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ENERGY TIMELINE

4 million B.C.

First known use of tools in East Africa (muscle power)

460,000 B.C.

First known use of fire in area now known as China

10,000 B.C.

Asphaltum from natural oil seeps used for variety of purposes on America's Pacific coast

9000 B.C.

Farming begins in the Middle East and elsewhere; people begin permanent villages

6500 B.C.

Metalworking with copper begins in Middle East

3500 B.C.

Sailboats powered by wind used on the Nile in Egypt

3200 B.C.

Wheels used in Urak, Mesopotamia

3000 B.C.

First recorded use of crude oil, in Mesopotamia

2000 B.C.

Chinese use crude oil for home heating

1500 B.C.

Hittites (Asia Minor) first produce wrought iron

1500 B.C.

Fire-starting kits carried in Europe

1500 B.C.

People around the world use hot springs for bathing, healing, recreation, cooking, heating

1000 B.C.

Iron becomes commonly used metal throughout Mediterranean

750 B.C.

Ironworking reaches Europe

500 B.C.

Magnetic properties of lodestone (type of iron) described by Thales of Miletus in Greece

500 B.C.

Iron plow share first used in Europe, improving the efficiency of plowing using muscle power

500 B.C.

Passive solar energy used in Greek homes

200 B.C.

Coal mining in China

50 A.D.

Hero of Alexandria invents first steam engine (but does not put it to productive use)

50

Romans make wide use of solar energy; improve glass windows

100

Greeks invent waterwheel

300

Natural gas drilling in China

644

First windmill with a vertical axis, recorded in Iran

700

Iron smelting introduced in Spain

1060

Possibly world's first city-wide space-heating project using geothermal built at Paquimé, Mexico

1088

Water-powered mechanical clock made by Han Kung-Lien of China

1100

Oil wells drilled in Europe and the Mediterranean

1100

Windmills introduced in Europe

1200

Coal mining begins in England

1320

Germans improve blast furnace, advancing the process of iron smelting and casting

1322

French village pipes water from hot springs for home heating

1400

Blast furnace introduced in Holland, enabling the first production of cast iron in Europe

1510

Leonardo da Vinci designs the precursor of the water-driven turbine

1582

Waterwheels first pump water from Thames River into mains in London

1615

Use of coal for heating in England increases, owing to rising timber costs

1680

Mills driven by waterpower in common use throughout Europe

1688

Large windows allow solar energy into buildings in France

1690

Widespread use of coal begins in Europe due to wood depletion

1695

Frenchman G. Buffon uses mirrors to concentrate sunlight to burn wood and melt lead

1698

Englishman T. Savery develops steam engine to pump water out of flooded coal mines

1700

Textile mills and other factories driven by waterpower throughout Europe

1700

Greenhouses with glass windows that take advantage of solar energy become popular

ENERGY TIMELINE (continued)**1705**

T. Newcomen, England, invents first practical steam engine

1709

Iron smelting process using coke developed by A. Darby, England; coal demand increases

1712

Piston-operated steam engine built by T. Newcomen

1746

B. Franklin conducts research that will later result in clearer understanding of electricity

1748

First American commercial coal production in Virginia

1752

B. Franklin's kite experiment verifies nature of static electricity; leads to invention of lightning rod

1757

First public gas streetlights in the American colonies light streets of Philadelphia

1769

Improved steam engine patented by J. Watt, England

1770

Spinning jenny patented by J. Hargreaves helps automate manufacturing

1782

J. Watt invents rotary steam engine; soon to have widespread use in factories

1785

Textile plant in England is the first to be powered by steam

1790

First working United States cotton mill

1792

British engineer W. Murdock invents "town gas"

1800

A. Volta produces the first electricity from a wet-cell battery

1800

Several French towns use geothermal energy for space heating

1800

Hot springs resorts flourish throughout United States, Europe, and Asia

1803

Robert Fulton builds first steam-powered boat

1804

R. Trevithick invents and operates first steam locomotive on a track

1807

Commercial paddle-wheel steamship cargo service begins in New York

1807

First public street lighting using town gas occurs in London

1814

First practical steam locomotive invented by G. Stephenson

1818

First steamship (*Savannah*) crosses the Atlantic

1820

A. Ampere, M. Faraday, and W. Sturgeon experiment with electromagnetism

1821

M. Faraday, England, demonstrates that electricity can produce motion

1821

First U.S. natural gas well drilled in Fredonia, New York

1825

First steam train passenger service offered in England

1830

Steam-driven cars common in London

1831

J. Henry perfects electric motor

1831

M. Faraday invents dynamo, one of the first electric generators

1839

Englishman W. Grove builds first fuel cell

1859

First oil well in America drilled in Pennsylvania

1860

First internal combustion engine built by E. Lenoir, Belgium

1860

The Geysers, California, opens resort for therapeutic hot spring bathing

1861

French scientist A. Mouchot patents world's first solar steam engine

1868

First modern focusing solar power plant heats water for steam engine in Algiers

1870

Z. Gramme perfects dynamo, making it the first workable electrical generator

1874

Power plant in England burns garbage (biomass) for electricity production

1876

N. Otto perfects first practical internal-combustion engine, later used in autos

1876

California's first "commercial" oil well drilled near Newhall, California

1878

T. Edison develops method to transmit electricity for common use

ENERGY TIMELINE (continued)

1879

T. Edison makes incandescent electric light practical

1881

J. d'Arsonval originates idea of using ocean as energy source

1882

Electric power stations go on-line in London and New York

1884

C. Parson develops first practical steam turbine electricity generator

1885

C. Benz develops the first working motorcar powered by gasoline

1886

Swede J. Ericsson invents first parabolic trough solar energy collector

1886

Up to 50 small hydropower plants generate electricity in America

1887

Stockton becomes first California city supplied with natural gas sent through pipelines

1888

First wind machine for electricity built in America

1890

Electricity begins to replace use of natural gas for lighting

1890

First dependable electric motor cars developed in France and Great Britain

1891

U.S. inventor C. Kemp patents first commercial solar water heater

1891

Tesla coil invented, producing first high-voltage electricity

1891

First long distance electrical lines completed in Germany

1892

P. LaCour, Denmark, designs efficient machine that generates electricity from wind

1893

First Ford gasoline buggy driven by inventor, H. Ford

1894

Texas oil discovered while drilling for water

1894

Pneumatic (air-filled) tires introduced in France by A. and E. Michelin

1896

First U.S. offshore oil wells (built on wooden piers) drilled near Summerland, California

1896

Niagara Falls hydropower plant sends first long distance electricity in U.S.

1897

C. Parsons outruns every ship in the water with his steam-driven boat, *Turbina*

1897

30 percent of homes in Pasadena, California, use solar water heaters

1898

Garbage (biomass) burned for electricity in New York

1900

Power plants driven by hydropower or fossil fuels dot the U.S.

1900

Calistoga, California, hosts over 30 hot springs resorts

1904

Electricity generated from geothermal steam in Larderello, Italy

1905

A. Einstein publishes relativity theory, revolutionizing understanding of energy

1908

First cheap, mass-produced car, the Model T Ford, is available

1910

Coal accounts for three-fourths of all fuel used in United States

1916

Einstein's unifying theory inter-relates mass, energy, magnetism, electricity, and light

1918

Denmark produces electricity from over 100 wind generators

1920

Midwest farms in U.S. widely use wind turbines for electricity

1920

Decade begins with oil and gas shortages in California

1928

More than 3 million American families own two cars

1929

After major discoveries, decade ends with surplus of oil and gas in California

1930

Iceland begins to work on large-scale geothermal district heating project

1930

Solar water heaters supply hot water to homes throughout Miami, Florida

1930

Propeller-type wind generators perfected by M. Jacobs in use all around U.S.

