Renewable Energy and State Economies

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The Council of
State Governments

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Renewable Energy and State Economies

May 2003

by

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The Council of
State Governments

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Executive Summary

Renewable energy sources are already recognized for their potential to help develop our energy security, improve environmental conditions and public health, and control consumer energy costs. The possibility that, in addition to these indirect benefits, renewable energy sources could help spur economic development in certain areas of the United States provides an interesting and valuable option to state policy-makers. This report examines the potential benefits of renewable energy development for state economies and will be a valuable asset to state decision-makers as they consider the future of their states' energy sectors.

Fueled by the sun, wind, water, plant and other organic matter, the Earth's heat and, in the case of hydrogen, a naturally occurring element, these inexhaustible resources are converted through the use of renewable energy technologies into usable forms of energy. Those currently with the most potential to benefit states include the following:

- **biomass energy** – generated from organic material;
- **geothermal energy** – produced using heat sources found within the earth;
- **hydrogen energy** – generated through the combustion of hydrogen;
- **solar energy** – produced using energy from the heat and light of the sun;
- **wind energy** – produced using the power from moving air.

Born out of a confluence of economic, environmental and political events in the 1970s, recent technological developments have made renewable energy sources more affordable. Therefore, since all states have some form of developable renewable resources, there are several reasons states should consider using renewable energy. These include its potential to do the following:

- stimulate local economies and create jobs;
- increase local and state tax revenue bases;
- provide environmental and public health benefits;
- allow states to better control consumer energy costs;
- reduce dependence on foreign oil;
- enhance domestic energy security and increase generation reliability.

In the United States, there is still adequate room for growth in energy consumption from renewable sources. As a percentage of total U.S. electricity generation, only about 2 percent comes from renewable sources when hydroelectric power is excluded. However, recent trends indicate that renewable energy development in the states is growing. States have a variety of policy options available when considering how to spur renewable energy development. Several states have instituted a range of initiatives and legislative changes to promote renewable energy development in order to capture the wide range of potential benefits. Of these potential benefits, the direct economic incentives of stimulating local economies, job creation and increased revenue generation have helped fuel states' interest in renewables.

1. Why This Report?

The concept of using renewable energy resources and the associated technologies that make renewable energy possible have been around for decades. Many renewable energy advocates have focused on the *indirect* benefits, which will be discussed later in further detail. These include energy security, decreased impacts on public health and the environment, increased reliability, and decreased volatility in fuel supply prices compared to fossil fuels. However, these arguments have had little effect on energy policy and resource decisions. This could in large part be attributed to the fact that these benefits, while real and tangible, are very difficult for states to quantify, especially with regard to future energy planning.

While several states have instituted or are currently considering initiatives and legislation to spur renewable energy development in order to capture the environmental benefits and control consumer energy costs, many factors suggest that policy debates on renewable energy are almost always about more than energy and the environment. As is the case with many policy discussions, the debate often reaches to the policies' economic impact.

Therefore, policy-makers need to consider the possibility of *direct* economic benefits to states, such as job and revenue creation, attracting economic investment and stimulating local economies, which could be brought by increased efforts to create a renewable energy sector.

Renewable resources and their associated technologies, several of which will be examined in this report, are tapped to produce various forms of energy. This report will focus on the potential of renewable resources used to generate electricity, which promise the most potential for states across the entire range of renewables. This is due to the fact that electricity is the most generated form of renewable energy, and electricity generation projects offer the most potential impact in terms of their economic benefits to states and local communities. The renewable resources with this potential include:

- **biomass energy** – generated from organic material;
- **geothermal energy** – produced using heat sources found within the earth;
- **hydrogen energy** – generated through the combustion of hydrogen;
- **solar energy** – produced using energy from the heat and light of the sun;
- **wind energy** – produced using the power from moving air.

Other renewable resources not included here include hydropower and ocean energy (also known as wave energy). Hydropower has existed since the late 19th century and, while technically a renewable resource, it is considered a conventional power source with respect to new renewable technologies and the purpose of this report. Therefore, due to its already long-term existence, it is not possible to gauge its economic potential as an emerging resource. Wave energy uses the power of ocean waves breaking on the shore to power generators. However, it falls at the opposite end of the spectrum from hydropower, as it is a very new concept and is now only in its initial development stages. Some initial projects have been constructed in Europe, but wave power is still in its infancy and no information exists to help document its potential impact on state economies.

The possibility that renewable energy sources could help spur economic development in certain areas of the United States – along with further developing our energy security and improving environmental conditions and public health – provides an interesting and valuable option to policy-makers. This report outlines the potential benefits of renewable energy sector development to state economies and will be valuable to state decision-makers as they consider the future of their states' energy sectors.

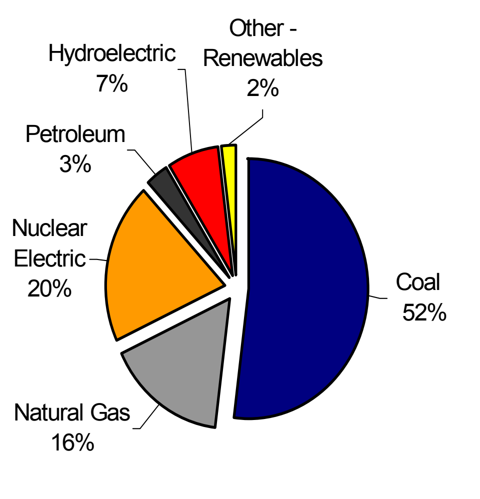
2. Why Renewable Energy and Why Now?

Renewable energy sources hold many potential benefits for society, especially given their properties and the fact that they are continually replenished by nature. Fueled by the sun, wind, water, plants, the Earth's heat and, in the case of hydrogen, a naturally occurring element, these inexhaustible resources are converted through renewable energy technologies into usable forms of energy.

In the United States, there is still adequate room for growth in energy consumption from renewable sources. As a percentage of total U.S. electricity generation it is rather small, with only about 2 percent coming from renewable sources when hydroelectric power is excluded (**see Figure 1**). However, recent trends indicate that renewable energy is growing, and while always recognized for its ability to produce multiple forms of energy, the potential for wide-ranging economic and social benefits has currently thrust renewables into the spotlight.

Many states have expanded and developed renewable energy resources due to their potential to reduce air pollution, control consumer energy costs and reduce dependence on foreign oil, along with the increased cost-competitiveness of renewable sources due to improving technologies. However, a powerful and more recent driving force is that states have found that, aside from achieving the above effects, renewable energy can be used to stimulate local economies. But renewable energy has not always been seen as an economic development tool. The push for renewable energy was originally born in a period when environmental issues and rising energy prices were major concerns for the majority of Americans.

Figure 1 **U.S. Net Electricity Generation by Source, 2000**



Source: Energy Information Administration, U.S. Department of Energy

Why Renewables Yesterday?

For several decades, interest in renewable energy resources, especially as a source for generating electricity, has been growing. Several domestic trends that were the outcome of a confluence of factors, some dating back to the 1970s, have resulted in support for renewable energy. Certainly, one of the foremost reasons renewables gained attention are environmental regulations covering electricity generation, which began in the 1970s and have since evolved. While legislative acts involving clean air standards had already been passed in 1955 and 1963, less than a decade later, growing environmental consciousness across the country deemed them inadequate. The Clean Air Act of 1970 was, therefore, a major revision setting more stringent standards. It established new primary and secondary standards for ambient air quality, set new limits on emissions to be enforced by both state and federal governments, and increased funding for air pollution research. It also forced electricity suppliers to incorporate environmental controls into their generation facilities. One end result of these legislative acts was that electricity suppliers also began investigating renewable energy sources for their ability to more cleanly produce electricity.

Another trend that helped fuel the early stages of renewable energy production was a desire to reduce the United States' vulnerability to higher energy prices and supply disruptions, born out of several incidents in the 1970s. In 1973, American support for Israel in the Arab-Israeli War led the Arab oil-producing nations to stop supplying oil to the United States and other Western nations. Overnight, oil prices tripled. In 1979, the coup in Iran caused oil prices to rise again, by more than 150 percent in a matter of weeks, bringing the average price of a barrel of oil to around $45 by the end of the year.

In addition, less than three months later in 1979, the nuclear industry experienced a catastrophe that served to blacken its reputation, when the Three Mile Island nuclear power plant suffered a partial meltdown. This accident, along with the decrease in electricity demand that resulted from conservation efforts of the 1970s energy crisis era, threw the nuclear industry into a growth slowdown from which it never recovered.

More importantly, this confluence of events fueled a sense of crisis that had been building in the United States with respect to the country's energy supply. Increased costs for fossil-fueled energy supplies, rising environmental concerns, the threat of supply disruptions stemming from foreign countries, and the reinforced concerns related to possible nuclear catastrophes all coalesced to provide the grounds for the real birth of renewable energy and the technologies that enable its production.

In the 1980s, the conversion of renewable energy resources was further fueled by federal and private investment in renewable technologies, improved efforts at selecting appropriate sources and siting production facilities, and lowered costs related to manufacturing and operations. As a result, the costs of producing electricity from renewable resources dropped, the difference between conventional and renewable resources diminished and the potential was seen for renewables to emerge as a viable, competitive energy source that could help alleviate the problems associated with energy costs, supply disruptions and environmental concerns.

Why Renewables Today?

Concerns about the environment, public health, energy security and price volatility continue to be motivating factors for the growth of renewable energy. With its continued growth, renewable energy has the potential to benefit the entire country in these areas.

Renewable energy sources have the ability to reduce pollution that results from burning fossil fuels. The debate over air pollution from vehicles is evident, but fewer people are aware that the generation and use of electricity produced from fossil fuels typically lowers air quality. In the United States, approximately 52 percent of electricity is generated by coal and 17 percent by natural gas, and both are a source of harmful emissions when used to generate power. In fact, electricity generation alone accounts for more than 40 percent of all U.S. carbon emissions, 26 percent of smog-producing nitrogen oxide emissions, 33 percent of mercury emissions and 64 percent of acid-rain-producing sulfur-dioxide emissions.[1] Renewable energy sources, which include wind, biomass, hydrogen fuel cells and solar power, are a much cleaner form of energy production than burning fossil fuels and emit very few, if any, harmful emissions. Therefore, renewables' emissions, or lack thereof, have made them an attractive energy source for suppliers to help avoid more stringent, future air regulations. Given that future air regulations could further limit emissions such as carbon dioxide, nitrogen oxides and mercury, the energy industry continues to develop renewable resources as part of its generation portfolios.

Energy security, another factor that contributed to the original emergence of renewable energy, has reemerged as a current concern that increased renewable energy development could help alleviate. Especially since September 11, 2001, foreign oil dependence has resurfaced as a concern that carries significant political and economic risks for the nation. The potential for disruption exists as the United States depends on foreign countries, including mainly Saudi Arabia, Venezuela and Mexico, for approximately 54 percent of its oil, which is up from 34 percent in 1973.[2] Therefore, the potential exists for significant damage to the U.S. economy.

In addition to possible disruptions that could result from foreign oil dependence, significant security risks are present in many of the country's domestic energy systems. These systems, which provide for the transport, storage and production of energy resources, include the electricity transmission grid, pipelines, hydropower dams, nuclear power plants, refineries and fuel tankers. The risks are numerous and varied. Petroleum tankers and refineries can release great quantities of flammable, dangerous substances if damaged. An accident at a nuclear plant has the potential to result in the death of a large number of people and the contamination of an area larger than several states. The destruction of large hydropower facilities could result in severe flooding. Indeed, much of our current energy infrastructure is extremely vulnerable.

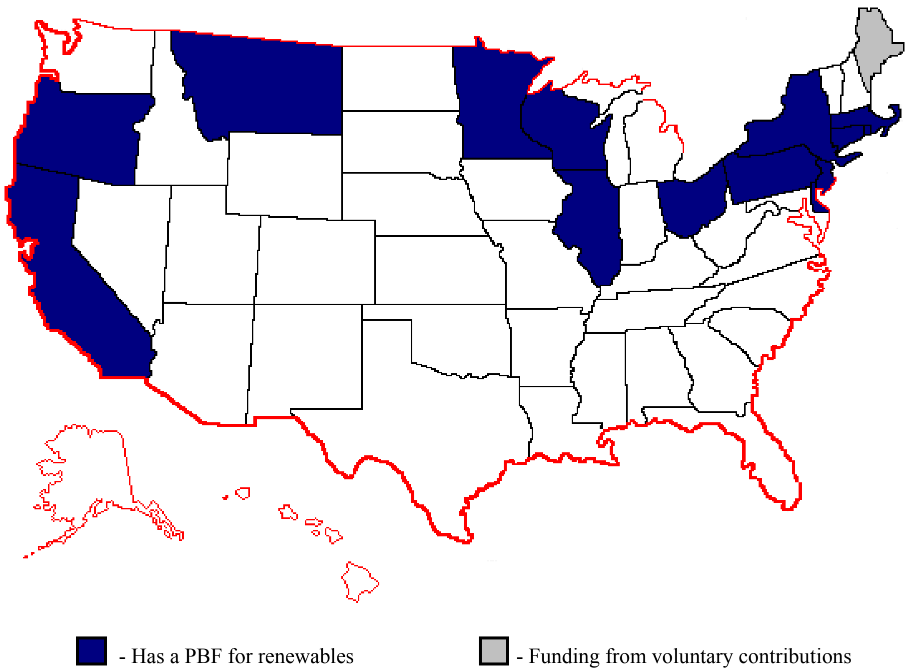
While our current energy system cannot be changed instantly, renewable energy sources can be employed in a manner that avoids compounding the problem. The employment of biomass-based fuels, such as biodiesel and ethanol, to supplement the U.S. transportation sector's reliance on foreign oil is a way to reduce our dependence on other energy sources. Also, renewable energy can contribute to the reliability of and lessen the vulnerabilities of our power systems. Renewable energy systems are smaller, more dispersed, and less prone to disruption than conventional electricity systems. In addition, renewable energy systems powered by wind, solar or geothermal resources cannot be easily disrupted and use fuel stocks that are not explosive or flammable. Therefore, many of our energy security concerns could be lessened by the increased development of renewable energy resources.

