GEOTHERMAL ENERGY

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Chapter 1 – Geothermal Energy

Geothermal energy is thermal energy generated and stored in the Earth. Thermal energy is the energy that determines the temperature of matter. The geothermal energy of the Earth's crust originates from the original formation of the planet and from radioactive decay of materials (in currently uncertain but possibly roughly equal proportions). The geothermal gradient, which is the difference in temperature between the core of the planet and its surface, drives a continuous conduction of thermal energy in the form of heat from the core to the surface. The adjective geothermal originates from the Greek roots (ge), meaning earth, andμ (thermos), meaning hot.

Earth's internal heat is thermal energy generated from radioactive decay and continual heat loss from Earth's formation. Temperatures at the core–mantle boundary may reach over 4000 ˚C (7,200 ˚F). The high temperature and pressure in Earth's interior cause some rock to melt and solid mantle to behave plastically, resulting in portions of mantle convecting upward since it is lighter than the surrounding rock. Rock and water is heated in the crust, sometimes up to 370 ˚C (700 ˚F).

From hot springs, geothermal energy has been used for bathing since Paleolithic times and for space heating since ancient Roman times, but it is now better known for electricity generation. Worldwide, 11,700 megawatts (MW) of geothermal power is online in 2013.[6] An additional 28 gigawatts of direct geothermal heating capacity is installed for district heating, space heating, spas, industrial processes, desalination and agricultural applications in 2010.[7]

Geothermal power is cost effective, reliable, sustainable, and environmentally friendly,[8] but has historically been limited to areas near tectonic plate boundaries. Recent technological advances have dramatically expanded the range and size of viable resources, especially for applications such as home heating, opening a potential for widespread exploitation. Geothermal wells release greenhouse gases trapped deep within the earth, but these emissions are much lower per energy unit than those of fossil fuels. As a result, geothermal power has the potential to help mitigate global warming if widely deployed in place of fossil fuels.

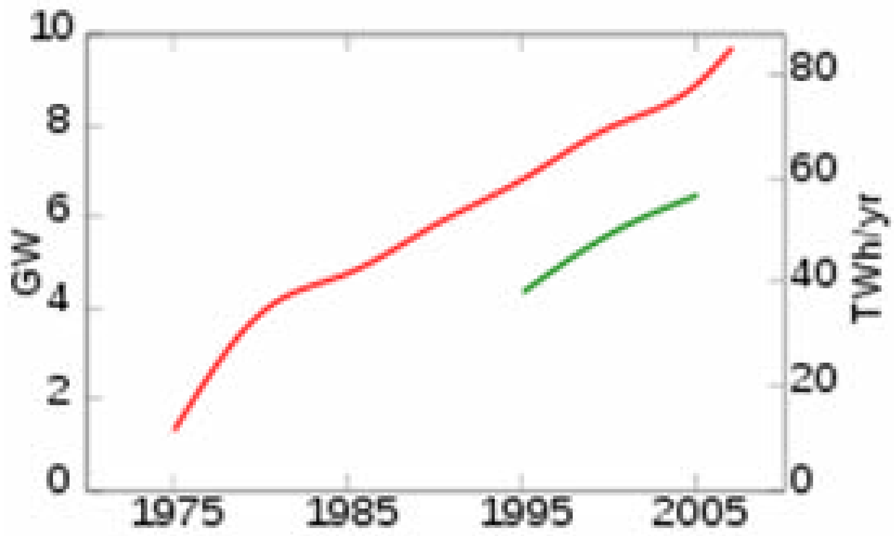
The Earth's geothermal resources are theoretically more than adequate to supply humanity's energy needs, but only a very small fraction may be profitably exploited. Drilling and exploration for deep resources is very expensive. Forecasts for the future of geothermal power depend on assumptions about technology, energy prices, subsidies, and interest rates. Pilot programs like EWEB's customer opt in Green Power Program show that customers would be willing to pay a little more for a renewable energy source like geothermal. But as a result of government assisted research and industry experience, the cost of generating geothermal power has decreased by 25% over the past two decades. In 2001, geothermal energy costs between two and ten US cents per kWh.

History

The oldest known pool fed by a hot spring, built in the Qin dynasty in the 3rd century BCE.

Hot springs have been used for bathing at least since Paleolithic times[12] The oldest known spa is a stone pool on China's Lisan mountain built in the Qin Dynasty in the 3rd century BC, at the same site where the Huaqing Chi palace was later built. In the first century AD, Romans conquered Aquae Sulis, now Bath, Somerset, England, and used the hot springs there to feed public baths and underfloor heating. The admission fees for these baths probably represent the first commercial use of geothermal power. The world's oldest geothermal district heating system in Chaudes-Aigues, France, has been operating since the 14th century.[13] The earliest industrial exploitation began in 1827 with the use of geyser steam to extract boric acid from volcanic mud in Larderello, Italy.

