufacturing facilities.

2 Introduction

Renewable energy is frequently touted as a tool for stimulating economic development. Research confirms that renewable energy development leads to economic impacts at the local, state, and the national levels (US DOE 2008, Pollin et al. 2008, Reategui and Tegen 2008).[3] However, these impacts vary, sometimes widely, depending on how investments in clean energy are distributed within the particular state, national, and global economy.

Where renewable energy equipment—wind turbines, solar photovoltaic (PV) panels, solar hot water heaters, geothermal heat pumps, steam turbines, and associated hardware—is produced is a primary factor in determining the magnitude of economic development impacts.[4] The Renewable Energy Policy Project (REPP) estimates that roughly 70% of the jobs generated by development of wind energy accrue in the manufacturing sector (Sterzinger and Svrcek 2004). Lantz and Tegen (2008) show that increasing the level of locally produced wind turbine equipment from 0% to 35% can increase the lifetime economic impacts of constructing wind projects in Iowa by more than 70%.[5] As a result, a state that successfully secures a large clean energy manufacturing sector is expected to see the greatest economic development impact from continued deployment of renewable energy.

Renewable energy manufacturing's impact on economic development is significant because renewable power production facilities are capital intensive—approximately 70-75% of the installed cost of a wind plant goes to purchasing wind turbines (Wiser and Bolinger 2009). Roughly three quarters of every dollar invested in a new wind energy facility is directed to the manufacturing sector. Wind energy is not alone in its capital-intensive nature; Stoddard et al., (2006) estimate that 68% of the total cost of concentrating solar power plants goes to equipment. Similarly, 60-64% of the cost of solar photovoltaics is in the cost of the modules and inverter (Wiser et al. 2009).

States are beginning to recognize the attributes and potential of the clean energy manufacturing sector and to actively court potential renewable energy manufacturers. One example of this is the participation of state officials in the nation's largest wind energy conference. Two years ago, the annual AWEA WINDPOWER conference had only one state with an economic development booth.[6] In 2009, the conference had 17 booths staffed by state representatives, each trying to market its potential as a future

[3] The U.S. Department of Energy's report *20% Wind Energy by 2030* (2008) places the total economic output from constructing and operating wind energy facilities that supply 20% of U.S. electricity needs at roughly $1.4 trillion between 2008 and 2030. The Political Economy Research Institute estimates that spending $100 billion over two years in six green infrastructure investment areas will create two million jobs throughout the economy (Pollin et al. 2008).

[4] Additional critical variables include the amount of renewable energy that is installed (i.e. the size of the total investment), the size and structure of the economy in question, the distribution of project-level revenues, and the amount of local goods and services used by the project (Lantz and Tegen 2008).

[5] For a scenario where 2,400 MW of wind power is added in Iowa, increasing the proportion of capacity made up of Iowa-built wind turbines from 0% to 35% increases the economic development impacts from $2.5 billion to nearly $4.5 billion (Lantz and Tegen 2008).

[6] This information is from interviews conducted for this report. For more information about these interviews, see the appendix.

home for wind energy related business.[7] Moreover, states are beginning to use policies to enhance their ability to recruit renewable energy manufacturers.[8]

This report discusses the status of renewable energy manufacturing in the United States and uses deployment scenarios based on proposed national RES legislation in the spring of 2009 (Sullivan et al., 2009) and the U.S. DOE report *20% Wind Energy by 2030* to estimate the potential scale of expenditures for renewable energy equipment over the next 10 to 20 years. In addition, the report discusses the types of variables that interest renewable energy manufacturers, and it provides guidance for developing clean energy manufacturing recruitment strategies in a manner that minimizes detrimental economic development competition between states and supports long-term economic development more broadly.

The report focuses on wind and solar energy technologies because they are two of the fastest growing clean energy technologies in the United States–both industries are experiencing annual U.S. investments of billions of dollars.[9] Furthermore, both industries are undergoing expansion of U.S.-based manufacturing capacity.[10]

---

[7] Jessica Isaacs, American Wind Energy Association, personal communication, May 2009.

[8] Kansas, Michigan, and New Jersey designed state policies to attract manufacturers. Kansas' Solar and Wind Manufacturing Incentive provides up to $5 million in financing recovered through payroll tax withholding from the required number of new employees. Michigan's Nonrefundable Business Activity Tax Credit provides manufacturers of renewable energy equipment a tax credit based on renewable energy related business activity. New Jersey's Edison Innovation Clean Energy Manufacturing Fund provides up to $3.3 million in grants and loans for development of new facilities and/or site improvements. For more information on these programs and other state-level manufacturing incentives, see http://www.dsireusa.org/.

[9] The U.S. wind energy industry invested approximately $16.4 billion in the development of more than 8,500 MW of new wind capacity in 2008. This record-breaking year resulted in 60% more installed wind capacity than 2007, which held the previous single-year installation record of 5,329 MW (Wiser and Bolinger 2009). Also in 2008, the U.S. solar energy industry grew by an estimated 1,265 MW and added 16% to the total installed solar capacity, according to the Solar Energy Industries Association (SEIA 2009).

[10] Late 2008 and early 2009 were marked by slowing expansion, and many existing facilities cut output because of the recession, which has reduced near-term demand for renewable energy equipment. However, analysts generally consider this a short-term slowdown and expect wind and solar manufacturing expansion to resume as the broader economy recovers.

3 Renewable Energy Manufacturing in the United States

Uncertainty about the magnitude and long-term stability of U.S. demand for renewable energy technology has historically discouraged investment in U.S.-based manufacturing facilities (Wiser et al. 2007), and renewable energy producers in the United States have generally imported renewable energy equipment.[11]

The *Emergency Economic Stabilization Act of 2008 (EESA)* and the *American Recovery and Reinvestment Act of 2009 (ARRA),* however, have created a more favorable long-term policy environment for renewables. Among the policy developments promulgated in these two pieces of legislation are: (1) an extension of the federal production tax credit (PTC) and the ability to convert the PTC into an investment tax credit, (2) an eight-year extension of the federal investment tax credit (ITC), (3) creation of the ARRA Section 1603 cash grant in lieu of the ITC program, and (4) establishment of the ARRA Section 48C manufacturing investment tax credit. Furthermore, the U.S. Congress continues to debate long-term policy measures, such as a National Renewable Energy Standard (RES) and schemes to limit carbon emissions that will impact renewable energy markets. Much of the debate is about how to best increase U.S. economic competitiveness, and this discussion often focuses on domestic manufacturing capabilities. Because of these developments, the long-term outlook for renewable energy is positive, and the wind and solar energy markets are seeing significant investment from clean energy manufacturers.

3.1 Wind Energy Manufacturing

Prior to 2006, only a few wind energy related manufacturers had facilities in the United States, and the single major original equipment manufacturer (OEM) of wind turbines with a U.S. manufacturing presence was GE (Wiser and Bolinger 2007).[12] By late 2007, industry experts estimated that about 30% of the equipment and components used in wind turbines was produced at U.S. facilities (Wiser et al. 2007). As of year-end 2008, at least 91 facilities in 27 states were producing wind turbine equipment and components. An additional 23 new facilities were announced in 2008, with expected production beginning in 2009 (Wiser and Bolinger 2009).

The operating and announced manufacturing facilities include the facilities of leading OEM manufacturers Acciona, Clipper, Gamesa, GE, Nordex, Siemens, and Vestas, as well as significant Tier I suppliers (e.g., blade and tower manufacturers).[13] These facilities generally are located in states near valuable wind resources, have access to well-trained labor forces, offer multiple modes of transportation, and engaged the wind energy

[11] Under high market uncertainty, states can generally do little to attract manufacturers. In some cases, states may be able to provide enough localized market certainty to justify a modest manufacturing investment or they may try to apply pressure on federal legislators to use policy to address underlying market conditions. Nevertheless, in the absence of an underlying market, states efforts to attract manufacturers are likely to be futile.