In addition, since renewable energy sources are continuously replenished by inexhaustible resources, not only can they contribute to energy security, but by being more predictable and in abundant supply, they can also help stabilize energy costs and free consumers from the volatile price swings that exist in the natural gas and oil markets due to supply and demand issues. Also, technological improvements and federal production incentives have made the cost of electricity produced from some renewable sources, such as wind energy, more cost-competitive compared to generating power from conventional sources, such as coal and natural gas. In addition, all renewable sources continue to become more cost-competitive. In fact, an analysis conducted by the Union of Concerned Scientists estimated that switching 20 percent of electricity generation across the United States to renewable sources by 2020 would save consumers \$4.5 billion.[3] Further details of renewable energy's growing competitiveness are provided in sector-specific sections later in this report.

Finally, and most recently, the states have contributed heavily to the growth of renewable energy through several different types of policies and programs. State clean energy policies, spurred by electricity restructuring, have created a range of options that states have taken advantage of to fuel their renewable energy sectors. While these will be examined in detail later in the report, it is relevant here to briefly discuss two of the most popular and powerful initiatives states have employed to promote renewables: public benefits funds and renewable portfolio standards.

Public benefits funds (PBFs), also referred to as system benefits charges, are state-level programs developed through the electric utility restructuring process as a measure to assure continued support for a wide array of renewable energy resources and energy efficiency initiatives. While states that went through electricity restructuring led the way with public benefits funds, regulated states have followed the trend. Currently, 15 states have some form of renewable energy fund to support cleaner energy alternatives, including wind, geothermal, solar energy, fuel cells and biomass (**see Figure 2**). It is estimated that, from 1998 to 2012, these funds will have contributed more than \$4.3 billion to the development of renewable energy resources.[4]

Figure 2 **State Public Benefits Fund (PBF) Map**



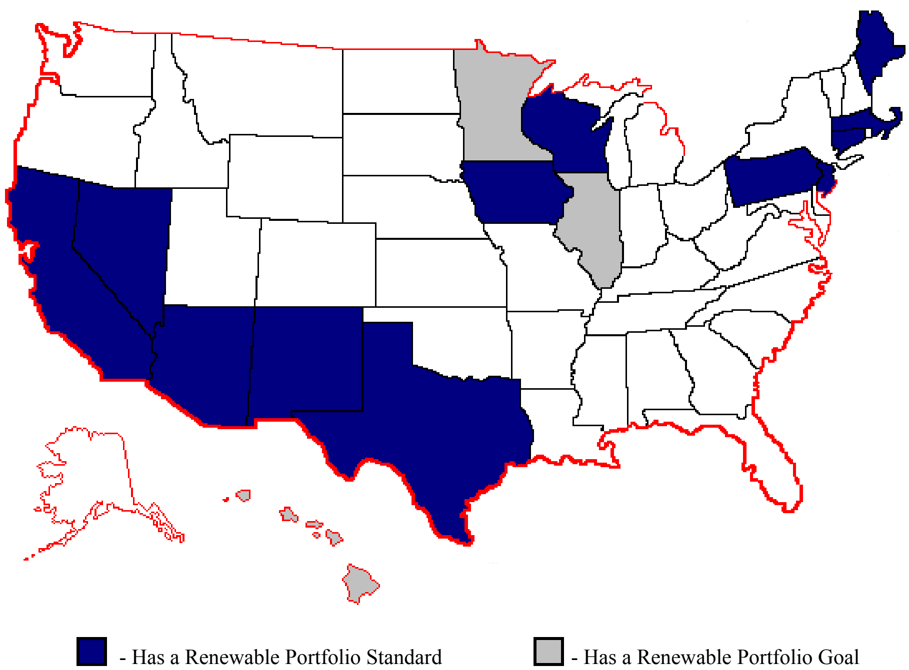
Source: Database of State Incentives for Renewable Energy (DSIRE), http://www.dsireusa.org

Renewable energy standards are the other popular tool that a growing number of states are adopting to stimulate growth in renewable energy supplies. Also brought about by electricity restructuring and then adopted by some regulated states, several states have passed mandates calling for the installation of renewable energy generation. Known as Renewable Portfolio Standards (RPS), they require that a certain percentage of a utility's overall or new generating capacity or energy sales must be derived from renewable resources. For example, Nevada's RPS calls for a 5 percent renewable energy requirement in 2003, rising to 15 percent by 2013, with 5 percent of the requirements to be met by solar energy.

Currently, 15 states have some form of RPS or renewable portfolio goal **(see Figure 3)**. Of the 12 states that have enacted RPS standards into law, it is estimated that, by 2012, more than 12,400 megawatts (MW) will be provided by renewable power sources. This represents more than a 90 percent increase compared to total U.S. levels in 1997 (excluding hydropower). Translated into power for consumption, this would be enough to supply more than 7.6 million homes.[5]

Therefore, due to a confluence of factors, such as state energy policies, environmental drivers, energy security and market concerns, and technological improvements, renewable energy capacity in the United States has steadily increased throughout the last few decades. As mentioned earlier, renewable electricity generation accounts for only 2 percent of the country's total electricity generation, and percentages vary widely by state (**See Appendix A for a state-by-state renewable generation comparison.**) However, renewable energy is growing and much of this growth is due to the fact that many states have begun to associate a more powerful driving force with the development of renewable energy sources – economic development. In some areas of the country, the trend toward greater use of these inexhaustible resources is growing due to the direct economic benefits that states are associating with their development.

Figure 3 **State Renewable Portfolio Standards (RPS) Map**



Source: Database of State Incentives for Renewable Energy (DSIRE), http://www.dsireusa.org

How Can Renewable Energy Help State Economies?

Aside from the potential benefits that have been mentioned thus far, a growing trend in the states suggests that several are using renewable energy as one way to encourage economic development and stimulate local economies. In many instances, money spent on energy leaves a community, going to outside utilities or energy suppliers. As will be explained through specific state examples and initiatives in each of the renewable sector-specific sections of this report, by developing renewable energy sources, which often employ native resources and local production, energy dollars are spent in the local economy, helping to generate local revenue.

In contrast, when dollars are spent on importing energy into a state or community, that money is no longer available to foster economic activity. Therefore, because energy purchases equal a large amount of personal and business expenditures across the country, when added up, the amount of money that leaves a local area represents a substantial loss to local communities in terms of income and jobs that could be used to strengthen their economies.

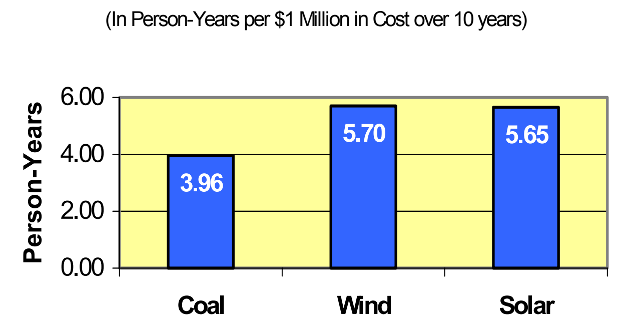
While examples of how states are doing this will be detailed in the subsequent sector-specific sections, it is useful at this point to get an idea of this concept's significance. The United States imports roughly 10 million barrels of oil and petroleum products each day, which totals a little over half our daily needs. The cost associated with importing this oil at current prices is over $200,000 per minute.[6] This money leaves the U.S. economy, going overseas to purchase oil.

Similarly, as money spent on energy can leave the country, so can it leave local and state economies when states import energy from other places. It has been estimated that for Midwestern states, approximately 80 percent of every dollar spent on energy leaves a state's economy.[7] To see the potential of how much money could be kept in local economies by using renewable energy, consider the concept of economic multipliers, which economists use to measure how much economic activity an investment can yield. According to estimates for Nebraska, money spent on renewable energy and energy efficiency has a multiplier of $2.32, while money spent on conventional fossil fuel energy sources has a multiplier of $1.48. Therefore, for every dollar spent on renewables and efficiency methods, more money is generated for the local economy.[8] Considering the size of the energy industry across the United States, it is easy to see how similar measurements could hold true for the rest of the country.

The energy industry is the largest combined industry in the United States. In total, electricity and natural gas provision; oil, coal and gas extraction; and petroleum and coal products totaled over $350 billion in 2001.[9] That amount is more than 4 percent of the country's private sector gross domestic product. And because it is a difficult number to isolate from GDP, this number does not take into account the manufacture of durable goods for the energy industry, such as power plant equipment, which would be an important factor in renewable energy's economic contributions, since it relies even more on the manufacture of equipment used in energy production than do conventional sources.

Given the size of the U.S. energy industry, one can easily see how future energy investment in a state can impact employment. Since renewable energy production is generally more labor-intensive than that of traditional fossil fuel-based energy, renewables can create more jobs for the money invested. A recent study by the Renewable Energy Policy Project, which examined the labor requirements of renewable energy projects, found that wind and solar electricity production offer 40 percent more jobs than coal, currently our largest fuel source for electricity generation (**see Figure 4**). Also, while electricity production from biomass does not usually employ more people than coal, the range of possible jobs available, when considering the various biomass fuel stocks available, extends beyond that of coal, which is traditionally limited to mining, preparation and transport.[10]

Figure 4 Coal, Wind & Solar Job Comparison



Source: Renewable Energy Policy Project, *The Work That Goes Into Renewable Energy.*

In addition, locally produced renewable energy has the potential to spur development of supporting industries in construction, operation, maintenance and other associated technological industries. Because renewable energy industries can provide a wide range of employment – such as operations and maintenance at wind or biomass facilities, manufacturing jobs at solar energy technology companies, or farming jobs from the growth and harvest of biomass to fuel electricity generators – there can be many opportunities for business development in renewable energy producing areas.

It has been estimated that tripling the country's use of biomass energy from farm residues and energy crops could produce approximately $20 billion in new income for farmers and rural communities.[11] Wind energy has similar potential for rural communities, according to the U.S. Department of Energy, which estimates that more than $1.2 billion in new income for farmers and 80,000 new jobs could be created by producing 5 percent of the country's electricity from wind energy by 2020.[12]

Similarly, the Regional Economics Applications Laboratory recently analyzed the economic impacts of implementing a clean energy development plan in the Midwestern states. The plan, known as *Repowering the Midwest,* was recently proposed by a regional coalition, representing citizen, economic and environmental interests. The analysis found that renewable energy development would create more than 68,000 new jobs across the 10-state region by 2020, generating approximately $6.7 billion in annual, additional economic output (see **Table 1** for a state-by-state breakdown over this timeframe).[13]

Table 1 Economic Impacts of the *Repowering the Midwest* Renewable Energy Plan

State	Net New Employment		Increased Annual Economic Impact	
	2010	2020	2010	2020
Illinois	8,700	13,500	$1 Billion	$1.5 Billion
Indiana	3,500	6,500	$300 Million	$600 Million
Iowa	2,400	5,700	$300 Million	$600 Million
Michigan	4,100	9,100	$400 Million	$1 Billion
Minnesota	3,900	6,400	$400 Million	$700 Million
Nebraska	1,500	2,600	$200 Million	$300 Million
North Dakota	1,000	2,100	$100 Million	$200 Million
Ohio	7,200	13,500	$600 Million	$1 Billion
South Dakota	1,300	2,600	$100 Million	$200 Million
Wisconsin	3,200	6,400	$300 Million	$600 Million
Total Region	**36,800**	**68,400**	**$3.7 Billion**	**$6.7 Billion**

Source: Regional Economics Applications Laboratory, *Job Jolt: The Economic Impacts of Repowering the Midwest.*

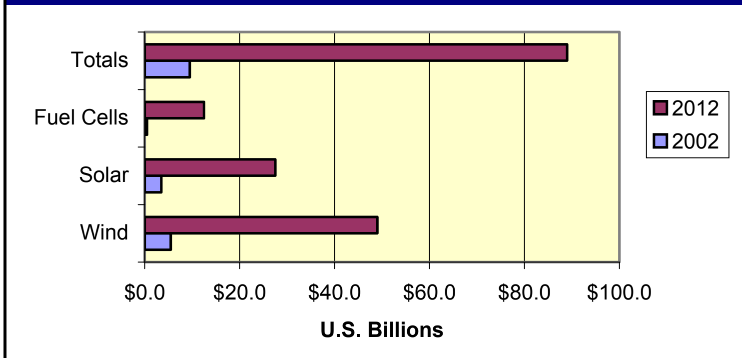
Additional tax revenue can be another boon of renewable energy development, due to the taxes from local energy production companies and from an increased worker base. In many cases, it has been found that generating power from renewable resources contributes more tax revenue than generating the same amount of power from traditional sources. In fact, the California Energy Commission found that solar thermal power plants yield twice the tax revenue of conventional, gas-fired plants, which are a large source of electricity in the state.[14] And, as will be detailed in future sector-specific sections, other states are seeing similar benefits from various renewable energy sectors.

