ENERGIZING APPALACHIA:

GLOBAL CHALLENGES AND THE PROSPECT OF A RENEWABLE FUTURE

Prepared for the Appalachian Regional Commission

By

Dr. Amy Glasmeier, Ron Feingold, Amanda Guers, Gillian Hay, Teresa Lawler, Alissa Meyer, Ratchan Sangpenchan, Matthew Stern, Wesley Stroh, Polycarp Tam, Ricardo Torres, Romare Truly, Amy Welch.

The Pennsylvania State University
Department of Geography

Finalized: September 2007

CONTENTS

Executive Summary

The global demand for energy is increasing at a staggering rate, particularly as growing countries such as India and China develop at an unprecedented pace. The capacity of conventional resources to meet this growing demand for energy is in serious question. The composition of future energy supplies now dominates the international energy discussion, as it is formative of economic security and development. The influence of energy supply on global relations cannot be overemphasized, and the addition of billions of new energy consumers to already strained conventional energy supplies will further exacerbate energy related tensions. Increasing demand for energy is operating in tandem with increasing global concerns over the impact of conventional energy on our environment, particularly referring to greenhouse gas emissions. As this new energy paradigm continues to reveal itself, actions are underway to establish and grow new energy sources. New sources will not only provide additional opportunities to satisfy growing demand, but non-fossil fuel sources can provide climate friendly alternatives to conventional fossil based resources. Renewable energy sources such as wind, solar and biomass power are growing in importance as resources to address growing energy demand and the requirement to control externalities from fossil fuel consumption.

Over the last three decades, the roles of renewable resources have evolved from experimental afterthoughts to viable means of energy supply. Having evolved over the last thirty years, much of the technology of wind, solar and even biofuels have reached a level of maturity where production has achieved economies of scale and large producers have taken over several of the market niches. An almost singular reliance on fossil fuels has stunted the growth of renewable energy industries in the US. The US now lags behind its global competitors in these strategic industries. Only 20 years ago, the US was an innovator and recognized leader in this emergent sector. Today, while known in the industry group simply based on the size of the national economy, the US is a distant fourth or fifth player in an industrial group that collectively and consistently is growing by at least 25 percent per year for the last five years and is expected to continue or exceed this rate of growth in the foreseeable future. Wind energy is primarily dominated by European companies, with only one of the top ten manufacturers based in the US. India is already a significant global player in the wind industry and China is positioned to enter into this industry in force over the next few years. The Solar energy market is less concentrated than wind and biofuels, with both retail and wholesale markets, than the wind industry, but it also is demonstrating similar trends to wind in that the US is now a net importer of solar photovoltaic (PV) modules.

What the evolving nature of manufacturing within these industries reveals is that the US is allowing itself to be shut out of one of the fasted growing industries in the world. As a nation with increasing annual energy demands itself, left unchecked, the US may well be reestablishing its future energy dependence on the manufacturing of energy equipment from beyond its own borders. Energy security issues aside, this means the US may not be positioning itself to capitalize on an energy sector it was foundational in creating. In particular, areas of the country that may have significant capacity to manufacture equipment for these industries may lose out on a tremendous opportunity for economic growth from the development of renewable energy technologies. It is from this perspective that this report reviews the renewable energy manufacturing potential of the Appalachian region. Experienced in equipment and components manufacturing, and with substantial infrastructure on the ground, Appalachia may be in a position to engage this growing energy sector and provide local growth in jobs and investment.

This report investigates the status and behavior of the wind, solar and biomass industries in order to better understand how domestically-based manufacturers might best engage this sector. It was revealed that significant consolidation has occurred in the wind industry and is beginning to occur in the solar industry. It is becoming increasingly difficult for small companies to gain a foothold and secure adequate market share in both of these industries. However, the growing demand for these resources has opened up opportunities for the manufacturers of equipment in the supply chain of the finished products to emerge.

To understand what opportunities exist for Appalachia to engage the renewable energy sector, this report analyzed the region's potential capacity to manufacture components for the wind, solar and biomass industries. This was accomplished by a comprehensive review of North American Industry Classification System codes and 2002 County Business Pattern Data collected by Bureau of the Census. Industry codes were selected based upon their degree of similarity to parts utilized by the wind, solar and biomass industries. Analysis reveals not only the degree of potential capacity, but also how it is distributed across the region. As a whole, Appalachian counties' possess almost 200,000 jobs in manufacturing parts and components that could, with modification, be suited for production of renewable energy components. This also includes almost 3,000 existing manufacturers within the region that possess similar potential to engage the renewable energy industry. More specifically, analysis reveals where highly concentrated manufacturing potential exists, either as a result of significant jobs, high numbers of manufacturing establishments or where several industry-specific components are manufactured. The concentrated nature of sub-components manufacturing potential within a given area offers a distinct opportunity for industries siting local manufacturing facilities. Each of the 13 Appalachian member states have counties with concentrated manufacturing potential of over 100 jobs or over five components in each of the three industries considered.

Furthermore, several areas of concentrated employment potential exist for each of the three sectors in excess of 1,000 jobs in a single county, including:

- Greenville County, South Carolina, with over 3,700 jobs and 19 establishments producing components similar to those needed by the wind industry;
- Wood County, West Virginia, with 2,710 jobs and three establishments producing components similar to those needed by the solar PV industry;
- Erie County, Pennsylvania, with over 6,835 jobs and 40 establishments producing components similar to those needed by the biomass electric generation industry;
- Regionally, over 28,000 potential manufacturing jobs exist within economically distressed or at-risk Appalachian counties.

Manufacturing potential is not immediately available for component production for each of these industries. Yet, tools exist that could enable or encourage manufacturing for renewable energy components ranging from educational programs and industry incubator programs to financial incentives and renewable energy policies. In particular, some states have developed and passed legislation providing tax credits for manufacturers producing equipment for renewable energy as well as for consumers who purchase equipment manufactured within their states. Even more, policies have been passed that provide incentives for manufacturers that site renewable facilities within economically depressed regions. Opportunities to pursue similar initiatives exist for Appalachian member states.

Recommendations to facilitate growth in renewable energy manufacturing and production in the region include the following:

Renewable Energy Manufacturers Tax Credits
Renewable Energy Portfolio (RPS) and Tax Credit Multipliers for In-State Manufacturing
Tax Credits or Multipliers for Manufacturing in Distressed Regions
Incubator Programs for Renewable Energy Industries
Renewable Energy Manufacturing Business Outreach Program
Bridging Local Manufacturing with Industry Suppliers and Vendors
Regional Renewable Energy Industry Consortiums
Production Tax Credits, Grants and Loans for Cellulosic Ethanol

In addition to the opportunity for manufacturing components for these industries, Appalachia may have the capacity to produce energy from renewable sources. In particular, beyond current uses of biomass in electrical energy cogeneration, the future of biomass energy extends beyond electricity generation and is growing most rapidly in the area of biofuel production. Ethanol production in the US is significant, and the development of new technologies to utilize cellulosic ethanol is rapidly progressing. It is widely held within the biofuel arena that cellulosic ethanol production will become a mainstream fuel source in the coming decade. Where wind and solar energy production capacity is highly variable across the Appalachian region, it is likely that substantial cellulosic ethanol resources exist throughout the region that can be harvested for this industry. This provides a distinct opportunity for Appalachia above and beyond equipment manufacturing. This report briefly explores the economic potential for this resource to be pursued in Appalachia.

In summary, the results of this report indicate that there is substantial potential to produce components for the rapidly growing renewable industries of wind, solar and biomass energy. The nature of the industry suggests that sub-component manufacturing may be an achievable near-term goal for the economic growth in the region. Medium-term potential for growing locally-based renewable firms exists as well, although the consolidating nature of the industry suggests this requires substantially more support from agencies such as State government and the Appalachian Regional Commission. Finally, long-term potential to become a significant biofuel energy producer may exist. Each of these opportunities will deliver much-needed growth to the region, from a set of industries that show the potential to continue rapid growth into the future.

Introduction

Over the last decade the global wind, solar and biomass industries have grown substantially. In the US alone, generation of wind energy has grown from 10 megawatts (MW) of installed capacity in 1981 to over 10,000 MW today. The solar industry has also experienced record growth: in 2005 a record level of PV was installed globally and the US ranked third in installed solar energy capacity with approximately 450 MW of installed PV capacity. Biomass energy generation has also grown steadily over the last decade and currently provides over 10,000 MW of heat and electrical energy for the US.[1] Growing most quickly in the biomass sector, however, is the production of ethanol and bio-diesel fuels, posing an opportunity of distinct importance for the Appalachian region. More specifically, there is a significant and growing emphasis on the development of cellulose-based ethanol production, derived from the woody and fibrous components of plants rather than the starchy seeds, fruits and roots. The development of such technology will enable the biofuel industry to capture a greater amount of existing biomass resources - resources believed to exist in substantial volumes in the Appalachian region.

For a variety of reasons, demand for all three of these energy sources is predicted to increase in the coming decades. The passage of various energy policies to address energy needs and diversification has proven to be a significant driver behind industry growth. For example, state-level renewable energy requirements detail specified amounts of generation from clean energy sources that must be provided. Renewable fuel requirements have also been instituted in some states, as well as by the nation-at-large with the passage of the *Energy Policy Act (EPACT) of 2005.* Tax incentives are also critical drivers for growth, and federal incentives augment new and existing incentives for renewable energy in an ever-increasing number of states.

The desire for low-emissions energy, relative to conventional energy

Note on Units

We talk about energy in terms of the amount of power over a period of time, for example 1 watt=joule/second. A 60-watt light bulb requires 60 joules of electricity every second, or 60 watts of electricity.

Kilowatts (kW) and megawatts (MW) are units of measurements used in association with large energy producers or users.

1 kW=1,000 watts, 1 MW=1,000 kW=1 million watts

MWs are the standard measure of the generation capability, or capacity, of a power plant. Power plants do not always produce as much power as they are fully capable (peak capacity) all the time, the average amount of power they produce compared to their full potential is referred to as their capacity factor.

For instance, wind power capacity is approximately 35%, and is reported as the average MW (MWa).

1MWa is enough to power approximately 1000 homes.

Source: NM Public Interest Research Group Education Fund Clean Energy Solutions

[1] National Renewable Energy Laboratory: Renewable Energy Poised to Realize Long Term Potential, June 2006: http://www.nrel.gov/director/pdfs/40768.pdf

sources, is also driving demand for these clean energy resources. Finally, steadily increasing and sometimes volatile prices for conventional fuels such as oil and natural gas are driving demand for relatively untapped alternatives that will likely have greater degrees of stability into the future.

There is a growing disconnect, however, between the increasing demand for energy from these sources and a diverse base within the US capable of producing the equipment to meet that demand. Of the record amount of wind installed in the US in 2005, only one US-based turbine manufacturer supplies a significant number of turbines – GE Wind, the only US company in the top ten global wind equipment suppliers.[2] Though GE has dominated the US market for the past three years, all of the remaining suppliers of turn-key products are internationally-based companies including Vestas (Denmark), Mitsubishi (Japan), Suzlon (India) and Gamesa (Spain).

The disparity between local demand and local supply forces a choice between either long-term industry dominance from a small handful of large international companies, largely based in Europe and Asia, or increasing domestic capacity to produce this equipment. The US is in a position to define its role in this growing market, particularly while the opportunity costs of developing manufacturing infrastructure are lower than they will be in the future. The US can pursue opportunities to carve out niches in these arenas, or it can relegate itself to the position of a mere consumer with regard to some of the fastest-growing industries across the globe.

How this opportunity relates to the Appalachian region is the subsequent focus of this report. It focuses primarily on two opportunities to engage Appalachia in the growing renewable energy sectors. The first focuses on the manufacturing of renewable energy equipment domestically. This can come in the form of growing and supporting additional domestic 'turn-key' product manufacturers within these industries to compete within the domestic and international arenas. The second involves establishing partnerships between Appalachian manufacturers of components in the supply chain for renewable technologies and equipment and existing manufacturers and renewable developers. Substantial increases in demand for renewable generation equipment have created significant shortfalls in components and materials for the wind and solar industry alike. This opportunity will be particularly important as internationally-based companies build US-based facilities to meet domestic demand. This opportunity is exemplified by the manufacturing facility in Pennsylvania being established by Gamesa, the world's fourth largest company in terms of market share (as of 2005).[3]

Initial analysis suggests that the region served by ARC may be well-positioned to capitalize on these growing markets, as presented by the results from analyses of the capacity of the Appalachian region to supply major components for renewable energy industries. Information has been compiled on existing manufacturing establishments,

---

[2] BTM Consult ApS: International Wind Energy Development World Market Update 2005 Forecast 2006-2010, Press Release: http://www.btm.dk/Pages/wmu.htm

[3] BTM Consult ApS: International Wind Energy Development World Market Update 2005 Forecast 2006-2010, Press Release: http://www.btm.dk/Pages/wmu.htm

employment totals, locations and sector concentrations within the region. Six-digit North American Industry Classification System (NAICS) codes were analyzed for all counties within the Appalachian region and reflect industry-specific manufactured components that are similar to, or substitutable for, the major manufactured components in the biomass, solar, and wind energy industries.

This analysis reflects not only the potential capacity to manufacture renewable components from existing establishments within the region, but also represents the potential distribution of increased manufacturing that might accompany continued growth in the renewable energy sector. The analysis reveals distribution of existing establishments within states as well as potential clusters of manufacturers with the potential to produce parts for individual energy sectors.

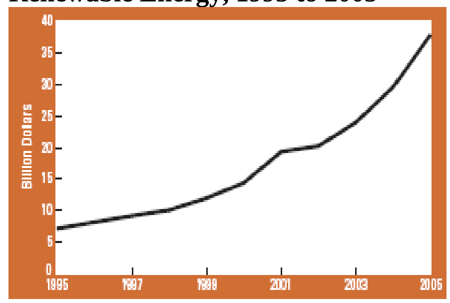
The ability of Appalachian-based manufacturers to compete within this global industry is the fundamental question. This report also addresses salient characteristics of three primary renewable industries, both domestically and internationally. Understanding such characteristics will be critical in plans to promote and develop manufacturing capacity within the Appalachian region.

Of particular interest in this report is the capacity of ARC's member states and counties to produce components for the biomass, solar and wind industry sectors. This report will convey that the region may be well-suited to produce components for these rapidly growing renewable energy sectors, beyond the opportunities that exist to produce energy from them. Finally, in addition to equipment or components manufacturing, this report explores opportunities for the Appalachian region to be at the forefront of the next wave of biomass energy production: cellulosic ethanol.

Renewable Energy Industry Analyses

The ability of Appalachian-based manufacturers to compete within the global wind, solar and biomass industries is an important question. This section of this report addresses characteristics of these three industries, both domestically and internationally. Understanding such characteristics will provide a basis for strategizing and planning the promotion and development of manufacturing capacity within the Appalachian region.

Figure 1. Annual Investment in Renewable Energy, 1995 to 2005



Source: REN21: Renewable Global Status Report 2006

In 2005, the renewable energy sector experienced a record level of investment, with $38 billion dollars put to expanding renewable energy capacity across the globe.[4] This level of investment is likely to continue, and provides the justification for increasing efforts to expand this industry domestically, as well as in areas with the technical capacity to benefit from further growth in this sector.

Wind

Using the kinetic energy of wind to generate electricity has become very common today. Historically, mankind has used wind for purposes far beyond this – from running mills to propelling seaborne ships. Generally, wind energy generation uses the uneven heating of the earth's surface (convection and advection currents) to transfer the kinetic energy of wind into electricity via turbines or generators. Wind turbines utilize this air as it flows past the rotor of a wind turbine and the rotor spins and drives the shaft of an electric generator.[5]

The benefits of wind energy range from its lack of fuel cost to its low-emissions capacity to produce electricity in addition to relatively low maintenance and operations needs. Also, wind energy is clean and abundant. However, due to the nature of the resource, the primary limit of wind power is that it does not produce 100 percent of its generating capacity all of the time. On average, a wind turbine produces at its nameplate capacity roughly 20 percent to 40 percent of the time, termed the 'capacity factor' of the resource. This is in comparison to other conventional resources and biomass energy generation

---

[4] Renewable Energy Policy Network for the 21st Century: Renewable Energy Global Status Report, 2006 Update. http://www.renewableenergyaccess.com/rea/news/story?id=41508

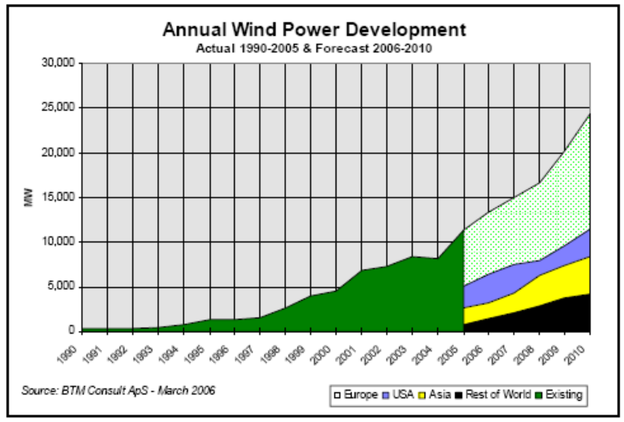
[5] American Wind Energy Association: http://www.awea.org/pubs/factsheets/Wind_Energy_How_does_it_Work.pdf

that have capacity factors typically between 70-80 percent of the time (gas typically around 60 percent and nuclear as high as 90 percent)[6].

Growth, Demand and the Future

As evidenced by increasing deployment across the globe, wind power generation is growing and investments in this industry are increasing at both a national and international level. Over the course of the last 25 years, the wind energy industry has grown significantly with 59,264 MW of installed wind energy generation across the globe at the end of 2005.[7] Wind is currently one of the fastest-growing energy sources globally, with a cumulative annual growth rate of approximately 26 percent in 2005, and sustained growth of over 20 percent over the last five years.[8]

Figure 2. Projected Growth in Wind Power Forecast for 2006-2010



Installations in 2006 are expected to be higher than the record level of installations in 2005 (11,407 MW in 2005 globally).[9] Projected growth rates remain high, with some analysts forecasting annual rates of installation around 16.4 percent through 2010.[10,11] Projections through 2010 suggest the US will add another 18,000 MW installed capacity building upon our current capacity of approximately 10,000 MW. Areas of highest growth will be centered in the US, India and China with sustained growth throughout Europe.[12]

Figure 3. Key Wind Markets 2005 - 2010

Country	Cumulative installation (MW)		CAGR (%)
	2005	2010 E	
France	775	5,575	48
China	1,264	7,764	44
Portugal	1,087	4,687	34
India	4,253	12,253	24
US	9,181	22,381	20

Source : BTM Consult ApS World Market Update 2005

[6] Renewable Energy Research Laboratory, University of Massachusetts, Amherst http://www.ceere.org/rerl/about_wind/RERL_Fact_Sheet_2a_Capacity_Factor.pdf
[7] http://www.renewableenergyaccess.com/rea/news/story?id=41304
[8] Chua, G. (2006) *Wind Power 2005 in Review, Outlook for 2006 and Beyond.* Article based on **US/Canada Wind Power Markets and Strategies 2005-2010.** Emerging Energy Research. www.emerging-energy.com
[9] /ibid, pg 1.
[10] BTM Consult ApS: International Wind Energy Development World Market Update 2005 Forecast 2006-2010, Press Release: http://www.btm.dk/Pages/wmu.htm
[11] Chua, G. (2006) *Wind Power 2005 in Review, Outlook for 2006 and Beyond.* Article based on **US/Canada Wind Power Markets and Strategies 2005-2010.** Emerging Energy Research. www.emerging-energy.com
[12] BTM Consult ApS: International Wind Energy Development World Market Update 2005 Forecast 2006-2010, Press Release: http://www.btm.dk/Pages/wmu.htm

Driving these rates of growth of demand both nationally and globally are several factors. Wind power is continuing to come down in cost, providing a viable alternative to the increasing costs of oil and natural gas. For example, severe ups and downs in the cost per unit of natural gas have motivated utilities to seek forms of energy with greater price stability, particularly as 70 percent of the costs of a natural gas-powered facility stems from its fuel supply costs.[13] Capital costs for wind power are concentrated up-front during the manufacturing and construction phases of a project, with virtually no fuel costs and comparably low operation and maintenance costs. These factors enable utilities to purchase wind energy at a stable price over long periods of time, reducing uncertainty for consumers and utilities, alike.

The price for wind power has come down over the course of the last few decades not only due to demand growth in the industry, but also as a result of financial incentives offered to developers of wind power projects. The Federal Renewable Energy Production Tax Credit (providing $0.018/kWh of wind energy produced) has been a significant component of the cost reduction of wind power spurring development in wind energy over the last decade.[14] Favorable accelerated depreciation rates also are a major incentive for developing power projects. In addition, many states across the country offer special incentives for wind energy, from research & development grants, to pilot project funding to state-based production tax credits. Section 9006 of the Federal Farm Bill also provides substantial funding for renewable energy projects for rural and agricultural residents and businesses, enabling many small-scale wind projects to receive support.

Standard prices for the purchase of power for wind ('feed-in-tariffs') have been a primary driver for the development in wind energy facilities globally, particularly in Europe (*i.e.* Germany and Denmark). Standard offers, or feed-in-tariffs, guarantee a set price for the purchase of wind energy sold to a utility or end user. The ability of wind power generators to sign long-term contracts at a guaranteed price has greatly reduced the risk to investors, encouraging development of renewable facilities.

Growth in the Wind Industry

Wind has expanded from 10 MW in 1981 to over 10,000 MW in 2006.

Wind had a cumulative annual growth rate of 26 percent in 2005.

Growth is projected to remain above 15 percent through 2010.

A record level of 11,407 MW of wind was installed across the globe in 2005

28,000 MW of wind are projected by industry analysts to be installed in the US by 2010.

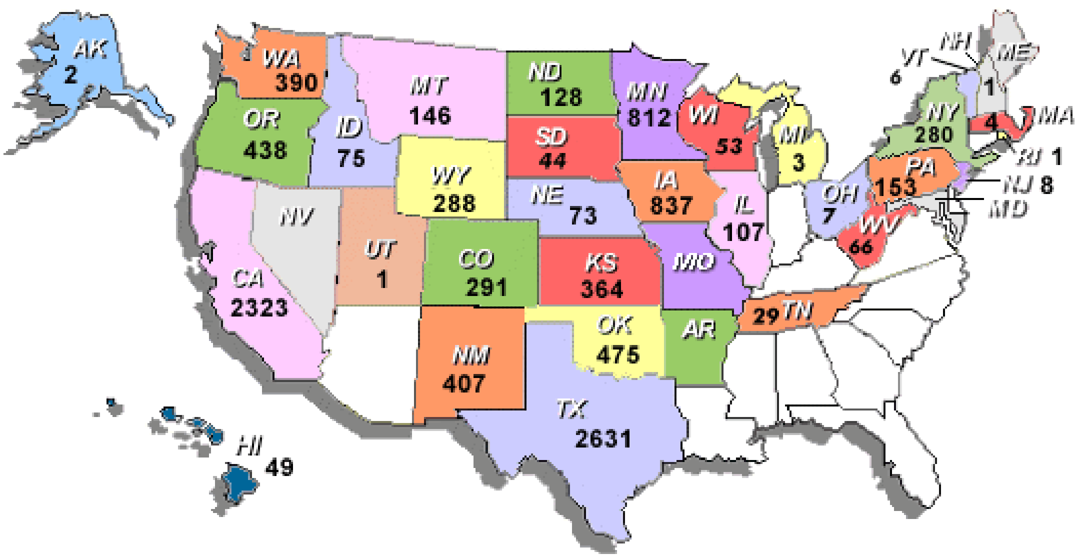
Also, many states and nations have passed public policies encouraging or requiring specified amounts of renewable energy to be supplied to electric consumers. These policies, often in the form of renewable

[13] Sterzinger, G. and J. Stevens. (2006) *Renewable Energy Potential A Case Study of Pennsylvania.* Renewable Energy Policy Project p.

[14] American Wind Energy Association, Policy, Transmission and Regulation website: http://www.awea.org/policy/ptc.html

portfolio standards or renewable electricity standards, have been used to set a baseline amount of energy from clean or climate friendly power sources. In theory, these standards are created to enable infant renewable energy technologies to get a foothold in the market place, eventually becoming competitive with conventional fuel sources over the course of a few years. Figure 4 shows the installed capacity in the United States.

Figure 4. Installed MW of Wind Wnergy in the United States, 2005.



(Source: American Wind Energy Association[15])

Of importance to note here are opportunities for states with relatively low wind energy resource production potential to participate in this industry's growth. Namely, there is great demand for manufactured wind components for this industry, demand that may offer a significant opportunity for states in the Appalachian region which may have significant manufacturing capacity rather than high wind resource potential.

Industry Activity: Strategy and Competitiveness

One of the key aspects of the wind industry is the substantial number of large, global companies that currently dominate market share in all of the major areas of high demand for wind energy. As the demand for wind energy has increased over the last several years, an increasing number of large, heavily diversified entities have entered into the market. Examples include GE, Siemens and Mitsubishi. Many of the largest companies either entered into the wind market or grew to prominence through the acquisition of existing wind companies and competitors. GE Wind entered into the arena through the acquisition of Enron Wind[16], Siemens grew its market share through the acquisition of Bonus Wind,

[15] American Wind Energy Association: http://www.awea.org/projects/index.html

[16] Of its many assets at the time of collapse in late 2001, Enron possessed Enron Wind -its wind equipment manufacturing subsidiary. They were global in the sense that they had sold turbines into the US, German, and Spanish markets, with manufacturing facilities in all of these countries plus the Netherlands. As part of the unloading of assets to pay off creditors, Enron Wind was sold to GE's Power Systems

and Vestas grew larger through the acquisition of NEG Micon, a previously significant competitor.

These examples reflect a growing development in the wind industry of larger companies actively acquiring or merging with other competitors, smaller manufacturers and component makers. A company that has grown to prominence serving the Indian market, Suzlon, has actively focused on acquiring and/or merging with components manufacturers such as Hansen Transmissions, the largest European gearbox manufacturer. Mergers with foreign-based entities and opening satellite manufacturing facilities in areas of increasing market demand are growing in prominence, as well. A sign of the relative maturity of the industry, companies like GE are forming partnerships with foreign companies such as Chinese-based Nanjing High Speed & Accurate Gear Company (NGC) to jointly develop gearboxes for GE's 1.5 MW wind turbines. NGC is now one of GE's leading component suppliers in the wind energy business.[17] Growth through acquisition is enabling the 'big' players to get even bigger while becoming more vertically integrated and thus able to raise entry barriers to keep out new entrants while limiting the growth of small companies. Even as recently as the late 1990s, it was possible for a company to grow through the ability to serve domestic demand, as demonstrated by India-based Suzlon. That window of opportunity, however, seems to be closing as large global players further extend their global reach.

Suzlon Energy Limited: Profile of an Industry Leader from the Ground Up

Growth in the wind industry in India had been tremendous and in 2005, India overtook Denmark in total installed capacity. In the middle of this rapid growth has risen Suzlon Energy, Asia's leading wind manufacturer and fifth largest supplier of turbines worldwide. Suzlon has been India's leading turbine producer for the past eight years, installing 53 percent of the country's capacity in 2005.

Suzlon: Founded in 1995
Headquartered in Pune, India
Revenues of $854,000 in 2006
8,600 employees, 1,900 overseas

Source: Suzlon Energy Ltd. Press Resease 2006, Suzlon Energy Ltd. continues record performance in Q1, FY07

Suzlon's founder, Tulsi Tanti, was a textile manufacturer in the early 1990s. Faced with escalating energy costs, Tanti installed wind turbines at his facility. From this experience, Tanti decided to buy bankrupt Sunwind, founding Suzlon wind in 1995. *Source: Venture Intelligence Blog: http://ventureintelligence.blogspot.com/2006/03/what-makes-suzlons-tanti-tick.html*

Suzlon is an example of a fully-integrated company, producing equipment exclusively for the wind industry. Facilities in Germany, India and the Netherlands are engaged in cutting-edge R&D. Manufacturing facilities are located in India, Belgium, China and the US. Suzlon now supplies turbines for projects from as far as the US, to Brazil to Australia, Europe and across Asia. *Source: Suzlon Annual Report 2005*

Components	Locations
Rotor blades	**India** : Daman, Maharashtra Gujarat, Pondicherry **US** : Minnesota **China** : Tianjin
Gearboxes	**Belgium** (Hansen Transmissions)
Generators	**India** : Maharashtra (JV with Elin, Austria)
Control systems	**India** : Daman, Pondicherry
Towers	**India** : Gujarat, Maharashtra

subsidiary in 2002 in its bankruptcy auction for $358 million. They also took over maintenance of Enron's wind farms. It was a profitable arena for Enron, making real money for the company. According to the *New York Times*, it grew from $50 m in 1997 to approximately $800 m by 2001 http://www.enron.com/corp/pressroom/releases/2002/ene/022002ReleaseWindLtr.html; http://query.nytimes.com/gst/fullpage.html?res=9F07E0D6173CF931A25757C0A9649C8B63.

[17] GE Wind, Press Release Aug. 30, 2006: GE, China's NGC to Jointly Develop Wind Turbine Gearbox. http://www.gepower.com/about/press/en/2006_press/083006.htm

Thus far, the window is not yet completely closed. Clipper Wind is an example of a US-based company that is working to accomplish a successful shift from small to middle to large industry player. In the near term, and perhaps of most widespread significance for American manufacturers, is the opportunity to supply components to an industry that is struggling to meet market demand.

According to energy industry analyst *Emerging Energy Research*, wind energy market share in 2005 was a factor of manufacturing capacity rather than competitive strategy:

> ". . .scale continues to drive competitive advantage. Attributes such as a good track record, capability to deliver large-scale projects, and market reach that is able to span multiple markets, are now par for the course. Building an edge in the competition for power purchase agreements entails taking these attributes to an even higher level and, at least for the near-term supply and demand scenario, simply having the wind turbines with which to build wind plants." [18]

Characteristics of the Wind Industry

- Dominated by highly consolidated and vertically integrated manufacturing firms
- The top 10 wind manufacturers supply over 95 percent of the global wind capacity
- The top 5 wind manufacturers supply over 80 percent of the global wind capacity
- One of the top ten is a US-based firm – GE wind
- The capacity to manufacture turbines determined market share in 2005
- Turbine suppliers are increasing their reliance on outsourced components

Market share in 2005 was ultimately determined by how many turbines a company could manufacture and supply. This situation has favored large, consolidated companies such as GE and Vestas, which possess the greatest market shares in the US and Canada, respectively. *Emerging Energy Research* has identified primary points along the supply chain acting as constraints, including gearboxes, castings and blades. Market share is protected or achieved by in-house manufacturing and ownership or close relationships with manufacturers of wind energy components. Growing wind companies such as Gamesa, Suzlon and Clipper have opened additional manufacturing facilities in the US for this reason.[19]

Suppliers of wind energy components have been reluctant to increase capacity due to the unstable market created by the Federal Production Tax Credit's (PTC) biannual expiration. Yet sustained demand over the last two years and into next year have encouraged increases, largely based upon this planning. However, analysts have pointed out that entities willing to take risks by jumping into the market have thus far been rewarded. Many vendors are sold out through the next expiration date of the PTC in

[18] Sterzinger, G. and J. Stevens. (2006) *Renewable Energy Potential A Case Study of Pennsylvania.* Renewable Energy Policy Project p.
[19] *Ibid.*

2007. The following year, 2008, will be important for the sustained momentum of the wind industry if the PTC expires again.[20]

In attempts to alleviate near-term supply constraints, wind industry vendors are increasing their reliance on outsourced component manufacturing – pushing original equipment manufacturers previously 100 percent vertically integrated to outsource much, if not all, of their supply. Restructuring the supply chain will enable the industry to become less subject to and reliant upon government support and interaction. Wind energy system and component manufacturers are addressing constraints by "moving production of non-essential components to low cost centers and increasing the number of venders supplying components", spreading risk outward from original equipment manufacturers.[21]

Also important to the ability of new players to enter and grow in this arena is the influence of project financing, and the requirements and preference of the lending institutions for project backing. The relationship between wind equipment suppliers, project developers, project financiers and project owners reinforces top manufacturers in the industry. Project developers not only contract with suppliers but seek funding for the project as a whole. This is important in two ways. First, developers often establish long-term relationships with suppliers in order to reduce project costs. Second, financiers are often only able to assess assets of the specific project they are financing, reinforcing their preference for large, established players in the industry. These 'proven' industries typically have no less than 100 installed turbines. Project developers, in response to project financing, are therefore unlikely to contract with companies that are not one of the top international players.[22]

The nature of project financing may determine the kind of arrangements developers have with wind technology suppliers. Private finance companies tend to fund projects on a non-recourse basis, a form of financing that preserves a proponent's other assets and makes available to creditors only the assets of the project itself, should any difficulties arise. As a result, investment companies tend to procure turbines from firms with strong financial and technological records. This usually means proven suppliers that have at least 100 turbines installed and operating in wind farms around the world. Companies that operate under these arrangements are therefore unlikely to engage a supplier outside the top six international companies.