1932

Englishman F. Bacon develops first successful fuel cell

ENERGY TIMELINE (continued)

1935

Rural electrification brings power to remote areas in U.S.; replaces most wind turbines

1936

America's Hoover Dam (for hydropower) completed

1939

Europeans O. Hahn, and L. Meitner unveil process of nuclear fission for energy

1940

First U.S. superhighway opens in Pennsylvania

1941

Almost 60,000 solar water heaters in use in Florida

1942

E. Fermi, using Einstein's theories, produces first controlled nuclear chain reaction in the U.S.

1943

132 MW produced from geothermal fields, Larderello, Italy

1944

U.S. National System of Interstate Highways established

1945

First nuclear bomb detonated in New Mexico

1945

5,000 U.S. homes have television sets

1947

Diesel-electric trains replace steam locomotives in U.S.

1948

One million U.S. homes have television sets

1950

Work-saving appliances and tools use increasing amounts of energy

1952

First U.S. hydrogen bomb detonated with 700 times force of fission bomb

1954

First solar cells used for electricity generation developed in U.S.

1954

First Russian nuclear power plant opens

1954

Advanced European steel-manufacturing method introduced in Detroit

1954

First fuel cells used in NASA space program

1955

First U.S. town powered by nuclear energy (pilot project) in Idaho

1958

First major offshore oil-drilling platform built in the Pacific Ocean near Summerland, California

1960

Commercial electricity first produced from geothermal energy at The Geysers, in California

1960

Environmental concerns increasingly relate to energy use and pollution

1960

German U. Hutterer perfects electrical wind turbine design, later adopted in U.S.

1963

First commercial nuclear power plant in U.S. opens in New Jersey

1965

Historic electrical blackout in northeastern North America

1966

Partial meltdown at nuclear power plant in Detroit

1966

La Rance tidal power plant built at the Rance estuary in France

1967

First microwave for home use introduced

1968

78 million U.S. homes have television sets

1969

France begins large district-heating projects with geothermal energy

1970

First Earth Day signals worldwide concern about environmental damage

1970

Solar water heating well established in Israel, Japan, Australia

1971

P. McCabe, Great Britain, and M. McCormick, U.S., begin development of first wave energy system

1973

Oil embargo opens up new era of electricity produced from renewable sources in U.S.

1973

Japan begins experiments with Ocean Thermal Energy Conversion (OTEC)

1974

J. Lindmayer, U.S., develops silicon photovoltaic cell for harnessing solar power

1977

Solar panels installed on the White House

ENERGY TIMELINE (continued)

1978

Public Utility Regulatory Policies Act, PURPA, requires utilities to buy power from qualifying independent producers

1979

Partial meltdown of nuclear reactor at Three Mile Island, Pennsylvania

1979

Experimental OTEC project begins producing electricity in Hawaii

1980

Europe and Asia invest widely in generation of electricity from wind power

1980

Nuclear power generates more electricity than oil in U.S.

1980

Large, powerful wind generators emerge as result of fuel shortages

1982

Solar One power tower in southern California proves that solar thermal power for electricity is feasible

1983

Three out of every four power plants in U.S. burn fossil fuels

1983

World's largest hydroelectric power plant opens in Brazil/Paraguay

1983

First solar thermal trough power plant opens in southern California

1984

Large scale biomass power plant opens in Vermont

1986

Worst-ever nuclear meltdown with nuclear fallout occurs at Chernobyl, Ukraine

1990

More than half of world's wind-generated electricity produced in California

1993

Nuclear power provides about one-fifth of U.S. electricity

1997

Hydropower now produces only 10 percent of U.S. electricity

1999

U.S. consumption of petroleum reaches all-time high, more than half for transportation

2000

Electricity generation produces almost 40 percent of all carbon dioxide emissions in U.S.

2000

Of the carbon dioxide emissions produced from electricity generation in the U.S., over 80 percent are from coal

2000

Injection of wastewater into The Geysers geothermal reservoir boosts electricity production

2000

Utility deregulation in some U.S. states results in ups and downs in opening up the energy production market

2000

State-of-the-art, multi-megawatt wind turbines replacing older models in U.S. and Europe

2000

8,000 MW of electricity being generated from geothermal in 22 countries

2000

Renewable resources (including large hydro) contribute 9 percent of electricity in U.S. and over 19 percent globally

2000

Nuclear energy provides 20 percent of electricity in U.S. and almost 17 percent globally

2000

Fossil fuels (coal, oil, gas) provide 71 percent of electricity in U.S. and 64 percent globally

2000

99 percent of U.S. households have a color television

2001

Power outages and cost spikes, especially in California, spur growth of small solar and wind

2002

In Russia, the world's oldest nuclear plant closes down. Nuclear power still accounts for some 16 percent of world electricity and 20 percent in U.S.

2003

The largest power outage in U.S. history hits the northeastern states and part of Canada

2005

International Climate Change Task Force warns of a "runaway" greenhouse effect if global temperatures rise 3.6°F above preindustrial levels

2005

Kyoto Treaty reducing greenhouse gas emissions takes effect with wide participation — but without the U.S.

2005

Increase in development of run-of-river hydropower with "low-impact" hydro as the ultimate standard

ENERGY TIMELINE (continued)

2006

Wind turbines have grown in capacity to double and triple the size of earlier models; Germany and U.S. greatest users

2006

More states regulate greenhouse gas emissions; some 26 percent of the U.S. population affected

2008

Crude oil prices exceed \$100 per barrel; U.S. gasoline prices exceed \$4 per gallon

2009

Ocean energy resources projects proposed in the Pacific (by the U.S., Australia, New Zealand, Japan, and South Korea) and the Atlantic (by Canada, Portugal, France and the U.K.)

2009

Offshore wind energy production in Europe increases 54 percent in a single year

2010

11,000 MW of geothermal power generated worldwide and much more projected

2010

Solar photovoltaics production doubling every three years

2010

Hydrogen fuel cell technology used by several major U.S. companies

2010

An estimated 25 percent of the world's population (about 1.6 billion people) remain without access to electricity

Note: Suggestions for the Energy Timeline are always welcome. Please send them to energyforkeeps@aol.com.

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GLOSSARY

A

acid precipitation (acid rain): any precipitation that primarily contains damaging sulfuric and nitric acids; may harm and/or destroy natural land or water habitats and corrode human structures including roads, buildings, and bridges

active solar: any system for collecting, storing, and releasing solar energy that requires an outside source of energy, such as fans or pumps, to operate system equipment

A.D.: any year after the birth of Jesus Christ; from the Latin, *anno Domini*, meaning “in the year of our Lord;” from 20 B.C. to 50 A.D. is 70 years

alloy: a mixture of different metals; for example, bronze, a mix of copper and tin; some alloys include metals mixed with non-metals (e.g., some kinds of steel are made of several metals plus carbon, a non-metal)

alternating current (AC): an electric current that reverses direction at regular intervals; caused by an alternating electromotive force (the force that produces an electric current)

alternative energy: sometimes defined as sources of energy other than fossil fuels, hydropower, or nuclear; often refers to transportation fuels other than gasoline — ethanol, biodiesel and hydrogen

alternator: an electric generator that produces alternating current

American Recovery and Reinvestment Act (ARRA): commonly referred to as the Stimulus or The Recovery Act; an economic stimulus package enacted by the 111th United States Congress in February 2009, intended to create jobs and promote investment and consumer spending during the recession

ampere (amp): a measure of the amount of current, or electrons, flowing in a wire over time; one ampere = 6.25×10^{18} electrons per second

anaerobic digestion: the breakdown of organic materials by bacteria in the absence of oxygen; results in the production of gases, primarily methane and carbon dioxide; occurs naturally or can be caused to occur under controlled conditions in an anaerobic digester

anemometer: a device for measuring wind speed

anode: the positively charged electrode in an electrical circuit or in an electrochemical reaction

aquafarming: the cultivation of fish and other water-dwelling organisms under controlled conditions

array: in general, a symmetrical arrangement of a large group, as in rows; in solar energy, usually refers to an arrangement of a large group of photovoltaic (solar) panels or mirrors

atom: the smallest particle of an element that retains the chemical properties of that element; composed of protons, neutrons, and electrons

B

balance of trade: the difference in value over a period of time between a country’s imports and exports

barrage: an artificial obstruction, such as a dam or an irrigation channel, built in a river or other waterway to increase depth or divert flow

baseload power: the amount of power needed to supply the minimum anticipated demand for electricity at any given time

