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Comparative Study Of The Utilization Of Geothermal Energy In Various Ways In India And Rest Of The World

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Abstract – *Geothermal energy is a great source of renewable energy. It is of great use in various fields now days. It can be used in original form, as well as for carrying out heating and cooling of residential and commercial buildings. A large quantity of plants and ground source cooling system (GSCS) are running and working in India and in foreign countries based on this concept. This paper present a comparative study of GSCS projects, resources, sites of geothermal energy , there specifications, utilization of this energy in various fields and the coefficient of performance of geothermal power plants(GTP) in India and abroad. It can also describe the major energy savings and facts defining the amount of energy production in India and other parts of the world. The comparison has been carried out on the various projects working on this technology and various aspects related to it between our country and across the world.*

Key words: **Geothermal energy. GSCS(Ground Source Cooling System), GPP(Geothermal Power Plant), GSHP(Ground Source Heat Pumps), EES(Earth Energy Systems).**

1. INTRODUCTION

Geothermal Energy or geothermal heat is main source of renew able energy which is obtained from nature in several parts of the world. This energy is present in a huge amount on the earth. It can be extracted from the earth; it is present in the form of hot springs, hot spots, in direct form etc. There are number of fields in which this energy is playing very important role but the main function which has been carried out by the use of this energy is providing heating and cooling to the buildings, may be residential, commercial. This depends on the site or the source of energy, higher the amount of heat is extracted the more efficient ground source cooling system becomes. Direct use of heat energy is also relevant now days. This energy is a very clean source of energy. This energy can be extracted without burning a fossil fuel. Ground source heat pump is a central heating and cooling system that transfers heat to or from the ground. Ground source cooling uses the ground water or earth or both as the source of heat in the winter and as the "sink" in the summer. For this reason, ground source cooling systems are known to be as earth energy systems (EES). Heat is removed from the earth through a liquid, such as ground water or an antifreeze solution, upgraded by a heat pump, and transferred to indoor air. During summer months, the process is reversed: heat is extracted from indoor air and transferred to the earth through the ground water and antifreeze solution. The temperature beneath the upper 6m of earth surface maintains a constant temperature between 10-16^0 C. These systems use a heat pump that can transfer heat from a cool space to a warm space against the natural direction of flow, or they can enhance the natural flow of heat from a warm area to a cool one. So these systems are very useful for the energy savings as well as for the reduction in CO_2 emissions,.

2. SITES AND SOURCES OF GEOTHERMAL ENERGY

2.1 India

India is a country , having a diverse geography. The source of geothermal energy or sites rich in geothermal heat are present in a large quantity. There are mainly 10 provinces having the potential sites of geothermal energy[1]. All these provinces are: Himalayan geothermal provinces, Naga – Lushai province, Andaman Nicobar island, Mahanadi Godavari, West Coast, Son Narmada Basin, Tapi and Aravalli Basin, Cambay Basin and South Indian Cratonic Nearly 400 hot springs are present in different provinces of India surface temperature of these springs ranges from 47-98^0 C. Thermal gradient range is 59-234^{0}C /km. India has a EGS potential the is waiting to be exploited. These geothermal sites have thermal waters directly being used for balneology and cooking. Indian geothermal areas either come under medium enthalpy or under low enthalpy geothermal resource areas(100-200^{0}C) and (< 100^{0}C). Geothermal exploration carried by the geological survey of India gave details about the potential geothermal sites of India. These sites are providing a large number of benefits like using geothermal energy directly for poultry farming, swimming. 80% of the electricity generation in India is spent for space cooling. Figure shown below depicts the major regions of geothermal potential in India: -

