Facts about Future Energy Resources

Introduction

Fossil fuels and nuclear energy, the resources used to meet most of our energy needs today, are expected to be widely used in the near future. However, fossil and nuclear energy resources are nonrenewable and will someday be exhausted, while their continued use poses environmental risks related to air pollution, global climate change, land use, and waste disposal. These challenges have stimulated the search for alternative means of producing and using energy.

New resources that are being researched or developed include hydrogen, nuclear fusion, ocean thermal energy conversion, and tidal and wave energy. (Solar, wind, and geothermal energy are dealt with in separate fact sheets).

Hydrogen

One fuel that has the potential of being widely used in the future is hydrogen gas (H_2). Like natural gas, hydrogen can be burned to heat buildings, cook food, and produce electricity in power plants. Should hydrogen replace natural gas, the existing natural gas pipeline network could be modified to transport hydrogen. Hydrogen gas can also be compressed in a fuel tank and used to power cars and buses, although difficulties in storing enough hydrogen for motor vehicles to run long distances need to be overcome. Another problem is building the infrastructure to refuel these vehicles.

Fuel cells have high efficiencies (up to 60 percent), or two to three times more efficient than an internal combustion engine running on gasoline. Hydrogen can be used in fuel cells. The electrons in hydrogen atoms generate electricity in the fuel cell. The combination of hydrogen and oxygen creates water and heat from the reaction. The heat may be used to produce electricity, but can be used simply to heat things. At the anode, hydrogen is split into protons and electrons. The electrons move down a separate channel generating electricity. The U.S. space program has used them since the 1960s; the space shuttle uses fuel cells to generate electricity. Electrical power plants could be built using large banks of fuel cells, while small groups of cells could provide electricity for individual home and commercial buildings. Experimental cars and buses powered by fuel cells have already been built and tested and in recent years have been coming onto the market.

Hydrogen is used to store energy produced in other ways. Plentiful hydrogen is available from water (H_2O), which can be split into gaseous hydrogen and oxygen using an electrical process called electrolysis. This process, however, is very energy intensive. Hydrogen can also be produced from natural gas and biomass resources (see Facts about Biomass). Hydrogen is cleaner than other fuels, although it is necessary to take into consideration from where the hydrogen is derived. When burned, because it is reacting with oxygen and nitrogen in the air, it produces only water vapor and, in some cases, small amounts of nitrogen oxides. Hydrogen is often considered a renewable fuel because the water vapor produced by burning hydrogen cycles back into the environment. But, Earth's supply of water is finite, so we are limited to what we have on Earth and the locations of these water sources may change over time. Hydrogen fuel, when produced by renewable sources of energy like wind or solar power, can be considered a renewable fuel. Although hydrogen's explosiveness has given it a reputation for being unsafe, studies have shown that hydrogen is no more hazardous than gasoline and natural gas.

Choosing a renewable source of electricity to produce hydrogen is important. Using electricity from coal- or nuclear-fueled power plants can erase hydrogen's advantage as a clean, renewable fuel. Using solar cells, hydroelectric dams, or wind turbines maintains this advantage. A number of experts foresee the expanded

Facts about Future Energy Resources

use of hydrogen going hand in hand with the increased development of renewable energy resources. Before hydrogen is widely developed, three goals must to be met: cheaper renewable electricity, improved fuel cells, and better ways to store hydrogen for vehicles. When these problems are solved, there is a good chance that hydrogen fuel and fuel cells will be common in the future. Since hydrogen can be produced from water and transported by pipeline, there would be few geographic restrictions to its use, making the future use of hydrogen possible in Wisconsin, the United States, and the rest of the world.

Nuclear Fusion

Nuclear fusion occurs when the nuclei of light elements (such as isotopes of hydrogen) are forced together at ultra-high temperatures and pressures to form the nucleus of a slightly heavier element (such as helium). Fusion releases large amounts of energy. The energy of the sun, other stars, and hydrogen bombs come from fusion. A fusion reaction can release over four times as much energy as does uranium fission.

The main challenge of controlled fusion has been to create the same high temperatures (15 million degrees Celsius/27 million degrees Fahrenheit) that exist in the sun's interior. Two strategies have been tried: confining and heating the hydrogen fuel inside a strong magnetic field and shooting hydrogen fuel pellets with powerful laser beams. During the past several decades, a number of countries have built experimental fusion reactors that use these two methods. Although progress has been made, creating a sustainable fusion reaction that produces more energy than it consumes has yet to be achieved.