B.C.: any year before the birth of Jesus Christ; from 20 B.C. to 50 A.D. is 70 years

binary power plant: geothermal power plant that uses a heat exchanger to transfer heat to a second (binary means two) liquid that flashes to vapor and drives a turbine-generator

biomass: anything that is, or was once, alive: wood, plant, animal waste, and gases, such as landfill methane gas, ethanol, or other gases derived from them; a renewable energy resource

blackout: the loss of electricity, caused intentionally or by an electrical power failure

blast furnace: a furnace in which the combustion of a fuel is intensified using blasts of air or pure oxygen

brine: water containing large amounts of salts, particularly sodium chloride

GLOSSARY (continued)

brownout: a reduction in electric power; may be the result of a shortage or mechanical failure, or may be intentional in response to excessive consumer demand

by-product: something produced in the making of something else; a secondary product produced from the production of a primary product

C

capacity: in electricity generation, the manufacturer's rating of maximum electrical output for one or more generating devices

carbon cycle: the chemical cycle in which the element carbon naturally circulates in various forms throughout the living and nonliving systems of the earth over time

carbon footprint: a measure of our impact on the environment and, in particular, climate change; relates to amount of greenhouse gases produced in our day-to-day lives through burning fossil fuels for electricity, heating, and transportation

carbon monoxide: a gaseous molecule composed of one atom of carbon and one atom of oxygen; is highly toxic to animals and humans

carbon sink: components of the global ecosystem that store carbon; includes all plants, the ocean, old-growth forest floor litter (duff), soils, fossil fuels, and certain minerals such as limestone

carbon-based compound: element whose atomic structure causes it to join with a variety of other elements, forming the basis of many different compounds; the basis of all living things, as well as for fossil fuels (hydrocarbons) and many other substances, including diamonds and graphite

cathode: the negatively charged electrode in an electrical circuit or in an electrochemical reaction

Celsius (C): also centigrade; the temperature scale that registers the sea-level boiling point of water as 100° and the freezing point as 0°

central receiving tower: a concentrating solar power technology; a tall structure with a top section that contains a liquid, such as molten salt, water, or liquid metal, that has a high heat capacity; this liquid is heated by the reflection of solar energy from concentrating mirrors aimed at the tower's focal point

chain reaction: in physics, a method of releasing energy from the atom in a multistage nuclear reaction, in which the release of neutrons from the splitting of one atom leads to the splitting of others

central station power plant: a large plant that produces electricity for transmission and distribution to customers on a grid

charcoal: a material containing large quantities of carbon, formed by heating wood or other organic material in the absence of air

Clean Air Act (CAA): federal law designed to protect public health by setting standards and enforcement regulations governing air pollution emissions from energy production and other human activities

cogeneration: the process of doing work utilizing two forms of energy, usually thermal (heat) energy and electrical energy, both produced simultaneously from one source

coke: a fuel that burns very hot; used primarily in metal production; produced by removing mainly the sulfur, which makes iron brittle when smelted, from coal

combined cycle power plant: power plant in which two different turbines — most commonly a gas turbine accompanied by a steam turbine — work in succession to produce electricity; most gas-fired power plants are combined cycle plants

combustion: the process of burning, which is a chemical change requiring the presence of oxygen that results in the production of heat and light

Community Choice Aggregation: a program in which a local agency purchases power from a producer rather than from the local utility, while the utility provides the agency's customers with transmission, distribution and billing services

GLOSSARY (continued)

complete circuit: a complete and circular path for an electric current to follow as it moves through wires and electrical devices

compound: substance made of two or more elements that are bonded together chemically

concentrating solar power: any of the solar energy systems (solar dish engines, parabolic troughs, and central receiving towers) that focus, or concentrate, the energy of the sun for energy production or storage

condenser: a device that uses a cooling process to cause a vapor to condense to a liquid

conduction: the transmission of electric charge or heat through a conductor

conductor: in electricity, a substance or medium that conducts, or transmits, an electric charge; in thermal energy, a medium that allows the movement of heat through it

conservation: the controlled use and systematic protection of natural resources such as water, minerals, forests, and soil; also, the practice of avoiding and reducing waste, as in the production of or use of electricity

containment vessel: at a nuclear power plant, a large structure that houses the reactor core, its radiation shield, and the reactor core's maintenance equipment; the containment vessel is surrounded by an outer concrete building designed to prevent the escape of radiation in the event of an internal power plant accident or by an external event such as an airplane crash

control rod: in a nuclear power plant, a long rod made of material that absorbs neutrons; a number of these are inserted amidst the fuel rods in the reactor core; control rods are raised and lowered as needed to control the nuclear chain reaction, and thus the amount of heat energy produced

controller: in a wind turbine, a computerized device that receives information from all the sensors on the turbine (including anemometers, blade positions, temperatures, fault conditions, loads, vibration etc.) and uses this information to determine how to control all the various devices on the turbine

crude oil: unprocessed oil (petroleum) that varies in color and in thickness (viscosity); contains many different compounds, which can be separated and used for a variety of products, including energy fuels such as gasoline, heating oil, and butane

crust: in geology, the relatively thin, outermost rock layer of the earth

D

decompose: to become broken down into basic components or elements; to rot

deflect: to cause to turn aside

demand: in electrical power, the amount of electricity needed at any given time, based on the amount being used by all electrical devices connected to the power supply through the power grid

dense (density): the amount of mass, or matter, that is in a given volume of something; e.g., the molecules of a substance that is very dense are packed very closely together

deplete: to use up or consume

direct current (DC): an electric current that flows only in one direction

direct use geothermal: systems that use geothermal resources directly for heat energy rather than for producing electricity; includes space heating, greenhouse and fish farm operations, bathing and swimming at health spas, and industrial applications such as food and timber drying

disclosure: the act or process of revealing or uncovering; in energy management, information regarding which energy resources are being used to produce electricity by a power provider

distributed generation: supplying on-site electricity using small generating units; can be comprised of similar systems or a variety of different system types; distributed generation is used to manage peak loads, to add extra power for a region without having to build a large power plant, to provide electricity for remote locations, or for a vital industry (such as a hospital) that needs power even when grid power is unavailable

GLOSSARY (continued)

dry steam power plant: geothermal power plant that uses steam directly from a steam-filled geothermal reservoir

dynamo: an electric generator that usually produces direct current

E

ebb: to fall away or recede

ecological: pertaining to the science of the relationships between organisms and their environments

ecosystem: the community of all organisms living in an area and their interactions with the physical environment

electric current: the flow of charged particles through a conductive material

electrical energy: the energy of electrical charges, usually electrons in motion

electrochemical: the interaction of electrical and chemical phenomena

electrode: a solid electric conductor, such as a piece of metal, through which an electric current enters or leaves a solution containing an electrolyte; also, a collector or emitter of electric charge, such as found in a fuel cell

electrolysis: chemical reaction caused by passing an electric current through a liquid containing an electrolyte, resulting in the break down of the liquid's molecules; the electrolysis of water releases hydrogen and oxygen, for example

electrolyte: a chemical compound which, when molten or dissolved, usually in water, will conduct an electric current; an electrolyte solution

electromagnetic spectrum: radiated energy waves as described in terms of their wavelengths and frequencies, including gamma rays, X-rays, ultraviolet, visible light, infrared radiation, microwaves, radar, television, and radio; the sun is the largest natural source of electromagnetic radiation

electromagnetism: the study of the relationship between magnetism and electricity; the phenomena of producing electricity using magnetism and vice versa

electron: a negatively charged component of an atom; exists outside of and surrounding the atom's nucleus; can either be free or bound to a nucleus

element: the simplest possible chemical, made up of its own particular kind of atom; most elements occur naturally, though some have also been made artificially

encroach: to advance beyond usual or proper limits

energy carrier: a medium, system, or substance for conducting energy from its source to its users; examples are electricity and hydrogen

energy conservation: management of energy resources and energy use to prevent waste, reduce costs, and ensure future availability

energy conversion (transformation): the process of changing energy from one form to another

energy farm: a farm that grows plants specifically as biomass energy crops; sometimes refers to an array of generators for wind, solar, or ocean resources

enhanced geothermal system (EGS): an innovative geothermal technology in which water is pumped into artificially fractured hot rock to create a geothermal reservoir; also referred to as an "engineered" geothermal system

estuary: a coastal bay or inlet at the mouth of a river or stream, where large quantities of fresh water and saltwater mix together; if undisturbed, estuaries are very fertile and provide habitat for a variety of wildlife.

