GeoEnergy: Directly To You

What is geothermal energy?

Geothermal energy is energy provided to us naturally through heat from the earth. The heat is extracted from the earth in various ways and is converted to useable energy.

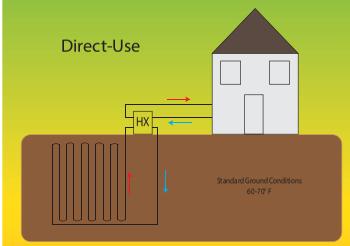
How do we use geothermal energy?

Geothermal energy can be used in two ways: Directly and Indirectly.

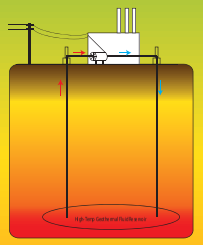
Direct-use applications involve taking the earth's heat and applying it to various uses, (such as heating a house), without converting the heat to electricity.

Indirect-use geothermal energy involves converting the heat from the earth into electricity. From there, the electricity is transferred to powerlines to be used in homes and buildings.

Direct-Use

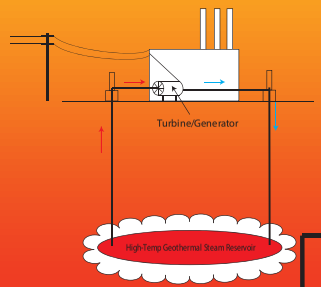


Indirect-Use



Power Production (Indirect Use)

Before learning about **direct-use geothermal energy,** it is important to know a little bit about how **electricity** is made through geothermal heat.
There are 2 different ways electricity can be produced.



Steam Power Plant (Flash Steam Plant)

Steam is collected from the geothermal reservoir.

Steam drives a turbine, the turbine powers a generator, the generator creates electricty, and electricty is sent to powerlines.

After the steam leaves the turbine, some of it condenses back into water and is reinjected underground where high temperatures will turn it back into steam. The rest of the steam that does not condense back into water is theejected from the plant.

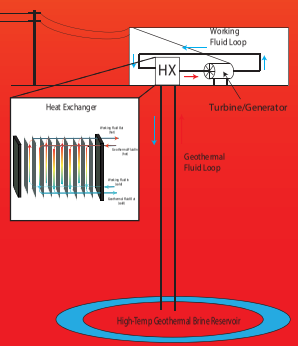
Binary Power Plant

Geothermally heated liquid, called brine, is collected from the geothermal reservoir

The hot geothermal brine is passed through a heat exchanger (HX), seen right, where heat is transfered to a different fluid, called working fluid, that can carry more energy. After passing through the heat exchanger, 100% of the geothermal brine is reinjected back into the reservoir.

When heated from geothermal brine, the working fluid evaporates to steam, the steam drives a turbine, the turbine powers a generator, the generator creates electricty, and electricty is sent to the powerlines.

This process is continued and contained within 2 closed loop systems.



Now that you know a little bit about geothermal electricity production, continue reading about **direct-use geothermal energy.**

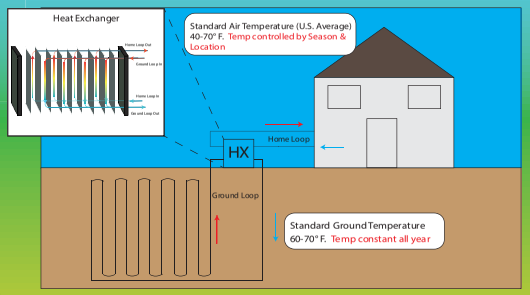
Low Temp

High Temp

All information used in the development of this infographic was taken from the Department of Energy sponsored *National Geothermal Academy.* If you are interested in learning more about the geothermal energy industry, please visit:
http://energy.gov/eere/geothermal/geothermal-technologies-office
or
http://www.geothermal.org/

Geothermal Heat Pumps (GHPs)

Geothermal heat pumps (GHPs) make it possible to not only heat, but also cool a house without traditional, noisy, and expensive air-conditioning units. GHPs are the most commonly used form of direct-use geothermal energy, accounting for approximately 47% of world-wide usage.



Applications:
- Heating
- Cooling
- Hot Water

(For individual homes)

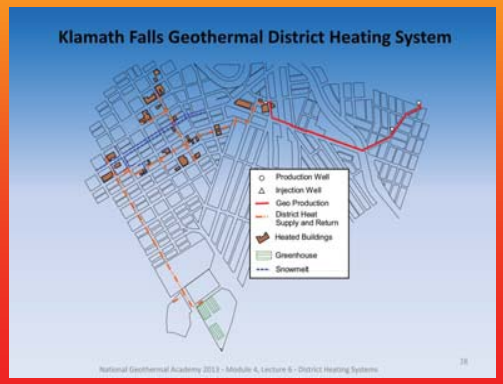
GHP vs Conventional (Air-Source Heat Pumps)
GHPs use earth temperatures (constant 60-70) which are typically closer to room temperature. Air-source systems use air temperatures (40-70° average depending on the season) which are less suitable for indoor conditioning.

