ALTERNATIVE ENERGY IS the generation of power from nontraditional sources as opposed to sources such as coal and oil. The main sources of alternative energy are hydropower, wind, solar, hydrogen, bioenergy, geothermal, and hybrid technology. Currently, the most prodigious source of alternative energy is produced by large-scale hydroelectricity schemes, which account for 16 percent of the world supply of energy. By comparison, the other sources combined generate approximately 4 percent.

**HYDROPOWER**

Hydropower is produced by constructing a dam wall across a river to create a reservoir. The stored water is then released through turbines built into the dam wall, generating electricity. Although the generation of hydroelectricity does not produce any climate-changing emissions, the construction of large dams does cause significant environmental and social problems. When completed in 2009, the Three Gorges Dam in China will be the world’s largest hydroelectricity scheme and able to generate 18,200 megawatts of power. However, the project will create a reservoir that is 412 miles (159 kilometers) long and will inundate 13 cities, submerge ancient archaeological and tourist sites, and make up to 1.2 million people homeless.

At an environmental level, a hydro-dam drastically changes the landscape and local hydrological processes. A dam hinders the movement of fish upstream, preventing them from spawning; downstream, less silt moves through the river system, starving the land of valuable nutrients. In heavily degraded landscapes, this loss of silt can be beneficial in reducing the need for dredging river estuaries. Another environmental impact of hydro technology is cold water pollution, in which the water in the deeper parts of the reservoir, normally at the dam wall, is significantly colder than at the surface. This temperature change has caused fish kills.

**WIND POWER**

Wind power is generated by the force of the wind, which spins rotor blades attached to a turbine. Modern wind turbines can be up to 305 feet (93 meters) tall with rotor diameters larger than the wingspan of a jumbo jet (210 feet [64 meters]), and which at full power can generate enough energy to power more than 500 homes. It is a very clean and efficient method of generating power, producing zero emissions of climate-changing gases, and it competes relatively well on price with other sources of traditional sources of power.

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The clean, efficient nature of wind energy has seen a rapid expansion in the development of wind farms. Energy generated by wind grew by 28 percent in 2004, and is the second-fastest growing source of alternative energy in the world. Consequently, major companies including General Electric and Siemens are now investing in the wind industry, ensuring that the cost of production becomes even more competitive with traditional forms of energy.

Wind energy is not without its critics. Due to the many social and political issues raised by the prospect of wind farming, including the availability of suitable sites, visual impacts, competing land pressures, and noise pollution fears, wind farms are increasingly being built offshore. Energy outputs can also be 50 percent higher offshore than onshore. The largest offshore wind farm in the world is the Horns Rev development in Denmark, a central plank in Danish government plans to cut carbon dioxide emissions by 50 percent, to 1988 levels, by 2030.

**SOLAR ENERGY**

Solar energy is created by harnessing the power produced by the sun, and can be generated in three ways. First, passive solar power manages natural light entering a building. Through the application of a combination of strategies, including correct building orientation and insulation, the temperature inside a structure can be maintained at a more comfortable level. This reduces the need for energy hungry air-conditioners and heaters.

Second, active solar power absorbs the sun’s heat through solar-thermal concentration systems. The most common concentration system is a solar hot water heater. Unfortunately, these systems are not highly efficient, and during winter in many parts of the northern hemisphere, a backup supply of electricity may be required.

A third, more efficient form of solar energy is generated in photovoltaic (PV) cells, which convert the energy captured from the sun into electricity. Until recently, PV cells had not made a large contribution to the alternative energy market because of their low conversion efficiency and relatively high cost. However, recent technological advances in PV efficiency have resulted in staggering improvements and
growth in its use. Between 2000 and 2004, grid-connected solar PV energy generation grew by 60 percent, and is now the fastest-growing alternative energy industry in the world.

Developments, including “thin-film” PV technology, allow any surface, such as the roof of a house, to be converted into a solar-electric power source. As of 2004, over 400,000 rooftops in Japan, Germany, and the United States were generating power in this way.

HYDROGEN

Hydrogen has been described by Royal Dutch Shell as the ultimate fuel source with the potential to revolutionize society’s use of energy. Hydrogen is the most common element in the universe, and is found in water and all living things. It can be produced in many ways, including through partial oxidation from fossil fuels such as gas and from renewable sources such as wind or the sun.

When hydrogen is used in a fuel cell, the only emissions are water. As an energy carrier, meaning it can be stored, hydrogen can be used in portable devices such as cars or buses. Shell suggests that vehicles powered by hydrogen fuel cells are 40–60 percent energy-efficient compared to internal combustion engines, which only use 30 percent of their fuel energy.

Iceland is pioneering the use of hydrogen as an alternative energy and plans to have the world’s first “hydrogen economy” by 2050. In Iceland, there is strong political support, a relatively small population, and a well-developed alternative energy sector (principally hydro and geothermal), which have collectively primed the conditions for the government to make significant energy changes. Iceland plans to convert all of Reykjavik’s buses to hydrogen by 2013 and begin conversion programs of its entire fishing fleet in 2015. In Regina, Canada, a trial to extract hydrogen from landfill gases by solar energy has begun, and is designed to reduce greenhouse gas emissions by 2,205 pounds (1 tonne) per household per year.

