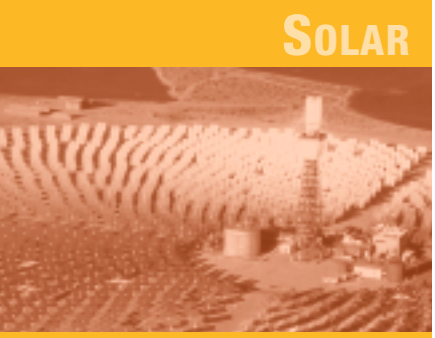
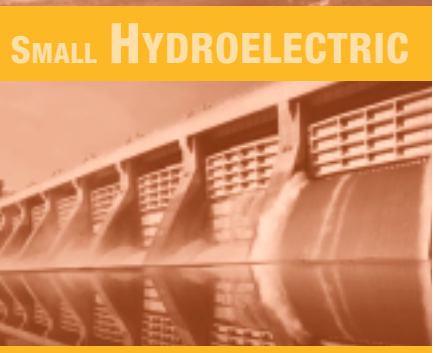
Renewable Energy

by Kent S. Markle

When you plug an electrical appliance into the wall socket, do you know where your electricity comes from? Probably the local public utility company. But how does the utility company generate the electricity you use at home? If it is like most power companies, it produces electrical power by burning fossil fuels—coal, natural gas, or oil—to make steam, which turns turbines to generate electricity at the power plant. To take one example of dependence on these three types of fossil fuel, in the United States in 1988, 88 percent of all the electricity generated came from coal, natural gas, and oil. They are non-renewable fuels, originating from organic matter of the late Paleozoic Era (several hundred million years ago) and estimated by most scientists to run out during this century. When coal, natural gas, and oil supplies are depleted, how will people see to read at night? What will power their cars, airplanes, buses, and trains? What will provide electricity for their computers and factories? Fortunately, there are renewable, alternative sources of energy for electricity and transportation that have well-developed technology.





Some renewable energy sources are well known and already in wide use. For example, hydroelectric power is generated by water in dams. In the U.S., hydroelectric power provides 10 percent of all electricity. Other alternative sources of energy are not well known to the public or are still in the developmental stages. The World Energy Council has identified six sources of energy to pursue as alternatives to non-renewable fossil fuels:

Solar (energy from the sun's rays)

Wind (energy from moving air)

Geothermal (energy from heat inside the earth)

Modern biomass (energy from plant and animal residue)

Ocean (energy from seawater movement and temperature changes)

Small hydroelectric (energy from small dams, such as those filled by melting snow)

It is worth pointing out why large hydroelectric (large dams that block rivers) and traditional biomass (firewood and charcoal) were excluded from the Council's focus. These two renewable sources of energy often cause environmental problems and other adverse effects. Large hydroelectric projects usually require long planning and construction, which delays their benefit, and sometimes results in social problems, such as displacement of people living near rivers that are dammed. Traditional biomass (burning trees) results in air pollution and deforestation. A combination of these six other alternative sources of energy may prove to be our best hope to fill the energy void created as supplies of fossil fuels gradually diminish.

History

Since the early days of the Industrial Age, industries and utility companies have relied on a variety of different sources of power. The Danes were pioneers in wind-generated electricity, building over 100 systems in 1890 to capture the North Sea winds. Coal was the fuel of choice for steam-powered engines, which were widely used in manufacturing and transportation. In fact, in the 1890s, more electric- and steam-powered cars were sold than those using gasoline. The world's first geothermal electric plant was built in Italy in 1904. Surprisingly, photovoltaic (solar) cells were built as early as the 1880s, but it wasn't until Bell Labs developed silicon cells in 1954 that solar cells could be used efficiently. In 1958, the Vanguard satellite was equipped with solar photovoltaic cells. The world's first power plant using the ocean's tides was built in France in 1966.

The global energy situation began to change significantly in the second half of the last century. For example, in the U.S., from 1950 to 1995, coal virtually disappeared as a heating source for homes. By 1995, natural gas was used for heat in over 50 percent of U.S. homes, and electricity was used in 27 percent of them. In about the same time frame, per capita electricity consumption rose by over 1,000 percent. Widespread ownership of energy-hungry appliances such as air conditioners, refrigerators, and clothes dryers contributed to this huge growth in energy consumption, while individual automobile ownership created a heavy demand for new petroleum supplies. By 1958, the U.S. had begun to consume more fuel of various kinds than it produced. Oil prices per barrel rose from about $5 in the 1960s to over $17 in October 1973, and further production limitations caused the price to rise to about $34 in 1981.