For a 60,000 BTU/hr load: (Load of about 15 homes)

Fuel oil	$1,765
Propane	$2,063
Natural Gas	$1,310
Electricity	$2,610
Geothermal	$746

District Heating

Geothermal district heating is very similar to a GHP. The main difference is in the scale of heat being provided. District heating can provide heat to whole cities instead of just singular houses. Displayed below is the geothermal district heating grid for Klamath Falls, Oregon.



Applications:
- Heating
- Cooling
- Hot Water
- Snowmelt sytems in sidewalks and bridges
- Industrial applications (food drying, dairies, etc)
- Geothermal greenhouses
- Fish farms

(City-wide Scale)

Klamath Falls, OR Case Study:
Produces geothermal fluid from 2 wells @ ~212°F
Procedure:
1) Geothermal fluid is pumped from the production wells to a central pumping station.
2) Geothermal fluid is passed through heat exchangers and injected back into the subsurface.
3) After being heated, the working fluid leaves the central pumping station at ~180°F.
4) The working fluid circulates through the city and returns to the centeral pumping station at ~140°F.

Low Temp

High Temp

Aquaculture

Geothermally heated fish farms are common in areas with cold climates and low to medium temperature geothermal resources.

Species	Tolerable Extremes (°F)	Optimum Growth (°F)	Growth Period of Market Size (months)
Oysters	32 – 97	76 – 78	24
Lobsters	32– 88	72 – 75	24
Penaeid shrimp			
Kuruma	40 - ?	77 – 87	6 – 8 typically
Pink	52 – 104	75 – 85	6 – 8
Salmon (Pacific)	40 – 77	59	6 – 12
Freshwater Prawns	75 – 90	83 – 87	6 – 12
Catfish	35 – 95	82 – 87	6
Eels	32– 97	73 – 86	12 – 24
Tilapia	47 – 106	72 – 86	-
Carp	40 – 100	68 – 90	-
Trout	32 – 89	63	6 – 8
Yellow Perch	32 – 86	72 – 82	10
Striped Bass	? - 86	61 - 66	6 – 8

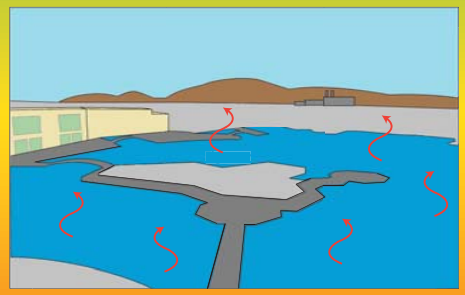
National Geothermal Academy – Module 4, Lecture 4 – July 29, 2013

World-wide usage:
- 3.2 billion kWh/year
- USA, China, Iceland, and Italy account for 76% of production

Design Considerations:
- Displayed above are typical temperature design considerations
- 100-150°F geothermal brine needed for cold climates
- Special ponds and tanks with specific dimensions are needed for harvesting process
- Pond/tank temperature must be closely maintained specifically for each species
- Water quality and disease control must be carefully monitored
- Under optimum conditions, fish growth period can be 30-50% faster

Balneology (bathing and spas)

The illustration below is based on the Blue Lagoon Spa in Reykjavik, Iceland.
Pictured in the background is the Svartsengi Geothermal Power Plant.

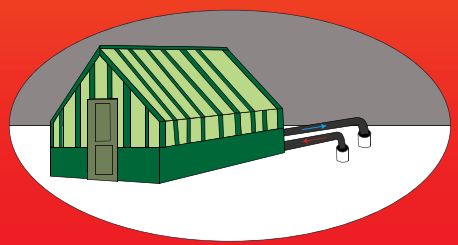


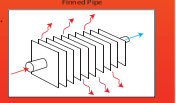
Health Benefits:
- Rest and relaxation
- Exercise
- Social recreation
- **Geothermal Muds**- shown to have positive effects on blood pressure, metabolism, and even arthritis

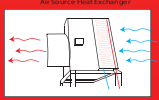
Design Considerations:
- Geothermal waters may need to be cooled or chlorinated.
- Temperature and flow rate must be closely monitored for heat loss through evaporation, radiation, etc.
- Humidity and ventilation must be controlled to maintain comfort of spa guests.

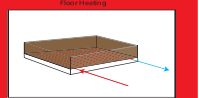
Agriculture

Geothermally heated greenhouses are commonly used in cold-weather environments where low to high temperature geothermal resources are abundant.









Application Benefits:
- Reduction of greenhouse operating costs
- Operation in cold climate conditions
- Perfect for low & high-temperature geothermal resources (75-195°)
- Controls internal humidity/condensation (prevents agricultural diseases)

World-wide usage:
- ~3,000 acres
- 6.5 billion kWh/year

Typical heating systems used to heat the greenhouses are shown to the right.