

RENEWABLE ENERGY 101

What is Renewable Energy? ¹

Renewable energy sources are those that are derived from the sun or other natural processes. Unlike carbon based fuel sources, they are also replenishable over short time periods, making for a sustainable environment and economy.

The major types of renewable energy include, but are certainly not limited to:

- Solar
- Wind
- Hydropower
- Biomass
- Geothermal

Solar: using sunlight (solar radiation of ultraviolet bandwidth) directly to generate electricity or for water heating, space heating, lighting and other applications. Solar Energy Technologies can be classified as:

- **Active Solar:** The two types of systems are:
 - Photovoltaic (PV) systems, which convert sunlight directly into electricity.
 - Solar Thermal:
 - Solar Water Heating systems use sunlight to heat water for homes, other buildings, and swimming pools.
 - Solar Space Heating can help heat your home in cold weather, and can even help cool your home in hot weather.

Active systems are characterized by the presence of solar collector panels, commonly located on the roof of a building, on freestanding poles; many other locations are possible given the trend toward solar-scapes (sunroom, car port and canopy clear panels) , and BIPV (building integrated PV such as within shingles and glazed glass). Newer thin-film applications are also available for small power and many flexible applications including standing seam architectural metal roofs.

An active system requires either: (1) additional electrical devices such as inverters, disconnect switches, meters and batteries to collect the DC energy and connect to the household AC electrical system for PV ; or (2) additional mechanical devices such as pumps or fans to transport solar-heated air or liquid to its point of use or to storage for solar thermal.

- **Passive Solar:** Passive systems have no solar panels but rather rely on architectural design and construction materials to collect or shed the sun's heat. Passive systems have few, if any, mechanical devices and depend primarily on natural processes such as radiation, convection, or conduction to transport the collected heat. The Midwest urban planning concept of laying out cities on a North-South grid pattern originated from the early Greco Roman Empire and was designed at that time to beneficially collect solar radiation from the southern exposure to heat homes, prior to the existence of any active heating systems. Today, passive systems use windows, doorways, greenhouses, trombe walls or skylights as solar collectors. Good passive solar architecture can reduce the energy consumption of a building by 50% or more with little of any added cost to the construction.

Wind: Wind turbines are designed to generate direct current (DC) electricity just like solar PV systems, and indeed the remainder of the electrical system components are identical (disconnects, inverter, batteries, etc). Small wind systems are systems that have peak outputs of less than 100kW. Individual owners may have wind turbines with peak outputs of only a few kW.

Wind is caused by the different rates at which different places on earth are warmed by the sun, the interaction between air of different temperatures, ocean and mountain breezes, and other climatological impacts of the earth's rotation. The energy in wind indirectly comes from the energy in sunlight. Wind has been used to propel ships for thousands of years and to power windmills for hundreds of years.

In 2005, the United States installed more new wind energy capacity than any other country in the world. The new capacity, totaling 2,431 megawatts (MW), was worth more than \$3 billion in generating equipment, and it brought the total national wind energy capacity to 9,149 MW. That's enough electricity to power 2.3 million average American households. In 2006, an additional 2,454 MW were installed, bringing the Nation's total installed capacity to 11,603 MW.

Hydropower: The energy of falling water, i.e. gravitational forces in our natural environment, can be used to generate electricity through the use of hydropower equipment. In basic terms, the major equipment includes the channeling of falling water through a piping system and pumps, which are allowed to free spin; when the turbine is coupled with an electrical generator, the system can produce electricity. With 80,000 megawatts (MW) of generating capacity, hydropower is the nation's largest renewable electricity source today.

Humans have been harnessing water to perform work for thousands of years. The Greeks used water wheels for grinding wheat into flour more than 2,000 years ago. Besides grinding flour, the power of the water was used to saw wood and power textile mills and manufacturing plants.

For more than a century, the technology for using falling water to create hydroelectricity has existed. The evolution of the modern hydropower turbine began in the mid-1700s when a French hydraulic and military engineer, Bernard Forest de Bélidor wrote *Architecture Hydraulique*. In this four volume work, he described using a vertical-axis versus a horizontal-axis machine.