[12] GE maintains U.S.-based and international manufacturing facilities all of which serve the U.S. domestic market and international markets.

[13] An OEM is the final assembler of all the individual components that constitute a completed product. Often, the OEM manufacturers also carry out the design and engineering of the final technology. OEM manufacturers are respectively served by Tier I component manufactures that are in turn served by Tier II and lower component manufacturers.

industry early.[14] Some states, including Arkansas, Colorado, Iowa, and Texas, already boast both an OEM presence and a Tier I presence. As well, states with historically strong manufacturing sectors, including Michigan, Indiana, Ohio, Pennsylvania, and Wisconsin, have started to see the impacts of wind energy manufacturing as the industry has begun to connect with domestic suppliers throughout the supply chain (*Wind Powering America 2009*). The distribution of open and announced facilities, as compiled by the American Wind Energy Association (AWEA) and the U.S. Department of Energy's Wind Powering America program, is shown in Figure 1.[15]

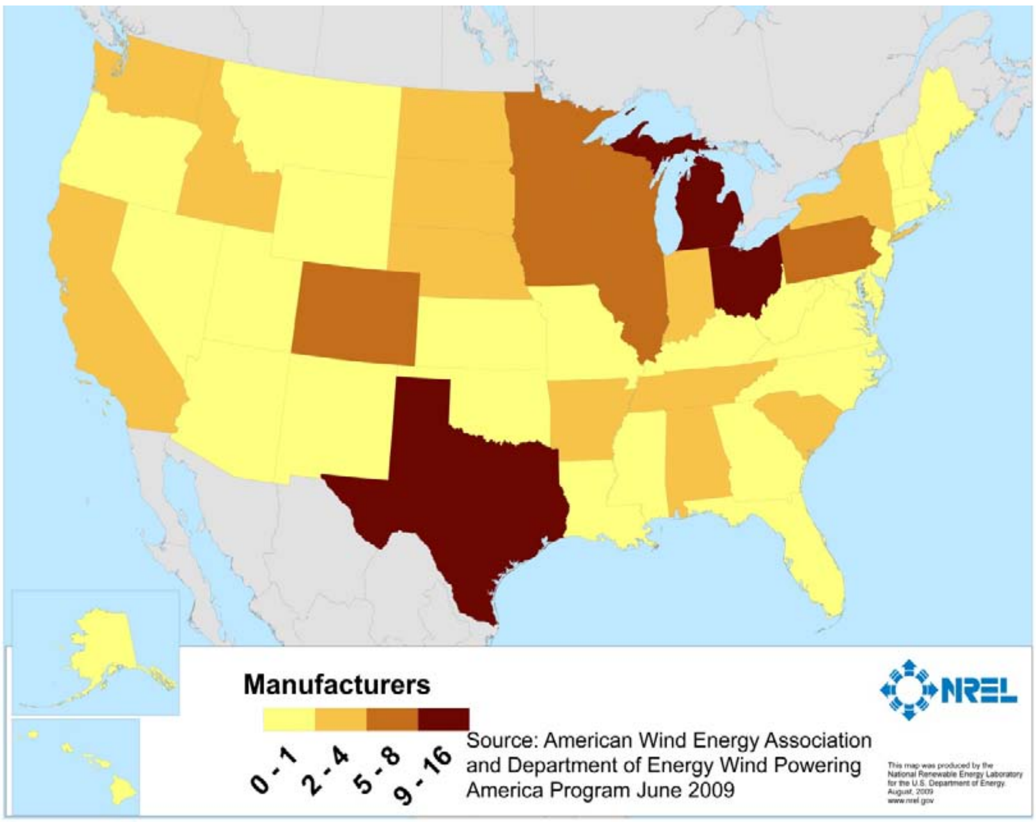


Figure 1. Opened and announced firms involved in wind energy manufacturing by state (*as of December 2008*)

The rapid ramp-up in U.S. manufacturing capacity has increased the domestic supply of wind energy components. AWEA now estimates that as much as 50% of the industry's equipment, by cost, is manufactured in the United States (AWEA 2009).[16] The desire of

[14] This information is from interviews conducted for this report. For more information about these interviews, see the appendix.
[15] Data represented in Figure 1 are based on reports by company press releases and local news reports. All data presented here have been confirmed with individual companies. Companies that have not publicly announced their participation in the wind industry are not included in this dataset. In addition, these data do not distinguish between individual firms for the number of employees supported by wind industry business nor do they distinguish between levels within the supply chain.
[16] Towers and blades installed on U.S. wind projects are often manufactured domestically. AWEA estimates that 50% of turbine equipment, by cost, is manufactured domestically. Estimates based strictly on the number of components suggest that of individual pieces (there are more than 8,000 in a wind turbine) a

OEMs to be present in the rapidly growing U.S. market is likely one driver of much of this expansion.[17] It has also been driven by the desire of OEMs to reduce transportation costs, ease logistical challenges, minimize the impacts of changes in currency valuation, and reduce import duties (USITC 2009). However, growth in wind power demand has also attracted existing manufacturing companies with the ability to easily transition into the wind energy industry (e.g., composite component manufacturers and precision gear producers) (*Wind Powering America 2009*).

In the near-term, the U.S. wind manufacturing industry is working through a period of oversupply. The recent ramp-up in manufacturing capacity, coupled with the current recession and the financial crises, has resulted in some furloughs and layoffs. Still, over the long-term, U.S. wind energy manufacturing is expected to continue to expand as the industry matures. In spite of continued growth, the substantial advancement of wind energy manufacturing capacity over the past three years means that the opportunities to attract manufacturers of wind turbines or components are not as wide open as they once were. Many of the high-level strategic decisions of global OEM firms have already been made.[18] Periodic expansions and the emergence of new market players will create opportunities for siting new OEM facilities, but these opportunities will be less frequent. Today, much of the opportunity for securing new wind energy manufacturing facilities in is in the lower-tier, component supplier levels.[19]

States that have been successful in securing OEM or Tier I wind energy manufacturing in recent years are well positioned to benefit from expansion of existing facilities. These states may have some advantages in attracting suppliers because of the efficiencies gained by clustering companies within an industry.[20] States with a high concentration of manufacturing expertise, capital, experience, and low operations costs are also well positioned to participate in component supplier opportunities. States without these assets may find it more difficult to compete in the wind industry's manufacturing sector.

3.2 Solar Energy Manufacturing

Like the wind energy industry, U.S. solar energy industries have expanded rapidly.[21] Also similarly, the solar energy industry can expect increased long-term market certainty brought about by the federal policy changes noted above.

great deal more are procured from producers outside of the United States. Next Energy, a Michigan-based non-profit whose work includes linking potential component suppliers and renewable energy OEMs, estimates that when individual pieces−rather than cost−are considered, only 20% of the parts going into a wind turbine are manufactured domestically.

[17] Buch et al. 2005 note that market access is a primary driver of expansions by multinational corporations.

[18] This conclusion was a consensus noted by the state economic development representatives interviewed for this work. Furthermore, it is verified by the fact that many major global wind energy OEMs (e.g., Acciona, Clipper, Gamesa, GE, Nordex, Siemens, and Vestas, and others) now have primary manufacturing facilities in the United States or have announced their locations in the United States.

[19] This information is from interviews conducted for this report. For more information about these interviews, see the appendix.

