Government of India
Ministry of New & Renewable Energy

Draft
National Policy on
Geo-Thermal Energy

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Draft National Policy on Geo-Thermal Energy

1. Preamble

1.1 The energy scenario in India is fast changing with the emphasis given in the XIIth Five Year Plan on non-conventional and renewable sources of energy. Though the dominance of fossil fuels, viz. coal and oil will continue in the energy sector for the next few decades, the concern for reducing the greenhouse gas emissions warrants increasing use of green energy/ non-conventional energy sources as a substitute to oil and coal. Solar energy and wind energy are major contributors of the renewable energy as these resources are widely distributed all over India and are available round the year. Geothermal energy is also an additional source of renewable energy with site specific availability and potentially consistent supply in all the seasons / throughout the year.

1.2 Geothermal Energy is heat stored in earth crust and being used for electric generation and also for direct heat application worldwide since beginning of last century. The total installed capacity for global geothermal power generation was estimated to be around 12.8 gigawatts (GW) till 2014. Top five leading countries in the geothermal power generation are USA, Philippines, Indonesia, Mexico and New Zealand. The total installed capacity, reported through the end of 2014 for geothermal direct utilization worldwide is around 70.3 GWt and the leading countries with the largest capacity of geothermal direct utilization are China, USA, Sweden, Turkey, Germany, France, Japan and Iceland. For harnessing Geothermal energy in the country the Ministry of New & Renewable Energy (MNRE) has been supporting R&D on exploration activities and Resource Assessment during last 25 years. This includes formation of expert groups, working group, core group and committees in addition to providing financial support for such projects and for resource assessment.

1.3 Government of India, Ministry of New and Renewable Energy (MNRE) has been contemplating major initiative in RDD&D of Geothermal technology for harnessing the geothermal energy in the country during past decades. Geothermal electricity generation is site and technology specific and India is in Low Geothermal Potential Region with low/medium heat enthalpy. Government is planning to encourage the demonstration projects at the first stage to assess the technical viability of the project before going to the commercial models.

1.4 Geothermal energy is a site specific renewable source of energy specifically suitable for catering to the energy needs of remote/interior localities. Considering the possible utility of geothermal energy as a substitute of heat as well as energy source, the Ministry of New & Renewable Energy has formulated policy guidelines for the exploration and development of geothermal resources in India.

1.5 This will be termed as "National Policy for Development of Geothermal Resources in India", henceforth called as "the Policy" in this document. The Policy guidelines are issued by the Ministry of New and Renewable Energy, which controls the non-conventional energy development and production in India, hereafter called as "The Ministry". These guidelines will be followed by all the agencies and departments associated with exploration and utilization of the geothermal resources. The various State Government Agencies representing the state governments would be called as "The State" henceforth. Geothermal energy resource would be termed as "prospect" in this document. A private entrepreneur interested in the development/exploration of geothermal resources will be termed as "the entrepreneur". The policy guidelines will come into effect with the date of issuance/notification. These guidelines are binding for all the geothermal prospect developments in India.

2. The Vision and Goals

2.1 As per the Honorable Prime Minister Vision on 24x7- Power For All ”the Government is committed to bring about a transformative change in the power sector and ensure affordable 24x7 power for all homes, industrial and commercial establishments and adequate power for farms, in the next few years”.

2.2 The vision of the geothermal policy is to make a substantial contribution to India’s long-term energy supply and reduce our national greenhouse gas emissions by developing a sustainable, safe, secure, socially and environmentally responsible geothermal energy industry, apart from creating new employment opportunities and leading to environmentally sustainable development by the means of deployment of 1,000 MW(therm) and 20 MW(elect) Geothermal Energy Capacity in the initial phase till 2022 and 10,000 MW(therm) & 1000 MW(elect) by 2030. Mitigating demand side electricity requirement by deploying Ground Source Heat Pumps (GSHP’S) and retrofitting the existing HVAC systems with Geo-exchange based system. Resource Assessment is being planned in 2016-2017 for public domain.

2.3 Ministry is planning to encourage the International Collaboration with the world leaders in Geothermal Energy like USA, Philippines, Indonesia, Mexico and New Zealand for support to accelerate deployment of geothermal energy by international investment promotion (100% FDI in RE Sector), Customized capacity building and technical assistance to key stakeholders, help in mitigating the exploratory risk, technological support etc.

3. Definition and Scope

3.1 The following definitions of Geothermal shall apply for the purpose of this Policy:

(i) Geothermal power is extracted from heat stored in the earth crust. This geothermal energy originates from the original formation of the planet, from radioactive decay of minerals, and from solar energy absorbed at the surface. It is clean and sustainable. Resources of geothermal energy range from the shallow ground to hot water and hot rock found a few miles beneath the Earth's

surface, and down even deeper to the extremely high temperatures of molten rock called magma. Geothermal energy is available around the clock, independent of the time of day and night, or of the current climatic conditions. Geothermal resources include dry steam, hot water, hot dry rock, magma, and ambient ground heat.

(ii) Direct use of geothermal energy means that the thermal energy from underground is used directly as heat (or cold), rather than being used to generate electricity. Direct heat uses of geothermal energy are major contributors to substitution of electricity. The hot springs with low reservoir temperatures, i.e., <130 °C can be utilized for direct heat uses. The hot water of 60° - 130 °C can be used for direct heat utilization if the difference in temperature with the surroundings is adequate to extract the heat content. Direct uses are useful in partial saving of the energy required in small-scale industrial uses, besides these applications, direct heat uses have a major societal impact in the form of bathing centres, skin cure centres, geothermal and botanical parks for entertainment purpose, spas used for tourist attraction, green housing and cold storage for utility of local population and farming industry.

3.2 The scope of the Policy encompasses Geothermal based heating and cooling system and Ground Source Heat Pumps (GSHP's), as listed below:-

(i) Geothermal Heating/Cooling: Considering the large requirements for space heating in mountainous regions of India that have extended and severe winters, and for space cooling / air-conditioning in most other parts of India throughout the year, policy will give a special emphasis on popularizing the use of Geothermal Heating/Cooling technologies by retrofitting of existing HVAC systems or by Ground Source Heat Pumps (GSHP).

(ii) Ground Source Heat Pumps (GSHP's) harvests heat absorbed in the soil of Earth's surface from solar energy. The soil provides a stable temperature at the range of 16-29°C all year round with minor fluctuation at a depth of 20 feet, the

temperature in the ground below 6 meters (20 ft) is roughly equal to the mean annual air temperature at that latitude at the surface. GSHP uses the earth relatively constant temperature between 16-29°C to provide heating, cooling, and hot water for homes, commercial by the means of exchanging heat with the ground from the system of pipes buried in the shallow ground or laid down in the river/pond/water bodies/sewage system near the building. It uses the earth as a heat source (in the winter) or a heat sink (in the summer). The heat removed from the indoor air during the summer can also be used to provide a free source of hot water.

(iii) Geo-exchange Well Definition: Geothermal heat exchange borewell is a uncased artificial excavation that uses the heat exchange capacity of the earth for heating and cooling, in which excavation the ambient ground temperature is 28 degrees Celsius or less, and which excavation uses a closed loop fluid system to prevent the discharge or escape of its fluid into surrounding aquifers or other geologic formations. In case of open loop system, at least two wells shall be used for this purpose, a source well that is used to draw water and an injection well that is used to return water to the ground after it is used for HVAC heat exchange. It does not add any chemicals (for HVAC water treatment or for other reason) to the water circulated in loop between source well and injection wells. The source and injection wells shall be designed and constructed according to IGSHPA standards.

4. History of Geothermal (GT) Studies in India

4.1 In India, preliminary assessments conducted by Geological Survey of India (GSI) have indicated prospects of development of Geothermal Power. Systematic efforts to explore the geothermal energy resources commenced in 1973 and preliminary assessment suggests that India is in low and medium heat enthalpy zone (100-180 °C) and 340 hot springs have identified in different parts of India with surface temperature ranges from 35 °C to as much as 98 °C.

4.2 At present India is at nascent stage of geothermal exploitation, 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.

4.3 In India, many activities have taken place in the area of exploration of Geothermal Energy. Thirty one areas have been examined in detail and shallow drilling has been done in sixteen areas (i.e., up to a maximum depth of —728 m in select areas and much less in other areas). Development of geothermal resources requires deeper level exploration and utilization of the energy for electricity generation. The deeper level exploration in India was held up due to non-availability of machinery and equipments for deep drilling.

4.4 To date the only direct-use of geothermal energy in the country is for bathing, swimming and balneology and in a few cases as a source of energy for cooking. The increase in the annual geothermal use for balneology, bathing and swimming has gone from 2,545 TJ in 2010 to 4,152 TJ in 2014, with an installed capacity is 981 MWt. It is estimated that 5.0 MWt and 150 TJ/yr is used for cooking, which is included in the other category. Thus, the total for the country is 986 MWt.

4.5 Residential & Commercial Building sector contributes to 30% of the total electricity consumption out of which 55% of electricity consumption is due to HVAC. Air-Conditioning and Process Cooling/Heating combined accounts for more than 65% of a Commercial or Industrial Building's Electricity Consumption, a large amount of CO_2 can be saved using geothermal based heating and cooling systems.

