Geothermal

Geothermal energy is the energy contained in the heated rock and fluid that fills the fractures and pores within the earth's crust. It originates from radioactive decay deep within the Earth and can exist as hot water, steam, or hot dry rocks.

The Technology

Commercial forms of geothermal energy are recovered from wells drilled 100–4,500 metres below the Earth's surface. The technology is well proven, relatively uncomplicated, and involves extracting energy via conventional wells, pumps, and/or heat exchangers.

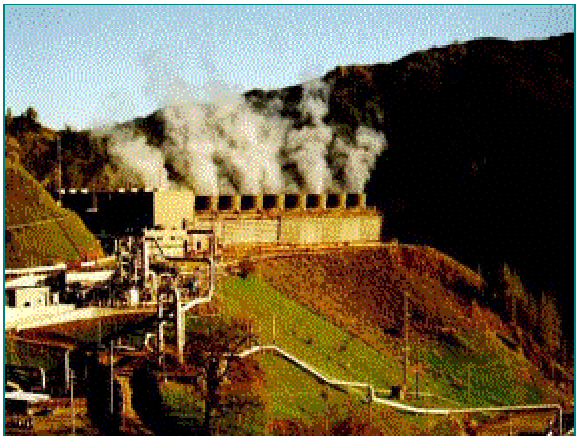
Geothermal energy can be used directly or indirectly, depending on the temperature of the geothermal resource. Geothermal resources are classified as low temperature (less than 90°C), moderate temperature (90°C - 150°C), and high temperature (greater than 150°C). The highest temperature resources are generally used only for electric power generation and found in volcanic regions. Low and moderate geothermal resources are found in most areas of the world.

Geothermal energy can be used directly in temperatures ranging from about 35°C to 150°C to heat buildings, greenhouses, aquaculture facilities and to provide industrial process heat. Indirectly, high temperature geothermal steam can be used to drive a turbine and create electricity or in heat pumps.

Using geothermal energy directly is 50 to 70 percent efficient compared to the 5 to 20 percent possible for the indirect use of generating electricity (although using the waste heat from generating electricity can also be used and thus boost the overall efficiency). Applications that use geothermal energy directly can also draw from both high and low temperature geothermal energy resources, where useful energy can be produced for as low as US$0.02/kilowatt-hour (kWh).

Low temperature geothermal energy can also be recovered almost anywhere with special "ground source" heat pumps. These pumps can use the earth as either a heat source for heating or as a heat sink for cooling. Using resource temperatures of 4°C to 38°C, the heat pump transfers heat from the soil to the building in winter and from the building to the soil in summer.

Extracting geothermal energy can have adverse environmental impacts, particularly air pollution from radon



Geothermal power plants, such as this one in the US, can be designed to produce both heat and power. (Photo courtesy Pacific Gas and Electric and NREL).

Costs
Electricity from Geothermal Steam
(US$/kW installed capacity)

Plant Size	*High Quality Resource*	*Low Quality Resource*
<5 MW	*$1600-2300*	*$1800-3000*
5-30 MW	*$1300-2100*	*$1600-2500*
>30 MW	*$1150-1750*	*$1350-2200*

Exploring and developing a steam field for electricity generation represents a significant portion of the overall investment and can amount to 30 percent of the overall cost for a project, depending on the quality of the geothermal resource.

Key Points:

- Geothermal energy is a well-proven energy resource that can be used to provide both heat and electricity via well-proven and mature technology.
- Geothermal energy resources exist in many areas of the world for both high and low temperature applications.
- Using geothermal energy directly for heating applications can be up to 70 percent efficient.
- Environmental issues associated with geothermal energy include the emission of sulphur and nitrogen gases. Environmental impact assessments are usually necessary.
- Useful geothermal energy for heating and cooling can be recovered almost everywhere with special heat pumps that utilise the heat of the earth just below the surface.
- Geothermal energy is renewable only if the rate of fluid extraction is less than recharge rate.

gas, hydrogen sulfide, methane, ammonia, and carbon dioxide emissions. Generally, the carbon dioxide emissions of a geothermal power plant are only five percent of the emissions from equivalent fossil fuel power plants. Using geothermal resources can also create substantial thermal pollution from waste heat.

