

Careers in Renewable Energy

The promise of a clean, never-ending (renewable) power and fuel supply in the United States depends on our ability to harness energy from sources such as the wind, sunlight, organic matter, the Earth's internal heat, and rivers. However, making this promise a reality requires workers dedicated to leading this country toward a sustainable energy future. If you are considering a career in renewable energy, this fact sheet can start you on your way. It will provide you with information on each of the major renewable energy technologies, the types of jobs you might find in each technology, and resources to help continue your research.

Marketplace Trends

The renewable energy industry involves many political, economic, environmental, and technological factors that interact with

each other to influence marketplace trends. It is helpful to understand some of these factors because an increase in the market for a certain technology can equal an increase in job opportunities.

There is currently a movement to restructure the power industry. Driven partially by the Energy Policy Act of 1992, the movement intends to provide customers with the opportunity to choose their power provider by decreasing regulation of and introducing competition among utilities. Restructuring is primarily occurring on a state-by-state basis.

Many companies that sell energy produced from renewable sources view the move toward utility restructuring as a great opportunity. In fact, in many states, restructuring has given rise to the glimmerings of a new industry—*green power marketing*. The concept of green power marketing is based on the assumption that consumers will choose and pay more for renewable energy products/services that reflect their environmental values. Green power marketing programs put a price on the environmental value of a product to overcome the cost barrier that has historically limited the generation of renewable energy on a large scale.



Jim Yost Photography, NREL/PIX02021

Leading the United States toward a sustainable energy future requires workers with many different degrees and types of training.



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There are a wide variety of professions available in the renewable energy industry.

Green marketing pilot programs show that the demand for renewable power products in a competitive marketplace may be quite large. Consumer demand for green power—along with the progress of utility restructuring and proposed state and federal mandates/incentives for consumers and utilities to purchase green power—could substantially strengthen the renewable power industry. This, in turn, may further decrease costs of renewable power and increase the number of jobs available in the renewable energy industry.

In addition to domestic markets, international markets for renewable energy systems are growing. International markets are driven by large remote needs for electricity, growing environmental concerns, and in some cases, a limited availability of fossil fuels.

Job Opportunities

There are a wide variety of professions available in the renewable energy industry. This fact can make it challenging to find the right professional niche, but it also provides the opportunity for individuals with many different types and degrees of training to get involved with renewable energy.

Some jobs—such as those in communications, community outreach, sales/marketing, and business support (e.g., corporate planning and finance, accounting, human resources, law, and information technology)—can be found in almost every renewable energy field. Other jobs are specific to individual renewable energy technologies, as shown

in the following discussion of the five main renewable energy power sources: wind, solar, bioenergy, geothermal, and hydropower.

Wind Power

People have been using energy from the wind for hundreds of years. Windmills have been used for pumping water or grinding grain. And today, the windmill's modern equivalent—a *wind turbine*—can use the wind's energy to generate electricity. A single, small- or intermediate-sized wind turbine can generate enough electricity to power a house or farm, while a number of large, utility-scale wind turbines can form *wind plants* or *wind farms* that generate enough electricity for tens of thousands of homes.

As the cost of generating electricity from wind power continues to fall, many electricity providers are starting to view wind as an attractive, renewable alternative to fossil fuels (such as coal and natural gas), which are not renewable. The wind industry has grown at a rate of 25 percent per year, making wind power the fastest-growing source of electricity-generation in the world during the 1990s. Although Europe has experienced the majority of growth in the wind industry, the United States installed 905 megawatts (MW) of capacity in 1999—a record year for new wind projects. The nation's total wind capacity reached 2500 MW in December 1999 and is expected to approach 5000 MW by the end of 2001.

Jobs in Wind Power

The wind industry employs both professional and skilled workers in a number of different capacities. New wind projects require people with business, meteorological, and engineering experience to plan and build projects. Meteorologists help engineers identify appropriate sites with suitable wind conditions. Engineers then design the wind plant, working with the utility companies and communities. Construction workers are needed to build the wind plant. And mechanical and electrical technicians, called “windsmiths,” are required to operate and maintain the wind turbines.



Warren Gretz, NREL/PX02131

A certification test engineer measures the noise from a wind turbine.



Warren Gretz, NREL/PX09150

Scientists are needed to research and develop renewable energy technologies.