exempt: excused or released from a requirement

F

Fahrenheit (F): the temperature scale that registers the sea-level boiling point of water as 212°F and the freezing point as 32°F

GLOSSARY (continued)

fissionable: in nuclear power, an unstable element that is capable of being split; in a nuclear power plant, fissionable material – primarily one form of uranium (U-235) – is used to produce a nuclear chain reaction

fissure: in geology, an extensive crack, break, or fracture in rock

fixed-speed wind turbine: a wind turbine that always turns at the same speed, regardless of how fast the wind is blowing; the machinery of a fixed-speed wind turbine is simpler than that in a modern variable-speed turbine

flash power plant: a geothermal power plant that uses a process in which geothermal water is suddenly converted to steam to drive a turbine

fossil fuels: coal, oil, natural gas, and products made from them; fossil fuels are the remains of once-living (organic) plants and animals formed underground and subjected to intense heat and pressure over millions of years; have high concentrations of carbon and hydrogen and can be burned, producing energy (as well as polluting emissions)

fuel rod: at a nuclear power plant, pellets of uranium (U-235) that are arranged in long rods, which are collected together into bundles and placed in the reactor core

fumarole: steam and gas, venting from the earth's crust

G

gas turbine: power plant turbine that is driven by a continuous blast of hot gas from the combustion of natural gas combined with high-pressure air

gasification: the process of converting into or becoming a gas

generator: a machine that transforms (converts) mechanical energy into electrical energy

geothermal energy: the heat energy of the earth; the earth's natural heat emanating outward from its interior and constantly renewed from the radioactive decay of certain elements in the crust and other geologic processes; a renewable energy resource

geothermal reservoir (hydrothermal aquifer): a large volume of underground water saturating (filling) porous and permeable rock, superheated by the hot rock and nearby hot magma

global climate change: long-lasting changes in Earth's weather patterns and systems, resulting in dramatic, possibly harmful, changes in habitats and ecosystems worldwide; is thought by many researchers to be caused by the overall (global) warming of the planet, resulting from an excess of man-made greenhouse gases in the atmosphere

green energy: any energy source considered to be environmentally friendly; commonly associated with renewable energy sources, but also sometimes used when referring to nonrenewable sources that produce few pollutants

green pricing: offering customers the choice of paying additional fees on their utility bill in order to support production from new renewable energy facilities, either nearby or in another region or state

green waste: yard trimmings (usually leaves, grass clippings, and tree and bush trimmings), typically collected in specially designated containers and used for various purposes, including as a source of biomass energy

greenhouse effect: the trapping of heat energy from the sun in Earth's atmosphere, notably by water vapor and greenhouse gases such as carbon dioxide, nitrous oxide, and methane; the resulting heat energy warms the planet's surface

greenhouse gas: any gas in the atmosphere that contributes to the greenhouse effect

grid: the interconnected system that transmits and distributes electricity, including power plant(s), transmission and distribution lines, towers, substations, and transformers

groundwater: water that collects underground, mostly from surface water that has seeped down through cracks and pores in rock

H

habitat: the place that is natural for the life and growth of an organism

GLOSSARY (continued)

head: in hydropower, the distance that water falls before it hits a turbine generator

headrace: a channel that feeds water into a water wheel or (when generating electricity) a turbine

heat (thermal) energy: the energy that flows from one body to another because of a temperature difference between them; the effects of heat energy result from the motion of molecules

heat engine: any device that converts heat energy into mechanical energy; typical heat engines include steam engines, steam and gas turbines, internal combustion (vehicle) engines, and Stirling engines

heat exchanger: device used to transfer thermal (heat) energy from a liquid flowing on one side of a barrier to a liquid flowing on the other side

heliostat: an instrument in which a mirror is automatically moved so that it reflects sunlight in a constant direction

high and low tide: the rise and fall of the earth's oceans, caused mainly by gravitational forces of the moon and the sun

horsepower: originally the power exerted by a horse when pulling; now, a unit of power equal to 745.7 watts per minute

hot dry rock: a potential source of accessible heat energy within the earth's crust; a geothermal resource created when hot but impermeable (does not allow water to pass through) underground rock structures are fractured to allow infiltration of water, thus creating an artificial geothermal reservoir

hydrocarbon: any compound made up of hydrogen and carbon; will combine with oxygen when burned, producing heat energy; includes all the fossil fuels

hydrogen gas: colorless, combustible gas that can be used as an energy source; does not occur naturally by itself, and must be separated from another substance, such as from water, biomass, or a fossil fuel

hydrogen sulfide: a gas with a disagreeable odor, frequently dissolved in geothermal waters in small amounts; toxic at high concentrations

hydropower: the mechanical force of rapidly flowing or falling water from rivers or storage reservoirs; a renewable energy source

I

impoundment: a structure which allows the accumulation and storage of water in a reservoir; a dam placed across a river

incandescent light bulb: a glass bulb of inert gas (gas that is not readily reactive) that emits visible light as a result of passing electricity through a filament found inside the bulb, causing it to heat and glow

indirect (hidden) costs: the costs of producing a product (including electricity) that are not directly accounted for by an industry or utility, but may be borne by other sectors of society

Industrial Revolution: the shift to large-scale factory production brought about by the extensive use of machinery, often driven by coal-fired steam engines; generally thought to occur between the 1750s to the mid to late 1800s; resulted in dramatic social, environmental, and economic changes

industrial: the practice of making goods; often implies the production of large quantities of manufactured items, as found in factories

infrared: heat radiation; part of the electromagnetic spectrum radiated from the sun and other hot objects

internal combustion engine: an engine, used primarily in vehicles, in which fuel is burned within the engine itself, rather than fuel being burned in an external furnace (as in a steam engine)

J

jet stream: a narrow belt of westerly winds found at high altitude that can reach speeds of up to 230mph (370 km/h)

GLOSSARY (continued)

K

kilowatt (kW): 1,000 watts

kilowatt-hour (kWh): the energy expended when 1,000 watts of electrical power are used for one hour

L

liquefied natural gas (LNG): a petroleum fuel condensed from its normal gaseous form into liquid, a form more suitable to be transported

M

magma: hot, thick, molten rock found beneath the earth's surface; formed mainly in the mantle; when magma surfaces (usually from a volcano), it is called lava

magnetic field: a condition found in the region around a magnet or electric current where detectable magnetic force is found at every point and with distinguishable magnetic poles

mantle: the zone of the earth below the crust and above the core, primarily filled with a mixture of molten and solid rock

manufacture: to make a finished product, often using large-scale industrial operations

marine (ocean) current: movement of ocean water: two-way (tidal) or one-way (like the Gulf Stream)

mass: in physics, the measure of the quantity of matter that an object or body contains

mass-produce: to manufacture in large quantities, often using assembly lines

mechanical energy: the energy of an object as represented by its movement, position, or both

medieval: relating to a period in European history, usually between ancient cultures and the Renaissance (A.D. 476 to 1453), during which scientific and philosophical innovations were often suppressed

megawatt (MW): 1,000 kilowatts

methane gas: an odorless, colorless, combustible gas that can be used as an energy source; the primary component of natural gas and a source for hydrogen gas

microbe: a micro-organism; microscopic life form

micro-grid: a mini-version of an electric grid using distributed energy resources; can be operated as part of a utility's distribution system or "islanded" for separate use

micro-hydro: a hydroelectric plant of small size, not necessarily connected to a grid; most are "run-of-river" plants that do not require a dam

modular: designed with standardized equipment and dimensions to allow for flexible arrangement and the ability to add more units

module: in solar energy, a group of photovoltaic (solar) cells wired together into a single unit that can be grouped in any combination with other modules; in geothermal, a turbine-generator unit

mud pot: a type of hot spring containing boiling mud

multi-megawatt wind turbine: very tall wind turbine with huge blades that catch the faster wind speeds found higher from the ground; those most commonly used can generate between 1-3 megawatts of electricity; more advanced designs may produce up to 6 megawatts, with some designs as large as 20 megawatts