In 1892, America's first district heating system in Boise, Idaho was powered directly by geothermal energy, and was copied in Klamath Falls, Oregon in 1900. A deep geothermal well was used to heat greenhouses in Boise in 1926, and geysers were used to heat greenhouses in Iceland and Tuscany at about the same time. Charlie Lieb developed the first downhole heat exchanger in 1930 to heat his house. Steam and hot water from geysers began heating homes in Iceland starting in 1943.



Global geothermal electric capacity. Upper red line is installed capacity; lower green line is realized production.

In the 20th century, demand for electricity led to the consideration of geothermal power as a generating source. Prince Piero Ginori Conti tested the first geothermal power generator on 4 July 1904, at the same Larderello dry steam field where geothermal acid extraction began. It successfully lit four light bulbs. Later, in 1911, the world's first commercial geothermal power plant was built there. It was the world's only industrial producer of geothermal electricity until New Zealand built a plant in 1958. In 2012, it produced some 594 megawatts.

Lord Kelvin invented the heat pump in 1852, and Heinrich Zoelly had patented the idea of using it to draw heat from the ground in 1912. But it was not until the late 1940s that the geothermal heat pump was successfully implemented. The earliest one was probably Robert C. Webber's home-made 2.2 kW direct-exchange system, but sources disagree as to the exact timeline of his invention. J. Donald Kroeker designed the first commercial geothermal heat pump to heat the Commonwealth Building (Portland, Oregon) and demonstrated it in 1946. Professor Carl Nielsen of Ohio State University built the first residential open loop version in his home in 1948. The technology became popular in Sweden as a result of the 1973 oil crisis, and has been growing slowly in worldwide acceptance since then. The 1979 development of polybutylene pipe greatly augmented the heat pump's economic viability.

In 1960, Pacific Gas and Electric began operation of the first successful geothermal electric power plant in the United States at The Geysers in California. The original turbine lasted for more than 30 years and produced 11 MW net power.

The binary cycle power plant was first demonstrated in 1967 in the USSR and later introduced to the US in 1981.[22] This technology allows the generation of electricity from much lower temperature resources than previously. In 2006, a binary cycle plant in Chena Hot Springs, Alaska, came on-line, producing electricity from a record low fluid temperature of 57 °C (135 °F).

Chapter 2- Geothermal Electricity

Electricity

The International Geothermal Association (IGA) has reported that 10,715 megawatts (MW) of geothermal power in 24 countries is online, which was expected to generate 67,246 GWh of electricity in 2010. This represents a 20% increase in online capacity since 2005. IGA projects growth to 18,500 MW by 2015, due to the projects presently under consideration, often in areas previously assumed to have little exploitable resource.

In 2010, the United States led the world in geothermal electricity production with 3,086 MW of installed capacity from 77 power plants. The largest group of geothermal power plants in the world is located at The Geysers, a geothermal field in California. The Philippines is the second highest producer, with 1,904 MW of capacity online. Geothermal power makes up approximately 27% of Philippine electricity generation.

Installed geothermal electric capacity

Country	Capacity (MW) 2007	Capacity (MW) 2010	Percentage of national electricity production	Percentage of global geothermal production

United States	2687	3086	0.3	29
Philippines	1969.7	1904	27	18
Indonesia	992	1197	3.7	11

Installed geothermal electric capacity

Country	Capacity (MW) 2007	Capacity (MW) 2010	Percentage of national electricity production	Percentage of global geothermal production
	953	958	3	9
Italy	810.5	843	1.5	8
New Zealand	471.6	628	10	6
Iceland	421.2	575	30	5
Japan	535.2	536	0.1	5
Iran	250	250		
El Salvador	204.2	204	25	
Kenya	128.8	167	11.2	
Costa Rica	162.5	166	14	

Installed geothermal electric capacity

Country	Capacity (MW) 2007	Capacity (MW) 2010	Percentage of national electricity production	Percentage of global geothermal production
Nicaragua	87.4	88	10	
Russia	79	82		
Turkey	38	82		
Papua-New Guinea	56	56		
Guatemala	53	52		
Portugal	23	29		
China	27.8	24		
France	14.7	16		
Ethiopia	7.3	7.3		

Installed geothermal electric capacity

Country	Capacity (MW) 2007	Capacity (MW) 2010	Percentage of national electricity production	Percentage of global geothermal production
Germany	8.4	6.6		
Austria	1.1	1.4		
Australia	0.2	1.1		
Thailand	0.3	0.3		
TOTAL	**9,981.9**	**10,959.7**		

Geothermal electric plants were traditionally built exclusively on the edges of tectonic plates where high temperature geothermal resources are available near the surface. The development of binary cycle power plants and improvements in drilling and extraction technology enable enhanced geothermal systems over a much greater geographical range. Demonstration projects are operational in Landau-Pfalz, Germany, and Soultz-sous-Forêts, France, while an earlier effort in Basel, Switzerland was shut down after it triggered earthquakes. Other demonstration projects are under construction in Australia, the United Kingdom, and the United States of

America.