During the 1700s and 1800s, water turbine development continued. In 1880, a brush arc light dynamo driven by a water turbine was used to provide theatre and storefront lighting in Grand Rapids, Michigan; and in 1881, a brush dynamo connected to a turbine in a flour mill provided street lighting at Niagara Falls, New York. These two projects used direct-current technology.

Alternating current is used today. That breakthrough came when the electric generator was coupled to the turbine, which resulted in the world's and the United States' first hydroelectric plant located in Appleton, Wisconsin, in 1882. Today, continuing advanced research on new turbine designs has been supported jointly by DOE and industry. The renewable s industry has, in the past decade been developing micro hydro systems which can be implemented on a private level rather than the traditional utility scale systems of the past.

While the technology for generating hydropower exists, traditional hydropower can sometimes be associated with environmental impacts, particularly with respect to fish passage and survival, water quality in reservoirs and downstream from dams, and altered flow regimes that may degrade physical habitat for fish below dams. For this reason, i.e. the land requirements for impoundments and dams, this renewable resource is often viewed with environmental sensitivity.

Biomass: using the energy in agricultural products and waste to generate electricity and other fuel. Biomass, such as agricultural products, vegetation, trash, or animal waste, can be converted to electricity and other fuel supplies. Biomass can be used to heat buildings, such as with a wood burning stove, and oils and alcohols can be extracted to power engines in cars and trucks. Biomass can also be used to generate electricity.

Specific Biomass Technologies:

- Landfill Gas
- Anaerobic Digestion
- Waste Wood
- Energy Crops

The first two technologies are the most mainstream today. Waste Management has recently made a commitment to introduce gas turbine electricity generation (and very importantly waste gas recovery) at over 80 of their facilities recently. The Los Angeles County Sanitation Districts has been employing landfill gas recovery systems for several decades. Anaerobic Digestion is employed at over 60% of the wastewater treatment plants nationwide for electricity and steam generation facilities.

Geothermal:

There are three types of Geothermal Energy Applications:

Power Plants - Power plant technologies are being used to convert hydrothermal fluids to electricity. The type of conversion used depends on the state of the fluid (whether steam or water) and its temperature.

Direct Use - Geothermal reservoirs of low-to moderate-temperature water — 68°F to 302°F (20°C to 150°C) — provide direct heat for residential, industrial, and commercial uses. This resource is widespread in the U.S., and is used to heat homes and offices, commercial greenhouses, fish farms, food processing facilities, gold mining operations, and a variety of other applications. Direct use of geothermal energy in homes and commercial operations is much less expensive than using traditional fuels. Savings can be as much as 80% over fossil fuels. Direct use is also very clean, producing only a small percentage (and in many cases none) of the air pollutants emitted by burning fossil fuels.

Heat Pumps - The geothermal heat pump, also known as the ground source heat pump, is a highly efficient renewable energy technology that is gaining wide acceptance for both residential and commercial buildings. Geothermal heat pumps are used for space heating and cooling, as well as water heating. Its great advantage is that it works by concentrating naturally existing heat, rather than by producing heat through combustion of fossil fuels.

Why Renewable Energy?

Renewable energy (RE) technologies have great potential to benefit our nation. They are essential to creating a sustainable environment and economy. They can **diversify our energy supply, reduce our dependence on imported fuels, improve the quality of the air we breathe, offset greenhouse gas emissions, and stimulate our economy by creating jobs in the manufacturing and installation of solar energy systems.**

Using solar energy as but one example of the RE technology, although solar electricity (also known as photovoltaics or PV) is not the sole answer to our myriad energy challenges, this renewable energy option can make an important contribution to the economy of the United States and the world. Photovoltaics (PV) are also an important energy technology for many reasons. As a solar energy technology, it has numerous environmental benefits. As a domestic source of electricity, it contributes to the nation's energy security. As a relatively young, high-tech industry, it helps to create jobs and strengthen the economy. As it costs increasingly less to produce and use, it becomes more affordable and available.