And many rural areas are discovering renewable energy's ability to supplement rural farm economies through the land lease arrangements common with wind energy generation and the growth of crops for biomass energy production. Not only do such arrangements stimulate farming communities by providing additional sources of income and employment, they also increase property tax revenue collected on energy generation assets in these areas. The sector-specific sections will provide several details on how these arrangements benefit local communities.

Finally, the long-term advantages of fostering renewable energy development and the growth of associated technology and industries go beyond the local economy. The United States leads the world in the manufacture of renewable energy power systems, and many of these are exported to developing and newly industrializing nations. Many of these countries lack the appropriate fuel reserves or sufficient energy transmission infrastructure to serve their needs, and renewable energy technologies are increasingly becoming the popular choice for electricity generation in these countries. According to recent market studies, it is estimated that solar power will grow from a $3.5 billion global industry in 2002 to more than $27.5 billion by 2012. Wind power is expected to expand from $5.5 billion in 2002 to more than $49 billion in 2012. And the hydrogen fuel cell industry is expected to grow from $500 million to more than $12.5 billion globally in the same time frame[15] (**see Figure 5**). Given these projected growth rates, it would behoove states to develop a strong market presence in these areas for the potential economic benefits that will exist in both the future domestic and international renewable markets.

Total world energy use is projected to increase 60 percent over current levels by 2020, with much of the growth expected to occur in the developing world. In particular, energy demand in developing Asia and Central and South America is projected to more than double by 2020. Both of these regions are expected to sustain energy demand growth of about 4 percent annually until 2020, accounting for about half of the total projected increase in world energy consumption and 83 percent of the increase for the developing world alone.[16]

Figure 5 **Wind, Solar, & Fuel Cells Projected Growth, 2002-12**



Source: Clean Edge, Inc., *Clean Energy Trends, 2003*

Similarly, renewable energy use is expected to increase worldwide by more than 53 percent by 2020.[17] Given the enabling technologies that are available and those being pursued in renewable electricity generation, the growing demand for electricity in developing nations has the potential to create jobs for American workers through the export of renewable energy technologies. Already the export of such renewable generation equipment to foreign countries is growing at a faster rate than the demand here in the United States. In addition to creating jobs, renewable energy exports provide states with another avenue through which to pursue increased levels of international commerce. Given the fiscal difficulties most states are currently facing, the ability to have companies at home opening an increasing number of channels to foreign markets is valuable indeed.

So far, this report has laid out the general idea that developing renewable energy sources can directly benefit state and local economies, as well as providing indirect benefits related to the environment, energy security and stabilized energy costs. An individual look at each of the renewable sectors will help further outline these benefits and demonstrate what specific states are doing in these areas to help their economies.

3. Biomass

Overview

Biomass, in general, is a term used to describe all of the Earth's plant and animal matter. As a renewable energy resource, biomass power is renewable electricity that is generated from plant material. Biomass used to produce electricity usually takes one of three forms:[18]

- energy crops grown specifically to be used as fuel, such as switchgrass or fast-growing trees;
- agricultural residues and by-products such as corn stalks, rice or nut hulls, sugarcane fiber, and straw;
- forest residues, including wood and pulp from forestry, forest-thinning operations, construction and wood-processing industries.

HOW BIOMASS IS USED TO CREATE ELECTRICITY

Since plant matter stores energy in the form of sunlight it uses to grow, biomass is actually a form of stored solar energy and can provide energy in the form of electricity, heat, steam and fuels. Biomass can be converted to electricity in two ways:

Direct combustion. This involves burning biomass to heat water in a boiler, which produces steam that is then channeled into a turbine to produce electricity. This is identical to the process used in conventional coal-fired generation plants. Almost all electric plants fueled by biomass currently use steam turbines. In a method known as co-firing, biomass is used to produce a portion of the electricity at an existing coal-fired plant, usually 1 to 15 percent, while coal is employed to generate the remaining electricity.

Biomass gasification. This involves converting solid biomass into a gaseous form. The gas is then burned in a combustion turbine to produce electricity. While this method is potentially much more efficient, it still in development and is not widely employed.

Currently, there are about 7,800 MW of biomass power capacity installed at more than 350 locations in the United States. This represents a little more than 1 percent of the total U.S. electric generating capacity and, when hydropower is excluded, produces over 50 percent of the country's renewable-source generation.[19]

Worldwide, biomass power is the largest source of non-hydro renewable electricity in the world, with an estimated 14,000 MW of annual worldwide installed generation capacity. With a little more than half of this amount, the United States is the world's largest biopower generator, producing around 44 billion kilowatt-hours per year, which is enough to power about 4.5 million average U.S. homes. This level of production represents approximately 1 percent of the total electricity generated annually and requires around 60 million tons of biomass per year.[20]

The costs associated with generating electricity from biomass vary greatly, depending on the technology used, the cost of the biomass fuel supplies and the size of the power plant involved. Biopower generation systems can range widely in size, from a few kilowatts for on-site generation units up to 80 MW for commercial power plants. The fundamental technology used to generate electricity from biomass has become more efficient and cleaner over time, but not much can be done to lower fuel costs because of the labor involved in the fuel collection process. The cost of electricity from a new biomass power plant in the early 1980s was 10 cents/kWh, but today, the cost is just under 5 cents/kWh, which is closer to being very competitive with traditional fossil-fueled generation sources.

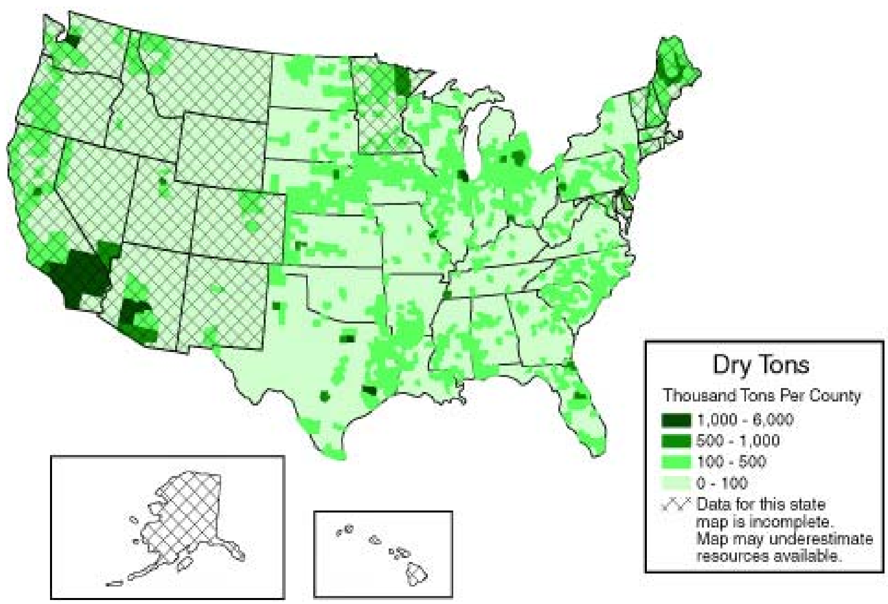
The potential to generate biopower throughout the United States is significant, due to the different types and amounts of biomass that can be grown across the country (**see Figure 6**). Herbaceous, or "grassy," biomass can been grown in the Midwestern states, energy crops are best produced in the upper Midwest, Lower Great Lakes region and the Mississippi Delta, while forest biomass is concentrated in the Southeast, Pacific Northwest, Northeast and Upper Great Lakes regions. Therefore, the United States is capable of providing a wide range of biomass supplies to fuel the biopower industry.

Economic Potential and State Activity

Currently, the U.S. biopower industry is located primarily in the Northeast, Southeast, and West Coast regions and represents more than $15 billion in investment, employing approximately 66,000 people. In the early 1990s, the U.S. biopower industry annually created more than $1.8 billion in personal and corporate income and generated over $460 million in state and federal taxes.[21]

Since biopower activities are primarily located in rural areas, it has the potential to help stimulate rural economies and could supply numerous jobs in the production, harvesting, preparation and transportation of energy crops. The U.S. Department of Energy estimates that developing dedicated energy crops that could be used to fire biopower generators could create more than 120,000 jobs by 2012.[22]

Figure 6 **U.S. Biomass Resources Map**



Source: Office of Energy Efficiency and Renewable Energy (EERE), U.S. Department of Energy

In fact, a study by the department's Oak Ridge National Laboratory found that farmers could grow 188 million dry tons of the energy crop switch-grass on 42 million acres of U.S. land by 2008. At a common price of less than $50 per dry ton delivered, this level of production would increase total U.S. net farm income by approximately $6 billion. The study also estimates that close to 150 million dry tons of corn stover and wheat straw, both agricultural residues that can be used to produce biopower, could increase farm income by an additional $2 billion, even if it is assumed that around 40 percent of the total residue would be collected and the remainder would be left to preserve soil quality.[23]

Maine is an example of a state that is successfully relying on biopower to generate electricity and economic benefits. Currently, Maine obtains a larger percentage of its electricity from non-hydro renewable sources that any other state, with the biomass power industry generating more than 25 percent of the state's electricity. In addition, the biomass power industry has created nearly 3,000 jobs in wood harvesting and transport, power plant operations and associated service sectors. At last estimate, the state had nearly 500 MW of installed biopower capacity in 21 generating plants across the state.[24]

The effect on Maine's rural communities can been seen in the impact of a single plant on one community. In Fort Fairfield, in rural northeastern Maine, a 32 MW biopower plant has created more than 140 operations and wood-harvesting jobs (the town had only 1,270 total jobs before the plant's existence) and supplies more than 30 percent of the town's property tax base. During the plant's two-year construction phase, the developers spent over $8 million in the state, including $5.3 million that went to local construction workers as wages.[25]

In terms of biomass potential, few states could see as many economic benefits from biopower as Illinois, according to a recent study, *Repowering the Midwest,* conducted by the Union of Concerned Scientists. According to the study, the biomass electricity industry could create almost 10,000 new jobs, providing an additional source of income to farmers and unemployed coal miners, more than half of whom have been laid off due to the falling demand for high-sulfur coal found in the state.[26]

In addition, biomass energy could help keep energy dollars from leaving Illinois. While exporting 30 million tons of coal annually, Illinois must import more than 22 million tons of low-sulfur coal, due to clean air regulations with which electricity generators must comply. The study found that producing biomass power could help keep more than $95 million in the state.[27]

4. Geothermal

Overview

Geothermal power plants use energy originating from the heat within the earth in the form of steam or hot water that is converted to steam, drawn from underground wells drilled into the earth. Temperatures of geothermal resources vary. Some produce water at a temperature greater than 572 degrees Fahrenheit, while others fall below the boiling point of 212 degrees Fahrenheit at the surface. While geothermal energy can be (and often is) used in certain "direct use" applications, such as heating and cooling, this section focuses on geothermal resources and electricity generation.

HOW GEOTHERMAL ENERGY IS USED TO CREATE ELECTRICITY

Geothermal generation uses steam or hot water, converted into steam, which is piped up from underground and used to drive a steam turbine, which powers an electric generator. In most cases, the remaining resources are injected back into the ground to help maintain the pressure of the geothermal reservoir and recharge the hydrothermal system. Geothermal energy can be converted to electricity using three types of power plants:

Flash steam turbine. This involves hot water geothermal reservoirs that exist at temperatures greater than 300 F, which are the most common and provide most of the resources for electric generation worldwide. In this process, hot water is separated, or "flashed," into both a steam, which is used to drive the turbine, and a liquid. Systems that employ multiple flash processes are possible, but those that employ a double flash process have been found to be the most economical.

Dry steam turbine. This involves channeling steam produced directly from the reservoir into a conventional turbine to produce electricity. While this method is easier and more direct, such reservoirs are rare and only a few are in use today.