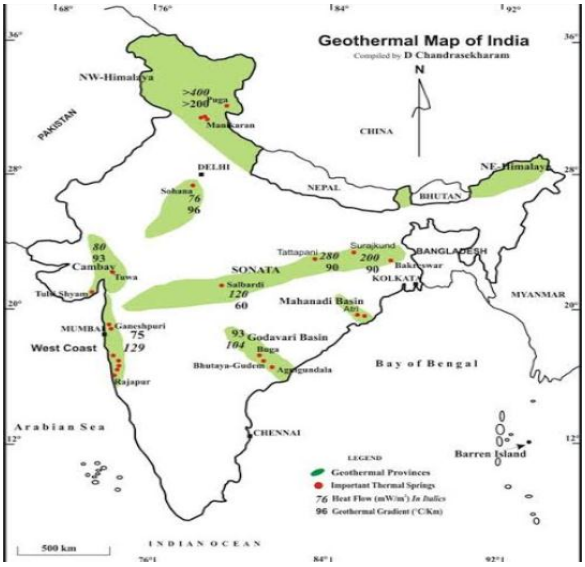

Fig-1: Geothermal energy sites in India

2.2 World

In the world, there are a large number of geothermal potential sites and they have been in use for a long time and they do have more capacity of heating and cooling in comparison to India. The main regions where the geothermal energy is present in huge amount are the countries like Austria, Switzerland, and Germany. Canada, Japan, US, UK. Turkey is also a great potential site of geothermal energy. Surface temperature ranges from 26-52^{0}C. The map shows the important sites of geothermal energy in the whole world.

Fig-2: Geothermal energy sites in World

3. GEOTHERMAL POWER PLANT

Geothermal power plants are operated in at least 24 countries up to 2010.

3.1 World

Geothermal power plants generate the power having a total capacity of 10.7GW in all the countries where GPP's in the varioyus countries of the world seems to be a large figure but 88% of this power generation is carried out in only 7 countries[2]. These countries are US, Philippiners, Indonesia, Mexico, Italy, Iceland, Newzealand, Iceland has the largest contribution of geothermal power. It provides 25% of the electricity suply and after Iceland the Philillines contributes power i.e. 18% to electricity supply.

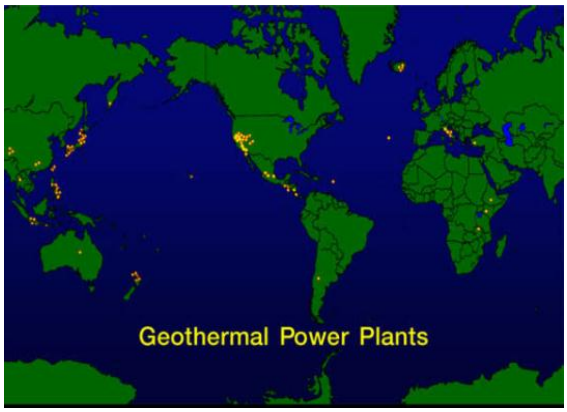

Fig-3: Geothemal Power Plant

3.2 India

In india the GPP's (Geotermal Power Plant) have not grown yet to a larger extent as in the other countries of the world but it has been investigated and explored that India has a very good potential for the establishment of geothermal poer plants and it can produce a power of 10,600Mega Watt(MW)[3].

4. GSCS SYSTEMS OR PROJECTS

A large number of ground source cooling system projects or GHP's are installed in several parts of the world in last years specially. The foreign countries are having a large number of GCSC systems in comparison to India and their growth has also been carried out recently. India is also undergoing development in this technique and at present a large number of GSCS systems are running and providing their services in many sectors and places where they are requried. So, some projects will be defined which are based on geothermal energy and heat along with their utilisation and power saving data.

4.1 Indian Projects

i) SASE, GSHP system Manali (Himachal Pradesh)

A higher geothermal heat flux is present in this region. GSHP system have been installed at one of the SASE(Snow and

Avalanche Atudy Establishment) campus. The present work deals with the study of performance and evaluation towards the energy saving purposes along with the reduction in GHG emissions. In this project, first the drilling of a test borehole was done upto 102m depth with a diametre of 127mm. A number of geological samples were collected with different depths and the analysis of the samples was carried out so as to get the information about the geological structure. After the confirmation of the site 27 bore holes were drilled and HDPE/MDPE pipe networks (5200m) werwe inserted into these bore holes so as to form a vertical U-shaped bent closed loop system after this the network of pipes have been coupled to a 100kW capacity GHP system[4]. An antifreeze solution (mixture of monoethylene glycol- 25% with water) flows through the ground loop circuit. On thr other hand refrigerant R410a has been used in GHP. An intermediate heat exchanger is coupled to the central heating plant transfer the heat from GHP to user load side[5].