Few power-generation technologies have as little impact on the environment as photovoltaics, and RE in general. As it quietly generates electricity from light, PV produces no air pollution or hazardous waste. It doesn't require liquid or gaseous fuels to

be transported or combusted. And because its energy source - sunlight - is free and abundant, PV systems can guarantee access to electric power.

PV frees us from the cost and uncertainties surrounding energy supplies from politically volatile regions. And in addition to reducing our trade deficit, a robust domestic PV industry creates new jobs and strengthens the U.S.

What is a Distributed Energy Resource?

Electricity from RE is a versatile technology that can be used for applications from the very small to the very large, from grid-connected systems to grid-independent systems, to hot water, space and industrial process heating, and power plants. Increasingly, in a competitive market, the U.S. electrical grid will come to rely on distributed energy resources. The modular nature of the technology enables us to construct distributed electricity-generating systems in increments as demands grow, to improve supply reliability, and to moderate distribution and transmission costs. In addition, many regions of the United States are becoming limited by transmission capacities and local emission controls, but solar electric, wind micro hydro electric, biomass and other RE power systems can be easily sited at the point of use with no environmental impact. And because renewable are widely available, we can build geographically diverse systems that are less vulnerable to international energy politics, volatile fossil-fuel-based markets, and transmission failures.

Distributed energy technologies are expected to supply an increasing share of the electricity market to improve power quality and reliability problems that have caused power outages and cost the United States economy \$119 billion a year (Electric Power Research Institute, Consortium for Electric Infrastructure to Support a Digital Society). We have only to remember August 14, 2003, when more than 50 million people in eight U.S. states and parts of Canada were left in the dark in the biggest blackout in the history of North America, to realize the potential power of adding solar electricity to our energy mix.

What is Net Metering?

While wind and solar resources are reliable, their output does not always match the system owner's electricity consumption. On a windy day, for instance, a wind turbine may produce more electricity than is needed on site. Owners of these systems should be able to feed excess electricity onto the power grid during times of excess and draw power from the grid during times of need, paying only for the net electricity they use. This is accomplished through a system called 'net metering,' where a bi-directional meter tracks the consumer's flow of energy and calculates how much electricity is actually used.

To illustrate this concept, consider a net metering system for a consumer whose power comes from a 4kW solar array. During the day, when the sun is shining, the array produces more energy than the consumer needs, and so the meter runs backwards

(essentially, the consumer is exporting energy to the grid). At night, when she's importing energy, her meter starts running forward again. At the end of the monthly billing period, the owner of the solar array pays only for her net energy consumption.

Net metering is an accurate and efficient way to track energy consumption and generation. Moreover, it gives customers increased freedom of choice in their source of energy, without penalizing those who invest in renewable generation.

DOMINION VIRGINIA NET METERING

Net metering is available to those customers, served on non-time of usage rate schedules, who own and operate, or contract with other persons to own or operate, or both, a "renewable fuel generator" for the primary purpose of offsetting all or part of the net metering Customer's (Customer) own requirements for Electricity Supply Service from the Company or Competitive Service Provider (CSP). A renewable fuel generator means an electrical generating facility that:

1. Has an alternating current capacity of not more than 10 kilowatts for residential customers and not more than 500 kilowatts for non-residential customers;
2. Uses as its total fuel source sunlight, wind, falling water, sustainable biomass, energy from waste, wave motion, tides, or geothermal power;
3. Is owned and operated, or contracts to be owned or operated, or both, by the Customer and is located on the Customer's premises;
4. Is interconnected to the Customer's wiring on the Customer's side of its interconnection with the Company and is operated in parallel with the Company's electric transmission and distribution system.

What needs to be done to mainstream these energy resources?

A national Energy policy as well as state energy policy must become a priority. The Congress is currently discussing alternative House and Energy Bills and are intending to pass legislation before the end of the year. It is important to get involved in asking questions of your representatives and trying to insure that a strong renewable energy element is included in the forthcoming legislation.