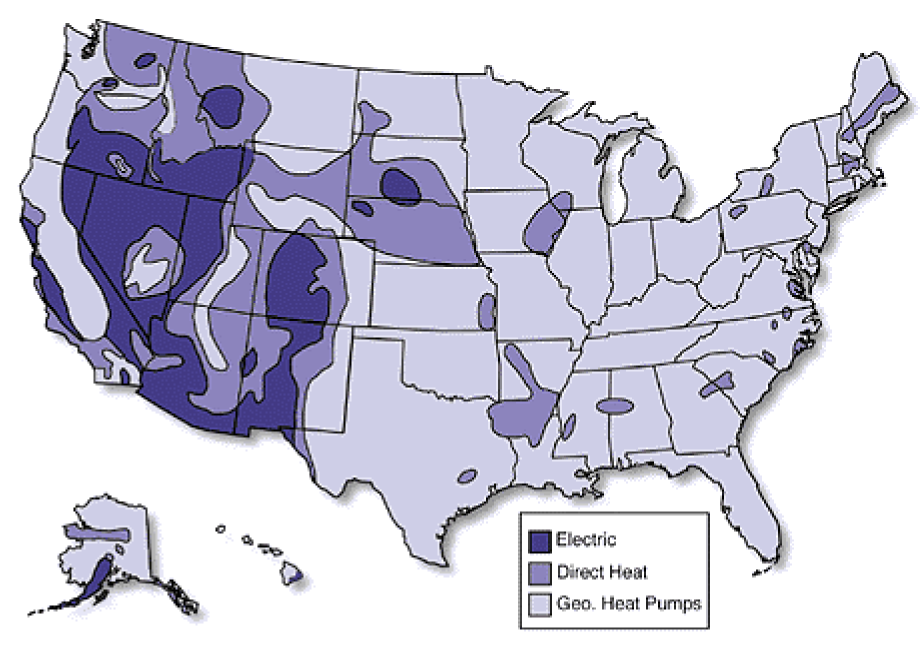
Binary cycle. Geothermal water is channeled into a heat exchanger, where it is used to heat a secondary working fluid that vaporizes and, in turn, is used to drive a generator. After exiting the turbine, the fluid is cooled and condensed back to a liquid, where it is sent back to the exchanger to repeat the process. Operating in a closed loop, the working fluid is not consumed in the process and, because it contains none of the corrosive elements naturally found in geothermal water and steam, does not damage or inflict as much wear and tear on the turbine. While more expensive to build and operate than steam-turbine plants, they can be used to generate electricity from geothermal resources spanning a wider, lower range of temperatures and are becoming more common.

Currently, there are about 2,800 MW of geothermal power capacity installed in the United States. This represents around 2 percent of the country's renewable-source generating capacity.

Worldwide, geothermal power is used in 21 countries, with an estimated 8,000 MW of installed generation capacity. Accounting for more than a third of this amount, the United States is the world's largest geothermal power generator, producing around 18 billion kilowatt-hours per year. While biopower generates more electricity, since geothermal electricity is almost completely used for utility generation, this level of production ranks geothermal energy as the second-largest grid-connected renewable electricity source in the United States, after hydropower.[28]

Much of this generation is located in association with the nation's hottest geothermal resources, which are located in the western United States, with more than 20 geothermal generation facilities located in California, Nevada, Utah and Hawaii. Nevada and California are the most reliant, with both using geothermal for close to 10 percent of their total electricity generation. Most of the potential for electricity generation lies in the western United States, but the area is significant (**see Figure 7**). And, with improved technology, this area could grow in the future.

Figure 7 **U.S. Geothermal Resources Map**



Source: Office of Energy Efficiency and Renewable Energy (EERE), U.S. Department of Energy

The costs of generating electricity from geothermal resources are greatly tied to the upfront expenditures necessary for the exploration and drilling operations and construction of the power plants. This is a result of the fact that, as with most renewable electricity plants and especially geothermal, the continual purchase of fuel resources to generate power is not necessary. Once developed, geothermal resources are essentially free. However the factors discussed above cause large geothermal power plants to yield a cost of $2,000 per installed kilowatt, which is close to twice the amount for coal- and gas-fired plants and even some renewable resource plants, such as wind, which costs about $1,000 per KW. Electricity produced from geothermal resources costs a little more than $0.05 per kilowatt-hour. Again, this is almost twice the cost of natural gas-fired plants and wind turbine generation in some areas, but still more competitive than some resources, such as solar power, which costs three to five times as much.[29]

However, in terms of generating unit size, geothermal power can be generated from units ranging in size of a few hundred kilowatts to more than 100 MW. Moreover, the technology is improving, which is helping bring down the cost of electricity produced from geothermal resources. The cost of generating power from geothermal energy has decreased by more than 25 percent in the past two decades alone. Therefore, the growing competitiveness of geothermal electricity is contributing to its ability to play a big part in the growth of renewable energy resources in the United States.

Economic Potential and State Activity

Currently, the U.S. geothermal power industry is located primarily in Western states, mainly California, Nevada, Utah and Hawaii. Contributing more than $1.5 billion per year to the U.S. economy, the geothermal energy industry, comprised of not only electricity production activities, but also businesses engaged in direct-use geothermal applications such as residential and commercial heating and cooling, also provides a large number of jobs, including 12,300 direct domestic jobs and close to 28,000 indirect jobs. The U.S. geothermal power industry provides the vast majority of these jobs, employing about 10,000 people involved in the installation, construction and operation of geothermal power plants in the United States and abroad, as well as the related activities of drilling and exploration, in addition to providing about 20,000 indirect domestic jobs.[30]

The potential for geothermal power in the United States is significant in both the short and long term. According to the Department of Energy's *International Energy Outlook 2002*, geothermal generating capacity is expected to increase by more than 87 percent by 2020, to 5,300 MW, and could provide more than 35 billion kilowatt-hours of electricity generation in the United States. This represents more than double the amount currently produced.[31]

Therefore, on the job front, with the Department of Energy's forecasted 87 percent increase in geothermal generating capacity over the next two decades, expanded geothermal power development has the potential to create as many as 35,000 new jobs in several different fields: drilling, power plant construction, equipment supply and manufacturing, and operation and maintenance.

In addition to creating jobs and income, geothermal power development could be a lucrative source of new revenue for states, local communities and landowners through the taxes, production royalties and lease fees associated with geothermal electricity generation. For instance, in Nevada, geothermal power plants annually provide for approximately $800,000 in county taxes and more than $1.7 million in property taxes.[32]

Geothermal power plant developers must pay federal and state income taxes on the profits from their operations, as well as royalties for production on federal or state lands. And, since many states assess property tax on the resource's value, and localities generally impose property taxes on the value of energy assets such as generation facilities, geothermal power developments can, and do in some Western states, provide a significant source of revenue.

Besides this direct form of revenue, in cases where production takes place on federal lands within a state, geothermal production can provide even more indirect revenue for that state. The U.S. Bureau of Land Management collects rent and royalties from geothermal plants that produce power on federal lands, in total about $41 million annually. Since half of these revenues are returned to the states, this can mean a significant amount of indirect revenue for some states. In Nevada, this return of revenue means more than $10 million annually for state coffers.[33]

Seeing the dual benefits of jobs for citizens and increased state revenue, both direct and indirect, states are fostering further development of geothermal resources. Over the next five years, in California and Nevada alone, more than 600 MW of new generation is planned, which will represent a greater than 20 percent increase in total U.S. geothermal generation capacity, and this doesn't take into account smaller projects planned for other states.

States can take advantage of other opportunities by developing geothermal energy. Internationally, geothermal power generation is expected to grow quite rapidly. States that develop geothermal resources at home, positioning themselves to attract associated industries and geothermal development companies, will be poised to reap the benefits of the resulting international commerce as these companies help foreign countries develop their own geothermal resources to generate electricity.

In recent years, American companies have signed contracts valued at close to $7 billion to develop geothermal power projects in parts of Latin America, Indonesia and the Philippines. In fact, by recent estimates, approximately 80,000 MW of projected electricity generating capacity could be brought on line in foreign countries by 2020. According to the U.S. Department of Energy, foreign countries will spend anywhere from $25 billion to $40 billion on geothermal electricity development during the next two decades, creating a wealth of opportunities for U.S. providers of geothermal products and services and the states within which they reside.[34]

5. Hydrogen and Fuel Cells

Overview

Hydrogen is the most abundant element in the universe. However, it does not occur naturally in a usable form. Therefore, hydrogen must be produced, or better yet extracted, through various means. As a renewable energy resource, hydrogen can be used in fuel cells to power a wide range of applications and systems, both large and small, including power generation, commercial and passenger vehicles, portable power systems, buildings and industrial facilities.

The U.S. hydrogen industry produces more than 9 million tons of hydrogen annually, which is enough to power 20-30 million cars or 5-8 million homes.[35] Primarily though, hydrogen is currently used in various industrial and commercial applications such as the following:

- metals treating
- chemical production
- petroleum refining
- electrical applications
- food production

As stated before, usable hydrogen does not occur naturally but it can be produced through several methods. Currently, a process known as steam methane reforming is the most common method and accounts for approximately 95 percent of all hydrogen production in the United States. However, other methods of hydrogen production include the following:[36]

- fossil fuel gasification – uses fossil fuel feedstocks such as natural gas, oil, and coal;
- electrolysis – involves splitting water using electricity, heat or light;
- thermal or biological conversion of biomass – involves the use of heat, known as pyrolysis, or microorganisms to produce a chemical reaction producing hydrogen from biomass.

This report focuses on hydrogen's potential to produce energy and generate electricity primarily through the use of fuel cells. As the area of hydrogen development currently receiving the most focus and the technology the Department of Energy has identified as the most beneficial means of using hydrogen, fuel cells hold the key to a cleaner, more renewable form of hydrogen energy than conventional combustion-based technologies that use fossil fuel feedstocks.[37]

HOW HYDROGEN FUEL CELLS CREATE ELECTRICITY

Hydrogen (or hydrogen-rich fuel) and oxygen are combined in a device known as a fuel cell to produce electrical energy through an electrochemical process. The fuel cell uses the chemical reaction to provide an external voltage, as does a battery, but differs from a battery in that the fuel is continually supplied in the form of hydrogen and oxygen gas. It produces electrical energy at a higher efficiency than just burning the hydrogen to produce heat to drive a generator.

Fuel cells have several benefits over conventional energy sources. They are more efficient than conventional combustion-based technologies and they are less polluting, since they emit smaller quantities of greenhouse gases. If pure hydrogen is used, as opposed to a hydrogen-enriched fuel, the only emissions are water and heat.[38]

Economic Potential and State Activity

Hydrogen generated electricity and fuel cells are for the most part still in the scientific development state. An examination of facts and statistics to describe hydrogen's future economic potential is virtually impossible, because this evidence does not yet exist, at least not in any form that results from "real-world" experiences. In addition, at this point, the costs associated with producing hydrogen for use in fuel cells are not clear due to the multitude of methods currently in development and the lack of emergence of one or two technologies as the most economically favorable. Due to this lack of empirical information, it is not possible at this point to adequately gauge this resource's true economic potential.

However, hydrogen has received a large amount of attention recently for its perceived potential to one day supply endless amounts of energy and to become our primary, and perhaps only, source of fuel. President Bush, who first addressed it in his recent State of the Union address, has called for a hydrogen initiative to provide funding for research and development programs to accelerate the adoption of hydrogen applications such as fuel cells, hydrogen-powered vehicles and hydrogen-fueling infrastructure. The idea is to bring us closer to achieving a "hydrogen economy," where almost any imaginable energy need in our society – from cooking and home heating to electricity, transportation and manufacturing – is fueled by hydrogen.

In addition, several states, hoping to become leaders in the sector and bolster their economies, have launched initiatives aimed at fostering the development and launch of large-scale business sectors focusing on fuel cell technologies. Therefore, although many of the details are not yet widely available, it is relevant here to at least briefly highlight these states' efforts to become leaders in the "hydrogen economy."

Michigan is one state that has launched a full-scale effort to focus on the development of fuel cell technologies. With the launch of the NextEnergy Project in 2002, Michigan grabbed the lead, viewing fuel cells as a potentially strong economic development tool. Designed as a high-speed business incubator project, the state aims to create a favorable business climate to attract companies engaged in the research, development, commercialization and manufacture of alternative energy technologies, especially hydrogen fuel cells. The coming advent of fuel cell technology and applications could completely transform major facets of the U.S. economy, including the automotive sector, upon which the state is heavily reliant. To not act now to bring the fuel cell industry to Michigan could cost the state upwards of 200,000 jobs in the future, according to estimates.[39]

Ohio is another Midwestern state that has jumped into the fuel cell race, recently launching a fuel cell initiative. As part of its larger 10-year, $1.6 billion Third Frontier Project to promote high-tech research and development within the state, the $100 million three-year fuel cell plan includes $75 million for low-interest loans for investment in the industry, $25 million for research and development and $3 million for worker training.[40]

In addition, along similar but less developed tracks at this point, states such as Illinois and New Mexico have recently launched efforts to lay similar groundwork in order to capitalize on coming opportunities in the fuel cell industry. The Illinois Department of Commerce and Economic Opportunity recently began a series of meetings designed to facilitate collaboration among the public and private sectors and academic institutions to evolve a unified plan to guide the development of a fuel cell sector within the state.[41] New Mexico recently held an action session, facilitated by the state's Department of Economic Development, aimed at developing a strategy to build business opportunities for the state through hydrogen fuel cell research.[42]

At the local level, through its efforts to reduce atmospheric pollutants and to support a recent resolution declaring it a "Hydrogen City," San Francisco has established a task force to review hydrogen technologies' potential. In addition to adopting such technologies for their environmental benefits, the task force has also concluded that the city should investigate opportunities to establish and attract long-term business relationships with companies involved in hydrogen technologies for the economic benefits.[43]

While hydrogen and fuel cell technologies are still in the developmental stages, hydrogen has been recognized as a potentially limitless resource and significant hydrogen development activity is occurring nationwide. As states such as those mentioned above continue their efforts in this sector, the economic outcomes they experience will no doubt lay the groundwork for other states' future involvement in the hydrogen and fuel cell arena.