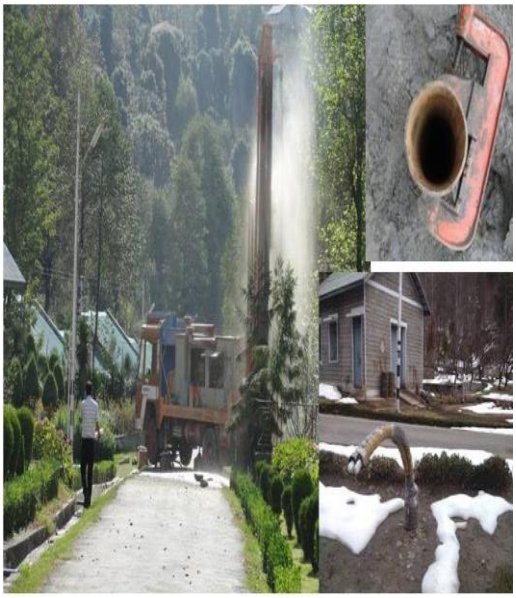

Fig-4: SASE, GSHP Sytem, Manali

This system provides heating of buildings adjacent to the SASE plant along with pre-fabricated huts in the campus. The energy saved is about 67% and the coefficient of performance calulated as 3.1.

ii) Geothermal heating and cooling system, Dholera , Gujarat

It is a system developed by collaboration of GIBBS, CEGE(Centre of Exellence for Geothermal Energy) and PDPU(Pandit Din Dayal Petroleum University). It was inaugrated on 13th December 2016. It includes the drilling of two bore wells of 1000ft depth which produces water at 45^0C temprature. The Swami Narayan Temple has been facilitated with this GSCS system. Water from ooling side of the system is used for comfort cooling of the assembly hall or temple premises. Output froom heating side ids utillised as an input to ORC(Organic Rankin Cycle) for power generation [6]. It provides 32TR capacity of cooling, hot water for cooking food, bathing etc.It helps to reduce water consumption, CO_2 emission and no chemical usage takes place with an energy saving of 20-50%.

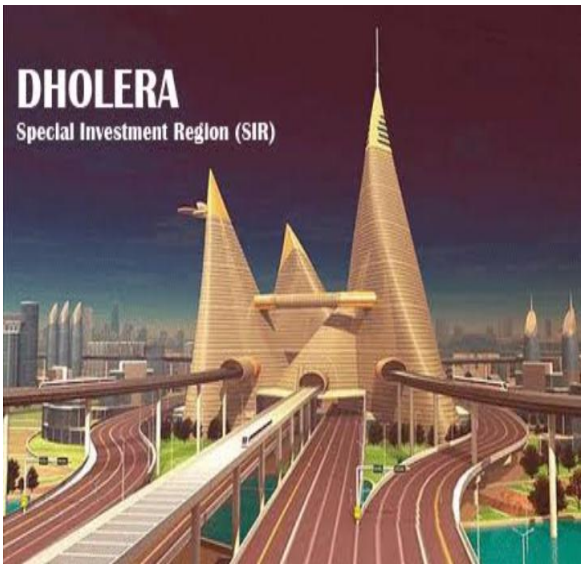

Fig-5: Dholera Site, Ahemdabad

iii) Puga Valley Geothermal Project

A large number of hot springs are present in Puga Valley , Ladakh. It's temprature ranges from 30-84^0C. The discharge rate is calculated as 300L/min and the geothermal gradient is noted to be about 0.35- 2.5^0C /m. Very small scale functions are carried out by the use of this energy like green house cultivation, poultry farming, experimental space heating and heating of pre-fabricated huts[7]. Tattapani geothermal field is also very important site of geothermal energy and provide the same facilities as Puga Valley porject along with the production of electricity by the use of GSCS system[8].

iv) Apollo Cancer Hospitals

In these hospitals cooling is provided in the hospital building by the use of GSCS system instead of using air conditioners. Geothermal India™ is the first company to sucessfully design and implement this open loop geothermal air conditioning GSCS system in hospitals in India.