[20] The agglomeration economies, or clustering advantages, of firms locating in a similar geographic area are often real. Though this type of analysis has not been done for renewable energy manufacturing, clustering advantages are likely to the extent that analysis of other industries applies.

[21] Installed photovoltaic (PV) capacity grew by 44% in 2008 and 36% in 2007 (Gelman and Hockett 2009).

However, solar energy technologies, which include solar PV, solar hot water heaters, and concentrating solar power (CSP), are more diverse than wind energy technologies. Further, a great deal of diversity exists within individual solar energy sectors. For example, solar PV includes traditional crystalline silicon, as well as a variety of thin-film PV technology. Each technology has its advantages and faces its own market barriers in terms of cost, market potential, and technological maturity. Moreover, each solar energy technology occupies its own position in the technology diffusion curve.[22] The variability in the solar sector means that opportunities for manufacturing of solar energy technologies are more varied and open. However, because the consumer markets are less mature, solar manufacturing opportunities involve potentially higher risks.[23]

Despite its less mature consumer markets, recent growth has resulted in the announcement and establishment of a number of solar energy manufacturing facilities in the United States. A few examples of OEM facilities recently announced include those of First Solar in Ohio, Schott Solar and Signet in New Mexico, SolarWorld AG and Solaicx in Oregon, and United Solar Ovonics in Michigan. SEIA estimates that domestic growth in the production of PV cells grew by 53% and overall solar manufacturing capacity grew by 65% in 2008 (SEIA n.d.).

Figure 2 highlights the distribution of firms involved in the production of solar energy equipment.[24] These data suggest that there are more solar energy manufacturers than wind energy manufacturers in the United States. However, Figures 1 and 2, which do not distinguish production, employment, and investment levels by individual firms, should not be interpreted to suggest that solar energy provides a larger opportunity for economic development. In addition, Figures 1 and 2 do not include the same level of detail with respect to lower-tier component manufacturers and are thus not direct comparisons.

---

[22] At present, solar energy markets are geared towards distributed and small utility-scale energy markets. In 2008, nearly 100% of installed capacity was in solar PV and solar water heating applications, and the largest utility-scale application was a 10 MW PV facility in Nevada. One 64 MW CSP project was completed in 2007, and a second 75 MW was under construction at year-end 2008. In addition, Ausra completed a 5 MW demonstration plant in 2008

[23] This information is from interviews conducted for this report. For more information about these interviews, see the appendix.

[24] Solar energy equipment includes solar PV cells and modules, solar thermal technology components, as well as racking components, inverters, and batteries used in solar energy installations. These data were collected by the Solar Energy Industries Association. Data do not distinguish between firms for the number of employees supported by the industry or for the respective position of each company in the industry supply chain.

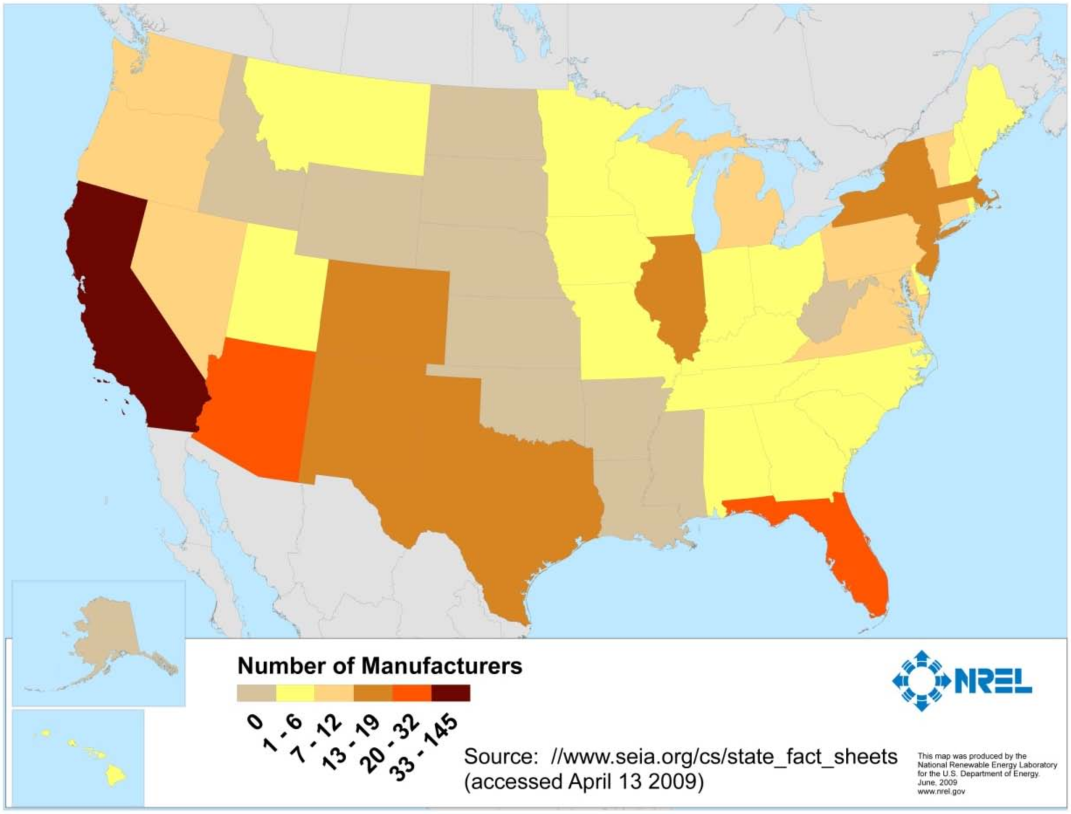


Figure 2. Opened and announced firms involved in solar energy manufacturing by state (*as of 2008*)

Much of the growth in solar manufacturing capacity has been in traditional crystalline silicon flat-plate and thin-film technologies.[25] However, the Schott Solar facility in New Mexico is expected to produce receiver tubes for concentrating solar power plants, and Ausra's Nevada Production Facility, which opened in 2008, is expected to produce 700 MW of concentrating solar power equipment annually at full capacity (SEIA 2009, and Ausra 2008).

Many of the world's dominant PV OEM solar manufacturers, including Sharp, Q-cells, Suntech, and Kyocera do not yet have a U.S. manufacturing presence, and despite growth in 2008, U.S. production of solar energy equipment constitutes less than 10% of global production (SEIA).[26] Still, the recent expansion of U.S. (and global) solar manufacturing capacity, coupled with the worldwide recession, has resulted in an oversupply of solar PV modules, lowering costs and putting increased pressure on the manufacturing supply

[25] It is worth noting that the Chinese are currently investing heavily in traditional crystalline silicon PV manufacturing capacity and the Chinese Company Suntech is one of the fastest growing global producers of traditional crystalline silicon PV panels. In contrast, U.S. investment has frequently targeted thin-film PV technologies. First Solar is a commonly cited success story with regard to thin-film technology.
[26] Reportedly, Suntech is in the process of selecting a U.S. manufacturing facility.

chain. This trend has left some economic development officials uneasy and concerned about the long-term viability of the domestic solar energy market.[27]

Solar OEMs include start-up companies emerging from R&D laboratories and larger corporations seeking to establish a presence in the U.S. market. Anecdotal evidence suggests that the start-up companies that emerge from laboratories often locate close to those same institutions. Examples of this trend include Abound Solar of Fort Collins, Colorado, which emerged from the research laboratories of Colorado State University and Suniva Inc., which is producing its technology in suburban Atlanta after emerging from research carried out at the Georgia Institute of Technology.

