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Guidelines for Exploration and Development of Geothermal Energy in India

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The development of a country is mainly dependent on the energy security. The main energy sources are mostly conventional energy sources contributing to greenhouse gases leading to global warming. The important Fossil fuels are i) Coal, ii) Petroleum, iii) Natural Gas and iv) Coal Bed Methane, besides this the alternate energy sources like biodiesel and biomass contributed marginally. The climate change perspective required to control the global warming required use of non- conventional, non-polluting sources of energy like i) Hydropower, ii) Nuclear, iii) Wind, iv) Solar and v) Tidal. The largescale installation of these energy sources revealed that these sources are mostly site specific and have particular time window for production. Considering the use of fossil fuels to net zero by the year 2070 (www.investindia), new technology sources like Hydrogen Cells, Electric Vehicles and Hydrogen vehicles have been introduced to substitute the petroleum-based transport system. Similarly, the geothermal energy is also being encouraged to replace the conventional energy sources. Geothermal energy is the heat stored inside the interior of the earth. Geothermal energy is a new and alternate, continuous and site-specific source of energy. The heat is stored in deep seated rocks which is brought to surface by the deep circulation of water. Geothermal energy is a renewable and environment friendly energy source as there is no burning of the fuel.

Geothermal Manifestations

A geothermal area is characterized by following manifestations 1. Hot water springs (Fig. 1), 2. Steam emission or Fumaroles, 3. Marshy land, 4. Mud pools, 5. Deposition of silica, sulphur, arsenic, borax, calcite on surface and 6. Local subsidence.

Geothermal resources are categorized as- i) Single phase-A field where only hot water or only steam is found, ii) Two Phase –In two phase flow hot water mixed with steam is found in the reservoir, iii) Dry phase- Hot dry rock where no fluid or steam is found as the rock is hard and compact. The rock is hot but the heat is not transferred to surface by water or steam, iv) Enhanced geothermal system- A hot rock system which is used for production by artificial fracturing for hot water production and v) Advanced geothermal system- In this system, a deep borehole is used to flush out heat /geothermal energy by deep circulation of water which collects heat and pumped to surface for power generation. This method can be used in old, unproductive oil boreholes if temperature in the boreholes is satisfactory. The main utilization methods are i) Steam based power plant, ii) Binary cycle power plant, iii) Greenhouse cultivation, iv) Refrigeration, cold storage, v) aquaculture, vi) Tourism and Bath centers, vii) Food processing, viii) Space heating *etc.*

Geothermal energy is considered as an Environmentally friendly energy as the CO₂eq emission is about 45 to 65 g/Kwh (IPCC). The hot water contains boron, Arsenic, Fluorine, which need to be monitored to avoid adverse effect on production. A deposition of silica, calcite, arsenic compound, sulphur is reported generally around hot springs and borehole vents. Hot water may contain dissolved sulphur, borax, Cs, Li, which can be separated as a byproduct during production. The hot springs / geothermal boreholes generally show emission of CO₂, SO₂, NO₂, NH₃, H₂, N₂, He, Ar, gases, which need to be studied before production planning. The other main irritant is continuous noise produced by steam emission/ production. Sometimes, there can be marshy ground, local subsidence due to pressure changes in underground caused by water movement. Besides this, during drilling, there is possibility of caving in the boreholes, steam emission and water flow during drilling operation. The drilling site is generally restored to normal to avoid environmental damage.

Geothermal resources can be utilized for electricity generation as well as direct heat uses, depending on the local geology, geography, economic conditions and discharge parameters. The utilization of heat content to various industrial application is called as direct heat uses. The electricity generation is

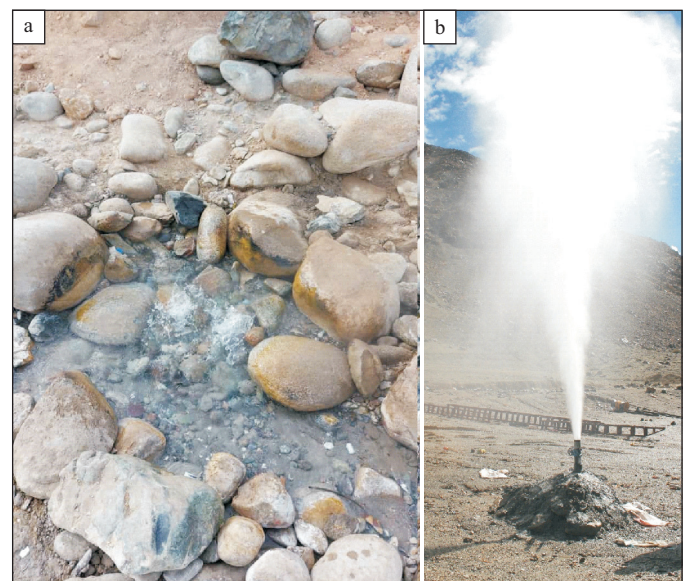


Fig. 1. a. Hot-spring at Chumathang, Ladakh; b. Sprout of borehole at Chumathang, Ladakh