As energy prices skyrocket and consumers struggle with high winter heating bills, states are recognizing a critical need to develop viable renewable energy sources. Traditionally, the hardest part of developing new energy sources has been the difficulty in ensuring a market for renewable energy, given renewable energy's high initial investment costs and the power industry's historic preference for fossil fuel.

States have taken the lead on developing these markets by enacting statewide Renewable Portfolio Standards (RPS). An RPS works by setting the minimum amount of renewable energy that must be developed by retail electricity vendors each year. The amount increases over time, steadily decreasing a state's dependence on traditional energy sources while simultaneously building a renewable energy infrastructure. In 2005, for example, an RPS could require a utility to supply 5% of its retail electricity sales through renewable energy; in 2007 the requirement might increase to 7%, and so on. Beyond this core principle, several attributes contribute to an RPS's effectiveness:

An RPS is compulsory and far reaching. Applying to all retail electricity within a state, it produces meaningful demand for renewable energy.

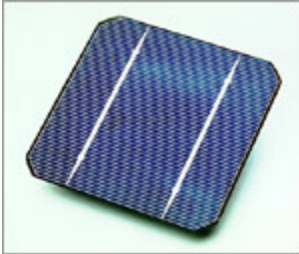
- Growth is paced and orderly. Predictably ratcheted upwards, it avoids boom and bust cycles and gives energy companies the certainty they need to invest in new technologies.
- Duration is long term. The RPS supports the renewable energy market long enough to ensure developers that they will recover their investment costs.
- Compliance is market based. With a few exceptions, the RPS generally does not specify a technology roadmap, and therefore companies pursue the most efficient routes to developing renewable energy given each state and region's differing capacities.

Developing a state's RPS should be high on every state and local Apollo Alliance's list of priorities. A meaningful RPS fulfills the main goals of the Apollo Alliance, achieving energy independence while adding new, good-paying jobs. The Union of Concerned Scientists has estimated that a national RPS requiring 20% in renewable energy sources by 2020 could generate 355,000 jobs across the country.^[1] Many of these benefits will be realized at the regional level, as renewable energy often utilizes indigenous resources.

1. © 2006 The Reinvestment Fund, www.trfund.com/sdf/energyed.html
2. NREL, www.eere.energy.gov/windandhydro/windpoweringamerica/small_wind.asp
3. USDOE, EERE, www1.eere.energy.gov/solar/to_economy.html

PHOTOVOLTAICS – Appendix A

PV Systems



A photovoltaic cell, the most basic building block of a PV system.



This array supplies 6.5 kilowatts of electricity to the Canyonlands Needles Outpost, an all-purpose general store, restaurant, gas station, and campground that serves visitors to the national park near Moab, Utah.



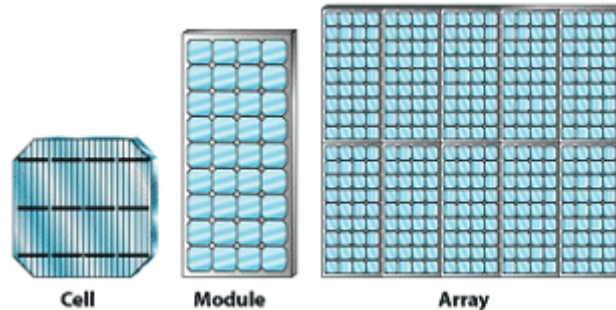
These two silicon modules are rated at about 50 watts each and generate power to illuminate an entry sign.

A photovoltaic (PV) or solar cell is the basic building block of a PV (or solar electric) system. An individual PV cell is usually quite small, typically producing about 1 or 2 watts of power. To boost the power output of PV cells, we connect them together to form larger units called modules. Modules, in turn, can be connected to form even larger units called arrays, which can be interconnected to produce more power, and so on. In this way, we can build PV systems able to meet almost any electric power need, whether small or large.