The growing demand for reliable electricity internationally has contributed to the growth of the U.S. PV industry.

Both industry and research laboratories constantly try to improve the design and efficiency of wind turbines. These research and development (R&D) groups generally employ mechanical, electrical, and aeronautical engineers with advanced degrees, as well as experienced technicians. However, others with technical backgrounds may also find jobs.

Solar Power

Anyone who has visited Florida in July knows that the sun can produce heat. And in 1839, French physicist Edmund Becquerel discovered that sunlight could also produce electricity (known as the *photoelectric effect*). Knowledge of the sun's ability to produce both heat and electricity has led to the invention of numerous technologies for capturing the sun's energy. The most common technologies produced and used in the United States today include photovoltaics, concentrating solar power (also known as solar thermal electric) systems, solar hot water systems, and passive solar building design.

Photovoltaics

Photovoltaic (PV) cells, also known as solar cells, produce electricity directly from sunlight. When a PV cell is exposed to the sun, the cell, which is made of semiconductor materials, absorbs a portion of the light that strikes it. If the energy from the absorbed light strikes electrons in the outer shell of an atom, these electrons are freed from their parent atoms. Free electrons can then travel into a circuit in the form of electricity. PV cells can be hooked together to meet many different types of electricity requirements, from pumping water to operating calculators and watches, and lighting homes and communities.

PV has traditionally been used in locations where it is expensive or impossible to send electricity through power lines. An increasing number of utility companies are experimenting with using PV to fill their small or more expensive power needs. Some homeowners and commercial building owners are integrating PV systems into their building designs to offset utility power demand and improve power reliability.

The growing demand for reliable electricity internationally has contributed to the growth of the U.S. PV industry—approximately 70 percent of PV systems manufactured in the United States are sold to other countries.

Concentrating Solar Power

Although the mechanics of each method differs, all three concentrating solar power (CSP) technologies—parabolic troughs, power towers, and parabolic dishes—use mirrors to focus incoming sunlight onto a receiver. The receiver collects the sun's energy in the form of heat, which can then be used directly or converted into electricity using a generator.

These technologies are currently in different stages of development. Troughs have a proven track record as a technology that can function effectively for large-scale power needs (such as those of a utility company) and are currently the least expensive way to produce solar electricity. Power towers have also demonstrated an ability to function on a large, utility scale, while parabolic dish systems, still under development, show promise for small-scale projects.



Warren Gretz, NREL/PX02336

A technician works on a concentrating solar power collector.

CSP technologies have caught the attention of some U.S. utility companies, as well as others interested in tapping into the projected consumer demand for green power supplies, even though the cost of using these technologies to generate electricity is still somewhat high.

Solar hot water systems are increasingly being installed in schools, hospitals, prisons, and other government facilities across the country.

Solar Hot Water

Energy from the sun can also be used to heat water for buildings and swimming pools. Solar water heating systems for buildings typically include a *solar collector*, in which fluid is heated by the sun, and a *storage tank*, which holds the hot fluid after it has been heated by the collector. Systems using fluids other than water require the additional step of passing water through a *heat exchanger* to heat the water. Swimming pool systems are very simple; they generally consist of collectors made of black plastic or rubber through which pool water is pumped to be heated.

Advances in solar hot water technology for buildings have dramatically cut the cost of solar water heaters from about \$.20 per kilowatt-hour (kWh) in 1980 to \$.08 to \$.10 per kWh in 2000. As a result, solar hot water systems are increasingly being installed in schools, hospitals, prisons, and other government-owned facilities across the country. However, the number of solar hot water systems purchased in the United States is still quite small compared to the number purchased in the rest of the world. In 1997, for example, Americans purchased approximately 25,000 systems. Of the systems purchased, the majority were for heating residential swimming pools.



Warren Gretz, NREL/PIX07164

Some architects specialize in passive solar building design.

Passive Solar Building Design

Building orientation, types of construction materials, glass selection, and architectural features all affect the overall energy performance of a building. For a passive solar building, designers consider these features early in the design process along with taking advantage of solar energy to heat and

light a building. They also design the building to be cool in summer.

It may cost more to design a passive solar building, but the savings achieved from decreasing the size of the mechanical and electrical systems to heat/cool and light the building, as well as energy cost savings, more than make up the difference.