[20] *Ibid.*
[21] Newswire Today (7/20/2006). 'Outsourcing to Help Wind Industry Avoid Supply Constraints.' Frost & Sullivan www.newswire.com
[22] International Market Research Reports, Industry Sector Analysis – Wind Energy: http://strategis.ic.gc.ca/epic/internet/inimr-ri.nsf/en/gr109984e.html

Top Wind Energy Manufacturers

Over the course of the last five years, cumulative annual growth in the industry has been 26.3 percent. The US, Germany, Spain and India lead the world in installed MW, with the top ten manufacturers supplying over 95 percent of global capacity.[23] Furthermore, the top five manufacturers represent over 80 percent of the total installed global capacity for wind energy.[24]

Figure 5. Top Wind Turbine Suppliers

The Top-10 suppliers 2005

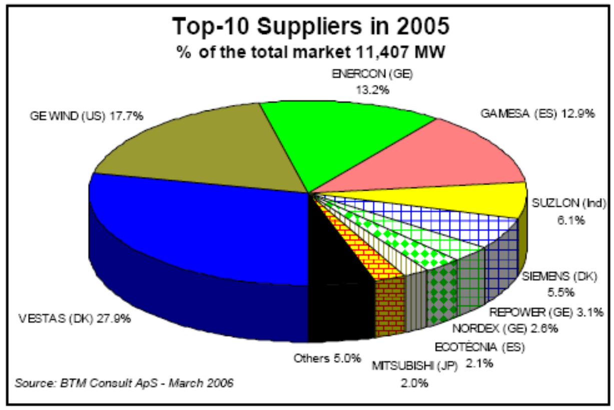


Table 1. Top Five Global Wind Energy Manufacturers (Headquarters, Installed Wind Energy Capacity in MW, Number of Employees, Manufacturing Facilities)

Company	HQ	Installed MW	Employees	Manufacturing Facilities
Vestas[25]	Denmark	20,818	10,618	Denmark, Germany, India, Italy, Scotland, England, Spain, Sweden, Norway, and Australia
GE[26]	USA	5,600	1,700	USA, Germany, Spain
Enercon[27]	Germany	10,200	8,000	Germany, Sweden, Brazil, India, Turkey
Gamesa[28]	Spain	7,547	8,186	Spain, USA (pending facilities in China, Portugal)
Suzlon[29]	India	4,253	5,300	India, Belgium (China and US FY06/07)

---

[23] BTM Consult ApS: International Wind Energy Development World Market Update 2005 Forecast 2006-2010, Press Release: http://www.btm.dk/Pages/wmu.htm
[24] Ibid.
[25] Vestas Website: Key Figures for Vestas: http://www.vestas.com/uk/profile/profile/main_figures/main_figures_uk.htm
[26] GE Wind Energy Website: http://www.gepower.com/businesses/ge_wind_energy/en/comp_snapshot.htm
[27] Enercom Website: At a Glance: http://www.enercon.de/en/_home.htm Capacity Installed: http://www.enercon.de/en/_home.htm
[28] Gamesa Annual Report 2005: http://www.gamesa.es/gamesa/modules/idealportal/uploadlink/memoria2005ing.pdf
[29] Suzlon Energy, LTD Suzlon Energy Ltd. continues record performance in Q1, FY07, Press Release: http://www.suzlon.com/images/you/SEL%20FY07%20Q1%20Release.pdf

Domestic Wind Market

As of December, 2005, the US had an installed wind capacity of 9,149 MW.[30] This number has grown to over 10,000 MW as of August, 2006. According to the American Wind Energy Association (AWEA), by the end of 2006 the US installed 3,000 new MWs of wind energy — more than the total capacity of the US in the year 2000. New manufacturing facilities have opened in Iowa, Pennsylvania and Minnesota, building on existing wind manufacturing facilities in Georgia, Florida, California and Oregon (not including components subcontracts).[31] Significant component manufacturing for the wind industry is occurring in California, Texas, Florida, Wisconsin, and Michigan. For a more detailed list of these manufacturers, including those located in Appalachian states, please see Appendix A.

Table 2. Wind Energy Manufacturers' Share of Installed Wind Energy Capacity in the US. (Note: GE acquired Enron Wind, Vestas acquired NEG Micon Wind.)

Manufacturers' shares of installed capacity for the past five years:

2005	GE Energy 1,433 MW	Vestas 700 MW	Mitsubishi 190 MW	Suzlon 55 MW	Gamesa 50 MW
2004	GE Energy 171 MW	Mitsubishi 120 MW	Vestas 97 MW		
2003	GE Energy 903 MW	Vestas 359 MW	Mitsubishi 201 MW	NEG Micon 129 MW	Gamesa 56 MW
2002	Vestas 175	NEG Micon 98 MW	GE Energy 62 MW	Mitsubishi 61 MW	Bonus 48 MW
2001	Vestas 653 MW	Enron 418 MW	Bonus 278 MW	Mitsubishi 221 MW	NEG Micon 119 MW

(Source: US Wind Energy Industry Rankings, AWEA)

As discussed previously, the American wind industry is faced with the challenge of establishing itself as a base of domestically-prominent wind equipment manufacturing. Given the strong demand for wind power generation in the US as well as Canada, the potential benefits of successfully entering the market are obvious. The question remains, however, as to how to best enter and sustain a company in this highly competitive market. The establishment of a viable 'Industry Consortium' to actively promote growth of the US wind industry, to help bridge the gap between small, middle and ultimately large players in the industry, is one suggestion. In order to promote successful research and development practices, it is important for US industry to penetrate existing R&D activity in Europe to further local industry growth in this arena. Finally, providing direct support for this mid-size 'infant' industry by providing a renewable energy

[30] American Wind Energy Association, US Wind Energy Industry Rankings: http://www.awea.org/pubs/factsheets/pdf/USwindindustryrankings2006.pdf
[31] American Wind Energy Association, U.S. Wind Energy Installations Reach New Milestone, Press Release: http://www.awea.org/newsroom/releases/US_Wind_Energy_Installations_Milestone_081006.html

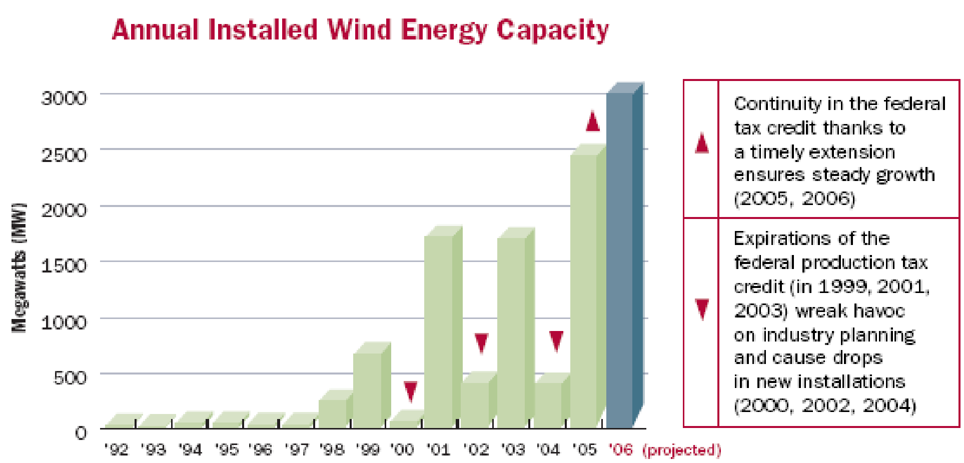
manufacturers' production tax credit for companies below a certain threshold would ease the market entry for both new and existing manufacturers.

Challenges to Industry Growth

As mentioned earlier, supply chain constraints exacerbated by the on-again, off-again PTC severely limited the number of turbines available for installation in both 2005 and 2006, and will likely be severely limiting in 2007. Also mentioned earlier is the nature of financing for large projects, which can limit new entrants into the market. In addition to these challenges, the following issues will ultimately require attention before wind energy can be fully realized:

> **Inconsistent national policy:** Unstable support for the wind industry at the national level has produced an environment of uncertainty for manufacturers, investors and project developers. This is evidenced most directly with the bi-annual expiration of the Federal Renewable Energy Production Tax Credit (PTC).[32] In the US, the single largest influence on consistent growth, as cited by the industry, is the impermanence of the Federal PTC, which provides $0.018/kWh for ten years for each facility. The credit has been available for two-year segments since its inception, expiring three times in the last seven years, leading to a 'boom and bust' cycle for the industry.[33] The PTC is currently set to expire again at the end of 2007.

Figure 6. Annual Installed Wind Energy Capacity and Patterns of Production Tax Credit Availability



(Source: AWEA Wind Power Outlook 2006)[34]

[32] Energy Information Administration: Electric Power Annual: http://www.eia.doe.gov/cneaf/electricity/epa/epa_sum.html
[33] Ibid.
[34] AWEA Wind Power Outlook 2006: www.awea.org

Transmission Capacity for Renewable Energy: Particularly relevant to long-term industry growth is the current lack of investment in transmission capacity across the US, which is flagging relative to demand growth and necessary capacity additions. Significant 'bottlenecks' exist in the current transmission grid, particularly between areas that possess large amounts of renewable energy generation capacity (*i.e.* Great Plains and Intermontane West) and the areas of highest growth in electricity demand, not to mention areas with the highest demand for renewable energy (*i.e.* California). Not only are there limits on existing capacity, but intermittent energy sources, such as wind, are significantly disadvantaged in Federal Energy Regulatory Commission (FERC) transmission interconnection procedures. Where the grid can operate as 'back-up' capacity for intermittent resources such as wind, utilities currently keep spinning reserves of energy waiting in the background, adding a layer of difficulty integrating wind into the existing energy mix.

Competition from Conventional Energy Sources: Wind energy has come down in cost over 80 percent in the last 20 years. However, even with growth in capacity over the last decade second only to natural gas, installation of wind energy is still largely driven by public policy.[35] Conventional power sources such as coal, natural gas and even nuclear energy are still largely favored by utilities across the country and receive substantial subsidies from state and federal governments.

Solar

One of the most significant global resources, solar energy can be utilized passively and actively. Passive solar energy is used in building design to maximize the natural lighting and heating benefits of the sun; active solar energy is captured to produce electricity via thermal or photovoltaic (PV) technologies. Solar thermal technology uses reflectors to focus light onto a central receiver that uses the gathered heat to power a turbine. This technology converts solar energy into mechanical energy, which is then converted into electricity.

Photo courtesy of the New Mexico Solar Energy Association

Solar electricity can also be produced using a PV cell. PV cells are composed of semiconductor materials that gather sunlight and directly convert it to electricity with no moving parts. Panels of these cells connect to form modules and arrays that have the capacity to produce enough power for several or more homes.[36] For example, a PV array the size of a football field would create 1.2 million kWh of electricity per year, enough for approximately 122 homes.[37]

[35] American Wind Energy Association, Resources Cost: http://www.awea.org/faq/cost.html
[36] New Mexico Public Interest Research Group Education Fund, *Clean Energy Solutions*. March 2002.
[37] Department of Energy, Energy Efficiency and Renewable Energy website: www.eere.energy.gov

The nature of the solar energy market creates several interesting dynamics in the industry. Demand for solar PV cells spans the spectrum from small residential PV systems to large commercial systems which generate electricity for entire corporate campuses or provide electricity generation for utility companies. Systems that provide energy to a grid system represent a portion of electricity generation in Italy, Spain, and the US under heavily subsidized markets.

Growth in the Solar Industry
Global solar PV installed capacity expanded from less than 500 MW in 1990 to over 5,000 MW by 2006.
Grid-tied solar PV experienced a 55% increase in installed capacity in 2005.
The average annual growth rate over the last 10 years has been 25%.
A record level of 1,460 MW of solar was installed across the globe in 2005

Growth, Demand and the Future

In general, the industry is currently characterized by demand exceeding supply. In 2005, total global capacity reached 5,400 MW of installed solar PV, 3,100 MW of which were connected to the grid.[38] Installations in 2005 were a record 1,460 MW of new capacity, led by Germany and Japan. However, this figure is estimated to only meet approximately 80 to 90 percent of solar PV demand.[39]

The availability and distribution of silicon is a major determinate of MW output. Approximately 95 percent of all solar systems produced today are made using mono- or polycrystalline silicon wafers.[40] This report will explore the influence that major international firms have on the market, the influence of raw material supply, and external factors such as regulation and subsidization. The main focus will be on US PV manufacturing firms and US subsidiaries of key international players.

Industry Structure

There are three general types of firms in the solar industry: independent solar power specialists, consolidated electronics and semiconductor manufacturers, and diversified energy companies.

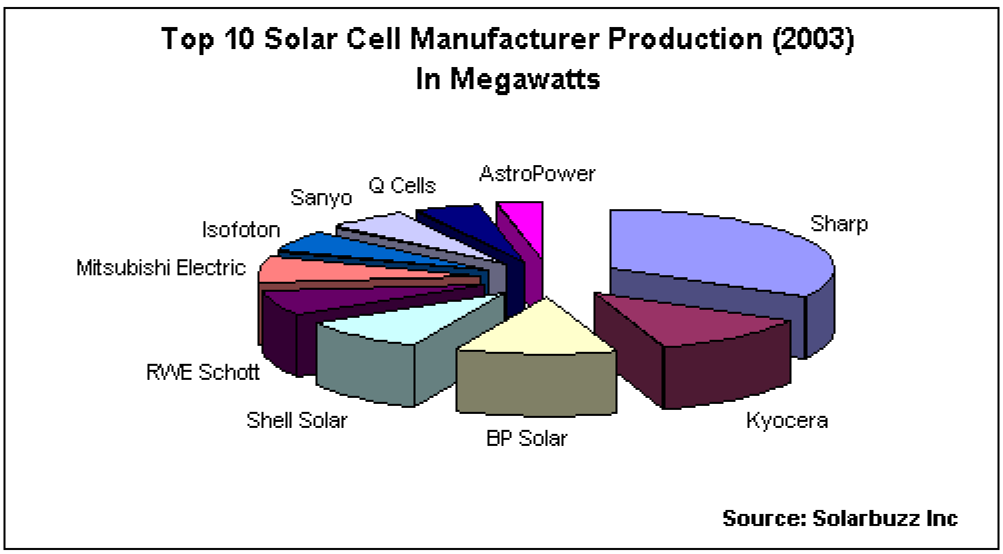
Independent solar power specialists concentrate on select components involved in the production of PV cells. Large international companies still dominate market share based on total megawatt production output per year.

[38] Renewable Energy Policy Network for the 21st Century: Renewable Energy Global Status Report, 2006 Update. http://www.renewableenergyaccess.com/rea/news/story?id=41508
[39] Renewable Energy Access News Story. website: http://www.renewableenergyaccess.com/rea/news/story?id=41508
[40] Department of Energy, Energy Efficiency and Renewable Energy: Quick Solar Facts: http://www1.eere.energy.gov/solar/pv_quick_facts.html

Consolidated electronics and semiconductor manufacturers such as Sharp, Kyocera, and Mitsubishi produce finished systems as well as many other electronic products. Many of the high-selling products manufactured by these electronic companies also use silicon as a raw material, and involve a comparable manufacturing process. Cell phone screens, flat panel televisions, and computer monitors, for example, all involve silicon and flat glass manufacturing processes. Companies that already produce electronics compatible with solar energy technologies have easily transitioned into solar PV manufacturing. Existing companies have the advantage of economies of scope and scale. These large multinational companies, while not specializing in solar energy, have advantages due to their preexisting infrastructures and greater availability of resources.

A similar story applies to diversified energy companies such as BP and Shell Solar. Because of their size and market reach, moving into new areas through acquisition rather than development is an efficient and relatively low-risk endeavor. However, Shell Solar was acquired by the smaller, solar-specific SolarWorld, illustrating that even the largest of firms is not unassailable. Yet the upstream portion of the solar industry remains dominated by a few large players involved in the manufacturing of PV cells, modules and systems.

Figure 7. Top Solar Cell Manufacturers in 2003.



Note: Shell Solar sold 100% of all crystalline silicon production to SolarWorld

The chart in Figure 7 displays the market distribution as of 2003. Within the past three years the characteristics of the market have shifted in several ways. The current market condition can be analyzed by using 2006 actual MW production output in conjunction with 2008 projected output[41].

[41] We offer this comparison purely as a rough benchmark. In ideal circumstances we would prefer to compare same year data, but even these figures give a good snapshot.

Total solar manufacturing capacity in 2005 was 1.1 gigawatts (GW) worldwide, with Japan accounting for 500 MW, Europe accounting for 300 MW, the US accounting for 140 MW, and the rest of the world 140 MW. By the end of 2006, total worldwide manufacturing capacity was expected to double to well over 2.4 GW, and although many companies report upgrades/factory openings in quarterly results, many others only provide long-term production capacity plans.

Table 3. Top Solar PV Manufacturers

Company	**Production Capacity**
Sharp	600MW; 2006
SunPower	300 MW projected 2008
Sanyo	260 MW projected 2008
Conergy	250 MW projected 2008
Q Cells	180 MW; 2006
SolarWorld	175MW; 2006 350 projected 2008
Suntech	150 MW; fiscal end 2005
Mitsubishi	135 MW; April 2005
Solar Company	Production Capacity
RWE Schott	130 MW; fiscal end 2005
Kyocera	120 MW; 2004
*BP Solar	75 MW; 2006 150MW projected 2008

It is important to note that the difference in projected and current output will likely affect the ranking of firms in the industry. However, some conclusions can still be made with this data set.

Sharp maintains a powerful lead in the market, with twice the production capacity of SunPower. While some companies have shifted in rankings, most of the big players remain dominate. This is an important characteristic of the solar industry. The large players listed above have significantly greater output than the next set of companies, making it difficult for small players to compete in the market.

Furthermore, while the current output from BP Solar does not place it within the top ten in 2006, the projected 2008 value does. This is especially significant due to the expansion of its existing manufacturing plant in Frederick, Maryland. BP Solar, pending their projected output, will be the largest PV producer in the United States.

Challenges and Opportunities

Silicon Availability: The biggest present difficulty facing the solar industry is the shortage of silicon. Polysilicon accounts for 25 percent of polycrystalline silicon wafers' input costs, and as previously noted, silicon wafers are considered the industry standard for PV technology. The current price (July 2007) of polycrystalline silicon is $60/kg which is double that of 2003.[42] Market forecasts expect the price to continue to increase to $80/kg in the next couple of years. All contracted silicon supply agreements are filled through 2007, meaning increased purchases must be made at the on-the-spot price of $100/kg .[43]

Companies currently holding contracts have the most power to increase output and subsequent revenues in the near future.

Table 4. Total Forecasted Polysilicon Capacity (in Metric Tons).[44]

Year	2004	2005	2006	2007	2008
Total Capacity	28,000	30,200	34,500	38,050	49,550

While capacity is increasing, it is increasing less than global MW production output projections, which explains the increase in price. Coping with the shortage of silicon and increase in prices may be the most influential factor to future success. Silicon supply is predicted by some analysts to become more available in the coming years, however, as large markets such as Germany begin to reduce the level of electricity buy-back rates in conjunction with efforts to increase silicon production.[45]

Those companies that secure silicon supplies will have much more stable forecasts of production in the foreseeable future. Suntech Power Holdings, Co. the top Chinese solar cell producer and a top ten competing player globally, has two major silicon wafer agreements with SolarWorld and MEMC for ten-year supplies of wafers. Along with their recent purchase of MSK Corp. of Japan, Suntech Power Holdings, Co is in a position to grow substantially in the near future.

Yet despite the threat of silicon's non-

Characteristics of the Solar Industry

Vertically integrated companies dominate the solar PV manufacturing industry and consolidation is expected to increase.

The top ten solar manufacturers supply the majority of the global solar PV capacity

All of the top five solar PV manufacturers are based in Japan or Germany

The ability to secure long term contracts for polysilicon through 2005 was critical to a firm's manufacturing capacity

[42] http://www.researchconnect.com/downloadreport.asp?RepID=20162
[43] Renewable Energy Access: News Story, website: www.renwableenergyaccess.com/rea/news/story?id=41508
[44] PJC estimates, Rare Metals News, Photon International
[45] Renewable Energy Access: Price Decrease and Consolidation: The Solar PV Supply Chain, www.RenewableEnergyAccess.com

availability, the demand for solar energy continues to increase and the price for large-scale solar energy-based supply has begun to decrease since the middle of 2006.[46] Renewable energy incentives and government subsidies provide a large opportunity for solar cell manufacturers. In the US, many of these programs are operated at a state level. For instance, the New Jersey Clean Energy Program initiated a $40 million per year incentive for solar, wind, and biomass projects. The program includes net metering, renewable energy credits and trading, and direct customer rebates. Direct rebates allow customers or businesses to apply for rebates of 50 to 70 percent of the system purchase cost, including installation and purchase price.[47] Incentives such as these can be compared to Germany's 100,000 rooftop program, or Japan's similar program. Germany's incentive program encourages consumers to purchase solar systems by offering 10-year low-interest loans to cover costs.[48] Japan has allotted over $200 million every year to rebate solar panels. This investment pushed Japan to number one globally in both MW installed and MW production output.[49] Increases in US renewable incentives should offset consumer costs and increase demand for PV, resulting in greater output among the domestic players.

New Technology and Innovation

Many companies are beginning to look beyond silicon wafer solar cells, and exploring new product technologies. InnovaLight, founded in 2001 and based in California, is one of several companies involved in PV film production. This technology involves silicon inking which uses much less silicon per cell. The finished product is thin and malleable and can even be placed in clothing. Moreover, the cells are able to capture more than just visible light waves resulting in a higher conversion rate.

Research and development of new technology may be the thriving strategy for competition in the solar industry. ARC programs to encourage solar industry growth should go beyond the scope of component production and look ahead to the promise of emerging technologies

Challenges to Industry Growth

The mature nature of the solar industry is a positive in the sense that the technology has been in existence for many decades. Components used in PV cells are already manufactured in many regions of the US. Yet industry growth cannot be spurred solely from the supply end. US demand is crucial not only for energy independence, but for economic independence as well. While the majority of PV systems produced in the US are currently exported overseas, incentive programs could help to increase domestic demand. Looking to other countries as examples, Germany and Japan have both shown

---

[46] Ibid.
[47] Database of State Incentives for Renewables and Efficiency, New Jersey: http://www.dsireusa.org/library/includes/map2.cfm?CurrentPageID=1&State=NJ&RE=1&EE=1
[48] Solar Integrated website: Germany: http://www.solarintegrated.com/germany.htm
[49] SEIA, The Solar Photovoltaic Industry in 2006: http://www2.dupont.com/Photovoltaics/en_US/assets/downloads/pdf/SEIA_StateofSolarIndustry2006.pdf

that offsetting costs through rebates can accelerate product penetration. Within the US, New Jersey's Clean Energy Program has successfully rebated the consumer costs of the purchase and installation of solar systems.

Demand can also be increased through increasing solar energy requirements for utility companies. Renewable Portfolio Standards require utility companies to have a percentage of their electricity come from renewable sources. However, only three states (Pennsylvania, New York, and Maryland) within the Appalachian Region currently have renewable portfolio standards. Pennsylvania's Alternative Energy Portfolio Standard is two-tiered. First, renewables such as wind, biomass, and solar are set at 1.5 percent in 2007 and should increase 0.5 percent every year until reaching 8 percent by 2020. Tier Two includes coal abatement and demand management which will contribute 10 percent by 2020. New York's Public Service Commission will require 25 percent by 2013.[50]

Even so, the US cannot make up the global market gap with current technology alone. Innovation is key to global competitiveness. Developing the US market for solar products requires more effective technology to reduce the problem of silicon shortages. Allocating tax dollars from utility revenues to support research and development in new technologies will have a direct impact on the competitiveness of US firms competing in the solar industry.

Not to be ignored, Appalachia has a commanding supply of science doctorates, research programs, and leading universities. Pennsylvania ranks fifth in number of doctoral scientists and has four of the top 15 undergraduate engineering programs. Maryland ranks second in the amount of federal R&D funding. Georgia Tech is home to the US Department of Energy's University Center of Excellence for Photovoltaics Research and Education (UCEP), one of two such centers.[51] The resources are available and will be of considerable advantage to the solar industry.

Biomass

Energy from biomass resources is unique relative to both wind and solar power for the simple reason that energy production requires a feedstock that is itself a commodity. This characteristic sets it apart from renewable sources such as solar and wind power in important ways, both economically and environmentally. Biomass production, harvesting and transport introduces both economic costs as well as opportunities and carries with it environmental considerations that do not exist with other forms of renewable energy. This has created a controversial and uncertain future for biomass energy, to say the least, and will be discussed in greater detail below.

Biomass can be derived from many sources and can be used in equally as many ways. Sources of biomass range from forest thinnings, to agricultural waste such as manure and

---

[50] Renewable Energy Policy Project website: www.repp.org/rps_map.html

[51] University Center of Excellence for Photovoltaics Research and Education: www.ece.gatech.edu/research/UCEP

corn stover, to methane gas from landfills. Many of these sources are currently produced as waste products from other agricultural or industrial processes, yet there is an increasing degree of research and activity around biomass production exclusively for use as a fuel in the form of dedicated energy crops. Short rotation woody crops including fast-growing willow and poplar species, as well as agricultural commodities such as corn are currently being grown for use as fuel feedstocks in the energy sector.

Biomass is burned directly to produce heat, to run a turbine, or to be converted into a biofuel or biogas, which is then used to produce electricity or transportation fuel. For the purposes of this report, biomass energy was divided into two categories. The first category deals with biomass electricity generation from dedicated steam facilities. The second category deals with biomass related fuel production, or biofuels.

Biomass Electricity Generation

Biomass experienced a 50-100 percent increase in production capacity in 2004 in several countries across the globe, bringing the total global biomass power capacity to over 44,000 MW by the end of 2005.[52]

There are four primary methods by which biomass can be used to produce electricity: direct-fired, co-fired, gasification and modular systems. Direct and co-fired facilities burn biomass fuel in a boiler to produce high pressure steam which is used to run a turbine. Direct-fired plants burn only biomass fuel, while co-fired facilities burn biomass in tandem with coal. Co-firing plants are the most economical, near-term opportunity for expanding biomass power generation. This process takes advantage of economies of scale associated with large coal burning facilities with only minor modifications to existing equipment with no fuel efficiency losses.[53] Virtually any form of biomass can be burned to produce electricity, though the energy content of different forms of plant material vary based upon physical properties including moisture content, heat value, mass, and chemical properties.

Source: Energy Efficiency and Renewable Energy

Currently, over 10,000 MW of biomass-derived energy is generated in the US: 5,000 MW from pulp and paper, 2,000 MW from dedicated biomass and 3,000 MW from municipal solid waste and landfill gas sources.[54] Biomass steam generation provides base load power from a clean energy source, and has been used to offset air emissions by many conventional energy producers. Yet, despite a large total installed capacity of biomass power generation in the US and across the globe, the average annual growth rate

Renewable Energy Policy Network for the 21st Century: Renewable Energy Global Status Report, 2006 Update. http://www.renewableenergyaccess.com/rea/news/story?id=41508

[53] US Department of Energy, Energy Efficiency and Renewable Energy: Technologies, Electric Power Generation, website: http://www1.eere.energy.gov/biomass/electrical_power.html

[54] National Renewable Energy Laboratory: Renewable Energy Poised to Realize Long Term Potential, June 2006: http://www.nrel.gov/director/pdfs/40768.pdf

between 2000 and 2004 was less than 5 percent.[55] This is significantly lower than the other renewable industries considered in this report. For this reason, this report also considers another arena of biomass energy utilization: biofuel energy production.

Biofuel Energy Production

In contrast to the low levels of growth in the biomass electric industry, the biofuel industry is experiencing tremendous levels of growth. The two dominant biofuels in use today are biodiesel and ethanol. This report will focus exclusively on ethanol as a resource.

Ethanol, in its current form, is primarily a simple sugar- or starch-based fuel refined from food crops such as corn, sorghum and sugar cane. Starch-based ethanol from corn is the primary biofuel produced in the US today, and involves the chemical conversion of sugar-based polysaccharides into an alcohol suitable for combustion in a conventional engine. Fuel blends containing ethanol are now relatively common, with over 30 percent of the gasoline in the US containing some level of starch-based ethanol.[56] However, there are many serious and complicated economic and environmental issues surrounding the use of food crops such as corn for the production of energy. For example, the National Academy of Sciences estimated that converting 100 percent of the corn grown in the US in 2005 to ethanol would have offset approximately 12 percent of the nation's gasoline demand. Furthermore, due to the net energy balance of corn ethanol of roughly 25 percent over fossil gasoline, the net energy gain from devoting 100 percent of the US corn crop to ethanol would have been only 2.4 percent.[57] The economics of devoting food crops to fuel production have been called into question due to the seemingly marginal gain.

It is also necessary to consider the impact of using food-based crops for ethanol production and the market impacts and interactions between crops grown for food or for fuel. The market has already experienced price increases for downstream products from corn as the price paid for corn has increased, ranging from staple products such as bread and tortillas to products containing corn syrup. Meat and diary products have also increased in price as the cost of feed for livestock and poultry has increased. Finally, the cost of other agricultural commodities has increased as farmers convert land into corn production and out of production for soybeans, for example. The myriad policies and subsidies embedded within the agricultural sector at both the national and international level further complicates the economic viability of growing a crop such as corn for ethanol production. In 2005, production costs for ethanol were roughly $0.46 per energy equivalent liter compared to $0.44/ liter for gasoline. Crop subsidies that lower crop prices dramatically impact the cost of ethanol, where corn prices are roughly 50 percent of a production facility's operating costs.[58] Finally, market fluctuations in gasoline prices

---

[55] Ibid.

[56] Renewable Fuels Association. (2006*) From Niche to Nation, Ethanol Industry Outlook 2006.* www.rfa.org

[57] Hill, J., Nelson, E., Tilman, D., Polasky, S., and D. Tiffany (2006) Environmental, economic, and energetic costs and benefits of biodiesel and ethanol biofuels. *PNAS* 103:30, 11206-11210,

[58] *Ibid.*

as well as efficiency gains in ethanol production improve the profitability of corn based ethanol, as do regulations promoting ethanol production. This economic picture changes further when crop growers consider converting less productive land into corn production to produce ethanol. In such situations, the net energy balance of ethanol decreases further as fossil inputs increase to attain productive crop yields. In sum, the economic reality of using corn to produce ethanol is both complicated and controversial. However, this is not the only challenge facing corn-based ethanol.

Significant environmental concerns revolving around large-scale corn production exist in terms of its energy, chemical in water inputs, and emissions. Corn inputs and impacts are higher than many other agricultural crops, including those corn is currently displacing. Corn requires higher levels of chemical fertilizers such as nitrogen and phosphorous, as well as pesticides that leach into the water supply and contaminate drinking water, lakes, rivers and create environmentally devastating realities such as the ‘dead zone’ in the Gulf of Mexico.[59] Also, where the National Academy of Sciences estimates that corn-based ethanol is roughly 12 percent less greenhouse gas-intensive as gasoline, there are growing concerns over ethanol’s relatively high emissions of air pollutants such as carbon monoxide, sulfur and nitrogen oxides, among others.[60]

As is the case with each of the renewable resources considered in this report, the availability or supply of renewable fuel within the Appalachian region is important when considering the possible generation of energy using non-conventional sources. Viability for both wind and solar-powered projects will be highly site-specific. Only some regions within Appalachia will be suited for the development of projects given these two land-dependent energy sources. Yet, due to the nature of biomass as a transportable feedstock for energy production, the capacity of Appalachia to produce energy from this resource will be governed by other factors. Namely, which biomass products and resources does the region currently produce or possess, what sources might it have the capacity to produce or possess, and under what circumstances might the region import fuel from elsewhere? As the answers to these questions are sought, particular opportunities for the Appalachian region may become immediately obvious. This report considers the manufacturing potential for Appalachia regarding many renewable energy sources; this opportunity may exist for ethanol as well. The region possesses considerable resources for research and development, in private, public and academic sectors, many of which are already employed in the biomass energy arena to some degree. Finally, the Appalachian region may bear considerable opportunities to develop biomass energy directly.

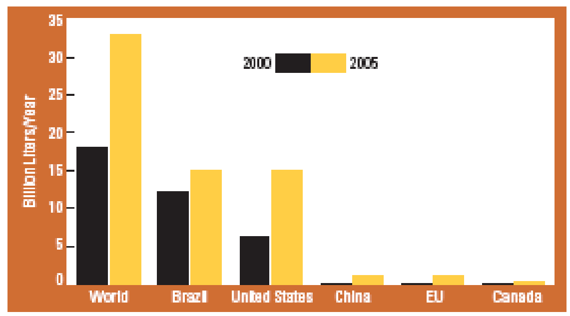
Corn-based ethanol, however, is not the only biomass derived fuel available. Considerable efforts are underway to bring lignocellulosic ethanol technology (referred to as ‘cellulosic’ for the purpose of this paper) to maturity. Chemical hydrolysis, enzymatic hydrolysis and gasification are three current methods by which cellulosic ethanol is produced, yet each of these technologies is still in relatively nascent stages of development.

---

[59] *Ibid.*
[60] *Ibid.*

There is substantial justification for moving from a starch-based ethanol focus to a cellulose-based ethanol focus, potentially alleviating some of the concerns raised above. For example, burning ethanol in conventional combustion engines is less greenhouse gas-intensive than burning petroleum. This is particularly important to consider since transportation fuel is responsible for roughly one-third of US-based greenhouse gas emissions.[61] However, the US Department of Energy calculates that cellulosic ethanol generates as much as 75 percent less greenhouse gas than oil, as compared with corn-based ethanol.[62] This differential is due, in large part, to the resource intensity of feedstock production in conventional starch and grain crops, mentioned above. Cellulosic feedstocks, though still in need of collection and delivery, can be composed of vegetative waste material as compared with the direct cultivation of resource-intense sugar and grain crops.

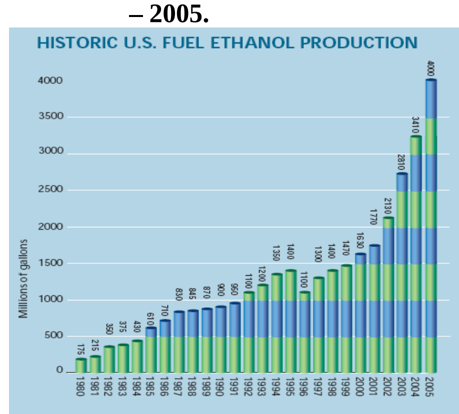
Figure 8. Global Ethanol Production, 2000 and 2005



Source: REN21 Renewables Global Status Report 2006

As the name suggests, cellulosic ethanol is derived from plant-based cellulose, a polymer of the disaccharide molecule found in the cell walls of mosses, seaweeds, annual and perennial plants, and trees. This is compared with starc-based polysaccharides that come from the fruits, seeds and roots of plants, and constitute a much lower fraction of global vegetable matter.[63] This speaks to the fact that cellulosic material is much more widely available than starch-based material, and can be derived from many more resources in many regions of the world. Additionally, better yield of energy per ton of feedstock from cellulosic biomass is possible, in the order of up to 10 tons versus 4 or 5 tons for even the most efficient grain crop yields.[64]

Figure 9. U.S. Ethanol Production 1980 – 2005.



As mentioned earlier, ethanol production from cellulosic resources is still in the development stage. There are few commercial operations in place across the globe, none of them in the US. The ethanol industry, domestically and abroad, is still largely focused on non-cellulosic biomass sources.

---

[61] Department of Energy, EERE www.eere.gov/biomass_news
[62] Department of Energy, EERE www.eere.gov/biomass_news
[63] McAloon, A., Taylor, F. and Yee, W. (2000) 'Determining the Cost of Producing Ethanol from Corn Starch and Lignocellulosic Feedstocks'. A Joint Study Sponsored by: U.S. Department of Agriculture and U.S. Department of Energy
[64] Sims, R., Hastings, T., Schlamadinger, B. Taylor, G. and Smi, T. (2006) 'Energy crops: current status and future prospects' *Global Change Biology*. 12, 2054–2076.