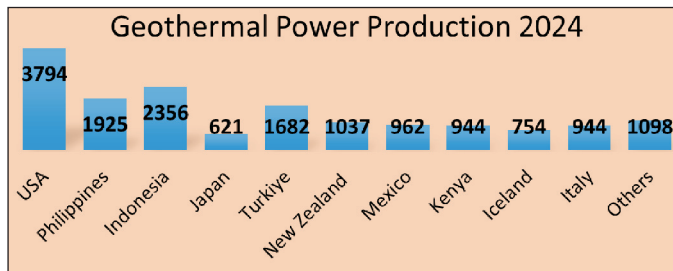


Fig. 2. Geothermal power generation worldwide (Thinkgeoenergy)

common use of geothermal energy. Worldwide >16000 MW of electricity is generated by geothermal energy sources, mostly in USA, New Zealand, Indonesia, Japan, Iceland, Philippines. Besides, the direct applications of heat are also popular in Iceland, Japan, New Zealand, Turkey, China (Fig. 2).

The use of low temperature for industrial application to substitute conventional energy sources are called direct heat uses. The important utilization schemes (Lindal, 1979) are:

- Geothermal Power Plant (Temperature >200°C - 100°C)
The resource with temperature > 200°C may be used for steam based geothermal power plant. In case of temperatures less than 180°C, Binary cycle power plant is feasible.
- Food Processing (Temperature <100°C)
Fruits and sea-weed drying, drying of vegetables, onions and fishes. Used for the food processing industry.
- Industrial Uses- Timber Washing, Sericulture (Temperature 80°C-140°C)
The low temperature hot water is used for sericulture, space heating, vegetable cleaning, and small-scale industrial uses.
- Greenhouse (Temperature 50°C-80°C)
The hot water can be used in space heating and hot bed heating in green house cultivation.
- Aquaculture and Agriculture, Crocodile Farming (Temperature <60°C):
The hot water of specific composition and temperature is used for aquaculture.
- Tourism, Spa, Swimming Pool (Temperature >40°C)
Almost all geothermal localities with hot water springs.
- Extraction of Rare Metals, Mineral Water Industry (Temperature >30°C)
Separation of Borax, Sulphur, Cesium, and Helium from hot water.

The present energy scenario in India shows a dominant contribution of fossil fuels. Presently total power generation capacity in India (Ministry of Power, 2025) is 500025 MW. The thermal power contributes 244799 MW, hydropower 50108 MW, Nuclear power 8780 MW and renewable energy 197202 MW (Fig. 3). Hence, India's renewable energy (RE) growth is vital for achieving ambitious climate change targets and the 2070 Net Zero Goal.

Considering the need to boost use of geothermal as a renewable source of energy, Ministry of New and Renewable

Energy, Government of India, (MNRE, 2025) has announced policy guidelines for exploration and development of geothermal energy in India. The policy provides details of the process for initiating geothermal investigation and exploration. The guidelines also describe various schemes for installation of power plant and funding options. These guidelines emphasize use of geothermal heat pumps for space heating and cooling.

Some salient points are as below-

1. Low- to medium-enthalpy resources such as hot rocks and shallow level fields, are useful for direct-use applications and geothermal heat pumps.
2. For the oil and gas industry, geothermal drilling is good opportunity to utilize dry wells, and producing the low-carbon energy. Considering the possible utility of geothermal energy as a substitute of heat as well as energy source, the Ministry of New & Renewable Energy (MNRE) has formulated policy for the exploration and development of geothermal resources in India.
3. To establish geothermal energy as one of major pillars of India's renewable energy in fulfilling the 2070 Net Zero Goal, and energy security and sustainable, secure, and responsible geothermal energy sector.
4. To build a robust public-private partnership for sustainable development of Geothermal resources.
5. Geothermal plants have no fuel cost, only O&M expenses and typically achieve high-capacity utilization factors above 80%, making them a reliable source of baseload renewable power.
6. Enhanced geothermal system and Advanced Geothermal Systems (AGS), hybrid geothermal power systems (integrated with solar PV, may be explored.
7. Data repository may be made.
8. The Ministry supports geothermal research, resource assessment, and pilot/demonstration projects under the MNRE R&D Scheme. Technology collaboration with pioneering countries, is allowed under the MNRE, R&D Scheme (RE-RTD). 100% FDI is allowed in renewables.
9. Ministry shall grant consent for exploration and development of geothermal energy, up to 30 years. Joint ventures between oil and gas companies, mineral companies, and geothermal developers suggested.
10. Long-term concessional loans from Public and Private Sector Financial Institutions, Sovereign Green Bonds, Viability Gap Funding (VGF), Loans/Grants for Risk Mitigation, Feed-in-tariff, etc. are also suggested. Soft loans may be made available by IREDA and others financing institutions.