5. Potential Geothermal regions/sources in India

5.1 The various assessment studies and surveys undertaken so far have resulted in the identification of 340 hot springs across India and India identified six most promising geothermal sites for the development of geothermal energy. These are, in decreasing order of potential:

- Tattapani in Chhattisgarh
- Puga in Jammu & Kashmir
- Cambay Graben in Gujarat

- Manikaran in Himachal Pradesh
- Surajkund in Jharkhand
- Chhumathang in Jammu & Kashmir

5.2 On the basis of enthalpy characteristics, the geothermal systems in India, can be classified into medium enthalpy (100°C-200°C) and low enthalpy (<100°C) geothermal systems. These are described as follows:

5.2.1 Medium enthalpy geothermal energy systems:

The medium enthalpy geothermal energy resources are associated with:

1. Younger intrusive granites as in Himalayas, viz Puga-Chumathang, Parbati, Beas and Satluj Valley geothermal fields.
2. Major tectonic features/lineaments such as the West Coast areas of Maharashtra;along the Son-Narmada-Tapi lineament zone at Salbardi, Tapi; Satpura areas in Maharashtra; Tattapani in Chhattisgarh and Rajgir-Monghyar in Bihar, Tatta and Jarom in Jharkhand and Eastern Ghat tracts of Orissa.
3. Rift and grabens of Gondwana basins of Damodar, Godavari and Mahanadi Valleys.
4. Quaternary and tertiary sediments occurring in a graban in the Cambay basin of West Coast.

5.2.2 Low enthalpy geothermal energy systems:

The low enthalpy geothermal energy systems are associated with:

1. Tertiary tectonism and neotectonic activity.
2. Shield areas with localized abnormal heat flow, which is normally very low.

(http://mnre.gov.in/file-manager/UserFiles/geothermaldatabase.html)

6. Geo-Exchange Pumps/ Ground Source Heat Pumps (GSHP's)

6.1 In spite of capacity addition in power generation, there remains a huge deficit between demand and supply. The national average demand- supply gap during peak hours is about 22%. So with an economy projected to grow at 6-8% per annum, rapid urbanization and improving standards of living for millions of Indian households, the demand is likely to grow significantly. Therefore increase in generation capacity only,

can't meet the demand of high growth rate. Simultaneously reducing the demand by proper Demand Side Management (DSM) activity by deploying Grund Source Heat Pumps is equally important for the energy security of our country. DSM becomes more prominent in countries like India where average T&D loss is near about 22%. Hence, Special emphasis is given to GSHP's in this policy in order the mitigate the demand side electricity requirement.

6.2 Ground Source Heat Pumps (GSHP's) use the earth's relatively constant temperature between 16 – 29 ^{0}C at a depth of 20 feet to provide heating, cooling, and hot water for homes and commercial buildings. GSHP harvests heat absorbed at the Earth's surface from solar energy. The temperature in the ground below 6 meters (20 ft) is roughly equal to the mean annual air temperature at that latitude at the surface it uses the earth as a heat source (in the winter) or a heat sink (in the summer). GHP's is effective in all kind of climate zones or can be deployed anywhere in India on 24 x 7 bases. Worldwide, Geothermal direct heat utilization and heating/cooling application is accepted as one of the most developed, cost-effective and proven renewable energy technologies to mitigate the demand side load in a sustainable manner. The total installed capacity, reported through the end of 2014 for geothermal direct utilization worldwide is around 70.3 GWt and the leading countries with the largest capacity of geothermal direct utilization are China, USA, Sweden, Turkey, Germany, France, Japan and Iceland.

6.2 GSHP's can be categorized as having closed or open loops and those loops can be installed in three ways: horizontally, vertically, or in a pond/lake, sewage system or other water bodies. In comparison to the traditional air conditioning systems, up to 50% energy savings can be achieved through this innovative technology. In addition, the technology is also 100% water efficient since it rejects heat using conduction, convection and advection and not through evaporation as in traditional A.C system cooling towers which lose approximately 6-8 litres of water per hour to the atmosphere for every ton of air conditioning.

6.3 Government of India, Ministry of New and Renewable Energy (MNRE) contemplate initiatives in RDD&D of Geothermal technology specifically for the purpose of cooling, drying, space heating, greenhouse cultivation, Industrial processes, Cold

Storage, Poultry & Fish Farming, Mushroom Farming, Horticulture etc. MNRE is also working in collaboration with BEE on increasing the efficiency by more than 50% of conventional HVAC system by retrofitting /replacing the cooling towers (Air cooled) by Geothermal based systems.

7. Who can avail the Programme

7.1 The scheme is open to public and private sector to carry out projects in India. In case foreign entrepreneur with proven technologies in consortium with indigenous companies to work on Indian sites will be benefited by the scheme as 100% FDI is allowed in Renewable Energy Sector. During the initial stage, funding of work for RDD&D may be supported where there is a demonstrable contribution to resolving specific Indian issues. Applications will be accepted from individual organizations, or from organizations acting in collaboration with other international organizations or with third level colleges/research institutes, either on a contractual basis or within consortia or joint ventures. Collaborative development programmes between manufacturers or service companies and research institutions or other centers of learning are encouraged.

7.2 All stake holders like HVAC Contractors & Suppliers, Food Processing Units Manufactures, Builders & contractors, Cold storage, Green House Manufacturer, Hotel/Restaurants Owners, Industry owners, Social Institutes, Schools Owners are encouraged to come forward for deployment of Geothermal Heat Pumps in India and suitable Demo grant will be provided on case to case basis.

8. Eligibility of the projects:

The Programme is intended to support organizations, universities or other third-level institutions in undertaking fundamental research and industry-led projects to develop and test Geo-thermal energy capture devices and systems. Third-level institutions wishing to undertake fundamental research should contact the relevant body for such funding (such as the Ministry of Earth Sciences, Geological Survey of India etc). For Geothermal Power exploration the entrepreneur may approach State Government

covering potential geothermal zone for block/Site allocation and further action on site exploration.

9. Proposed MNRE support for Geo-thermal Energy

9.1 Awarding suitable area of land for developing the project and maintenance of production wells, thereby securing the commercial viability of the project. Government shall provide land on lease at prices charged to government departments.

9.2 Soft loans may be made available at concessional interest rate as applicable in other RE technologies through Indian Renewable Energy Development Agency (IREDA) for supporting exploration activity.

9.3 The Agency is entitled to carbon credits acquired through the geothermal heat utilization / electricity generation.

9.4 The involvement of foreign entities may be encouraged for exploration and development of geothermal resources provided the "foreign collaboration" is tied up with technology transfer as 100% FDI is allowed in Renewable Energy Sector.

9.5 Ministry of Finance, Government of India already providing 80% depreciation for installation of heat pumps during the first year of installation. They are categorized as energy saving devices under wasted heat recovery equipments. In order to encourage geothermal projects in country, Ministry had already proposed to Finance Ministry for a revenues ruling in terms of import, excise relaxation & tax benefits on equipments and machinery required for initial setting up of Geothermal heating & cooling projects including geothermal heat pumps and geothermal power generation projects.

9.6 The level of funding will be decided on a case by case basis. A major thrust would be given through this Policy to Innovation, Research & Development and Demonstration in the field of Geo-thermal Power Generation and Geo-exchange Pumps. The proposed funding is given in the table below. The project is eligible for funding up to these levels; the actual funding level provided will depend on the detailed evaluation of the project with regard to: administrative and technical compliance; acceleration of the development of Geo-thermal energy in India; ability to overcome technical and other barriers; contribution to the development of an indigenous and

Indian Collaborative GT industry; environmental compatibility; project management capability. Funding for projects which are found technically viable is done through National Clean Energy Funds (NCEF).

9.7 The categories below represent the maximum level of support which could be available

Project Types	In-principle Subsidy
RDD&D Projects (Power)	**Phase-I:** 50% of Deep Drilling cost and in case of failure it will be converted into grant subject to development of site as direct use geothermal heating/cooling. **Phase-II:** On successfully completion of Phase-I, 30% of the rest balance amount will be given as subsidy.
Industrial Projects (Power)	30% of Capital Cost (Maximum support of 9 Cr/MW)
Public Good (Direct Heating/cooling) **Ground Source Heat Pump(GSHP's)** **or Geo-exchange Pumps**	30% of System cost in the form of incentives with maximum support of Rs 50,000 /TR for first 300 MWt capacity (Individual plant of more than 100 TR capacity), Rs 30,000/TR for next 400 MWt and Rs 10,000/TR for last 300 MWt target capacity i.e. 1000 MWt.

9.8 Each category is defined as follows:

a. **RD&D Projects (Power):** In this category the Research, Design, Development and Demonstration (RDD&D) of the New technology for the deployment of the Geothermal Energy including its Hybridization with other Renewable Energy (RE) Technology will be considered to initiate geothermal based power generation Scheme stresses to carry out survey/studies for resource assessment/development of geothermal fields of the country. The power produced in terms of Electrical Units defined by CERC will be incentivized as per the scheme .Under the above programmes of the Ministry, Research & Development (R&D), Technology Development, Demonstration Projects and projects on other related activities are submitted to the Ministry for the financial support. Such projects are scrutinized in the Ministry for support and approval of the competent authority.

b. **Industrial Projects (Power):** In this category the projects comprising to only power production and distribution to the state utilities with revenue generation will be considered. The power produced in terms of Electrical Units defined by CERC will be incentivized as per the scheme.

c. **Public Good (Direct Heat) :** Project comprising for thermal applications for instance the geothermal fluid can be used for space heating, greenhouse cultivation, cooking etc ,in those projects MNRE would facilitate the NGO's, entrepreneurs, Central or State PSU's and other private players.

d. **Ground Source Heat Pump:** The basic principle on which the GSHP works is "refrigeration cycle". The refrigerant carries the heat from one "space" to another. The heat pump's process can be reversed. The earth is the main source and sinks of heat and utilizes constant temperature at 10-300 meter below the earth surface. In winters it provides heat and summers it takes the heat. The heat pumps can be adopted to any kind of building at any place as India has a high potential for direct heat use/GSHP.