6. Solar

Overview

Solar electricity production uses energy from the sun, falling on the earth in the form of heat and sunlight. The two primary methods of electricity production using solar energy are photovoltaic (PV), which uses sunlight, and solar thermal, which draws on the sun's heat. While solar energy resources are most popularly used through miniature solar technologies in the PV cells that power countless consumer products, such as hand-held calculators, watches, battery chargers and portable lights, this section focuses on solar energy resources used for electricity generation.

HOW SOLAR ENERGY IS USED TO CREATE ELECTRICITY

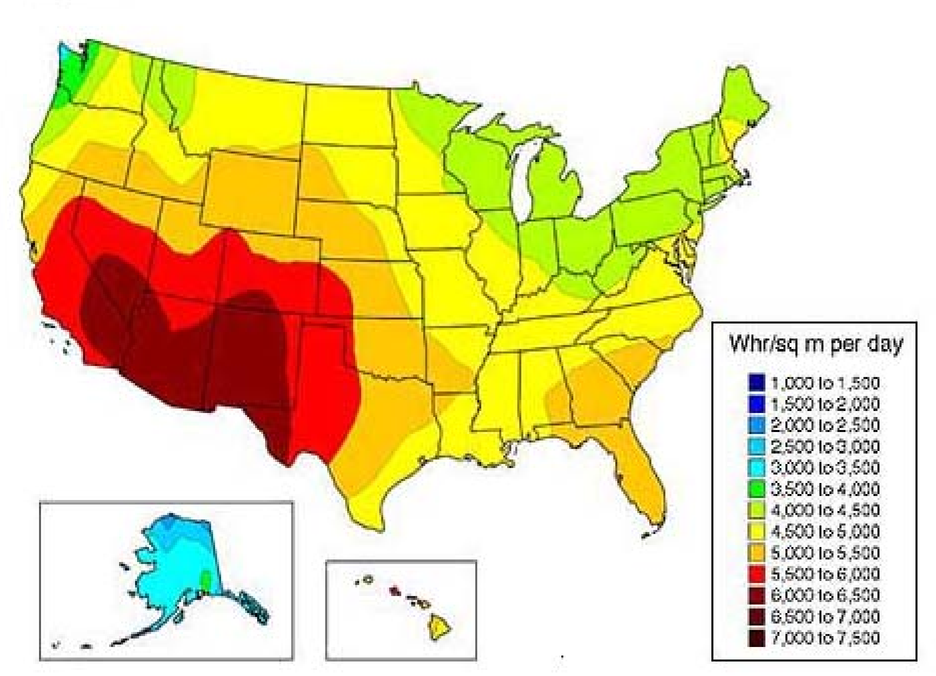
Solar electricity generation is conducted through two different methods: 1) the use of photovoltaic systems to use the energy from sunlight, and 2) solar thermal systems, which employ heat from the sun's rays to generate power using one of three types of solar concentrators. Both photovoltaics and solar thermal systems are explained below.

Photovoltaic systems. Involve the direct conversion of light ("photons") into electricity ("voltage"), hence the term photovoltaic. Using a unit known as a PV cell, made of layers of semiconducting materials, incoming light strikes the PV panels, knocking some electrons loose and causing electricity to flow. The amount of power generated is proportional to the sunlight's intensity. PV cells produce direct current (DC) electricity and can provide stand-alone power supplies or can be connected to a power grid. PV cells can be connected to devices known as inverters to produce alternating current (AC) and to charge batteries that can be used as backup when solar generation is not possible during times of low sunlight.

Solar thermal systems. Use heat from the sun's rays by concentrating them through the use of reflective surfaces to heat a receiver filled with some type of oil or heat-exchange fluid. The heated fluid is then used to generate steam to drive a turbine that generates the electricity. There are three main types of solar concentrators in use today: 1) Power towers that use a field of mirrors to reflect solar rays onto a receiver atop a tall tower. The fluid in the receiver is heated and passed through an exchanger to produce steam to drive the generator. 2) Parabolic trough systems concentrate the solar energy onto a receiver pipe placed at the center point of a curved trough-like reflector. The fluid in the pipe is then heated to boil water, producing the steam that drives the generator. 3) Parabolic dish systems work much like the trough systems in that they use a reflector, although dish-shaped, to concentrate solar energy on a focal point of the dish to heat fluid in a receiver that boils water to run a steam turbine.

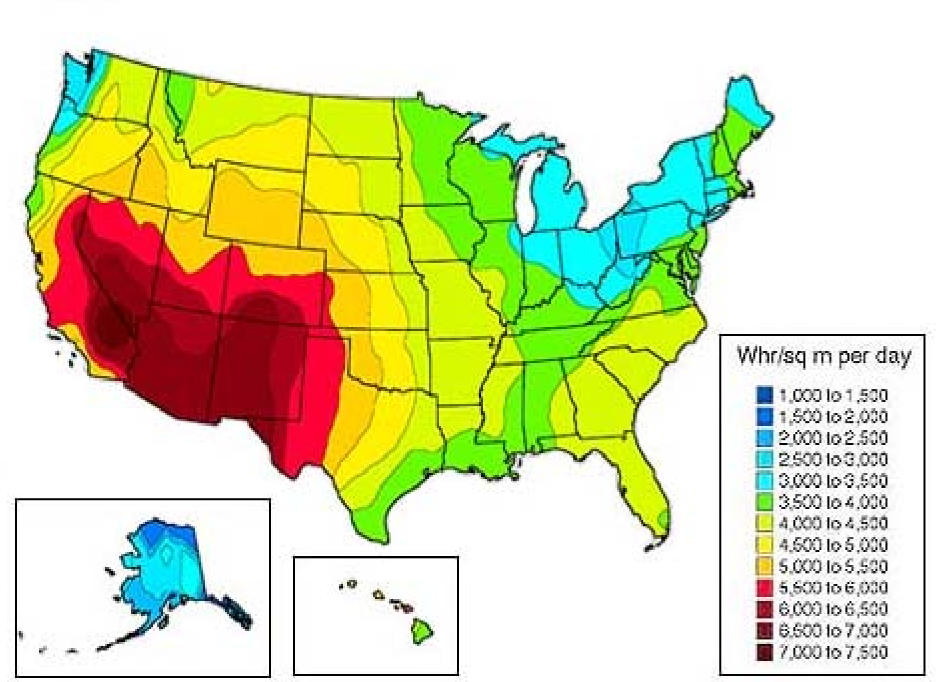
Calculating the current installed generating capacity associated with solar energy systems is extremely difficult. The number is hard to quantify due to the existence of both grid-connected and individual, off-the-grid systems that are thought to power as many as 25,000 homes. However, in the late 1990s, photovoltaic systems alone were thought to produce more than 800 million kilowatt-hours of electricity annually, which is enough to power approximately 100,000 average U.S. homes. The U.S. Department of Energy estimates that total solar energy produced in the states equals less than 1 percent of all energy generated from renewable sources.[44] However, the potential to generate electricity from solar energy is significant, not just in the Southwest (as some people might assume), but across most of the country (**see Figures 8a and 8b**).

Figure 8a U.S. Solar Resources (Flat-Plate Collector) Map



Source: Office of Energy Efficiency and Renewable Energy (EERE), U.S. Department of Energy

Figure 8b U.S. Solar Resources (Concentrating Collector) Map



Source: Office of Energy Efficiency and Renewable Energy (EERE), U.S. Department of Energy

The figures depict solar energy generation capacity across the United States from flat-plate collectors (**Fig. 8a**), which use photovoltaic systems, and concentrated solar collection systems (**Fig 8b**), which use solar thermal systems. A large area of the United States receives at least 3,500 watts-hours (or 3.5 kilowatt-hours) per square meter per day. The average U.S. home needs somewhere in the range of 25 kWh per day so that, even in the lowest range areas, a solar collection module operating at a reasonable 30 percent efficiency would require a collection area no larger than the size of an average living room to provide enough power for the entire home. States in the Sunbelt and western United States, where solar energy is much more intense, have the potential to power thousands of homes through the use of moderate sized solar facilities.

During the oil crisis and rising inflation of the late 1970s and early 1980s, major oil and energy companies saw the need to invest in renewable energy technologies as a way to protect themselves against what seemed at that time an uncertain future for fossil fuels. Spurred by the development of solar technologies in the western United States, primarily California, the companies focused on developing solar energy resources for their long-term use by electric utilities. Since this approach was not focused on attaining short-term profitability, it yielded solar technologies that were not even close to being cost-competitive with fossil fuels.

However, through the efforts of the solar industry and the U.S. Department of Energy, solar PV costs have been reduced by more than 300 percent since the early 1980s. The cost for solar electricity, depending on whether PV technology or solar thermal systems are used, is between $0.15 per kWh to $0.50 per kWh. As the costs associated with solar electricity continue to fall, solar resources will become more attractive and help this technology move from primarily stand-alone applications to grid-based utility applications.

Economic Potential and State Activity

Although the total installed capacity and extent of the solar electricity sector is hard to gauge, the economic impact is at least slightly easier to ascertain. With more than 850 companies – the majority of which are involved in the photovoltaic side of the sector, manufacturing, installing and selling solar system components – the industry is believed to bring in more than $300 million annually while employing approximately 15,000 people. Many of these are high-quality jobs in engineering, manufacturing, sales, service, installation and maintenance.[45]

Solar generation facilities of the scale required to provide significant economic benefit to a community are virtually nonexistent at this point, due largely to the more expensive cost of solar generated electricity as detailed above. However, solar is slowly becoming more cost-competitive with the help of improved technologies.

California offers an excellent example of the economic benefits that solar energy can provide on a more expanded basis in the future. The world's largest concentrating solar power facility, the Solar Electric Generating Systems plant, is located in California's Mojave Desert. With a capacity of 354 MW, it supplies the electricity needs of approximately 500,000 people.[46] The facility has benefited the state economy from the very start, requiring over 1 million job hours to construct. Currently employing around 250 people, over its 30-year lifespan, the facility is expected to contribute $11.6 million in tax revenue to the local government, $65.8 million to the state government, and $228.9 million to the federal government.[47]

While this example is promising, solar electricity generation has not yielded the windfall to state economies that it was originally thought to promise in terms of the construction and operation of generation facilities. This is primarily due to the current lack of cost-competitiveness compared to traditional fossil fueled sources. Therefore, many states have not seen the widespread use of solar energy or solar technologies to produce electricity. However, the international market for solar technology has driven the industry and continues to foster its development.

It has been estimated that more than 2 billion people in the developing world have no electricity in their homes, which provides a market for which solar electricity is well suited. Solar power systems have a high degree of reliability and also flexibility in that applications of a wide range of sizes can be developed to fit project needs. In addition, when used in stand-alone applications, solar power systems do not require transmission lines, which can add significant costs to any electrification project, especially those in the Third World.

The worldwide solar industry has grown significantly since the mid-1970s, as the photovoltaic industry has seen sales grow from less than $2 million in 1975 to greater than $750 million in the mid-1990s. Currently, the United States leads the world in solar research and manufacturing, accounting for approximately 40 percent of production, with around 75 percent of this output being exported, mostly to developing countries.[48]

According to the U.S. Department of Energy, total solar shipments in 2001 were valued at $305 million, representing a 13 percent gain over the previous year. Those shipments dedicated solely to electricity generation, both grid-based and remote stand-alone applications, increased by 25 percent and 43 percent, respectively.[49] Therefore, with the largest share of growing global solar commerce, the states could foster development of solar technology industries at home to take advantage of current and emerging overseas markets.

7. Wind

Overview

This form of electricity generation draws upon the wind, which blows because of circulation patterns and differences in atmospheric pressure created by geography and temperature differences across the Earth's surface, driven by heat from the sun. Therefore, wind is actually considered an indirect form of solar energy. Wind energy has been harnessed for thousands of years for direct use in powering sailboats and also windmills to grind grain. The use of wind for conversion into electricity is a popular trend and, although the last form of renewable energy to be addressed in this report, it is the fastest growing renewable source of electricity in the United States and the world.