4.2 World Projects

The GSCS systems are not new or recently developed systems, in the other countries of the world. These systems are existing there for a long time and have also provided a large amount of facilities like heating and cooling of buildings. This technology has grown upto a very large

extent, in several parts of the world and electricity generation is carried out by the use of this technology. Other fields of utilisation also exists.

i) Philadelphia Enterprise Centre(USA)

This is the example which shows that the heating and cooling of the institutional buildings is done by the installation of GSCS systems. In this centre the network of HDPE pipes have been buried or grouted underground , in which the antifreeze solution flows and these pipes are connected to the heat pump for extraction or release of heat according to the requirement in summers and winters. When the temprature is below 0^0C, zntifreeze solution is used , otherwise water is the best alternative.

ii) Richard Stockton College (Pomona. New Jersey)

This is the oldest college in New Jersey which used this system in 1994. After the installation of this system, the initial cost through energy savings was recovered in less than foue years.

iii)United States Project

In US, most of the units are designed for peak cooling load and are oversized for heating. In US, this system has seen a steady increase in last 10 years. Annual growth rate is about 12%. Around 80,000 units are installed in US and of these units 46 % are horizontal as well as vertical closed loop system[9]. In Texas , over 600 schools have installed these units for heating and cooling. Galt house East hotels in Louissvilie, Kentucky carries heating and air conditioning by GHP's in 600 hotel rooms, 100 apartments and 89,000m^2 of office space having a total area of 161,650m^2. The temprature is around 14^0C. The cooling capacity is measured about 15.8MW whereas heating capacity is recorded as 19.6MW and the nergy consumption is around 53%.

iv)European Countries GSCS systems

In Europe, GSCS systems are used on a medium scale but due to distribution of energy in limited regions, the utilization of these resources can be done more efficient by GSHP systems.

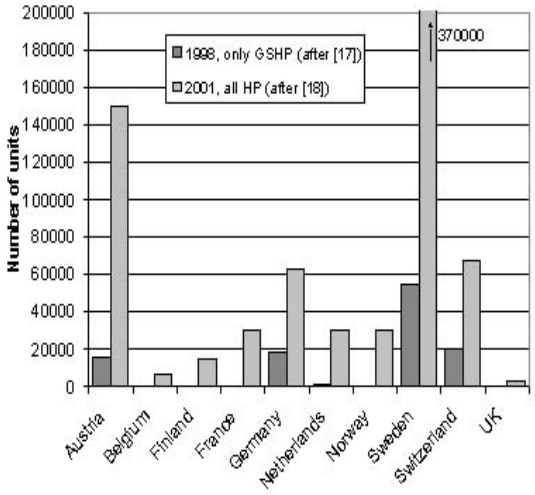

Fig-6: Number of installed Heat Pump Units In Some European Countries.

More than 20 years of R&D focusing on GSHP in Europe resulted in a wel establishesd concept of sustainability for this technology, as well as sound design and installation criteria. Thes systems require currently for each KWh of heating or cooling output 0.22-0.35 KWh of electricity, and it is 30-50% less than seasonal power consumption of air-to-air heat pumps[10].

v)Projects in Germany

Here the humidity in sumer time offers us to use these pumps for cooling in a de-humidification mode. These systems have the special features of using the cold of the ground directly, without chillers, and they show a extermely high coefficient of performance[11].This type of first system was build in 1987.

vi)Switzerland

At present, there are over 25,000 GHP's in operation. The first installation was done in 1980, but a rapid progress occurred and now Switzerland has the largest contribution in this field. Total installed capacity is 525MWt and an energy production of about 780GWh is recorded.

vii) Norway Project

In Nydalen, Oslo, 180 rock wells will provide heating and cooling to a building area of 200,000m^2. The project is largest in europe and by using the heat pumps and geothermal wells , heat is collected from and stored in the ground. In the summer, heat is pumped into the ground. In this situation bedrock temprature may be increased from 8^0C to 25^0C[12]. The output of heating obtained is 9MW and of cooling is 7.5MW.

5. UTILISATION

5.1 India

Cooling and heating of residential and small scale buildings along with the prefabricated huts. Bathing, cooking. Swimming, poultry farming. Balenology and green house cultivation.

5.2 World

Heating and cooling of residential , commercial and institutional buildings including hotels, schools, offices., CO_2 emission reductions by IEA in UK. Healthy Centre at IslesatScilly, space heating, Air conditioning of food stores , electricity generation, greenhouse and covered heating, raceway heating, agriculture crop drying, snow melting, aquaculture pond heating, desalination, frost protection, geothermal tourist parks.