The thermal efficiency of geothermal electric plants is low, around 10–23%, because geothermal fluids do not reach the high temperatures of steam from boilers. The laws of thermodynamics limits the efficiency of heat engines in extracting useful energy. Exhaust heat is wasted, unless it can be used directly and locally, for example in greenhouses, timber mills, and district heating. System efficiency does not materially affect operational costs as it would for plants that use fuel, but it does affect return on the capital used to build the plant. In order to produce more energy than the pumps consume, electricity generation requires relatively hot fields and specialized heat cycles. Because geothermal power does not rely on variable sources of energy, unlike, for example, wind or solar, its capacity factor can be quite large – up to 96% has been demonstrated. The global average was 73% in 2005.

Types

Geothermal energy comes in either vapor-dominated or liquid-dominated forms. Larderello and The Geysers are vapor-dominated. Vapor-dominated sites offer temperatures from 240 to 300 °C that produce superheated steam.

Liquid-dominated plants

Liquid-dominated reservoirs (LDRs) were more common with temperatures greater than 200 °C (392 °F) and are found near young volcanoes surrounding the Pacific Ocean and in rift zones and hot spots. Flash plants are the common way to generate electricity from these sources. Pumps are generally not required, powered instead when the water turns to steam. Most wells generate 2-10MWe. Steam is separated from liquid via cyclone separators, while the liquid is returned to the reservoir for reheating/reuse. As of 2013, the largest liquid system is Cerro Prieto in Mexico, which generates 750 MWe from temperatures reaching 350 °C (662 °F). The Salton Sea field in Southern California offers the potential of generating 2000 MWe.[17]

Lower temperature LDRs (120–200 °C) require pumping. They are common in extensional terrains, where heating takes place via deep circulation along faults, such as in the Western US and Turkey. Water passes through a heat exchanger in a Rankine cycle binary plant. The water vaporizes an organic working fluid that drives a turbine. These binary plants originated in the Soviet Union in the late 1960s and predominate in new US plants. Binary plants have no emissions.

Thermal energy

Lower temperature sources produce the energy equivalent of 100M BBL per year. Sources with temperatures of 30–150 °C are used without conversion to electricity as district heating, greenhouses, fisheries, mineral recovery, industrial process heating and bathing in 75 countries. Heat pumps extract energy from shallow sources at 10–20 °C in 43 countries for use in space heating and cooling. Home heating is the fastest-growing means of exploiting geothermal energy, with global annual growth rate of 30% in 2005 and 20% in 2012.

Approximately 270 petajoules (PJ) of geothermal heating was used in 2004. More than half went for space heating, and another third for heated pools. The remainder supported industrial and agricultural applications. Global installed capacity was 28 GW, but capacity factors tend to be low (30% on average) since heat is mostly needed in winter. Some 88 PJ for space heating was extracted by an estimated 1.3 million geothermal heat pumps with a total capacity of 15 GW.

Heat for these purposes may also be extracted from co-generation at a geothermal electrical plant.

Heating is cost-effective at many more sites than electricity generation. At natural hot springs or geysers, water can be piped directly into radiators. In hot, dry ground, earth tubesor downhole heat exchangers can collect the heat. However, even in areas where the ground is colder than room temperature, heat can often be extracted with a geothermal heat pump more cost-effectively and cleanly than by conventional furnaces. These devices draw on much shallower and colder resources than traditional geothermal techniques. They frequently combine functions, including air conditioning, seasonal thermal energy storage, solar energy collection, and electric heating. Heat pumps can be used for space heating essentially anywhere.

Iceland is the world leader in direct applications. Some 92.5% of its homes are heated with geothermal energy, saving Iceland over $100 million annually in avoided oil imports. Reykjavík, Iceland has the world's biggest district heating system. Once known as the most polluted city in the world, it is now one of the cleanest.