Multinational manufacturers tend to plan more in terms of existing infrastructure, workforce capabilities, operations costs, and transportation logistics (Buch et al. 2005).[28] Component manufacturers are more diverse and range from producers of basic hardware for balance-of-plant requirements to laboratories that produce highly specialized materials.

3.3 Future Market Expectations

Clean energy manufacturing is forecast to be a growth opportunity, but it is not one without limits. It is estimated roughly $13.3 billion was spent on wind and PV related equipment in 2008.[29] In addition, certain states are better positioned to capitalize on the potential renewable energy manufacturing opportunities by virtue of their geography and existing manufacturing capital. As a result, understanding the scale of the opportunity for clean energy manufacturing is critical for state policymakers who are only now recognizing the opportunities and for states that do not have notable strategic assets (an existing manufacturing base and/or geographic advantages).

The scale of opportunity depends directly on deployment of wind and solar technologies. This analysis considers two different U.S. build out scenarios to estimate the scale of domestic investment in renewable energy equipment over the next ten to twenty years. Assuming that U.S.-based manufacturing will serve a future export market could significantly increase the scale of the opportunity. However, forecasting global renewable energy growth as well as the U.S. ability to compete on an export basis is beyond the scope of this work.

The first scenario is based on the U.S. Department of Energy's report *20% Wind Energy by 2030* (DOE 2008). This scenario provides an estimate of the potential investment in wind energy over the next twenty years. The second scenario is from deployment as modeled under business-as-usual and three proposed National RES debated in U.S.

---

[27] This information is from interviews conducted for this report. For more information about these interviews, see the appendix.
[28] Ibid.
[29] Calculated value based on 2008 installed capacity for wind and PV and assuming an estimated cost of $1,360/kW (2008$) for wind turbine generators (Wiser and Bolinger 2009) and a combined cost of $4,817/kW (2008$) for PV modules and the inverter (Wiser et al. 2009); the combined PV and inverter cost is calculated from the average 2007-installed cost and the percentage of total installed cost constituted by the PV modules and inverter as presented by Wiser et al. (2009).

Congress in the spring of 2009 (Sullivan et al. 2009). A few important caveats about manufacturing market scale estimates include:

- The values below reflect first-order estimates of expenditures on renewable energy equipment alone. They do not include expenditures on transmission, labor, professional services, or balance-of-plant (BOP) equipment (electrical wiring, concrete, etc.) incurred during construction of a new renewable energy electricity facility.
- The values below are based on today's costs and reflect constant 2008 dollars; cost escalation as has been observed in recent years in the wind energy industry is not accounted for. Likewise, continued cost declines as have been observed in solar PV are also not considered.[30]
- The values do not include potential costs associated with premature equipment failures, repair parts, or operations and maintenance expenses.
- To the extent that deployment deviates from these scenarios discussed here, the expected investment in renewable energy equipment will also vary.

Under the *20% Wind Energy by 2030* report, 305 GW of wind energy are installed in the United States (DOE 2008). This represents a more than 10-fold increase in installed U.S. capacity. Given that roughly 25.3 GW of land-based wind energy capacity were installed at the end of 2008, approximately 280 GW of wind power remain to be installed by 2030 (AWEA 2009). In 2008, the average cost of building an onshore wind project was $1,915/kW (2008$). Of this cost, roughly $1,360 (2008$) is attributed to the cost of the wind turbines themselves (Wiser and Bolinger 2009). For offshore installations, O'Connell and Pletka (2007) estimate costs to range from $2,200/kW to $2,520/kW (2008$). Assuming that the cost of offshore turbines is a slightly lower percentage (5%) of total project costs when compared with onshore turbines, the cost of an offshore turbine can be approximated at $1,460 to $1,660/kW.[31] Further, by assuming that offshore costs are at the high end of the estimated range and that average real wind turbine prices remain relatively constant moving forward, one can approximate that under the 20% by 2030 scenario, the investment in wind turbine equipment will be approximately $400 billion (an average of slightly more than $19 billion per year).

The second build out scenario considered includes multiple forms of renewable energy generation. In this analysis, the deployment of all renewable energy resources is estimated to range from 163 to 261 MW depending on the details of each RES proposal

[30] Solar (and wind) costs may decline greatly over the next 20 years. In addition, cost changes may greatly impact demand for renewable energy equipment. However, the purpose of this analysis is simply to gauge the scale of the market for renewable energy equipment resulting from U.S. demand. For this purpose, these assumptions are sufficient.

[31] Ultimately, the percentage of total project costs constituted by offshore wind turbine generators may differ greatly from that of onshore projects. However, this analysis is intended merely to provide a sense of the magnitude of renewable energy equipment expenditures that may occur over the next 20 years. Therefore, the balance of plant (BOP) costs for offshore facilities are assumed to be slightly greater as a percentage of total installed project costs. The basis for this adjustment is that BOP costs are increased due to advanced foundations and underwater collection and transmission infrastructure.

(Sullivan et al. 2009).[32] Figure 3 summarizes the expected deployment through 2030 for each technology type in each of the scenarios considered in this report. Under the various proposals considered here, energy efficiency provisions prominent in the Bingaman and Waxman cases are expected to reduce renewable energy deployment relative to the business-as-usual case (Sullivan et al. 2009).

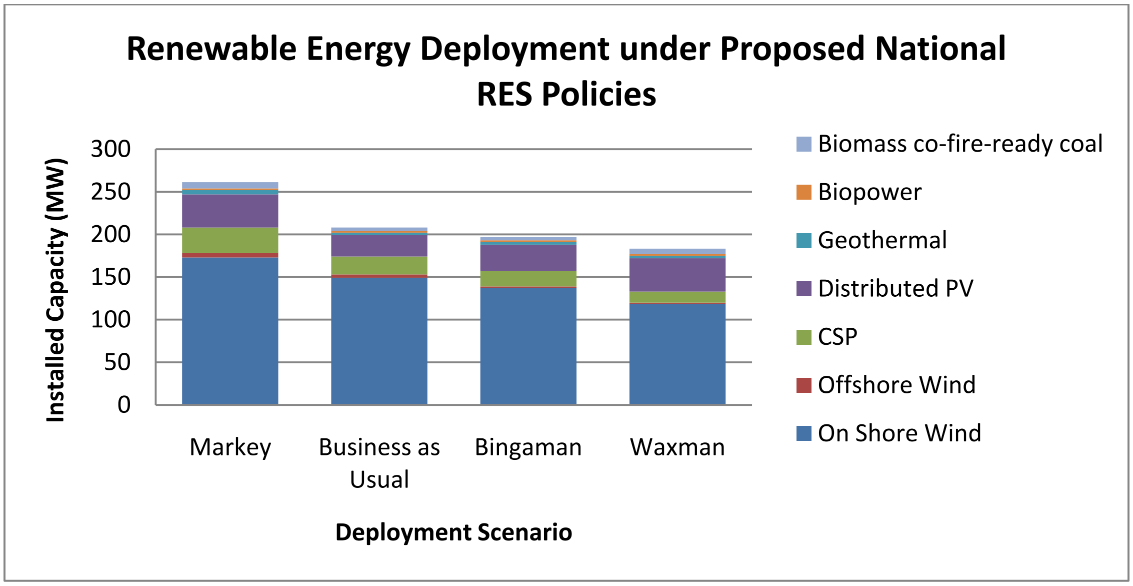


Figure 3. Installed RE capacity under business-as-usual (BAU) and various proposed national RES policies (Sullivan et al. 2009)

When applying existing equipment cost data to the installed capacity for each individual technology in the deployment scenarios forecast by Sullivan et al. (2009), equipment expenditures are on the order of $290-$430 billion or an average of $14-$20 billion per year through 2030. Figure 4 details the expected investment for each individual technology based on the above scenarios. Table 1 details the cost estimates used to arrive at these values.