By the mid-1980s, geologists and other scientists began to make predictions about how long the world's petroleum supplies would last. By estimating future rates of oil consumption, then taking into account the amount of proven petroleum reserves, they calculated that supplies could last between 50 and 100 years longer. Of course, their calculations can vary depending on fluctuations in consumption and discoveries of new oil fields. Nuclear power, which had once been the energy hope of the future, no longer seemed so attractive after accidents at Three Mile Island in the U.S. in 1979 and Chernobyl in the Soviet Union in 1986 changed the public's perception of its safety. France has continued to operate nuclear plants for 75 percent of its electricity, with a good safety record, however, other countries have scaled back plans for building nuclear generating facilities, and the disposal of spent radioactive fuel remains a problem.

Recent developments

The future is bright if new technologies in alternative fuels are exploited wisely around the world. Every country can meet the challenging energy demands of the future if national and local governments dedicate themselves to building power plants that use these renewable energy sources. In the U.S., following the creation of the Department of Energy in 1977, several important renewable energy sources were developed for industrial and residential power. In 1980, a geothermal plant that generates 10 megawatts of electricity was built in Brawley, California. Also in California in the early 1980s, more than 15,000 large wind generators with a combined capacity of 1,300 megawatts were installed near Palm Springs. The first commercial synthetic gas plant began operation in the state of North Dakota in 1983. After federal and state laws were passed giving tax credits for renewable energy users, manufacturing and shipments of solar panels increased by over 500 percent between 1982 and 1996. Tougher pollution laws gave an extra incentive to produce cleaner energy.

However, a drop in oil prices in the mid-1980s combined with government leaders more friendly to oil and gas companies than to alternative energy development policies led to the expiration of tax credits for solar collectors and the shutdown of the two largest solar dish plants. Still, there were signs for hope. By 1990, over 100 landfill methane power plants were in operation. Concerns about pollution and global warming have given operators of alternative energy plants added public support.

Let's take a closer look at how various renewable energy technologies are being used around the world and how they might be used more widely.

Solar

Ultimately, almost all energy comes from the sun. The energy stored in coal, oil, and natural gas is the result of photosynthesis carried out by plants that lived hundreds of millions of years ago. Wind energy is actually the movement of the atmosphere driven by the heat from the sun. Currently solar energy is used two ways: for heat (thermal) and to generate electricity (photovoltaic). Solar rays can be directly thermal in two ways: actively as can be seen in the thousands of rooftop water heaters throughout Italy and Greece, and passively with proper design of homes and buildings. Improvements in photovoltaic (or solar electric) panels continue to make this technology more applicable, especially for developing countries without widely established power grids that transport electricity generated at large public utilities. Increased efficiency of converting sunlight to electricity, using thin film silicon panels or copper indium thin film, has been an ongoing goal of several manufacturers of solar energy technology.

Opposite from the top left:

A Solar powered electric generation facility in Barstow, CA ©PhotoDisc

A Wind powered electric generation facility outside of Palm Springs, CA ©PhotoDisc

A Geothermal electric generation facility in the mountains of California ©AP/WideWorld Photo

A Sugarcane crop being grown for conversion to ethanol and other types of biomass. ©AP/WideWorld Photo

An inexhaustible supply of energy from ocean water movement and temperature changes yet to be developed ©PhotoDisc

A small hydroelectric facility harnesses water power without the significant impact on the surrounding environment of major dams ©PhotoDisc

Right:

An experimental array of solar reflectors designed to maximize the energy from sunlight throughout the day ©PhotoDisc

Benefits of Renewable Energy Not Captured in Standard Economic Accounts

Social and economic development: Production of renewable energy, particularly biomass, can provide economic development and employment opportunities, especially in rural areas, which tend to have limited opportunities for economic growth. Renewable energy can thus help reduce poverty in rural areas and reduce pressures for urban migration.

Land restoration: Growing biomass for energy on degraded lands can provide the incentives and financing needed to restore lands rendered nearly useless by previous agricultural or forestry practices. Although lands farmed for energy would not be restored to their original condition, the recovery of these lands for biomass plantations would support rural development, prevent erosion, and provide a better habitat for wildlife than at present.