Jobs in Solar Power

Growth of the solar power industry creates high-wage, skilled jobs throughout the country for individuals with many different types of training. R&D groups at national laboratories, universities, and private companies develop and continually improve solar products to lower their costs and improve their reliability. Individuals employed in solar R&D generally have professional degrees in electrical, mechanical, and chemical engineering; materials science, and/or physics. Many of the people involved with technologies that are still under development, such as parabolic dish systems, focus on R&D.

As each technology progresses from the R&D phase toward full-scale commercialization, an increasing number of both professional and skilled workers are needed to sell, manufacture, design, install, and maintain equipment. The PV and solar hot water industries currently employ the majority of these workers, including electricians, engineers, technicians, and technical managers. As utility-scale CSP technologies become commercially viable, the CSP industry will eventually require an increasing number of these workers, as well as engineers and construction workers to design and build power plants. The passive solar industry involves many of these professions as well, but also employs architects and builders.

Bioenergy

The energy stored in *biomass* (organic matter) is called *bioenergy*. People have been burning biomass, such as trees and straw, to cook and warm themselves for thousands of years. Today we not only heat 25 million homes with wood, we also produce 10.2 billion watts of electricity (less



Warren Gretz, NREL/PIX0284

Farmers and foresters grow energy crops for biofuel and biopower production.

than 1 percent of what we use as a nation) from wood waste and waste from other biomass. And we derive up to 0.4 percent of all our transportation fuels (about 1.5 billion gallons) from corn, which is used to produce ethanol.

While we have always used wood and other biomass for heat, the pro-

duction of electricity and fuels has grown from virtually nothing 20 years ago to what it is today, helping bioenergy become second only to hydropower as the largest source of renewable energy in the world. In addition, we use biomass instead of petroleum to produce between 11 to 15 billion pounds of consumer products, including plastics, glues, furniture, paints, and chemicals.

But as bioenergy technologies and biobased products stand poised to help achieve energy independence for our nation, the conversion of biomass into fuels and products still remains more difficult than the processes used for petroleum or coal.

Jobs in Bioenergy

Universities, national laboratories, and industry are working together to find solutions to the difficult problems surrounding the production and use of biomass for energy and products. These R&D efforts require chemists, agricultural specialists, microbiologists, biochemists, and engineers, just to name a few.

Biofuel, biopower, and biobased product plants are most cost-effective when located near their source of biomass. Thus, bioenergy industry development has a special appeal because it creates direct and indirect jobs in rural areas of the country, and may prove to be a profitable complement for many existing agricultural and forestry businesses.

Engineers and construction workers are needed to design and build bioenergy plants, while electrical/electronic and mechanical technicians, engineers (mechanical, electrical, and chemical), mechanics, and equipment operators are needed to run and maintain these plants. Some may even require individuals cross-trained in areas such as engineering and biology, or chemistry and agriculture.

Jobs in bioenergy today cut across a wide spectrum of specialties and skills. And if R&D and industrial efforts succeed in making bioenergy more commercially profitable, we may see a dramatic increase in the number of bioenergy-related jobs. We'll need more farmers and foresters to produce and harvest biomass resources, more truckers to transport the resources to the power and fuel plants, and more operators to run facilities.



David Parsons, NREL/PIX06881

A worker operates equipment at a generating station that burns wood to produce electricity.

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Geothermal Energy

Heat from the earth, called geothermal energy, is yet another renewable energy resource that people have used over the years. Geothermal energy heats water seeping into underground reservoirs, which can then be tapped for a variety of uses.



David Parsons, NREL/PIX01572

A worker monitors equipment operation at a geothermal power plant.

Low to medium temperature (70° to 225°F) water reservoirs can be used directly to heat buildings, grow and dry crops, melt snow on sidewalks, and for fish farms. This is called the *direct use* of geothermal energy. The energy produced from high temperature reservoirs (225° to 600°F) can spin a turbine to generate electricity.

Current drilling technology limits the development of geothermal resources to relatively shallow, water- or steam-filled reservoirs, most of which are found in the western part of the United States. Researchers are developing new technologies for capturing the heat in the deeper, “dry” rocks, which would support drilling almost anywhere.