[32] Cases analyzed by Sullivan et al., (2009) reflect draft bills proposed individually by Representative Edward Markey of Massachusetts and Senator Jeff Bingaman of New Mexico as well as a draft bill proposed jointly by representative Markey and fellow Representative Henry Waxman of California. Scenarios include: a 25% by 2025 RES with no provisions for energy efficiency (Markey), a 20% by 2021 RES, with 25% of the standard fulfilled by energy efficiency (Bingaman), and a 25% by 2025 RES target, with 20% of the standard fulfilled by energy efficiency (Waxman).

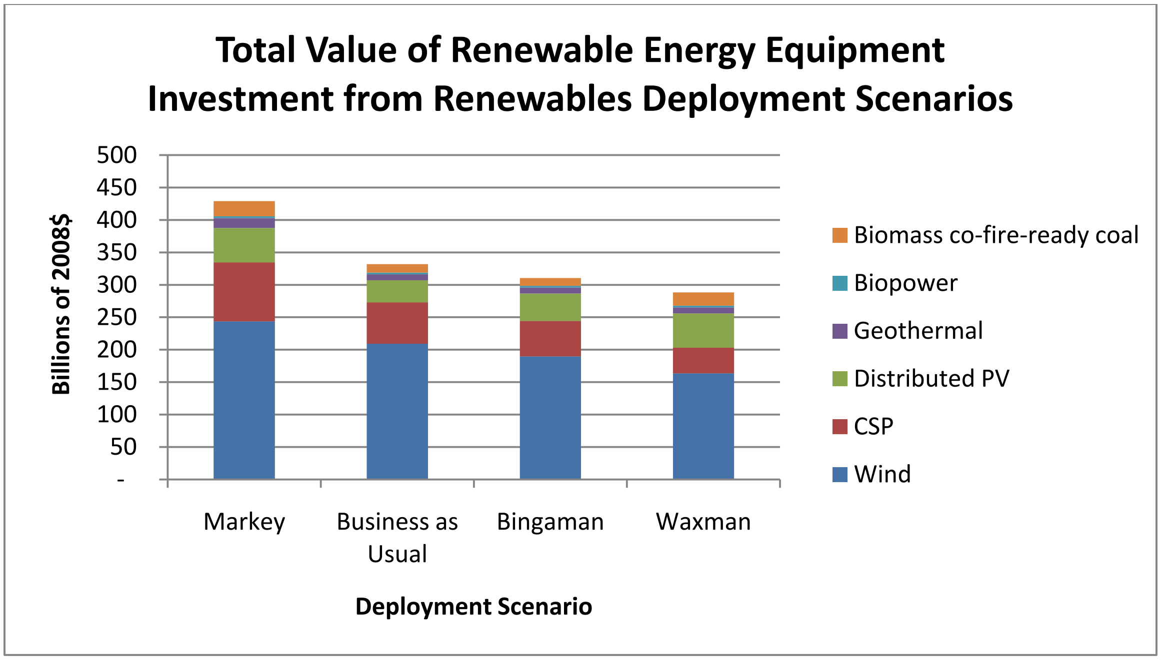


Figure 4. First-order estimate of investment in renewable energy equipment installed in the domestic market as expected under BAU and proposed national RES policies in Sullivan et al. (2009)

Table 1: Cost Estimates Used to Approximate the Order of Magnitude of Investment in RE Equipment under Various National RES Scenarios through 2030.

Technology	Total Installed Cost per GW (millions of 2008$)	Percentage Attributed to RE Equipment	Estimated Equipment Cost per GW (millions of 2008$)
On Shore Wind	$1,915	71%	$1,360
Offshore Wind	$2,520	66%	$1,663
CSP	$4,862	62%	$3,038
Distributed PV	$7,770	62%	$4,817
Geothermal	$3,461	35%	$1,211
Biopower	$5,000	65%	$3,250
Biomass co-fire-ready coal	$5,000	65%	$3,250

Sources include: Wiser and Bolinger (2009), O'Connell and Pletka (2007), NREL's JEDI CSP model (http://www.nrel.gov/analysis/jedi/), Wiser et al. (2007), and personal communication with NREL geothermal and biomass technology analysts. Geothermal and biomass equipment costs reflect current industry estimates.

For context, the total value of the construction machinery industry, including primary production as well as repair parts was approximately $25 billion dollars in 2006 and 2007. In 2007, the farm machinery industry produced approximately $17.5 billion in goods while the household appliances industry produced approximately $23 billion in goods (US Census Bureau).

As a result, this analysis indicates that domestic demand for renewable energy manufacturing will support a substantial investment in renewable energy equipment. If a large portion of this equipment were manufactured in the United States, the renewable energy manufacturing industry would be on par with other significant contributors to the U.S. economy (Table 2).

Table 2. Annual Investment in RE Equipment through 2030 Compared with the Value of Existing Industry Goods Produced in 2007

Industry or Sector	Average Annual Value of Goods Produced (Billions of 2008$)
Wind Energy (DOE 20% Wind Energy by 2030 Scenario)	$19
Renewable Energy (Proposed National RPS Scenarios)	$14-$20
Construction Machinery	$25
Farm Machinery	$17.5
Household Appliances	$23

Note: Existing Industry data are from 2007 and include primary production (production of new equipment) as well as production of repair and replacement parts. Renewable industry estimates are based solely on domestic demand for new equipment. A significant repair and replacement parts industry, or a robust export market for renewable energy equipment could dramatically increase the scale of renewable energy equipment production.

Source: Existing Industry Data from the U.S. Census Bureau, Current Industrial Report

4 Siting Fundamentals

Developing a strategy to attract manufacturers requires that states understand the process and variables that determine where new facilities are located. This section examines the siting of new manufacturing facilities and assesses the use of policy to ensure state resources are directed constructively. This portion of the report seeks to shed some insights into the typical strategy that guides business decision-makers.[33]

4.1 The Decision-making Process

Firm-level siting decisions are a balance of broader business strategy and economic efficiency. Typically, they proceed via a process that may be divided into higher-level stages (Oman 2000). In the first stage, investors and executives analyze how an expansion fits their firm's long-term business strategy. During this stage, firms develop a short-list of potential sites based on fundamental business considerations that include:

- **Reduced operating costs:** Companies looking to export technology or seeking to lower production costs may site new facilities in locations with the lowest overall operating cost (Buch et al. 2005). This strategy helps corporations with low transportation costs and little or no perceived benefit from manufacturing in the markets where their products are sold. Renewable energy manufacturers with low transportation costs often prioritize long-term operations costs.
- **Improved access to high potential markets:** Companies that face high transportation costs, trade restrictions, or limited market share may seek to reduce costs and enhance their competitive position by establishing manufacturing facilities in regions near markets forecast to have high growth. Many firms expand internationally primarily for improved access to markets (Buch et al. 2005). High transportation costs have encouraged wind energy OEMs to locate proximate to the wind-rich Great Plains. Over the long-term, such factors may also become significant for solar manufacturers who, like architectural glassmakers, may seek to minimize long-haul shipments of fragile glass panels.
- **Clustering Efficiencies:**[34] Increased efficiency results from clustering similar firms of a given industry in the same area (Bobonis and Shatz 2007). As a result, firms may look to locate in industry-specific hubs in order to maximize spillovers in workforce capabilities, infrastructure benefits, and supplier proximity. To some extent, these clustering efficiencies appear to be shaping siting decisions in both the wind and solar energy industries.[35]
- **Regional Infrastructure:** Firms, especially those serving broader regional markets, may evaluate the infrastructure associated within a region to focus their

[33] Obviously, not all business will precisely follow the methodology described here. For example, one renewable energy manufacturer considering a new facility in the United States opened the siting process to bid effectively telling states to make offers. This approach is rare, but it demonstrates the variability that exists among manufacturing firms.