Reduced air pollution: Renewable energy technologies, such as methanol or hydrogen for fuel-cell vehicles, produce virtually none of the emissions associated with urban air pollution and acid deposition, without the need for costly additional controls.

Abatement of global warming: Renewable energy use does not produce carbon dioxide and other greenhouse emissions that contribute to global warming. Even the use of biomass fuels will not contribute to global warming: the carbon dioxide released when biomass is burned equals the amount absorbed from the atmosphere by plants as they are grown for biomass fuel.

Fuel supply diversity: There would be substantial interregional energy trade in a renewable-intensive energy future, involving a diversity of energy carriers and suppliers. Energy importers would be able to choose from among more producers and fuel types than they do today and thus would be less vulnerable to monopoly price manipulation or unexpected disruptions of supplies. Such competition would make wide swings in energy prices less likely, leading eventually to stabilization of the world oil price. The growth in world energy trade would also provide new opportunities for energy suppliers. Especially promising are the prospects for trade in alcohol fuels such as methanol derived from biomass, natural gas (not a renewable fuel but an important complement to renewables), and in the future, hydrogen.

Excerpted from Chapter 1 of *Renewable Fuels and Electricity for a Growing World Economy,* edited by Johansson, Kelly, Reddy and Williams, 1993, Island Press.

As technology has improved, the cost of using solar energy has dropped. In 1996, the average price of solar panels was one-tenth what it was in 1975. However, one concern about widespread use of solar panels to generate the large amounts of electricity needed for industries and cities is the environmental impact—they take up a lot of space and are highly visible. But this is an acceptable trade-off because solar energy is totally clean and panels have a long lifespan. Panels are also easy to maintain for there are no moving parts, only moving electrons!

A more serious concern for widespread use is that solar energy is an intermittent energy source, as are wind and tides. Therefore, storage of excess energy or backup sources of energy are needed for times when there is not adequate sunshine for the panels to function efficiently. Improved battery technology has made use of photovoltaic panels easier for users in remote areas who live "off the grid" of the public utility company and need to store excess power. In some areas, users of solar panels who are connected to the grid may sell back any surplus power to the public utility company.

Development of thin film technology has made solar power viable for use in some forms of transportation (see Prospects for Transportation below). For all its advantages, however, solar power remains the least used of the main alternative energy sources.

Opposite from top:

Generators inside a hydroelectric Plant ©PhotoDisc

Livestock's indifference to wind powered electric generators allows for the multiple use of land ©PhotoDisc

Below:

An Ohio state official fills up with ethanol in a state owned vehicle that has been fitted with special cylinder heads and fuel injectors to run on ethanol, gasoline, or any combination of the two fuels. ©AP/WideWorld Photo

Modern Biomass

Biomass simply means fuel produced from organic sources. Traditional biomass such as wood, charcoal, and other plant matter has been the fuel of choice for thousands of years, and it remains so in many parts of the world. Modern biomass, however, includes other types of fuel derived from plants, such as the residues of existing agricultural, livestock, and lumber industries, from forests planted and harvested renewably, and from farms dedicated to this purpose.

Biomass needs to be produced on a sustainable basis, whether on deforested lands or on excess agricultural land, and never from virgin forests. Some of the most suitable locations are areas where widespread deforestation has already occurred, but there are still other possible sources of biomass. For example, residues from the processing of pulpwood, cereals, and logging operations can be processed into gas or burned in power plants to generate electricity. Methane from urban landfills and from animal and human wastes is another potential type of fuel derived from biomass, although the derivation of fuels from landfills requires the labor-intensive separation of various materials.

As an alternative to non-renewable energy sources, modern biomass may have the greatest potential for growth, especially in transportation and powering vehicles. For example, Brazil has been a leading nation in the use of ethanol (alcohol-based fuel) for automobiles. It is derived from sugar cane and grains grown specifically to produce ethanol. Biomass also looks promising as a fuel source for electricity if it is burned in small, local power stations.

Small Hydroelectric

The high capital cost and environmental and social impact of large hydroelectric power plants (large dams) have made small hydroelectric power (SHP) an attractive alternative in recent years. Rather than building huge dams with lakes behind them that submerge entire towns or beautiful rivers and canyons, some countries have opted to generate electricity using small hydroelectric power plants. Switzerland has used the power of melting snow running off the Alps for years. According to a UNESCO survey conducted in China, about 800 of its 2,300 counties can be electrified using SHP and the government is giving preferential loans and tax exemptions to SHP developers.