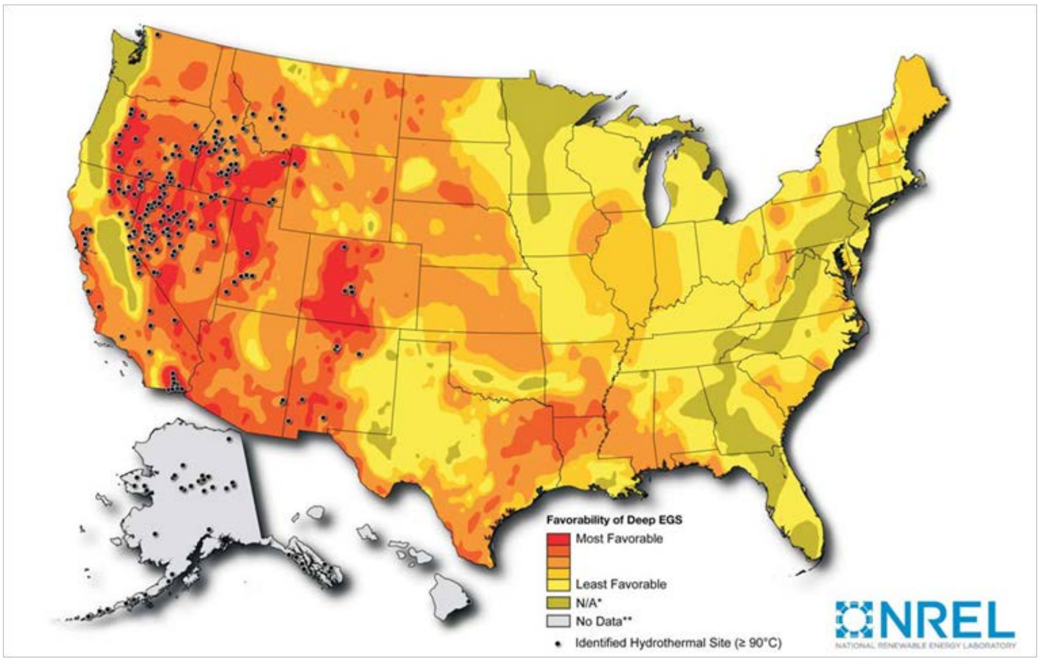
Enhanced geothermal

Enhanced geothermal systems (EGS) actively inject water into wells to be heated and pumped back out. The water is injected under high pressure to expand existing rock fissures to enable the water to freely flow in and out. The technique was adapted from oil and gas extraction techniques. However, the geologic formations are deeper and no toxic chemicals are used, reducing the possibility of environmental damage. Drillers can employ directional drilling to expand the size of the reservoir.

Small-scale EGS have been installed in the Rhine Graben at Soultz-sous-Forêts in France and at Landau and Insheim in Germany.

Chapter 3 -The geothermal resource

Below Earth's crust, there is a layer of hot and molten rock, called magma. Heat is continually produced in this layer, mostly from the decay of naturally radioactive materials such as uranium and potassium. The amount of heat within 10,000 meters (about 33,000 feet) of Earth's surface contains 50,000 times more energy than all the oil and natural gas resources in the world.



U.S. geothermal resources. Source: U.S. Energy Information Administration, Annual Energy Review 2011.

The areas with the highest underground temperatures are in regions with active or geologically young volcanoes. These "hot spots" occur at tectonic plate boundaries or at places where the crust is thin enough to let the heat through. The Pacific Rim, often called the Ring of Fire for its many volcanoes, has many hot spots, including some in Alaska, California, and Oregon. Nevada has hundreds of hot spots, covering much of the northern part of the state.

These regions are also seismically active. Earthquakes and magma movement break up the rock covering, allowing water to circulate. As the water rises to the surface, natural hot springs and geysers occur, such as Old Faithful at Yellowstone National Park. The water in these systems can be more than 200˚C (430˚F).

Seismically active hotspots are not the only places where geothermal energy can be found. There is a steady supply of milder heat—useful for direct heating purposes—at depths of anywhere from 10 to a few hundred feet below the surface virtually in any location on Earth. Even the ground below your own backyard or local school has enough heat to control the climate in your home or other buildings in the community. In addition, there is a vast amount of heat energy available from dry rock formations very deep below the surface (4–10 km). Using the emerging technology known as Enhanced Geothermal Systems (EGS), we may be able to capture this heat for electricity production on a much larger scale than conventional technologies currently allow. While still primarily in the development phase, the first demonstration EGS projects provided electricity to grids in the United States and Australia in 2013.

If the full economic potential of geothermal resources can be realized, they would represent an enormous source of electricity production capacity. In 2012, the U.S. National Renewable Energy Laboratory (NREL) found that conventional geothermal sources (hydrothermal) in 13 states have a potential capacity of 38,000 MW, which could produce 308 million MWh of electricity annually .

State and federal policies are likely to spur developers to tap some of this potential in the next few years. The Geothermal Energy Association estimates that 125 projects now under development around the country could provide up to 2,500 megawatts of new capacity .

As EGS technologies improve and become competitive, even more of the largely untapped geothermal resource could be developed. The NREL study found that hot dry rock resources could provide another 4 million MW of capacity, which is equivalent to more than all of today's U.S. electricity needs .

Not only do geothermal resources in the United States offer great potential, they can also provide continuous baseload electricity. According to NREL, the capacity factors of geothermal plants—a measure of the ratio of the actual electricity generated over time compared to what would be produced if the plant was running nonstop for that period—are comparable with those of coal and nuclear power [5]. With the combination of both the size of the resource base and its consistency, geothermal can play an indispensable role in a cleaner, more sustainable power system.

