Geothermal Education Material

1. WHAT IS GEOTHERMAL ENERGY?

The word "Geothermal" comes from the Greek words geo (earth) and therme (heat). So, geothermal means earth heat.

Our earth's interior - like the sun - provides heat energy from nature. This heat - geothermal energy - yields warmth and power that we can use while reducing pollutants to the environment.

Geothermal heat originates from the earth's fiery consolidation of dust and gas over 4 billion years ago. At earth's core - 6437 kilometres deep - temperatures may reach over 4982 degrees C.

Geothermal energy draws sustainable power from the natural heat of the earth. It is the thermal energy contained in the rock and fluid (that fills the fractures and pores within the rock) in the earth's crust. It is believed that the ultimate source of geothermal energy is radioactive decay occurring deep within the earth. The presence of volcanoes, hot springs and other thermal phenomena are surface evidence of our planet's heat resource.

2. HOW DOES GEOTHERMAL ENERGY WORK?

The heat from the earth's core continuously flows outward. It transfers (conducts) to the surrounding layer of rock, the mantle. When temperatures and pressures become high enough, some mantle rock melts, becoming magma. Then, because it is lighter (less dense) than the surrounding rock, the magma rises (convects), moving slowly up toward the earth's crust, carrying the heat from below.

Sometimes the hot magma reaches all the way to the surface, where we know it as lava. But most often the magma remains below the earth's crust, heating nearby rock and water (rainwater that has seeped deep into the earth) - sometimes as hot as 370 degrees C. Some of this hot geothermal water travels back up through faults and cracks and reaches the earth's surface as hot springs or geysers, but most of it stays deep underground, trapped in cracks and porous rock. This natural collection of hot water is called a geothermal reservoir.

Tapping geothermal resources requires drilling into permeable zones of super-heated water trapped in geothermal reservoirs. Once tapped, these underground reservoirs can provide geothermal plants with water or steam hot enough to generate electricity.

3. HOW IS GEOTHERMAL USED?

Geothermal heat is used in some creative ways; its use is limited only by our ingenuity.

From earliest times, people have used geothermal water that flowed freely from the earth's surface as hot springs. The oldest and most common use was just relaxing in the comforting warm waters. But eventually, this "magic water" was used (and still is) in other creative ways. The Romans, for example, used geothermal water to treat eye and skin disease. At Pompeii, geothermal water was used to heat buildings.

As early as 10,000 years ago, aboriginal peoples used hot springs water for cooking and medicine. For centuries, the Maoris of New Zealand have cooked "geothermally" and, since the 1960s, France has been heating up to 200,000 homes using geothermal water.

Today, high temperature geothermal resources are accessed by drilling wells into geothermal reservoirs to bring the hot water or steam to the surface. In order to know where to drill geothermal production wells, geologists, geochemists, drillers and engineers do a lot of exploring and testing to locate underground areas that contain this geothermal water. Once the hot water and/or steam travels up the wells to the surface, it can be used to generate electricity in geothermal power plants or for energy saving non-electrical purposes.

Direct Uses. Using geothermal water or steam 'directly' conserves electricity and replaces the use of polluting energy resources with clean ones. Once the heat from the water or steam has been used, it is returned underground. Geothermal waters ranging from 10 degrees C to over 150 degrees C are used directly from the earth:

- to soothe aching muscles in hot springs, and health spas (*balneology*);
- to help grow flowers, vegetables, and other crops using rows of pipes carrying geothermal installed in greenhouses or under soil (where flowers or vegetables are not protected by the shelter and warmth of a greenhouse). This ensures that the ground does not freeze, providing a longer growing season and overall faster growth of plants (*agriculture*).
- to shorten the time needed for growing fish, shrimp, abalone and alligators to maturity (*aquaculture*);
- to pasteurize milk, dry onions and lumber, and to wash wool (*industrial uses*); and
- for space heating of individual buildings and of entire districts. This is - besides hot spring bathing - the most common and the oldest direct use of nature's hot water.

Geothermal district heating systems pump geothermal water through a heat exchanger, where it transfers its heat to clean city water that is piped to buildings in the district. There, a second heat exchanger transfers the heat to the building's heating system. The geothermal water is injected down a well back into the reservoir to be naturally heated and used again.