10. Eligible Cost

10.1 Costs Allowable

Costs directly associated with delivery of a project may be eligible for support. In the case of successful applicants, only eligible expenditure incurred from the date of approval of the application by the Authority will be considered for funding. Expenditure incurred before this date is ineligible. Therefore Applicants must not begin any work for which funding is sought before the date of approval. The aid intensity will be calculated on the basis of the costs of the research project to the extent that they can be considered as eligible. All eligible costs must be allocated to a specific category of R&D. The following costs shall be eligible:

- Costs of Machinery and equipment used for power production in the research & Development project are considered as eligible.
- Cost involved in digging the geothermal well at potential sites.
- Cost of contractual research, technical knowledge and patents bought or licensed from outside sources at market prices, where the transaction has been

carried out at arm's length and there is no element of collusion involved, as well as costs of consultancy and equivalent services used exclusively for the research activity.

- Other operating expenses, including costs of materials, supplies and similar products incurred directly as a result of the research activity.

In case of a subsequent commercial use of demonstration or pilot projects, the feed-in tariff (FIT) will be revised as per the PPA with the state utility.

11. Role of State

11.1 The role and active participation of the States is crucial in the planning and implementation of Geothermal programmes. The State Governments would be asked to designate an existing agency suitably empowered and funded to act as nodal agency for development and promotion of Geothermal in their States. Proposals for prospecting and exploration of geothermal energy resources would be submitted to the MNRE through State Nodal Agencies (SNA).The SNAs should forward the proposals to MNRE within a period of one month from the date of submission by the applicant / Agency. Decision on the proposals submitted to MNRE through SNAs should be conveyed to the respective SNAs within a period of three months from the date of receipt at MNRE. The SNA would convey the decision to the applicant / Agency within a period of one month from the receipt of the application

11.2 State Government / SNA may facilitate on the evacuation of power to nearest input station, etc on the recommendation from Ministry. State Electricity Board may purchase power from the producer as per MNRE guidelines for renewable energy sources. A minimum 25% of the power generated should be sold to the State Electricity Board at mutually agreed rates. The producer will be at liberty to sell rest of the power to any suitable customer at prevalent rates recommended by the competent authority.

11.3 The State Governments should facilitate land acquisition on lease at prices charged to government departments for development of geothermal energy projects on priority basis. Awarding suitable area of land for developing the project and

maintenance of production wells, thereby securing the commercial viability of the project.

11.4 A committee of at least three members comprising representatives of MNRE, State Government and Industry/Academia shall evaluate the report and recommendations of the prospecting / exploration agency for further exploration / exploitation activity in the area.

12. Awareness and Capacity Building

12.1 Support will be provided for creation of awareness about the role and importance of Geothermal Energy in the energy sector, as well as for wide dissemination of information about its potential and opportunities in mitigating the demand side electricity requirement by deploying Ground Source Heat Pumps.

12.2 The required expertise in these areas needs to be acquired to carry out a complete characterization of the geothermal energy resources in the country. This can be achieved through collaboration channels existing between MNRE and geothermally advanced countries such as Iceland, Philippines, New Zealand and Australia.

12.3 Significant thrust would be provided to capacity building and training and development of human resources. Universities, Polytechnics and Industrial Training Institutes will be encouraged to introduce suitable curricula to cater to the demand for trained manpower in geothermal sector. Efforts will also be directed at enhancing and expanding consultancy capabilities to meet the diverse requirements of this sector.

12.4 Programmes for public awareness in utility of geothermal energy for societal benefits may be arranged by organizing interactive sessions and lectures, and by publishing popular articles.

13. Application, Evaluation and Approval Procedure

13.1 Application Form

Applicants must demonstrate strong technical and theoretical foundation for their technology and be able to describe satisfactorily the theoretical performance of a proposed device. The theoretical model must provide evidence for the performance and cost of the proposed device. Application form will be available on the MNRE website and project developer need to apply as per the format of the application form. Applicants can also submit the application form and associated documents electronically to the OEDU email or by hardcopy. Larger scale projects will also be required to demonstrate a viable Business Development Plan.

13.2 Evaluation Criteria

Once the proposal is received by MNRE through hard copy or in electronic version of the Application Form containing electronic signatures, after that MNRE will scrutinize the proposals as per the evaluation criteria. Proposals will be evaluated to determine:

- Administrative compliance with programme requirements.
- Technical merit.
- Compliance with the programme objectives.
- Ability to facilitate and accelerate the development and deployment in India of competitive Geo-thermal energy products, processes and systems.
- Ability to enable technical and other barriers to the development and introduction of Geo-thermal Energy to be overcome.
- Contribution to the development of an indigenous Geo-thermal industry.
- Environmental compatibility of the technology/project.
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13.3 Approval Procedure

Sanctioned Central Financial Assistance amount shall be released in a single installment on successful commissioning of the project and performance testing of the project which would inter-alia imply operation of the project for at least three months at minimum 80% of rated capacity. A committee of at least three members comprising

representatives of MNRE, State Government and Industry/Academia will be deputed for on-spot assessment of project. The entire capital subsidy amount would be released to the beneficiary's loan account in the lending financial institution/banks for the purpose of offsetting the loan amount only after successful commissioning of project as per DPR norms and receipt of copies of statutory clearances and requisite project related information / documents. In case the project is set up by the developer through its own resources, the Central Financial Assistance would be released directly to them only after the successful completion of project.

MNRE will perform the following action before the approval of the project grant:

- Review the Project Completion Report
- Review all financial documentation
- Carry out a Project Site Inspection on a sample of projects. These inspections may take place at any stage of the project including: during the project; the project review or post project completion.

For comments:

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DRAFT GUIDELINES FOR DEVELOPMENT OF GEO-THERMAL ENERGY IN INDIA

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Table of Contents

Chapter 1

Introduction

The energy scenario in India is fast changing with the emphasis given in the XII Five Year Plan on non-conventional and renewable sources of energy. Though the dominance of fossil fuels, viz. coal and oil will continue in the energy sector for the next few decades, the concern for reducing the greenhouse gas emissions warrants increasing use of green energy/ non-conventional energy sources as a substitute to oil and coal. Solar energy and wind energy are major contributors of the renewable energy as these resources are widely distributed all over India and are available round the year. Geothermal energy is also an additional source of renewable energy with site specific availability and potentially consistent supply in all the seasons / throughout the year.

Geothermal energy is renewable if proper techniques are used for exploration, utilization and management of this energy resource. Government of India has formulated a National Mineral Policy for exploration and mining of mineral resources. Similarly a policy of exploration and exploitation of oil and gas as well as atomic minerals and thermal power generation has been released by the Government of India. As the mandate for exploration of geothermal energy resources on a national scale was primarily bestowed on Geological Survey of India (GSI), most exploration and drilling activities were carried out by them, with complementary efforts from the National Geophysical Research Institute (NGRI) and a few other organizations. Also, the utilization of geothermal energy was pending due to non-availability of both robust estimates of potential for different geothermal fields as well as appropriate machinery and equipment for drilling and exploitation. For these reasons, a formal policy on Exploration and Development of Geothermal Energy Resources has not been conceptualized so far. With the advent of the worldwide progress in geothermal energy utilization, private entrepreneurs have started taking initiative in geothermal energy exploration. The increase in demand for power in rural sector has necessitated the exploitation of site specific energy sources as a substitute to fossil fuel energy. Hence, it has become imperative to formulate guidelines and policy for exploration of the geothermal energy resources and their further utilization for power production and direct heat utilization.

Realistic estimates of geothermal energy potential in India are not available. While a few locations suggest some geothermal energy potential based on shallow drilling done by the GSI two to three decades ago, this is not considered adequate and relevant basis to conclude on the potential. India's geologic setting is also not favourable for the occurrence of very large geothermal energy potential of the kind found in the active volcanic regions such as Phillipines, United States of America, New Zealand, Indonesia, or countries such as Iceland that are located over mid-oceanic ridge where magmatic source of heat is abundant. There may be opportunities for larger capacity once EGS technology is commercially proven and is brought to India. Nevertheless, it is thought that a sizeable geothermal potential exists in the hot spring zones of India. However, in the absence of sufficient and relevant preliminary data regarding the potential of the resources coupled with the lack of policy support, this sector has failed to pick up any momentum so far. The objective of this document is to recommend some of the policy measures to promote the exploitation of geothermal energy for electricity generation in India.

Considering the high risk and capital costs involved in geothermal energy generation, the sector requires some support from the government in the form of formulation of a clear geothermal policy with preferably a single window for obtaining all clearances for execution of geothermal projects and some monetary support in terms of tariff support or capital incentives. Several countries like the United States, Indonesia, Philippines and Australia have clearly defined numeric targets and favourable policies for the promotion of geothermal energy and provide various fiscal and tax incentives for the promotion of renewable energy generation including geothermal energy.

As there is absence of relevant data necessary for geothermal development, either some government agency or private companies would need to undertake this work. Certainly, in the interest of saving time and optimizing resources on the national level, it may need to be a combination of both. However, there needs to be a clear process of achieving over a mid- to-long time period. Also, the roles and responsibilities of these parties (government/private) need to be well articulated to avoid discrepancies in the future. For example, if a private player needs to be roped in at a very early stage, what would be a transparent process for identifying and short listing a single party, what should be the evaluation criteria, who would evaluate it, etc.?

The recent developments in the energy sector have given impetus to the development of non-conventional energy sources. The need to control green house gases emission and global warming has created an urgency to explore the new avenues for energy sources. India is presently banking on solar and wind energy as a main substitute to fossil fuels, while other sources of energy are coming up with contribution at local level.

