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GEOHERMAL ENERGY

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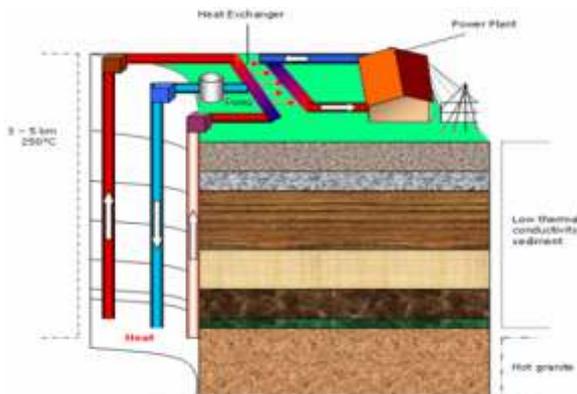
Abstract

Heat energy continuously flows to the Earth's surface from its interior, where central temperatures of about 6 000°C exist. The predominant source of the Earth's heat is the gradual decay of long-lived radioactive isotopes (40K, 232Th, 235U and 238U). The outward transfer of heat occurs by means of conductive heat flow and convective flows of molten mantle beneath the Earth's crust. This results in a mean heat flux at the Earth's surface of 80kW/km² approximately. This heat flux, however, is not distributed uniformly over the Earth's surface; rather, it is concentrated along active tectonic plate boundaries where volcanic activity transports high temperature molten material to the near surface. Although volcanoes erupt small portions of this molten rock that feeds them, the vast majority of it remains at depths of 5 to 20 km, where it is in the form of liquid or solidifying magma bodies that release heat to surrounding rock. Under the right conditions, water can penetrate into these hot rock zones, resulting in the formation of high temperature geothermal systems containing hot water, water and steam, or steam, at depths of 500 m to >3,000 m. -

Keywords: Radioactive Isotopes (40K, 232Th, 235U and 238U), Heat flux, Off-grid developments, Cascade, Eco-friendly energy sources, Flashed steam plant, Enhanced geothermal systems (EGS), Geothermal generating capacity, Exploration stage, Life-cycle analysis of geothermal power generation, Conversion efficiency, Geothermal co-generation

Characteristics and Applications of Geothermal Energy

Geothermal energy is an enormous, underused heat and power resource that is clean (emits little or no greenhouse gases), reliable (average system availability of 95%), and homegrown (making us less dependent on foreign oil). Geothermal resources range from shallow ground to hot water and rock several miles below the Earth's surface, and even farther down to the extremely hot molten rock called magma. Mile-or-more-deep wells can be drilled into underground reservoirs to tap steam and very hot water that can be brought to the surface for use in a variety of applications.



The general characteristics of geothermal energy that make it of significant importance for both electricity production and direct use include:

Geothermal energy can be used very effectively in both on- and off-grid developments, and is especially useful in rural electrification schemes. Its use spans a large range from power generation to direct heat uses, the latter possible using both low temperature resources and "cascade" methods. Cascade methods utilise the hot water remaining from higher temperature applications (e.g., electricity generation) in successively lower temperature processes, which may include binary systems to generate further power and direct heat uses (bathing and swimming; space heating, including district heating; greenhouse and open ground heating; industrial process heat; aquaculture pond and raceway heating; agricultural drying; etc.) - See more at: <http://www.eai.in/ref/ae/geo/geo.html#sthash.uQGGXsUW.dpuf>

Geothermal Energy Scenario: India and the world

Geothermal power plants operated in at least 24 countries in 2010, and geothermal energy was used directly for heat in at least 78 countries. These countries currently have geothermal power plants with a total capacity of 10.7 GW, but 88% of it is generated in just seven countries: the United States, the Philippines, Indonesia, Mexico, Italy, New Zealand, and Iceland. The most significant capacity increases since 2004 were seen in Iceland and Turkey. Both countries doubled their capacity. Iceland

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has the largest share of geothermal power contributing to electricity supply (25%), followed by the Philippines (18%).