Growth, Demand and the Future

Brazil has historically led the world in ethanol production, producing over 4 billion gallons per year (mmgy) in 2005 from sugar cane. However, the US now exceeds Brazil in total production capacity, and has the capacity to produce 5.3 mmgy of ethanol, over 80 percent from corn, in over 110 refineries across the country. Furthermore, 79 more refineries, adding 6 mmgy to that capacity, are in some stage of planning or construction.[65] China, with capacity over 1,000 mmgy, is the closest to Brazil and the US, followed by India at 450 mmgy based on 2005 year end estimates.

The Energy Policy Act 2005 (EPACT 2005) set a national Renewable Fuel Standard for the US, requiring that the domestic production of ethanol increase from 4 mmgy in 2006 to 7.5 mmgy by 2012. This policy also established a provision that requires production of 250 million gallons of cellulosic ethanol by the end of 2012. Tax credits for the installation of biofuel infrastructure were also included in the EPACT of 2005.

Production-based incentives have also been created to spur further development in the ethanol industry, such as the Federal Volumetric Ethanol Excise Tax Credit (VEETC).[66] Passed in 2004, the VEETC provides a partial federal excise tax exemption of 51 cents per gallon for ethanol blended into gasoline. In 2005, the use of ethanol reduced the US trade deficit $8.7 billion by eliminating the need to import 170 million barrels of petroleum oil.[67]

Global production of ethanol is increasing. In addition to growth in the US, at least eight countries now possess ethanol blending mandates.[68] Most nations producing ethanol have done so to increase domestic consumption while reducing transportation costs. Countries like Brazil are now capitalizing on growing global demand by exporting fuel to countries such as the US and Japan. This is generating activity across the globe, inspiring many nations to develop incentives to grow their local industries for both domestic demand and export. To encourage domestic production, many nations' impose import taxes on ethanol and biofuels. For example, the US imposes $0.54 per gallon tariffs on the import of ethyl alcohol for fuel production.[69] These tariffs are sufficiently low to encourage imports and therefore act as significant barriers to market entry for domestic producers.[70] Even with the $0.54 per gallon tariff, the US imported over 653.3 million gallons of ethanol from Central and South America in 2006, a 383 percent increase over

---

[65] Renewable Fuels Association Press Release December 2006: October Ethanol Production Ties All Time High: http://www.ethanolrfa.org/media/press/rfa/2006/view.php?id=918

[66] Renewable Fuels Association, Biofuel Outlook 2006 http://www.ethanolrfa.org/objects/pdf/outlook/outlook_2006.pdf

[67] United States Department of Agriculture

[68] Renewable Energy Policy Network for the 21st Century: Renewable Energy Global Status Report, 2006 Update. http://www.renewableenergyaccess.com/rea/news/story?id=41508

[69] Ethanol subsidies (2007). Econbrowser. Retrieved 6/11/2007 from: http://www.econbrowser.com/archives/2007/02/ethanol_subsidi.html

[70] Renewable Fuels Association, Biofuel Outlook 2006 http://www.ethanolrfa.org/objects/pdf/outlook/outlook_2006.pdf

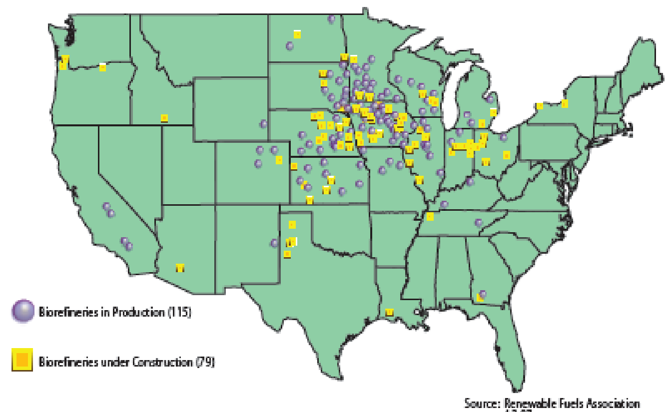
2005.[71] It is necessary to stress that the rapid growth in global ethanol production is primarily sugar- and starch-based production from food crops.

Industry Activity

Unlike its renewable energy counterparts in the wind and solar industries, the ethanol industry has a large base of activity in the US. Though initially an industry dominated by farmer-owned production facilities, large chemical and energy companies like DuPont, BP, Archer Daniels Midland, Cargill, and Monsanto are becoming major players and are deeply engaged in this thriving market. Some of these companies are buying into cooperatively-owned ethanol plants while others, such as BP, are investing in research for cellulosic ethanol. Each of these different players has a varying degree of influence on an American bioeconomy.

As the ethanol refinery map demonstrates, the US industry is based primarily in the Midwestern region of the country. Where the ethanol industry has historically been concentrated within the hands of only a few firms, new entrants into the market are increasing. Most notably, the Federal Trade Commission recently announced that, with 15 new firms entering the market in 2006 (raising the total in the industry to 90), ethanol production is no longer 'highly' concentrated.[72] According to the FTC and the Renewable Fuels Association, the number of firms and the locations of biorefineries are expected to increase further through 2007.

Figure 10. US Ethanol Refinery Locations,



The first commercial cellulosic facility was scheduled to begin construction in the fall of 2006 in Spain. Though only in its early stages of development, expectations are this technology will be widely deployed over the next decade and grow to become a dominant resource in the biofuel arena.

Challenges to Industry Growth

Absentee ownership structures alter the flow of resources into and out of the communities producing the feedstocks as well as the fuel. The current trajectory for development of ethanol suggests that large industry will continue to dominate this sector unless other priorities are considered. The shape of this emerging sector will depend on the social

[71] Renewable Fuels Association "Industry Statistics" 2005 Retrieved 5/16/07 from: http://www.ethanolrfa.org/industry/statistics/#F
[72] Renewable Fuels Association, Press Release December, 2006: New Producers Increase Competition in US Ethanol Market: http://www.ethanolrfa.org/media/press/rfa/2006/view.php?id=912

organization of the involved corporations, regulatory bodies, federal initiatives, environmental organizations, farmers and commodity groups.

The future bioeconomy will depend, to a great degree, on the resolution of social, environmental, and economic impacts of biofuel production. Given the growing recognition of environmental impacts of agriculture and concern about the effects of agricultural restructuring on rural livelihoods and communities, the landscape and social changes possible in a transition to increased production of energy feedstocks from agriculture deserve further examination. In particular, it is relevant to ask whether such production will support or undermine economic and environmental sustainability.

Sources & Methodology

Six-digit North American Industry Classification System (NAICS) codes were analyzed for all counties within the Appalachian region. The NAICS codes, collected by the US Census Bureau and compiled into County Business Pattern (CBP) data, reflect industry-specific manufactured components that are similar to, or substitutable for, the major manufactured components in the biomass, solar, and wind energy industries, as identified by the Renewable Energy Policy Project.[73]

Several NAICS codes are relevant to more than one renewable energy industry. Where establishments or jobs exist that may serve more than one industry, aggregated sector data is presented with shared sectors included in parentheses.

Important socio-economic and population data is included for each sector and region as well, on a county by county basis. Five socio-economic status designations, determined and assigned annually by ARC, reflect county-level economic indicator thresholds based upon three-year average unemployment rates, *per capita* market incomes and poverty rates.[74] The five classifications are as follows:

1) **Distressed:** 150 percent or greater of US average unemployment rate; 67 percent or less of US average *per capita* market income; and 150 percent or greater of US average poverty rate; or twice the poverty rate and past one other threshold,
2) **At-Risk:** 125 percent or greater of US average unemployment rate; 67 percent or less of US average *per capita* market income; and 125 percent or greater of US average poverty rate; past two of the distressed level thresholds,
3) **Transitional:** any county that is worse than the US average for one or more of the above indicators but does not fully meet the criteria for distressed or at-risk designations,
4) **Competitive:** 100 percent or less of US average unemployment rate; 80 percent or more of US average *per capita* market income; and 100 percent or less of US average poverty rate, and
5) **Attainment:** 100 percent or less of US average unemployment rate; 100 percent or more of US average *per capita* market income; and 100 percent or less of US average poverty rate.

Finally, population estimates and county level designations created by the Office of Management and Budget were included for each ARC county with renewable energy manufacturing potential. Metropolitan Statistical Areas (labeled 'Metro') reflect regions that have "at least one urbanized area of 50,000 or more population, plus adjacent territory that has a high degree of social and economic integration with the core as

[73] Sterzinger, G. and M. Svrcek. (2005) "Component Manufacturing: Ohio's Future in the Renewable Energy Industry." Renewable Energy Policy Project.
[74] Appalachian Regional Commission; Online Resources: County Economic Status, Fiscal Year 2006: www.arc.gov/index.do?nodeId=56

measured by commuting ties."[75] Micropolitan Statistical Areas (labeled 'Micro') reflect regions that have "at least one urban cluster of at least 10,000 but less than 50,000 population, plus adjacent territory that has a high degree of social and economic integration with the core as measured by commuting ties."[76] Each of these designations is defined in terms of whole counties, or equivalent entities such as the independent cities in Virginia. Counties not meeting either criteria are labeled 'Rural/ Other' for the purposes of this report.

Results of the analysis are presented in three major sections:

1) **Appalachian Regional Totals:** presenting summaries of each states' total manufacturing potential by resource and regional totals;
2) **Sector Specific Totals:** presenting employment and firm totals for the biomass, solar and wind industries individually and across all ARC member states;
3) **State by State Totals:** presenting counties for each state with substantial potential for renewable component manufacturing.

[75] Office of Management and Budget Bulletin No. 06-01: Appendix – as corrected May 26, 2006. Metropolitan, Micropolitan, and Combined Statistical Areas and New England City and Town Area Definitions: www.whitehouse.gov/OMB
[76] *Ibid.*

Potential Manufacturing Capacity in Appalachia

The Appalachian Regional Commission (ARC), tasked with the goal of promoting economic development within the greater Appalachian region, is composed of representatives from each of its 13 member states: Alabama, Georgia, Kentucky, Maryland, Mississippi, North Carolina, New York, Ohio, Pennsylvania, South Carolina, Tennessee, Virginia and West Virginia. This section of the report presents an analysis of the capacity of the Appalachian region to supply major components for the wind, solar and biomass renewable energy industries. This section provides information compiled on existing manufacturing establishments, employment totals, locations and sector concentrations within the region.

The analyses that follow are aimed at demonstrating the relative capacity of Appalachia as a whole, of ARC individual member states, and then ARC counties, to manufacture components for the renewable energy sector. These analyses reflect not only the potential capacity to manufacture renewable components from existing establishments within the region, but also the potential distribution of increased manufacturing that might accompany continued growth in the renewable energy sector. Analysis in this section of the report reveals distribution of existing establishments within states, and potential clusters of manufacturers with the potential to produce parts for individual energy sectors. The results are presented for each major energy sector, the Appalachian region as a whole, as well as for each ARC member state.

Resource Sector Analyses

The first section of this analysis considers manufacturing potential specific to each of the renewable sources considered.

Appalachian counties were categorized as having high concentrations of manufacturing potential by meeting one of the following four criteria:

1) Employment of 100 or more in firms with the technical capacity to produce components for the wind industry;

2) Ten or more establishments with the technical capacity to produce components for the wind industry;

3) Five or more distinct components that could serve the industry;

4) An average establishment size of 125 employees or more.

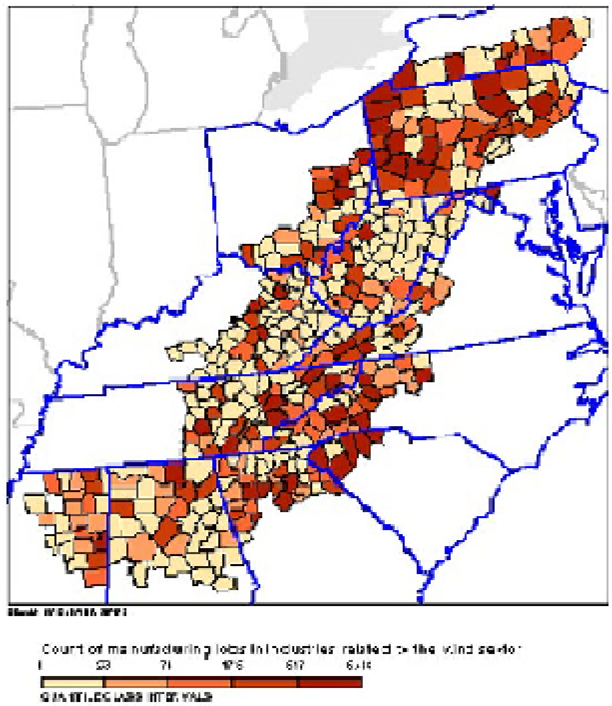
Wind

Results of the analysis revealed that there are currently almost 90,000 jobs and over 1,300 establishments in Appalachia manufacturing components related to those needed by the wind industry. Each ARC member state has a wind manufacturing potential exceeding 800 jobs.

> 83,269 jobs/1,254 establishments in exclusive wind category
> 89,579 jobs/1,318 establishments in aggregate wind category

Of particular importance is the degree of concentrated manufacturing that exists in the region. Figure 11 shows by county where concentrations exist with over 100 jobs. These sites provide opportunities for industry to procure significant amounts of components or several component types from one consolidated area.

Figure 11
Number of Jobs in Industries with the Potential to Produce Parts & Components for the Wind Industry



Source: County Business Patterns Enhanced Seven Digit NAIC Data, Andrew Isserman, University of Illinois at Urbana-Champaign, Personal communication, 2006.

Table 5. Counties with Concentrated Wind Manufacturing Potential.
This table includes counties with job totals of 1,500 or greater. Jobs producing components relevant to other sectors are noted in parentheses in the first column, with each county listed in decreasing order based upon the number of jobs within each respective county.

Sector	State	County	# of Estabs	# of Jobs	# of Com-ponents	Socio-Economic Status	Population Class	Primary City(s)
Wind (Biomass/Solar)	PA	Erie	66	5,374	8	Transitional	Metro	Erie
Wind (Biomass)	SC	Greenville	23	4,595	8	Competitive	Metro	Greenville
Wind	PA	Westmoreland	42	2,012	6	Competitive	Metro	Pittsburgh
Wind (Biomass/Solar)	GA	Gwinnett	36	1,894	7	Attainment	Metro	Atlanta Sandy Springs Marietta
Wind (Biomass/Solar)	NY	Broome	18	1,889	8	Transitional	Metro	Binghamton
Wind	SC	Anderson	27	1,865	4	Transitional	Metro	Anderson
Wind (Biomass/Solar)	PA	Allegheny	59	1,809	9	Attainment	Metro	Pittsburgh
Wind	PA	Lycoming	17	1,715	6	Transitional	Metro	Williamsport
Wind (Biomass/Solar)	TN	Knox	36	1,570	8	Transitional	Metro	Knoxville

The major wind turbine components consist of:

The rotor, which includes blades, hub and pitch drive, nacelle and tower;
The nacelle, which includes frame, generator, power train, drive shaft and electronic equipment;
The tower, which includes rolled steel, flanges and bolts, and concrete base.

The following components, as identified by their NAICS codes, were considered in this report:

Plastics product manufacturing
Iron foundries
Fabricated structural metal
Printed circuits and electronics assemblies
Measuring and controlling devices
Motors and generators
Electronic equipment and components
Turbines, turbine generators and turbine generator sets
Industrial and commercial fans and blowers

Currently, the most limited point in the supply chain involves the production of the wind turbine gearbox, a part of the nacelle. Manufacturing related to gearbox production includes:

Ball and roller bearings
Industrial speed chargers
Power transmission equipment

Analysis reveals that Appalachia produces over 17 percent of the nation's ball and roller bearings and over 11 percent of the nation's power drives. Both of these parts are fundamental components of the turbine gearbox, for which significant shortfalls in production exist. Ball bearing manufacturing is concentrated in South Carolina, Tennessee, Georgia and New York with almost 4,800 total jobs. Appalachia produces a substantial portion of the nation's generator sets as well, with over 25 percent of the country's manufacturing for this component. Finally, there are over 12,700 potential jobs and almost 150 establishments with the potential capacity to manufacture parts for this industry in counties designated 'At-Risk' or 'Distressed' by ARC.

Based upon this analysis, the Appalachian region may have a significant opportunity to capitalize on this expanding industry. This is particularly the case as large firms expand production capacity within the US, with Gamesa's new manufacturing facility in Pennsylvania a case in point. Regional components manufacturers can exploit an opportunity such as this, as Motors & Controls International of Hazelton, PA has.

Solar

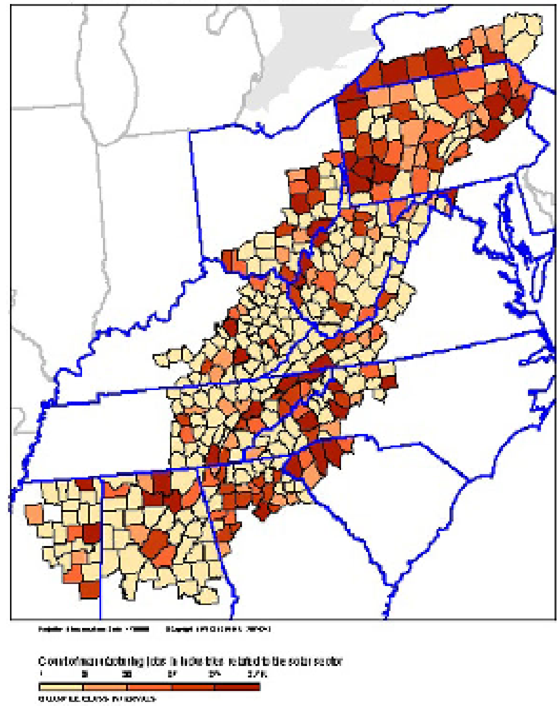
Results of the analysis revealed that there are currently almost 41,000 jobs and over 650 establishments in Appalachia manufacturing components related to those needed by the solar industry. Twelve of the thirteen ARC member states have a solar manufacturing potential exceeding 790 jobs.

> 34,693 jobs/ 571 establishments in exclusive solar sector
> 40,757 jobs/ 668 establishments in aggregate solar sector

Figure 12 shows where regions of concentration with over 100 jobs exist by Appalachian county for potential solar equipment manufacturing. These sites provide opportunities for the industry to procure a significant amount of components or several component types from one consolidated area.

Figure 12

Number of Jobs in Industries with the Potential to Produce Parts & Components for the Solar Industry



Source: County Business Patterns Enhanced Seven Digit NAIC Data, Andrew Isserman, University of Illinois at Urbana-Champaign, Personal communication, 2006.

Table 6. Counties with Concentrated Solar-Related Component Job Totals of 1,000 or Greater. Jobs that are relevant to other sectors are noted in parentheses in the first column, with each ARC county listed in decreasing order based upon the number of jobs within each respective county

Sector	State	County	# of Estabs	# of Jobs	# of Components	Socio-Economic Status	Population Class	Primary City(s)
Solar	WV	Wood	3	2,710	2	Transitional	Metro	Parkersburg Marietta (OH) Vienna
Solar (Biomass/Wind)	PA	Allegheny	40	2,612	8	Attainment	Metro	Pittsburgh
Solar (Biomass/Wind)	NC	Watauga	31	1,923	6	Transitional	Micro	Boone
Solar (Biomass)	PA	Westmoreland	19	1,487	7	Competitive	Metro	Pittsburgh
Solar (Biomass)	SC	Greenville	15	1,485	5	Competitive	Metro	Greenville
Solar (Biomass/Wind)	SC	Spartanburg	10	1,322	5	Transitional	Metro	Spartanburg
Solar	NC	Forsyth	11	1,319	4	Attainment	Metro	Winston-Salem
Solar	NC	Burke	2	1,277	2	Transitional	Metro	Hickory Lenoir Morganton
Solar	PA	Luzerne	12	1,152	4	Transitional	Metro	Scranton Wilkes-Barre

PV cells consist of 10 different manufacturing components, all of which are already being manufactured in the ARC counties in some capacity.

The following components, as identified by their NAICS codes, were considered in this report:

Plastics Material and Resin Manufacturing
Unlaminated Plastics Film and Sheet (Except Packaging)
Flat Glass
Sheetmetal Work Manufacturing
Semiconductors and Related Devices
Current-Carrying Wiring Device Manufacturing
Instrument Manufacturing for Measuring and Testing
Storage Batteries
Electronic Equipment and Components, NEC
Switchgear and Switchboard Apparatus Manufacturing

Analysis reveals that the Appalachian region produces over 17 percent of the flat glass in the nation, mentioned as a major part of photovoltaic modules. Tennessee alone has almost 1,000 jobs producing flat glass.

Appalachia also produces over 14 percent of the nation's plastics material and resin manufacturing, another major part of a PV module. Finally, there are almost 3,000 potential jobs and over 60 establishments with the potential capacity to manufacture parts for this industry in ARC designated 'At-Risk' or 'Distressed' counties.

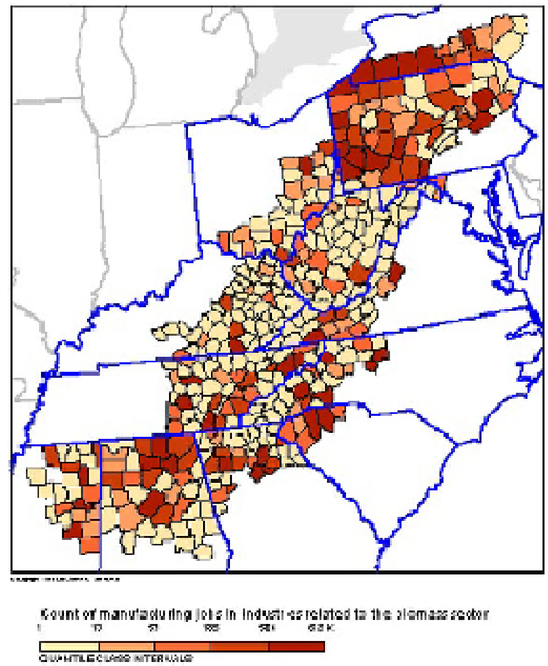
Biomass

Manufacturing analysis was performed for the biomass steam generation industry exclusively, as a mature industry present in the region. Results of the analysis revealed that there are currently almost 82,000 jobs and over 900 establishments in Appalachia manufacturing components related to those needed by the biomass industry. Twelve of the thirteen ARC member states have a biomass electric generation manufacturing potential exceeding 1,400 jobs.

46,997 jobs/ 614 establishments in exclusive biomass category
81,836 jobs/ 912 establishments in aggregate biomass category

Figure 13

Number of Jobs in Industries with the Potential to Produce Parts & Components for the Biomass Industry



Source: County Business Patterns Enhanced Seven Digit NAIC Data, Andrew Isserman, University of Illinois at Urbana-Champaign, Personal communication, 2006.

University of Illinois at Urbana-Champaign, Personal communication, 2006.

Figure 13 shows where regions of concentration with over 100 jobs exist by Appalachian county for potential biomass equipment manufacturing. These sites

Table 7. Counties with Concentrated Biomass-Related Component Job Totals of 1,500 or Greater. Jobs that are relevant to other sectors are noted in parentheses in the first column, with each ARC county listed in decreasing order based upon the number of jobs within each respective county

Sector	State	County	# of Estabs	# of Jobs	# of Components	Socio-Economic Status	Pop. Class	Primary City(s)
Biomass (Solar Wind)	PA	Erie	40	6,835	15	Transitional	Metro	Erie
Biomass (Solar Wind)	PA	Allegheny	63	6,202	15	Attainment	Metro	Pittsburgh
Biomass (Solar Wind)	SC	Greenville	19	3,715	8	Competitive	Metro	Greenville
Biomass (Solar)	TN	Hamilton	29	3,322	12	Competitive	Metro	Chattanooga
Biomass (Solar)	VA	Bristol City	5	3,112	4	Transitional	Metro	Kingsport, TN, Bristol, TN, Bristol, VA
Biomass (Solar)	PA	Westmoreland	27	2,265	13	Competitive	Metro	Pittsburgh
Biomass (Solar Wind)	SC	Spartanburg	17	1,944	13	Transitional	Metro	Spartanburg
Biomass	NY	Steuben	8	1,905	5	Transitional	Micro	Corning
Biomass	PA	Fulton	2	1,889	2	Transitional	Rural/ Other	
Biomass (Solar)	NC	Buncombe	13	1,632	9	Competitive	Metro	Asheville

provide opportunities for the industry to procure significant amount of components or several component types from one consolidated area

The following components, as identified by their NAICS codes, were considered in this report:

Mineral Wool,
Power Boiler and Heat Exchanger,
Industrial Valve,
Construction Machinery,
Air Purification Equipment,
Heating Equipment,
Conveyor and Conveying Equipment,
Fluid Power Cylinder and Actuators,
Power, Distribution, Specialty Transformer,
Railroad Rolling Stock,
Heavy Gauge Metal Tank,
Air Conditioning and Warm Air Heating Equipment,
Pump and Pumping Equipment,
Air and Gas Compressor,
Overhead Traveling Crane,
Hoist and Monorail System,
Turbines, Turbine Generators and Turbine Generator Sets,
Switchgear and Switchboard Apparatus, and
Electronic Equipment and Components, and other general purpose machinery and instrument related equipment.

Finally, our analysis shows that there are almost 6,000 jobs and over 90 establishments in ARC designated "At-Risk" or "Distressed" counties involved in the manufacturing of equipment suited for the biomass industry.

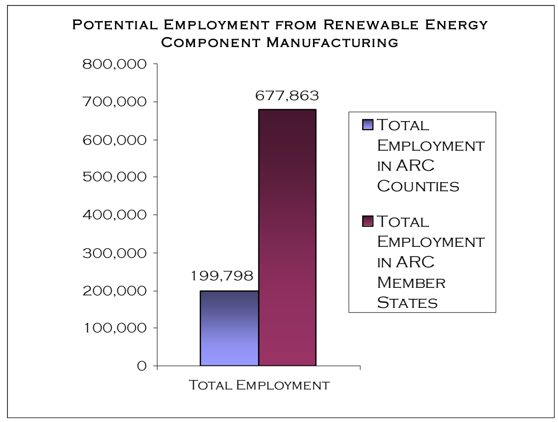
As with the wind and solar industries, these components and their six-digit NAICS codes were identified as central to biomass steam generation facility manufacturing by the Renewable Energy Policy Project.

Appalachian Regional Totals

This section of the analysis reflects potential renewable energy manufacturing totals for the region as a whole. Total potential employment and establishment figures for all counties within the regions' member states and ARC counties' are shown in Figures 14a and 14b, respectively.

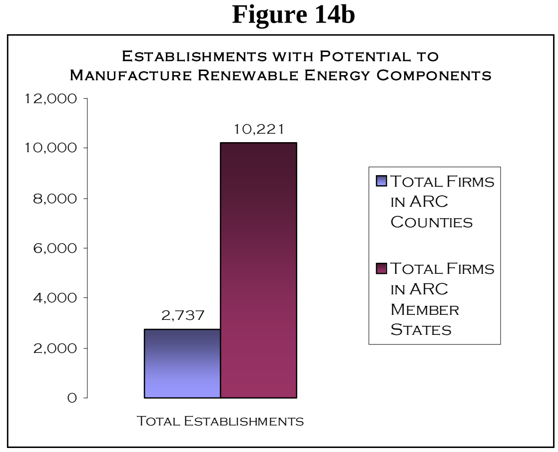
These figures reflect that approximately 30 percent of the potential jobs from renewable energy manufacturing within each ARC member state as a whole exist in ARC counties, while approximately 27 percent of the establishments reside in ARC counties. ARC counties currently possess almost 200,000 jobs suited to produce renewable energy components and almost 3,000 existing manufacturers within the region possess the capacity to produce renewable energy components.

Figure 14a



However, the share of employment (Figure 15) and the location of establishments (Figure 16) are not equally distributed among all of the ARC member states or their respective counties. Pennsylvania possesses the largest job potential in the region, followed by Tennessee, North Carolina and South Carolina, respectively. Employment totals range from 1,438 in Maryland, possessing 1 percent of the potential, up to 60,115 in Pennsylvania with 30 percent of the employment potential. Pennsylvania also leads in total number of establishments with renewable manufacturing potential.

Figure 14b



It is important to note that the number of counties encompassed within Appalachia varies greatly among member states, ranging from all of West Virginia's 55 counties to 52 of Pennsylvania's, to only six from South Carolina and three from Maryland.

Figure 15. **Percentage of potential employment for ARC member states, including totals for combined biomass, solar and wind facilities.**

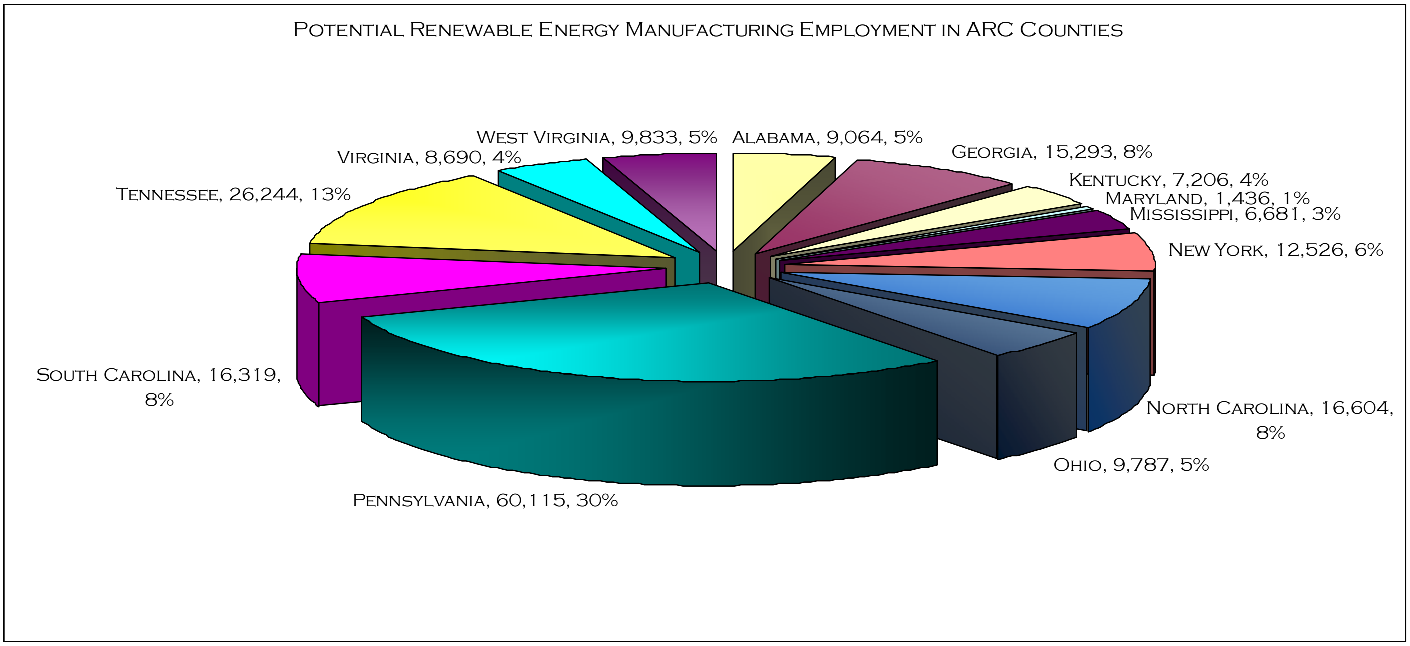
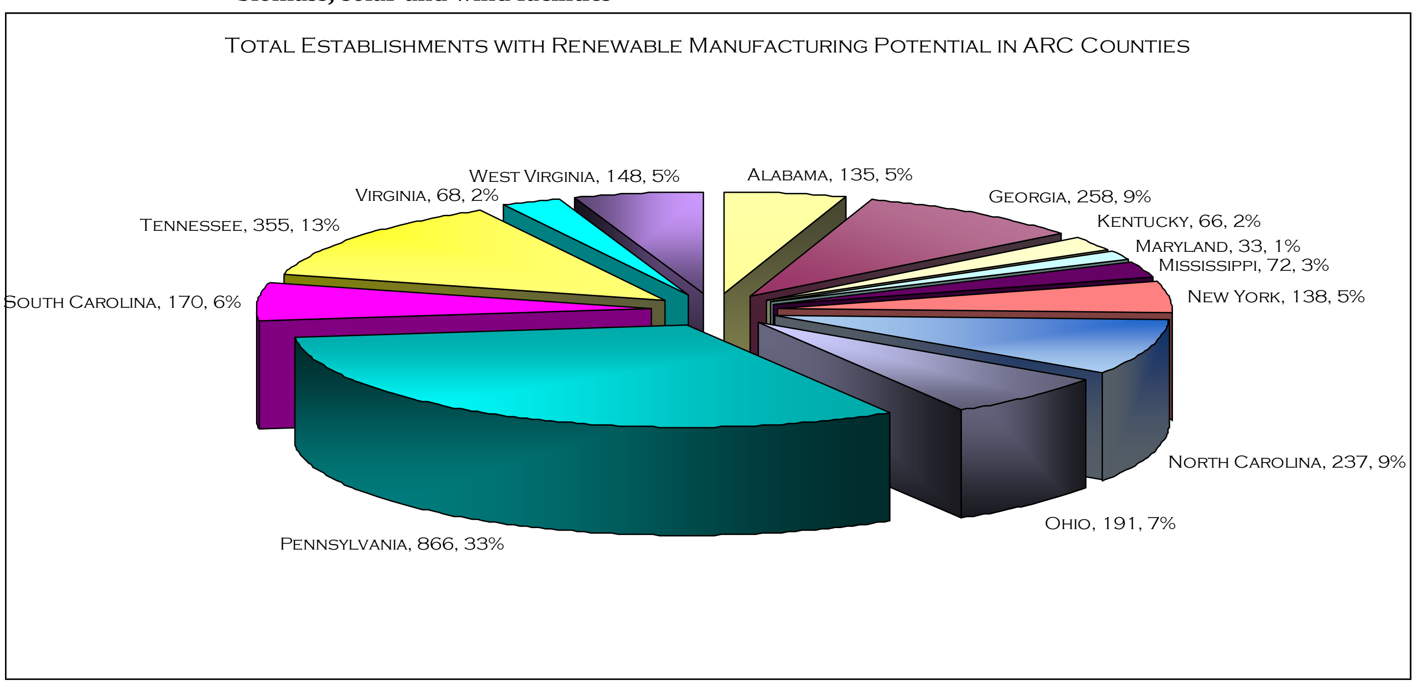


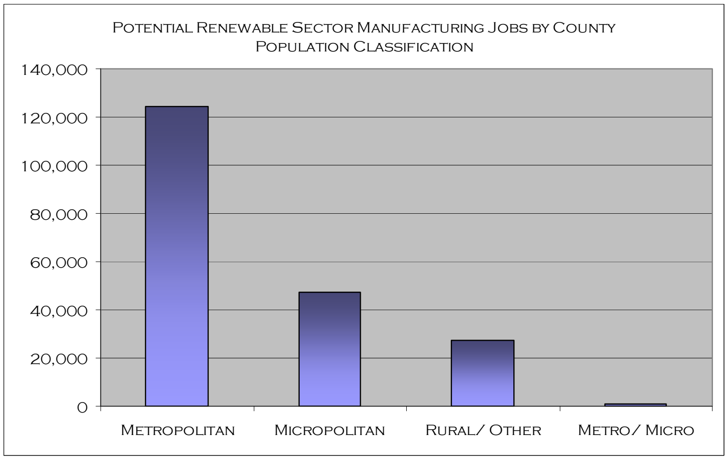
Figure 16. Percentage of manufacturing establishments for ARC member states, including totals for combined biomass, solar and wind facilities



The proportion of jobs and potential establishments are also not equally shared among the renewable energy sectors considered. The ratio of jobs and establishments are shown in Figures 15 and 16, respectively. Wind, solar and biomass resource totals include jobs and facilities that may be capable of producing components for multiple renewable technologies. For example, totals for both wind and biomass include the manufacturing of turbines, turbine generators and turbine generator sets. As a result, the aggregate totals for each resource are higher than the non-resource-based totals proposed for the region and for each state or county.