N

nacelle: in a wind turbine, a covered housing that protects the gear box, high- and low-speed shafts, generator, controller, and brake

NASA: the National Aeronautics and Space Administration; United States' space exploration agency; many scientific and technological advances that originated at NASA have been introduced into other industries

negative charge: one of two kinds of electric charge, the kind carried by an electron

GLOSSARY (continued)

net metering: a program offered by power producers that encourages grid-connected consumers to generate some or all of their own electricity using specific, usually renewable, resources; in many cases, this type of program allows the consumer's meter to turn backwards when they are producing more power than they are using, and some utilities will pay the consumer for the net excess power generated

neutron: an electrically neutral subatomic particle

nitric acid: a transparent, colorless to yellowish, corrosive substance; one of the components of acid precipitation

nitrogen oxides: gases formed mainly from nitrogen and oxygen; one of the damaging components of acid precipitation

nonrenewable energy: energy sources that do not regenerate themselves in a useful amount of time, including fossil fuels and nuclear fuels

nuclear fission: a reaction in which an atomic nucleus is split into fragments, releasing large quantities of energy; fission means "to split"

nuclear fuels: minerals, such as uranium, from which energy is liberated by a nuclear reaction

nuclear fusion: a reaction in which nuclei are combined (fused) to form a more massive nucleus, accompanied by the release of energy

nucleus: the positively charged central region of an atom (plural: nuclei)

O

ocean energy: the mechanical energy of ocean tides, currents, and waves, and the thermal energy of the solar and geothermal heat stored in waters of the ocean; a renewable energy source

ocean thermal energy: the solar and geothermal heat stored in waters of the ocean

Ocean Thermal Energy Conversion (OTEC): ocean energy technology that produces electricity – sometimes along with clean drinking water – by taking advantage of the temperature difference between warm surface ocean water and cold water from the ocean depths

oil refinery: factory where crude oil is separated into various components and cleaned to remove some impurities

oil rig: large collection of machines, hoists, and power equipment, established on land or on platforms or barges in open water; used to drill down into oil reserves found in underground rock

old-growth forest: forest having a mature ecosystem, including presence of old woody plants (mainly trees), and the wildlife and smaller plants associated with them; typically old-growth forest floors are made up of "duff," a rich layer of debris, decomposing matter, and leaves

one-way marine currents: deep oceanic currents, such as the Gulf Stream, that result from varying conditions of ocean water including differences in temperature and water density

organic decay: the breakdown of organic matter as a result of bacterial or fungal action; rot

organic: derived from living organisms

oscillating: to swing back and forth with a steady, uninterrupted rhythm

ozone: a highly reactive molecule made of three atoms of oxygen; high in the atmosphere ozone forms a protective layer that filters out harmful ultraviolet radiation; is formed at Earth's surface as a harmful component of photochemical smog

P Q

parabolic: a curved geometric shape based on the parabola; when radiant energy, such as sunlight, hits a parabolic surface and is reflected back, all the reflected radiant waves pass through one area of space in front of the parabolic surface known as the focus; in solar energy, parabolic surfaces, such as parabolic mirrors, are used to concentrate radiant waves from the sun

GLOSSARY (continued)

parabolic trough: a concentrating solar power technology that utilizes a long, trough-shaped parabolic reflector to focus the sun's energy onto a pipe that contains a liquid, usually an oil, that's used in a heat exchanger to boil water from steam

particulates: solid particles and liquid droplets suspended in the air, including smoke, soot, dust, and ash

passive solar: techniques using the structure of a building for heating or cooling that require no collectors, pumps, or other devices; examples include large, south-facing windows to allow solar energy in to warm the house, or awnings to block solar radiation to cool the house

peak load: the time(s) of day and times of year when consumers demand (use) the most electricity

peaking power: power to fill the electricity demand, or need, that exceeds the amount of baseload power available at any given time

penstock: a conduit or pipe that carries water from a storage reservoir or from upriver to a turbine

photochemical smog: a complex mixture of air pollutants, produced in the lower atmosphere by the reaction of hydrogen and nitrogen oxides when exposed to sunlight; is unsightly, damages vegetation, and leads to eye and respiratory ailments in animals and humans

photon: tiny bundles of electromagnetic radiation that move rapidly from one place to another at the speed of light; sometimes considered a flow of particles; the sun emits huge quantities of photons

photovoltaic: refers to the ability to convert photons into electrical energy; photons are used to dislodge electrons from atoms of silicon or other materials, causing them to migrate, producing an electric current

policy: a plan or general set of guidelines that reflects a particular set of values and influences specific actions and decisions

porous: in geology, able to hold water in spaces within rock

power: an application of force or energy; in physics, the rate at which work is performed or energy converted; technically, the amount of current times the voltage level at a given point measured in wattage or watts; often used interchangeably with the word "electricity"

positive charge: one of two kinds of electric charge, the kind carried by a proton

proton: a positively charged subatomic particle found in all nuclei

pumped storage: a system of generating electricity using water pumped from a lower reservoir to a higher storage site and later released to fall back to the lower reservoir when extra electricity is needed; used as a method of "storing" energy; generally, surplus electric power is used to pump the water uphill when electricity demand is low

R

radiant energy: energy transmitted in the form of rays, waves, or particles

radioactive: emitting radiation, either from unstable (fissionable) nuclei or from a nuclear chain reaction

reactive: an element or compound that tends to participate readily in chemical reaction

reactor core: in a nuclear power plant, the contained assembly of fuel rods, around which a liquid or gas flows in pipes to remove the resulting heat energy

rebate: return of a percentage of the cost of an item

regenerate: to renew the supply of something, such as an energy resource

renewable energy: any energy resource that is naturally regenerated or renewed within a useful amount of time and is to that extent inexhaustible

Renewable Portfolio Standards: a set of standards, adopted by a government, designed to ensure that a certain percentage of various renewable energy resources be included in the portfolio (or resource mix) of its power providers

GLOSSARY (continued)

resistance: in physics, opposition to the passage of electric current, causing electric energy to be transformed into heat

rotor: the rotating part (blades and hub) of an electrical or mechanical device such as a wind turbine

run-of-river (diversion): hydropower system that produces electricity while still maintaining the natural or near-natural flow of a river (as opposed to creating an impoundment to hold the river back to form a reservoir); most run-of-river systems divert some of the water to an electrical powerhouse and then return it to the river

S

scrubber: an apparatus used to remove impurities from gaseous emissions

semi-conductor: a material, usually silicon, which combines characteristics of a conductor (allowing current to flow) and an insulator (resisting current), suitable for use in electronics

silicon: one of the most abundant elements on Earth; always occurs in combination with other elements; high heat is required to isolate it; widely used in products such as glass, ceramics, computer microchips, and solar photovoltaic cells

sluice: an artificial channel for conducting water

smart grid: an electrical system that makes use of sensors and other devices to enhance the system's efficiency, as when supply is matched to demand in particular locations and at particular times

smelt: to melt ore (rock containing valuable minerals, especially metals) in order to separate the metal from the rock

solar cell: a photovoltaic device that converts solar energy into electrical energy using an electrochemical reaction in which electrons are caused to move, creating an electrical current

solar dish engine: a concentrating solar power technology that uses either one large, dish-shaped parabolic mirror, or a group of these mirrors, to concentrate the thermal (heat) energy of solar radiation onto a receiver; a heat engine in the receiver converts the concentrated heat into mechanical energy to drive an electrical generator

solar energy: heat and light radiated from the sun; a renewable energy source

solar panel: a group of around 10 solar photovoltaic modules (see solar cell) that are assembled together into a panel

spent fuel: fissionable material left over from a nuclear reaction; spent nuclear fuel is still radioactive, therefore toxic; classified as hazardous waste, and must be handled and stored properly for safety

stand-alone wind turbine: a wind turbine that is not part of a wind farm; most commonly used in remote or rural locations and often not connected to the electrical grid

static electricity: an accumulation of electric charge (as opposed to the movement of electric charge known as electric current); imbalance between positive and negative charges

steam reforming: a form of fuel processing often used to produce hydrogen gas, frequently from natural gas or biomass; uses a special process involving high-temperature steam and a catalyst (substance that increases the rate of a chemical reaction without being consumed in the process)