Extensive global distribution; it is accessible to both developed and developing countries.

Environmentally friendly nature; it has low emission of sulphur, CO₂ and other greenhouse gases.

Indigenous nature; it is independent of external supply and demand effects and fluctuations in exchange rates.

Independence of weather and season

Contribution to the development of diversified power sources. The number of countries utilizing geothermal energy to generate electricity has more than doubled since 1975, increasing from 10 in 1975 to 24 in 2004. In 2003, total geothermal energy supply was 20 MTOE (metric Tonne Oil Equivalent), accounting for 0.4% of total primary energy supply in IEA member countries. The share of geothermal in total renewable energy supply was 7.1%. Over the last 20 years, capital costs for geothermal power systems decreased by a significant 50%. Such large cost reductions are often the result of solving the "easier" problems associated with science and technology improvement in the early years of development.

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Although geothermal power development slowed in 2010, with global capacity reaching just over 11 GW, a significant acceleration in the rate of deployment is expected as advanced technologies allow for development in new countries. Heat output from geothermal sources increased by an average rate of almost 9% annually over the past decade, due mainly to rapid growth in the use of ground-source heat pumps. Use of geothermal energy for combined heat and power is also on the rise. - See more at:

India has reasonably good potential for geothermal; the potential geothermal provinces can produce 10,600 MW of power (but experts are confident only to the extent of 100 MW). But yet geothermal power projects has not been exploited at all, owing to a variety of reasons, the chief being the availability of plentiful coal at cheap costs. However, with increasing environmental problems with coal based projects, India will need to start depending on clean and eco-friendly energy sources in future; one of which could be geothermal.

Technology

Mile-or-more-deep wells can be drilled into underground reservoirs to tap steam and very hot water that drive turbines that drive electricity generators. Four types of power plants are operating today

Flashed steam plant

The extremely hot water from drill holes when released from the deep reservoirs high pressure steam (termed as flashed steam) is released. This force of steam is used to rotate turbines. The steam gets condensed and is converted into water again, which is returned to the reservoir. Flashed steam plants are widely distributed throughout the world - See more at:

Dry steam plant Usually geysers are the main source of dry steam. Those geothermal reservoirs which mostly produce steam and little water are used in electricity production systems. As steam from the reservoir shoots out, it is used to rotate a turbine, after sending the steam through a rock-catcher. The rock-catcher protects the turbine from rocks which come along with the steam. Binary power plant In this type of power plant, the geothermal water is passed through a heat exchanger where its heat is transferred to a secondary liquid, namely isobutene, isopentane or ammonia-water mixture present in an adjacent, separate pipe. Due to this double-liquid heat exchanger system, it is called a binary power plant. The secondary liquid which is also called as working fluid, should have lower boiling point than water. It turns into vapor on getting required heat from the hot water. The vapor from the working fluid is used to rotate turbines. The binary system is therefore useful in geothermal reservoirs which are relatively low in temperature gradient. Since the system is a completely closed one, there is minimum chance of heat loss. Hot water is immediately recycled back into the reservoir. The working fluid is also condensed back to the liquid and used over and over again. Hybrid power plant Some geothermal fields produce boiling water as well as steam, which are also used in power generation. In this system of power generation, the flashed and binary systems are combined to make use of both steam and hot water. Efficiency of hybrid power plants is however less than that of the dry steam plants. Enhanced geothermal system.

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Enhanced geothermal system

The term enhanced geothermal systems (EGS), also known as engineered geothermal systems (formerly hot dry rock geothermal), refers to a variety of engineering techniques used to artificially create hydrothermal resources (underground steam and hot water) that can be used to generate electricity. Traditional geothermal plants exploit naturally occurring hydrothermal reservoirs and are limited by the size and location of such natural reservoirs. EGS reduces these constraints by allowing for the creation of hydrothermal reservoirs in deep, hot but naturally dry geological formations. EGS techniques can also extend the lifespan of naturally occurring hydrothermal resources. Given the costs and limited full-scale system research to date, EGS remains in its infancy, with only a few research and pilot projects existing around the world and no commercial-scale EGS plants to date. The technology is so promising, however, that a number of studies have found that EGS could quickly become widespread.