Other countries are giving assistance for the development of small hydroelectric power. In Nepal, the government is providing loans and materials to SHP equipment manufacturers, and in Pakistan, the Ministry of Science and Technology has subsidized SHP construction. Similar efforts are occurring in the Andean region of Latin America and in Canada. All of these places are especially suited for small hydroelectric power generation because they have high mountain ranges. As the engineering and equipment required for SHP become more widespread, other countries with mountains and rivers should be able to take advantage of this clean source of electricity.

Wind

The use of wind energy is growing faster than any other type of renewable energy because of improvements in wind turbine technology over the past 20 years. The best locations for wind as an energy source are coasts, mountains, and plains. Like solar rays, wind is also a form of intermittent renewable energy, available only about 30 percent of the time. Often, when the sun isn't shining, the wind is blowing, so many users rely on wind turbines to complement solar panels.

Most of the world's wind generation capacity is located in the United States, Denmark (the pioneer in wind generation), the Netherlands (famous for its use of windmills), Germany, and India. While wind generation of electricity is clean, some disadvantages include the noise of the blades of windmills and the appearance. A large wind farm on a hillside is clearly visible, in the same way that large arrays of solar panels are. People who rely on wind-generated electricity, however, may not mind the view of clean energy being created.

Web Sites of Interest

World Energy Council
http://www.worldenergy.org/

This Web site contains information on the Council's Energy Data Center, events, and publications. A well-organized site, it includes sections on energy resources and technology, markets in transition, worldwide reserves, and production and consumption of both fossil and renewable fuels.

World Council for Renewable Energy
http://www.world-council-for-renewable-energy.org/

This Web site includes information on another energy council and its publications, including an easy-to-download action plan for the proliferation of renewable energy and the formation of the Group of Renewable and Efficient Energy Nations (Green Nations).

Energy Information Administration
http://www.eia.doe.gov/

The EIA's site includes data on production, prices, and consumption of petroleum, coal, and renewable and alternative fuels. It includes a twice-weekly "World Energy Update" and also has dozens of informative tables and graphs on specific renewable energy topics.

Energy Efficiency and Renewable Energy Network
http://www.eren.doe.gov/

EREN describes its site as a comprehensive resource for the U.S. Department of Energy on energy efficiency and renewable energy information. It features access to more than 600 links and 80,000 documents, and sections on efficient technologies and renewable energy sources, including hydrogen, ocean, wind, geothermal, hydropower, and solar.

Center for Renewable Energy and Sustainable Technology
http://www.crest.org/index.html/

In conjunction with the Renewable Energy Policy Project, CREST reports on energy issues, works to improve energy policy, and studies the job creation potential of renewable energy.

Chelsea Green
http://www,chelseagreen.com/

This Web site of the largest publishers of books on sustainable living lists many books and has 332 links to other useful Web sites.

Above:

Turbines convert the geothermal steam (176° C/350° F) into mechanical energy to drive electric generators in this power generation facility in the Calpine Sonoma region of California. ©AP/WideWorld Photo

Opposite from top:

Photovoltaic panels provide not only power but shade for passengers on this unique solar and wind powered boat, The Solar Sailor, in Sydney, Australia. It also has a propane powered back-up generator. ©AP/WideWorld Photo

Sunswift II, an entry by the University of South Wales, is seen here in traffic with conventional internal combustion engine cars as it attempts a record for 3,010 kilometers (1,870 miles) across Australia from Darwin to Adelaide in the World Solar Challenge car race. To cross the continent in less than a week, solar powered vehicles must average a speed of 91 kph (55 mph). ©AP/Wide-World Photo

Geothermal

Geothermal energy, or heat from the earth in the form of steam, has been used for many years for heating buildings. Geothermal energy is renewable only if the water that brings the heat to the surface as steam is replenished. A recent application of geothermal heating is in greenhouses. For example, a large flower-growing operation in the state of New Mexico uses geothermal energy to heat over ten hectares of greenhouses in the winter so that roses will be available for sale during major holidays in February (Valentine's Day), March or April (Easter), and May (Mother's Day).

In addition to heating, geothermal electrical generating facilities have been installed in over 20 countries and the potential for many more exists worldwide.

