GEOTHERMAL ENERGY

Brief History

Geothermal is our Earth's (geo) internal heat (thermal).
Humans have used geothermally heated waters since antiquity for bathing, medicinal purposes, and in the extraction of minerals, such as sulfur, silica, and certain borates. First electrical power generation occurred from a **dry-steam reservoir in Italy in 1904** with commercial production occurring about 10 years later. Power generation from a **liquid-dominated reservoir** was first utilized in **New Zealand in the late 1950s.** The first commercial geothermal power generation in the **United States began in 1960** at "The Geysers" in Northern California.

Today (2019), the United States is the world's largest producer of electrical geothermal power, about 3500 megawatts (MW), which **represents about 27% of the world's geothermal power installed capacity**. For reference, one million watts are equal to one megawatt, which is enough power to **serve the needs of about 750-1000 homes** depending on the time of day, season, and other factors.

HELLO!
My name is Steam Meiser,
I'm going to be your guide.

You can see geothermal energy when you look at a volcano. I bet you've made model volcano at school.

Space and Water Heating

Warm geothermal water **(100°C or below boiling)** can be used directly for space and water heating. Related uses are called District Heating and GeoExchange. These uses are more widespread than hot geothermal fluids used in electrical power production.

Fossil Fuel Free

Geothermal systems provide a clean operation in which **no fossil fuels are burned**, thus, very low levels of greenhouse gases are emitted. Fossil fuels burned for energy are coal, oil, and gas.

Agriculture

Geothermally heated water, too cool to produce electrical power, can instead be used to **grow vegetables and ornamental flowers**. Iceland uses geothermal heat in greenhouses to grow vegetables and select fruits, mainly strawberries, **elimjnating the need to import them and thereby reducing costs to consumers.**

Aquaculture - Fish Farming

Warming water through geothermal heat is used **to help growth of smolt (young trout or salmon)** at fish hatcheries. It is also used to grow **prawns, eels, and even alligators** (for their hides).

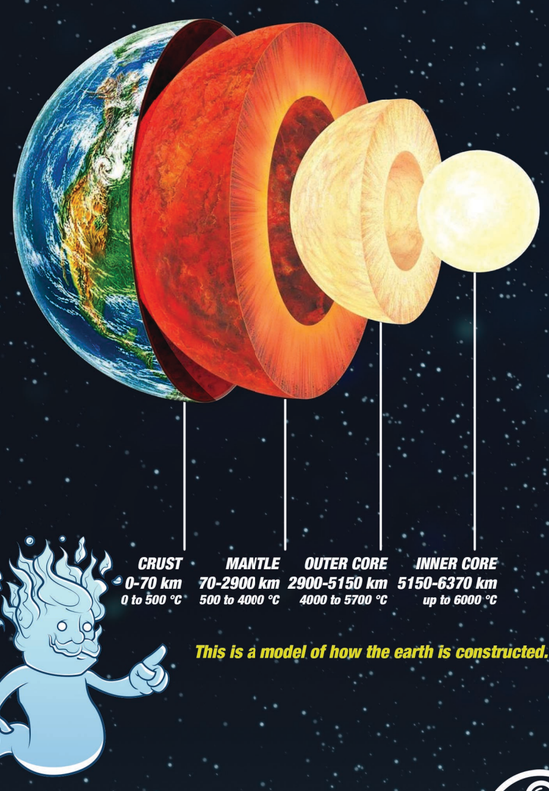
Electrical Generation

When the temperature is 150°C or above, geothermal systems are able to **generate large-scale electricity to supply cities, and heavy industries** with a low environmental impact.

Industrial Processes

Many industries (such as lumber drying and food canning and processing) apply geothermal systems **for almost any process that requires heating or cooling**, with lower operational cost than conventional heating systems.

Nice Clean Water Vapor!



******The layers of Earth (Credit: https://phys.org/news/2015-12-earth-layers.html)***

This is a model of how the earth is constructed.

Environmentally Friendly

Air Emissions

Geothermal power plants produce no nitrous oxides and **no harmful gases are released** during the course of operation of closed-loop binary geothermal plants.

For flash and steam plants, emissions of CO_2 per megawatt-hour (MWh) are extremely low, about 100 lbs of CO_2 per MWh, compared to about 1100 lbs of CO_2 per MWh for natural-gas-fired power plants, the cleanest-burning fossil fuel.

Land Use

Geothermal power plants have **the smallest footprint of all energy production technologies** on a per megawatt basis. The wind power footprint is about 4 times as big. Solar photovoltaic power uses more land, about 10 times larger footprint. Coal-fired power plants with the related coal mining use the most space.

Unlike most other power generation facilities, geothermal power plants **can coexist with other forms of land use**, including agriculture, grazing, spas and resorts (e.g., the famous Blue Lagoon in Iceland), fish farms, and even within close proximity to residential areas (e.g., Steamboat geothermal power complex in Reno, Nevada).

Water Use

Flash and steam geothermal plants consume water via evaporation in order to cool and condense the steam; this requires make-up water for re-injection to **keep the geothermal reservoir pressurized and producing** at a constant level.

At The Geysers in northern California, a symbiotic relationship was forged when **The Geysers accepted treated effluent**, which was becoming a disposal problem for the town of Santa Rosa and communities in Lake County, to be re-injected and maintain sustainability of the geothermal reservoir.

Air-cooled binary geothermal plants **consume no water and are well-suited for arid climates** like the Basin and Range of Nevada.

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