Many of these impacts can be controlled with technology that re-injects waste gases or fluids back into the geothermal well. The area of land impacted by a geothermal development is relatively small and such developments can usually co-exist successfully with other land uses.

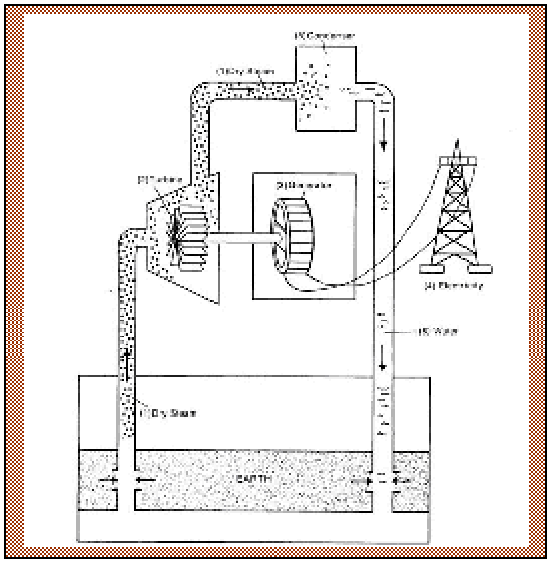
A geothermal field (Photo: Pacific Gas and Electric, courtesy NREL).

Other drawbacks include the problem of mineral deposits on the components, and the need to drill new wells after a few years of use. It is important to note that geothermal energy is renewable only if the rate of extraction is less than the recharge rate. Currently, few geothermal projects for generating electricity meet this requirement.

The Industry and Market Trends

Geothermal energy has been harvested commercially since the early part of the 20th century. The use of geothermal energy has increased rapidly since 1970 and now occurs in more than 45 countries.

About 9,000 MW of electricity is currently generated from geothermal resources, and the equivalent of 9,000 MW is recovered for direct heating applications. There is significant potential to expand the use of geothermal energy for both electricity generation and industrial heating applications.



Total investment in geothermal energy from 1973 to 1995 was about US$22 billion, and the industry continues to grow at about 16 percent per annum in electricity generation and about 6 percent in direct uses.

Currently, Costa Rica, El Salvador, Kenya, and Nicaragua generate 10 to 20 percent of their electricity from geothermal resources, while the Philippines generates 22 percent and plans to add 580 MW in the period 1999–2008.

Project Risks

Technology:

Using geothermal energy presents few technical risks as the technology is based on conventional pumps, heat exchangers, steam turbines and generators.

Environmental:

An environmental impact assessment is usually required to explore and extract geothermal energy. Extracting geothermal energy can release noxious waste gases such as sulphur dioxide and carbon monoxide. These risks can often be addressed with technology that re-injects waste gases back into the geothermal well. Other adverse impacts may include land subsidence and increased seismic activity.

Planning:

The geothermal resource must be carefully assessed but often is not fully known until a geothermal reservoir is utilised over a sustained period of time. Financial risks include the relatively high levels of capital investment for exploration, drilling wells and the installation of plant and equipment.

If present trends continue, geothermal electricity generating capacity could increase from about 10,000 MW at the start of 2000, to 58,000 MW in 2020.

The market for ground-source heat pumps is also growing rapidly. In the US, 300,000 domestic and commercial systems are in operation, and under a current incentive scheme, sales could reach 400,000 annually by 2005.

There is considerable interest and research in technology to generate electricity from hot dry rock geothermal resources. In this process, water is injected into the geothermal well and then recovered as steam, which is used to drive turbine generator sets. As the technology, however, is still experimental it is not yet ready for commercial deployment.