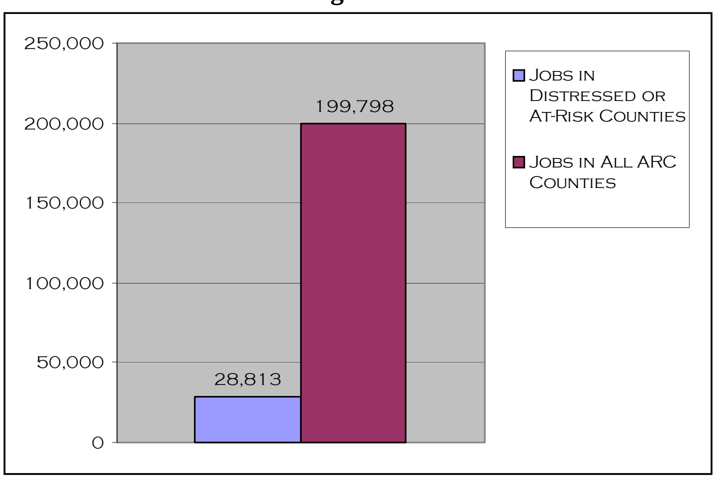
These figures demonstrate that the wind energy sector possesses the greatest manufacturing potential in ARC counties, with potential jobs totaling 89,579 and establishments totaling 1,318. Biomass follows closely, with potential job and establishment totals of 81,836 and 912 respectively. The solar energy sector possesses 40,757 potential jobs and 668 potential manufacturers in the region. Again, these figures reflect aggregated totals for each sector

Figure 17



The distribution of jobs and establishments between counties designated rural based on OMB's population-based classification scheme is shown in Figure 17. The concentration of manufacturing within metropolitan areas within the Appalachian region is roughly three times that of those in micropolitan regions and roughly five times that of areas classified as rural/other.

Figure 18



The total potential jobs within economically depressed counties within the ARC are shown in Figure 18 relative to job totals for all counties within the ARC.

The next section of this analysis examines sector specific employment and manufacturing establishments by individual ARC states. These results reflect county level totals.

State Analyses

This section of the analysis contains employment and establishment totals for each Appalachian state, to the county level. State totals, combining all renewable employment and establishments are shown in Table 8, as well as the renewable industry with the highest employment totals for that state. Industries with close totals were included in parentheses.

Table 8. State Employment and Establishment Data

.

State	Total Employment	Total Establishments	Average Establishment Size	Primary Renewable Industry
Alabama	9,064	134	67.1	Biomass
Georgia	15,293	258	59.3	Wind
Kentucky	7,206	66	109.2	Wind
Maryland	1,436	33	43.5	Wind
Mississippi	6,681	72	92.8	Biomass
North Carolina	16,604	237	90.8	Wind (Solar, Biomass)
New York	12,526	138	70.1	Biomass (Wind)
Ohio	9,787	191	51.2	Wind
Pennsylvania	60,115	866	69.4	Biomass (Wind)
South Carolina	16,319	170	96.0	Wind (Biomass)
Tennessee	26,244	355	73.9	Wind
Virginia	8,690	68	127.8	Biomass
West Virginia	9,833	148	66.4	Solar (Wind)
TOTALS	**199,798**	**2,737**	**73.0**	

Each state in the Appalachian region possesses some degree of employment for each renewable energy sector reviewed. Summaries for each type of renewable resource are shown in Table 9. Appendix C contains detailed data on concentrated employment within each Appalachian state.

Table 9.

Summary State Employment and Establishment Data by Renewable Resource*
(*Dominant manufacturing component is in parentheses)

ALABAMA	**Wind**	**Solar**	**Biomass**
Employment	2,180	1,408	6,428
Establishments	29	34	94
County with Greatest Employment Concentration	Madison: 627 Jobs, 8 Facilities, 3 Components	Morgan: 444 Jobs, 2 Facilities, 2 Components	Jefferson: 1,280 Jobs, 25 Facilities, 12 Components
Employment in At-Risk Counties	424 (Ball and Roller Bearings)	73 (Current Carrying Wiring Devices)	895 (Conveyor and Conveying Equip)
GEORGIA	**Wind**	**Solar**	**Biomass**
Employment	7,113	2,587	5,969
Establishments	126	77	67
County with Greatest Employment Concentration	Gwinnett: 1,894 Jobs, 36 Facilities, 7 Components	Gwinnett: 336 Jobs, 18 Facilities, 7 Components	Gwinnett: 1,342 Jobs, 25 Facilities, 11 Components
KENTUCKY	**Wind**	**Solar**	**Biomass**
Employment	4,499	1,545	1,482
Establishments	38	14	15
County with Greatest Employment Concentration	Jackson: 1,051 Jobs, 5 Facilities, 3 Components	Madison: 749 Jobs, 2 Facilities, 2 Components	Whitley: 520 Jobs, 1 Facility, 1 Component
Employment in At-Risk Counties	1,360 (Plastics Products)	357 (Sheetmetal)	320 (Switchgear and Switchboard)
MARYLAND	**Wind**	**Solar**	**Biomass**
Employment	851	465	124
Establishments	16	12	7
County with Greatest Employment Concentration	Washington: 676 Jobs, 13 Facilities, 7 Components	Washington: 391 Jobs, 10 Facilities, 4 Components	Washington: 88 Jobs, 6 Facilities, 5 Components
MISSISSIPPI	**Wind**	**Solar**	**Biomass**
Employment	3,517	1,042	2,346
Establishments	24	16	36
County with Greatest Employment Concentration	Lowndes: 535 Jobs, 5 Facilities, 3 Components	Alcorn: 401 Jobs, 1 Facility, 1 Components	Lee: 1,160 Jobs, 3 Facilities, 2 Components
Employment in At-Risk Counties	944 (Motors and Generators)	723 (Plastics Film & Sheet, Plastics Material & Resin)	373 (Power Boiler And Heat Exchanger)
NEW YORK	**Wind**	**Solar**	**Biomass**
Employment	5,544	1,613	6,495
Establishments	71	31	48
County with Greatest Employment Concentration	Broome: 1,889 Jobs, 18 Facilities, 8 Components	Steuben: 546 Jobs, 3 Facilities, 1 Component	Steuben: 1,905 Jobs, 8 Facilities, 5 Components
NORTH CAROLINA	**Wind**	**Solar**	**Biomass**
Employment	4,619	4,350	5,542
Establishments	74	44	59
County with Greatest Employment Concentration	Watauga: 1,483 Jobs, 29 Facilities, 7 Components	Watauga: 1,923 Jobs, 31 Facilities, 6 Components	Buncombe: 1,632 Jobs, 13 Facilities, 9 Components
Employment in At-Risk Counties	1,685 (Plastics Products)	40 (Sheetmetal)	583 (Industrial Valve)
OHIO	**Wind**	**Solar**	**Biomass**
Employment	5,480	2,641	2,060
Establishments	94	44	57
County with Greatest Employment Concentration	Columbiana: 837 Jobs, 13 Facilities, 4 Components	Washington: 803, 6 Facilities, 2 Components	Tuscarawas: 861 Jobs, 9 Facilities, 7 Components
Employment in At-Risk Counties	648 (Iron Foundries)	122 (Plastics Material and Resin)	432 (Air Conditioning and Warm Air Heating Equip)

PENNSYLVANIA	Wind	Solar	Biomass
Employment	23,649	10,789	32,309
Establishments	396	205	346
County with Greatest Employment Concentration	Erie: 5,374 Jobs, 66 Facilities, 8 Components	Allegheny: 2,612 Jobs, 40 Facilities, 8 Components	Erie: 6,835 Jobs, 40 Facilities, 15 Components
Employment in At-Risk Counties	314 (Power Transmissions)	211 (Unlaminated Plastics Film and Sheet)	94 (Heating Equip)
SOUTH CAROLINA	**Wind**	**Solar**	**Biomass**
Employment	10,036	4,096	5,994
Establishments	92	41	46
County with Greatest Employment Concentration	Greenville: 4,595 Jobs, 23 Facilities, 8 Components	Greenville: 1,485 Jobs, 15 Facilities, 5 Components	Greenville: 3,715 Jobs, 19 Facilities, 8 Components
Employment in At-Risk Counties	1,219 (Ball and Roller Bearings)	40 (Plastics Material and Resin)	78 (Industrial Valves)
TENNESSEE	**Wind**	**Solar**	**Biomass**
Employment	13,590	3,707	9,845
Establishments	192	64	117
County with Greatest Employment Concentration	Knox: 1,570 Jobs, 36 Facilities, 8 Components	Hawkins: 723 Jobs, 2 Facilities, 2 Components	Hamilton: 3,322 Jobs, 29 Facilities, 12 Components
Employment in At-Risk Counties	389 (Plastics Products)	184 (Plastics Material and Resin)	42 (Air Conditioning and Warm Air Heating Equip)
VIRGINIA	**Wind**	**Solar**	**Biomass**
Employment	3,453	793	4,931
Establishments	29	14	29
County with Greatest Employment Concentration	Russell: 736 Jobs, 1 Facility, 1 Component	Bristol City: 295 Jobs, 2 Facilities, 1 Component	Bristol City: 3,112 Jobs, 5 Facilities, 4 Components
Employment in At-Risk Counties	986 (Plastics Products)	81 (Semiconductors and Related Devices)	159 (Mineral Wool, Conveyor Equip)
WEST VIRGINIA	**Wind**	**Solar**	**Biomass**
Employment	3,688	4,414	2,055
Establishments	75	40	48
County with Greatest Employment Concentration	Ritchie: 1,177 Jobs, 3 Facilities, 1 Component	Wood: 2,710 Jobs, 3 Facilities, 2 Components	Hancock: 588 Jobs, 2 Facilities, 2 Components
Employment in At-Risk Counties	649 (Plastics Products)	123 (Plastics Material and Resin)	283 (Instruments and Related Products)

Recommendations

This report has identified where opportunities to manufacture components for the renewable energy sector exist for Appalachia. However, the establishments identified do not currently produce such components. In order to capitalize upon the growth within the renewable energy industries, given the particulars of their respective organizational characteristics, a shift from current production to renewable components production must occur. The best approach to transitioning to renewable components manufacturing is not immediately obvious, though several mechanisms are available that may successfully enable and encourage manufacturers to pursue opportunities within this arena.

Several states have taken steps to encourage manufacturers of renewable energy equipment to site facilities within their borders. Efforts range from direct negotiations with manufacturers and offering tax abatements and financial packages, to tax credits and incentives to any firm or facility producing components specific to renewable energy industries. Currently, nine states offer 'Industry Recruitment' incentives for renewable energy.[77] Industry Recruitment incentives consist of efforts and programs created to attract equipment manufacturers for renewable energy technologies. Such programs typically consist of tax credits and abatements, grants and negotiated commitments from the issuing entity to purchase a specified amount of production. Examples include Washington State's tax abatement for solar energy manufacturers and wholesalers. In-state producers enjoy a 40 percent reduction in the state's business and occupation tax. Washington's policy also includes mechanisms to increase the tax incentive for facilities sited in economically depressed regions. Three ARC member states currently possess manufacturing recruitment incentives, including New York with its NYSERDA Renewable Energy Technology Manufacturing Incentive, Ohio with its Fuel Cell Grant and Loan Program, and Virginia with its Solar Manufacturing Incentive Grant program.

Attempts to transition existing manufacturers to pursue markets in renewable energy will likely differ from outright courting of new manufacturing. Outreach and education programs for manufacturers with the technical capacity to produce renewable energy components, such as those identified in this report, may be an appropriate mechanism to employ. The following is a brief list of potential tools to encourage renewable energy manufacturing in the Appalachian region.

Financial Incentives

> **Renewable Energy Manufacturers Tax Credits**: Such policies offer corporate tax incentives for companies engaged in renewable energy equipment manufacturing. Credits can be applied against gross receipts tax, manufacturers' taxes and extraction taxes, among others, paid by manufacturers of renewable

[77] Database for State Incentives for Renewables and Efficiency, Washington Incentives for Renewable Energy: website: www.dsireusa.org

equipment. The breadth and scope of renewable equipment and technologies eligible under such incentives are at the discretion of the instituting body.

Renewable Energy Portfolio Standards (RPS) and Tax Credit Multipliers for In-State Manufacturing: Such policies can be included in existing or pending renewable energy requirements and set asides such as RPS's or Renewable Energy Standards (RES) that enable those entities subject to the requirement to receive extra credits toward their requirement by purchasing equipment manufactured in a designated area. Increasing the effective tax incentive for consumers of renewable energy equipment that purchase from an in-state manufacturer can also be offered, to both residential and commercial entities.

Tax Credits or Multipliers for Manufacturing in Distressed Regions: Similar to the previous policy, credit multipliers can be provided to entities subject to RPS if they purchase equipment manufactured from distressed regions. More immediately, tax credit multipliers can be offered to renewable manufactures that site facilities in regions designated as economically distressed.

Research and Development and 'Advanced' Technology Grants and Loans: Offering grants and low interest loans for entities engaged in innovative R&D or high tech technologies can encourage growth in the industry.

Incubator Programs for Renewable Energy Industries: These programs provide support through education, business services and even space for entrepreneurs interested in renewable energy technologies in the Appalachian region.

Organizational or Educational Programs

Renewable Energy Manufacturing Business Outreach Programs: These can establish or augment existing business and manufacturing education programs to provide education and information on opportunities to transition to or engage renewable energy industries.

Bridging Local Manufacturing with Industry Suppliers and Vendors: By providing a forum or infrastructure, programs can build bridges between the renewable energy industry and regional facilities capable or interested in producing equipment for that industry.

Regional Renewable Energy Industry Consortiums: Consortiums can provide an arena where active industries can enhance coordination in the region. Services to improve upon supply chain management and customer relationship management can also benefit the competitiveness of the region's renewable energy industries.

Other

Support for State and Federal Renewable Energy Policies: Providing or continuing support for state and federal incentives that drive demand or reduce the costs of renewable energy technology and energy production will be important to continue near and long-term growth in these new industries. Renewable Portfolio Standards offer certainty for all levels of the renewable energy industry, from equipment manufacturers, to project developers and financers, to utilities and consumers. Maintaining and supporting consistent tax credit policy, available over longer timeframes with established sunset clauses are also important, as evidenced by the cycling passage and expiration of the federal PTC for renewable energy.

Production Tax Credits, Grants and Loans for Cellulosic Ethanol: Tax credits based upon the units of renewable energy produced can encourage ethanol refining facilities to site within a given region. Providing incentives and low interest starter loans specific to the cellulosic industry can jump start the region in the production of this form of fuel. Grants associated with R&D in the cellulosic arena can also help establish a foundation for the nascent industry in the region, perhaps in association with existing research and educational institutions.

Renewable Fuel Standards: Augmenting the Federal Renewable Fuel Standard with passage of a long-term goal for cellulosic fuel production or consumption in the region can provide for certainty for investors and producers of cellulosic ethanol.

Immediate next steps, however, should involve an in-depth assessment of the manufacturers identified in this report. Beyond their technical capacity to produce components for renewable energy industries, important aspects of their transitional capacity must be gauged. Ownership and management structures must be identified in addition to assessing each establishment’s interest and means to transition production capacity. Additionally, outreach to existing renewable energy industries, particularly those interested in diversifying their supply chain or expanding local energy production can provide important cues for expanding manufacturing capacity within the Appalachian region.

Conclusion

As energy demands continue to increase and interest in clean, renewable sources grows, the economic opportunities to produce equipment for the production of renewable energy will expand. Investigating the characteristics of renewable energy industries expose where some of the greatest opportunities exist, for both near-term and long-term economic growth. The rapid expansion currently experienced within renewable energy industries such as wind and solar power has created a situation where the sub-components for these industries are in high demand. Producing such parts may be one of the most immediate opportunities to capitalize on this growth industry for a region with existing technical capacity to manufacture renewable energy equipment, such as Appalachia.

Even in a climate of increasing consolidation, demand is forcing large, integrated firms to outsource much of their non-essential components manufacturing. Windows of opportunity exist for manufacturers poised to produce these needed components, and can provide for long-term supply contracts with established companies. Where a handful of domestic manufacturers are currently producing parts for the renewable energy industry, dominated by states such as California, there is significant room for domestic demand for renewable energy equipment to be met with domestic supply. Sub-components manufacturing may be the most immediate and achievable opportunity for wide-scale engagement, particularly as large, international firms expand US-based production capacity to meet domestic demand. Already in both the wind and solar industries European wind firms and Japanese solar firms contract with US-based component manufacturers for needed parts.

This report provides an initial assessment of the potential capacity of the Appalachian region to supply components for the wind, solar and biomass industries. Where there is marked variation in each Appalachian state's capacity to produce parts for these three industries, analysis shows that substantial capacity exists to produce renewable energy components. Each state possesses some level of production capacity, for each of the three industries investigated, ranging from hundreds of jobs to tens of thousands of jobs for each single industry. As a whole, almost 3,000 establishments exist in Appalachia with the technical capacity to manufacture renewable energy equipment. These facilities employ almost 200,000 people in the region. Pennsylvania alone possesses over 60,000 jobs in potential renewable components manufacturing, followed by Tennessee with over 26,000 jobs. Maryland, with only three counties in the Appalachian region, still possesses over 1,000 jobs in potential renewable components manufacturing.

Even further, there are concentrated manufacturing potentials within each state that provide significant opportunities to develop regions of specialization for renewable energy industry-specific product manufacturing. Such concentrated regions are attractive to larger equipment suppliers interested in contracting for sub-components manufacturing.

Numerous mechanisms exist which can encourage domestic manufacturing at many levels. Financial incentives can enable or encourage both sub-components manufacturing as well as turn-key, integrated facility establishment. This can function to either grow a domestically- or locally-based firm through tax abatements, low interest loans to launch a new renewable energy enterprise or facilitate the siting of larger, established firms within a given region. Finally, fostering a renewable manufacturing-friendly zone through incubation, outreach and coordination can better enable local industry to transition to renewable energy manufacturing.

In addition to components manufacturing, Appalachia may contain the resource base to become a leader in cellulosic ethanol production. Given the current uncertainties regarding the nature and extent of the cellulosic resource within the region as well as the timeframe for available commercial cellulosic technology, it may be in the best interest of the region to position itself to be an early entrant into the industry. Getting in on the ground floor of the industry and becoming an early industry leader could produce substantial economic benefit to the region.

APPENDICES

Appendix A. Renewable Energy Manufacturers

Top Ten Global Wind Energy Equipment Manufacturing Firms (based upon 2005 Market Share)

1 – Vestas[11]

- Headquarters: Denmark
  - Began manufacturing wind turbines in 1979, exclusively in wind energy since 1987
  - Production facilities in Denmark, Germany, India, Italy, Scotland, England, Spain, Sweden, Norway, Australia, and China
  - Acquired NEG Micon in 2004
  - Decreasing sales in Germany and North America; increasing Southern Europe, Oceania, and Asia
- Revenue/Size
  - 11,200 employees (June 2006)
  - Global market share of 35%; US market share of 28%
  - 204 MW delivered to North America in 2004; down 62% from 2003
  - Approximately 40,000 MW installed wind capacity

2 – GE Wind[78] (subsidiary of GE Industries)

- Headquarters: Atlanta, GA, United States
  - Major facilities in: Atlanta, GA; Greenville, SC; Houston, TX; Melbourne and Pensacola, FL; San Jose, CA; Schenectady, NY; Tehachapi, CA; Wilmington, NC; France; Italy; Hungary; Norway, Quebec; Germany
  - Vertically integrated wind turbine production, though heavily diversified beyond wind turbine manufacturing
- Revenue/Size (reflects GE Energy subsidiary totals – engaged in conventional equipment manufacturing in addition to wind)
  - $16.5 billion in 2005
  - ~34,000 employees

3 – Enercon Gmbh[79]

- Headquarters: Aurich, Germany
  - Production facilities in: Turkey, Brazil, Sweden, India and three in Germany
  - Founded in 1984, and has retained ownership through the last 20 years (no major acquisitions)
  - Works exclusively in the wind sector; in-house production of most components(produce blades, turbines, towers)

---

[78] GE Power Fact sheet: http://www.gepower.com/about/info/en/downloads/05_fact_sheet_global.pdf
[79] Enercon Gmbh website: Facts and Figures: http://www.enercon.de/en/_home.htm

- Revenue/ Size: 3rd largest by sales in 2005, 2nd largest amount of installed MW globally
    - $88,100,000 annual sales[80]
    - 8,186 employees globally
    - 13.2% of global market share for sales in 2005
    - 10,200 MW installed wind capacity

4 – Gamesa[81]

- Headquarters: Spain
    - Gamesa's renewable energy segment makes wind turbines and operates wind farms. The company has sold many of its wind farms in Europe to Electrabel.
- Revenue/ Size: 4th in installed MW globally in 2005
    - 1,745,000 Euros Revenue in 2005
    - 8,186 employees
    - Has experienced positive growth in both sales and employment in the last year.
    - Gamesa Wind US carries out the manufacturing, sales and operation and maintenance of Gamesa's wind turbines in the USA as well as in Canada

5 – Suzlon

- Headquarters: Pune, India
    - Production facilities in India and the United States (explicitly stated to meet North American demand[82]), China and Belguim; Engineering R&D HQ in Germany, Blade R&D HQ in Netherlands, Global Expansion HQ in Denmark.
    - Founded in 1995, private equity placement in 2004, acquired Hansen in 2006.
    - Works exclusively in the wind sector
    - Vertically integrated: manufacturing of generators, towers, control systems (India), gearboxes (Hansen Transmissions - Belgium), and blades (India, US, China).
    - Provide services from project development, manufacturing, installation and service operation.
- Revenue/ Size: 5th largest by sales in 2005, 5th in installed MW globally
    - $854,000,000 sales[83]
    - 5,300 employees globally (8,600 reported to investors 10/2006[84])
    - 6.1% of global market share for sales in 2005
    - 4,253 MW installed wind capacity

---

[80] Hoovers: http://premium.hoovers.com.ezaccess.libraries.psu.edu/subscribe/basic/factsheet.xhtml?ID=yryykrkct

[81] Gamesa Corporation Annual Report 2005: http://www.gamesa.es/gamesa/modules/idealportal/uploadlink/memoria2005ing.pdf

[82] http://www.suzlon.com/locations.htm

[83] http://www.suzlon.com/Investors%20Presentation.pdf

[84] http://www.suzlon.com/Investors%20Presentation.pdf

6 – Seimens[85]

- Headquarters: Germany
    - Company not limited to wind; involved in automation products, controls, drives, instruments, and power distribution products
    - Acquired Bonus Energy A/S in Dec. 2004
- Revenue/Size
    - 5,800 installed turbines
    - 4,498 installed MW (of which 1400 MW are installed in Germany)
    - Net Sales of Siemens Power Generation 8,061 million Euro
    - 33,000 employees

7 – RePower Systems[86]

- Headquarters: Germany
- Revenue/Size: 7th largest by sales in 2005
    - 2004 Sales of $411.1 (mil) [R2] [Positive growth in sales & employment]
    - 583 employees.

8 – Nordex[87]

- Headquarters: Norderstedt, Germany
    - Production Facilities: Germany, China
- Revenue/Size: 8th largest by sales in 2005
    - 308,000,000 Euro in 2005 - Turnover
    - 730 employees

9 – Ecotecnia[88]

- Headquarters: Spain
    - Production facilities: Spain
    - Founded in 1981; Acquired by Mondragon Corporation 1999 (the 7th largest business group is Spain, the world's largest worker cooperative owning 260 widely diverse companies (financial services, automotive, capital goods, construction, household goods, etc.)
    - Manufacturing in wind and solar sector, project development and construction
- Revenue/ Size: 9th largest by sales in 2005
    - 183, 000,000 Euros annual sales in 2005
    - 680 employees

---

[85] Seimens website: www.powergeneration.siemens.com/en/windpower/index.cfm
[86] Repower Systems, Global Perspectives, Annual Report 2005. http://www.repower.de/index.php?id=372&L=1
[87] Nordex website: Key Figures and Facts: http://www.nordex-online.com/en/company-career-career/key-figures-and-facts.html
[88] Mondragon Annual Report: http://www.mcc.es/ing/magnitudes/memoria2005.pdf

- 2.1% of global market share for sales in 2005
- 948 MW installed wind capacity

10 – Mitsubishi Power Systems

- Headquarters: Tokyo, Japan (parent) MPS HQ in Lake Mary, FL
  - Production facility in Lake Mary, FL
  - Subsidiary of Mitsubishi Heavy Industries: Work in many sectors of heavy industry, also in other power sectors: including gas, steam, geothermal, combined cycle power production.
  - In house production of turbines (Japan, US), joint venture with TPI Composites (US) to produce blades in Juarez, Mexico (formed "Vien Tek" in joint venture)[89]
  - Provides services including project management and design construction for power plants.
- Revenue/ Size: 10th largest by sales in 2005
  - $319,600,000 annual sales[90], including all other turbines manufactured in US facility
  - 2% of global market share for sales in 2005
  - 558 MW installed wind capacity

Others - BTM Consultants highlight two emerging companies as holding significant promise in coming years, the Chinese firm Goldwind and the Indian firm NPEC.[91] Other wind energy companies producing large wind turbines include winWind based in Finland and Fuhrlander based in Germany.

Wind Energy Components Suppliers

LM Glasfiber Group: Largest Wind Turbine Blade Manufacturer in the world

HQ: Denmark

- Production Facility in South Dakota

$24,100,000 Revenue[92]

- Operating profit (EBIT) fell 6% from DKK 95 million to DKK 89 million. The lower profit is due in part to a greater proportion of sales in USD in H1 2005. This adversely impacted LM GlasFiber is still not able to procure all raw materials and components locally in USD. The other reason for the lower profit is raising prices of composite

---

[89] http://www.mpshq.com/medialine_index.htm#news

[90] Hoovers Online: http://premium.hoovers.com.ezaccess.libraries.psu.edu/subscribe/co/factsheet.xhtml?ID=rrrkfhftkstkshx

[91] BTM Consult ApS: International Wind Energy Development World Market Update 2005 Forecast 2006-2010, Press Release: http://www.btm.dk/Pages/wmu.htm

[92] Hoovers Online: http://premium.hoovers.com.ezaccess.libraries.psu.edu/subscribe/basic/factsheet.xhtml?ID=ycrtyxcsj

materials such as resin, carbon fibers and core materials (excerpt directly from NetComposites Website).[93]

Hansen Transmissions (acquired by Suzlon Wind)

Headquarters: Antwerp, Belgium

- Production Facilities: Belgium

Leading gear manufacturer

Acquired by Suzlon Energy

Marlec Engineering Co LTD[94]

Headquarters: Corby Northants, UK

Component: Balance of System, Batteries, Small Wind Applications

MG srl[95]

Headquarters: Fossano, Italy

Component: Manufacturer of plate bending machines for the construction of wind towers.

Greenworld[96]

Headquarters: Varna, Bulgaria

Component: wind turbines (large), wind energy towers and structures (large), wind energy systems (large).

Nascom

Headquarters: Sindh Pakistan

Component: Utility Grade (Large) Wind Towers

Domestic Wind Power Manufacturers

Clipper Windpower[97]

Headquarters: Carpentaria, CA

- Production facilities: California, Iowa
- Clipper Windpower is a conglomeration of subsidiaries formed in 2001 (first public offering in the European Alternative Investment Market in 2005), a vertically integrated company providing turbines primarily for the domestic market

---

[93] Net Composites: http://www.netcomposites.com/news.asp?3249

[94] Energy Source Guides Wind Energy Wholesale Suppliers http://energy.sourceguides.com/businesses/byP/wRP/byB/wholesale/byN/byName.shtml

[95] Energy Source Guides Wind Energy Wholesale Suppliers http://energy.sourceguides.com/businesses/byP/wRP/byB/wholesale/byN/byName.shtml

[96] *Ibid*

[97] Clipper Windpower Plc 2005 Annual Report: http://www.clipperwind.com/pdfs/2005_annual_report_web.pdf

- Clipper currently offers the largest turbine (2.5 MW) manufactured in North America
- Looking to expand into the European and Latin American markets

Revenue/ Size:

- $15.9 million USD[98] (Clipper Windpower Plc actually posted a significant reduction in turnover revenue in 2005 of only $2.7 million as a result of the selling off of large production facilities, Clipper posted a net loss for 2005 of $ 19 million as a result of lower turnover and subsequent large capital investments in increased manufacturing capacity)[99]
- 127 employees

Trinity Structural Towers[100]

Headquarters: Dallas, TX

- Subsidiary of Trinity Industries

One of largest producers of wind towers in North America

- 12.1 million in sales
- 160 employees

Also involved in turbine components, concrete and aggregates, product transportation and specialized coatings

Builds turbines as large as 2.5 MW

Wind Components Manufacturers in ARC Member States[101]

Maryland Wind Components Manufacturers[102]:

Fibox, Inc.

Headquarters: Glen Burnie, MD

Component: Nema 4x non-metallic enclosures

New York Wind Components Manufacturers[103]:

GE Energy.

Headquarters: Schenectady, NY

Component: large wind turbines (1.500 - 3.600 kW), utility-scale wind turbine generators.

[98] Hoovers Online: Clipper Windpower Inc Information: http://premium.hoovers.com/subscribe/basic/factsheet.xhtml?ID=ychftrhx

[99] Clipper Windpower Plc 2005 Annual Report: http://www.clipperwind.com/pdfs/2005_annual_report_web.pdf

[100] www.trinitytowers.com

[101] These establishments are located within ARC member states, but are not necessarily located within the ARC's jurisdiction.

[102] Renewable Energy Source Guides, Large Wind Components Manufacturers: http://energy.sourceguides.com/businesses/byGeo/US/byP/wRP/lwindcomp/byS/WI/WI.shtml

[103] Renewable Energy Source Guides, Large Wind Components Manufacturers: http://energy.sourceguides.com/businesses/byGeo/US/byP/wRP/lwindcomp/byS/WI/WI.shtml

Pennsylvania Wind Components Manufacturers[104]:

Motors & Controls International

Headquarters: Hazleton, PA

Component: wind energy system Inverters (large), Variable Speed Generators (VSG)

SunEnergy Tehnologies, Inc.

Headquarters: Philadelphia, PA

Component: wind energy system components

Ohio Wind Components Manufacturers[105]:

Canton Drop Forge

Headquarters: Canton, OH

Component: wind energy system components (large)

Engineering Methods, Inc

Headquarters: Cincinnati , OH

Component: Engineering Software, FEA & Engineering Design Services and Consulting

Michael Byrne Manufacturing, Inc

Headquarters: Mansfield , OH

Component: wind energy system components (large)

Molded Fiberglass Company

Headquarters: Ashtabula, OH

Component: wind energy system components (large), large wind turbine rotor blades 20 meters and longer

National Electric Coil

Headquarters: Columbus, OH

Component: Windings for any generator above 1 MW, driven by any fuel or turbine type

Parker Hannifin Corporation

Headquarters: Cleveland, OH

Component: wind energy system components (large), hydraulic systems for large wind turbines, motion and control systems for large wind turbines

Tennessee Wind Components Manufacturers[106]:

Thomas & Betts Corporation

Headquarters: Memphis, TN

Component: wind energy system components (large), wind energy towers and structures (large), wind turbine support structures, lattice steel towers, tubular steel towers.

---

[104] Renewable Energy Source Guides, Large Wind Components Manufacturers: http://energy.sourceguides.com/businesses/byGeo/US/byP/wRP/lwindcomp/byS/WI/WI.shtml

[105] Renewable Energy Source Guides, Large Wind Components Manufacturers: http://energy.sourceguides.com/businesses/byGeo/US/byP/wRP/lwindcomp/byS/WI/WI.shtml

[106] Renewable Energy Source Guides, Large Wind Components Manufacturers: http://energy.sourceguides.com/businesses/byGeo/US/byP/wRP/lwindcomp/byS/WI/WI.shtml

Virginia Wind Components Manufacturers[107]:

Fiber Technology Corporation

Headquarters: Lorton, VA

Component: wind energy system components (large)

Wind Components Manufacturers – U.S. Other

California Wind Components Manufacturers[108]**:**

Access Energy

Headquarters: Beverly Hills, CA

Component: wind energy system components (large), wind energy systems (large), back up systems, distributed energy systems, solar cells, wind farm, Hydrogen and bio-ethanol systems.

Dutch Pacific, LLC

Headquarters: Westlake Village, CA

Component: wind turbines (large).

RLH Industries, Inc.

Headquarters: Orange, CA

Component: wind turbines (large)

Solera Industries, Inc.

Headquarters: Morgan Hill, CA

Component: wind energy system components (large)

Thelen, Reid & Priest, Inc.