HOW WIND IS USED TO CREATE ELECTRICITY

Wind generation capitalizes on energy from the wind to generate electricity through the following simple process:

Energy is captured through blowing winds via the use of wind turbines. The turbines usually employ a tower-like structure that has rotors consisting of two to three propeller-like blades mounted on a shaft. The wind makes the blades turn, transferring this energy to the shaft of an electric generator. Wind turbines are generally mounted on large towers that are 100 feet or more in height so as to take advantage of faster winds.

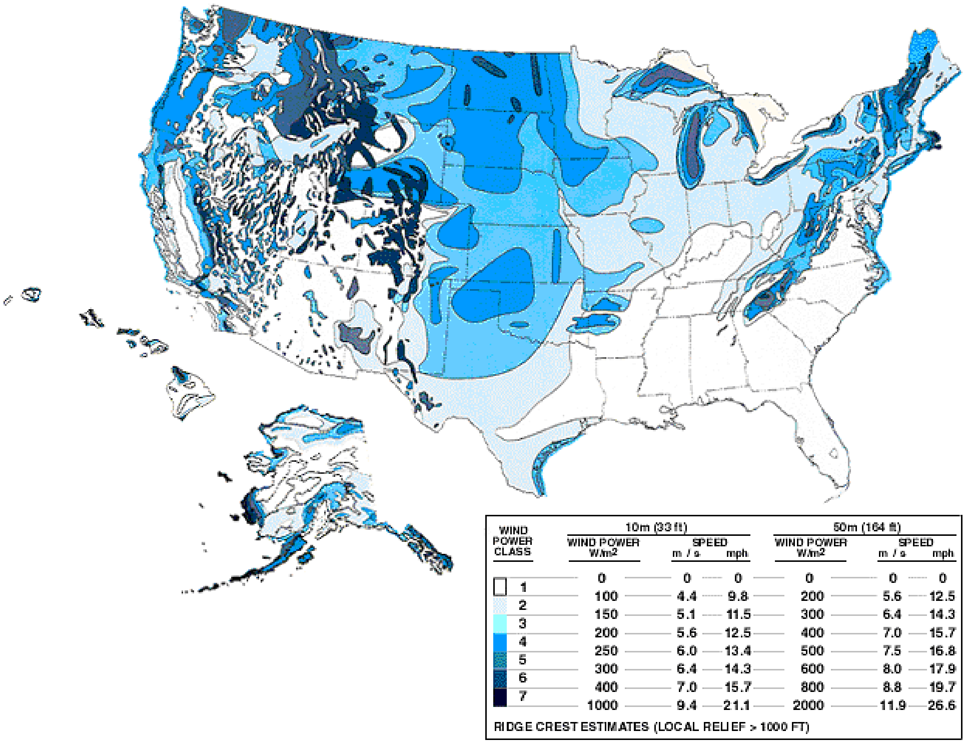
Currently, there are about 4,685 MW of wind power capacity installed in the Unites States, ranking it third in the world behind Germany and Spain. This represents a little less than 1 percent of the country's renewable-source generating capacity. By the end of this year, installed wind generation capacity is expected to exceed 6,000 MW and produce 15 billion to 17 billion kWh of electricity, which is enough to power approximately 1.5 million average U.S. households.[50]

Worldwide, wind energy is the most common source of renewable energy, with an installed capacity exceeding 31,000 MW and generating enough power to supply more than 7.5 million average U.S. households. The European Union is the world's largest wind energy market with an installed generation capacity of 23,056 MW worth over $6.3 billion. Germany leads the way with more than 12,000 MW of installed capacity, followed by Spain with 4,830 MW.[51]

While many people believe that wind energy is used only in a small portion of the United States, mainly the Midwestern plain states, wind energy is actually available over a much larger geographical region. In fact, approximately one-third of the United States, in an area extending from Minnesota to Texas to Wyoming, has adequate wind resources to generate electricity in an economically competitive manner. Nationwide, 46 of the 50 states possess some kind of developable wind resources[52] (**see Figure 9**).

In addition, several states have come to that conclusion and this is reflected in the broad extent to which wind generation projects are located across the United States (**see Figure 10**). Therefore, wind energy is not just a resource to be developed by a few states.

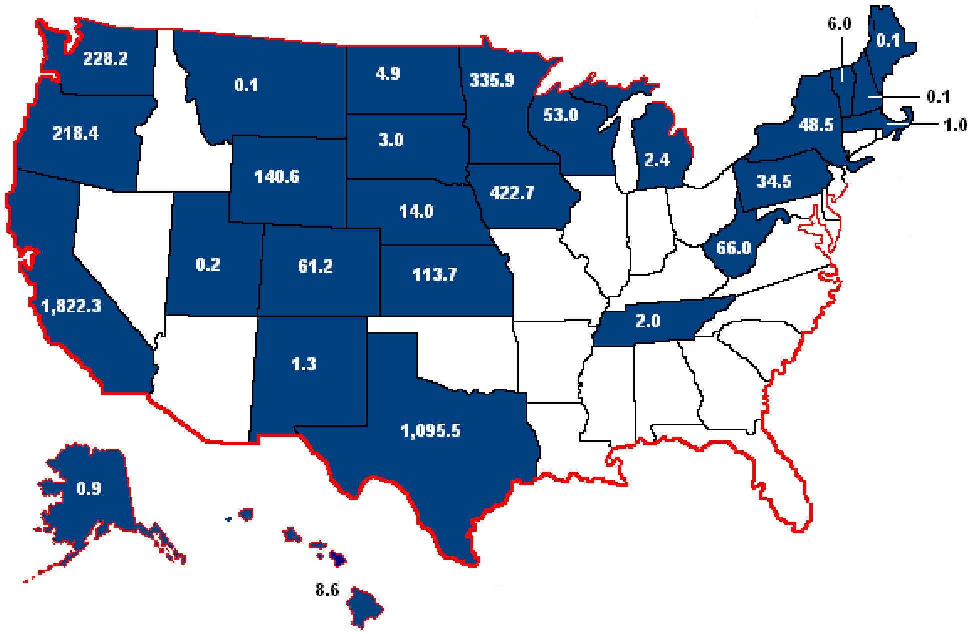
Figure 9 U.S. Wind Power Resources Map



Source: Office of Energy Efficiency and Renewable Energy (EERE), U.S. Department of Energy

The power in the wind is expressed by a classification of wind power classes. Each class is defined by a range of wind speed and power, defined in terms of watts per square meter. The corresponding classes range from 1 (least energetic) to 7 (most energetic). The higher the class, the more powerful the wind in that area is and, therefore, the better the area's potential to generate wind power.

Figure 10 U.S. Wind Power - Installed Generation Capacity (MW)



Source: American Wind Energy Association, *Wind Power Outlook 2003*

The costs of wind generation are very competitive with those of fossil-fueled generation. The cost of wind power falls in the neighborhood of $0.05 per kWh and this does not include the federal production tax credit now in place. The credit, which is $0.015 per kWh, adjusted for inflation, applies to the first 10 years that a new wind plant operates, reducing the cost of wind power over the average 30-year lifetime of a wind plant to around $0.04 kWh.[53]

In addition, the decline of wind energy prices is outpacing conventional sources. The cost of wind power has dropped by 15 percent with each doubling of installed capacity worldwide, which happened three times during the 1990s. In fact, wind power today costs only about one-fifth as much as it did in the mid-1980s. And the cost of wind power is expected to decline by around another 40 percent by 2006.[54]

Indeed, factors such as the growing competitiveness, improving technology and reliability of wind power have all combined to fuel double-digit growth in the United States. During the past five years, U.S. wind energy facilities have grown by an average of 24.5 percent per year.

Economic Potential and State Activity

Currently, the wind power industry provides more than 2,000 direct jobs and approximately another 6,000 indirect jobs, many related to the operation and maintenance of existing wind plants. The industry also contributes directly to the economies of 46 states, with power plants and manufacturing facilities that produce wind turbines, blades, electronic components, gearboxes, generators, and a wide range of other equipment.

The American Wind Energy Association (AWEA) estimates that every megawatt of installed wind capacity creates about 2.5 job-years of direct employment (short-term construction and long-term operations and maintenance jobs) and about eight job-years of total employment (direct and indirect). This means that a 50-MW wind farm creates 125 job-years of direct employment and 400 job-years of total employment.[55]

In addition, export markets are growing rapidly. Overseas markets account for about half of the business of U.S. manufacturers of small wind turbines and wind energy developers. Small wind turbine markets are diverse and include many applications, both on-grid (connected to a utility system) and off-grid (stand-alone). A recent study predicts that small wind turbine sales will increase fivefold by 2005.[56]

Therefore, the potential economic benefits from wind are enormous. At a time when U.S. manufacturing employment is generally on the decline, the production of wind equipment is one of the few potentially large sources of new manufacturing jobs on the horizon. It has been estimated that wind installations worldwide will total more than 75,000 MW during the next decade, or more than $75 billion worth of business. If the U.S. industry could capture only a 25 percent share of the global wind market, many thousands of new jobs would be created.

Wind farms can also revitalize the economies of rural communities, providing steady income through lease or royalty payments to farmers and other landowners. Although leasing arrangements can vary widely, a reasonable estimate for income to a landowner from a single utility-scale turbine is about $3,000 a year. For a 250-acre farm, with income from wind at about $55 an acre, the annual income from a wind lease would be $14,000, with no more than two to three acres removed from production. Such a sum can significantly increase the net income from farming. Farmers can grow crops or raise cattle next to the towers. Wind farms may extend over a large geographical area, but their actual "footprint" covers only a very small portion of the land, making wind development an ideal way for farmers to earn additional income.[57]

California leads the United States in the wind energy sector, with substantial benefits to the state's economy. Throughout the late 1990s, the wind industry in California paid more than $31 million in salaries each year and contributed to the state's local communities by paying about $7 million in property taxes annually.[58] And California recently adopted policies that should almost double the share of electricity it gets from renewables by 2017, a move that should yield even more economic benefits.

New York also expects to reap the benefits of enhancing its renewable energy sector. The state plans to increase the percentage of electricity supplied from renewable energy sources from 17 percent currently to 25 percent by 2012, mostly through increases in wind generation. The AWEA has estimated that this will generate more than $100 million a year in income, jobs and local tax revenue. In addition, thousands of construction jobs will be created.[59]

As states continue to develop wind resources, they stand to generate a wide range of benefits for their economies, perhaps even wider than most other forms of renewable energy. Wind power projects yield income, jobs, land owner revenue, income- and property-tax revenue for communities and positive effects on local services.

8. State Policy Options

When considering the economic potential that increased renewable energy development holds for a given state, policy-makers need to be aware of the tools and options available to them in order to craft effective renewable energy policy. This section includes some common measures states are using to develop or expand their renewable energy resources. These options are significant because the majority of electricity issues have traditionally been decided at not the federal, but state level. And many states have used a combination of these measures to help develop and nurture their renewable energy sectors.

The following will first outline the two most popular and successful measures states are currently using: Public Benefits Funds and Renewable Portfolio Standards. This will be followed by a section discussing in more general terms some of the other options available to states that are either not as widely employed, have been less successful, or are market-based incentives, which have been more difficult to gauge thus far in terms of their effectiveness in promoting renewable development.

Public Benefits Funds

Also known as Systems Benefit Charges or System Benefits Funds, Public Benefits Funds (PBFs) are policy initiatives currently used by states to deliver the benefits of not only renewable energy development, but also energy efficiency to all customers. Originally developed through the electric utility restructuring process as a way to assure continued support for renewable energy resources, the funds are essentially pools of money created from small charges added to customers' electricity bills. Normally these charges amount to only a small fraction of residential, commercial and industrial customers' bills (hundredths or thousandths per penny charge). The funds pay for education programs promoting renewable or energy efficiency initiatives, support for renewable energy research and development, low-income support programs and rebates on renewable energy systems.

As discussed earlier, 15 states currently have some form of public benefits fund (**see Figure 2**). The attraction for states to these funds is their potential to quickly build money for renewable energy and energy efficiency programs. It is estimated that, from 1998 to 2012, these funds will contribute more than $4.3 billion to the 14 states that require mandatory contributions to them.[60] Maine, the other state with a PBF, has no mandated funding and only allows voluntary contributions, yet the fund has raised approximately $70,000 to date.

California is considered the prime example of state renewable energy funds. Through the state's 1996 electric industry restructuring legislation (AB 1890), California created a $540 million fund for renewables. The fund's success led to legislation in September 2000 (AB 995) to extend the program through 2012, at the same annual levels, creating an additional $1.35 billion for renewable energy. The California Energy Commission manages the program and administers funds through accounts aimed at fostering the following:[61]

- Existing technologies – Aimed at supporting existing renewable projects in the state, this program accounts for 45 percent, or $243 million, of the fund.
- New technologies account – Renewable projects brought on line by the end of 2001 have gained support from this program, which accounts for 30 percent, or $162 million, of the current fund.
- Emerging technologies account – Administered through rebate programs, new projects using technologies such as fuel cells, solar thermal electric and wind turbines are supported by 10 percent, or $54 million, of the current fund.
- Consumer side account – Provides rebates to consumers who purchase green power and is supported by 15 percent, or $81 million, of the current fund.