Geothermal energy is a site specific renewable source of energy specifically suitable for catering to the energy needs of remote/interior localities. Considering the possible utility of geothermal energy as a substitute of heat as well as energy source, the Ministry of New & Renewable Energy has formulated policy guidelines for the exploration and development of geothermal resources in India.

This will be termed as "National Policy for Development of Geothermal Resources in India", henceforth called as "the Policy" in this document. The Policy guidelines are issued by the Ministry of New and Renewable Energy, which controls the non-conventional energy development and production in India, hereafter called as "The Ministry". These guidelines will be followed by all the agencies and departments associated with exploration and utilization of the geothermal resources. The various State Government Agencies representing the state governments would be called as "The State" henceforth. Geothermal energy resource would be termed as "prospect" in this document. A private entrepreneur interested in the development/exploration of geothermal resources will be termed as "the entrepreneur". The policy guidelines will come into effect with the date of issuance/notification. These guidelines are binding for all the geothermal prospect developments in India.

Key Components of a National Policy on Geothermal Energy

Geothermal energy is a natural heat resource stored in the interior of the earth which requires transportation to surface for utilization. Thus, the source requires exploration activity, mining activity and production for fruitful utilization of the energy.

The following work components need to be considered for exploration and utilization of the geothermal energy.

1. Prospecting and mining lease
2. Exploration for geothermal resource
3. Systematic geochemical studies and geophysical surveys
4. Reservoir extent and parameters
5. Environmental and pollutant studies

6. Drilling data with sub-surface temperature profile and production parameters
7. Reservoir characteristics and resource assessment
8. Production potential, suitable technology and thermodynamic input parameter
9. Economics of the project
10. Societal issues

Chapter 2

Authority / Ownership of Geothermal Resources

The policy should clearly define who owns the geothermal resource — whether it is the State or the Central government and which Agencies would provide the relevant approvals / permits on drilling/mining, land lease, etc. There has been a school of thought that geothermal resources should be treated as "water resources", and therefore fall under the purview of the government. However, the process of handing over information and dividing responsibilities between the Central and State governments needs to be clearly articulated.

Geothermal resource neither falls under solid mineral resource category nor shallow ground water resource category. Geothermal fluids constitute a liquid resource situated in the deep underground. Prospecting for mineral resources is controlled by state governments while the ground water development and utilization is controlled by ground water exploitation guidelines set out by the central and state governments. Considering these aspects, though the land owner has a right to exploit shallow ground water, he will not have any right to exploit any geothermal resource located beneath his land. Geothermal resources / prospects will be considered as National Resource, as is the case with hydrocarbons. State guidelines may however be followed for providing relevant approvals / licenses for exploration and mining. The Even though it is a National Resource, the Central Government will not claim royalty on production of geothermal power.

Geothermal Springs vis-à-vis Religious Places

In India, places of worship have developed in the vicinity of most hot springs. Concrete enclosures *("kunds")* have been built covering the area of the hot spring discharges, which are traditionally used for religious bathing, hot water baths in cold areas and balneological purposes. A number of people earn their livelihood from such activities. Before development of such areas for utilization of geothermal energy can be contemplated, awareness campaigns need to be launched by local government to make the local population awar e of the benefits of such utilization and possible sharing of the resources.

As far as possible the surface manifestations may be preserved and their public utilities continued with the condition that such activities will not adversely affect the quality of water as well as the existence of the surface thermal manifestations. The local authorities may be involved in implementing these measures. The exploitation of the resource can be undertaken simultaneously in these areas without affecting the thermal manifestations and by involving the local population.

By-products

The mineral by-products from the hot springs such as silica, borax, cesium and other alkali minerals may be exploited by the developer; however the extraction of such byproducts would require assessment of the impact on the primary resource and associated risks with mitigation measures, if any. The license for exploitation of geothermal resource shall be utilized for the purpose for which it is given, i.e., power generation and / or direct heat utilization. However, the extraction of by-products from geothermal waters can be done by getting proper relevant license.

Chapter 3

Prospecting and Exploration License

The guidelines included here pertain to:

- Evaluation of proposal
- Identification of single / multiple parties for grant of license
- Progress review
- Evaluation of final report and recommendations for further work

Evaluation of proposal:

Proposals for prospecting and exploration of geothermal energy resources would be submitted to the MNRE through State Nodal Agencies (SNA). Prospecting / exploration programs by the government agencies may be intimated to the MNRE. As the development of geothermal energy is more akin to the oil exploration, the policy guidelines are similar to exploration of the petroleum and natural gas. To avoid the duplicate issuance of licenses and overlapping of the prospecting leases/activities, the proposals forwarded to the MNRE through the SNAs will be reviewed by MNRE. The SNAs should forward the proposals to MNRE within a period of one month from the date of submission by the applicant / Agency. Decision on the proposals submitted to MNRE through SNAs should be conveyed to the respective SNAs within a period of three months from the date of receipt at MNRE. The SNA would convey the decision to the applicant / Agency within a period of one month from the receipt of the application.

Time line of project:

- The evaluation shall take into consideration, among other criteria, the expertise and experience available with the Applicant / Agency in prospecting and exploration of Geothermal and/or other natural resources.
- The reconnaissance survey and prospecting of the geothermal resource may take up to a maximum of 6 months time and the Report may be submitted to MNRE by the Agency at the end of the 12 month period.

- The period for the exploration in a particular prospect may be fixed at a maximum of three years. The progress of exploration will be reviewed every year. The final report has to be submitted at the end of 3 years. An extension of up to 3 months may be granted based on the progress and local ground conditions/logistics for submission of final report. The progress of the work will be reviewed every six months. If the Applicant / Agency have not carried out desired work for consecutive two years, the license will be terminated. After termination of the contract the Applicant / Agency should leave the area within a period of three months. Prospecting / exploration license is not transferable. The licensee is free to leave the area within a period of six months from the grant of license in case they are not willing to continue the prospecting or the exploration in that area.

- A committee of at least three members comprising representatives of MNRE, State Government and Industry/Academia shall evaluate the report and recommendations of the prospecting/ exploration agency for further exploration/exploitation activity in the area.

- An Applicant / Agency which exits from the allocated block prematurely or whose exploration license is cancelled due to non-activity will lose the right for exploration in the block, which will then become open for exploration/ exploitation by the other agencies in the panel.

The license can be issued for prospecting, exploration and exploitation (power generation) along with direct heat uses or for only direct heat uses as required. For non-electrical uses the procedure for grant of license shall remain same but for the fact that the time period will be the actual period required for the execution of the project, as mentioned in the DPR of the project and shall not exceed two years.

Procedure for selection of the agency for prospecting/ exploration / electricity generation:

- The Policy guidelines come in force from the date of issue. The prospecting licenses granted before the issue of the policy guidelines may be honored by the respecting State Governments, if feasible.
- The license for projects leading to / involving power generation may be granted by pooling together the applications received every three months and evaluating the technical capability / financial ability of the agency to carry out the project, a process similar to open bids.

- The procedure is especially useful in geothermal prospects in Puga- Chhumthang in Ladakh, Parvati Valley (Manikaran, etc) in Himachal Pradesh, Tatapani in Chhattisgarh, Unhavare (Khed & Tamhane), Tural in West Coast; where baseline data are available to take up the exploration / exploitation activity.

Procedure for selection of the agency for direct heat uses:

Same procedure as above may be followed with emphasis on implementation of the project rather than generation of exploration data.

Chapter 4

Mandatory Clearances

List of clearances required for Power Plant

1) The applicant / Agency should be registered with the Ministry of Commerce and Industry.

2) Memorandum of understanding to be signed with State Nodal Agency (SNA).

3) Land Acquisition for Power Plant, Dam site, pipeline, cooling towers and borewells may involve one or more of the following types of lands

   i) Government land
   ii) Private land
   iii) Forest land
   iv) Any other land

   The prevalent land acquisition rules may be followed. The necessary Land Acquisition Certificate and No Objection Certificate from competent authority should be enclosed with DPR for the further development of the resource.

4) Environmental Clearance for Power Plant and other requirements.

   i) State Pollution Conservation board (SCPB) and / or Ministry of Environment and Forests (MoEF) clearance as applicable, should be submitted.

   ii) Water drawal permission, if applicable, should be submitted.

5) Civil Aviation Clearance from Airport Authority of India, if necessary.

6) Permission from State Government for construction of Power Plant

7) Permission from State Government for construction of Water Storage facility

8) Valid Power Purchase Agreement (PPA) should be submitted.

The above guidelines / clearances are suggestive in nature and are subject to change depending upon local ground conditions.

Chapter 5

Prospecting and Exploration

Geothermal resources are deep seated with different temperature and pressure conditions and chemical composition as compared to ground water resources. Geothermal resources are also different from solid mineral resources. Hence, the exploration and exploitation for geothermal resources require a different set of guidelines from those applicable to either groundwater or mineral resources.

MNRE shall prepare a baseline data for selected fields comprising of location, basic geology, temperature, discharge, and chemical analysis of water. It is desirable to have data on temperature and lithology for at least one borehole of 100 m depth in each of the selected geothermal sites for the guidance of the investors. Similar studies had already been done by G.S.I but still the areas with the minimum depth of 100 m is still to be taken up to have a Revised Geothermal Map of India.

The Project Proposal shall be in two phases.

Phase I (Exploration and Resource Estimation): It shall include the prospecting and / or exploration plan along with the cost estimates. Exploration is an expensive activity and requires heavy outlay. The entrepreneur may get support up to 50% of the deep drilling exploration cost on the basis of performance for completion of a specific level of exploration, i.e., block-wise or borehole-wise. The grant / support shall discontinue immediately if the party leaves / abandons the exploration midway.