The world's largest district heating system is in Reykjavik, Iceland. Since it started using geothermal energy as its main source of heat Reykjavik, once very polluted, has become one of the cleanest cities in the world.

GeoExchange. Animals have always known to burrow into the earth, where the temperature is relatively stable compared to the air temperature, to get shelter from winter's cold and summer's heat. People, too, have sought relief from bad weather in earth's caves. Today, with GeoExchange systems, we take advantage of this stable earth temperature - about 7 - 15 degrees C just a few feet below the surface - to help keep our indoor temperatures comfortable.

GeoExchange is the industry's term used to describe an alternative to traditional oil- gas- or coal-fired heating, ventilation and air conditioning (HVAC) systems. GeoExchange systems circulate water or other liquids through pipes buried in a continuous loop (either horizontally or vertically) next to a building. Depending on the weather, the system is used for heating or cooling.

- *Heating*: Earth's heat (the difference between the earth's temperature and the colder temperature of the air) is transferred through the buried pipes into the circulating liquid and then transferred again into the building.

- *Cooling*: During hot weather, the continually circulating fluid in the pipes 'picks up' heat from the building - thus helping to cool it - and transfers it into the earth.

This heat 'exchange' between the ground and the building is accomplished by using standard pump and compressor technology. Geoexchange systems have also been referred to as earth energy systems, or geothermal heat pump systems. GeoExchange Systems use very little electricity and are very easy on the environment. In the U.S., the temperature inside over 300,000 homes, schools and offices is kept comfortable by these energy saving systems, and many thousands more are used worldwide. The U.S. Environmental Protection Agency has rated GHP's as among the most efficient of heating and cooling technologies.

Electricity Generation. Since the first geothermally-generated electricity in the world was produced at Larderello, Italy, in 1904, the use of geothermal energy for electricity has grown worldwide to about 7,000 megawatts in twenty-one countries around the world. The United States alone produces 2700 megawatts of electricity from geothermal energy, electricity comparable to burning 60 million barrels of oil each year.

In geothermal power plants, steam, heat or hot water from geothermal reservoirs provides the force that spins the turbine generators and produces electricity. Once used, the geothermal water is returned down an injection well into the reservoir to be reheated, to maintain pressure, and to sustain the reservoir.

There are three kinds of geothermal power plants. The kind we build depends on the temperatures and pressures of a reservoir.

1. A dry steam reservoir produces steam but very little water. The steam is piped directly into a dry steam power plant to provide the force to spin the turbine generator.

The largest dry steam field in the world is The Geysers, about 145 kilometres north of San Francisco. Production of electricity started at The Geysers in 1960, at what has become the most successful alternative energy project in history.

2. A geothermal reservoir that produces mostly hot water is called a hot water reservoir and is used in a flash power plant. Water ranging in temperature from 150 - 370 degrees C is brought up to the surface through the production well where, upon being released from the pressure of the deep reservoir, some of the water flashes into steam in a separator. The steam then powers the turbines.
3. A reservoir with temperatures between 120 - 180 degrees C is not hot enough to flash enough steam but can still be used to produce electricity in a binary power plant. In a binary system, the geothermal water is passed through a heat exchanger where its heat is transferred into a second (binary) liquid, such as isopentane, that boils at a lower temperature than water. When heated, the binary liquid flashes to vapour, which, like steam, expands across and spins the turbine blades. The vapour is then recondensed to a liquid and is reused repeatedly. In this closed loop cycle, there are no emissions to the air. The binary power plant system is the most likely technology to be used in British Columbia.

The Geothermal Resources Act, administered and maintained by the Ministry of Energy, Mines and Petroleum Resources, governs only geothermal resources 80 degrees C and above. Of the three types of uses listed above, this would include the higher temperature direct uses and electricity generation.