PV systems can be classified into two general categories: [flat-plate systems](#) or [concentrator systems](#). We will talk about the differences between these two types of systems later on.

By themselves, modules or arrays do not represent an entire PV system. We also need structures to put them on that point them toward the sun, and components that take the direct-current electricity produced by modules and "condition" that electricity, usually by converting it to alternate-current electricity. We might also want to store some electricity, usually in batteries, for later use. All these items are referred to as the "balance of system" (BOS) components.

Combining modules with the BOS components creates an entire PV system. This system is usually everything we need to meet a particular energy demand, such as powering a water pump, or the appliances and lights in a home, or, if the PV system is large enough, all the electrical requirements of a whole community.



The basic photovoltaic or solar cell typically produces only a small amount of power. To produce more power, cells can be interconnected to form modules, which can in turn be connected into arrays to produce yet more power. Because of this modularity, PV systems can be designed to meet any electrical requirement, no matter how large or how small.

Table 1. System Energy Payback Times for Several Different Photovoltaic Module Technologies.

(1700 kWh/m²/yr insolation and 75% performance ratio for the system compared to the module.)

Cell Technology	Energy Payback Time (EPBT)¹ (yr)	Energy Used to Produce System Compared to Total Generated Energy² (%)
Single-crystal silicon	2.7	10.0
Non-ribbon multicrystalline silicon	2.2	8.1
Ribbon multicrystalline silicon	1.7	6.3
Cadmium telluride	1.0	3.7

1. V. Fthenakis and E. Alsema, "Photovoltaics energy payback times, greenhouse gas emissions and external costs: 2004-early 2005 status," *Progress in Photovoltaics*, vol. 14, no. 3, pp. 275-280, 2006.

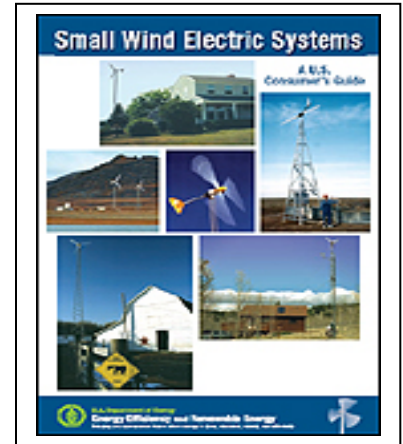
2. Assumes 30-year period of performance and 80% maximum rated power at end of lifetime.

WIND – Appendix B

The following links will provide you with more information about wind energy and the Wind Energy Program's research and development efforts. Some of the documents are available as Adobe Acrobat PDFs. [Download Adobe Reader](#).

Selected Wind Energy Topics

- [Wind Energy Basics](#)
- [Low Wind Speed Turbine Technology](#)
- [Distributed Wind Energy Technology](#)
- [Wind Powering America](#)
- [Federal Wind Siting Information Center](#)
- [Systems Integration](#)
- Wind Energy Program Multiyear Program Plan 2007 - 2012 ([PDF 2.3 MB](#))
- Wind Power Today ([PDF 2.1 MB](#))
- Annual Report on U.S. Wind Power Installation, Cost, and Performance Trends: 2006 ([PDF 2.4 MB](#))
- Annual Report on U.S. Wind Power Installation, Cost, and Performance Trends: 2006 (A presentation from Ryan Wisler and Mark Bolinger, Lawrence Berkeley National Laboratory ([PDF 2.9 MB](#)))
- Wind Energy Program 2006 Peer Review Report ([PDF 535 KB](#))



U.S. Department of Energy - Energy Efficiency and Renewable Energy²Wind and Hydropower Technologies Program - Wind Powering AmericaSmall Wind Electric Systems: A U.S. Consumer's Guide

Date: 9/12/2007

English ([PDF 1.3 MB](#)) and Spanish ([PDF 1.5 MB](#)) [Download Adobe Reader](#)

This guide provides consumers with information to help them determine whether a small wind electric system can provide all or a portion of the energy they need for their home or business based on their wind resource, energy needs, and economics.