Phase II (Plant setup and Power Production): It shall include Power Production Technology and Plan Outlay. The power production units have to be installed at selected site with proper arrangements for the supply of hot water / steam. The party shall get up to 30% of the financial grant from Central / State government, including the cost of land and licenses for installation of power plant on the balance amount after phase I. The Party is free to generate rest of the funds from internal sources or commercial borrowings without any liability to the Government.

The Policy encourages Government — Public — Private partnership. The Project can be implemented in joint partnership (public — private or private party with active support / funding by State Government as feasible). The development of infrastructure for the local population will necessarily be a part of the project keeping in view the Corporate Social Responsibility.

Reconnaissance survey and prospecting lease

Geothermal resource assessment in an area requires reconnaissance survey for deciding the prospect to be explored. The reconnaissance permit and prospecting lease may be issued by the MNRE in collaboration with the State Government, initially for an area of 50-100 sq. km.

The prospecting lease may be issued to the Applicant / Agency which has already applied for reconnaissance permit. The normal fees as applicable for mineral prospecting may be changed for reconnaissance permit/ prospecting lease. In case of the prospects where this work has been completed already by Geological Survey of India (GSI) or other Government Agencies, a copy of such reports may be included with the application and the initial stage of reconnaissance permit and prospecting license may be waived off, if so desired by the Applicant / Agency. The reconnaissance survey and prospecting of the geothermal resource may take maximum 6 months time and the report may be submitted to MNRE at the end of 12 month period. The Applicant / Agency should specifically mention about the further continuation of work in the prospect or vacate the prospect. In case the Applicant / Agency decide to continue further work, it should identify the specific area within the prospect lease for further exploration and may vacate the remaining area. The Agency which has carried out prospecting has the right to carry out further exploration of the block under the prospecting lease, subject to the stipulations mentioned Chapter 3. If the Agency fails to submit the report at the end of 12 months, the prospecting lease would be automatically cancelled.

The reconnaissance report / prospecting report shall comprise, but not limited to, the following information:

i) map of the area with location parameters of the hot springs
ii) geological map and drainage map
iii) discharge and temperature of the hot springs

iv) chemical analysis of hot water springs and ground water, dug well samples with sample location map

v) report of geophysical surveys

vi) Recommendations, with the proposed area for further study/exploration, or rejection of prospect. If the Applicant / Agency reject the prospect of the area for exploration / exploitation, the prospect will be immediately open for prospecting by next applicant in the panel.

Exploration

Exploration activity can be taken up in the area already under prospecting license. The maximum area for exploration license should be demarcated by the party and shall not exceed 100 sq. km. The application may contain

i) Map of the area with co-ordinates and drainage

ii) Dughole / trench plan and Borehole Plan

iii) Drilling plan with depth and size of the boreholes

iv) Details of the work plan including ancillary studies / geological / geophysical / geochemical surveys

v) Estimated cost of exploratory drilling

vi) Supporting financial document to substantiate the availability of funds for exploration

vii) Technical expertise or collaboration agreements for undertaking exploratory studies.

The Applicant / Agency will be liable to follow forest and environmental laws applicable for exploration. The taxes and levies of state governments have to be paid by the Applicant / Agency. The MNRE and SNA may assist the Applicant / Agency in application for obtaining necessary clearances.

The Applicant / Agency are liable to submit annual progress report. The final report has to be submitted within 3 years. If necessary, an extension of up to 3 months for submission of the final exploration report with suitable recommendations may be considered. An expert committee of at least 3 members comprising representatives of MNRE, Central Government, State Government / SNA, and Industry / Academia shall evaluate the report for considering the recommendations of the exploration agency for further activity in the area.

The exploration report shall comprise:

i) Geological maps with borehole locations
ii) Detailed map of the borehole plan/ geology (on 1:10,000 scale) of the area under exploration
iii) Borehole lithology
iv) Geophysical survey reports
v) Discharge and temperature parameters of the boreholes
vi) Well testing data
vii) Borehole water geochemistry and report on any other studies carried out on the borehole rock samples, gas/ water samples
viii) Reservoir characteristics/ parameters
ix) Resource potential
x) Recommendations
xi) Application for further activity in the area or rejection of the area.

Often, the exploration involves activities in non-urban un-inhabitated areas. The entrepreneurs will have to comply with the provisions of forest and environmental laws. It is imperative that all the entrepreneurs will obtain forest/ environmental clearance before taking up the exploration activities. The impact on physical features of the Earth's surface due to exploration/ drilling activity may be compensated by adopting suitable mitigation measures.

Cost of drilling geothermal boreholes is very high as the depths of boreholes are in the range of 2-3 km. Therefore, to economise the drilling cost, a number of boreholes may have to be drilled in the immediate vicinity of the geothermal reservoir. Moreover, the deep drilling for geothermal exploration is similar to the oil exploration, and integrated multi-utility drilling has to be employed to cut down the costs. Hence, more number of exploratory boreholes per sq. km. may be allowed in case of geothermal exploration.

Chapter 6

Assessment of Geothermal Energy Potential and Preparation of DPR

Assessment of Geothermal Energy Potential

Following data shall be made mandatory for assessment of a resource:

1. Geology and structural map
2. Temperature survey and thermal gradient
3. Hot spring locations, temperature and discharge
4. Chemical analysis of hot springs, borehole discharge
5. Plan of boreholes, depth, temperature / pressure logs, discharge data
6. Geophysical survey report
7. Reservoir temperatures inferred from various techniques.
8. Reservoir extent
9. Assessment of resource potential.
10. Estimates of expected production based on discharge of boreholes.
11. Assessment of production capacity based on resource potential, reservoir extent and technology used.

The assessment can be for overall energy source. While preparing a document for a project, the assessment can be made in two parts, total energy and recoverable energy. The recoverable energy could be in the form of power generation and the other industrial uses as heating, cooling, food processing representing virtual power generation.

Detailed Project Report (DPR)

The DPR shall contain following information:

Part — I

a) Background of the Project Proposal
b) Information as mentioned under "Assessment of Geothermal Energy Potential".

Part-II (Development Plan)

1. Technology used; power plant details.
2. The parameters of hot water input and output.
3. Feasibility study including production capacity, disposal of effluent water, cooling tower parameters, sustainability of production.
4. Details of power transmission plan
5. Environmental aspects
6. Social and legal aspects like rehabilitation of villagers, preservation of heritage structures, preservation of natural springs, culture and development of local area.

Part —III

Economic aspects of power generation

1. Cost Estimates

   i. Cost of exploration
   ii. Cost of power plant, cooling tower, waste management system
   iii. Cost of civil construction, infrastructure development roads, buildings, cooling ponds, etc.
   iv. Cost of transmission system
   v. Cost of local development, rehabilitation, etc.
   vi. Cost of Operation and Maintenance (O&M)
   vii. Cost of Corporate Social Responsibility (CSR), if any

2. Income Generation

   i. Income from sale of electricity
   ii. Income from incentives
   iii. Income from Clean Development Mechanism (CDM)
   iv. Income from other sources

3. Details of financing

   i. Private investment
   ii. Funding from government, direct or in form of incentives
   iii. Foreign funding
   iv. Public equity funding
   v. Corporate institutional — bank finance

4. Cost benefit ratio-

   i. Power production cost
   ii. NPV of project
   iii. IRR of Project
   iv. Balance sheet, profit- loss analysis, cash flows

LIST OF DOCUMENTS TO BE ENCLOSED WITH DPR

1. Entrepreneur Certificate from Competent Authority
2. Permission from State Govt. / Electricity Board for power plant construction
3. Certificate of MNRE / CEA for electricity generation, technical and financial feasibility
4. Environmental clearances
5. Forest clearance
6. Land acquisition certificate and N.O.C. to use land for industrial purpose
7. NOC of local village panchayat (if required)
8. Clearance for uses of surface / ground water
9. Clearance for construction of high rise buildings if any.
10. NOC from private land owners if construction is on private land.
11. Technical collaboration certificate, if required
12. Bank guarantee, finance details documents from bank and finance institutions
13. Registration as power plant producer (Copy of Memorandum of Association)
14. Agreement for sell / purchase of power
15. Manpower planning

Chapter 7

Power Production

i. The Applicant/Agency which has already completed prospecting /exploration in a particular block shall be given priority for development of the geothermal prospect and power production. The Agency may be an individual company, a joint venture company, a consortium, or a public / private party with agreement for technical consultancy and/or financial support from a national / international Agency.

ii. In case the party which has carried out exploration is not willing to take up the development of the prospect, or gets the development permit but does not show desired performance for a period of one year after completion of the exploration, open tenders may be invited for development of the geothermal prospect.

iii. The party willing to undertake development shall submit a DPR comprising exploration data, potential of the prospect, the discharge and temperature parameters in support of the production potential. The methodology and technology to be used for production shall be included. A supporting evidence to prove the production potential based on the resource parameters has to be submitted.

iv. Complete plan of production with production layout may be submitted. The plan may be proposed with average life of 20 years for the production machinery/project.

v. Financial outlay of the plan with payback period, IRR etc. may be submitted.

vi. The private entrepreneur has to comply with the provisions of the state government regarding land acquisition, environmental clearance and rehabilitation. The MNRE will provide assistance in speedy implementation of these projects with facility of single window system.

vii. The non-conventional / renewable energy development Agencies of the State will finalise the grant of lease/prospecting license and production permissions in a joint meeting with MNRE/Nodal group at MNRE to avoid duplicate issuance of licenses and delay in processing.