Geothermal heat pumps (GHPs) allow us to take advantage of the Earth’s constant temperature (around 55°F) just a few yards beneath the surface to heat and cool buildings, and to produce hot water. GHPs transfer heat between the building and the ground by circulating fluid through underground pipes. Currently, the majority of GHPs produced in the United States are purchased domestically, primarily in the Midwest. But as technology improvements reduce the costs of installing GHPs, the demand for this technology will continue to grow throughout the country.

Jobs in Geothermal Energy

The geothermal industry employs both skilled workers and those with professional degrees.

Developing hot water reservoirs requires geologists, geochemists, geophysicists, hydrologists, reservoir engineers, mud loggers, hydraulic engineers, and drillers to locate, assess, and access the reservoirs.

Environmental scientists prepare environmental impact studies, and permit and leasing specialists obtain the land rights.

Geothermal direct-use technologies create jobs for heating engineers, and in the building and agricultural industries. For electricity production, engineers (electrical and mechanical) and construction workers—along with electrical technicians, electricians, electrical machinists, welders, riggers, and mechanics—are needed to design and construct power plants.

Mechanical engineers, geologists, drilling crews, and heating, ventilation, and air conditioning contractors are needed to manufacture and install GHPs. In addition, mechanical and electronic engineers, geologists, chemists, and materials scientists are required for ongoing R&D.



Warren Greiz, NREL/PIX05683

A fish farmer uses a net to catch fish, which are raised in geothermally heated waters.

The geothermal industry employs both skilled workers and those with professional degrees.

Hydropower

Hydropower, which uses the energy of flowing water to produce electricity, is the largest and least expensive source of renewable energy produced in the United States today. In fact, hydropower now generates approximately 10 percent of the electricity used in our country (wind, solar, geothermal, and biomass combined produce less than 1 percent). Most hydropower projects use a dam and a reservoir to retain water from a river. When the stored water is released, it passes through and rotates turbines, which spin generators to produce electricity.

The hydropower industry now also employs environmental scientists to assess environmental impacts and address environmental remediation.

Water stored in a reservoir can be accessed quickly for use during times when the demand for electricity is high. Other hydropower plants, called “run of the river” projects, do not require dams. Instead, a portion of a river’s water is diverted into a canal or pipe to spin turbines.

Many large-scale dam projects have been criticized for altering wildlife habitats, impeding fish migration, and affecting water quality and flow patterns. As a result of increased environmental regulation, the National Hydropower Association forecasts a decline in hydropower use through 2020. R&D efforts have succeeded in reducing many of these environmental impacts through the use of fish ladders (to aid fish migration), fish screens, new turbine designs, and reservoir aeration. Although funding has been limited, current research focuses on the development of a “next generation turbine,” which is expected to further increase fish survival rates and improve environmental conditions.

Jobs in Hydropower

As with many of the other renewable energy technologies, the design, construction, and maintenance of hydropower plants requires electrical and mechanical engineers, technicians, and skilled workers. If the hydropower project also

involves managing the reservoir and the surrounding land, the developer will also hire recreation planners, resource managers, and educators. In addition, state and federal licensing laws now require current or prospective hydropower plant developers to assess the environmental effects of their operation. Thus, the hydropower industry now also employs environmental scientists (biologists, hydrologists, ecologists, and wildlife habitat specialists, for example) to assess environmental impacts and address environmental remediation. Environmental scientists, as well as engineers, also participate in R&D efforts through private companies, national laboratories, and universities.

A career in renewable energy is a valuable way for individuals with a wide range of skills and interests to help guide the United States toward a secure, environmentally conscious energy future. For more information on energy careers, specific renewable technologies, and market forecasts, consult the resource list below.

Resources

The following resources may provide more information on renewable energy technologies and careers. This list does not cover all the available resources on renewable energy technologies and careers, nor is the mention of any resource to be considered a recommendation or endorsement.

Energy Efficiency and Renewable Energy Clearinghouse (EREC)

P.O. Box 3048
Merrifield, VA 22116
Phone: 1-800-DOE-EREC (1-800-363-3732)
Fax: (703) 893-0400
E-mail: doe.erec@nciinc.com
Web site: <http://www.eren.doe.gov/consumerinfo/>

Provides free general and technical information to the public on the many topics and technologies pertaining to energy efficiency and renewable energy.