Headquarters: San Francisco, CA

Component: all system components (large)

Wind Energy Conversion Systems

Headquarters: North Palm Springs, CA

Component: Electrical distributor Wind energy Specialty

WindTesting.com

Headquarters: Tehachapi, CA

Component: wind energy system components (large), wind energy system components (small), wind turbines (large), wind turbines (small), wind energy systems (large)

Wind Energy Company

Headquarters: Lancaster , CA

Component: wind energy system components (large)

---

[107] Renewable Energy Source Guides, Large Wind Components Manufacturers: http://energy.sourceguides.com/businesses/byGeo/US/byP/wRP/lwindcomp/byS/WI/WI.shtml

[108] Renewable Energy Source Guides, Large Wind Components Manufacturers: http://energy.sourceguides.com/businesses/byGeo/US/byP/wRP/lwindcomp/byS/WI/WI.shtml

Texas Wind Components Manufacturers[109]

Nicholson-Paige Electric

Headquarters: Ransom Canyon, TX

Component: submersible pump wire and specialized cable, wind energy system components (large)

Trinity Structural Towers

Headquarters: Fort Worth, TX

Component: wind energy system components (large), wind energy towers and structures (large)

Barr Fabrication, LLC

Headquarters: Brownwood, TX

Component: wind energy towers and structures (large), wind energy system components (large)

Washington Wind Components Manufacturers[110]

Global Energy Concepts, LLC

Headquarters: Kirkland, WA

Component: wind energy systems (large), wind energy systems (small), wind turbines (large), wind turbines (small), wind energy system components (large), wind energy system components (small), All aspects of wind energy)

Spin Trends, LLC

Headquarters: Walla Walla, WA

Component: Condition Monitoring and assessment of Bearings, gears and critical components of: wind power plants, wind energy system components (large)

Toray Composites (America), Inc

Headquarters: Tacoma, WA

Component: , wind energy system components (large)

Wisconsin Wind Components Manufacturers[111]

Powertrain Engineers

Headquarters: Pewaukee, WI

Component: wind energy system components, wind energy systems (large)

Tower Tech Systems, Inc.

Headquarters: Manitowoc, WI

Component: wind energy towers and structures (large), wind turbines (large), wind energy system components

Florida Wind Components Manufacturers[112]

---

[109] Renewable Energy Source Guides, Large Wind Components Manufacturers: http://energy.sourceguides.com/businesses/byGeo/US/byP/wRP/lwindcomp/byS/WI/WI.shtml

[110] Renewable Energy Source Guides, Large Wind Components Manufacturers: http://energy.sourceguides.com/businesses/byGeo/US/byP/wRP/lwindcomp/byS/WI/WI.shtml

[111] Renewable Energy Source Guides, Large Wind Components Manufacturers: http://energy.sourceguides.com/businesses/byGeo/US/byP/wRP/lwindcomp/byS/WI/WI.shtml

American Wire Group

Headquarters: , Hallandale, FL

Component: wind energy system components

USA Solar & Wind, Inc.

Headquarters: Tallahassee , FL

Component: wind energy system components, , wind power plants, wind energy towers and structures (large)

ElectricPowerforless.biz

Headquarters: Jacksonville Beach, FL

Component: wind energy system components

Idaho Wind Components Manufacturers[113]

Windland, Inc

Headquarters: Boise, ID

Component: refurbished wind turbines

Windpower Unlimited, LLC

Headquarters: Filer, ID

Component: wind energy system components

Michigan Wind Components Manufacturers[114]:

Citation Corporation

Headquarters: Novi, MI

Component: wind energy system components, wind power components from ductile iron, blade extenders, hubs, tower flanges and frame components

Danotec Motion Technologies, LLC

Headquarters: Ann Arbor, MI

Component: wind energy system components, Variable Speed Brushless Motors

K & M Machine Fabrication, Inc

Headquarters: Cassopolis, MI

Component: wind fabricated structures (large), wind energy system components (large), bedplates, hubs and gear boxes

Minnesota Wind Components Manufacturers[115]

SMI and Hydraulics

Headquarters: Porter, MN

---

[112] Renewable Energy Source Guides, Large Wind Components Manufacturers: http://energy.sourceguides.com/businesses/byGeo/US/byP/wRP/lwindcomp/byS/WI/WI.shtml

[113] Renewable Energy Source Guides, Large Wind Components Manufacturers: http://energy.sourceguides.com/businesses/byGeo/US/byP/wRP/lwindcomp/byS/WI/WI.shtml

[114] Renewable Energy Source Guides, Large Wind Components Manufacturers: http://energy.sourceguides.com/businesses/byGeo/US/byP/wRP/lwindcomp/byS/WI/WI.shtml

[115] Renewable Energy Source Guides, Large Wind Components Manufacturers: http://energy.sourceguides.com/businesses/byGeo/US/byP/wRP/lwindcomp/byS/WI/WI.shtml

Component: wind energy system components (large), wind energy towers and structures Wind Tower Footing Material, Anchor Bolts, Imbed Rings and Rebar.

Montana Wind Components Manufacturers[116]

LineHaul Logistics, Inc

Headquarters: Missoula, MT

Component: wind energy system components (large), wind turbines

Planetary Systems, Inc

Headquarters: , Ennis, MT

Component: wind energy system components

Solar PV Manufacturers

The following information was gathered from a base of Corporate Annual Reports and from resources such as Hoovers Online.

Kyocera[117]

Head Quarters- Kyoto, Japan

US Division- Scottsdale, AZ

Total Revenue $- 10,098,000

US/ Solar Revenue$- '06 $117mm product group containing solar cells

Employees- 58,559

Components/NAICS- PV cells (335311, 42172, 333611)

Products- Solar & Hybrid Power Systems, Solar Panels, Solar Water Pumping, Solar Modules, Investors, Controllers, Batteries, Solar Electricity, Solar Power Solar, Wind Turbine, Solar Company

US Manufacturing- None

Sharp[118]

Head Quarters- Osaka, Japan

US Division- Mawah, NJ

Total Revenue $- 24,113 mm

US/ Solar Revenue$- 291billion (total for groupings of "other electronics")

Employees- 46,741 – 54,900

Components/NAICS- PV cells, Inverters

US Manufacturing- Memphis, Tennessee

---

[116] Renewable Energy Source Guides, Large Wind Components Manufacturers: http://energy.sourceguides.com/businesses/byGeo/US/byP/wRP/lwindcomp/byS/WI/WI.shtml

[117] Hoovers Online: http://premium.hoovers.com.ezaccess.libraries.psu.edu/subscribe/co/factsheet.xhtml?ID=ffffcrxktjsfhhkjtc&ticker=KYO

[118] Hoovers Online: http://premium.hoovers.com.ezaccess.libraries.psu.edu/subscribe/co/factsheet.xhtml?ID=ffffcrkxhjsfhyjsth

Solar World

Head Quarters- Bonn, Germany
US Division- Camarillo, CA
Total Revenue $- 272.7mm
US/ Solar Revenue$- 26.9mm
Employees- 616
Components/NAICS- PV cells, Solar film, inverters, Batteries
2006 acquisition of Shell Solar (100% of crystalline solar activities of the shell group.) With this merger, SolarWorld will be the largest US producer of solar products. SolarWorld parent company, Duetchse Solar AG, has signed a 10 year silicon wafer agreement with Suntech China's #1 solar company and number 8 globally. SolarWorld is both a customer and competitor of Suntech.

Conergy[119]

Head Quarters- Hamburg, Germany
US Division- Santa Fe, NM
Total Revenue - $629,000,000 sales in 2005
US/ Solar Revenue: $ 25mm
Employees- 724
Components/NAICS- PV Cells, Inverters
Products- The company makes components such as photovoltaic modules, mounting systems, and both off-grid and grid-connected inverters. It also makes solar collectors, control units, pumps, storage tanks, and other solar thermal products
US Manufacturing- None
50/50/08 plan: 50% rev abroad, 50% renewable. This comment is a "Strategy/Vision" and illustrates the desire of Conergy to grow abroad, especially in the US. '08: Voltwerk, PA location is a channel for distribution. This shows an interest in locating facilities in the US and this is location is an ARC county; R&D and engineering potential.
#2 worldwide sales (#1 Germany) this is the companies own statement
Built largest solar plant = 10MW
Conergy is one of Suntech's largest customers

Sanyo

Head Quarters-Osaka, Japan
US Division- San Diego, CA, and Detroit, MI
Total Revenue: $21,804 mm
US/ Solar Revenue $- Semiconductor Branch in Saddle Brooke NJ, 75.7MM
Employees- 106,389
US Manufacturing- San Diego, CA Detroit, Michigan

[119] Hoovers Online:
http://premium.hoovers.com.ezaccess.libraries.psu.edu/subscribe/co/factsheet.xhtml?ID=rysyrsyrjryjfjy

In 1994 Sanyo "combined forces" with Soltec, a solar PV cell company since the '70s. Demonstration of large firms gaining markets through acquisition.

SunPower

Head Quarters- Sunnyvale, CA

US Division- Sunnyvale, CA

Total Revenue $- 65.3 MM (the third quarter ended September 30, 2006 was $65.3 million, up 19% from the prior quarter's revenue of $54.7 million and up 198% from the third quarter 2005 revenue of $21.9 million.)

Employees- 788 (1yr growth 89.4%)

Components/NAICS- A-300, SPR series and STM series, solar cells and panels

In 2002, Cypress Semiconductor company purchased a majority interest in SunPower and subsequently funded much of the mass production for A-300 solar cells (press release 10/18/06); For the year 2007, the contract calls for SunPower to purchase approximately $20 million of silicon ingots from REC SciTech. This contract builds on previous ingot supply agreements and purchase orders between the two companies. SunPower's silicon supply for 2007 remains sufficient to produce 110 megawatts of cell production.

Matrix Solar

Head Quarters- Albuquerque NM

US Division- Albuquerque NM

Total Revenue $- 52.5mm

Employees- 300

Components/NAICS- Assembles Solar PV Modules

Parent Company Automation Tooling Systems (ATS) (largest Turn Key based in Canada)

Matrix subsidiary Photowatt International Europe PV cell manufacturer.

Evergreen Solar

Head Quarters- Marlboro, MA

US Division- Marlboro, MA

Total Revenue: $36 MM (87% growth)

US/ Solar Revenue: $ 90% of sales

Employees- 290 (16% growth)

Components/NAICS- String ribbon wafer technology (develops and manufactures solar power cells and panels.)

Spire Solar

Head Quarters- Bedford, MA

US Division- Bedford, MA

Total Revenue: $22.4 mm

US/ Solar Revenue: $*0.3MM

Employees- 118

Components/NAICS- Solar Manufacturing equipment, Turnkey production lines, wafer and module systems/installation
Company press release states that 3rd quarter sales increase is due to increase in solar cell production and manufacturing base sales

EPV (Energy Photovoltaic Inc.)
Head Quarters- Lawrenceville, NJ
US Division- Lawrenceville, NJ
US/ Solar Revenue$- 1mm
Employees- 50

InnovaLight
Head Quarters- Santa Clara, CA
US Division- Santa Clara, CA
Total Revenue $- 1.5mm
US/ Solar Revenue$- 1.5mm
Employees- 15
Components/NAICS- Ultra thin silicon PV, very flexible and can capture new UV wave levels

GreenMountain Engineering
Head Quarters- San Francisco, CA
US Division- San Francisco, CA
US/ Solar Revenue: $0.3mm
Employees- 20
Components/NAICS- raw material production (LLC).(541330)

UniSource Energy
Head Quarters- Tucson, AZ
US Division- Tucson, AZ
Total Revenue $- 1,229.5MM
Employees- 1,947
Components/NAICS- Electric Power Transmission, Control, and Distribution
US Manufacturing-
Sold its Global Solar Energy (subsidiary) in 2006 to Solon AG for 16MM. UniSource gains most of its revenue from utility subsidiaries.

MEMC Electronic Materials
Head Quarters- St. Peters MO
US Division- St. Peters MO
Total Revenue $- 1107.4mm
US/ Solar Revenue$- 10% polysilicon
Employees- 5,500

Components/NAICS- Makes silicon wafers, and also solar grade polysilicon for PV cells
US Manufacturing- Hillsborough MT, San Jose CA, Maryland Heights MT
Largest customer is Samsung Electronics, which also includes Texas Instruments.

Konarka

Head Quarters- Lowell, MA
US Division- Lowell, MA
Total Revenue $- .5mm (2003)
US/ Solar Revenue$- .5mm (2003)
Employees-
Components/NAICS- OV cells, thin converters
Founded 2001, former military project, this company has over 200 global patents. Like InnovaLight, their cells can capture energy from all light sources not just visible.

BP Solar

Head Quarters- London, England
US Division- Frederick, MD
Total Revenue: $245,486 mm
Employees- >106,000
Components/NAICS- BP solar manufactures cells, wafers, and complete systems - starting to sell ready to install PV modules at Home Depot.
BP has recently allocated 1.6 Billion dollars to an alternative energy campaign. This includes solar wind and biofuels. However, 1.6 billion is more than most other solar companies have even accounted for in sales.

Suntech Power Holdings, Co. Ltd

Head Quarters- Jiangsu, China
Total Revenue: $226 mm
Employees- 1374
Components/NAICS- PV sells and solar electric systems for both on and off grid
Suntech is the number eight company in the world and the leader in China. They have recently purchased MSK corp. of Japan. This acquisition will gain them access to the difficult-to-enter Japanese solar market. The company has also signed 10-year silicon wafer cell agreements with both SolarWorld and MEMC

Photowatt (Part of ATS Automation—Acquired by Matrix Solar in 1997)

Head Quarters- France, Cambridge, Canada
Total Revenue: $121.9 mm
US/ Solar Revenue: $121.9 mm

Employees- 711
Components/NAICS- photovoltaic, solar energy, products including installation kits and solar power system designs

Q Cells
Head Quarters- Thalheilm, Germany
Total Revenue: $351mm
US/ Solar Revenue: $351MM
Employees- 500
Components/NAICS- PV Cells

BTU International
Head Quarters- N. Billercia, MA
US Division- N. Billercia, MA.
Total Revenue $- 66.4mm
US/ Solar Revenue$- 66.4mm
Employees- 177
Components/NAICS- supplier of semiconductor wafers for solar and thermal process equipment
In 2006, purchased RTC Radiant Technology corp. which adds a new line for furnaces used in the manufacturing of photovoltaic systems

Advanced Silicon /REC
Head Quarters- Silver Bell, MT
US Division- Silver Bell, MT
Total Revenue $- 89.6mm
US/ Solar Revenue$- 89.6mm
Employees- 410
Components/NAICS- produces polycrystalline silicon not a PV maker
US Manufacturing- Washington
Norway's Renewable Energy Corporation (REC) now has a 75% stock in advanced silicon

Thirteen additional solar energy materials suppliers were located abroad with facilities in the following countries: United Kingdom (3), Japan (2), Italy (1), Germany (2), France (1), China (2), Austria (1), and Argentina (1). [120]

Solar Materials Suppliers and Solar Cell Manufacturers in ARC States[121]

AFG Industries, Inc.

[120] SolarBuzz, Fast Solar Energy Facts: http://www.solarbuzz.com/FastFactsIndustry.htm
[121] SolarBuzz, Fast Solar Energy Facts: http://www.solarbuzz.com/FastFactsIndustry.htm

Facility: US, Kingsport TN
Components: Tin oxide coated glass for thin film solar cells

DuPont Tedlar
Facility: US, Buffalo NY
Components: Tin oxide coated glass for thin film solar cells

Ferro
Facility: US, Cleveland, OH
Components: Thick film paste

Torpedo Specialty Wire, Inc.
Facility: US, Rocky Mount, NC
Components: PV tabbing and bus ribbon products

Ulbrich
Facility: US, Westminster, SC
Components: Solar cell tabbing and bus ribbon

Solar Power Industries
Facility: US, Vernon, PA
Components: Multicrystalline silicon

Additional Solar Energy Materials Suppliers in the US [122]

Asahi Glass Corporation Electronic Materials
Facility: US, Hillsboro, OR
Components: Glass Frits

Cermet Materials, Inc.
Facility: US, Wilmington, DE
Components: Thick film paste

Crane Nonwovens
Facility: US, Dalton, MA
Components: Craneglas glass fibre matting

Global Wedge, Inc.
Facility: US, Riverside, CA
Components: Glass, Tedlar, EVA, tabbing and glass fibre mat

Madico

[122] SolarBuzz, Fast Solar Energy Facts: http://www.solarbuzz.com/FastFactsIndustry.htm

Facility: US, Woburn, MA
Components: PVF composite films for module backing

Specialized Technology Resources, Inc.
Facility: US, Enfield, CA
Components: EVA

Sputtering Materials, Inc.
Facility: US, Reno, NV
Components: Thin film planar and ratable target materials for solar cells

Additional Solar Cell Manufacturers in the US [123]

Energy Conversion Devices, Inc.
Facility: US, Rochester Hills, MI
Components: Amorphous silicon thin film

First Solar LLC
Facility: US, Phoenix, AZ
Components: Cadmium Telluride

GE Energy (Solar Division)
Facility: US, Newark, DE
Components: Monocrystalline silicon

Iowa Thin Film Technologies
Facility: US, Boone, IA
Components: Amorphous silicon thin film on plastic substrate

Terra Solar, Inc
Facility: US, Carson, CA
Components: Monocrystalline silicon

United Solar Ovonic
Facility: US, Auburn Hill, MI
Components: Amorphous silicon thin film

There are over 62 solar cell manufacturers abroad located in over 18 countries. China leads with over 14 manufactures, India has 11 and Japan has 10.[124]

[123] SolarBuzz, Fast Solar Energy Facts: http://www.solarbuzz.com/FastFactsIndustry.htm
[124] SolarBuzz, Fast Solar Energy Facts: http://www.solarbuzz.com/FastFactsIndustry.htm

Biomass – Ethanol Production

Abengoa, S.A.[125]

Location: Seville, Spain
Employment: 11,082
Sales: $2,396,400,000
Product: Biofuels for transport, bioethanol, and biodiesel
Description: Subsidiary is Abengoa Bioenergy which is headquartered in St. Louis, MO

Archer Daniels Midland[126]

Location: Decatur, Illinois
Employment: 25,641
Sales: $36,596,100,000
Product: Processes crops to make food, animal feed, renewable fuels, and natural alternatives to industrial chemicals.
Description: Global distributor of quality foods.

Aventine Renewable Energy Holdings, Inc.[127]

Location: Pekin, Illinois
Employment: 280
Sales: $935,500,000
Product: Makes ethanol, bioproducts, and feed products.
Description: A leading producer and marketer of ethanol in the United States.

Danisco A/S Genencor International[128]

Location: Copenhagen, Denmark (Genencor - Palo Alto, CA)
Employment: 10,636
Sales: $3,540,400,000
Product: Produces food ingredients.
Description: Among the technological leaders in converting biomass - starch and non-starch materials - into ethanol. Enzymes such as STARGENTM and SPEZYMETM have made the production of bioethanol a cost-effective proposition.

Harvest Biofuels BV

Location: Austria

---

[125] Hoovers Online: January 16, 2007: http://premium.hoovers.com.ezaccess.libraries.psu.edu/subscribe/co/factsheet.xhtml?ID=rfrcshcjyrfkjhr

[126] Hoovers Online: January 16, 2007: http://premium.hoovers.com.ezaccess.libraries.psu.edu/subscribe/co/factsheet.xhtml?ID=rfrtcffryfkhxj

[127] Hoovers Online: January 16, 2007: http://premium.hoovers.com.ezaccess.libraries.psu.edu/subscribe/co/factsheet.xhtml?ID=rcsrttstssttxys

[128] Ibid: http://premium.hoovers.com.ezaccess.libraries.psu.edu/subscribe/co/factsheet.xhtml?ID=sfshcyfjrxktyx

Description: Harvest Biofuels BV is a subsidiary of Harvest Energy Limited, one of the largest suppliers of high quality gasolines and diesel road fuels to the U.K. independent sector and one of the market leaders for supply of bio-ethanol and bio-diesel road fuels in the United Kingdom

Caltex Australia Limited[129]

Location: Sydney, 2000, Australia
Employment: 3,046
Sales: $8,939,900,000
Product: It is engaged in the refining, distribution and marketing of fuels and lubricants across the country
Description: Australia Limited is the largest refiner and marketer of petroleum products in Australia with operations in all states and territories

CHS, Incorporated[130]

Location: Inver Grove Heights, MN
Employment: 6,370
Sales: $11,941,100,000.00
Product: CHS trades grain and sells supplies to members through its stores. It also processes soybeans for use in food and animal feeds, and markets petroleum.
Description: CHS is one of the nation's largest suppliers of ethanol-enhanced gasoline and a leading marketer of biodiesel products. CHS is an owner of US BioEnergy, a premier ethanol manufacturer, distributor and marketer.

CSR Limited[131]

Location: Chatswood, New South Wales, Australia
Employment: 6,363
Sales: $2,037,800,000
Product: CSR Limited is now heavy into construction materials such as plasterboard, cement fiber products, roof tile, clay brick, and insulation.
Description: CSR has operations in sugar milling, sugar refining, and ethanol production and is expanding its capacity to generate commercially renewable electricity.

Cargill, Inc.[132]

Location: Waytaza, MN
Employment: 149,000 in 63 countries

[129] Hoovers Online, January 18, 2007: http://premium.hoovers.com.ezaccess.libraries.psu.edu/subscribe/co/factsheet.xhtml?ID=rtfycykhfttrkjc
[130] Hoovers Online, January 18, 2007: http://premium.hoovers.com.ezaccess.libraries.psu.edu/subscribe/co/factsheet.xhtml?ID=hktrxffjrckrkk
[131] Hoovers Online, January 18, 2007: http://premium.hoovers.com.ezaccess.libraries.psu.edu/subscribe/co/factsheet.xhtml?ID=hjtkhkhfkytjyx
[132] Hoovers Online, January 18, 2007: http://premium.hoovers.com.ezaccess.libraries.psu.edu/subscribe/co/factsheet.xhtml?ID=cffksffjtcsrxs

Sales: $75,208,000,000
Product: Cargill's diversified operations include grain, cotton, sugar, and petroleum trading; financial trading; food processing; futures brokering; and agricultural services including animal feed and fertilizer production.
Description: manufactures ethanol at two production facilities in the heart of the cornbelt: Eddyville, IA; and Blair, NE; makes biodiesel in Iowa Falls, IA

Matrix Service Company[133]
Location: Tulsa, OK 74116
Employment: 2,092
Sales: $493,900,000
Product: ethanol and petroleum refining
Description: provides construction, and repair and maintenance services primarily to the downstream petroleum and power industries in the United States and Canada

VeraSun Energy Corporation[134]
Location: Brookings, SD 57006
Employment: 160
Sales: $236.4 million
Product: The Company is one of the nation's leading producers of ethanol,
Description: The Company is selling a branded fuel, VE85, at service stations in the Midwest

Hawkeye Holdings Inc[135].
Location: Iowa Falls, IA
Employment: 85
Sales: $89,100,000
Product: 1) Product ethanol 2) Produce and sell distillers grains as ethanol co-products
Description: Like most ethanol producers, Hawkeye also markets distiller grains (a by-product of the manufacturing process) as animal feed

[133]Hoovers Online, January 18, 2007: http://premium.hoovers.com.ezaccess.libraries.psu.edu/subscribe/co/factsheet.xhtml?ID=rfjffrrhrfhxtk
[134] Hoovers Online, January 18, 2007: http://premium.hoovers.com.ezaccess.libraries.psu.edu/subscribe/co/factsheet.xhtml?ID=rcsrtrfjktfjrjc
[135] Hoovers Online, January 18, 2007: http://premium.hoovers.com.ezaccess.libraries.psu.edu/subscribe/co/factsheet.xhtml?ID=rhfcchrjrhftjyy

Appendix B – Concentrated Renewable Manufacturing

County Level Biomass Manufacturing Capacity

Table B-1. Counties with substantial biomass presence were selected for either their total number of potential jobs in the biomass sector, total number of establishments per county, the potential number of different types of components for the biomass sector, or average firm size.

Sector	State	County	# of Estabs	# of Jobs	# of Component Types	Socio-Economic Status	Pop. Class	Primary City(s)
Biomass	AL	Jefferson	25	1280	12	Transitional	Metro	Birmingham, Hoover
Biomass (Solar)	AL	Morgan	4	1266	3	Transitional	Metro	Decatur
Biomass	AL	Marshall	3	699	3	Transitional	Rural/ Other	
Biomass (Solar Wind)	AL	Madison	10	529	9	Attainment	Metro	Huntsville
Biomass (Solar Wind)	AL	De Kalb	2	453	2	Transitional	Micro	Fort Payne
Biomass	AL	Cullman	3	415	3	Transitional	Micro	Cullman
Biomass (Solar Wind)	AL	Shelby	14	393	9	Attainment	Metro	Birmingham, Hoover
Biomass	AL	Marion	1	310	1	At-Risk	Rural/ Other	
Biomass	AL	Limestone	2	286	2	Transitional	Metro	Huntsville
Biomass (Solar Wind)	GA	Gwinnett	25	1342	11	Attainment	Metro	Atlanta-Sandy Springs-Marietta
Biomass	GA	Barrow	3	1158	2	Transitional	Metro	Atlanta-Sandy Springs-Marietta
Biomass	GA	Bartow	3	883	3	Competitive	Metro	Atlanta-Sandy Springs-Marietta

Sector	State	County	# of Estabs	# of Jobs	# of Component Types	Socio-Economic Status	Pop. Class	Primary City(s)
Biomass (Solar)	GA	Hall	4	697	4	Transitional	Metro	Gainesville
Biomass	GA	Stephens	2	363	2	Transitional	Micro	Toccoa
Biomass (Solar Wind)	GA	Cherokee	7	319	5	Attainment	Metro	Atlanta-Sandy Springs-Marietta
Biomass	GA	Gordon	2	304	2	Transitional	Micro	Calhoun
Biomass	KY	Whitley	1	520	1	Distressed	Micro	Corbin
Biomass (Solar)	KY	Laurel	1	320	1	At-Risk	Micro	London
Biomass	KY	Magoffin	1	170	1	Distressed	Rural/ Other	
Biomass	MS	Lee	3	1160	2	Transitional	Micro	Tupelo
Biomass	MS	Clay	1	577	1	Distressed	Micro	West Point
Biomass	MS	Winston	1	511	1	Distressed	Rural/ Other	
Biomass	MS	Union	3	436	3	Transitional	Rural/ Other	
Biomass	MS	Marshall	2	255	2	Distressed	Metro	Memphis, TN
Biomass	MS	Tishomingo	2	232	2	At-Risk	Rural/ Other	
Biomass (Solar)	NC	Buncombe	13	1632	9	Competitive	Metro	Asheville
Biomass (Wind)	NC	Forsyth	12	1322	9	Attainment	Metro	Winston-Salem
Biomass (Solar Wind)	NC	Watauga	16	1052	9	Transitional	Micro	Boone

Sector	State	County	# of Estabs	# of Jobs	# of Component Types	Socio-Economic Status	Pop. Class	Primary City(s)
Biomass	NC	Davie	1	578	1	Competitive	Metro	Winston-Salem
Biomass	NC	Rutherford	2	504	2	At-Risk	Micro	Forest City
Biomass	NY	Steuben	8	1905	5	Transitional	Micro	Corning
Biomass (Wind)	NY	Allegany	2	1253	2	Transitional	Rural/ Other	
Biomass	NY	Cattaraugus	4	1119	3	Transitional	Micro	Olean
Biomass	NY	Cortland	2	713	2	Transitional	Micro	Cortland
Biomass (Solar Wind)	NY	Chautauqua	4	530	4	Transitional	Micro	Jamestown, Dunkirk, Fredonia
Biomass	NY	Chemung	3	373	3	Transitional	Metro	Elmira
Biomass (Solar Wind)	NY	Broome	9	296	6	Transitional	Metro	Binghamton
Biomass (Solar Wind)	OH	Tuscarawas	9	861	7	Transitional	Micro	New Philadelphia, Dover
Biomass	OH	Columbiana	13	392	9	Transitional	Micro	East Liverpool-Salem
Biomass (Solar Wind)	PA	Erie	40	6835	15	Transitional	Metro	Erie
Biomass (Solar Wind)	PA	Allegheny	63	6202	15	Attainment	Metro	Pittsburg
Biomass (Solar)	PA	Westmoreland	27	2265	13	Competitive	Metro	Pittsburgh
Biomass	PA	Fulton	2	1889	2	Transitional	Rural/ Other	
Biomass (Solar)	PA	Washington	15	1385	6	Transitional	Metro	Pittsburgh

Sector	State	County	# of Estabs	# of Jobs	# of Component Types	Socio-Economic Status	Pop. Class	Primary City(s)
Biomass	PA	Luzerne	18	1163	9	Transitional	Metro	Scranton, Wilkes-Barre
Biomass (Solar)	PA	Beaver	7	783	6	Transitional	Metro	Pittsburg
Biomass (Solar Wind)	PA	Cambria	8	645	4	Transitional	Metro	Johnstown
Biomass	PA	Mercer	11	608	7	Transitional	Metro	Youngstown, OH, Warren, OH, Boardman, OH
Biomass	PA	Schuylkill	6	516	4	Transitional	Metro	Pottsville
Biomass	PA	Lycoming	7	503	6	Transitional	Metro	Williamsport
Biomass	PA	Mifflin	3	471	3	Transitional	Micro	Lewistown
Biomass (Solar Wind)	PA	Butler	15	470	11	Competitive	Metro	Pittsburg
Biomass	PA	Bedford	2	402	1	Transitional	Rural/ Other	
Biomass	PA	Northumberland	2	349	3	Transitional	Micro	Sunbury
Biomass (Wind)	PA	Indiana	8	332	5	Transitional	Micro	Indiana
Biomass	PA	Jefferson	5	307	5	Transitional	Rural/ Other	
Biomass (Solar Wind)	PA	Somerset	6	241	6	Transitional	Micro	Somerset
Biomass	PA	Lawrence	7	232	5	Transitional	Micro	New Castle
Biomass (Solar Wind)	SC	Greenville	19	3715	8	Competitive	Metro	Greenville
Biomass (Solar Wind)	SC	Spartanburg	17	1944	13	Transitional	Metro	Spartanburg

Sector	State	County	# of Estabs	# of Jobs	# of Component Types	Socio-Economic Status	Pop. Class	Primary City(s)
Biomass (Solar)	TN	Hamilton	29	3322	12	Competitive	Metro	Chattanooga
Biomass	TN	Warren	3	1297	3	Transitional	Rural/ Other	
Biomass (Solar)	TN	Putnam	11	934	8	Transitional	Micro	Cookeville
Biomass (Solar Wind)	TN	Greene	10	914	8	Transitional	Micro	Greeneville
Biomass (Solar Wind)	TN	Washington	9	783	7	Transitional	Metro	Johnson City
Biomass (Solar Wind)	TN	Knox	13	355	9	Transitional	Metro	Knoxville
Biomass	TN	Monroe	1	350	1	Transitional	Rural/ Other	
Biomass	TN	Rhea	1	336	1	Transitional	Rural/ Other	
Biomass (Solar Wind)	TN	Anderson	7	184	5	Transitional	Metro	Knoxville
Biomass (Solar)	VA	Bristol City	5	3112	4	Transitional	Metro	Kingsport, TN, Bristol, TN, Bristol, VA
Biomass	VA	Washington	3	444	3	Transitional	Metro	Kingsport, TN, Bristol, TN, Bristol, VA
Biomass	VA	Buena Vista City	2	331	2	Transitional	Rural/ Other	Buena Vista City
Biomass	VA	Rockbridge/ Buena Vista/ Lexington City	2	319	2	Transitional	Rural/ Other	Lexington City
Biomass (Solar)	VA	Bland	2	276	2	Transitional	Rural/ Other	
Biomass (Solar)	VA	Tazewell	5	221	5	Transitional	Micro	Bluefield, WV
Biomass	WV	Hancock	2	588	2	Transitional	Metro	Weirton, WV, Steubenville, OH

Sector	State	County	# of Estabs	# of Jobs	# of Component Types	Socio-Economic Status	Pop. Class	Primary City(s)
Biomass (Solar Wind)	WV	Cabell	6	318	6	Transitional	Metro	Huntington, WV, Ashland, KY
Biomass	WV	Greenbrier	1	206	1	At-Risk	Rural/ Other	
Biomass (Solar Wind)	WV	Raleigh	6	182	5	Transitional	Micro	Beckley

Figure B-1. Counties with potential biomass job totals over 1,000

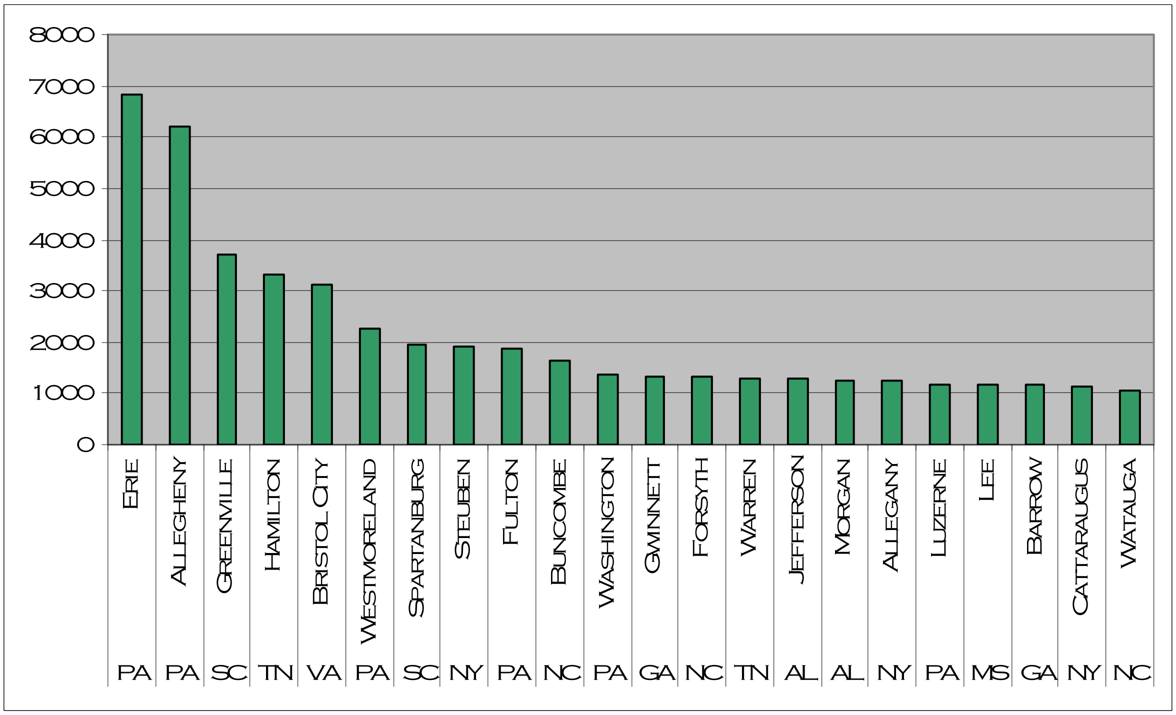


Figure B-2. The number of potential establishments and the number of different biomass components for counties with job totals over 1,000