HYDROPOWER – Appendix C

Advanced Hydropower Technology



At the Wanapum Dam on the Columbia River, a fish-friendly turbine runner that helps salmon smolts pass through the turbine is under test.

The Advanced Hydropower Technology (AHT) activity supports the development of technologies that will enable existing hydropower projects to generate more electricity with less environmental impact. This will be done by: 1) developing new turbine systems that have improved overall performance, 2) developing new methods to optimize hydropower operations at the unit, plant, and reservoir system levels, and 3) conducting research to improve the effectiveness of the environmental mitigation practices required at hydropower projects.

The main objective of DOE's research into Advanced Hydropower Technology is to develop new system designs and operation modes that will enable both better environmental performance and competitive generation of electricity. While DOE does not own or operate hydropower projects, the products of DOE's research will allow hydropower projects to generate cleaner electricity. DOE-sponsored projects will develop and demonstrate new equipment and operational techniques that will optimize water-use efficiency, increase generation, and improve environmental performance and mitigation practices at existing plants. Research efforts contributing to the success of these objectives include:

- Testing a new generation of large turbines in the field to demonstrate that these turbines are commercially viable, compatible with today's environmental standards, capable of balancing environmental, technical, operational, and cost considerations.
- Developing new tools to improve water use efficiency and operations optimization within hydropower units, plants and river systems with multiple hydropower facilities.
- Identifying improved practices that can be applied at hydropower plants to mitigate for environmental effects of hydro development and operation.

When fully adopted, the products of DOE's research will enable up to a 10% increase in the hydropower generation at existing dams, with net benefits to the environmental quality of rivers in the U.S.

Environmental performance has been defined in terms of the survival of fish passing through the turbines, dissolved oxygen and other water quality parameters downstream of a dam, and downstream habitat conditions for fish. The advanced turbine research to date has produced two types of new conceptual designs: 1) modifications to existing Kaplan and Francis turbines, and 2) an innovative turbine runner with a helical screw shape, patterned after centrifugal pumps.

Biological design criteria have also been developed in laboratory tests of fish response to physical stresses such as hydraulic shear and pressure changes. Through the combination of laboratory, field, and computational studies, new solutions to environmental problems at hydropower projects are being found. Much of this work is cost-shared with the U.S. Army Corps of Engineers and with other industry partners.

BIOMASS – Appendix D

Specific Biomass Technologies:

- [Landfill Gas](#)
- [Anaerobic Digestion](#)
- [Waste Wood](#)
- [Energy Crops](#)

Landfill Gas

Most trash that is not recycled is sent to a landfill. As the trash decays, it gives off methane. The gas that is captured from landfills contains methane, water vapor, and smaller amounts of other gases. Landfill gas can be safely incinerated to produce heat to generate electricity.

While burning landfill gas creates carbon dioxide, a contributor to global warming, the methane itself is a far worse contributor to global warming. So it is much better to capture the landfill gas, burn it, and use the energy than to let it simply escape into the air or to flare it in an open burn.

Landfill gas is considered to be a renewable energy source because we are able to continue to produce large amounts of trash.

Anaerobic Digestion

Anaerobic digestion is a process that converts organic waste, such as manure, agricultural waste and food processing waste into methane gas. The resulting gas can be used to power an electricity generator or for other purposes.

Waste Wood

Waste wood from timber production can be burned for heat or to generate electricity. To learn more about obtaining energy from waste wood, visit these sites:

- [US Department of Energy - Waste Wood](#)
- [Bio Research and Development - Energy from Waste Wood](#)
- [State University of New York - Willow Biomass project](#)

Energy Crops

Energy crops are crops used primarily as energy sources, rather than being grown for food or other purposes. The same crop may also be used for food, lumber, or paper, but growing methods may differ when the primary goal is energy. Examples include certain trees and crops used to make vegetable oils and ethanol. The products of energy crops are sometimes mixed with the products of other biomass sources.