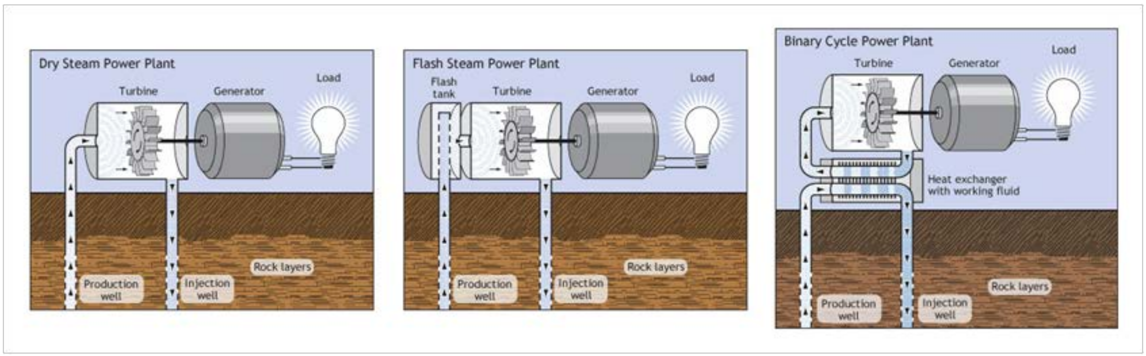
Salt Wells geothermal plant in Nevada. Photo: U.S. Department of Energy

Chapter 4 -How geothermal energy is captured

Geothermal springs for power plants. Currently, the most common way of capturing the energy from geothermal sources is to tap into naturally occurring "hydrothermal convection" systems, where cooler water seeps into Earth's crust, is heated up, and then rises to the surface. Once this heated water is forced to the surface, it is a relatively simple matter to capture that steam and use it to drive electric generators. Geothermal power plants drill their own holes into the rock to more effectively capture the steam.

There are three basic designs for geothermal power plants, all of which pull hot water and steam from the ground, use it, and then return it as warm water to prolong the life of the heat source. In the simplest design, known as dry steam, the steam goes directly through the turbine, then into a condenser where the steam is condensed into water. In a second approach, very hot water is depressurized or "flashed" into steam which can then be used to drive the turbine.

In the third approach, called a binary cycle system, the hot water is passed through a heat exchanger, where it heats a second liquid—such as isobutane—in a closed loop. Isobutane boils at a lower temperature than water, so it is more easily converted into steam to run the turbine. These three systems are shown in the diagrams below.



The three basic designs for geothermal power plants: dry steam, flash steam, and binary cycle. Image: U.S. Department of Energy.

The choice of which design to use is determined by the resource. If the water comes out of the well as steam, it can be used directly, as in the first design. If it is hot water of a high enough temperature, a flash system can be used; otherwise it must go through a heat exchanger. Since there are more hot water resources than pure steam or high-temperature water sources, there is more growth potential in the binary cycle, heat exchanger design.

The largest geothermal system now in operation is a steam-driven plant in an area called the Geysers, north of San Francisco, California. Despite the name, there are actually no geysers there, and the heat that is used for energy is all steam, not hot water. Although the area was known for its hot springs as far back as the mid-1800s, the first well for power production was not drilled until 1924. Deeper wells were drilled in the 1950s, but real development didn't occur until the 1970s and 1980s. By 1990, 26 power plants had been built, for a capacity of more than 2,000 MW.

Because of the rapid development of the area in the 1980s, and the technology used, the steam resource has been declining since 1988. Today, owned primarily by the California utility Calpine and with a net operating capacity of 725 MW, the Geysers facilities still meets nearly 60 percent of the average electrical demand for California's North Coast region (from the Golden Gate Bridge north to the Oregon border) [6]. The plants at the Geysers use an evaporative water-cooling process to create a vacuum that pulls the steam through the turbine, producing power more efficiently. But this process loses 60 to 80 percent of the steam to the air, without re-injecting it underground. While the steam pressure may be declining, the rocks underground are still hot. To remedy the situation, various stakeholders partnered to create the Santa Rosa Geysers Recharge Project, which involves transporting 11 million gallons per day of treated wastewater from neighboring communities through a 40-mile pipeline and injecting it into the ground to provide more steam. The project came online in 2003, and in 2008 provided enough additional electricity for approximately 100,000 homes.

One concern with open systems like the Geysers is that they emit some air pollutants. Hydrogen sulfide—a toxic gas with a highly recognizable "rotten egg" odor—along with trace amounts of arsenic and minerals, is released in the steam. Salt can also pose an environmental problem. At a power plant located at the Salton Sea reservoir in Southern California, a significant amount of salt builds up in the pipes and must be removed. While the plant initially put the salts into a landfill, they now re-inject the salt back into a different well. With closed-loop systems, such as the binary cycle system, there are no emissions and everything brought to the surface is returned underground.

Direct use of geothermal heat. Geothermal springs can also be used directly for heating purposes. Geothermal hot water is used to heat buildings, raise plants in greenhouses, dry out fish and crops, de-ice roads, improve oil recovery, aid in industrial processes like pasteurizing milk, and heat spas and water at fish farms. In Klamath Falls, Oregon, and Boise, Idaho, geothermal water has been used to heat homes and buildings for more than a century. On the east coast, the town of Warm Springs, Virginia obtains heat directly from spring water as well, using springs to heat one of the local resorts.

In Iceland, virtually every building in the country is heated with hot spring water. In fact, Iceland gets more than 50 percent of its primary energy from geothermal sources [9]. In Reykjavik, for example (population 118,000), hot water is piped in from 25 kilometers away, and residents use it for heating and for hot tap water.

New Zealand's Wairakei geothermal power station. Photo: Pseudopanax.