One alarming trend that could threaten the future of Public Benefits Funds is that, due to recent budget shortfalls, several states have been considering dismantling their funds to help pay for other programs. For renewable energy development to succeed, many states with PBFs will have to consider very seriously if they want to possibly derail future renewable energy successes, since abolishing these funds would significantly affect the amount of money available to develop renewable energy. However, fortunately for those states considering PBFs as a renewable development tool, the budget crunch should not affect their decisions to establish one, since these funds are built through customer charges on electricity consumption and would require no funding from states to establish.

Renewable Portfolio Standards

Renewable Portfolio Standards (RPS) require that a certain percentage of a utility's overall or new generating capacity or energy sales must come from renewable resources. Currently, there are two ways states approach their renewable goals. Some states mandate that a specific percentage of generation or sales must come from renewables at the outset of the RPS and this remains standard. For example, Maine requires that 30 percent of total electric sales must come from renewable sources. While Maine's 30 percent requirement is the highest RPS nationwide, it is not considered the most aggressive since the state already has the highest percentage of renewable use in the country at greater than 50 percent of total capacity, made up mostly of hydropower and some biomass.

The other method is for states to phase in their requirements over a period of years. California, for example, passed legislation in September 2002 requiring electricity providers to increase their purchase of renewable generated electricity by 1 percent each year, beginning in 2003, until reaching the standard of 20 percent by 2017. In addition to being the most aggressive RPS in the country, the state supports a wide range of renewable technologies as eligible to contribute electricity to the program, including everything from wind energy to biomass to solar thermal electricity.

Currently, as previously discussed, 15 states have some form of RPS or renewable portfolio goal **(see Figure 3)**. Of the 12 states that have enacted RPS standards into law and have established mandated levels, it is estimated that, by 2012, more than 12,400 MW will be provided by renewable power sources. This will represent a greater than 90 percent increase over total U.S. levels in 1997 (this excludes hydropower).[62]

While several states have set more aggressive levels for their renewable standards, Texas is considered a national model when considering how to develop a successful state RPS initiative. In December 1999, the state Public Utility Commission issued the Renewable Energy Mandate Rule. Created by Senate Bill 7, which was signed into law by then-Governor George W. Bush, the rule established Texas' renewable portfolio standard, established a renewable energy credits trading program, and defined the renewable energy purchase requirements for electricity suppliers in the state. In addition to the 880 MW of existing renewable generation, the standard calls for 2,000 MW of new renewable generation to be installed in Texas by 2009 (approximately 3 percent of the total in-state generation). The schedule calls for 400 MW to 650 MW to be added by the end of every other year (for example, 850 MW by 2004, then 1,400 MW by 2006). In addition, the renewable energy sources that make up the qualifying list for generation projects are fairly diverse, including solar, wind, biomass or biomass-based waste products and hydroelectric.[63]

Although enacted in 1999, the Texas RPS became effective January 1, 2002 with the first phase calling for 400 MW of renewable generation to be installed by the end of 2002. Instead, more than 900 MW were installed by the end of the year and Texas now has more than 1,000 MW of wind generation capacity alone. Many energy and policy experts agree that the Texas RPS has been so successful due to several factors. First, Texas had good renewable resources and included a wide variety of qualifying technologies under the RPS. In addition, the state benefited from a good RPS rule established by legislation that included several key provisions. The legislation made the new renewable requirements high enough that it helped attract new market growth as renewable energy suppliers saw an opportunity. In addition, it mandated that the requirements applied evenly to all power providers and included significant financial penalties for noncompliance. And, finally, the state established a renewable energy credits trading program to allow an additional way for requirements to be satisfied, but which gave participants and new market entrants (mainly renewable energy companies) added incentive to participate.[64]

Renewable portfolio standards have emerged as an effective and popular tool for promoting renewable energy. RPS policies can be structured to allow flexibility in fulfilling their mandate by using a combination of renewable energy sources, in effect leaving it up to the market to decide. This can be critical, because not all states have the same renewable resources. For example, Arizona has greater solar resources than Kentucky, and Kansas has greater wind resources than South Carolina. In addition, an effective RPS policy can essentially create new markets for renewable energy and help reduce market barriers, providing renewable energy providers with access to a more level playing field when competing with conventional energy suppliers. States have taken the lead and demonstrated that an RPS can effectively stimulate renewable energy growth. With their ability to be adapted to each state's unique energy market, states desiring to develop their renewable energy sources should give renewable portfolio standards serious consideration.

Additional Options

While the two best and most popular measures used by states have been examined, it is important to recognize that states have numerous policy options and incentives available when crafting successful renewable energy policies. And many states have chosen to use a combination of options. Because the remaining measures vary widely from state to state and are very flexible in their implementation, they are not as easy to examine in detail as RPS and PBF policies; therefore, the following section will broadly outline some of the other policies, incentives and programs that states can implement.

Net metering standards basically give consumers the ability to generate their own electricity and receive credit for any excess power they generate beyond their needs, which is effectively provided or "sold" to the local system. The idea behind net metering is that individual consumers will most likely employ renewable energy as the source that powers their generation units, such as small wind turbines or rooftop solar panels, thereby increasing renewable energy use within the state. In most states, residential, commercial and industrial customers are eligible to participate in net metering programs, but some states restrict eligibility to particular customer classes. Currently, 33 states have some form of statewide net metering program in place. Because net metering programs vary widely across the country, and individual renewable generation units have yet to emerge as a relevant, or in some cases feasible, aspect of our nation's energy sector, such programs have yet to benefit states' renewable energy sectors. In part due to the costs of the technology and also technical limitations in several areas of the United States that limit how customers can provide power to their local systems, especially from renewable sources, net metering has yet to make a significant impact on renewable energy growth in the states. The cost and technical barriers must first be overcome before net metering will truly benefit states' renewable energy efforts.

Green Power Purchasing is a program employed at the state and local levels that allows governments, universities and even businesses to support renewable energy by buying renewably generated electricity. Currently, 16 states have some form of green power purchasing at the state or local level. States using green-purchasing programs usually require a certain percentage of electricity purchased for state government buildings to come from renewable resources. At the local level, city governments, for instance, usually purchase "green power" for streetlights, water pumping stations and other municipal facilities. Variations of this program include "Community Choice" programs, where states have allowed local governments to aggregate their electricity loads, basically purchasing power in blocks to provide for the needs of the entire community. Currently, five states (Iowa, Minnesota, Montana, New Mexico and Washington) require utilities to provide green power purchasing programs to their individual customers. However, for states and local governments, green purchasing might be considered more of a "commitment program," since it helps support the renewable market in states that use it without providing for a larger, mandatory level of participation.[65]

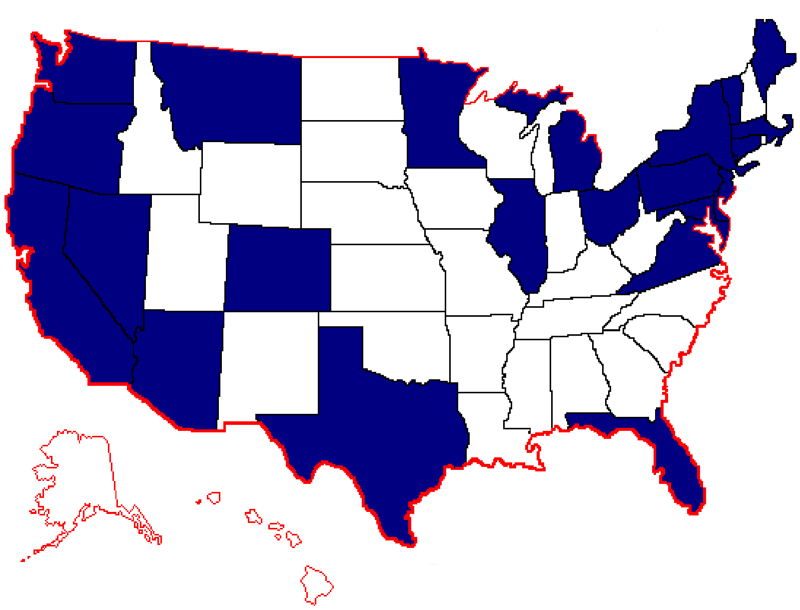
Financial incentives are another option for states to consider when promoting renewable growth. These include sales and property tax relief as well as production incentives to encourage generation of renewable electricity.

- *Sales tax incentives* are very simple in that they usually provide an exemption from the state sales tax for the purchase of renewable energy equipment. Most states with such policies allow the sales tax exemptions on the purchase of any renewable energy technologies, while some states limit them to certain sectors. For example, in Minnesota the sales tax exemption applies only to wind and photovoltaic equipment, while in Iowa the program applies to only wind and ethanol-based fuel production equipment. Currently, 17 states have some form of statewide sales tax incentive for renewable energy.

- *Property tax incentives* are another option that states can use. These incentives usually fall into one of three categories: exclusions, exemptions or credits. The majority of these incentives used by states are employed as exemptions where any additional value that the purchase of a renewable energy device adds to the property is not included in the property's taxed value. For example, if a renewable-powered generator costs $5,000, compared to $3,000 for a traditional system, the renewable system is assessed at $3,000. Currently, 25 states have some form of statewide property tax incentive. In some instances, since property taxes are collected locally, states allow local authorities to provide a property tax incentive for renewable energy devices. Six states (Connecticut, Iowa, Maryland, New Hampshire, Vermont and Virginia) exercise this option.

- *Production incentives* are another financial option available to states to encourage renewable energy activity. This option can be used in the form of a tax credit or an actual cash incentive, both of which reward the generation of electricity instead of just the installation of equipment. This incentive can be employed at various levels, from the state to the local utility; however, only eight states employ it at the statewide level. When employed as a tax credit, states usually provide around 1 cent to 1.5 cents per kWh for electricity generated from renewable resources. Rebates or cash payments are the other form of production incentive used, which allow states and local governments to provide project owners with incentives based on electricity production on a dollar-per-kilowatt-hour basis. Currently, 22 states offer some form of production incentive in the form of a rebate, cash payment or tax credit at the statewide level. These types of incentives can be a more effective mechanism for ensuring quality renewable energy projects, since they reward ongoing performance instead of just a one-time capital investment.

Figure 11 **State Generation Disclosure Rules Map**



Source: Database of State Incentives for Renewable Energy (DSIRE), http://www.dsireusa.org

Finally, a very easily instituted and more general program to promote renewables is demonstrated in the *Generation Disclosure Programs* that some states use. These programs require electricity suppliers to provide their customers with added information about the energy they supply. The information, which must be displayed on a customer's bill, often displays the mix of fuel sources used to generate their electricity. Designed to help consumers make informed decisions about their choice of energy and supplier, disclosure programs provide states a tool not only to educate customers about electricity but also to prepare in-state markets for increased renewable generation. Polls have consistently shown that a majority of consumers would like their power to come from renewable sources. In addition, many are willing to pay a premium for this option. Currently, 23 states have some form of disclosure program in place (**see Figure 11**).

Conclusion

Renewable energy holds many potential benefits for states. Through developing renewable resources, states have the ability to reduce air pollution, protect customers from volatile energy prices, enhance national energy security and independence, and stimulate economic development. The costs of renewable energy production have been steadily decreasing throughout recent decades and the potential economic benefits have influenced many states' expansion and development of renewable resources.

Many policy options exist that states can use to expand and encourage development of their renewable energy resources. And many states have used not just one, but a combination of these measures to help develop and nurture their renewable energy sectors. This is important to recognize, because there is no single "silver bullet" solution available to states to encourage renewable energy growth. States must consider their own unique circumstances and available resources to enact an effective renewable energy policy.

To date, renewable portfolio standards and public benefit funds have been most successful for states that have employed them. Well-designed renewable portfolio standards require mandatory levels of renewable energy production, providing for creation and stimulation of a renewable sector, yet allowing market forces to guide the development and resource choices of the market. Public benefit funds have been successful in providing states with money to promote and develop their renewable sectors. Through these funds, several states have raised significant amounts of money to fund noteworthy renewable energy activity. Renewable Portfolio Standards and Public Benefits Funds could be adapted to the needs of almost any state. States should seriously consider these two options when looking to develop their renewable energy sectors.

Through the development of renewable energy resources, not only do states have the ability to gain significant social benefits but also, more importantly, in this current period of tight state budgets and slow economic growth, states have the ability to stimulate their economies. Renewable energy development has the potential to directly affect local economies through the creation of jobs, production and purchase of goods and services, and the generation of land use revenue and taxes. Therefore, states should take advantage of this potential and attempt to include renewable energy development into their future state energy plans.