[34] Clustering efficiencies are more commonly identified in the academic literature as agglomeration economies.

[35] This trend is evidenced anecdotally by the concentration of wind energy manufacturers in Iowa, Colorado, and Arkansas among other locations.

search (Coughlin and Segev 2000). Multiple transportation capabilities become more important when shipping large components like wind turbine blades or towers. Solar technology, which is generally modular, may not require as diverse shipping capacity. Nevertheless, sound regional transportation capacity is often high on any renewable energy manufacturers list of siting variables.[36]

- **Workforce characteristics:** Even when a particular market looks promising, firms often seek a region with an educated and skilled workforce or lower wage rates (Coughlin and Segev 2000). Broad regions may be overlooked because of workforce deficiencies or worker expectations. States with low wage rates or a highly skilled manufacturing workforce are likely to have an advantage in attracting new renewable energy production investment.

At the highest level, siting decisions are based on opportunities for either significantly reduced operating costs (characteristic of export-based businesses) or enhanced access to a promising new market (characteristic of companies looking to minimize transportation or trade costs). After identifying a few sites that may serve their broader business interests, firms look to the specific attributes of potential sites (Oman 2000). Such considerations may include:[37]

- **Immediate local infrastructure:** A well-designed industrial park or existing facility may help finalize an individual firm's siting decision.
- **Business and government relations:** Courteous and transparent relations between government and business create a stable and clearly defined future, which is a vital business interest.
- **Local incentives:** Incentives in the form of tax subsidies or direct grants are part of most government efforts to secure manufacturing facilities.
- **Potential competitors or suppliers:** Firms may want to isolate themselves from competition but desire to be proximate to potential suppliers.
- **Quality of life variables:** Companies are often concerned with local public services (e.g., primary and secondary school systems), culture, and recreational opportunities. Such attributes are important when executives, management, staff, and families are expected to relocate.
- **Public investment in the broader community:** Public support for parks, recreation, and public spaces may be viewed as indicators of community values or local government values.
- **Community enthusiasm:** Company representatives sometimes mention community support for projects as drivers in the decision-making process. In addition, supportive communities may help simplify the permitting and approval processes, thereby reducing costs.

[36] This information is from interviews conducted for this report. For more information about these interviews, see the appendix.
[37] These considerations are derived from the personal interviews conducted for this report (see the Appendix for details) as well as a sample of economics literature on this topic, including work cited in this report by Bobonis and Shatz (2007), Buch et al. (2005), Coughlin and Segev (2000), and Oman (2000).

In addition to the above considerations, firms also gauge the level of public interest in their siting decisions and consider whether local policymakers are working to stimulate the local demand for their products.

4.2 Renewable Energy Siting Variables

Manufacturing needs vary for renewable energy technologies, and lower-tier manufacturers expand the range of siting needs. As a result, states are likely to benefit from evaluating their strengths and examining their abilities to meet the diverse needs of renewable energy industries.

The need for local demand and long-term market stability is a common theme in discussions with economic development and industry officials.[38] Businesses like to know the expected market demand for their products or services both in the short and long term. Businesses are also interested in ensuring that the renewable energy market in the United States is robust and growing. Therefore, many firms stated that they prefer states with progressive renewable energy deployment policies and states that are actively moving forward the national discussion on U.S. renewable energy policy.[39] For the wind energy industry, transportation costs can be a significant part of the total cost of a wind turbine. OEMs often seek states that are close to regions with valuable wind resources. Likewise, transport of wind turbine equipment requires specific local and regional infrastructure. In contrast, first tier and lower renewable energy component suppliers may be less constrained by resource areas or transportation infrastructure (e.g., rail, waterway, etc.), but they require more engineering and machining production expertise. These suppliers, which may have diverse markets for their goods and services, may not prefer states that take a progressive renewable energy policy position. Instead, lower-tier suppliers may be more interested in workforce characteristics, local government dynamics, overall operations costs, and incentive packages.

Traditionally, transportation costs have been a lesser consideration for solar OEMs, but this may change as the industry matures. Transporting large volumes of glass can challenge manufacturers, and they may ultimately desire to be proximate to high-value markets. Nevertheless, the solar energy industry like the wind energy industry entails an array of lower-tier suppliers for which proximity to demand is less important. Early decisions by manufacturers suggest that the solar energy industry prioritizes the ability to leverage existing assets, including R&D capabilities as well as workforces and infrastructure with preexisting silicon refining and production capacity.[40]

[38] This information is from interviews conducted for this report. For more information about these interviews, see the appendix.

[39] Though this was a common theme, it was not ubiquitous. Other firms noted that the value of progressive renewable energy policy depends on the scale of the market resulting from state policy as well as general market demand and transportation costs. In some cases, particularly for products with lower transportation costs, the value of proximity to market may not offset other factors that influence siting decisions.

[40] Of course, thin-film or solar thermal technologies that do not use silicon do not benefit from existing silicon production capacity. These locations hold less appeal for solar technologies that are not based on amorphous silicon.

5 The Role for Policy

Given the long-term outlook for renewables, the United States is an attractive manufacturing location for firms looking to serve the North American renewable energy market. However, in today's economy, the desire for renewable energy manufacturing jobs could quickly exceed the market demand for renewable energy products.

Competition among states for a finite pool of renewable energy manufacturing investment can benefit and challenge state policymakers targeting renewable energy manufacturing opportunities. On one hand, competition can drive states to invest directly in infrastructure and human capital in order to attract both foreign and domestic investment. On the other hand, competition can drive up the financial and fiscal incentives that local governments feel they need to attract manufacturers. Data from the automotive industry indicate that the public investment per job increased by a factor of more than 40 between 1980 and 1997 (Oman 2000). However, past a point, incentives grow so large they no longer represent a net benefit for their provider. Furthermore, to the extent that increased incentives shift funds from investment in infrastructure and workforce development, relying on incentives to attract new manufacturers may actually diminish a state's ability to maintain or develop its fundamental economic assets (Oman 2000).[41] Sound policy plays a key role in attracting both renewable energy investment and investment from unrelated industries. However, it also plays a role determining the balance of costs and benefits associated with attracting new investment.

5.1 Policy Impacts on Siting Locations and State Experiences

For many years, economists argued that states had little influence on the siting decisions of business (Oman 2000). However, given the development of modern transportation and communication networks along with broader trends toward globalization and larger multi-national corporations, economists now recognize that state and local policy play a role in siting decisions (Oman 2000). Nevertheless, state policy is secondary to basic business strategy in its influence (Buch et al. 2005).

Despite their secondary role, states have sought to maximize their influence in siting decisions by using incentives and recruitment packages. Survey data indicate that between 1977 and 1996 the number of states offering incentives for direct investment generally, more than doubled. A 1995 survey of U.S. corporate executives showed that nearly 80% of firms received incentives for siting facilities where they did (Oman 2000). At least 19 states currently offer incentives aimed at renewable energy business recruitment (DSIRE n.d.).

The policy tools used have historically emphasized financial incentives. Property tax rebates, income tax credits, grants, loans, and sales tax exemptions are common, while infrastructure improvements may be part of broader incentive packages. Leading states in renewable energy manufacturing, including Arkansas, Colorado, Iowa, Michigan, New Mexico, and Oregon have all provided individualized incentive packages to the facilities

[41] A great deal of analysis has been devoted to this area, and although it is difficult to pinpoint the whole array of costs and benefits, at some point the costs of government incentive packages certainly exceed the benefits that communities realize from a new manufacturing facility.

they have secured and have largely relied on traditional tools, including tax assistance, long-term and short-term loans, job training funds, and physical infrastructure assistance (*Wind Powering America 2009*).