Stirling engine: an engine that has a sealed chamber where heat is focused on one side, causing the air inside to expand and push down on a piston; as the piston moves, air flows to the cold side of the engine where it is cooled; a second piston pushes the cooled air back to the hot side

strait: a narrow channel joining two larger bodies of water

subatomic particle: any of various units of matter below the size of an atom, including neutrons, protons, and electrons

GLOSSARY (continued)

substation: in electrical transmission, the location of the transformer equipment that decreases or increases the voltage of electric current flowing through transmission and distribution lines

sulfur oxides: pungent, colorless gases formed mainly by the combustion of fossil fuels; considered a major air pollutant

sulfuric acid: a colorless to dark brown, highly corrosive, dense liquid; sulfur oxide dissolved in water

sustainable: a process, system, or technology that does not deplete resources or cause environmental damage and thus lasts indefinitely; a school of thought that advocates preserving environmental, social, and economic resources, including energy resources, for future generations

synthetic: not natural; the combination (synthesis) of materials to form a product that may or may not occur naturally

system efficiency: input (of energy or work) versus output (of energy or work) of a system, often expressed as a ratio (energy in divided by energy out); theoretically, the ratio is never one-to-one

T

tailrace: the part below a water wheel or water turbine through which the used (spent) water flows

tectonic plates: the large sections of the earth's crust that are slowly moving over the mantle; the plates interact with one another at their boundaries, causing a variety of geologic phenomena including earthquake and volcanic activity

telegraph: apparatus historically used to communicate Morse code at a distance over a wire using electrical impulses

temperate zone: a region with a moderate climate, characterized by being neither too hot nor too cold

terrain: the surface features of an area of land

textile: cloth, especially that manufactured by weaving or knitting

thermal energy: see heat energy

thermal power plant: any type of power plant that uses heated fluid (normally steam) to drive one or more turbine-generators; usually a plant that burns fossil fuels, though geothermal and solar thermal plants require no combustion

thin film PV: a form of solar photovoltaic receptor which uses lightweight materials; a technology which makes solar panels more manageable and less costly than heavier forms of panel, but generally requires more surface area

thorium: a naturally occurring, slightly radioactive metal, estimated to be about three to four times more abundant than uranium in the Earth's crust

tidal currents: the two-directional, in and out and up and down movements of the ocean along coastlines

tidal fence: an ocean energy technology that uses a long, connected series of underwater turbines that tap tide currents to produce electricity

tidal power plant: marine current energy technology that uses the mechanical energy of ocean tides to produce electricity; traditional tidal systems situate turbines in a barrage (dam) through which the tides come in and out; newer designs use free-standing, generally submerged, turbines located at or near shorelines, bays, and channels

town gas: gas (composed mainly of hydrogen) that is manufactured from raw materials such as coal, coke, or oil; is distinguished from natural gas, which occurs naturally in underground deposits; during the 1800s town gas was widely distributed through pipelines to many cities and towns in Europe and America for light and heat

transformer: device used to "step-up" (increase) or "step-down" (decrease) the voltage of electric current

transmission lines: towers and wires through which high-voltage electricity travels over long distances

transmit: to send from one place to another

turbine: bladed, wheel-like device caused to spin by the force of pressurized steam or gas, wind, or moving water; used in electricity production to drive an electrical generator

GLOSSARY (continued)

U

U.S. Environmental Protection Agency (EPA): a federal agency of the United States with the mission of protecting the nation's natural environment; establishes and enforces regulations through a network of regional offices

ultraviolet: radiant waves that are part of the electromagnetic spectrum; are invisible to the human eye; solar ultraviolet radiation comes in several wavelengths, one of which is harmful to biological life, but most of which is absorbed by upper atmospheric ozone layer

unburned hydrocarbons: air pollutants that come from the incomplete combustion of fossil fuels and from the evaporation of petroleum fuels, industrial solvents, painting and dry cleaning chemicals

uranium: a heavy, silvery-white metallic element that is radioactive and toxic; exists in 14 different forms, or isotopes; is extracted from ores for use in research, nuclear fuels, and nuclear weapons

V

vaporize: to convert into a vapor, the gaseous state of a substance

variable-speed wind turbine: turbine that can respond to wind speed changes

voltage: the measure of the electrical force that "pushes," or drives, an electric current

W X Y Z

wastewater: the collective discharge from toilets, sinks, showers, washing machines, storm-sewers, etc.; can be cleaned, or "treated," to remove most of the toxic components and then used for purposes other than consumption by animals or humans

water cycle: the natural process of the movement of Earth's water as it evaporates from bodies of water, condenses, precipitates (rains, sleet, hail, snows) and returns to those bodies of water, in a continuous cycle

watt (W): the rate of electrical current flow, when one ampere is driven, or "pushed," by one volt

watt-hour (Wh): the energy expended when one watt of electrical power is used for an hour

wet-cell battery: a battery, or "cell," in which an electrochemical reaction occurs in an electrolyte

wetland: a lowland area, such as a marsh, swamp, or estuary, that is saturated with moisture; provides a rich habitat for wildlife; absorbs heavy metals and filters out toxins, releases oxygen into the air while removing carbon dioxide and other greenhouse gases; provides flood control and is a significant factor in the recharge of groundwater

wind energy: the mechanical force of moving air saturated with kinetic energy; a renewable energy source

wind farm: a cluster of wind turbines located in areas with reliably favorable wind speeds, such as on high windy mountain passes or gusty open plains; can also be situated on farms or ranches alongside crops and grazing animals

ADDITIONAL INFORMATION RESOURCES

These listings are selected from the wealth of information available on all aspects of energy use. First listed are information resources specific to each chapter, followed by a more general information section. Many of the listings include great website links.

CHAPTER 1: ENERGY HISTORY

California Energy Commission Energy Time Machine

[www.energyquest.ca.gov/time machine](http://www.energyquest.ca.gov/time_machine)

Extensive timeline of energy history from the dawn of history to present day.

Milestones in the History of Energy and Its Uses

EIA Energy Ant Kids Site

www.eia.doe.gov/kids/milestones

Traces significant events in the history of energy; links to "Pioneers in Energy" and "Energy in the United States, 1635-2000."

See also "Other Information Resources," pages 181-184.

CHAPTER 2: ELECTRICITY

Electricity Online

ThinkQuest

www.thinkquest.org

Explores the physics, practical applications, and history of electricity in an interactive, online format.

See also "Other Information Resources," pages 181-184.

CHAPTER 3: BIOMASS

California Biomass Energy Alliance

805-386-4343

www.calbiomass.org

General biomass information; specific information on California biomass power plants; ask an expert.

National Renewable Energy Laboratory (NREL)

Clean Energy Basics

About Biomass Energy

www.nrel.gov/learning/re_biomass.html

Information about state-of-the-art biomass technologies; general information on using biomass for energy.

U.S. Department of Energy (DOE)

Office of Energy Efficiency and Renewable Energy Biopower Division

www1.eere.energy.gov/biomass/abcs_biopower.html

Information on all aspects of using biomass for energy; links to related organizations and information sources; library; photo gallery.

CHAPTER 3: GEOTHERMAL

GeoHeat Center

Oregon Institute of Technology

541-885-1750

<http://geoheat.oit.edu>

General information on geothermal energy, especially its use at lower temperatures; geothermal heat pumps; where geothermal resources are located and being used; access to experts; links to other information sources.

Geothermal Education Office

www.geothermal.marin.org

Information and educational materials on all aspects of geothermal energy; geothermal curriculum unit, videos, maps; posters.

Geothermal Energy Association

www.geo-energy.org

202-454-5261

Trade association and advocacy organization promoting use of geothermal energy; lists of all U.S. geothermal power plants; papers on environmental and economic impacts of geothermal energy development.

ADDITIONAL INFORMATION RESOURCES (continued)

Geothermal Resources Council

www.geothermal.org
530-758-2360

Primary membership and educational organization for the geothermal industry worldwide; library of downloadable semi-technical papers on geothermal energy.