viii. The private entrepreneur is free to have collaboration with any legally permitted national or international company/consortium following guidelines issued by the Ministry of External Affairs/ Ministry of Finance.

ix. The entrepreneur has to acquire land through proper procedure. The State Government will assist in acquisition process once the terms and conditions for acquiring the land by private parties are finalized / approved with the local governing body.

x. The MNRE shall provide all the encouragement for development of geothermal energy. The geothermal energy development involves two phases, exploration and production. Although the exploration activity is expensive, once the production starts, the geothermal power becomes cost effective in the long run as the cost of fuel is negligible when compared to the cost of fossil fuels. Considering these aspects the MNRE may provide following incentives to the geothermal prospect exploration and development:

- Geothermal prospect / energy may be declared as a priority for energy development.
- The incentives for geothermal energy development may be granted at par with the solar energy.
- MNRE may provide subsidy/ financial grant up to 50% cost of the exploration (Deep drilling) and once the reservoir is established then 30% grant will be given on the rest balance amount for commercial power production.
- MNRE may facilitate through State Government / SNA for the evacuation of power to nearest input station, etc.
- Soft loans may be made available at concessional interest rate as applicable in other RE technologies through Indian Renewable Energy Development Agency (IREDA) for supporting exploration activity.
- The import of machinery / equipments for exploration and power production may be exempted from customs duty and import duty.
- Generation based incentives in line with solar/wind energy programme may be considered.
- The Agency is entitled to carbon credits acquired through the geothermal heat utilization / electricity generation.

xi. The developer shall have the responsibility to maintain the sustainability of production from the reservoir and avoid over-exploitation of the reservoir by adopting appropriate reservoir management techniques.

xii. In case the Agency which has explored the geothermal prospect relinquishes the area / block for further development, i.e., power production, then the data generated by the Agency which relinquishes the right to development will have to be submitted to the MNRE immediately. The MNRE shall then give the Executive Summary of the exploration data to the Agencies applying for the development of the area. The Agency which finally gets the contract to develop the power plant / geothermal resource will have the right to get the complete data of exploration in that area. However, the Agency has to pay royalty / charges as per the government guidelines to the original Agency who has carried out the initial exploration.

Chapter 8

Sale of power

Transmission of the generated electricity to the nearest grid shall be the responsibility of the producer. The power shall be transmitted to the nearest grid point/ local distribution point as per the agreement with the State Electricity Board. State Electricity Board may purchase power from the producer as per MNRE guidelines for renewable energy sources. A minimum 25% of the power generated should be sold to the State Electricity Board at mutually agreed rates. The producer will be at liberty to sell rest of the power to any suitable customer at prevalent rates recommended by the competent authority. The electricity may also be supplied to local surrounding area, thus reducing the load on grid distribution. The power charges will be paid as per the power received by transmission lines at the grid point.

These guidelines will be enforced for a period of 5 years after which these may be reviewed, if necessary.

Chapter 9

Direct uses of geothermal heat energy

Direct heat uses of geothermal energy are major contributors to substitution of electricity. The hot springs with low reservoir temperatures, i.e., <130 °C can be utilized for direct heat uses. The hot water of 60° - 130 °C can be used for direct heat utilization if the difference in temperature with the surroundings is adequate to extract the heat content. Direct uses can be made available at the sites where the transportation and transmission of electricity and water may be difficult due to remoteness of the area. Geothermal projects are multi-purpose projects; the effluent water from electricity generation plants can, depending on the temperature of sink water, also be used for direct heat uses. Direct uses are useful in partial saving of the energy required in small-scale industrial uses like vegetable drying, concrete block curing, etc. Besides these applications, direct heat uses have a major societal impact in the form of bathing centres, skin cure centres, geothermal and botanical parks for entertainment purpose, spas used for tourist attraction, green housing and cold storage for utility of local population and farming industry.

We shall consider the Geothermal Heat Pumps or Ground Source Heat Pumps, which are used for space heating and cooling, as part of direct heat uses and shall be given priority in indigenization.

In India, direct heat utilization has only been carried out on a demonstration basis at Puga, Chhumathang, Manikaran and Parbati valley. It is therefore proposed that the MNRE should encourage suitable direct heat utilization at different geothermal areas. MNRE shall formulate site specific direct heat utilization schemes which shall be implemented through local agencies like spa centres through Tourist Development Corporation, green housing and cold storage, etc. through Marketing Federations and suitable local bodies. The direct heat utilization by MNRE will have social benefit as well as impact on the development of low temperature geothermal resources. This effort will also make the public in general and the industry in particular aware about the role geothermal energy can play in development of interior areas and for societal benefits.

The producer shall be encouraged to utilize the water effluent from power plant for direct uses, like house heating, aquaculture, green housing, canning, bottling, pulp making, fish drying, drying of wool and fibres, milk pasteurization, brewing of low percentage alcoholic beverages, and a host of other uses. MNRE shall provide technology for direct uses of effluent water as well as heat/ electricity substitution.

Geothermal Heating/Cooling:

Considering the large requirements for space heating in mountainous regions of India that have extended and severe winters, and for space cooling / air-conditioning in most other parts of India throughout the year, a special emphasis should be given on popularizing the use of Geothermal Heating/Cooling technologies by retrofitting of existing HVAC systems or by Ground Source Heat Pumps (GSHP) as a national mission. Appropriate research initiatives should be undertaken by the Industry / Academia and supported by MNRE to study the feasibility of adopting this technology in different climatic conditions and bringing down the cost through different measures.

This Policy recommends that the geothermal heating / cooling technology be indigenized to make it a readily available / off-the-shelf utility in the commercial markets. Appropriate incentives to consumers for encouraging substitution of conventional fuels, possibly in line with solar water-heaters but on a larger scale, shall be considered.

For all practical purposes, the use of Geothermal Heat Pumps shall come under direct heat use applications. The following two variants need to be considered:

(i) True "Ground Source Heat Pumps" that do not exploit the subsurface water aquifers but extract the constant ground temperature at a depth of a few tens of metres, and
(ii) Heat Pumps that exploit the groundwater aquifers by pumping warm waters from the ground and circulate it inside the buildings.

While no formal license shall be required in the case of the former, separate guidelines on the extraction of groundwater from subsurface aquifers, in line with existing local guidelines for withdrawal of groundwater, shall be applicable in the case of the latter.

License for Direct Heat Uses

It is proposed that the license for direct heat uses be granted separately from the prospecting and exploration licenses, in case of projects where proposal for electricity generation is not submitted. The license for direct heat uses and electricity generation may be de-linked in such cases. In case the project for direct heat utilization is to be upgraded for power generation, the procedures laid down for license of power plant project shall be followed from the appropriate stage of exploration.

The main stages in direct heat utilization proposals shall be as follows.

- Submission of prospecting proposal to State Nodal Agency (SNA), and processing and decision on the proposal — 3 months,
- Prospecting including geological mapping, geophysical and geochemical surveys—6 months,
- Final submission of the Report and DPR preparation — 6 months,
- Implementation of the project with final production stage — maximum 24 months with review of progress once every 6 months.

As the direct heat uses are mostly for the benefit of local population, the State Government will also have participation in the project in the form of creation of infrastructure (roads, etc.) and utilization of direct heat use utilization products. The investment required for creating this infrastructure shall be a part of the project for which suitable grant will be disbursed by the State Government or Central Government as applicable. This system will also encourage State Government — Public — Private partnership. The local population shall be given priority in utilization of direct heat scheme products rather than exporting them on commercial basis.

The direct heat use schemes may be considered as employment generation and economy development projects for the local population. Local persons may be given opportunity, particularly in non-technical jobs in the project and sale / distribution of the products, thereby turning these schemes into project of social benefits.

It is proposed that the direct heat use schemes be treated as vehicles of infrastructure development and Central Government may contribute 30% of project cost in the form of incentives and funding with maximum support of Rs 50,000 /TR. The State Government may contribute in the form of land and licenses. The entrepreneur may be expected to contribute the rest amount of project cost including the funding generated from commercial institutions at its own risk. As Heat Pumps already qualifies for the 80 % accelerated depreciation during the first year of installation. Ministry will provide import duty exemption during the first 3 year of technology promotion till the Indian industries are not established under “Make in India” scheme.

Chapter 10

Public-Private Partnership

The exploration of most of the geothermal resources in India has been completed up to a shallow level (i.e., up to a maximum depth of —728 m in select areas and much less in other areas). Development of geothermal resources requires deeper level exploration and utilization of the energy for electricity generation. The deeper level exploration in India was held up due to non-availability of machinery and equipments for deep drilling. Considering the large scale investment required for development of geothermal resources, partnership between the private, public and government sectors may be encouraged. The technology flow and assessment of resources may be supervised by public sector / government while the field operations and logistics may be managed by the private sector. The involvement of foreign entities may be encouraged for exploration and development of geothermal resources provided the "foreign collaboration" is tied up with technology transfer as 100% FDI is allowed in Renewable Energy Sector. The foreign collaboration has to be approved with the intention of active participation rather than just a role of sleeping partner or consultant, as per the prevailing government rules. The development of infrastructure for the local population will necessarily be a part of the project keeping in view the Corporate Social Responsibility (CSR).