6. RESULTS AND DISCUSSION

Geothermal energy has a great potential so as to facilitate the humans with a large number of benefits. The utilisation of geothermal energy directly and in the form of GSCS sysytem or GSHP system is increasing rapidly in India. In comparison to other parts or other countries of the world which are working on this technology for a long time , India is a newely arising country in this field. Till now, a lot of work has been done and a number of potential sites have been explored. A large number of sectors rae using this technique and are providing various benefits like the reduction in emission of green house gases and energy savings upto a large extent i.e. upto 67% of energy savings is done, but there is a great difference in the capacity of installed systems in India and mojor countries which are hub of this energy. The total capacity of installed systems in India is of 203MW with a capacity factor of 0.25, while the present installed capacity in the world is estimated to be 12,000MWt and annual energy used is about 72,000TJ. Total utilisation in India is 986MWt and 4302TJ/yr which is very small in comparison to the world. India is developing in this field day by day and many of plants have yet to be installed in future by the Indian Companies having collaboration with several famous companies of the world like Reykjavik, Iceland.

Table -1: Potential of geothermal energy.

Places	Surface Temperature of hot springs	Thermal Gradient Range
INDIA	47-98^{0}C	59-234^{0}C/km
WORLD	26-52^{0}C	30-60^{0}C/km

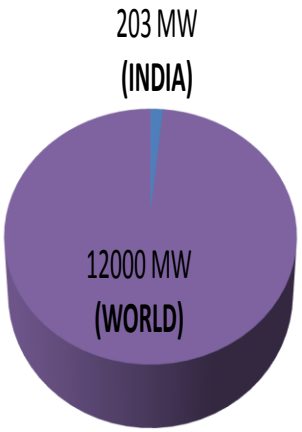

Fig-7: Total capacity of installed GSCS systems.

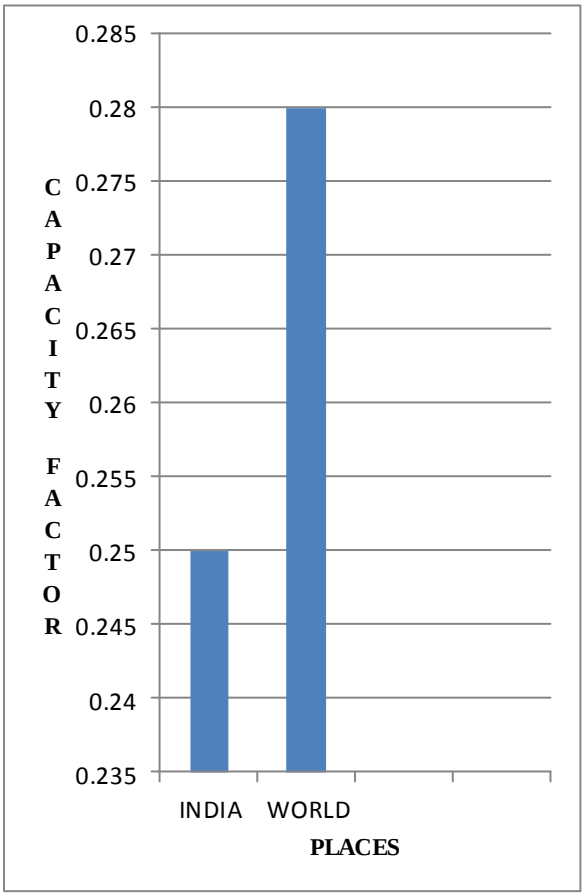

Fig-8: Capacity factor of installed systems.

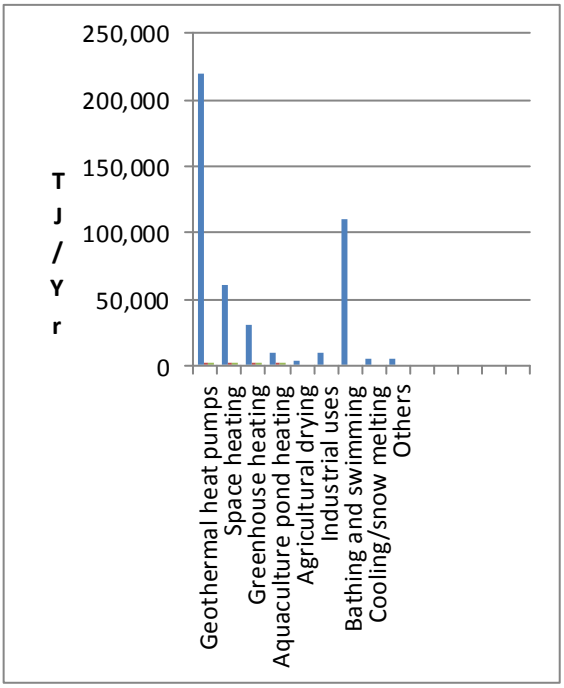

Fig-9: Fields utilizing geothermal energy directly in the world.