Despite the widespread use of financial incentives, empirical evidence on their impact is mixed. According to some economists, the power of incentive policies to explain the location of direct investment is limited. Broad-based analysis of labor subsidies, capital subsidies, and foreign trade zones indicates that these tools, as applied in the United States, offer no explanatory value in the siting of foreign direct investment (Bobonis and Shatz 2007).[42] Further, financial incentives are often justified as a mechanism to generate jobs in underdeveloped or depressed areas, but econometric analysis finds little evidence that depressed areas are better served by such packages (Oman 2000). Finally, lessons learned from the auto industry indicate that increasing competition between states for limited investment dollars tends to increase the size and sophistication of incentive packages but does not influence the actual amount of direct investment (Oman 2000).[43] This evidence has led economists to recommend focusing on long-term economic development and investing in diverse sets of durable assets, including human capital and modern infrastructure while reducing entry barriers, rather than devoting significant resources to incentive packages (Oman 2000).[44]

Nevertheless, economic development officials often identify financial incentives as an important marketing tool, and industry officials often place financial incentives among their top considerations when evaluating new manufacturing sites. Still, industry officials interviewed for this report generally noted that financial incentives alone are not sufficient to justify the large investment that a new manufacturing facility entails. Thus, it seems that financial incentives may be an important component for keeping a specific state competitive, but long-term economic growth results from a portfolio of economic development programs.

5.2 Applying Policy Tools

A holistic economic development strategy that seeks to maximize the impact of the renewable energy sector will be based in traditional economic drivers like human capital, a diverse economic base, and modern infrastructure. It may require tailoring for the needs of renewable energy industries. Such a policy strategy might include:

- **State and local infrastructure development:** The dispersed nature of renewable energy resources means that the equipment frequently travels long distances to the point of installation. Ensuring that state and local infrastructure is capable of transporting equipment to valuable resource areas is an important element of supporting renewable energy business development. And, it fits well with a

[42] To every rule there are exceptions and the media often highlight cases where large financial incentives have helped to secure a given business siting. However, the evidence indicates that when there are broad trends the incentive policies noted here have no statistically significant explanatory value.

[43] In the auto industry the value of incentives paid per job grew from roughly $4,000 in the early 1980s to over $168,000 per job in the 1990s.

[44] Economists are also critical of removing funds from existing public investment to fund excessive financial incentives that may be in place to compensate for deficiencies in overarching strategic criteria (e.g., proximity to market, existing infrastructure, or market stability).

broader economic development strategy, as infrastructure is a vital component of any advanced economy (Coughlin and Segev 2000, Oman 2000).

- **Education and workforce training:** Robust education and workforce training are critical to all economic development strategies (Coughlin and Segev 2000, Oman 2000). Modifying university programs, community college curriculums, and transitional training programs to prepare workers for opportunities in the renewable energy industry can leverage existing assets. Investment in public education can support R&D and lead to cleantech spin-offs from public research institutions (e.g., Abound Solar from Colorado State University and Suniva Inc. from the Georgia Institute of Technology as noted above).
- **Direct outreach and marketing:** Bobonis and Shatz (2007) document the positive impacts of foreign recruiting offices in countries from which firms are expanding. Visits by high-ranking state officials can also enhance marketing and outreach efforts.[45]
- **Community development and quality of life programs:** Many firms seeking to attract the best and brightest must consider quality of life when choosing a siting location. Investment in public services, parks and recreation, and other projects that impact quality of life metrics can assist in community and state differentiation.[46]
- **Predictable regulatory and governing environment with limited barriers to entry:** All businesses prefer predictable, stable markets (Oman 2000). Outside investors favor policy environments with fair competition and limited barriers to entry (Buch et al. 2005). Increasing government transparency and providing for stable and predictable regulatory environments, while minimizing government-based barriers to entry ensures that local government is doing their part to enhance the local business climate.
- **Provision of fiscal and financial incentives:** States may seek a level of incentives that keeps them competitive with other states pursuing new manufacturing investment. However, relying solely on financial incentives to attract investment will not offset an absence of basic components necessary for a viable business. Coupling incentives with broad-based programs will ultimately support long-term economic development (Oman 2000).
- **Detailed resource and market analysis:** Competition from other states can be mitigated by specifying a niche that clearly connects existing strengths with renewable energy industry needs. Analysis that provides a thorough understanding of the renewable energy industry and details the characteristics of the local economy is vital to this process.[47]

[45] This information is from interviews conducted for this report. For more information about these interviews, see the appendix.
[46] Ibid.
[47] Ibid.

- **Advancement of renewable energy markets:** States with established renewable energy markets sometimes have an advantage in attracting OEM manufacturers. State political leaders who promote federal renewable energy policy also demonstrate commitment to renewable energy technologies that may differentiate their states from others.[48]

6 Summary and Conclusions

Renewable energy markets in the United States are growing rapidly, and the long-term outlook for the industry is positive. In addition, the economic development impacts of renewable energy are notable even without considering the impacts of U.S.-based manufacturing. However, a great deal of renewable energy job generation will occur outside the United States if the country continues to import much of its renewable energy equipment.

Over the next 20 years, the investment in renewable energy equipment resulting from domestic demand is estimated to be $14-$20 billion. As such, domestic demand for renewable energy manufacturing represents a large but not unlimited opportunity. Moreover, the strategic advantages inherent in geographic location and existing manufacturing assets suggest that large-scale renewable energy manufacturing facility will not likely be sited in every state even in best-case scenarios (i.e., widespread global deployment and a robust export market).

Marketing strategies for states seeking to attract manufacturers may be best served by multi-faceted strategies that allow them to compete in terms of financial incentives but are more focused on differentiating themselves by leveraging and strengthening durable assets. Policy measures designed with this goal in mind emphasize broad-based infrastructure development, industry-specific worker training, progressive renewable energy deployment policies, and a stable regulatory environment, as well as investment in public education and research, community development, and quality of life factors.

A long-term broad based approach such as that outlined here takes time to reveal its value. Nevertheless, it is more likely to yield a sustainable outcome whether the resulting economic development is due to investments made by the renewable energy industry or another unrelated industry that may be better suited to the resources of a state or community.

[48] Ibid.

References

American Wind Energy Association (AWEA). (2009). *AWEA Annual Wind Industry Report.* Washington D.C.: AWEA.

Ausra Incorporated. (2008). "Ausra Opens First U.S. Solar Thermal Power Factory." http://ausra.com/news/releases/080630.html Accessed June 24, 2009.

Bobonis, G. J.; Shatz, H. J. (2007). "Agglomeration, Adjustment, and State Policies in the Location of Foreign Direct Investment in the United States." *The Review of Economics and Statistics* (89:1); pp. 30-43.

Buch, C. M.; Kleinert, J.; Lipponer, A.; Toubal, F. (2005). "Determinants and Effects of Foreign Direct Investment: Evidence from German Firm-level Data." *Economic Policy* (20:41); pp. 51-110.

Coughlin, C. C.; Segev, E. (2000). "Location Determinants of New Foreign-Owned Manufacturing Plants." *Journal of Regional Science* (40:2); pp. 323-351.

Database of State Incentives for Renewable Energy and Energy Efficiency. n.d. http://dsireusa.org/ Accessed June 2009.