Incentives to private players

Incentives need to be provided to private players in consideration of the fact that geothermal power projects being capital-intensive and risk-prone require large investor support and that there needs to be private participation for early and steady development of geothermal resources. They could be in the form of:

a. Awarding suitable area of land for developing the project and maintenance of production wells, thereby securing the commercial viability of the project. The State Governments should facilitate land acquisition for development of geothermal energy projects on priority basis.
b. Government shall provide land on lease at prices charged to government departments.

c. Incentives similar to other renewable programs in India, namely solar, biomass may be granted. The Return on Equity (ROE) for geothermal projects could also be made similar to other power projects in India, thereby ensuring reasonable earning. The ROE for these projects could be higher than for other projects due to the additional risk associated in geothermal exploration.
d. Import subsidies may be granted to maintain a lower cost for the project, as most of the equipments for project will be imported.
e. The foreign investors may be provided investor friendly schemes for repatriation of profits.
f. Direct and indirect tax benefits may be granted at par with the solar or biomass energy projects to support the high cost of exploration and power generation, and to encourage private participation in the geothermal industry.
g. The direct heat utilization methods which replace fossil-fuel based electric power may be granted similar incentives.

The R & D project and foreign collaboration project shall specify:

- Components of technology to be indigenized / transferred,
- Road Map for technology transfer with time period,
- Collaboration project shall include 30% indigenization of technology projects in first stage and 50% indigenization of the project in the second stage,
- Technology transfer plan may be agreed mutually by the private party and the foreign collaborator keeping in view the above guidelines but must specify the road map to complete indigenization of the technology,
- The foreign collaborator shall have direct responsibility in implementation of the project and shall not be a mere outsourcing agency giving sub-contracts to complete the work,
- The sale of electricity to State Government shall be guided by the tariffs decided by the Local Electricity Tariff Regulatory Authority.

Guidelines on import of machinery eligible for import subsidies and other tax incentives

The import of machinery to be used for geothermal projects should be strictly limited to critical equipment for geothermal power production / direct heat utilization, and should be made only after a thorough assessment of the status of the indigenous supplies.

A tentative list of equipment / machinery that could be eligible for import subsidies is as follows.

Exploration

- Geophysical survey kits (Magnetotelluric / Deep Resistivity Surveys (> 1000 m depth)
- Well-logging units (e.g., multi-logger with borehole testing facility)
- DGPS / GPS and software
- Software for modeling and interpretation of geophysical datasets
- Geochemical analysis units such as ICPMS, EPMA, Fluid inclusion studies, water / gas analysis kits
- Drilling machinery, or contracts for drilling by outsourcing, cementing units
- Drilling accessories such as drilling bits / diamond core bits, rods, casings, double tube instruments, perforated / production casings, heavy duty pumps, water / mud circulation units, etc.

Production

- Steam separators
- Flashing units
- Binary cycle plants
- Dry steam turbine / generation units
- Cooling tower machinery (forced draft cooling equipments)
- Accessories for turbine and generator
- Reinjection pumps / production pumps

Direct Heat Utilization

- Cold storage circulation plants
- Chillers to be used for geothermal retrofitting purpose (>300 TR)
- De-ionization / mineral content removal plants
- Heavy duty heat exchangers
- Control units for production / generation and distribution of thermal power.

Chapter 11

Production Sharing Contract for geothermal power

1. The wheeling / transmission of the electricity generated from the grid point onwards shall be the responsibility of the State Government / SNA. In case electricity is sold to third party the transmission shall be at the mutually agreed price.
2. MNRE shall provide incentive for transmission of the electricity generated from geothermal resources.
3. The production sharing with the local government shall be with the mutual agreement at the prices fixed for the other non-conventional energy source generation like solar and biomass energies.
4. In energy surplus states, the power producer shall be at liberty to sell the electricity directly to third party, with payment of mutually agreed royalty. The Applicant / Agency shall get bonus incentives for increase in production.
5. Technology for development of geothermal energy resources is relatively new to India. The initial prospecting / exploration and assessment of resources require a proper technical support. MNRE shall arrange to provide technical support through national / international collaborations / consultants, for exploration, assessment and development of these resources.
6. As the initial investment for the exploration and power production is very high, a fixed policy may be adopted for the incentive / purchase price of the electricity generated. A simple formula suggested is as follows:

   Subsidy by Govt. = (Cost of production) - (Purchase price of geothermal power)

7. The scientific data of specific geothermal field may be made available to the entrepreneur as per the level of activity, prospecting / exploration / DPR stage, as per the norms of the government.

Chapter 12

Data Repository and Access

MNRE would function as a National Data Repository, in partnership with Geological Survey of India (GSI), for all geothermal energy related datasets generated in the country. The National Repository will maintain all the data generated by government / public sector / private organizations including the data of prospecting, exploration, exploitation and technology demonstration projects. GSI would create necessary infrastructure for state-of-art archiving and retrieval facilities and ensure smooth access to the datasets by authorized parties. Necessary support would be provided by MNRE.

The data available with the National Repository would be made available for research and commercial exploitation free of cost or on payment basis for which necessary guidelines will be formulated by a committee constituted by the MNRE. The data generated during prospecting, exploration, exploitation, demonstration project will be property of the data-generating Agency for a lock-in period of three years after which the data will be placed in the public domain. In case, the data is used by other agencies during the lock-in period, a part consultation fee may be made available to the data generating Agency, as per the guidelines decided by the committee of the MNRE. However, if the prospecting / exploration / exploitation Agency decide to discontinue work in the lease area, the data will automatically be placed in the public domain. The data generated by government agencies will be made available to the public as per the existing rules.

Available datasets

Geological Survey of India (GSI) has explored several potential geothermal resource areas in the country and therefore possesses the majority of geological and geothermal datasets. Also most of the dataset are available in the GSI website. Other government agencies have also participated in geothermal exploration in India, such as the National Geophysical Research Institute (NGRI), the Central Electric Authority (CEA) and a few other institutions. The geophysical data obtained primarily for the oil and gas bearing regions are available with the Directorate General of Hydrocarbons (DGH). Relevant datasets from GSI, NGRI, ONGC, CEA, DGH, etc. should be made available to the National Data Repository for use by the geothermal industry.

Presently, the data and information primarily exist in the following forms:

1. Published data in form of scientific papers, annual reports, scientific publication.
2. Technical Reports of Geological Survey of India, National Geophysical Research Institute, Central Electricity Authority (CEA/ONGC), etc., both published and unpublished.
3. Unpublished Reports and documents (notes, compilations, etc). The unpublished reports may be in final forms like circulated reports on mapping and exploration, including maps, sections, etc.
4. Basic data on the investigations carried out such as geophysical survey data and report, chemical analysis data, any other type of basic data and report.
5. Reports of commercial value.
6. Soft copy of any type of data mentioned above.

These data can be archived and preserved in the proposed Data Repository, both in hard copy and soft copy formats.

Access to data and information

In order to facilitate critical analysis and resource assessment by interested parties, basic geological, geochemical and geophysical data for the geothermal areas need to be made easily accessible. The following guidelines may be followed.

- The published material by government and private parties may be made openly available to all citizens at the price of publication.
- The unpublished data may be categorized as (a) General data, and (b) classified data for exploration and exploitation purpose.
- All data generated by private, public sector and government agencies shall be supplied to the nodal officer of the Data Repository. The nodal officer will categorize the data and preserve it for future use in hard copy as well as soft copy. In case of soft copies of reports where maps are not included, hard copies of maps can be converted into soft copies through outsourcing. The data shall be made available to the government agencies, public and private parties, etc. as per the guidelines of the Ministry.
- The data may be made available to the parties interested in geothermal development as per the following norms:
    a) Party interested in prospecting lease: Executive summary / Meta data of the mapping / exploration report of the area
    b) Party interested in exploration: Prevailing exploration data / report available, as per the guidelines of the MNRE
    c) DPR stage: The exploration and various survey reports.

  The above mentioned data can be spared at specific request from an Agency working in a specific area at the cost / consultancy charges mentioned by the data `generating / holding Agency.
- The data shared with government/ public / private Agency for exploration and / or development of the geothermal resource shall be for exclusive use of the said party. The concerned party has responsibility to keep the data secret and transfer of data to any other party associated with the development of particular geothermal field is not permitted at any cost. The party seeking data shall give an undertaking to MNRE stating that the data will be secure with them and shall not be transferred to any other party or Agency. The transfer of data to a third party will be liable for action as per government rules.

Chapter 13

Research and Development, Technology Demonstration and Dissemination

Geothermal fields in India provide a unique opportunity to develop indigenous technologies targeted at exploiting low-to-moderate enthalpy geothermal resources, unlike the high enthalpy resources powered by magmatic / volcanic systems as in the case of geothermal developed nations. Therefore, investment in research and development — for geothermal exploration, power production as well as direct heat utilization, should constitute a key feature of the National Geothermal Energy Policy of India.

Research and Development in the Geothermal Energy Sector could be supported on the following lines:

Suggested R&D components

a) Establishment of state of art laboratories for geochemical and geophysical analysis and modelling; modernization of equipment like EPMA, isotope studies, etc. required for geothermal resource assessment.
b) Efficient and low-cost, site specific drilling technology
c) Reservoir studies and modelling techniques for better assessment of resource potential
d) Techniques for improving production rates
e) Improving the efficiency of power generating cycles
f) Environmental impact mitigation
g) Awareness and Outreach

The Academia and / or Industry could be encouraged by the MNRE to take up research projects on each of the above and related areas.

Technology Demonstration Projects

The MNRE will support one technology demonstration project each for power generation and direct use in most potential site, depending on feasibility and need. The site(s) for demonstration plant could be identified by MNRE and / or State Government Agency. The State Government should necessarily be a partner in the project. In principle, the existing Policy Guidelines for R & D cum Technology Demonstration Projects as provided by MNRE (subject to modifications from time to time) and approval mechanisms already in place such as the R & D Proposal Advisory Committee (RDPAC) shall be followed.