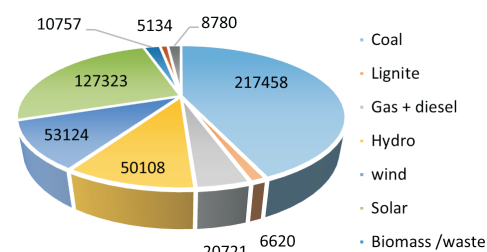


Fig. 3. Installed power generation capacity in India, 2025.

11. Import duty/ GST exemptions on geothermal equipment, machinery, and services, GST exemption on equipment.
12. Centers of Excellence (CoE) in Geothermal Energy may be opened.
13. The Ministry may issue detailed guidelines with standard operating procedure (SOP) for the implementation of geothermal projects in the country.

Assessment of geothermal fields in India was started in 1973 at the initiation of UNDP. Total 381 springs were reported with surface temperature of 30°C to 97°C (GSI, 2022). These hot springs are grouped into 10 provinces. The Indian hot springs localities are classified in 10 provinces listed below (Padhi and Pitale, 1995).

Geothermal Provinces of India

The major Geothermal provinces of India are:

- 1) Himalayan belt
- 2) Naga-Lushai Province
- 3) Andaman Nicobar Islands
- 4) West Coast Province
- 5) Cambay Graben Province
- 6) Aravalli Province
- 7) Son-Narmada-Tapi province
- 8) Godavari Valley Province
- 9) Mahanadi valley Province
- 10) South Indian Cratonic Province

Though geothermal policy was declared recently, various organizations like GSI, NGRI, NHPC, PDEU, OIL, ONGC have already taken up investigation and research projects for geothermal energy utilization. The main utilization projects taken up in India are as below:

- 1) Manuguru hot springs: Hot springs near Manuguru in Telangana have temperature up to 50°C and discharge of up to 800 lpm (GSI, 2022). The boreholes drilled for coal exploration also yield hot water up to 55°C. Exploration for geothermal resources has yielded maximum temperature of 81°C up to the depth 1000m. A borehole reported discharge of 850 lpm. A 20 KW binary cycle power plant is installed by SCCL at Manuguru.
- 2) ONGC Energy has taken up drilling up to 1000m depth, in Puga geothermal field, Ladakh, to establish a 1 MW geothermal power plant (Thinkgeoenergy).
- 3) Hot spring water is used as energy source for cooking at Manikaran,
- 4) Helium extraction is taken up by BARC at Bakreshwar
- 5) Tourist attraction at Tatapani, Chhattisgarh (Sarolkar, 2025), Ganeshpuri, Tural, Unhavra (Khed) in West Coast, Bakreshwar, West Bengal and NER.
- 6) A Binary cycle power plant planned by Oil India limited, at Dirang hot spring Arunachal Pradesh (Arunachalnewslive).

The main constrains in development of geothermal resources are 1) Inaccessible area, 2) Fossil fuels are cheaper than

renewable energy, 3) Deep exploration is needed, 4) Technology has to be imported and 5) Lack of Public – Private partnership.

Suggestions

- 1) Rate of geothermal power purchase may be decided
- 2) Geothermal exploration may be considered as R and D activity, granting import duty concessions
- 3) Norms for funding geothermal project may be decided
- 4) Priority of development of Geothermal fields may be listed based on resource potential
- 5) The MNRE guidelines have suggested measures to overcome these issues.

Conclusions

Geothermal energy is an active, sustainable, environment friendly, renewable energy source. Geothermal resources are useful as substitute energy in specific sites. Most of the prospect are $\approx 125^{\circ}\text{C}$ to 160°C . Binary cycle power plant and direct heat use may be possible. MNRE has taken up lead role in developing geothermal energy in India. Need to have interaction with industry for utilization of geothermal energy. NGRI may have collaboration with deep exploration and power generation companies for industrial utilization of the energy. Efforts may be continued for installation of demonstration geothermal power plant.

Thus, the guidelines issued by MNRE are a positive step forward for initiating research and development projects in India, which will surely boost the geothermal energy utilization in India.

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