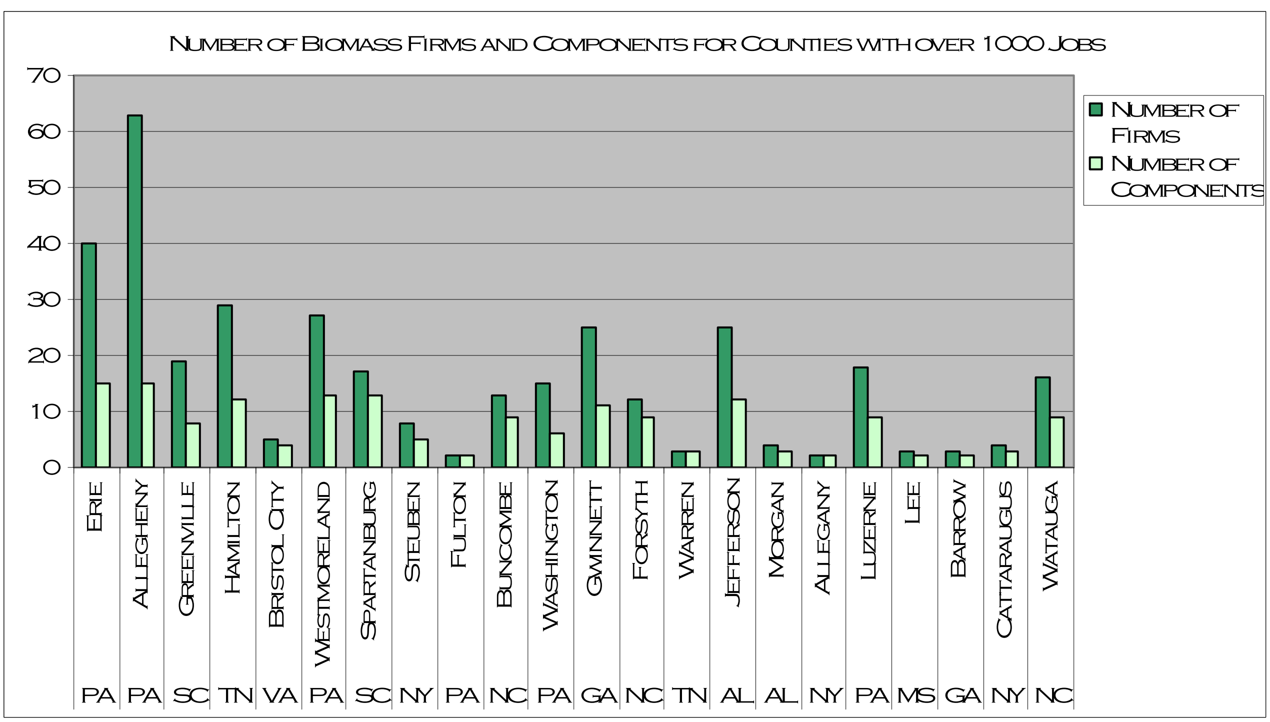


Figure B-3. Counties with potential biomass job totals from 500 to 999

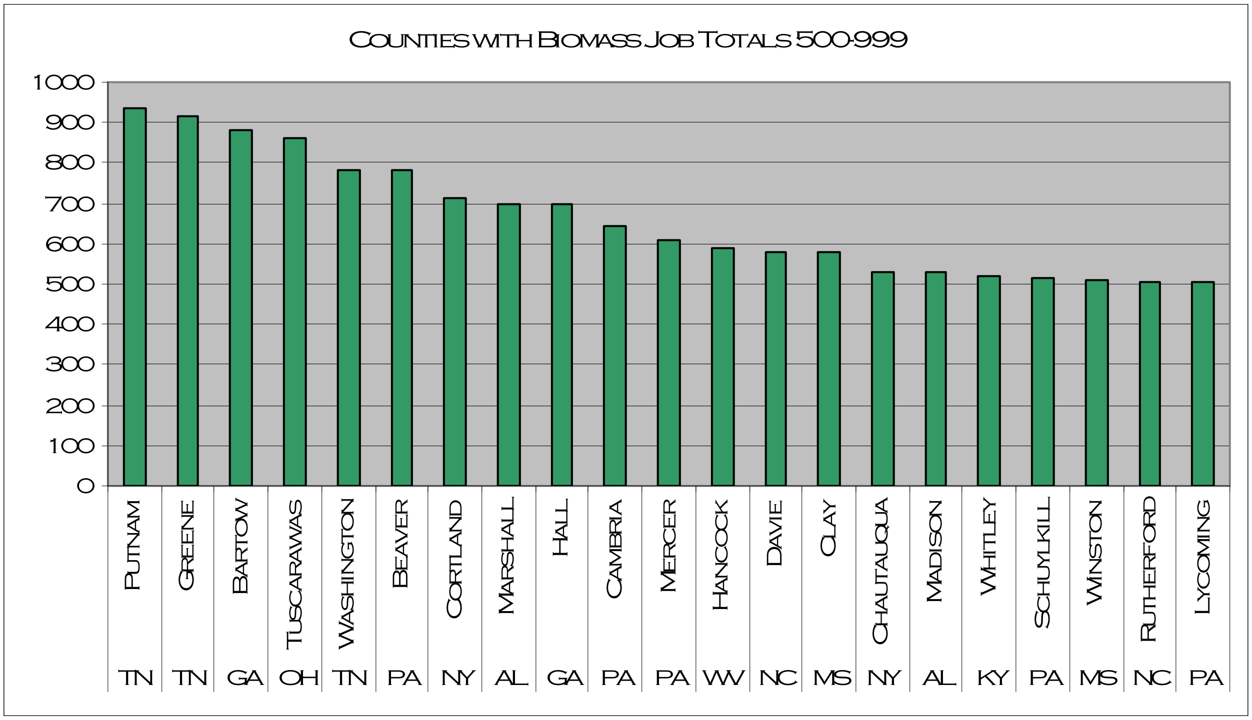


Figure B-4. The number of potential establishments and the number of different biomass components for counties with job totals between 500 and 999

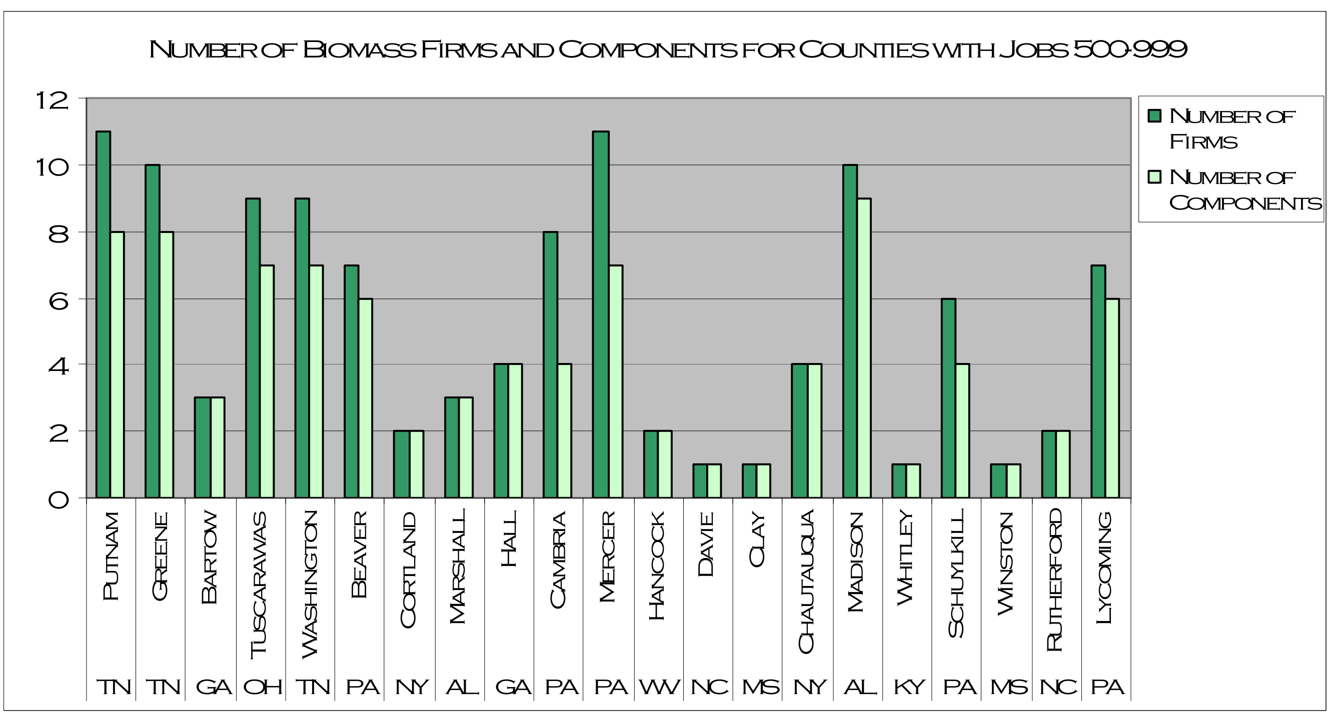


Figure B-5. Counties with potential biomass job totals from 80 to 499

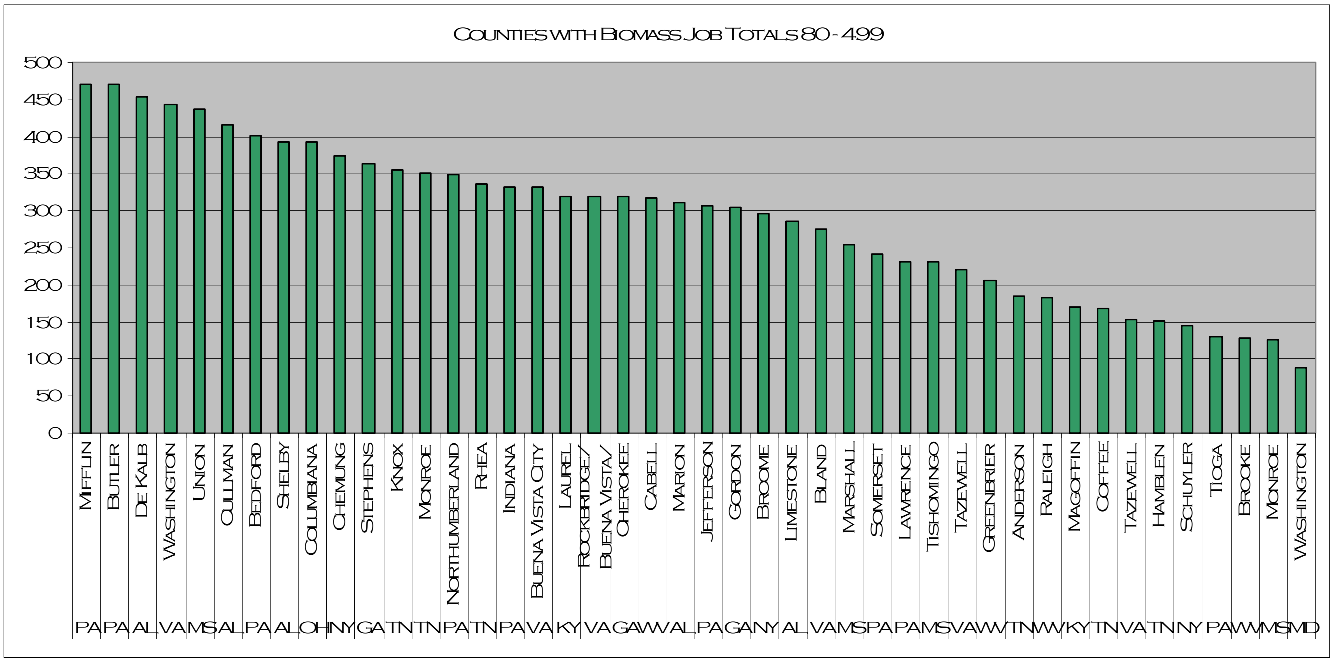
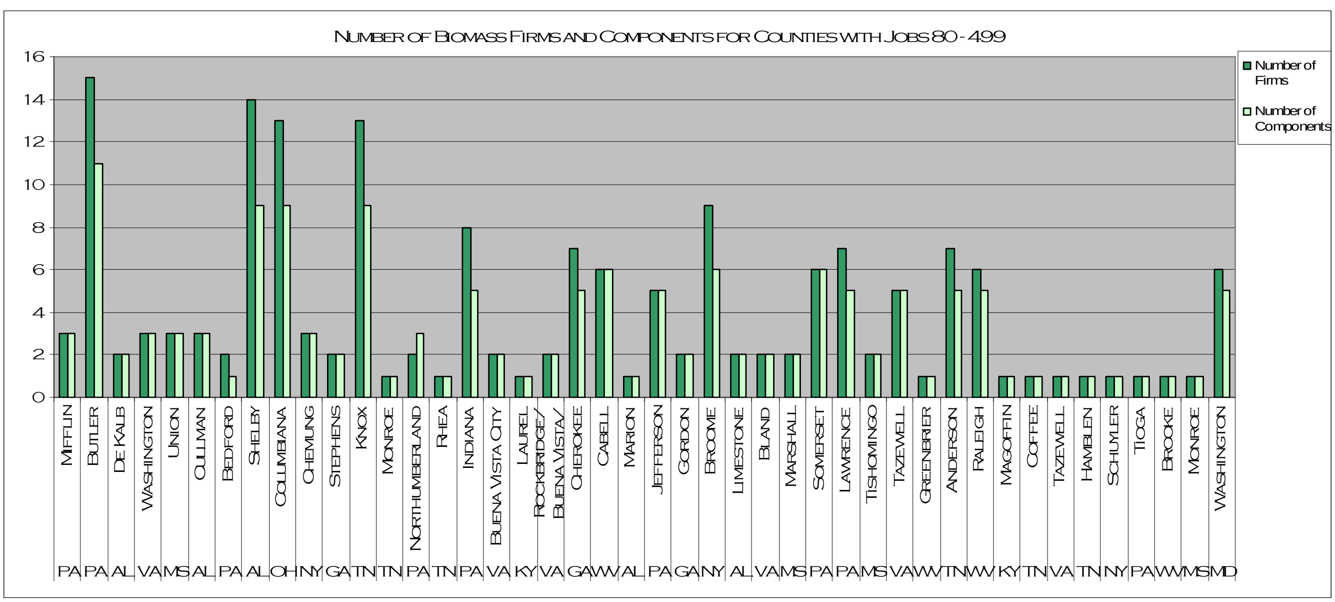


Figure B-6. The number of potential establishments and the number of different biomass components for counties with job totals between 80 and 499



County Level Solar Manufacturing Capacity

Counties with substantial solar presence were selected for either their total number of potential jobs in the solar sector, total number of establishments per county, the potential number of different types of components for the solar sector, or average firm size.

Table B-2. Counties are listed that meet at least one of the following criteria: job totals of 500 or greater, 10 or greater establishments, an average size of 125 employees or greater or five or more components for the industry are produced. Jobs that are relevant to other sectors are noted in parentheses in the first column, with each ARC county listed in decreasing order based upon the number of jobs within each respective county.

Sector	State	County	# of Estabs.	# of Jobs	# of Components	Socio-Economic Status	Population Class	Primary City(s)
Solar (Biomass)	AL	Morgan	2	444	2	Transitional	Metro	Decatur
Solar (Biomass Wind)	AL	Madison	13	292	5	Attainment	Metro	Huntsville
Solar (Biomass Wind)	AL	Marshall	2	274	2	Transitional	Rural/ Other	
Solar (Biomass Wind)	AL	Jefferson	10	183	4	Transitional	Metro	Birmingham, Hoover
Solar	GA	Gwinnett	18	336	7	Attainment	Metro	Atlanta-Sandy Springs-Marietta
Solar	GA	Habersham	1	170	1	Transitional	Micro	Cornelia
Solar	KY	Madison	2	749	2	Transitional	Micro	Richmond, Berea
Solar (Biomass)	KY	Laurel	1	320	1	At-Risk	Micro	London
Solar	KY	Russell	1	180	1	Distressed	Rural/ Other	
Solar (Biomass Wind)	MD	Washington	10	391	4	Competitive	Metro	Hagerstown, MD, Martinsburg, WV
Solar	MS	Alcorn	1	401	1	At-Risk	Micro	Corinth

Sector	State	County	# of Estabs.	# of Jobs	# of Components	Socio-Economic Status	Population Class	Primary City(s)
Solar (Biomass Wind)	NC	Watauga	31	1923	6	Transitional	Micro	Boone
Solar	NC	Forsyth	11	1319	4	Attainment	Metro	Winston-Salem
Solar	NC	Burke	2	1277	2	Transitional	Metro	Hickory, Lenoir, Morganton
Solar (Biomass)	NC	Buncombe	9	670	5	Competitive	Metro	Asheville
Solar	NY	Steuben	3	546	1	Transitional	Micro	Corning
Solar (Biomass Wind)	NY	Broome	12	279	6	Transitional	Metro	Binghamton
Solar	NY	Cattaraugus	1	279	1	Transitional	Micro	Boone
Solar	NY	Broome	10	191	5	Transitional	Micro	Olean
Solar	NY	Allegheny	1	176	1	Transitional	Rural/ Other	
Solar	OH	Washington	6	803	2	Transitional	Metro	Parkersburg, WV, Marietta, OH, Vienna, WV
Solar	OH	Muskingum	5	712	3	Transitional	Micro	Zanesville
Solar	OH	Hocking	1	150	1	Transitional	Rural/ Other	
Solar	OH	Clermont	6	144	5	Competitive	Metro	Cincinnati, Middletown
Solar (Biomass Wind)	PA	Allegheny	40	2612	8	Attainment	Metro	Pittsburg
Solar (Biomass)	PA	Westmoreland	19	1487	7	Competitive	Metro	Pittsburgh
Solar	PA	Luzerne	12	1152	4	Transitional	Metro	Scranton, Wilkes-Barre

Sector	State	County	# of Estabs.	# of Jobs	# of Components	Socio-Economic Status	Population Class	Primary City(s)
Solar (Biomass Wind)	PA	Erie	25	977	8	Transitional	Metro	Erie
Solar	PA	Schuylkill	7	702	3	Transitional	Metro	Pottsville
Solar (Biomass)	PA	Beaver	9	600	5	Transitional	Metro	Pittsburg
Solar (Biomass)	PA	Washington	8	488	3	Transitional	Metro	Pittsburgh
Solar	PA	Lackawanna	14	424	3	Transitional	Metro	Scranton, Wilkes-Barre
Solar	PA	Crawford	2	337	2	Transitional	Micro	Meadville
Solar	PA	Huntingdon	1	115	1	At-Risk	Micro	Huntington
Solar (Biomass)	SC	Greenville	15	1485	5	Competitive	Metro	Greenville
Solar (Biomass Wind)	SC	Spartanburg	10	1322	5	Transitional	Metro	Spartanburg
Solar	SC	Oconee	2	860	2	Transitional	Micro	Seneca
Solar	TN	Hawkins	2	723	2	Transitional	Metro	Kingsport, TN, Bristol, TN, Bristol, VA
Solar (Biomass)	TN	Hamilton	16	670	6	Competitive	Metro	Chattanooga
Solar (Biomass Wind)	TN	Knox	8	417	5	Transitional	Metro	Knoxville
Solar	TN	Sullivan	1	304	1	Transitional	Metro	Kingsport, TN, Bristol, TN, Bristol, VA
Solar	TN	Loudon	1	226	1	Transitional	Metro	Knoxville
Solar	TN	De Kalb	1	176	1	Transitional	Rural/ Other	

Sector	State	County	# of Estabs.	# of Jobs	# of Components	Socio-Economic Status	Population Class	Primary City(s)
Solar	TN	Cocke	1	167	1	At-Risk	Micro	Newport
Solar (Biomass)	TN	Bradley	1	154	1	Competitive	Metro	Cleveland
Solar (Biomass)	VA	Bristol City	2	295	1	Transitional	Metro	Kingsport, TN, Bristol, TN, Bristol, VA
Solar	VA	Covington City	1	164	1	Transitional	Rural/ Other	Covington City
Solar	WV	Wood	3	2710	2	Transitional	Metro	Parkersburg, WV, Marietta, OH, Vienna, WV
Solar (Biomass Wind)	WV	Cabell	6	308	5	Transitional	Metro	Huntington, WV, Ashland, KY
Solar	WV	Harrison	2	266	2	Transitional	Micro	Clarksburg
Solar	WV	Marion	1	224	1	Transitional	Micro	Fairmont
Solar	WV	Wayne	1	118	1	At-Risk	Metro	Huntington, WV, Ashland, KY

Figure B-7. Counties with potential solar job totals over 500.

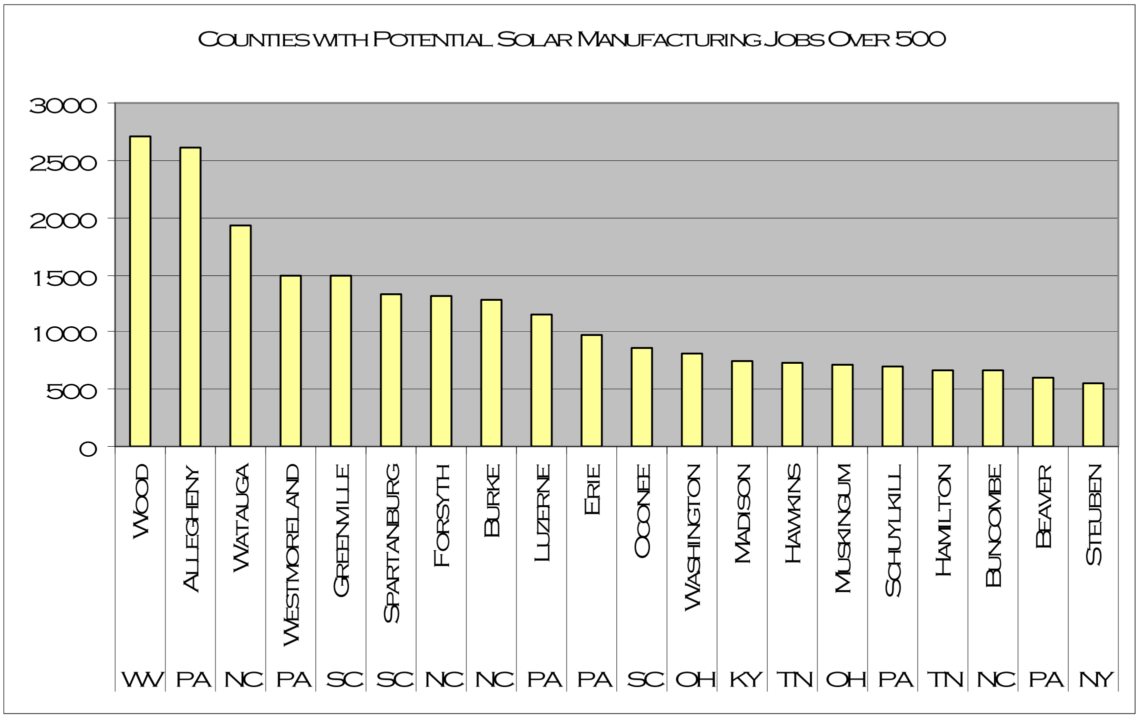


Figure B-8. The number of potential establishments and the number of different solar components for counties with job totals over 500.

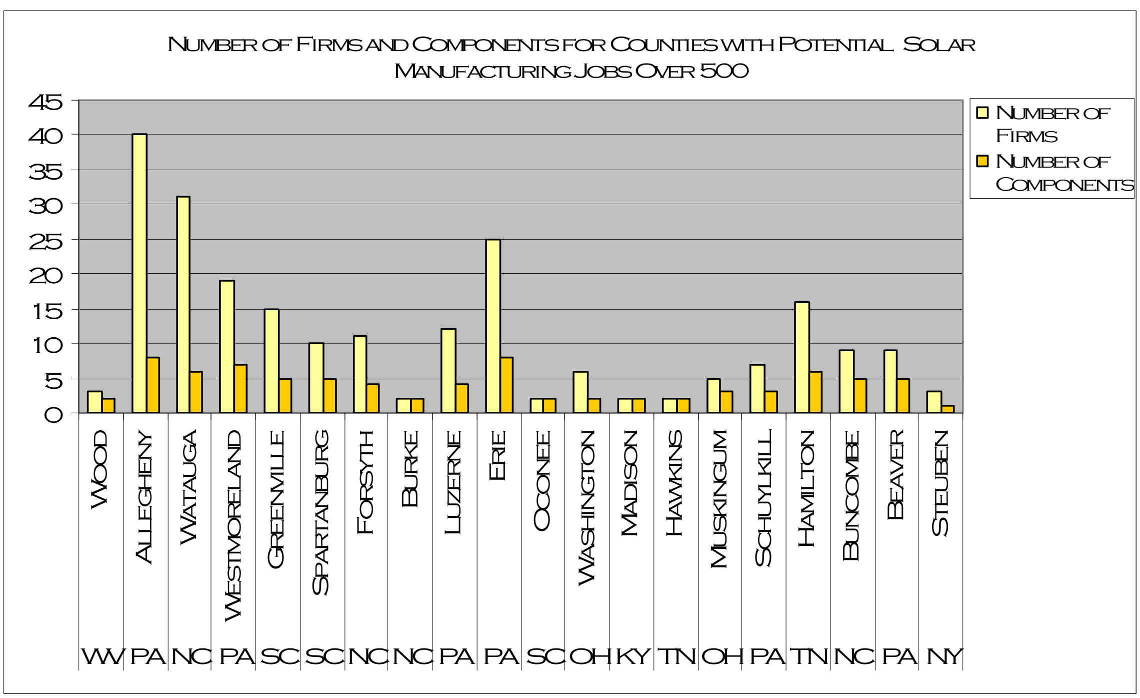


Figure B-9. Counties with potential solar job totals from 200 to 499.

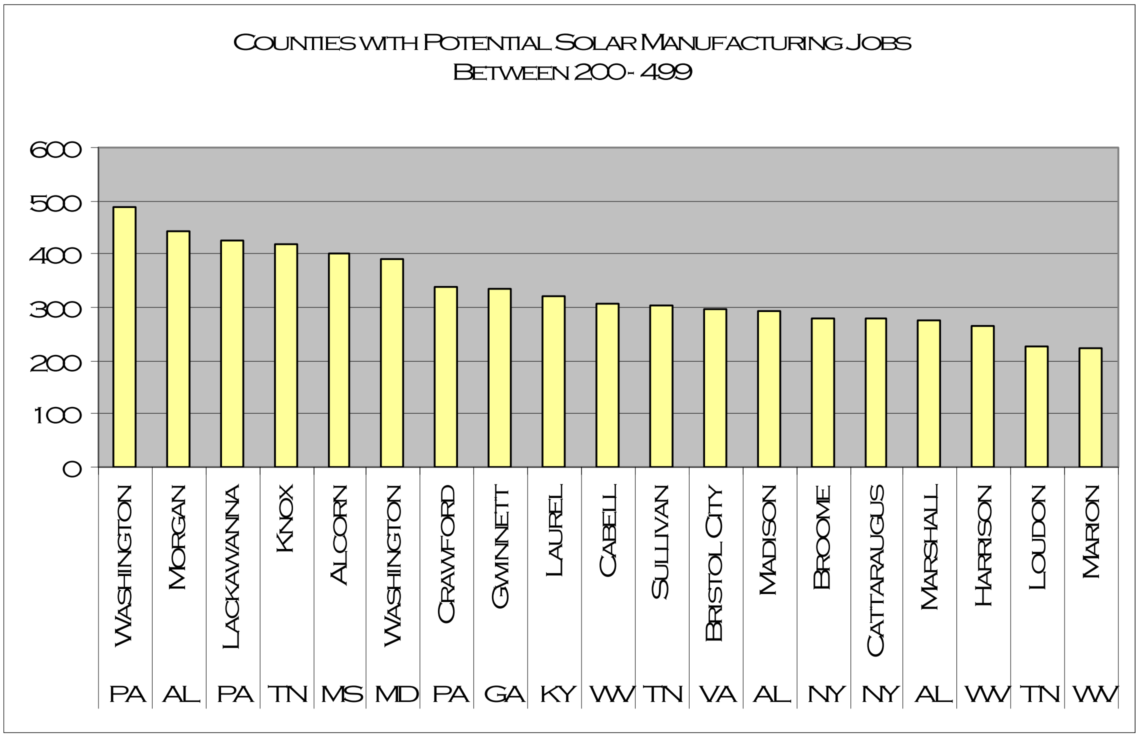


Figure B-10. The number of potential establishments and the number of different solar components for counties with job totals between 200 and 499.

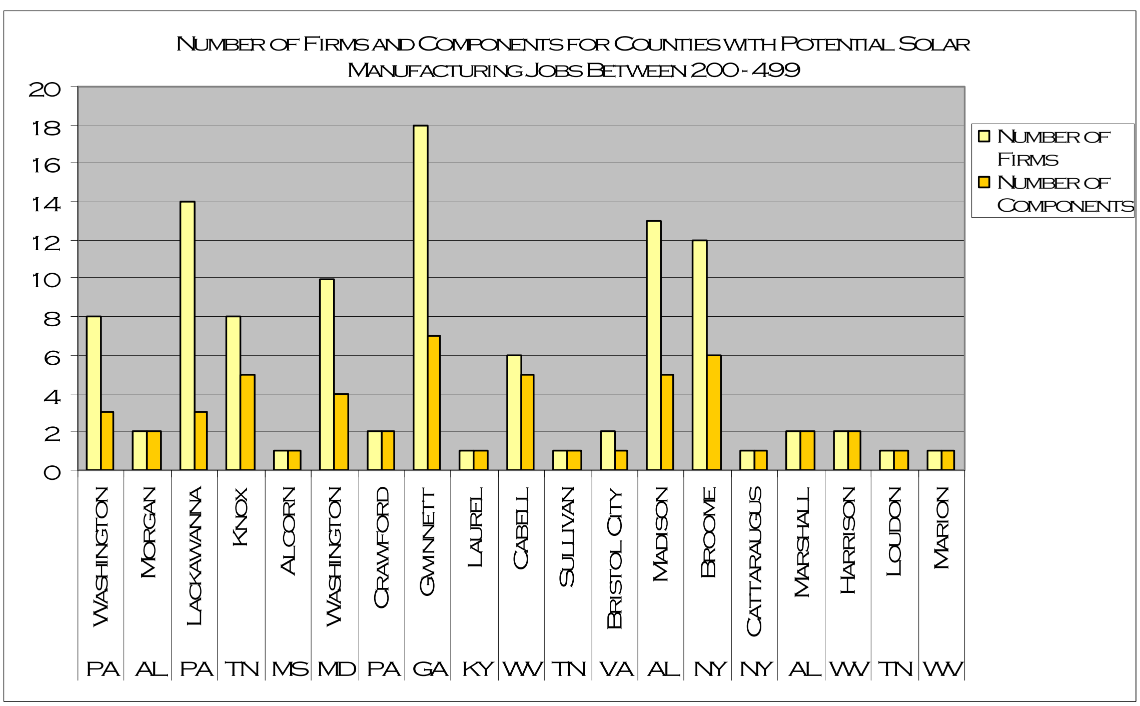


Figure B-11. Counties with potential solar job totals from 115 to 199.

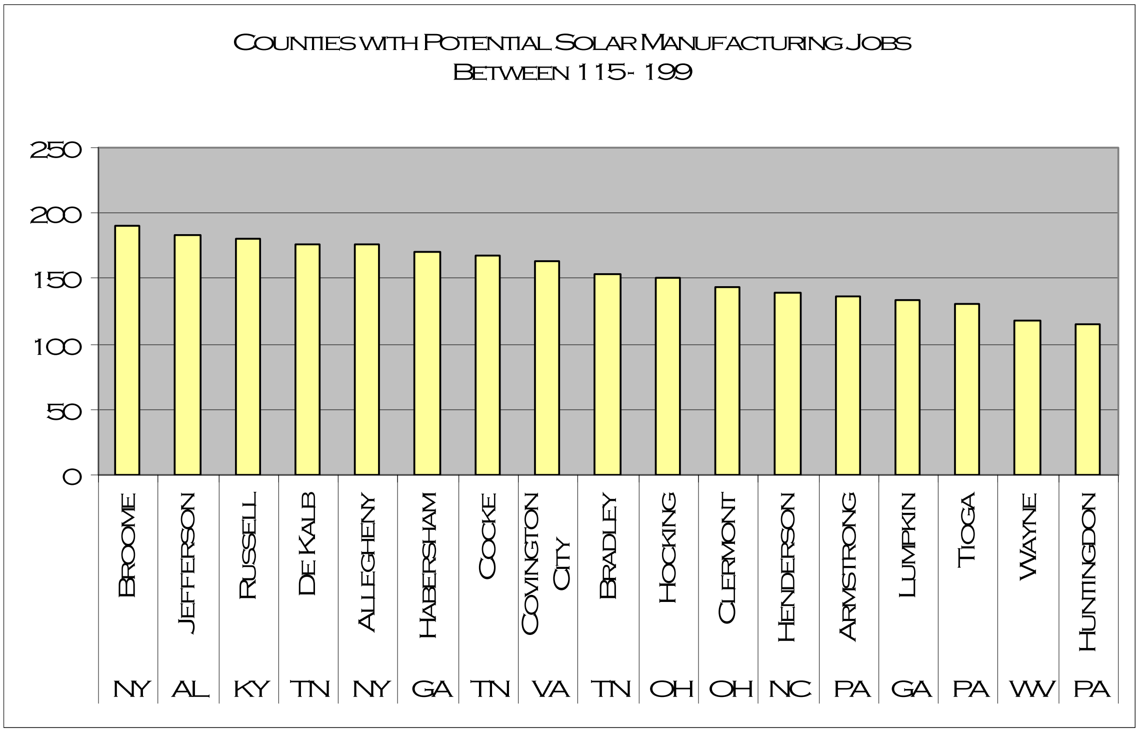
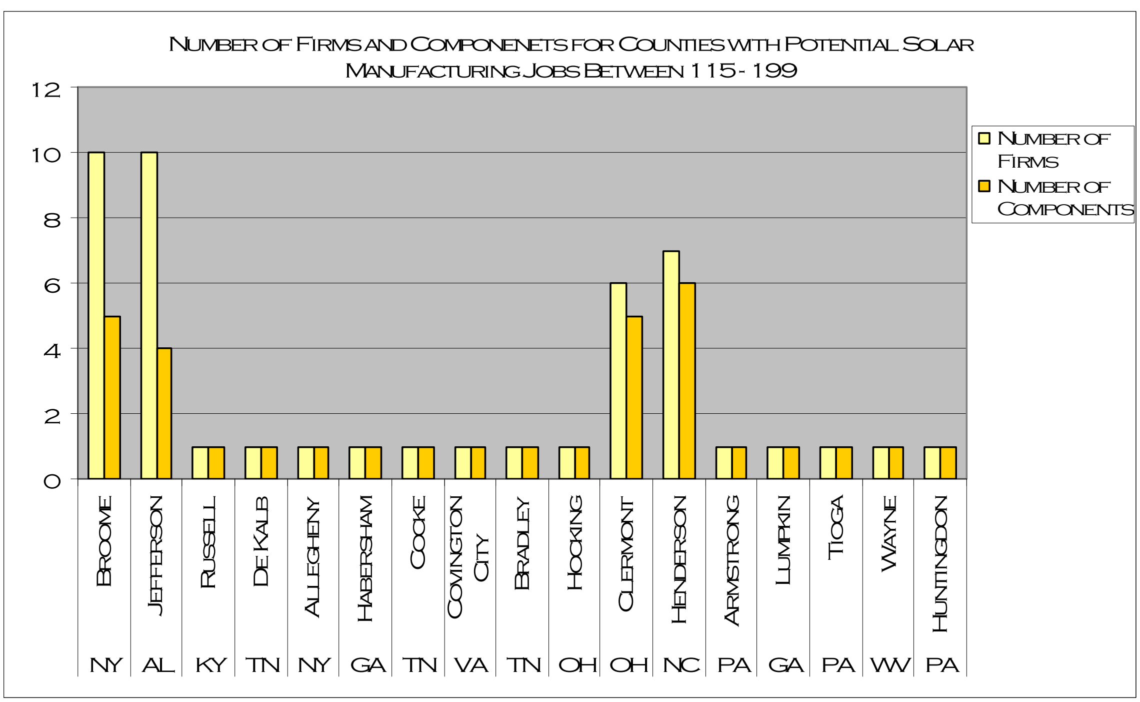


Figure B-12. The number of potential establishments and the number of different solar components for counties with job totals between 115 and 499.