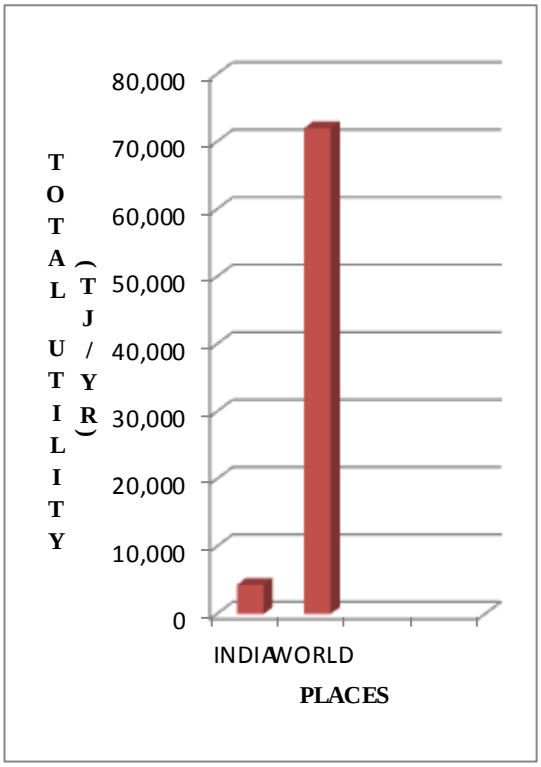

Fig-10: Total utilization TJ/yr

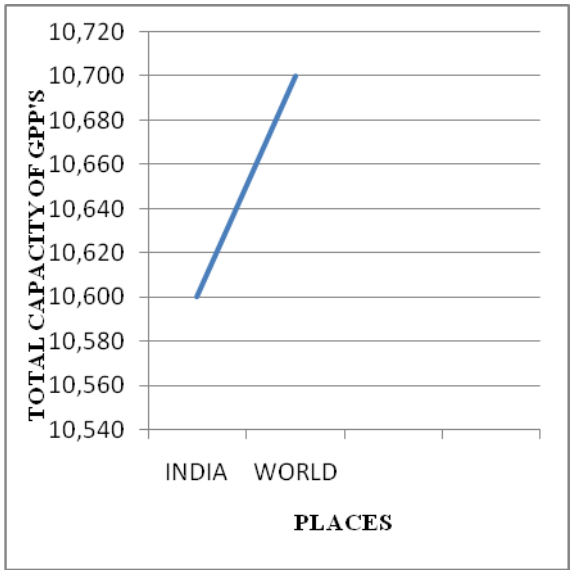

Fig-11: Geothermal power plants total capacity in (MW).

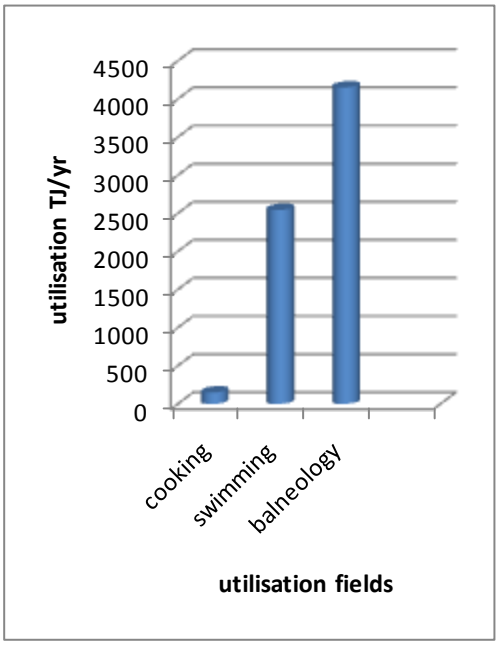

Fig-12: Direct utilization of geothermal energy in India.

7. CONCLUSION

Geothermal energy and GSCS systems are providing a lot of facilities and benefits to the whole world. These are installed in sufficient numbers in India and the world. This technology is in developing stage in India in comparison to the other parts of the world, but India is working efficiently on this technique and developing it day by day, so as to facilitate itself with its benefits. The plans have also been formed to explore this technology in future.

8. ACKNOWLEDGEMENT

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