Ocean

The sea could provide an abundant supply of renewable energy, but the large engineering challenges and negative effects on the ecology of coastal areas have limited its use. Thermal gradients, or currents caused by varying temperatures in the water, have the greatest potential as a source of renewable energy, especially in tropical areas. Large heat exchangers are required to capture the energy of thermal gradients. Tidal energy has the widest present application, because it uses dams and turbines similar to those now in use for hydroelectric power plants. The constant movement of the waves is the third possible form of energy from the ocean. Ocean energy has vast promise for the future but will need financial support from governments and cooperation between neighboring countries to handle the large start up costs and to overcome the negative environmental impact on bays, marshes, beaches, and marine animals.

Prospects for Transportation

Most present forms of transportation run on fossil fuels, in particular petroleum-based fuels. Most automobiles burn gasoline, commercial airplanes burn jet fuel, and most large trucks and trains burn diesel fuel. How will this huge sector of global transportation propel itself when petroleum reserves run out? What about the other uses of oil? More than one petrochemical engineer has observed that petroleum is far too useful a substance to be wasted on transportation needs, which can be met using other sources of energy. Many chemical compounds and plastics, however, can be manufactured only from petroleum.

Support for alternative transportation modes as a way to reduce reliance on fossil fuels is growing. The Race Across Australia, in which solar-powered cars cruise in excess of 80 kph (50 mph), has provided an incentive to designers to develop improved engineering techniques. Already electric cars, actually hybrid vehicles that combine gasoline engines and electric motors, are being manufactured and marketed by Toyota and Honda. Improvements in battery technology, making them lighter and more efficient, will help

make electric cars more attractive to the public. Certainly, electric buses and streetcars, which used to be common in many cities of the world, may need to be reintroduced. Of course, this suggests that more people will need to use public transportation, especially in countries where there is an overreliance, even infatuation, with private cars, such as the United States. Increased use of electric vehicles will require generating more electricity, which can be done using renewable fuels, thus helping to reduce consumption of fossil fuels and at the same time reducing the air and noise pollution caused by internal combustion (gasoline and diesel) engines.

Where Do We Go from Here?

What will it take for renewable energy sources to be exploited on a wider basis? International cooperation, through such organizations as the World Energy Council, is needed to coordinate policy planning, research and development, and economic assistance efforts. Also, changes are needed in the way that electric utility companies, petroleum companies, and automobile manufacturers operate.

Electric utility companies need to act as energy distributors as much as producers. They can integrate new renewable energy technologies into existing grids and ensure that new equipment is properly designed and efficiently connected. Large oil companies could also act as brokers for renewable fuels from diverse markets, for example, by helping to start biomass plantations on deforested or overgrazed lands in countries where they currently drill for oil. These international corporations could benefit local communities by providing jobs, engineering skills in chemical processing, and capital in exchange for the product they would market. Automobile manufacturers will need to make changes in existing practices by increasing their support for research and development of alternatives to gasoline cars and by making a genuine commitment to design changes to improve fuel efficiency.

Other renewable sources of energy, such as hydrogen-powered cars, are not yet sufficiently developed to meet the growing world demand for energy. But clearly, the production of vast amounts of energy using technology that exploits renewable sources will be needed as the world enters the inevitable post-fossil fuel future.

Glossary

biomass (bio=life) fuel produced from living organisms, e.g. plant matter or methane

derivation taking from, e.g. the derivation of fuels from landfills

emissions materials or radiation given off, e.g. air pollution emissions

facilities buildings and factories, e.g. electricity generating facilities

fluctuations changes or variations, e.g. seasonal fluctuations in heating oil use

fossil fuels fuels created at the same time as the fossils around them, about 230 to 180 million years ago, e.g. coal, oil and natural gas, also known as "non-renewable" fuels

geothermal (geo=earth, therm=heat) heat from the earth

grid the network of electric power supply lines

hydroelectric (hydro=water) electricity from water

incentive a reason to do something, e.g. money or laws

intermittent part-time, on and off, e.g. solar and wind energy

photovoltaic (photo=light, volt=electricity) electricity from sunlight, e.g. photovoltaic (solar) panels

renewable something we can grow or collect more of, e.g. wood or sunlight

replenish to replace or put back, e.g. replenish the water in geothermal reservoirs

residue that which remains, leftovers, e.g. the residue from logging operations is small bits of wood, branches and twigs, and sawdust

viable practical or able to be done, e.g. solar power is viable for most desert regions

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