4. WHAT PARTS OF THE WORLD HAVE GEOTHERMAL ENERGY?

Electricity and Direct Use. Geothermal reservoirs, that are close enough to the surface to be reached by drilling, can occur in places where geologic processes have allowed magma to rise up through the crust, near to the surface, or where it flows out as lava. The crust of the earth is made up of huge plates, which are in constant but very slow motion relative to one another. Magma can reach near the surface in three main geologic areas:

1. Where earth's large oceanic and crustal plates collide and one slides beneath another, called a subduction zone. The best example of these hot regions around plate margins is the Ring of Fire -- the areas bordering the Pacific Ocean: the South American Andes, Central America, Mexico, the Cascade Range of the U.S. and Canada (British Columbia), the Aleutian Range of Alaska, the Kamchatka Peninsula of Russia, Japan, the Philippines, Indonesia and New Zealand;
2. Spreading centers, where these plates are sliding apart, (such as Iceland, the rift valleys of Africa, the mid-Atlantic Ridge and the Basin and Range Province in the U.S.); and
3. Places called hot spots-- fixed points in the mantle that continually produce magma to the surface. Because the plate is continually moving across the hot spot, strings of volcanoes are formed, such as the chain of Hawaiian Islands.

The countries currently producing the most electricity from geothermal reservoirs are the United States, New Zealand, Italy, Iceland, Mexico, the Philippines, Indonesia and Japan, but geothermal energy is also being used in many other countries.

GeoExchange Systems. GeoExchange systems can be used almost world-wide. The Earth's temperature a few feet below the ground surface is relatively constant everywhere in the world (about 7 - 14 degrees C), while the air temperature can change from summer to winter extremes. Unlike other kinds of geothermal heat, shallow ground temperatures are not dependent upon tectonic plate activity or other unique geologic processes. Thus, geothermal heat pumps can be used to help heat and cool homes anywhere.

5. HOW MUCH GEOTHERMAL ENERGY IS THERE?

Thousands more megawatts of power than are currently being produced could be developed from already-identified hydrothermal resources. With improvements in technology, much more power will become available. Usable geothermal resources will not be limited to the "shallow" hydrothermal reservoirs at the crustal plate boundaries. Much of the world is underlain (5-10 kilometres down), by hot dry rock - no water, but lots of heat. Scientists in the U.S.A., Japan, England, France, Germany and Belgium have experimented with piping water into this deep hot rock to create more hydrothermal resources for use in geothermal power plants. As drilling technology improves, allowing us to drill much deeper, geothermal energy from hot dry rock could be available anywhere. At such time, we will be able to tap the true potential of the enormous heat resources of the earth's crust.

6. WHAT ARE SOME OF THE ADVANTAGES OF USING GEOTHERMAL ENERGY TO GENERATE ELECTRICITY?

Clean. Geothermal power plants, like wind and solar power plants do not have to burn fuels to manufacture steam to turn the turbines. Generating electricity with geothermal energy helps to conserve non-renewable fossil fuels, and by decreasing the use of these fuels, reduce emissions that harm our atmosphere. There is no smoky air around geothermal power plants -- in fact some are built in the middle of farm crops and forests, and share land with cattle and local wildlife. For ten years, Lake County California, home to five geothermal electric power plants, has been the first and only county to meet the most stringent governmental air quality standards in the U.S.

Easy on the land. The land area required for geothermal power plants is smaller per megawatt than for almost every other type of power plant.

Reliable. Geothermal power plants are designed to run 24 hours a day, all year. A geothermal power plant sits right on top of its fuel source. It is resistant to interruptions of power generation due to weather, natural disasters or political rifts that can interrupt transportation of fuels. Once developed, geothermal energy provides long-term, stable revenues.

Flexible. Geothermal power plants can have modular designs, with additional units installed in increments when needed, to fit growing demand for electricity.

Keeps Dollars at Home. Money does not have to be exported to import fuel for geothermal power plants. Geothermal "fuel'" - like the sun and the wind - is always where the power plant is; economic benefits remain in the region and there are no fuel price shocks.

Helps Developing Countries/ Communities Grow. Geothermal projects can offer all of the above benefits to help developing countries/ communities grow without pollution. Installations in remote locations can raise the standard of living and quality of life by bringing electricity to people far from "electrified" population centers.

SOURCES OF INFORMATION:

- CanGEA Website: What Is Geothermal? (http://www.cangea.ca/what-is-geothermal)
- Geothermal Education Office Website: Geothermal Energy Facts (http://www.geothermal.marin.org/pwrheat.html)