Ground-source heat pumps. A much more conventional way to tap geothermal energy is by using geothermal heat pumps to provide heat and cooling to buildings. Also called ground-source heat pumps, they take advantage of the constant year-round temperature of about 50˚F that is just a few feet below the ground's surface. Either air or antifreeze liquid is pumped through pipes that are buried underground, and re-circulated into the building. In the summer, the liquid moves heat from the building into the ground. In the winter, it does the opposite, providing pre-warmed air and water to the heating system of the building.

In the simplest use of ground-source heating and cooling, a tube runs from the outside air, under the ground, and into a building's ventilation system. More complicated, but more effective, systems use compressors and pumps—as in electric air conditioning systems—to maximize the heat transfer.

In regions with temperature extremes, such as the northern United States in the winter and the southern United States in the summer, ground-source heat pumps are the most energy-efficient and environmentally clean heating and cooling systems available. Far more efficient than electric heating and cooling, these systems can circulate as much as 3 to 5 times the energy they use in the process. The U.S. Department of Energy found that heat pumps can save a typical home hundreds of dollars in energy costs each year, with the system typically paying for itself in 8 to 12 years. Tax credits and other incentives can reduce the payback period to 5 years or less.

More than 600,000 ground-source heat pumps supply climate control in U.S. homes and other buildings, with new installations occurring at a rate of about 60,000 per year [12]. While this is significant, it is still only a small fraction of the U.S. heating and cooling market, and several barriers to greater penetration into the market remain. For example, despite their long-term savings, geothermal heat pumps have higher up-front costs. In addition, installing them in existing homes and businesses can be difficult, since it involves digging up areas around a building's structure. Finally, many heating and cooling installers are simply not familiar with the technology.

However, ground-source heat pumps are catching on in some areas. In rural areas without access to natural gas pipelines, homes must use propane or electricity for heating and cooling. Heat pumps are much less expensive to operate than these conventional systems, and since buildings are generally widely spread out, installing underground loops is often not an issue. Underground loops can be easily installed during construction of new buildings as well, resulting in savings for the life of the building. Furthermore, recent policy developments are offering strong incentives for homeowners to install these systems. The 2008 economic stimulus bill, Emergency Economic Stabilization Act of 2008, included an eight-year extension (through 2016) of the 30 percent investment tax credit, with no upper limit, to all home installations of Energy Star certified geothermal heat pumps.

Chapter 5 -Geothermal Energy Pros and Cons

The temperature at earth's core exists at roughly 7200 degrees Fahrenheit. This is due to the decay of radioactive materials millions of years ago. The high temperature beneath the earth's surface can produce enormous amount of energy that could produce several gigawatts of electricity. Technically speaking, geothermal energy is a renewable source of energy that can produce energy as long as earth exists.

Geothermal energy is a type of energy that can really make it easy for companies to get what they need without using a lot of fossil fuels in the process. In this article, we're going to take a closer look at some of the most important pros and cons that are related to using geothermal energy for your home or for your business when it comes to energy.

Pros of Geothermal Energy

1. Renewable: Geothermal energy is extracted from earth's core and will be available as long as earth exists. It is therefore renewable and can be used for roughly another 4-5 billion years. While fossil fuels have an expiry date, renewable sources like geothermal energy is not going to expire anytime soon.

2. Environment Friendly: Geothermal energy is green in all aspects of its production and use! It is actually known for having the least impact of any power source. When it comes to the process of developing and making it, geothermal power is practically completely emission free. There is absolutely zero carbon used when it comes to the production of this type of power. Also, the whole procedure can clean out sulfur that may have generally been discharged from other processes.

3. No Fuel Needed: No fuel is used at all during the production and use of the energy. Why? Because there is absolutely no mining or transportation related to the process, which means that there aren't trucks emitting fumes and gas, which means that the atmosphere is not being as affected by the process.

4. Abundant Supply: With geothermal energy, there are no shortages or other sorts of problems that sometimes occur with other types of power. They are not subject to the same issues as solar or wind power, which means that you won't get a shortage because the weather isn't cooperating with what you want. There is a practically boundless supply. It is also intrinsically basic and dependable, so you don't have to worry about it being more of a hassle than it is actually worth.

5. Significant Savings for Home Owners: There has been a tremendous increase in the number of homeowners who want to utilize geothermal energy for heating and cooling purposes. The result is that less energy is used for heating homes and offices which results in significant savings for home owners. It might prove expensive initially but 30-60% savings on heating and 25-50% savings on cooling can cover that cost within few years. A geothermal heat pump can help you save enough money in energy costs.

6. Smallest Land Footprint: Geothermal energy extracts heat from hot water, the steam from hot water move the turbines that produce electricity. To extract this energy, substantial amount of piping is required to be laid underground. But, thanks to new innovation in the field of technology, geothermal energy has the smallest land footprint of any major energy source in the world.

The costs are very competitive. As of now, geothermal energy is quite cost aggressive in a few areas where it is being produced, so you want to keep an eye on how much it is changing the world of energy in the areas where it is located.