The fundamental challenge in the transition to a hydrogen-based energy system is that although hydrogen is ubiquitous, releasing it and storing it in a usable form requires energy inputs, which must come from other sources. As long as these are conventional sources (oil and gas), the switch to hydrogen represents only a modest change in the overall structure and environmental impact of the energy economy. Accompanied by a switch to a set of alternative sources, however, hydrogen offers a high potential source. And while new infrastructure is also required in order to make hydrogen readily available to the public, the Tyndall Centre for Climate Change Research, a British think-tank, argues that such problems can be overcome—and that with the right levels of investment in infrastructure, high numbers of vehicles could be potentially powered by hydrogen by mid-century.

From a social perspective the introduction of a hydrogen economy has the potential to have a profound impact. With the right infrastructure, any country can produce hydrogen. This would allow the world to operate on a more energy even footing and give poorer countries access to power currently denied them.

BIOENERGY

Bioenergy fuels are an alternative source that can also greatly reduce climate-changing emissions from vehicle use. There are two key types of bio-fuels: ethanol and bio-diesel, and both can be produced from a number of food stocks including sugar, soybeans, corn, and wheat. Brazil is the largest producer of ethanol products and operates over 300 distilleries, accounting for 50 percent of global exports.

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Ethanol is generally used as a 10 percent blend with gasoline (petrol) and can be used in most vehicles without the need for engine modifications. Specially designed “flex-fuel” vehicles operate with 85 percent ethanol; there are currently 4 million such vehicles in North America. Cellulose ethanol is made from nonfood stock such as straw, and as such does not compete with the food industry.

The increased use of bio-fuels by the developed world is having significant environmental and social impacts on developing countries such as Brazil. Large swaths of tropical rainforest in the Amazon Basin are being cleared to grow soybeans and sugarcane for ethanol production. This is causing significant biodiversity loss, degrading water quality, and having a negative impact upon the region’s indigenous peoples, who rely on healthy, intact forests. Moral debates are also discussing the ethics of burning an edible food source for fuel while millions of people around the world face famine.

Bio-diesel is produced from a chemical reaction between vegetables and oil. Bio-diesel has similar properties to petroleum diesel fuel, but has 85 percent fewer cancer-causing agents. It is most commonly used as a 20 percent blend with petro-diesel. France is the largest user of bio-diesel, where it is commonly used for heating and mixed as a 50 percent blend with petro-diesel to power vehicles.

Biomass energy refers to the generation of power resulting from the burning of organic materials, such as agricultural and household waste in an energy-for-waste energy power station. While the use of biomass greatly reduces the amount of waste deposited at landfill sites, there is concern at the levels of carbon dioxide and methane released as a consequence of burning organic materials.

**HYBRID TECHNOLOGY**

Hybrid technology can significantly reduce carbon dioxide emissions from vehicle use. A hybrid vehicle is one that is powered using a mixture of gasoline and electric sources. There are several different types of hybrid vehicles, including the full-hybrid, which can be powered by gasoline or battery power alone; an assist-hybrid, which uses an electrical source when the car requires extra power; and a plug-in-hybrid, which is attached to the main power for recharging. Like the full-hybrid vehicle, the plug-in-hybrid is powered solely from an electrical source.

**GEOTHERMAL ENERGY**

Geothermal, or hot rock energy, generates electricity by the injection of water into a borehole in rocks with temperatures of at least 200 degrees C. The water is heated upon contact with the rock and is returned to the surface via a second borehole in the form of steam, which is then used to turn turbines that generate electricity. The cooled steam is then reinjected back into the first borehole where the process begins again. Geothermal energy can also be used to heat buildings by pumping heated water from the ground into pipes that feed internal radiators.

Researchers at the Australian National University argue that hot rock energy is a vast, environmentally friendly, and economically attractive energy source. The geothermal industry is dominated by several major companies including Ansaldo, Fuji, and Mitsubishi and is generated in many countries around the world. Use is highest in the Philippines, with geothermal energy providing approximately 27 percent of power needs. In Iceland, 85 percent of all the nation’s space-heating needs are met by direct geothermal energy.

**NUCLEAR POWER**

Although the nuclear power industry describes itself as an alternative energy, uranium is nonrenewable and the amount to be found naturally is finite. The European Commission estimates that with current
levels of uranium consumption, known uranium resources, will last just 42 years. Further, energy use
during plant construction and the storage of radioactive waste makes the adoption of nuclear energy in
many parts of the world environmentally, politically, and socially problematic. However, due to the
overwhelming evidence of climate change and a rapid rise in carbon dioxide emissions from the burning
of fossil fuels, governments and scientists, including Sir James Lovelock, the originator of the Gaia
Hypothesis, are advocating an increased use of nuclear power as a means of reducing and limiting the
impact of global warming.

ALTERNATIVE ENERGY INDUSTRY
The alternative energy industry is enhancing many lives through the creation of over 1.7 million wellpaid
jobs. Over half a billion dollars is invested each year in developing countries for renewable energy
projects. No single alternative energy source can provide the world with all its energy needs, but
together, the various sources can greatly reduce the reliance on fossil fuels, thus conserving valuable
resources and reducing the chance of catastrophic climate change. As the global supply of fossil fuels
become scarcer and their environmental consequences become more apparent and unacceptable by
society, alternative energy sources will play an increasing role in meeting the power needs of the world.

SEE ALSO:
Bioenergy; Dams; Deforestation; Geothermal Energy; Global Warming; Greenhouse Gases;
Hydrogen Fuel; Hydropower; Indigenous Peoples; Solar Energy; Think Tanks; Three Gorges Dam;
Wind Power.

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