Should fusion power plants ever be built, they could provide Wisconsin and the rest of the world with abundant electrical energy. This is because plentiful amounts of deuterium, the hydrogen isotope needed for fusion, are found in ordinary water. However, controlling fusion has proved to be a formidable engineering challenge, and it may be many decades before a successful fusion reactor becomes a reality. Even then, it may take many more years to design and construct commercial fusion plants. Some experts believe that fusion power plants could be built by the middle of the twenty-first century, while others do not foresee them ever becoming a reality.

Ocean Thermal Energy Conversion (OTEC)

The large temperature difference between the warm surface waters of tropical oceans and the cold, deep waters lying beneath them provides a potential energy source. A device that works like a refrigerator in reverse can use this difference in temperature to drive a turbine that generates electricity. This process, called ocean thermal energy conversion (OTEC), could provide electricity for tropical islands and coastal nations. OTEC power plants can be placed offshore on floating platforms; they do not need to be built on land.

Since the sun produces the temperature difference between surface and deep ocean waters, the energy source for OTEC plants is inexhaustible for the foreseeable future. On the other hand, OTEC plants are more expensive to build than other types of electrical power plants, and the technology is still young. The best sites for OTEC are often located far from the nations and population centers that most need electricity. The temperature differences in bodies of water outside of tropical latitudes are too small to operate an OTEC power plant. For this reason, OTEC power plants on Wisconsin's Great Lakes are not feasible.

Tidal and Wave Energy

Changes in tide levels can be harnessed as a source of energy by building a barrier similar to a dam across a bay and allowing the incoming and outgoing tides to spin turbines that produce electricity. A large tidal energy site has been built in Canada's Bay of Fundy, near Maine. The tide changes in Alaska's Cook Inlet are also large enough to be harnessed for energy.

Facts about Future Energy Resources

Ocean waves can also be used as an energy source. Ocean waves oscillate, moving in a circular motion. Terminator devices capture an oscillating water column and cause it to move up and down. Scientists and inventors have designed and tested experimental devices that harness the kinetic energy in a wave to generate electricity through turbines. Some of the more promising designs are undergoing demonstration testing at commercial scales.

Tidal and wave energy are renewable resources that produce little or no pollution. Despite these advantages, the potential for developing tidal or wave energy is limited to a few coastal areas. Tidal and wave energy systems may also affect aquatic life. The equipment must also be able to withstand storms and saltwater corrosion.

Because of these limitations, many experts do not foresee tidal and wave energy making a major contribution toward meeting the energy needs of the United States or the world. The Great Lakes do not experience large tides, so tidal energy is not an option for meeting Wisconsin's energy needs. Harnessing wave energy from the Great Lakes may be technically feasible, but it is not likely to be pursued because of limited energy output and high costs.

Outlook

Hydrogen has the best chance of being widely used in the future. Sources of hydrogen are plentiful, it has many uses, and most of the needed technology has already been developed. However, hydrogen is not a primary energy source like solar or wind power; it is used to store energy produced by other means and an input of external energy is needed to power hydrogen fuel cells. Nuclear fusion continues to pose formidable engineering problems and waste disposal and storage obstacles. Limited sites, high costs, and the need for technological development will also likely restrict the growth of OTEC, tidal, and wave energy systems. However, technical breakthroughs combined with the proper economic and environmental incentives may result in the successful development of these energy resources, despite their limitations. In addition, development of energy resources unknown to today's society may also occur.

References

Bureau of Ocean Energy Management: boem.gov/renewable-energy/renewable-energy-program-overview

National Aeronautics and Space Administration (NASA): solarscience.msfc.nasa.gov/interior.shtml

Office of Energy Efficiency & Renewable Energy, U.S. Department of Energy: energy.gov/eere/office-energy-efficiency-renewable-energy

Renewable Energy World: renewableenergyworld.com

World Nuclear Association: world-nuclear.org

Wisconsin Office of Energy Innovation. Wisconsin Energy Statistics Book: psc.wi.gov/Pages/Programs/OEI/WisconsinEnergyStatistics.aspx

The Wisconsin K-12 Energy Education Program is supported through funding from

Wisconsin K-12 Energy Education Program (KEEP)
College of Natural Resources
University of Wisconsin-Stevens Point