7. Innovation in Technology: When it comes to green energy, geothermal energy is one of the first types that is being explored. New innovations are coming out for it all of the time, which means that it will likely be easier to deal with some of the difficulties with the technology as time goes on. It can also be manufactured underground. New innovations that are coming out are basically guaranteed to be able to use lower temperatures in future iterations of the technology as well.

Cons of Geothermal Energy

1. Suitable to Particular Region: Everything that deals with geothermal power seems to be really far away from, well, everything that is in and around the area. Prime destinations are exceptionally zone specific, so you can't really find geothermal power outside of those areas. Also, the prime destinations are frequently a long way from urban areas, which means that they're virtually useless when it comes to cities and such.

2. High Initial Costs: For those residential owners who are thinking to use geothermal energy, high upfront costs is something that turns out to be a huge setback to them. For an average sized home, installation of geothermal heat pumps costs between $10,000 – $20,000 that can pay off itself in another 5-10 years down the line through significant cost savings.

3. Cost of Powering the Pump: Geothermal heat pumps still needs a power source that can run it. The pumps needs electricity to run that can transfer energy from earth's core to the home. For a homeowner who is planning to go green, can use few solar panels that can power heat pump to draw energy from the earth's reservoir.

4. Surface Instability: Geothermal has become infamous for causing earthquakes as setting up of geothermal power plants can alter the land's structure. A process called hydraulic fracturing is an integral part for building a large scale and efficient geothermal system power plants that can trigger earthquakes.

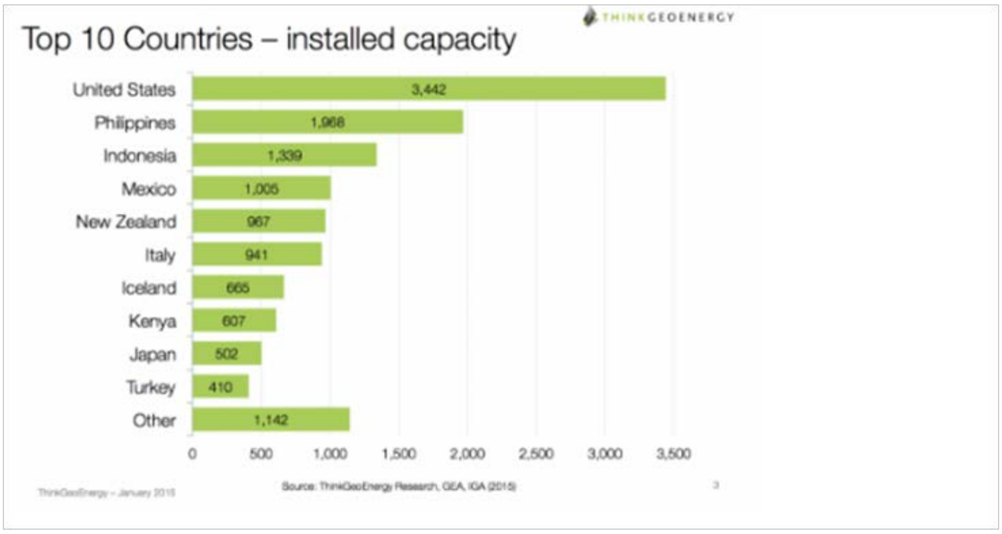
5. Environmental Concerns: There are some environmental concerns. Water use is one of the big concerns, because geothermal power uses a lot of water in its processes and such. There are also a number of different compounds that go into the air, water, and ground as a result of the process, including sulfur dioxide and silica discharges, both of which can harm the environment if you aren't careful about it.

Sometimes, you have to deal with some technical difficulties as a result of the way that geothermal power is used. Misfortunes can occur because of how far the power has to travel, and mistakes can occur sometimes that make it difficult for the energy to get to people in an efficient manner.

6. High Temperatures Needed: The process is not exactly an easy one for you to execute. Boring into warmed rock is extremely troublesome. In order for geothermal processes to begin, you also need the area in question to be at least 350 degrees Fahrenheit, otherwise the processes may not occur as you wish them to.

7. May Run Out of Steam: You have to be incredibly careful when you are trying to check everything that is related to geothermal energy. Mind must be taken to watch the heat and not to abuse it, because if the heat is not taken care of properly, it can cause a meltdown or other issues where the energy is not properly distributed or used.

Chapter 6 – Top Countries using geothermal energy



Direct Use Data 2015

Country	Usage (MWt) 2015
United States	17,415.91
Philippines	3.30
Indonesia	2.30
Mexico	155.82
Italy	1,014.00
New Zealand	487.45

Iceland	2,040.00
Japan	2,186.17
Iran	81.50
El Salvador	3.36
Kenya	22.40
Costa Rica	1.00
Russia	308.20
Turkey	2,886.30
Papua-New Guinea	0.10
Guatemala	2.31
Portugal	35.20
China	17,870.00
France	2,346.90
Ethiopia	2.20
Germany	2,848.60
Austria	903.40
Australia	16.09
Thailand	128.51

Chapter 7 -The future of geothermal energy

Geothermal energy has the potential to play a significant role in moving the United States (and other regions of the world) toward a cleaner, more sustainable energy system. It is one of the few renewable energy technologies that can supply continuous, baseload power. Additionally, unlike coal and nuclear plants, binary geothermal plants can be used a flexible source of energy to balance the variable supply of renewable resources such as wind and solar. Binary plants have the capability to ramp production up and down multiple times each day, from 100 percent of nominal power down to a minimum of 10 percent.