Organizations

American Bioenergy Association

1001 G. Street, N.W., Suite 900 E.
Washington, D.C. 20001
Web site: <http://www.biomass.org/>

Promotes the economic and environmental benefits of biomass utilization.

American Solar Energy Society (ASES)

2400 Central Avenue, Suite G-1
Boulder, CO 80301
Phone: (303) 443-3130
Fax: (303) 443-3212
E-mail: ases@ases.org
Web site: <http://www.ases.org/>

A solar energy information source for everyone, from homeowners to public officials.

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American Wind Energy Association (AWEA)

122 C. Street, N.W., Suite 380
Washington, D.C. 20001
Phone: (202) 383-2504
Fax: (202) 383-2505
E-mail: windmail@awea.org
Web site: <http://www.awea.org/>

Advocates the development of wind energy.

Energy Information Administration (EIA)

U.S. Department of Energy
ER-30
1000 Independence Avenue, S.W.
Washington, D.C. 20585
Phone: (202) 586-8800
E-mail: infctr@eia.doe.gov
Web site: <http://www.eia.doe.gov>

Provides energy data and analyses to assist businesses, government, and the public in understanding energy issues.

Environmental Careers Organization

179 South Street
Boston, MA 02111
Phone: (617) 426-4375
Web site: <http://www.eco.org/>

Works to enhance the development of environmental careers through internships, career advice, career products, and research and consulting.

Geothermal Education Office

664 Hilary Drive
Tiburon, CA 94920
Phone: 1-800-866-4436
Fax: (415) 435-7737
E-mail: geo@marin.org
Web site: <http://geothermal.marin.org/>

Along with other educational resources, offers useful information on geothermal careers.

Geothermal Energy Association (GEA)

209 Pennsylvania Avenue, SE
Washington, D.C. 20003
Phone: (202) 454-5261
Fax: (202) 454-5256
E-mail: geo@geo-energy.org
Web site: <http://www.geo-energy.org/>

A trade association of U.S. companies who support the expanded use of geothermal energy.

Geothermal Resources Council (GRC)

P.O. Box 1350
2001 Second Street, Suite 5
Davis, CA 95617-1350
Phone: (530) 758-2360
Fax: (530) 758-2839
E-mail: grc@geothermal.org
Web site: <http://www.geothermal.org/index.html>

Serves as a focal point for the continuing professional development of its members.

National Hydropower Association (NHA)

1 Massachusetts Avenue, N.W., Suite 850
Washington, D.C. 20001
Phone: (202) 682-1700
Fax: (202) 682-9478
E-mail: info@hydro.org
Web site: <http://www.hydro.org/>

Seeks to secure hydropower's place as a reliable and renewable energy resource that serves national environmental and energy policy objectives.

Renewable Fuels Association

1 Massachusetts Avenue, N.W., Suite 820
Washington, D.C. 20001
Phone: (202) 289-3835
Fax: (202) 289-7519
E-mail: info@ethanolrfa.org
Web site: <http://www.ethanolrfa.org/>

Works to expand the production and consumer use of renewable fuels.

Solar Energy Industries Association (SEIA)

1616 H. Street, N.W., 8th floor
Washington, D.C. 20006-4999
Phone: (202) 628-7745
Fax: (202) 628-7779
Web site: <http://www.seia.org/main.htm>

Puts out information on solar careers approximately every three years and sometimes posts employment opportunities on its Web site.

Web sites

Energy Career Guide

Energy Education Online
Web site: <http://www.energied.ecw.org/career.html>

Provides information on energy careers, schooling, employers, and books.

Energy Efficiency and Renewable Energy Network (EREN)

U.S. Department of Energy
Web site: <http://www.eren.doe.gov/>

Provides access to hundreds of links and thousands of documents on energy efficiency and renewable energy topics.

Occupational Outlook Handbook

U.S. Department of Labor
Superintendent of Documents
P.O. Box 371954
Pittsburg, PA 15250-7954
(202) 512-1800
Web site: <http://stats.bls.gov/ocohome.htm>

Provides general information on a wide variety of careers, including those in renewable energy. A hard copy may be ordered by calling the phone number or writing to the address above.

Solstice

Center for Renewable Energy and Sustainable Technology (CREST)
Web site: <http://solstice.crest.org/index>

Contains general renewable energy resources, including a directory of energy-related graduate school programs.