While burning the products of energy crops creates carbon dioxide, the crops remove carbon dioxide as they grow, reducing the overall impact on the environment. Fuel for cars and trucks has been a major goal in the development of energy crops. For more information on energy crops, including wood, visit these sites:

- [US DOE Energy Efficiency and Renewable Energy - Biofuels](#)
- [US DOE Energy Efficiency and Renewable Energy - Ethanol](#)
- [US DOE Energy Efficiency and Renewable Energy - Alternative Fuels](#)
- [National Biodiesel Board](#)
- [State University of New York - Biomass Portal](#)
- [Biomass Research & Development](#)
- [Western Regional Biomass Energy Program - Switchgrass](#)

GEOHERMAL – Appendix E

The Direct–Use Resource

Low–temperature geothermal resources exist throughout the western U.S., and there is tremendous potential for new direct–use applications. A recent survey of 10 western states identified more than 9000 thermal wells and springs, more than 900 low– to moderate–temperature geothermal resource areas, and hundreds of direct–use sites.

The survey also identified 271 collocated sites – cities within 5 miles (8 kilometers) of a resource hotter than 122 degrees F (50 degrees C) – that have excellent potential for near–term direct use. If these collocated resources were used only to heat buildings, the cities have the potential to displace 18 million barrels of oil per year!

Tapping the Resource

Direct–use systems typically include three components:

- A production facility – usually a well – to bring the hot water to the surface;
- A mechanical system – piping, heat exchanger, controls – to deliver the heat to the space or process; and
- A disposal system – injection well or storage pond – to receive the cooled geothermal fluid.

Operations Using Heat Directly from the Earth

District and Space Heating



The first modern district heating system - Oregon Institute of Technology; installed 1964.

The primary uses of low–temperature geothermal resources are in district and space heating, greenhouses, and aquaculture facilities. A 1996 survey found that these applications were using nearly 5.8 billion megajoules of geothermal energy each year – the energy equivalent of nearly 1.6 million barrels of oil!

In the U.S., more than 120 operations, with hundreds of individual systems at some sites, are using geothermal energy for district and space heating. District systems distribute hydrothermal water from one or more geothermal wells through a series of pipes to several individual houses and buildings, or blocks of buildings. Space heating uses one well per structure. In both types, the geothermal production well and distribution piping replace the fossil-fuel-burning heat source of the traditional heating system.

Geothermal district heating systems can save consumers 30% to 50% of the cost of natural gas heating. The tremendous potential for district heating in the western U.S. was illustrated in a 1980s inventory which identified 1,277 geothermal sites within 5 miles of 373 cities in 8 states.



A fish farm in Colorado.

Greenhouse and Aquaculture Facilities

Greenhouses and aquaculture (fish farming) are the two primary uses of geothermal energy in the agribusiness industry. Thirty-eight greenhouses, many covering several acres, are raising vegetables, flowers, houseplants, and tree seedlings in 8 western states. Twenty-eight aquaculture operations are active in 10 states.

Most greenhouse operators estimate that using geothermal resources instead of traditional energy sources saves about 80% of fuel costs – about 5% to 8% of total operating costs. The relatively rural location of most geothermal resources also offers advantages, including clean air, few disease problems, clean water, a stable workforce, and, often, low taxes.



Crop dehydration plant in Nevada.

Industrial and Commercial Uses

Industrial applications include food dehydration, laundries, gold mining, milk pasteurizing, spas, and others. Dehydration, or the drying of vegetable and fruit products, is the most common industrial use of geothermal energy. The earliest commercial use of geothermal energy was for swimming pools and spas. In 1990, 218 resorts were using geothermal hot water.

Geothermal Heat Pumps ▶

The geothermal heat pump, also known as the ground source heat pump, is a highly efficient renewable energy technology that is gaining wide acceptance for both residential and commercial buildings. Geothermal heat pumps are used for space heating and cooling, as well as water heating. Its great advantage is that it works by concentrating naturally existing heat, rather than by producing heat through combustion of fossil fuels.