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Appendix A - Total Renewable Net Generation by State, 2000 (Thousand Kilowatt-hours)

	Total Renewable Generation	Hydro Generation	Non-Hydro Renewable Generation	Total Generation	Non-Hydro Renewable % of Total Generation
Alabama	9,893,796	5,817,631	4,076,165	124,111,000	3.28%
Alaska	1,001,819	1,001,819	0	5,946,000	0.00%
Arizona	8,358,799	8,354,216	4,583	89,102,000	0.01%
Arkansas	3,964,519	2,370,483	1,594,036	43,975,000	3.62%
California	60,837,447	38,333,786	22,503,661	265,059,000	8.49%
Colorado	1,473,799	1,454,415	19,384	43,661,000	0.04%
Connecticut	2,679,447	526,312	2,153,135	33,478,000	6.43%
Delaware	18,838	0	18,838	190,936,000	0.01%
Florida	5,777,115	86,769	5,690,346	190,936,000	2.98%
Georgia	5,585,596	2,480,797	3,104,799	120,488,000	2.58%
Hawaii	920,863	103,458	817,405	9,874,000	8.28%
Idaho	11,449,953	10,966,695	483,258	90,234,000	0.54%
Illinois	1,052,219	143,828	908,391	177,404,000	0.51%
Indiana	718,158	588,276	129,882	127,970,000	0.10%
Iowa	1,486,392	904,010	582,382	41,519,000	1.40%
Kansas	15,332	15,332	0	44,834,000	0.00%
Kentucky	2,336,861	2,324,568	12,293	92,600,000	0.01%
Louisiana	3,324,742	532,290	2,792,452	89,938,000	3.10%
Maine	7,412,683	3,590,815	3,821,868	13,051,000	29.28%
Maryland	2,551,029	1,732,619	818,410	50,204,000	1.63%
Massachusetts	3,261,977	1,065,159	2,196,818	39,286,000	5.59%
Michigan	4,317,273	1,427,679	2,889,594	104,221,000	2.77%
Minnesota	2,975,477	931,383	2,044,094	51,429,000	3.97%
Mississippi	1,680,304	0	1,680,304	37,153,000	4.52%
Missouri	682,773	599,920	82,853	76,627,000	0.11%
Montana	9,670,180	9,623,257	46,923	28,803,000	0.16%
Nebraska	1,517,238	1,500,724	16,514	29,123,000	0.06%
Nevada	3,800,259	2,429,468	1,370,791	35,639,000	3.85%
New Hampshire	2,533,872	1,427,214	1,106,658	14,945,000	7.40%
New Jersey	1,378,350	14,036	1,364,314	58,205,000	2.34%
New Mexico	229,616	221,152	8,464	33,994,000	0.02%
New York	27,791,854	24,909,572	2,882,282	138,039,000	2.09%
North Carolina	4,911,383	3,137,816	1,773,567	122,115,000	1.45%
North Dakota	2,130,536	2,122,561	7,975	31,285,000	0.03%
Ohio	1,230,439	583,048	647,391	148,437,000	0.44%
Oklahoma	2,425,120	2,276,933	148,187	55,510,000	0.27%
Oregon	38,818,986	38,115,630	703,356	51,414,000	1.37%
Pennsylvania	5,020,695	2,290,232	2,730,463	205,502,000	1.33%
Rhode Island	120,106	4,867	115,239	5,926,000	1.94%
South Carolina	2,953,223	1,533,490	1,419,733	92,614,000	1.53%
South Dakota	5,715,508	5,715,508	0	9,698,000	0.00%
Tennessee	7,195,858	6,396,209	799,649	95,203,000	0.84%
Texas	2,599,570	828,963	1,770,607	379,757,000	0.47%
Utah	907,078	746,125	160,953	65,329,000	0.25%
Vermont	1,580,862	1,221,090	359,772	6,687,000	5.38%
Virginia	2,856,083	711,983	2,144,100	76,694,000	2.80%
Washington	81,754,454	80,262,889	1,491,565	108,811,000	1.37%
West Virginia	1,165,335	1,150,903	14,432	92,783,000	0.02%
Wisconsin	3,139,284	1,985,634	1,153,650	59,230,000	1.95%
Wyoming	1,256,946	1,011,035	245,911	59,248,000	0.42%
Total	**356,480,046**	**275,572,599**	**80,907,447**	**4,159,027,000**	**1.95%**

Source: Energy Information Administration, *Renewable Energy Annual 2001*.

Appendix B - Glossary

biofuel: Renewable hydrocarbon fuel, usually alcohol (e.g. methanol, ethanol) derived from various plant feedstocks.

biogas: A combustible gas (composed primarily of methane) generated from animal dung or farm and household wastes. Biogas provides a cheap source of energy, especially in rural regions in developing countries.

biomass: Organic non-fossil material of biological origin, such as wood, crops, crop residues, organic waste and animal waste, which constitutes a renewable energy source.

biomass energy: Energy available from organic material in the environment, that originated as solar energy absorbed by plants and was converted into chemical energy by photosynthesis. Biomass energy, mainly in the form of wood, was the main source of energy prior to the development of fossil fuels. It includes energy available in wood, crops, crop residues, industrial and municipal organic waste, food processing waste and animal wastes.

carbon dioxide (CO_2): One of the major greenhouse gases, CO_2 is human-generated carbon dioxide produced mainly by the burning of fossil fuels.

combustion: A chemical reaction in which a substance combines with oxygen, in a process known as oxidation, to release energy.

electricity: Refers to stationary or moving electric charges. Electric charge is a fundamental property of matter and is produced by the movement of electrons, which carry a negative charge. Electricity is the result of the accumulation or motion of numbers of electrons through a conductor, produced by a voltage.

emission: The release or discharge of a substance into the environment; generally refers to the release of gases or particulates into the atmosphere.

energy: Scientifically known as the capacity to do work. Energy cannot be created or destroyed, but it can be stored and converted between a variety of different forms such as heat, light, electricity and motion to meet specific needs. Energy is measured in joules (J) or watt-hours (Wh) but more usually mega-joules (MJ) or kilowatt-hours (kWh). There is no simple universal classification of energy forms, but most classifications include:

- *chemical* – the energy released during a chemical reaction
- *electrical* – the energy associated with an electric charge in an electric field
- *kinetic* – the energy possessed by an object in motion
- *nuclear* – the energy released during nuclear reaction
- *potential* – the energy possessed by an object as a result of its position. An object at rest retains the energy expended to place it in that position. If the object moves into motion, the potential energy will become kinetic energy.

radiant – energy transmitted in the form of radiation
thermal – heat energy

fossil fuels: Refers to fuels that have been generated by "fossilized" plant and animal matter over millions of years, such as coal, oil and natural gas.

fuel cells: Electrochemical devices that convert a fuel's energy directly to electricity through a chemical reaction instead of combustion, similar to a battery. Fuel cells do not follow the traditional extraction of energy in the form of combustion heat, conversion of heat energy to mechanical energy (through a turbine), and finally turning mechanical energy into electricity (using a dynamo). Fuel cells chemically combine the molecules of a fuel and oxidizer without burning. A more advantageous form of energy production, fuel cells generally do not contain the inefficiencies nor emit the pollution associated with the traditional forms of combustion.

generation (electricity): The process of producing electrical energy from other forms of energy. Generation also refers to the amount of electricity produced, usually expressed in some unit of watt-hours (Wh).

generator: A mechanical device used to produce DC (direct current) electricity. Power is produced when coils of wire pass through magnetic fields inside the generator. Most alternating current (AC) generating sets are also referred to as generators, although they are really alternators.

geothermal energy: Energy available from the molten and semi-molten rocks beneath the earth's crust. The high temperatures created in adjacent solid rocks in certain areas causes sub-surface water to be superheated or converted into steam, which can be converted into electricity in a power plant or directly used for space heating.

green marketing/pricing: Green pricing programs allow electricity customers to pay for renewable energy development through direct payments on their monthly utility bills. For renewable electricity, green pricing is generally considered a method that allows for the "pricing" of the non-market benefits of renewables.

grid: The layout of an electrical transmission and distribution system.

hydropower: The use of water-power to generate electricity by utilizing the kinetic energy available in flowing water. Where the slope of a stream is steep or a natural waterfall exists, the water is directed through a turbine to drive an electric generator.

incentives: Subsidies and other government actions where the indirect financial assistance is provided.

kilowatt (kW): A measurement of electricity equal to 1,000 watts.

kilowatt-hour (kWh): A measurement of electricity with respect to time. One kilowatt-hour is equal to one kilowatt being used for a period of one hour. Equal to 1,000 watt-hours.

megawatt (MW): A measurement of electricity equal to 1 million watts.

megawatt-hour (MWh): A measurement of electricity with respect to time. One megawatt-hour is equal to one megawatt being used for a period of one hour. Or, equivalently, one kilowatt being used for 1,000 hours.

natural gas: A mixture of hydrocarbons in gaseous from, found in pockets beneath the earth's surface, usually in association with liquid petroleum. It consists largely of methane (over 85 percent) but contains additional hydrocarbons such as ethane and propane formed from the decay, or "fossilization," of organic matter.

net metering: Arrangement that permits a facility or consumer, using a meter that reads the inflow and outflow of electricity, to sell any excess power it generates over its requirements back to the electrical grid to offset consumption.

non-renewable resource: A natural resource that cannot be replaced once it has been consumed. This applies particularly to fossil fuels, but it also describes other mineral resources that are present in fixed quantities in the earth. While new resources are continuously being created by natural processes, replacement may take millions of years, and society consumes them much more rapidly than they are replaced. Therefore, in human terms, these resources are basically non-renewable.

nuclear power: Electricity generated by using heat from a nuclear reactor to produce steam that powers a turbine.

photovoltaic (PV) cell: An electronic device, consisting of layers of semiconductor materials and electrical contacts, which can convert light directly into electricity (direct current).

power: The rate of doing work, or more generally the rate of converting energy from one form to another. See the definition of energy. Measured in watts (W). For example, an inverter rated at 800 watts can provide that amount of power continuously.

public benefits fund (PBF): Usually a program, funded through a small fee on electricity used, to fund various initiatives, such as low-income energy assistance, energy efficiency, consumer energy education, and renewable energy technologies development. Also known as a Systems Benefit Charge and System Benefit Fund.

pyrolysis: The thermal decomposition of biomass at high temperature in the absence of oxygen.

renewable energy: Energy from natural sources that are naturally regenerative and virtually inexhaustible. Generally includes wind, geothermal, water, biomass and solar power.

renewable portfolio standard (RPS): A mandate that ensures that renewable energy constitutes a certain percentage of total energy generation or consumption, usually within a specific state.

solar energy: Radiant energy produced in the sun as a result of nuclear fusion reactions. It is transmitted to the Earth through space by electromagnetic radiation, called photons, which interact with the Earth's atmosphere and surface. Extremely hot, the bulk of the radiation is high energy at ultraviolet and visible light wavelengths.

solar thermal energy: Energy produced by using the sun's rays to heat a gas or liquid that is used to generate steam, which powers an electrical generator.

subsidy: A financial benefit or form of assistance given to producers, usually in the form of grants, low-interest loans or tax allowances, which enables them to sell or export goods at less than their costs of production.

solar cell: See photovoltaic (PV) cell.

solar module: Generally a collection of PV cells, called a photovoltaic panel.

solar power: Electricity generated by conversion of sunlight, either directly through the use of photovoltaic panels, or indirectly through solar-thermal processes.

solar thermal: A form of power generation using concentrated sunlight to heat water or other fluid to produce steam that is then used to drive a motor or turbine.

solar energy: The radiant energy of the sun, which can be converted into other forms of energy, such as heat or electricity.

transmission system: An interconnected group of electric transmission lines and associated equipment for transferring large amounts of electricity between points of supply and points where it is transformed (or stepped down in power) for delivery over the distribution system lines to consumers or other electric systems.

turbine: Rotary engine that converts the energy of a moving stream of water, steam or gas into mechanical energy. Through the use of a wheel, or rotor, with paddles, propellers, blades or buckets to catch the flow, turbines convert the kinetic energy of fluids to mechanical energy, which is then transferred through a drive shaft to operate a machine, compressor or electric generators.

utility: A public or private company that supplies a basic service, such as electricity, gas or water, to the general public.

watt (W): A measurement of power, commonly used to measure electricity.

watt-hour (Wh): A measurement of electricity with respect to time. One watt-hour is equal to one watt being used for a period of one hour.

wind energy: Energy from moving air that is converted into electricity, by using the wind to turn electricity generators. Wind energy has a number of advantages over conventional forms of energy. It is pollution-free and renewable.

wind farm: A cluster of wind turbines (anywhere from a few to several hundred) for generating electricity, they are usually erected in areas where there is steady wind.

wind generator: A mechanical device used to produce electricity from the wind, usually driven by a wind turbine connected to it.

wind turbine: A device that converts wind energy into mechanical energy that is then used, most often, to drive electric generators.

wind power class: A classification method used to describe the usable wind resource (for electricity generation purposes) at a particular site. From a range of 1 to 7, a classification of 1 indicates the least amount of energy, while a classification of 7 indicates the greatest amount of energy.