Gelman, R.; Hockett, S. (2009). *2008 Renewable Energy Databook.* DOE/GO-102009-2827. Washington D.C.: U.S. Department of Energy, Energy Efficiency and Renewable Energy.

Lantz, E.; Tegen, S. (2008). *Variables Affecting Economic Development of Wind Energy.* NREL/CP-500-43506. Golden, CO: National Renewable Energy Laboratory, Conference Paper.

O'Connell, R.; Pletka, R. (2007). *20 Percent Wind Energy Penetration in the United States: A Technical Analysis of the Energy Resource*. Project Number 144864. Walnut Creek, CA: Black & Veatch.

Oman, C. (2000). *Policy Competition for Foreign Direct Investment: A Study of Competition Among Governments to Attract FDI.* Paris: Organization for Economic Cooperation and Development.

Pollin, R.; Garrett-Peltier, H.; Heintz, J.; Scharber, H. (2008). *Green Recovery: A Program to Create Good Jobs and Start Building a Low Carbon Economy.* Amherst, MA: Political Economy Research Insitute (University of Massachussetts Amherst).

Reategui, S.; Tegen, S. (2008). *Economic Development Impacts of Colorado's First 1000 Megawatts of Wind Energy.* NREL/CP-500-43505. Golden, CO: National Renewable Energy Laboratory.

Sherwood, L. (2008). *U.S. Solar Market Trends 2007.* Latham, NY: Interstate Renewable Energy Council.

Stoddard, L.; Abiecunas, J.; O'Connell, R. (2006) *Economic, Energy , and Environmental Benefits of Concentrating Solar Power in California.* NREL/SR-550-39291. Golden, CO: National Renewable Energy Laboratory.

Solar Energy Industries Association (SEIA). (2008). *US Solar Industry Year in Review.* Washington DC: SEIA.

Solar Energy Industries Association. (n.d.). http://www.seia.org/galleries/pdf/Solar_manufacturing_tax_credit.pdf Accessed June 24, 2009.

Sterzinger, G.; Svrcek, M. (2004). *Wind Turbine Development: Location of Manufacturing Activity.* Washington DC: Renewable Energy Policy Project.

Sullivan, P.; Logan, J.; Bird, L.; Short, W. (2009). *Comparative Analysis of Three Proposed National Renewable Electricity Standards.* NREL/TP-6A2-45877. Golden, CO: National Renewable Energy Laboratory.

Tegen, S. (2006). *Comparing Statewide Economic Impacts from Wind, Coal, and Natural Gas in Arizona, Colorado, and Michigan.* NREL/TP-500-37720. Golden, CO: National Renewable Energy Laboratory.

U.S. Census Bureau. (2007). *Current Industrial Reports.* http://www.census.gov/manufacturing/cir/ Accessed June 24, 2009.

U.S. Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy. (2008). *20% Wind Energy by 2030: Increasing Wind Energy Contribution to the U.S. Electricity Supply.* DOE/GO-102008-2567.

U.S. International Trade Commission (USITC). (June 2009). *Wind Turbines: Industry & Trade Summary.* ITC-02. Washington DC: Office of Industries.

Wiser, R.; Bolinger, M. (2007). *Annual Report on Wind Power Cost, Installation, and Performance Trends: 2006.* DOE/GO-102007-2433. U.S. Department of Energy Office of Energy Efficiency and Renewable Energy.

Wiser, R.; Bolinger, M. (2009). *Annual Report on Wind Power Cost, Installation, and Performance Trends: 2008.* DOE/GO-102009-2868. U.S. Department of Energy Office of Energy Efficiency and Renewable Energy.

Wiser, R.; Barbose, G.; Peterman, C. (2009). *Tracking the Sun: The Installed Cost of Photovoltaics in the U.S. 1998-2007.* LBNL-1516E. Berkeley, CA: Lawrence Berkeley National Laboratory.

Wiser, R.; Bolinger, M.; Barbose, G. (2007). *Using the Federal Production Tax Credit to Build a Durable Market for Wind Power in the United States.* LBNL-63583. Berkeley, CA: Lawrence Berkeley National Laboratory.

Appendix

Data regarding the experiences of states engaged in efforts to attract clean energy manufacturers were based on five detailed interviews between the authors and state economic development officials and representatives of non-governmental organizations (NGOs) who work to build the green economy in their respective states. This information was supplemented by detailed interviews conducted with ten active renewable energy equipment manufacturers.

The authors selected the state representatives based on their states' success securing clean energy manufacturers, their ability to represent specific regions of the country, and their willingness to be inteviewed. Industry manufacturer interviewees were chosen to reflect a diversity of renewable energy technologies and locations but were limited by industry participation. The sample of interviewees is biased towards the West, Midwest, and Southwest as no interviews were completed by persons in the Northeast, Mid-Atlantic, or Southeast.

Interviews were conducted during April, May, and December of 2009 and generally covered topics including:

- What companies and investors seek out in specific siting locations
- Strategies viewed as having been key to successful efforts.
- The extent and impact of intersate competition
- Strategies for dealing with interstate competition
- Concern (or lack thereof) over future outsourcing of clean energy manufacturing

REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 0704-0188*

1. REPORT DATE *(DD-MM-YYYY)* February 2010	**2. REPORT TYPE** Technical Report	**3. DATES COVERED** *(From - To)*

4. TITLE AND SUBTITLE
State Clean Energy Policies Analysis (SCEPA): State Policy and the Pursuit of Renewable Energy Manufacturing

5a. CONTRACT NUMBER
DE-AC36-08-GO28308

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
E. Lantz, F. Oteri, S. Tegen, and E. Doris

5d. PROJECT NUMBER
NREL/TP-6A2-46672

5e. TASK NUMBER
IGST.9000

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
National Renewable Energy Laboratory
1617 Cole Blvd.
Golden, CO 80401-3393

8. PERFORMING ORGANIZATION REPORT NUMBER
NREL/TP-6A2-46672

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)
NREL

11. SPONSORING/MONITORING AGENCY REPORT NUMBER

12. DISTRIBUTION AVAILABILITY STATEMENT
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

13. SUPPLEMENTARY NOTES

14. ABSTRACT *(Maximum 200 Words)*
Future manufacturing of renewable energy equipment in the United States provides economic development opportunities for state and local communities. However, demand for the equipment is finite, and opportunities are limited. U.S. demand is estimated to drive total annual investments in renewable energy equipment to $14-$20 billion by 2030. Evidence from leading states in renewable energy manufacturing suggests that economic development strategies that target renewable energy sector needs by adapting existing policies attract renewable energy manufacturing more than strategies that create new policies. Literature suggests that the states that are most able to attract direct investment and promote sustained economic development can leverage diverse sets of durable assets—like human capital and modern infrastructure–as well as low barriers to market entry. State marketing strategies for acquiring renewable energy manufacturers are likely best served by an approach that: (1) is multi-faceted and long-term, (2) fits within existing broad-based economic development strategies, (3) includes specific components such as support for renewable energy markets and low barriers to renewable energy deployment, and (4) involves increased differentiation by leveraging existing assets when applicable.

15. SUBJECT TERMS
renewable energy; renewable energy sector; renewable energy equipment; manufacturers; manufacturing; site; siting; siting decisions; renewable energy markets; state policies; policy; economic development strategies; economic development strategy; state marketing strategies; state marketing strategy; economic development; state; local; demand; investment; direct investment; durable assets; state renewable energy markets; infrastructure development; workforce training; community development; fiscal incentives; financial incentives; United States

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
Unclassified	Unclassified	Unclassified	UL		19b. TELEPHONE NUMBER *(Include area code)*

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

F1147-E(10/2008)