U.S. Department of Energy (DOE)

Office of Energy Efficiency and Renewable Energy
Geothermal Technologies Program
www1.eere.energy.gov/geothermal

Information on all aspects of geothermal energy and links to other geothermal energy sites.

CHAPTER 3: HYDROPOWER

Bonneville Power Administration (BPA)

800-282-3713
www.bpa.gov

General information on large hydro and related subjects.

Bureau of Reclamation Power Program Hydropower Information

www.usbr.gov/power

Topics covered include history of hydropower in the United States; background information on hydropower, major hydropower producers; links to other sources of information; educational materials for K-8, including "Nature of Water Power."

Foundation for Water and Energy Education

800-279-6375
www.fwee.org

Many educational materials on hydropower; information on all aspects of hydropower including environmental impacts.

National Hydropower Association

202-682-1700
www.hydro.org

Advocacy organization promoting the widespread use of hydropower; access to basic hydropower information.

U.S. Department of Energy (DOE)

Office of Energy Efficiency and Renewable Energy
Hydropower Division

www1.eere.energy.gov/windandhydro

Information on all aspects of hydropower; links to other hydropower resources and organizations.

CHAPTER 3: OCEAN

Ocean Energy Council

561-793-0320
www.oceanenergycouncil.com

Basic information on ocean energy and extensive links to government and industry sites.

Ocean News & Technology

www.oceanrenewable.com

Information about conferences, legislation, and jobs in the marine renewable industries.

U.S. Department of Energy (DOE)

Office of Energy Efficiency and Renewable Energy
Ocean Topics

www.eere.energy.gov

Information on all aspects of ocean energy and links to other ocean energy sites.

CHAPTER 3: SOLAR

American Solar Energy Society

303-443-3130
www.ases.org

Advocacy organization promoting widespread use of solar energy; information on all aspects of solar energy; magazine: *Solar Today*; Solar Guide Fact Base; publications; educational materials: videos, slides, activities.

Florida Solar Energy Center Teacher Resources

www.fsec.ucf.edu/ed/teachers

Information on all aspects of solar energy; student contests such as Junior Solar Sprint and Hydrogen Sprint; offers many teaching resources including units on energy in general, solar energy, alternative fuels, and environmental issues.

ADDITIONAL INFORMATION RESOURCES (continued)

Project Sol

Arizona Public Service (APS)
www.aps.com/my_community/solar/solar_6.html

A solar education site developed by APS (an Arizona power supplier); topics include energy from the sun, electrical energy, inside PV systems, power for the future; solar data; virtual tour of a photovoltaic cell.

U.S. Department of Energy (DOE)

Solar Decathlon

www.solardecathlon.gov/for_teachers.cfm

Interactive website for teachers covering various topics, including solar energy and energy efficiency.

CHAPTER 3: WIND

American Wind Energy Association

202-383-2500

www.awea.org

Advocacy organization promoting widespread use of wind energy; information on all aspects of wind energy; online bookstore; "Wind Energy Weekly" covers wind industry, global climate change, and energy policy; resource library; information on specific wind energy projects.

U.S. Department of Energy (DOE)

Office of Energy Efficiency and Renewable Energy Wind Energy Program

www1.eere.energy.gov/windandhydro

Information on wind energy basics, including how wind turbines work; wind turbine research, and wind energy projects; links to other organizations; resources for teachers and students; photo gallery.

Wind Energy Resource Atlas of the United States

National Renewable Energy Laboratory

<http://rredc.nrel.gov/wind/pubs/atlas>

Atlas showing the quality of wind energy resources in various parts of the United States.

CHAPTER 3: HYDROGEN

Fuel Cell Store

303-237-3834

www.fuelcellstore.com

Fuel cell products for classroom and for the general public; products include fuel cell demonstration kits, fuel cell systems and accessories; resources for students and teachers, including fuel cell experiments, books, posters, and videos.

National Hydrogen Association

202-223-5547

www.hydrogenus.org

Advocacy organization promoting the widespread use of hydrogen fuel; basic information on hydrogen fuel; resources for students and educators.

Schatz Energy Research Center

707-826-4345

www.humboldt.edu/~serc

Working in affiliation with Humboldt State University's Environmental Resources Engineering program, develops and promotes renewable energy technologies, especially hydrogen fuel cells, zero emission vehicles, and solar hydrogen power systems; information on all aspects of hydrogen and fuel cells; educational materials.

CHAPTER 3: FOSSIL FUELS

Petroleum Education

Paleontological Research Institution

607-273-6623

www.museumoftheearth.org

"From the Ground Up: The World of Oil" covers all aspects of oil including geology basics, oil history, hydrocarbon systems, daily uses of oil.

U.S. Department of Energy (DOE)

Fossil Energy Division

www.fe.doe.gov

Extensive information on all aspects of fossil fuel production and use in the United States and globally; recent fossil fuel news items; clean coal and natural gas technologies; "For Students" section.

ADDITIONAL INFORMATION RESOURCES (continued)

CHAPTER 3: NUCLEAR

Nuclear Energy Institute

202-739-8000
www.nei.org

Advocacy organization promoting the use of nuclear energy; information on nuclear technologies; public policy issues; nuclear data; library; "NEI Science Club," teachers and kids site that includes games, information, curricular materials.

U.S. Department of Energy (DOE)

Office of Nuclear Energy, Science and Technology
www.ne.doe.gov

Information on all aspects of nuclear energy; nuclear power research; space and defense power programs; nuclear facilities management; nuclear fuel supply security; public information.

CHAPTER 4: ENERGY, HEALTH, AND THE ENVIRONMENT

Earth Island Institute

415-788-3666
www.earthisland.org

Institute researching and promoting a wide variety of projects on conservation, preservation, and restoration both nationally and globally; "Earth Island Journal," many publications; news and citizen action alerts; information on starting your own action project.

National Oceanic and Atmospheric Administration

202-482-6090
www.noaa.gov

Researches and disseminates information on all aspects of climate, weather, and the oceans; weather forecasting satellite imagery; ocean exploration; fisheries; climate research; air quality; coastal services; undersea laboratory; library and archives; photo library.

See also Chapter 5 information resources and "Other Information Resources" pages 181-184.

CHAPTER 5: ENERGY MANAGEMENT STRATEGIES AND ENERGY POLICY

Alliance to Save Energy

202-857-0666
www.ase.org

Advocacy organization promoting energy efficiency; energy efficiency programs, including "Energy Science Fair," "Green Schools," "New School Construction," and "Downloadable Educator Lesson Plans."

American Council for an Energy-efficient Economy

202-429-2248
www.aceee.org

Organization dedicated to advancing energy efficiency; advises on and provides educational information on energy policy, energy efficient buildings, industry, transportation; publications and other consumer information. Look for "Consumer Guide to Home Energy Savings."

Astronomy Picture of the Day (APOD)

National Aeronautics Space Administration
<http://antwrp.gsfc.nasa.gov/apod/ap001127.html>

Satellite composite photo taken Nov. 27, 2000, shows "Earth at Night": highlights developed or populated areas of the earth's surface; can be used to demonstrate differences in resource consumption between developed and developing nations.

Carbon Footprint

www.carbonfootprint.com/calculator.aspx

An educational and easy-to-use carbon footprint calculator.

Redefining Progress: Sustainability Program

510-444-3041
www.rprogress.org/programs/ecological.footprint

Partnership of organizations dedicated to sustainability; calculate your own ecological footprint; ecological footprint concepts and methods; sustainability education resources; publications.

ADDITIONAL INFORMATION RESOURCES (continued)

Rocky Mountain Institute

970-927-3851
www.rmi.org

Fosters sustainable social, economic, and environmental practices; information on energy, climate, water, transportation, energy efficient buildings; Kids site; educational materials; newsletter, bookstore.

Union of Concerned Scientists

See page 184.

U.S. Environmental Protection Agency (EPA)

www.epa.gov

Federal government health and environment regulatory agency; information on many topics including laws and regulations, environmental management, health topics, pollution prevention, economics, compliance and enforcement; educational resources; extensive Global Warming Site, including Kids site and educator materials and information.