County Level Wind Manufacturing Capacity

Counties with substantial wind manufacturing potential were selected for either total number of potential jobs in the solar sector, total number of establishments per county, the potential number of different types of components for the wind sector, or average firm size.

Table B-3. Counties are listed that meet at least one of the following criteria: job totals of 500 or greater, 10 or greater establishments, an average size of 125 employees or greater or five or more components for the industry are produced. Jobs that are relevant to other sectors are noted in parentheses in the first column, with each ARC county listed in decreasing order based upon the number of jobs within each respective county.

Sector	State	County	# of Estabs	# of Jobs	# of Components	Socio-Economic Status	Population Class	Primary City(s)
Wind (Biomass Solar)	AL	Madison	8	627	3	Attainment	Metro	Huntsville
Wind (Biomass Solar)	AL	De Kalb	2	453	2	Transitional	Micro	Fort Payne
Wind (Biomass Solar)	AL	Marshall	3	360	2	Transitional	Rural/ Other	
Wind	AL	Marion	1	300	1	At-Risk	Rural/ Other	
Wind (Biomass Solar)	GA	Gwinnett	36	1894	7	Attainment	Metro	Atlanta-Sandy Springs-Marietta
Wind	GA	Hall	12	1345	5	Transitional	Metro	Gainesville
Wind	GA	Douglas	5	760	2	Competitive		
Wind	GA	Bartow	8	664	3	Competitive	Metro	Atlanta-Sandy Springs-Marietta
Wind	GA	Lumpkin	2	261	2	Transitional	Rural/ Other	
Wind	KY	Jackson	5	1051	3	Distressed	Rural/ Other	

Sector	State	County	# of Estabs	# of Jobs	# of Components	Socio-Economic Status	Population Class	Primary City(s)
Wind	KY	Rowan	2	861	2	At-Risk	Rural/ Other	
Wind	KY	Clark	4	680	2	Transitional	Metro	Lexington-Fayette
Wind	KY	Rockcastle	1	383	1	At-Risk	Micro	Richmond, Berea
Wind (Biomass Solar)	MD	Washington	13	676	7	Competitive	Metro	Hagerstown, MD, Martinsburg, WV
Wind	MS	Lowndes	5	535	3	At-Risk	Micro	Columbus
Wind	MS	Prentiss	4	482	1	Transitional	Rural/ Other	
Wind	MS	Noxubee	1	188	1	Distressed	Rural/ Other	
Wind (Biomass Solar)	NC	Watauga	29	1483	7	Transitional	Micro	Boone
Wind	NC	Buncombe	18	1451	7	Competitive	Metro	Asheville
Wind	NC	Rutherford	11	1017	2	At-Risk	Micro	Forest City
Wind (Biomass)	NC	Forsyth	19	639	6	Attainment	Metro	Winston-Salem
Wind	NC	Caldwell	6	618	3	Transitional	Metro	Hickory, Lenoir, Morganton
Wind	NC	Burke	4	469	3	Transitional	Metro	Hickory, Lenoir, Morganton
Wind	NC	Cherokee	2	358	2	At-Risk	Rural/ Other	
Wind	NC	Haywood	1	166	1	Transitional	Metro	Asheville
Wind	NC	Jackson	1	128	1	Transitional	Rural/ Other	

Sector	State	County	# of Estabs	# of Jobs	# of Components	Socio-Economic Status	Population Class	Primary City(s)
Wind (Biomass Solar)	NY	Broome	18	1889	8	Transitional	Metro	Binghamton
Wind (Biomass Solar)	NY	Chautauqua	13	1153	6	Transitional	Micro	Jamestown, Dunkirk, Fredonia
Wind (Biomass)	NY	Allegheny	5	696	4	Transitional	Rural/ Other	
Wind	NY	Chemung	4	599	4	Transitional	Metro	Elmira
Wind	NY	Tompkins	2	307	2	Transitional	Metro	Ithaca
Wind	OH	Columbiana	13	837	4	Transitional	Micro	East Liverpool-Salem
Wind (Biomass Solar)	OH	Tuscarawas	15	812	5	Transitional	Micro	New Philadelphia, Dover
Wind	OH	Guernsey	5	710	1	Transitional	Micro	Cambridge
Wind	OH	Gallia	2	437	2	Transitional	Micro	Point Pleasant, WV
Wind	OH	Clermont	13	435	5	Competitive	Metro	Cincinnati, Middletown
Wind	OH	Scioto	3	348	2	At-Risk	Micro	Portsmouth
Wind	OH	Coshocton	2	329	2	Transitional	Micro	Coshocton
Wind (Biomass Solar)	PA	Erie	66	5374	8	Transitional	Metro	Erie
Wind	PA	Westmoreland	42	2012	6	Competitive	Metro	Pittsburgh
Wind (Biomass Solar)	PA	Allegheny	59	1809	9	Attainment	Metro	Pittsburgh
Wind	PA	Lycoming	17	1715	6	Transitional	Metro	Williamsport

Sector	State	County	# of Estabs	# of Jobs	# of Components	Socio-Economic Status	Population Class	Primary City(s)
Wind	PA	Beaver	12	1027	3	Transitional	Metro	Pittsburgh
Wind (Biomass Solar)	PA	Butler	23	970	7	Competitive	Metro	Pittsburgh
Wind (Biomass Solar)	PA	Tioga	5	891	4	Transitional	Rural/ Other	
Wind	PA	Mercer	15	844	5	Transitional	Metro	Youngstown , OH, Warren, OH, Boardman, OH
Wind	PA	Luzerne	10	812	3	Transitional	Metro	Scranton, Wilkes-Barre
Wind	PA	Crawford	15	678	4	Transitional	Micro	Meadville
Wind (Biomass)	PA	Indiana	7	578	4	Transitional	Micro	Indiana
Wind	PA	Mifflin	5	517	2	Transitional	Micro	Lewistown
Wind	PA	Lackawanna	10	513	2	Transitional	Metro	Scranton, Wilkes-Barre
Wind	PA	Snyder	4	483	1	Transitional	Micro	Selinsgrove
Wind	PA	Lawrence	10	420	3	Transitional	Micro	New Castle
Wind	PA	Washington	14	372	3	Transitional	Metro	Pittsburgh
Wind	PA	Bradford	1	340	1	Transitional	Micro	Sayre
Wind	PA	Union	2	330	2	Transitional	Micro	Lewisburg
Wind (Biomass Solar)	PA	Cambria	10	303	4	Transitional	Metro	Johnstown

Sector	State	County	# of Estabs	# of Jobs	# of Components	Socio-Economic Status	Population Class	Primary City(s)
Wind	PA	Clearfield	1	135	1	At-Risk	Micro	DuBois
Wind (Biomass)	SC	Greenville	23	4595	8	Competitive	Metro	Greenville
Wind	SC	Anderson	27	1865	4	Transitional	Metro	Anderson
Wind (Biomass Solar)	SC	Spartanburg	26	1484	7	Transitional	Metro	Spartanburg
Wind	SC	Cherokee	4	1219	3	At-Risk	Micro	Gaffney
Wind	SC	Oconee	5	636	3	Transitional	Micro	Gaffney
Wind (Biomass Solar)	TN	Knox	36	1570	8	Transitional	Metro	Knoxville
Wind	TN	Warren	6	915	3	Transitional	Rural/ Other	
Wind	TN	Unicoi	10	911	3	Transitional	Metro	Johnson City
Wind (Biomass Solar)	TN	Anderson	12	843	4	Transitional	Metro	Knoxville
Wind	TN	Hamilton	22	744	4	Competitive	Metro	Chattanooga
Wind (Biomass Solar)	TN	Blount	13	675	5	Transitional	Metro	Knoxville
Wind (Biomass Solar)	TN	Washington	3	657	3	Transitional	Metro	Johnson City
Wind	TN	Hawkins	4	632	3	Transitional	Metro	Kingsport, TN, Bristol, TN, Bristol, VA
Wind	TN	McMinn	3	415	2	Transitional	Micro	Athens
Wind	TN	Marion	2	379	2	Transitional	Metro	Chattanooga

Sector	State	County	# of Estabs	# of Jobs	# of Components	Socio-Economic Status	Population Class	Primary City(s)
Wind	TN	Rhea	2	377	1	Transitional	Rural/ Other	
Wind	TN	Overton	2	224	2	Transitional	Micro	Cookeville
Wind	TN	Macon	1	146	1	Transitional	Metro	Nashville-Davidson, Murfreesboro
Wind	TN	Hancock	1	128	1	Distressed	Rural/ Other	
Wind	VA	Russell	1	736	1	Transitional	Rural/ Other	
Wind	VA	Smyth	1	708	1	At-Risk	Rural/ Other	
Wind	VA	Bristol City	2	362	2	Transitional	Metro	Kingsport, TN, Bristol, TN, Bristol, VA
Wind	VA	Covington City	1	359	1	Transitional	Rural/ Other	Covington City
Wind	VA	Pulaski	2	295	1	Transitional	Metro	Blacksburg, Christiansburg, Radford
Wind	WV	Ritchie	3	1177	1	Distressed	Rural/ Other	
Wind	WV	Boone	2	385	1	At-Risk	Metro	Charleston
Wind	WV	Jackson	1	312	1	Transitional	Rural/ Other	
Wind	WV	Kanawha	10	204	2	Transitional	Metro	Charleston

Figure B13. Counties with potential wind job totals over 1,000.

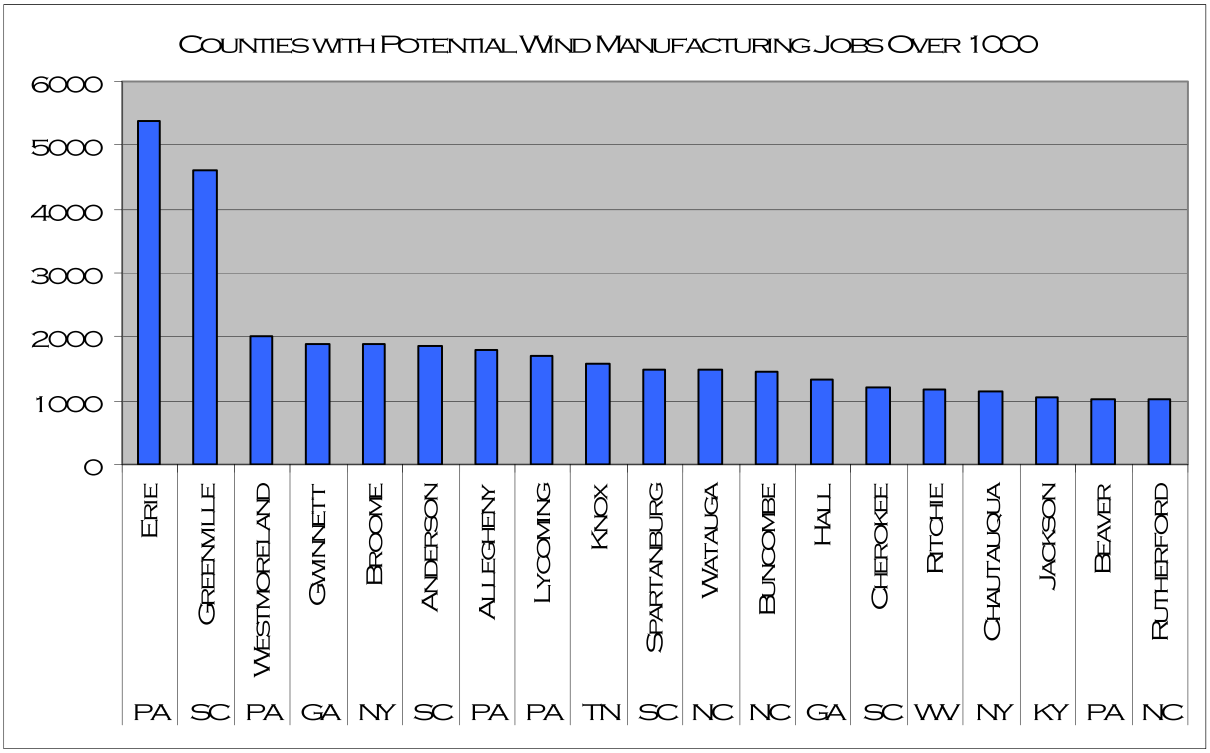
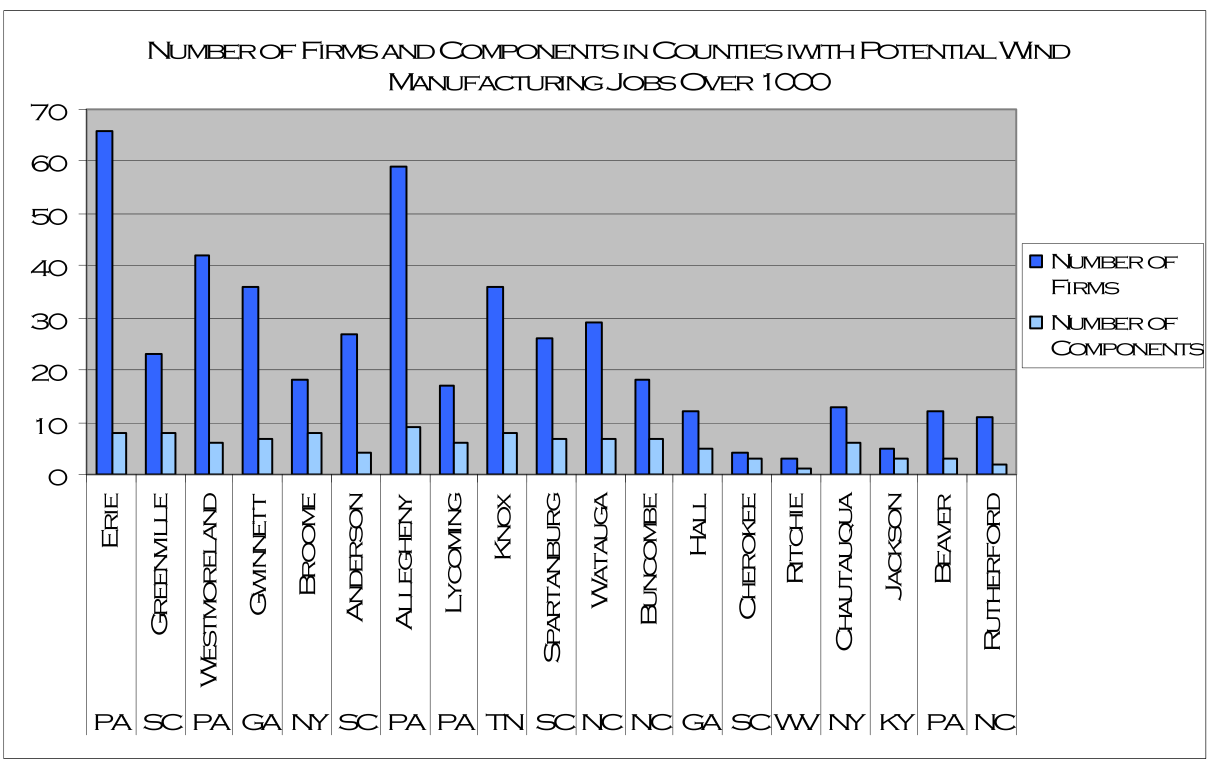


Figure B-14. The number of potential establishments and the number of different wind components for counties with job totals over 1,000.



Appendix C - State Manufacturing Potential Totals

ALABAMA

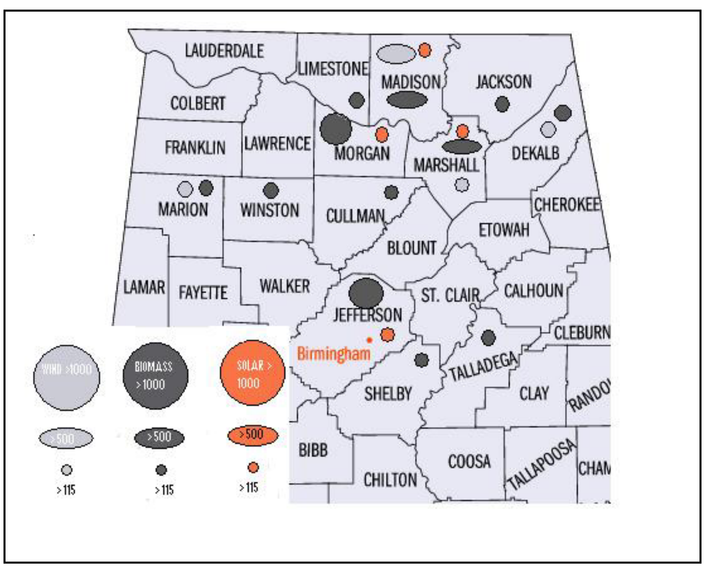
Table C-1. Counties in Alabama with concentrated employment totals over 100

Sector	County	# of Estabs	# of Jobs	# of Comps.	Socio-Economic Status	Pop. Class	Primary City
Biomass	Jefferson	25	1280	12	Transitional	Metro	Birmingham Hoover
Biomass (Solar)	Morgan	4	1266	3	Transitional	Metro	Decatur
Biomass	Marshall	3	699	3	Transitional	Micro	Albertville
Wind (Biomass Solar)	Madison	8	627	3	Attainment	Metro	Huntsville
Biomass (Solar Wind)	Madison	10	529	9	Attainment	Metro	Huntsville
Biomass (Solar Wind)	De Kalb	2	453	2	Transitional	Micro	Fort Payne
Wind (Biomass Solar)	De Kalb	2	453	2	Transitional	Micro	Fort Payne
Solar (Biomass)	Morgan	2	444	2	Transitional	Metro	Decatur
Biomass	Cullman	3	415	3	Transitional	Micro	Cullman
Biomass (Solar Wind)	Shelby	14	393	9	Attainment	Metro	Birmingham, Hoover
Wind (Biomass Solar)	Marshall	3	360	2	Transitional	Micro	Albertville
Biomass	Marion	1	310	1	At-Risk	Rural/ Other	
Wind	Marion	1	300	1	At-Risk	Rural/ Other	
Solar (Biomass Wind)	Madison	13	292	5	Attainment	Metro	Huntsville

Sector	County	# of Estabs	# of Jobs	# of Comps.	Socio-Economic Status	Pop. Class	Primary City
Biomass	Limestone	2	286	2	Transitional	Metro	Huntsville
Solar (Biomass Wind)	Marshall	2	274	2	Transitional	Micro	Albertville
Biomass	Jackson	5	263	4	At-Risk	Micro	Scottsboro
Solar (Biomass Wind)	Jefferson	10	183	4	Transitional	Metro	Birmingham, Hoover
Biomass	Talladega	4	122	3	At-Risk	Micro	Talladega, Sylacuaga
Biomass	Winston	3	111	3	At-Risk	Rural/ Other	

Figure C-1. Locations of manufacturing facilities by resource type.

Large circles indicate total employment greater than 1000, ellipses indicate employment over 500, and small circles indicate employment over 100. Orange indicates solar manufacturing, dark gray indicates biomass, and light gray indicates wind.



GEORGIA

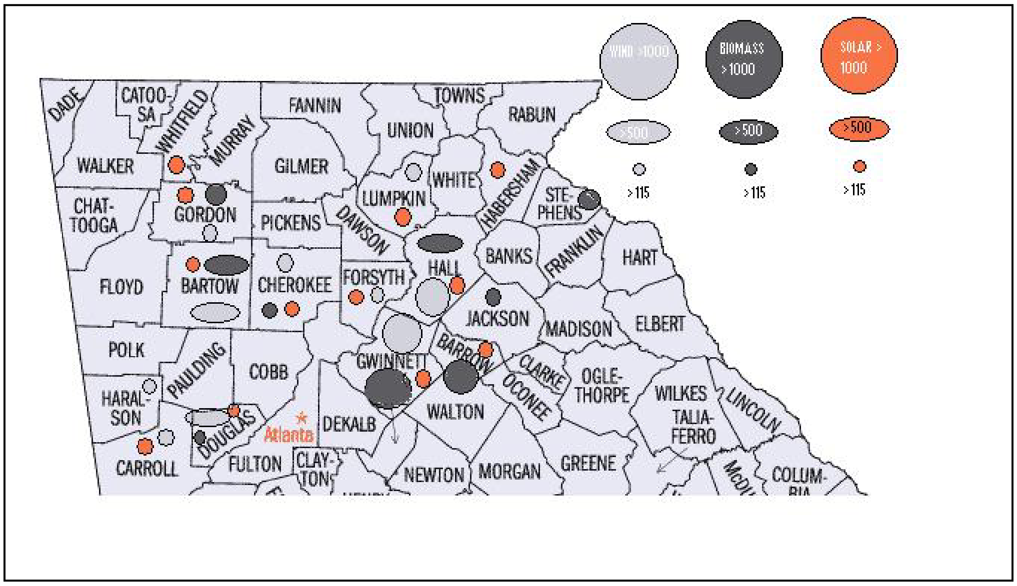
Table C-2. Counties in Georgia with concentrated employment totals over 100.

Sector	County	# of Estabs	# of Jobs	# of Comps.	Socio-Economic Status	Pop. Class	Primary City
Wind (Biomass Solar)	Gwinnett	36	1894	7	Attainment	Metro	Atlanta Sandy Springs Marietta
Wind	Hall	12	1345	5	Transitional	Metro	Gainesville
Biomass (Solar Wind)	Gwinnett	25	1342	11	Attainment	Metro	Atlanta Sandy Springs Marietta
Biomass	Barrow	3	1158	2	Transitional	Metro	Atlanta Sandy Springs Marietta
Biomass	Bartow	3	883	3	Competitive	Metro	Atlanta Sandy Springs Marietta
Wind	Douglas	5	760	2	Competitive	Metro	Atlanta Sandy Springs Marietta
Biomass (Solar)	Hall	4	697	4	Transitional	Metro	Gainesville
Wind	Bartow	8	664	3	Competitive	Metro	Atlanta Sandy Springs Marietta
Wind	Cherokee	8	386	2	Attainment	Metro	Atlanta Sandy Springs Marietta
Wind	Forsyth	7	363	3	Attainment	Metro	Atlanta Sandy Springs Marietta
Biomass	Stephens	2	363	2	Transitional	Micro	Toccoa
Solar	Gwinnett	18	336	7	Attainment	Metro	Atlanta Sandy Springs Marietta
Biomass (Solar Wind)	Cherokee	7	319	5	Attainment	Metro	Atlanta Sandy Springs Marietta
Biomass	Gordon	2	304	2	Transitional	Micro	Calhoun
Solar	Douglas	5	267	2	Competitive	Metro	Atlanta Sandy Springs Marietta

Sector	County	# of Estabs	# of Jobs	# of Comps.	Socio-Economic Status	Pop. Class	Primary City
Wind	Lumpkin	2	261	2	Transitional	Rural/ Other	
Biomass	Douglas	5	247	3	Competitive	Metro	Atlanta Sandy Springs Marietta
Solar (Biomass)	Forsyth	5	225	3	Attainment	Metro	Atlanta Sandy Springs Marietta
Solar	Whitfield	3	224	3	Competitive	Metro	Dalton
Biomass (Solar)	Jackson	4	201	4	Transitional	Rural/ Other	
Solar	Bartow	4	200	3	Competitive	Metro	Atlanta Sandy Springs Marietta
Wind	Haralson	3	176	1	Transitional	Metro	Atlanta Sandy Springs Marietta
Solar	Habersham	1	170	1	Transitional	Micro	Cornelia
Solar (Biomass)	Hall	7	168	3	Transitional	Metro	Gainesville
Solar	Gordon	3	144	2	Transitional	Micro	Calhoun
Solar	Lumpkin	1	134	1	Transitional	Rural/ Other	
Wind	Carroll	5	127	3	Transitional	Metro	Atlanta Sandy Springs Marietta
Wind	Gordon	3	119	1	Transitional	Micro	Calhoun
Solar	Carroll	3	118	3	Transitional	Metro	Atlanta Sandy Springs Marietta
Solar	Barrow	5	114	1	Transitional	Metro	Atlanta Sandy Springs Marietta
Solar (Biomass Wind)	Cherokee	3	101	3	Attainment	Metro	Atlanta Sandy Springs Marietta

Figure C-2. Locations of manufacturing facilities in Georgia by resource type.

Large circles indicate total employment greater than 1000, ellipses indicate employment over 500, and small circles indicate employment over 100. Orange indicates solar manufacturing, dark gray indicates biomass, and light gray indicates wind.



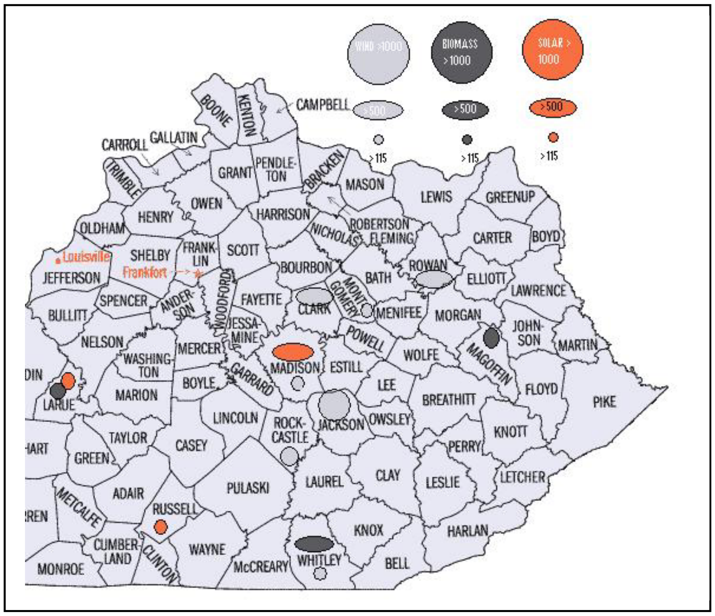
KENTUCKY

Table C-3. Counties in Kentucky with concentrated employment totals over 100.

Sector	County	# of Estabs	# of Jobs	# of Comps.	Socio-Economic Status	Pop. Class	Primary City
Wind	Jackson	5	1051	3	Distressed	Rural/ Other	
Wind	Rowan	2	861	2	At-Risk	Rural/ Other	
Solar	Madison	2	749	2	Transitional	Micro	Richmond Berea
Wind	Clark	4	680	2	Transitional	Metro	Lexington Fayette
Biomass	Whitley	1	520	1	Distressed	Micro	Corbin
Wind	Montgomery	4	456	2	Transitional	Micro	Mount Sterling
Wind	Rockcastle	1	383	1	At-Risk	Micro	Richmond Berea
Wind	Madison	3	344	3	Transitional	Micro	Richmond Berea
Biomass (Solar)	Laurel	1	320	1	At-Risk	Micro	London
Solar (Biomass)	Laurel	1	320	1	At-Risk	Micro	London
Wind	Whitley	3	294	1	Distressed	Micro	Corbin
Biomass	Madison	3	241	3	Transitional	Micro	Richmond Berea
Solar	Russell	1	180	1	Distressed	Rural/ Other	
Biomass	Magoffin	1	170	1	Distressed	Rural/ Other	

Figure C-3. Locations of manufacturing facilities in Kentucky by resource type.

Large circles indicate total employment greater than 1000, ellipses indicate employment over 500, and small circles indicate employment over 100. Orange indicates solar manufacturing, dark gray indicates biomass, and light gray indicates wind.



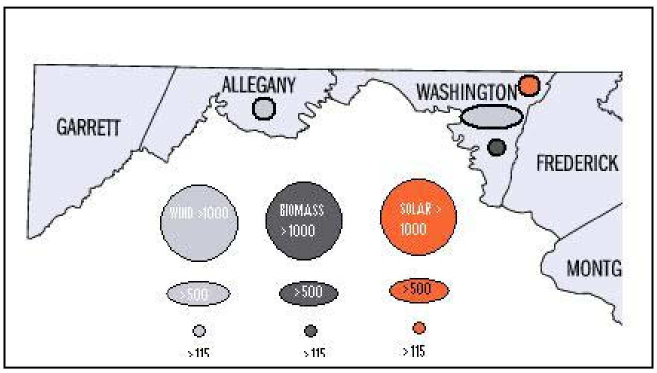
MARYLAND

Table C-4. Counties in Maryland with concentrated employment totals over 100.

Sector	County	# of Estabs	# of Jobs	# of Comps	Socio-Economic Status	Pop. Class	Primary City
Wind (Biomass Solar)	Washington	13	676	7	Competitive	Metro	Hagerstown, MD, Martinsburg, WV
Solar (Biomass Wind)	Washington	10	391	4	Competitive	Metro	Hagerstown, MD, Martinsburg, WV
Wind	Allegany	2	173	1	Transitional	Metro	Cumberland
Biomass (Solar Wind)	Washington	6	88	5	Competitive	Metro	Hagerstown, MD, Martinsburg, WV

Figure C-4. Locations of manufacturing facilities in Maryland by resource type.

Large circles indicate total employment greater than 1000, ellipses indicate employment over 500, and small circles indicate employment over 100. Orange indicates solar manufacturing, dark gray indicates biomass, and light gray indicates wind.



MISSISSIPPI

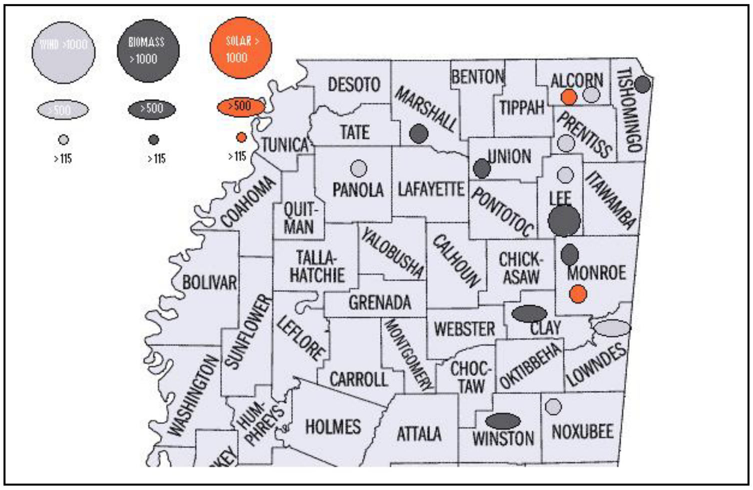
Table C-5. Counties in Mississippi with concentrated employment totals over 100.

Sector	County	# of Estabs	# of Jobs	# of Components	Socio-Economic Status	Pop. Class	Primary City
Biomass	Lee	3	1160	2	Transitional	Micro	Tupelo
Biomass	Clay	1	577	1	Distressed	Micro	West Point
Wind	Lowndes	5	535	3	At-Risk	Micro	Columbus
Biomass	Winston	1	511	1	Distressed	Rural/ Other	
Wind	Prentiss	4	482	1	Transitional	Rural/ Other	
Biomass	Union	3	436	3	Transitional	Rural/ Other	
Solar	Alcorn	1	401	1	At-Risk	Micro	Corinth
Wind	Alcorn	4	327	3	At-Risk	Micro	Corinth
Solar	Monroe	3	318	1	At-Risk	Rural/ Other	
Biomass	Marshall	2	255	2	Distressed	Metro	Memphis, TN
Biomass	Tishomingo	2	232	2	At-Risk	Rural/ Other	
Wind	Noxubee	1	188	1	Distressed	Rural/ Other	
Biomass	Monroe	1	126	1	At-Risk	Rural/ Other	
Wind	Panola	4	118	2	Distressed	Rural/ Other	
(Biomass Solar Wind)	Kemper	2	112	1	Distressed	Micro	Meridian

Sector	County	# of Estabs	# of Jobs	# of Components	Socio-Economic Status	Pop. Class	Primary City
Wind	Lee	2	101	2	Transitional	Micro	Tupelo

Figure C-5. Locations of manufacturing facilities in Mississippi by resource type.

Large circles indicate total employment greater than 1000, ellipses indicate employment over 500, and small circles indicate employment over 100. Orange indicates solar manufacturing, dark gray indicates biomass, and light gray indicates wind.