Potential



The rocks comprise of Archean, Proterozoic, the marine and continental Palaeozoic, Mesozoic, Tertiary, Quaternary etc., More than 300 hot spring locations have been identified by Geological survey of India (Thussu, 2000). The surface temperature of the hot springs ranges from 35 C to as much as 98 C. These hot springs have been grouped together and termed as different geothermal provinces based on their occurrence in specific geotectonic regions, geological and structural regions such as occurrence in orogenic belt regions, structural grabens, deep fault zones, active volcanic regions etc., Different orogenic regions are – Himalayan geothermal province, Naga-Lushai geothermal province, Andaman-Nicobar Islands geothermal province and non-orogenic regions are – Cambay graben, Son-Narmada-Tapi graben, west coast, Damodar valley, Mahanadi valley, Godavari valley etc.

- Puga Valley (J&K)
- Tattapani (Chhattisgarh)
- Godavari Basin Manikaran (Himachal Pradesh)
- Bakreshwar (West Bengal)
- Tuwa (Gujarat)
- Unai (Maharashtra)
- Jalgaon (Maharashtra)

Historical Capacity & Consumption Data

There is no installed geothermal generating capacity as of now and only direct uses (eg.Drying) have been detailed.

Direct Uses

Total thermal installed capacity in MWt:	203.0
Direct use in TJ/year	1,606.3
Direct use in GWh/year	446.2
Capacity factor	0.25

It has been estimated from geological, geochemical, shallow geophysical and shallow drilling data it is estimated that India has about 10,000 MWe of geothermal power potential that can be harnessed for various purposes. Rocks covered on the surface of India ranging in age from more than 4500 million years to the present day and distributed in different geographical units.

Geothermal Field	Estimated (min.) reservoir Temp (Approx)	Status
Puga geothermal field	240°C at 2000m	From geochemical and deep geophysical studies (MT)
Tattapani Sarguja (Chhattisgarh)	120oC - 150°C at 500 meter and 200 Cat 2000 m	Magnetotelluric survey done by NGRI
Tapoban Chamoli (Uttarakhand)	100°C at 430 meter	Magnetotelluric survey done by NGRI
Cambay Garben (Gujrat)	160°C at 1900 meter (From Oil exploration borehole)	Steam discharge was estimated 3000 cu meter/ day with high temperature gradient.
Badrinath Chamoli (Uttarakhand)	150°C estimated	Magneto-telluric study was done by NGRI Deep drilling required to ascertain geothermal field
Geothermal Field	Reservoir Temp (Approx)	Status
Surajkund Hazaribagh (Jharkhand)	110°C	Magneto-telluric study was done by NGRI. Heat rate 128.6 mW/m2
Manikaran Kullu (H P)	100°C	Magneto-telluric study was done by NGRI Heat flow rate 130 mW/m2
Kasol Kullu (H P)	110°C	Magneto-telluric study was done by NGRI

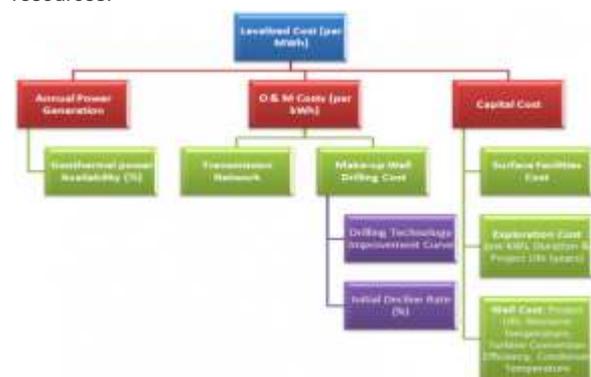
Current Projects

There are no operational geothermal plants in India. Cost, Price and Challenges

Unlike traditional power plants that run on fuel that must be purchased over the life of the plant, geothermal power plants use a renewable resource that is not susceptible to price fluctuations. New geothermal plants currently are generating electricity from 0.05\$ to 0.08\$ per kilowatt hour (kwh). Once capital costs .Once the capital costs have been recovered price of power can decrease below 0.05\$ per kwh. The price of geothermal is within range of other electricity choices available today when the costs of the lifetime of the plant are considered.