The R & D projects have to be intimated to MNRE for verifying the relevance of the projects to geothermal technology improvement. The subjects of projects may change from time to time but shall have direct bearing on indigenization of the technology / project.

Concerned State Government Agencies may consider forming SPV in P-P-P mode of involving concerned State Agencies, Private / Public sector / consortium and local populace of the area where the project is going to be grounded. The Private / Public Sector Company / consortium may have majority stake and the share of the concerned State Government Agencies may be mutually decided between the partners of the SPV depending on their contributions.

Providing necessary land and obtaining clearance for the project from all concerned agencies may be the responsibility of the concerned State Government Agency, following concept of single window clearance. If the demonstration project is upgraded to a commercial venture, the incentives for such upgradation will be as per the guidelines laid down for the regular power production/direct heat utilization project.

This technology demonstration exercise will bring in immense benefits to the country in terms of testing its own expertise and capabilities, as well as to identify technological gaps that can then be acquired from geothermal power producing countries.

Possible sites for undertaking R&D Technology Demonstration Projects in India include:

1. Puga-Chhumathang, Ladakh (J & K)
2. Tatapani, Surguja District, Chattisgarh
3. Tapoban, Uttarakhand
4. Unhavre Khed, Tural and Ganeshpuri, West Coast of Maharashtra
5. BakreshWar, West Bengal
6. Sohna, Haryana
7. Manikaran / Tapoban, Parbati Valley (Himachal Pradesh)
8. Surajkund / Rajgir, Jharkhand
9. Taptapani, Orissa
10. Warm water springs of Andhra Pradesh, Kerala, Tamil Nadu, depending on suitability and feasibility.

Chapter 14

Capacity Building

Capacity building is a major requirement keeping in view the growing need for trained manpower in this sector. The advent of geothermal development in India requires additional manpower for exploration, development and production purposes. At the same time, it is necessary to invest in technological development, drilling capabilities and infrastructure for manufacturing equipments for geothermal power production as well as direct use applications.

Manpower and Technological Needs

It has been realized, especially during the last two decades, that the majority of hot water springs in India (other than Barren Islands in the Andaman and Nicobar), constitute primarily low-to-moderate enthalpy geothermal resources. To improve the economic viability of exploiting such resources, it is necessary to adopt newer techniques of assessment of geothermal energy potential and their exploitation. Combined heat and power options need to be developed, apart from techniques to improve the output of binary cycles. An integrated, multidisciplinary approach to exploration and assessment is called for.

MNRE shall facilitate creation of technical manpower by providing training facility in India and abroad. The training activity may be supported initially for a period of 3 years by MNRE. For this purpose, an Institution such as the National Geophysical Research Institute (CSIR) / GSI may be designated as the Nodal Agency.

Enhancement of expertise through training opportunities abroad

It is observed that a few critical gaps in expertise available in India need to be covered by training of qualified scientists / researchers in the following directions:

1. Integrated modeling of geothermal systems by combining information from geological, geophysical, geochemical and drilling investigations,
2. Estimation of reservoir temperatures using state-of-art chemical geothermometry.

3. Estimation of geothermal energy potential (expected power output over a specified number of years) using methods appropriate to Indian hot springs.
4. Improvement of economic viability of geothermal power plants fuelled by low temperature/low enthalpy resources through enhancement of efficiency of binary cycles as well as adoption of combined heat and power options.
5. Exploration and assessment of enhanced geothermal systems (Hot Dry Rock/Hot Fractured Rock systems).

The required expertise in these areas needs to be acquired to carry out a complete characterization of the geothermal energy resources in the country. This can be achieved through collaboration channels existing between MNRE and geothermally advanced countries such as Iceland, Philippines, New Zealand and Australia.

Creation of Manpower in Basic Geothermics in India

For all practical purposes, no university / Institute in India offers courses on Basic or Applied Geothermics. The NGRI is the only Institute in the country where a small but dedicated research and development programme in basic geothermics and its applications exists. Besides expertise in systematic acquisition of geothermal / heat flow data and thermophysical properties of rocks, the NGRI has the entire basket of geophysical and geochemical tools that could be gainfully employed for geothermal exploration. However, it is necessary to initiate programmes focused towards reorienting / utilizing those subsurface probing capabilities to deep geothermal exploration as well as acquire expertise in new modeling techniques. It is important to expand this programme to include a larger group of geologists and geophysicists in the country. Considering the shortage of trained manpower in exploration and development of geothermal resources in India, it is imperative to create manpower trained in the fundamental tenets of Geothermics and its interface with other geophysical and geochemical techniques. Programmes for public awareness in utility of geothermal energy for societal benefits may be arranged by organizing interactive sessions and lectures, and by publishing popular articles. Suggested method for creation of trained manpower is provided below:

A dedicated, 6-months long, course in Geothermics with a strong focus on practical geothermal exploration could be given every year, at least for three consecutive years, by pooling experts from India (NGRI, GSI, IITs, and ONGC) as well as abroad utilizing the existing channels for collaboration with geothermally advanced countries. Both Academia as well as the Industry could sponsor participants. NGRI could serve as a Nodal Agency in this case.

The programme could be implemented by pooling expertise from the following organizations:

a) Geological Survey of India (GSI): Geological mapping, geochemical surveys, structural mapping, and laboratory studies in petrology, geochemistry and fluid inclusions.
b) National Geophysical Research Institute (NGRI), Hyderabad: Heat Flow/ borehole temperature measurements, thermophysical properties of rocks, geophysical exploration using magnetotelluric / deep resistivity / seismic / gravity surveys, modern instrumentation utilities such as ICPMS, EPMA, etc., data interpretation and modeling.
c) Oil and Natural Gas Corporation Limited (ONGC): Reservoir studies, characterization and modeling of deep subsurface reservoirs and their properties, drilling, geophysical well logging.
d) U.N. University (Iceland) / Geothermal Institute (Auckland): Geothermal drilling and downhole well testing, analysis of drilling and well testing data, data integration and resource assessment, production planning, operation and maintenance, power production control.
e) On-site training: The training programme shall include visits to select geothermal fields in India (Puga, Chhumathang, Parbati Valley, Tatapani, Bakreshwar, West Coast g roup in Maharashtra, etc.) and hands-on practical training visits to active drilling projects, power production plants, and modern instrumentation and laboratory facilities in New Zealand, Japan, Indonesia, Iceland, Phillipines, etc.

Support to technology manufacturers

To devise a long-term vision for sustainable geothermal development in India, roping in the key indigenous developers / manufacturers to invest in this technology and manpower development are important. There could be research benefits, in the form of tax incentives, for organizations willing to set up infrastructure to manufacture equipments / develop technology for geothermal exploration, assessment and production, and providing necessary training facilities.

Chapter 15

Protection of the Environment

Geothermal energy being a relatively clean and green energy, the environmental impact is much lower when compared to the other energy sources. Geothermal "direct use" facilities have minimal or no negative impacts on the environment. Geothermal power plants are relatively environment friendly. They are successfully operated even in the farmlands, desert areas and dense forests with minimal environmental impact. In view of the above considerations, usual restrictions for forest and environmental clearances for development of energy resources may not be applicable to the projects involving exploration and exploitation / development of geothermal energy resources.

Pollutants

The main environmental pollutants emitted in geothermal development projects are:

a) Gases

- Hydrogen Sulphide gas (H_2S) sometimes occurs in geothermal reservoirs. H_2S has a distinctive rotten egg smell that can be detected easily at very low concentrations (a few parts per billion). It is subject to regulatory controls for safety of workers because it can be toxic at high concentrations. Equipment for scrubbing H_2S from geothermal steam at production level removes most of this gas.
- Carbon dioxide (a major greenhouse gas) occurs naturally in geothermal steam but geothermal plants release amounts less than 4% of that released by fossil fuel plants. Further, there are no emissions at all when closed-cycle (binary) technology is used.
- Besides these gases, small quantities of NO_2, SO_2 and ammonia are present in Geothermal fluids.

b) Groundwater

- Geothermal water contains higher concentrations of dissolved minerals compared to water from cold groundwater aquifers.
- Geothermal water contains silica, chloride, sulphate, carbonates, arsenic and fluoride as main constituents which may cause environmental hazard if found in very high quantities.

Environmental Impact Assessment and Mitigation

1) There is need to control the environmental impact of effluents in gaseous form as well as minerals dissolved in fluids during the geothermal production stage. The gases emitted during the production stage have to be segregated and siphoned out using modem techniques like gas separators. The radicals dissolved in water have to be treated to reduce the precipitation of minerals like silica and calcite which block the production pipes. Hence, every production programme must have facilities to monitor gas emissions and quantity of dissolved radicals in geothermal waters to plan suitable mitigation measures. In case of arsenic and fluorine content above the permissible limits, measures must be taken to reduce the quantities of these elements.

2) Often, the exploration involves activities in non-urban un-inhabitated areas. The Agencies will have to comply with the provisions of forest and environmental laws. It is imperative that all the Agencies will obtain forest/environmental clearance before taking up the exploration activities. The impact on physical features of the Earth's surface due to exploration/drilling activity may be compensated by adopting suitable mitigation measures.

3) Necessary measures should be taken to avoid mixing of geothermal waters with the shallow groundwater as geothermal waters may contain pollutants which are hazardous for human consumption. It should be ensured that the surface run-off of spent geothermal waters should conform to the WHO guidelines for water use for irrigation / human consumption. In this context, it is suggested that re-injection of spent water shall be encouraged.

It will be mandatory for all the geothermal energy utilization Agencies to monitor and prepare a quarterly environmental impact assessment report with special mention on the mitigation measures adopted.