The costs for electricity from geothermal facilities are also becoming increasingly competitive. The U.S. Energy Information Administration (EIA) projected that the levelized cost of energy (LCOE) for new geothermal plants (coming online in 2019) will be less than 5 cents per kilowatt hour (kWh), as opposed to more than 6 cents for new natural gas plants and more than 9 cents for new conventional coal [12]. There is also a bright future for the direct use of geothermal resources as a heating source for homes and businesses in any location.

However, in order to tap into the full potential of geothermal energy, two emerging technologies require further development: Enhanced Geothermal Systems (EGS) and co-production of geothermal electricity in oil and gas wells.

Enhanced geothermal systems. Geothermal heat occurs everywhere under the surface of the earth, but the conditions that make water circulate to the surface are found in less than 10 percent of Earth's land area. An approach to capturing the heat in dry areas is known as enhanced geothermal systems (EGS) or "hot dry rock". The hot rock reservoirs, typically at greater depths below the surface than conventional sources, are first broken up by pumping high-pressure water through them. The plants then pump more water through the broken hot rocks, where it heats up, returns to the surface as steam, and powers turbines to generate electricity. The water is then returned to the reservoir through injection wells to complete the circulation loop. Plants that use a closed-loop binary cycle release no fluids or heat-trapping emissions other than water vapor, which may be used for cooling.

A 2006 study by MIT found that EGS technology could provide 100 gigawatts of electricity by 2050. The Department of Energy, several universities, the geothermal industry, and venture capital firms (including Google) are collaborating on research and demonstration projects to harness the potential of EGS. The Newberry Geothermal Project in Bend, Oregon has recently made significant progress in reducing EGS project costs and eliminating risks to future development. The DOE hopes to have EGS ready for commercial development by 2015. Australia, France, Germany, and Japan also have R&D programs to make EGS commercially viable.

One cause for careful consideration with EGS is the possibility of induced seismic activity that might occur from hot dry rock drilling and development. This risk is similar to that associated with hydraulic fracturing, an increasingly used method of oil and gas drilling, and with carbon dioxide capture and storage in deep saline aquifers. Though a potentially serious concern, the risk of an induced EGS-related seismic event that can be felt by the surrounding population or that might cause significant damage currently appears very low when projects are located an appropriate distance away from major fault lines and properly monitored. Appropriate site selection, assessment and monitoring of rock fracturing and seismic activity during and after construction, and open, transparent communication with local communities are also critical.

Low-temperature and co-production of geothermal electricity in oil and gas wells. Low-temperature geothermal energy is derived from geothermal fluid found in the ground at temperatures of 150°C (300°F) or less. These resources are typically utilized in direct-use applications, such as heating buildings, but can also be used to produce electricity through binary cycle geothermal processes. Oil and gas fields already under production represent a large potential source of this type of geothermal energy. In many existing oil and gas reservoirs, a significant amount of high-temperature water or suitable high-pressure conditions are present, which could allow for the co-production of geothermal electricity along with the extraction of oil and gas resources. In some cases, exploiting these geothermal resources could even enhance the extraction of the oil and gas.

An MIT study estimated that the United States has the potential to develop 44,000 MWs of geothermal capacity by 2050 by coproducing geothermal electricity at oil and gas fields—primarily in the Southeast and southern Plains states. The study projected that such advanced geothermal systems could supply 10 percent of U.S. baseload electricity by 2050, given R&D and deployment over the next 10 years [17].

According to DOE, an average of 25 billion barrels of hot water is produced in United States oil and gas wells each year. This water, which has historically been viewed as an inconvenience to well operators, could be harnessed to produce up to 3 gigawatts of clean, reliable baseload energy [16]. This energy could not only reduce greenhouse gas emissions, it could also increase profitability and extend the economic life of existing oil and gas field infrastructure. The DOE's Geothermal Technologies Office is working toward a goal of achieving widespread production of low-temperature geothermal power by 2020.

These exciting new developments in geothermal will be supported by unprecedented levels of federal R&D funding. Under, the American Recovery and Reinvestment Act of 2009, $400 million of new funding was allocated to the DOE's Geothermal Technologies Program. Of this $90 million went to fund seven demonstration projects to prove the feasibility of EGS technology. Another $50 million funded 17 demonstration projects for other new technologies, including co-production with oil and gas and low temperature geothermal. The remaining funds went towards exploration technologies, expanding the deployment of geothermal heat pumps, and other uses. These investments are already beginning to expand the horizons of geothermal energy production and will likely continue to produce significant net benefits in the future

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