Worldwatch Institute Resource Center

202-452-1999
www.worldwatch.org

Independent research organization advocating environmental sustainability; resource center topics include energy resources, climate change, transportation pollution, biodiversity, food, population, and water issues; publications and news alerts.

See below for more information on sustainability, energy policy, and management.

OTHER INFORMATION RESOURCES

American Council on Renewable Energy (ACORE)

202-293-1123
www.acore.org

Non-profit organization formed to accelerate the adoption of renewable energy technologies into the mainstream of American society; focus on trade, finances, and policy; promotes all renewable energy options.

Acorn Naturalists

800-422-8886
www.acornnaturalists.com

Books and other teaching materials on many topics including environmental education, outdoor education, science inquiry, interpreting cultural and natural resources, "GEMS" ("Great Explorations in Math and Science"), earth science, ecology, plant and animal studies, and the ocean.

Ask an Energy Expert

1-800-DOE-3732
www.eere.energy.gov/industry/bestpractices/energymatters/archives.html

A division of U.S. DOE Office of Energy Efficiency and Renewable Energy; answers questions ranging from how to make your school more energy efficient to specifics on the use of renewable energy.

Bonneville Power Administration (BPA)

800-282-3713
www.bpa.gov

General information on water, hydroelectricity, energy conservation, electric safety, resource planning and BPA history.

California Energy Commission (CEC)

General: 916-654-4287
Toll Free in California: 1-800-555-7794
www.energy.ca.gov

Consumer Energy Center Website; information about energy efficiency, energy statistics, and renewable energy; rebate information news releases; programs include energy efficiency, renewable energy development, alternative fuel vehicles.

California Energy Commission Kids Site: Energy Quest

www.energyquest.ca.gov

"Time Machine," "The Energy Story" (all aspects of energy and energy resources), games, energy terms, "How Things Work," science projects, "Ask Professor Questor," teacher and parent resources.

ADDITIONAL INFORMATION RESOURCES (continued)

California Mineral Education Foundation

916-655-1050
www.calmineraled.org

Charitable education corporation developed to provide mineral education programs for K-12 teachers. Covers wide variety of geological topics, as well as mining and processing of minerals.

Center for Energy Efficiency and Renewable Technologies (CEERT)

916-442-7785
www.ceert.org

Based in Sacramento, public interest coalition working towards policy change and public education regarding the use of sustainable, environmentally sound methods to meet California's energy needs. Up-to-date information on renewable energy technologies, energy efficiency, and energy policy.

Chelsea Green: Books for Sustainable Living

800-639-4099
www.chelseagreen.com

Wide range of sustainable living books and some videos on topics such as energy-efficient homes, stand-alone renewable energy systems, ecological architectural design, and renewable energy.

Energy for Keeps

www.energyforkeeps.org

Supplemental information for this book, including student activities, information for teachers, reader comments and suggestions.

Energy Ant: DOE Kids Zone

www.eia.doe.gov/kids

Energy history, articles on various energy topics, "What is Energy," "Kids Corner," "Energy Quiz," teacher resources.

Foundation for Water and Energy Education

www.fwee.org

Information related to the use of water as a renewable resource in the Pacific Northwest.

The Franklin Institute

214-448-1200
www.fi.edu

Museum online resource; science history; energy information; online study unit topics include wind, plate tectonics, oceans; links to many other resources; "Community Science Action Guides" include global warming, fossil fuel depletion, nuclear energy, energy resources, and visual animations of energy at work.

How Stuff Works

www.howstuffworks.com

Reliable information source on just about every topic, including many specific energy-related topics.

Interstate Renewable Energy Council (IREC)

518-458-6059
www.irecusa.org

Non-profit organization formed to accelerate the sustainable utilization of renewable energy sources and technologies in and through state and local governments and community activities; strong education and community outreach programs.

National Energy Education Development (NEED)

703-257-1117
www.need.org

Partner with U.S. DOE's Rebuild America and "Energy Smart Schools." Information about energy resources, including how their use impacts the environment; K-12 curriculum material including hands-on activities about the science of energy, electricity, efficiency and conservation; training and professional development; photo gallery.

National Energy Foundation

801-908-5800
www.nef1.org

Information about renewable energy, efficiency, and conservation. Materials catalog, NEF Academy for professional development, Energy Action Programs (energy awareness and energy management for schools, community, home), student programs include "Academy of Energy," "Fueling the Future," and "Igniting Creative Energy."

ADDITIONAL INFORMATION RESOURCES (continued)

National Renewable Energy Laboratory (NREL)

303-275-3000
www.nrel.gov/education

U.S. DOE's laboratory for renewable energy and energy efficiency research and development; general information on state-of-the-art renewable energy technologies; Office of Education Program provides renewable energy and energy efficiency curriculum, activities, projects; student competitions; teacher training, including direct access to current renewable energy research.

National Science Resources Center

Smithsonian Institution/The National Academies
www.si.edu/nsrc

Many educational resources on all topics, including energy; publications; science newsletter; links to many resources; science curriculum units for both middle school and K-6.

Northeast Sustainable Energy Association

413-774-6051
www.nesea.org

Education section provides interdisciplinary K-12 materials on energy, transportation, and the environment; links to Green Car Club, Clean Energy, and Green Buildings.

NOVA Science in the News

Australian Academy of Science
www.science.org

Up-to-date linked information on various science topics, geared for high school level; categories include environment, physical sciences, and technology; includes links to such topics as climate, electromagnetism, and plate tectonics.

Renewable Energy Partnership

www.repartners.org

Helps public power, electric co-ops, and tribal utilities get current, reliable information about renewable power; a one-stop shop for researching renewable energy options; information on best green power marketing practices; deep-links to topics such as industry calendars, green power, state and federal funding opportunities, case studies, transmission studies, tools for market research, tools for identifying and screening renewable resources; resources to educate customers.

Renewable Energy Policy Project (REPP)

www.crest.org

Information on renewable energy; energy and the environment, efficiency, and policy issues; library archives; "Global Energy Marketplace," e-mail newsletter; up to date news; recent trends.

Renewable Energy Project Kits

Pembina Institute, Canada
www.re-energy.ca

Provides background information on selected renewable energy resources (including wind, hydropower, solar, biomass); includes detailed directions for building working models.

Renewable Energy World

www.jxj.com/magsandj/rew

Website containing many articles from magazine of same title; global coverage of state-of-the-art renewable energy projects and policy issues; information is rather technical, but students can skim for general information; one of the best sources for up-to-date information; check to see if it will give you free subscription to the print-version magazine.

Sustainable Energy Coalition

202-293-2898
www.sustainableenergycoalition.org

Advocacy organization that promotes federal support for energy efficiency and renewable energy technologies; energy facts and statistics; energy policy information; links to many energy experts.

ADDITIONAL INFORMATION RESOURCES (continued)

Tennessee Valley Authority Kids Site

www.tvakids.com

Information on protecting the environment, making electricity, "Green Power," electrical safety, TVA history; teacher resources include a K-12 renewable energy curriculum and "Energy Sourcebooks" with teacher guides and energy education activities.

Union of Concerned Scientists

National Headquarters

Phone: 617-547-5552

West Coast Office

Phone: 510-843-1872

www.ucsusa.org

Partnership of scientists and citizens for scientific analysis, policy development and citizen advocacy promoting practical and sustainable environmental solutions in many areas including energy use and pollution; programs include support for renewable energy development and policies.

U.S. Department of Energy (DOE)

Energy Information Administration

202-586-8800

www.eia.doe.gov

Ask an Expert; Energy data, analyses, forecasts, and publications about specific energy resources, as well as general publications such as "Monthly Energy Review," the "Annual Energy Review," the "Short-Term Energy Outlook," and the "Annual Energy Outlook."

U.S. Department of Energy (DOE)

Office of Energy Efficiency and Renewable Energy

202-586-9220

www.eere.energy.gov

Portals to related U.S. DOE offices, as well as to many other programs related to energy efficiency and renewable energy; energy education programs include energy curriculum, science projects and activities, student competitions, and student resources; oversees "EnergySmart Schools" and "Rebuild America" programs.

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