NORTH CAROLINA

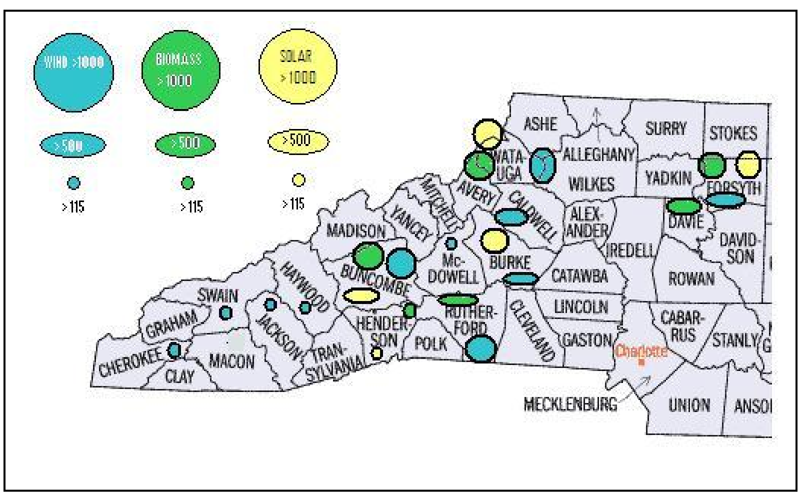
Table C-6. Counties in North Carolina with concentrated employment totals over 100.

Sector	County	# of Estabs	# of Jobs	# of Components	Socio-Economic Status	Pop. Class	Primary City
Solar (Biomass Wind)	Watauga	31	1923	6	Transitional	Micro	Boone
Biomass (Solar)	Buncombe	13	1632	9	Competitive	Metro	Asheville
Wind (Biomass Solar)	Watauga	29	1483	7	Transitional	Micro	Boone
Wind	Buncombe	18	1451	7	Competitive	Metro	Asheville
Biomass (Wind)	Forsyth	12	1322	9	Attainment	Metro	Winston-Salem
Solar	Forsyth	11	1319	4	Attainment	Metro	Winston-Salem
Solar	Burke	2	1277	2	Transitional	Metro	Hickory Lenoir Morganton
Biomass (Solar Wind)	Watauga	16	1052	9	Transitional	Micro	Boone
Wind	Rutherford	11	1017	2	At-Risk	Micro	Forest City
Solar (Biomass)	Buncombe	9	670	5	Competitive	Metro	Asheville
Wind (Biomass)	Forsyth	19	639	6	Attainment	Metro	Winston-Salem
Wind	Caldwell	6	618	3	Transitional	Metro	Hickory Lenoir Morganton
Biomass	Davie	1	578	1	Competitive	Metro	Winston-Salem
Biomass	Rutherford	2	504	2	At-Risk	Micro	Forest City
Wind	Burke	4	469	3	Transitional	Metro	Hickory Lenoir Morganton

Sector	County	# of Estabs	# of Jobs	# of Components	Socio-Economic Status	Pop. Class	Primary City
Wind	Cherokee	2	358	2	At-Risk	Rural/ Other	
Biomass (Solar Wind)	Henderson	4	217	3	Competitive	Metro	Asheville
Wind	Swain	2	169	1	At-Risk	Rural/ Other	
Wind	Haywood	1	166	1	Transitional	Metro	Asheville
Solar (Biomass Wind)	Henderson	7	139	6	Competitive	Metro	Asheville
Wind	Jackson	1	128	1	Transitional	Rural/ Other	
Wind	McDowell	3	108	3	At-Risk	Rural/ Other	

Figure C-6. Locations of manufacturing facilities in North Carolina by resource type.

Large circles indicate total employment greater than 1000, ellipses indicate employment over 500, and small circles indicate employment over 100. Yellow indicates solar manufacturing, green indicates biomass, and blue indicates wind.



NEW YORK

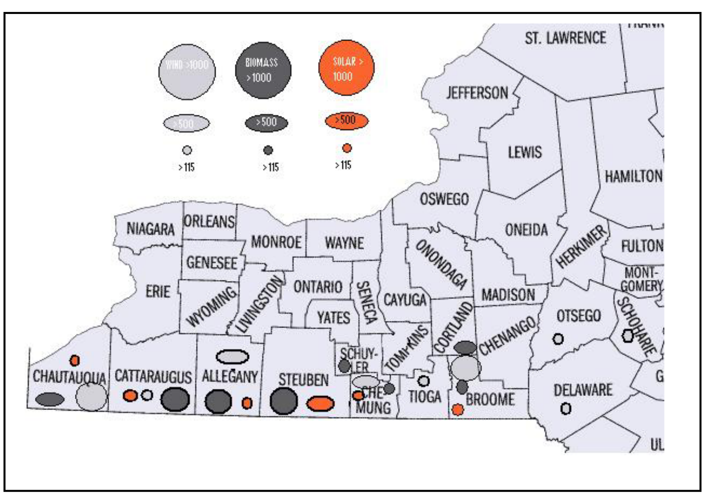
Table C-7. Counties in New York with concentrated employment totals over 100.

Sector	County	# of Estabs	# of Jobs	# of Components	Socio-Economic Status	Pop. Class	Primary City
Biomass	Steuben	8	1905	5	Transitional	Micro	Corning
Wind (Biomass Solar)	Broome	18	1889	8	Transitional	Metro	Binghamton
Biomass (Wind)	Allegany	2	1253	2	Transitional	Rural/ Other	
Wind (Biomass Solar)	Chautauqua	13	1153	6	Transitional	Micro	Jamestown Dunkirk Fredonia
Biomass	Cattaraugus	4	1119	3	Transitional	Micro	Olean
Biomass	Cortland	2	713	2	Transitional	Micro	Cortland
Wind (Biomass)	Allegany	5	696	4	Transitional	Rural/ Other	
Wind	Chemung	4	599	4	Transitional	Metro	Elmira
Solar	Steuben	3	546	1	Transitional	Micro	Corning
Biomass (Solar Wind)	Chautauqua	4	530	4	Transitional	Micro	Jamestown Dunkirk Fredonia
Biomass	Chemung	3	373	3	Transitional	Metro	Elmira
Wind (Biomass Solar)	Ostego	7	315	4	Transitional	Micro	Oneonta
Wind	Tompkins	2	307	2	Transitional	Metro	Ithaca
Biomass (Solar Wind)	Broome	9	296	6	Transitional	Metro	Binghamton
Solar (Biomass Wind)	Broome	12	279	6	Transitional	Metro	Binghamton

Sector	County	# of Estabs	# of Jobs	# of Components	Socio-Economic Status	Pop. Class	Primary City
Solar	Cattaraugus	1	279	1	Transitional	Micro	Olean
Solar	Allegany	1	176	1	Transitional	Rural/ Other	
Solar (Biomass Wind)	Chautauqua	3	146	2	Transitional	Micro	Jamestown Dunkirk Fredonia
Biomass	Schuyler	1	145	1	Transitional	Rural/ Other	
Wind	Schoharie	3	129	2	Transitional	Rural/ Other	
Wind	Delaware	3	128	3	Transitional	Rural/ Other	
Wind	Tioga	4	123	3	Transitional	Metro	Binghamton
Solar	Chemung	3	113	2	Transitional	Metro	Elmira
Wind	Cattaraugus	4	111	3	Transitional	Micro	Olean

Figure C-7. Locations of manufacturing facilities in New York by resource type.

Large circles indicate total employment greater than 1000, ellipses indicate employment over 500, and small circles indicate employment over 100. Orange indicates solar manufacturing, dark gray indicates biomass, and light gray indicates wind.



OHIO

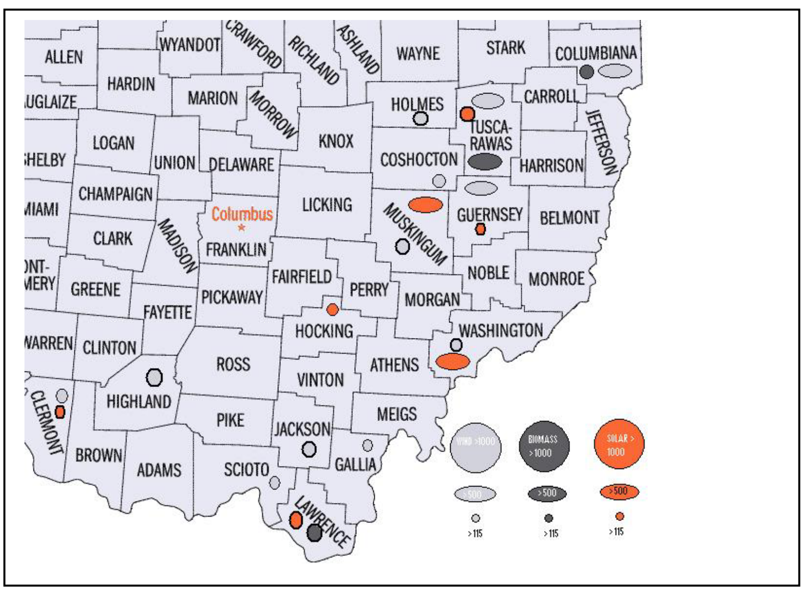
Table C-8. Counties in Ohio with concentrated employment totals over 100.

Sector	County	# of Estabs	# of Jobs	# of Components	Socio-Economic Status	Pop. Class	Primary City
Biomass (Solar Wind)	Tuscarawas	9	861	7	Transitional	Micro	New Philadelphia Dover
Wind	Columbiana	13	837	4	Transitional	Micro	East Liverpool-Salem
Wind (Biomass Solar)	Tuscarawas	15	812	5	Transitional	Micro	New Philadelphia Dover
Solar	Washington	6	803	2	Transitional	Metro	Parkersburg, WV Marietta, OH, Vienna, WV
Solar	Muskingum	5	712	3	Transitional	Micro	Zanesville
Wind	Guernsey	5	710	1	Transitional	Micro	Cambridge
Wind	Gallia	2	437	2	Transitional	Micro	Point Pleasant, WV
Wind	Clermont	13	435	5	Competitive	Metro	Cincinnati Middletown
Wind	Highland	4	429	2	Transitional	Rural/ Other	
Biomass	Columbiana	13	392	9	Transitional	Micro	East Liverpool Salem
Wind	Scioto	3	348	2	At-Risk	Micro	Portsmouth
Wind	Muskingum	4	331	3	Transitional	Micro	Zanesville
Wind	Coshocton	2	329	2	Transitional	Micro	Coshocton
Solar (Biomass Wind)	Tuscarawas	5	328	4	Transitional	Micro	New Philadelphia Dover
Biomass	Lawrence	5	317	4	At-Risk	Metro	Huntington, WV Ashland, KY

Sector	County	# of Estabs	# of Jobs	# of Components	Socio-Economic Status	Pop. Class	Primary City
Wind	Jackson	4	244	3	At-Risk	Rural/ Other	
Wind	Washington	7	176	3	Transitional	Metro	Parkersburg, WV Marietta, OH, Vienna, WV
Solar	Guernsey	4	150	3	Transitional	Micro	Cambridge
Solar	Hocking	1	150	1	Transitional	Rural/ Other	
Solar	Clermont	6	144	5	Competitive	Metro	Cincinnati, Middletown
Wind	Holmes	7	127	2	Transitional	Rural/ Other	
Solar	Lawrence	2	107	2	At-Risk	Metro	Huntington, WV Ashland, KY

Figure 8. Locations of manufacturing facilities in Ohio by resource type.

Large circles indicate total employment greater than 1000, ellipses indicate employment over 500, and small circles indicate employment over 100. Orange indicates solar manufacturing, dark gray indicates biomass, and light gray indicates wind.



PENNSYLVANIA

Table C-9. Counties in Pennsylvania with concentrated employment totals over 100.

Sector	County	# of Estabs	# of Jobs	# of Components	Socio-Economic Status	Pop. Class	Primary City
Biomass (Solar Wind)	Erie	40	6835	15	Transitional	Metro	Erie
Biomass (Solar Wind)	Allegheny	63	6202	15	Attainment	Metro	Pittsburgh
Solar (Biomass Wind)	Allegheny	40	2612	8	Attainment	Metro	Pittsburgh
Biomass (Solar)	Westmoreland	27	2265	13	Competitive	Metro	Pittsburgh
Biomass	Fulton	2	1889	2	Transitional	Rural/ Other	
Wind	Lycoming	17	1715	6	Transitional	Metro	Williamsport
Solar (Biomass)	Westmoreland	19	1487	7	Competitive	Metro	Pittsburgh
Biomass Solar)	Washington	15	1385	6	Transitional	Metro	Pittsburgh
Biomass	Luzerne	18	1163	9	Transitional	Metro	Scranton Wilkes-Barre
Solar	Luzerne	12	1152	4	Transitional	Metro	Scranton Wilkes-Barre
Wind	Beaver	12	1027	3	Transitional	Metro	Pittsburgh
Solar (Biomass Wind)	Erie	25	977	8	Transitional	Metro	Erie
Wind	Mercer	15	844	5	Transitional	Metro	Youngstown, OH, Warren, OH, Boardman, OH
Wind	Luzerne	10	812	3	Transitional	Metro	Scranton Wilkes-Barre
Biomass (Solar)	Beaver	7	783	6	Transitional	Metro	Pittsburgh

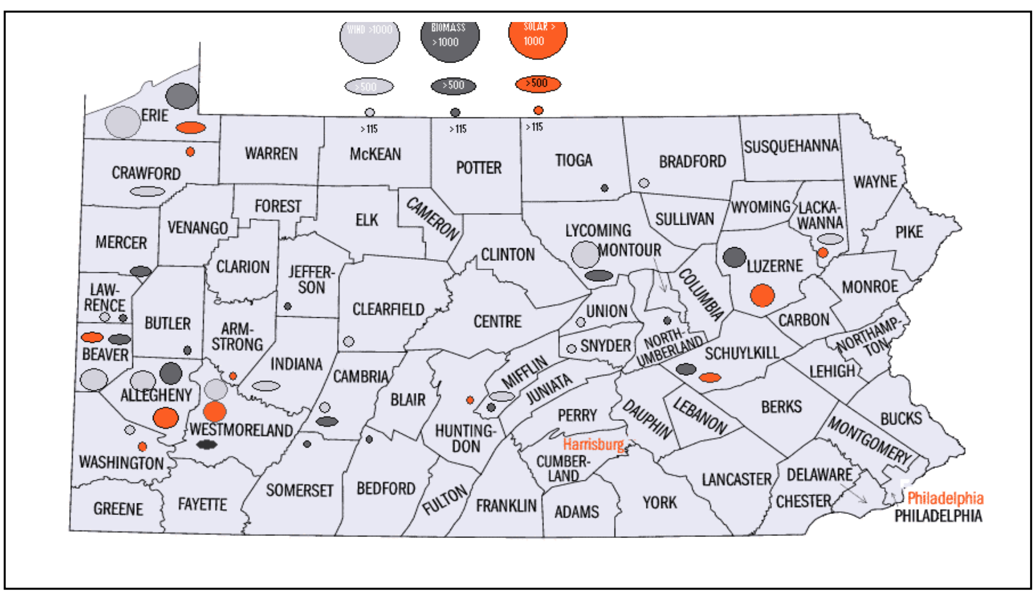
Sector	County	# of Estabs	# of Jobs	# of Components	Socio-Economic Status	Pop. Class	Primary City
Solar	Schuylkill	7	702	3	Transitional	Micro	Pottsville
Wind	Crawford	15	678	4	Transitional	Micro	Meadville
Biomass (Solar Wind)	Cambria	8	645	4	Transitional	Metro	Johnstown
Biomass	Mercer	11	608	7	Transitional	Metro	Youngstown, OH, Warren, OH, Boardman, OH
Solar (Biomass)	Beaver	9	600	5	Transitional	Metro	Pittsburgh
Biomass	Schuylkill	6	516	4	Transitional	Micro	Pottsville
Wind	Lackawanna	10	513	2	Transitional	Metro	Scranton Wilkes-Barre
Biomass	Lycoming	7	503	6	Transitional	Metro	Williamsport
Solar (Biomass)	Washington	8	488	3	Transitional	Metro	Pittsburgh
Biomass	Centre	7	474	4	Transitional	Metro	State College
Biomass	Mifflin	3	471	3	Transitional	Micro	Lewistown
Biomass (Solar Wind)	Butler	15	470	11	Competitive	Metro	Pittsburgh
Wind	Jefferson	7	470	4	Transitional	Rural/ Other	
Wind	Bedford	4	454	2	Transitional	Rural/ Other	
Solar	Lackawanna	14	424	3	Transitional	Metro	Scranton Wilkes-Barre
Wind	Lawrence	10	420	3	Transitional	Micro	New Castle

Sector	County	# of Estabs	# of Jobs	# of Components	Socio-Economic Status	Pop. Class	Primary City
Biomass	Bedford	2	402	1	Transitional	Rural/ Other	
Biomass	Northumberlan d	2	349	3	Transitional	Micro	Sunbury
Wind	Bradford	1	340	1	Transitional	Micro	Sayre
Solar	Crawford	2	337	2	Transitional	Micro	Meadville
Biomass (Wind)	Indiana	8	332	5	Transitional	Micro	Indiana
Biomass	Jefferson	5	307	5	Transitional	Rural/ Other	
Biomass	Warren	4	299	4	Transitional	Metro/ Micro	Allentown, Bethlehem/ Warren
Wind	Blair	3	296	3	Transitional	Metro	Altoona
Solar (Biomass Wind)	Monroe	6	292	3	Transitional	Micro	East Stroudsburg
Biomass (Solar Wind)	Somerset	6	241	6	Transitional	Micro	Somerset
Biomass	Lawrence	7	232	5	Transitional	Micro	New Castle
Wind	Centre	3	226	2	Transitional	Metro	State College
Biomass	McKean	2	210	2	Transitional	Micro	Bradford
Solar	Lawrence	3	185	2	Transitional	Micro	New Castle
Solar	Mercer	6	177	3	Transitional	Metro	Youngstown, OH, Warren, OH, Boardman, OH
Wind	Carbon	5	154	2	Transitional	Metro	Allentown, Bethlehem

Sector	County	# of Estabs	# of Jobs	# of Components	Socio-Economic Status	Pop. Class	Primary City
Biomass (Solar Wind)	Monroe	2	148	2	Transitional	Micro	East Stroudsburg
Solar	Armstrong	1	137	1	Transitional	Metro	Pittsburgh
Wind	Clearfield	1	135	1	At-Risk	Micro	DuBois
Biomass (Solar Wind)	Tioga	1	131	1	Transitional	Rural/ Other	
Solar (Biomass Wind)	Tioga	1	131	1	Transitional	Rural/ Other	
Solar	Huntingdon	1	115	1	At-Risk	Micro	Huntington
Solar (Biomass Wind)	Butler	6	113	3	Competitive	Metro	Pittsburgh

Figure C-9. Locations of manufacturing facilities in Pennsylvania by resource type.

Large circles indicate total employment greater than 1000, ellipses indicate employment over 500, and small circles indicate employment over 100. Orange indicates solar manufacturing, dark gray indicates biomass, and light gray indicates wind.



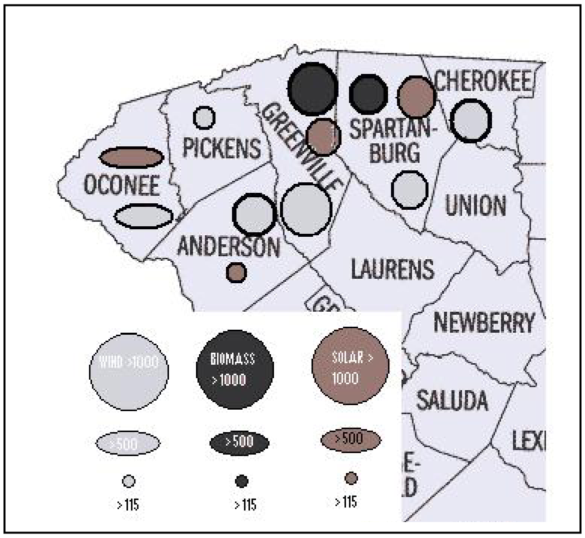
SOUTH CAROLINA

Table C-10. Counties in South Carolina with concentrated employment totals over 100.

Sector	County	# of Estabs	# of Jobs	# of Components	Socio-Economic Status	Pop. Class	Primary City
Wind (Biomass)	Greenville	23	4595	8	Competitive	Metro	Greenville
Biomass (Solar Wind)	Greenville	19	3715	8	Competitive	Metro	Greenville
Biomass (Solar Wind)	Spartanburg	17	1944	13	Transitional	Metro	Spartanburg
Wind	Anderson	27	1865	4	Transitional	Metro	Anderson
Solar (Biomass)	Greenville	15	1485	5	Competitive	Metro	Greenville
Wind (Biomass Solar)	Spartanburg	26	1484	7	Transitional	Metro	Spartanburg
Solar (Biomass Wind)	Spartanburg	10	1322	5	Transitional	Metro	Spartanburg
Wind	Cherokee	4	1219	3	At-Risk	Micro	Gaffney
Solar	Oconee	2	860	2	Transitional	Micro	Seneca
Wind	Oconee	5	636	3	Transitional	Micro	Seneca
Solar	Anderson	9	339	3	Transitional	Metro	Anderson
Wind	Pickens	7	237	3	Transitional	Metro	Greenville
Biomass	Anderson	4	134	3	Transitional	Metro	Anderson

Figure C-10. Locations of manufacturing facilities in South Carolina by resource type.

Large circles indicate total employment greater than 1000, ellipses indicate employment over 500, and small circles indicate employment over 100. Orange indicates solar manufacturing, dark gray indicates biomass, and light gray indicates wind.



TENNESSEE

Table C-11. Counties in Tennessee with concentrated employment totals over 100.

Sector	County	# of Estabs	# of Jobs	# of Components	Socio-Economic Status	Pop. Class	Primary City
Biomass (Solar)	Hamilton	29	3322	12	Competitive	Metro	Chattanooga
Wind (Biomass Solar)	Knox	36	1570	8	Transitional	Metro	Knoxville
Biomass	Warren	3	1297	3	Transitional	Rural/ Other	
Biomass (Solar)	Putnam	11	934	8	Transitional	Micro	Cookeville
Wind	Warren	6	915	3	Transitional	Rural/ Other	
Biomass (Solar Wind)	Greene	10	914	8	Transitional	Micro	Greeneville
Wind	Unicoi	10	911	3	Transitional	Metro	Johnson City
Wind (Biomass Solar)	Anderson	12	843	4	Transitional	Metro	Knoxville
Biomass (Solar Wind)	Washington	9	783	7	Transitional	Metro	Johnson City
Wind	Hamilton	22	744	4	Competitive	Metro	Chattanooga
Solar	Hawkins	2	723	2	Transitional	Metro	Kingsport, TN Bristol, TN Bristol, VA
Wind (Biomass Solar)	Blount	13	675	5	Transitional	Metro	Knoxville
Solar (Biomass)	Hamilton	16	670	6	Competitive	Metro	Chattanooga
Wind (Biomass Solar)	Washington	3	657	3	Transitional	Metro	Johnson City
Wind	Hawkins	4	632	3	Transitional	Metro	Kingsport, TN Bristol, TN Bristol, VA

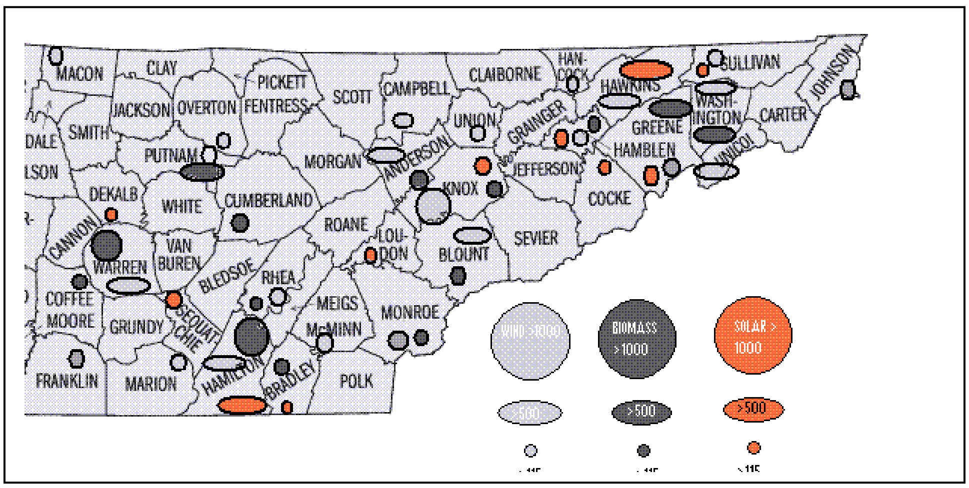
Sector	County	# of Estabs	# of Jobs	# of Components	Socio-Economic Status	Pop. Class	Primary City
Wing	White	6	450	4	Transitional	Rural/ Other	
Solar (Biomass Wind)	Knox	8	417	5	Transitional	Metro	Knoxville
Wind	McMinn	3	415	2	Transitional	Micro	Athens
Wind	Marion	2	379	2	Transitional	Metro	Chattanooga
Wind	Sullivan	9	378	4	Transitional	Metro	Kingsport, TN Bristol, TN Bristol, VA
Wind	Rhea	2	377	1	Transitional	Rural/ Other	
Biomass (Solar Wind)	Knox	13	355	9	Transitional	Metro	Knoxville
Biomass	Monroe	1	350	1	Transitional	Rural/ Other	
Biomass	Rhea	1	336	1	Transitional	Rural/ Other	
Wind	Hamblen	5	323	3	Transitional	Metro	Morristown
Solar (Biomass)	Hamblen	4	321	3	Transitional	Metro	Morristown
Solar	Sullivan	1	304	1	Transitional	Metro	Kingsport, TN Bristol, TN Bristol, VA
Wind	Franklin	3	296	1	Transitional	Micro	Tullahoma
Wind	Monroe	3	259	3	Transitional	Rural/ Other	
Solar	Loudon	1	226	1	Transitional	Metro	Knoxville
Wind	Overton	2	224	2	Transitional	Micro	Cookeville

Sector	County	# of Estabs	# of Jobs	# of Components	Socio-Economic Status	Pop. Class	Primary City
Biomass (Solar)	Bradley	2	188	2	Competitive	Metro	Cleveland
Biomass (Solar Wind)	Anderson	7	184	5	Transitional	Metro	Knoxville
Solar	De Kalb	1	176	1	Transitional	Rural/ Other	
Wind (Biomass Solar)	Greene	4	176	3	Transitional	Micro	Greeneville
Wind	Union	2	169	2	At-Risk	Metro	Knoxville
Biomass	Coffee	1	168	1	Transitional	Micro	Tullahoma
Solar	Cocke	1	167	1	At-Risk	Micro	Newport
Solar	Sequatchie	2	160	2	Transitional	Metro	Chattanooga
Solar (Biomass)	Bradley	1	154	1	Competitive	Metro	Cleveland
Biomass (Solar)	Hamblen	1	152	1	Transitional	Metro	Morristown
Wind	Johnson	2	148	2	Distressed	Rural/ Other	
Wind	Macon	1	146	1	Transitional	Metro	Nashville-Davidson Murfreesboro
Wind	Putnam	5	137	1	Transitional	Micro	Cookeville
Wind	Hancock	1	128	1	Distressed	Rural/ Other	
Solar (Biomass Wind)	Greene	3	114	2	Transitional	Micro	Greeneville
Biomass (Solar Wind)	Blount	5	107	4	Transitional	Metro	Knoxville

Sector	County	# of Estabs	# of Jobs	# of Components	Socio-Economic Status	Pop. Class	Primary City
Wind	Campbell	3	107	3	At-Risk	Rural/ Other	
Biomass	Cumberland	3	107	2	Transitional	Micro	Crossville

Figure C-11. Locations of manufacturing facilities in Tennessee by resource type.

Large circles indicate total employment greater than 1000, ellipses indicate employment over 500, and small circles indicate employment over 100. Orange indicates solar manufacturing, dark gray indicates biomass, and light gray indicates wind.



VIRGINIA

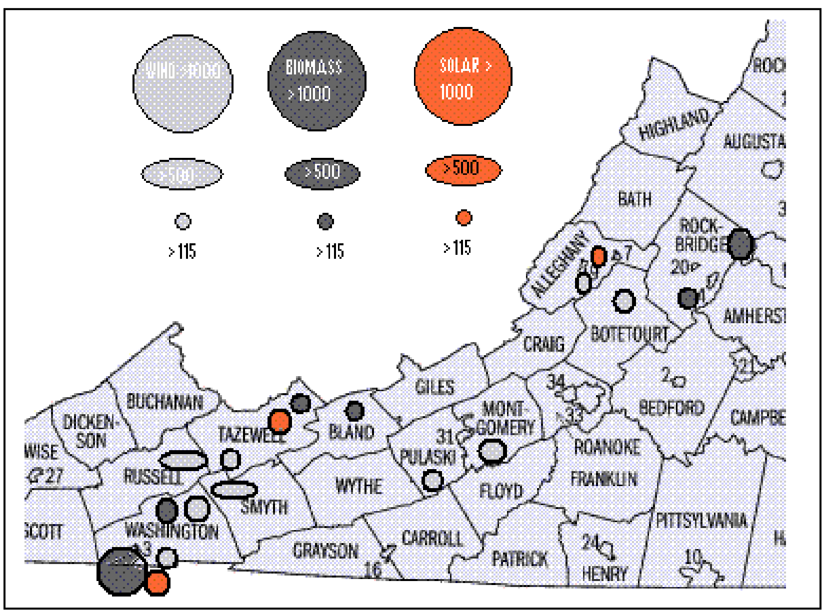
Table C-12. Counties in Virginia with concentrated employment totals over 100.

Sector	County	# of Estabs	# of Jobs	# of Components	Socio-Economic Status	Pop. Class	Primary City
Biomass (Solar)	Bristol City	5	3112	4	Transitional	Metro	Kingsport, TN Bristol, TN Bristol, VA
Wind	Russell	1	736	1	Transitional	Rural/ Other	
Wind	Smyth	1	708	1	At-Risk	Rural/ Other	
Biomass	Washington	3	444	3	Transitional	Metro	Kingsport, TN Bristol, TN Bristol, VA
Wind	Bristol City	2	362	2	Transitional	Metro	Kingsport, TN Bristol, TN Bristol, VA
Wind	Covington City	1	359	1	Transitional	Rural/ Other	Covington City
Biomass	Buena Vista City	2	331	2	Transitional	Rural/ Other	Buena Vista City
Biomass	Rockbridge	2	319	2	Transitional	Rural/ Other	
Solar (Biomass)	Bristol City	2	295	1	Transitional	Metro	Kingsport, TN Bristol, TN Bristol, VA
Wind	Pulaski	2	295	1	Transitional	Metro	Blacksburg, Christiansburg, Radford
Biomass (Solar)	Bland	2	276	2	Transitional	Rural/ Other	
Biomass (Solar)	Tazewell	5	221	5	Transitional	Micro	Bluefield, WV
Wind	Washington	4	197	2	Transitional	Metro	Kingsport, TN Bristol, TN Bristol, VA
Wind	Tazewell	6	191	3	Transitional	Micro	Bluefield, WV
Solar (Biomass)	Tazewell	3	185	3	Transitional	Micro	Bluefield, WV

Sector	County	# of Estabs	# of Jobs	# of Components	Socio-Economic Status	Pop. Class	Primary City
Solar	Covington City	1	164	1	Transitional	Rural/ Other	Covington City
Wind	Montgomery	2	157	2	At-Risk	Metro	Blacksburg Christiansburg Radford
Wind	Botetourt	2	142	1	Attainment	Rural/ Other	

Figure C-12. Locations of manufacturing facilities in Virginia by resource type.

Large circles indicate total employment greater than 1000, ellipses indicate employment over 500, and small circles indicate employment over 100. Orange indicates solar manufacturing, dark gray indicates biomass, and light gray indicates wind.



WEST VIRGINIA

Table C-13. Counties in West Virginia with concentrated employment totals over 100.

Sector	County	# of Estabs	# of Jobs	# of Components	Socio-Economic Status	Pop. Class	Primary City
Solar	Wood	3	2710	2	Transitional	Metro	Parkersburg, WV Marietta, OH Vienna, WV
Wind	Ritchie	3	1177	1	Distressed	Rural/ Other	
Biomass	Hancock	2	588	2	Transitional	Metro	Weirton, WV, Steubenville, OH
Wind	Boone	2	385	1	At-Risk	Metro	Charleston
Biomass (Solar Wind)	Cabell	6	318	6	Transitional	Metro	Huntington, WV Ashland, KY
Wind	Jackson	1	312	1	Transitional	Rural/ Other	
Solar (Biomass Wind)	Cabell	6	308	5	Transitional	Metro	Huntington, WV Ashland, KY
Solar	Mason	3	281	3	Distressed	Micro	Point Pleasant, WV
Wind	Ohio	4	281	3	Transitional	Metro	Wheeling
Solar	Harrison	2	266	2	Transitional	Micro	Clarksburg
Solar	Marion	1	224	1	Transitional	Micro	Fairmont
Biomass	Greenbrier	1	206	1	At-Risk	Rural/ Other	
Wind	Kanawha	10	204	2	Transitional	Metro	Charleston
Biomass (Solar Wind)	Raleigh	6	182	5	Transitional	Micro	Beckley
Wind	Wood	3	164	2	Transitional	Metro	Parkersburg, WV Marietta, OH Vienna, WV

Sector	County	# of Estabs	# of Jobs	# of Components	Socio-Economic Status	Pop. Class	Primary City
Wind	Harrison	3	139	2	Transitional	Micro	Clarksburg
Wind	Putnam	5	139	2	Competitive	Metro	Charleston
Biomass	Brooke	1	128	1	Transitional	Metro	Weirton, WV Steubenville, OH
Wind	Greenbrier	3	122	3	At-Risk	Rural/ Other	
Biomass	Kanawha	4	120	3	Transitional	Metro	Charleston
Solar	Wayne	1	118	1	At-Risk	Metro	Huntington, WV Ashland, KY
Wind	Cabell	5	114	2	Transitional	Metro	Huntington, WV Ashland, KY

Figure 13. Locations of manufacturing facilities in West Virginia by resource type.

Large circles indicate total employment greater than 1000, ellipses indicate employment over 500, and small circles indicate employment over 100. Orange indicates solar manufacturing, dark gray indicates biomass, and light gray indicates wind.