Most of the costs related to geothermal power plants are related to resource exploration and plant construction. Like oil and gas exploration, it is expensive and because only one in five wells yield a reservoir suitable for development .Geothermal developers must prove that they have reliable resource before they

can secure millions of dollar required to develop geothermal resources.



Drilling

Although the cost of generating geothermal has decreased by 25 percent during the last two decades, exploration and drilling remain expensive and risky. Drilling Costs alone account for as much as one-third to one-half to the total cost of a geothermal project. Locating the best resources can be difficult; and developers may drill many dry wells before they discover a viable resource. Because rocks in geothermal areas are usually extremely hard and hot, developers must frequently replace drilling equipment. Individual productive geothermal wells generally yield between 2MW and 5MW of electricity; each may cost from \$1 million to \$5 million to drill. A few highly productive wells are capable of producing 25 MW or more of electricity.

Transmission

Geothermal power plants must be located near specific areas near a reservoir because it is not practical to transport steam or hot water over distances greater than two miles. Since many of the best geothermal resources are located in rural areas, developers may be limited by their ability to supply electricity to the grid. New power lines are expensive to construct and difficult to site. Many existing transmission lines are operating near capacity and may not be able to transmit electricity without significant upgrades. Consequently, any significant increase in the number of geothermal power plants will be limited by those plants ability to connect, upgrade or build new lines to access to the power grid and whether the grid is able to deliver additional power to the market.

Barriers

- Finding a suitable build location.
- Energy source such as wind, solar and hydro are more popular and better established; these factors could make developers decided against geothermal.
- Main disadvantages of building a geothermal energy plant mainly lie in the exploration stage, which can be extremely capital intensive and high-risk; many companies who commission surveys are often disappointed, as quite often, the land they were interested in, cannot support a geothermal energy plant.
- Some areas of land may have the sufficient hot rocks to supply hot water to a power station, but many of these areas are located in harsh areas of the world (near the poles), or high up in mountains.
- Harmful gases can escape from deep within the earth, through the holes drilled by the constructors. The plant must be able to contain any leaked gases, but disposing of the gas can be very tricky to do safely.

Geothermal companies

- Panx Geothermal
- LNJ Bhilwara
- Tata Power
- Thermax
- NTPC
- Avin Energy Systems
- GeoSyndicate Power Private Limited
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RD&D Priorities

- In the case of geothermal energy, several topics are identified as being key to its advancement in the global market place. These are related to cost reduction, sustainable use, expansion of use into new geographical regions, and new applications. The priorities are categorized as "general" or specific to RD&D.

General priorities:

- Life-cycle analysis of geothermal power generation and direct use systems.
- Sustainable production from geothermal resources.
- Power generation through improved conversion efficiency cycles.
- Use of shallow geothermal resources for small-scale individual users.
- Studies of induced seismicity related to geothermal power generation (conventional systems and enhanced geothermal systems).

Specific RD&D priorities:

- Commercial development of EGS.
- Development of better exploration, resource confirmation and management tools.
- Development of deep (>3 000 m) geothermal resources.
- Geothermal co-generation (power and heat).

Geothermal Research Centres**MeSy India**

MeSy India acts as technical arm to governmental institutions in the conduction of scientific and geothermal research projects, and stimulates new R&D projects in collaboration with Indian national research institutions and international organizations, in particular in the field of techniques and earthquake mechanisms, reservoir induced seismicity, advanced mining technologies, ground water production stimulation, use of geothermal energy, hazardous underground waste storage.