

Strategic Planning for Developing Ecosystem for Large Scale Implementation of GSHP Systems in India

Abhishek CHOUDHARY and Dwijen VAIDYA

National Institute of Industrial Engineering, Mumbai, Maharashtra, India - 400087

Abhishek.choudhary.2020@nitie.ac.in; Dwijen.vaidya.2020@nitie.ac.in

Keywords: Low Enthalpy Geothermal Reservoir, Ground Source Heat Pump, Renewable Energy Application, Space Heating and Cooling

ABSTRACT

India has set an ambitious target of producing 175 GW of energy by the end of 2022 and reach the goal of 500 GW of energy production using renewable energy sources by turn of the decade. India is consciously aligning its energy strategies to the United Nations Sustainable Development Goals (UNSDGs) in order to meet the exponentially growing demand, innovations in sustainable and efficient sources of energy is need of the hour. Considering climatic and geological conditions, India possess tremendous scope for Ground Source Heat Pump (GSHP) based low enthalpy heating and cooling systems. India is also coming up with new policy on geothermal energy providing significant encouragement for GSHP installations. This paper intends to assess the impact and feasibility of large-scale implementation of GSHP ecosystem in India. The feasibility analysis is followed by strategic planning for capacity building, necessary skill development and streamlining of supply chains to meet the growing demand. This planning is carried out through technical and commercial feasibility analysis, demand forecasting and by consulting all the stakeholders including engineers, managers, policy makers and investors. This document can be used as a ready reference to guide inventors and entrepreneurs. The document also comments on significance of GSHP systems in the concept of net zero energy buildings.

INTRODUCTION

India continues to be one the fastest growing major economies of the world, the continuously growing GDP has helped transform the country. Competing close with China, and soon to overtake Germany in the tally, the ever-growing stability has provided India with a lee way to enhance the purchasing power and thus benefit with a better standard of living. Since 2016 more the 271 million people residing in the country have risen out of poverty. This shows a sharp decline in the number of people living in poverty in India, dropping from 55% in 2005-06 to 28% in 2016-17. With the growing quality of life and the improvement in the living standards of the people, Indians are looking forward to having the basic necessities available to a larger set of population. With a greater disposable income at hand, India has seen an enormous increase in the use of electricity. More than 12 million people are said to enter the workforce each year, and with this enters the need for greater divulsion of resources and energy consumption. The percentage of people having access to electricity grew from 70% to 96% in the last decade and with the government focusing more in similar reforms, the transformation is inevitable. According to a survey in 2014, India consumed 637.43 kg of oil equivalent energy use per capita, while the neighboring countries Pakistan and Nepal were using 484.45 kg and 412.72 kg respectively. Although the developed countries like America and Canada are leaps ahead with 7000 kg of oil equivalents, India is soon destined to play catchup. To make matters worse India ranks 81 in overall energy self-sufficiency at 66% in 2014.

ENERGY CONSUMPTION IN INDIA: AT A GLANCE

According to the 2019 data, India has become the world's third largest producer of electricity with an installed capacity of 368.79 Giga Watts (December 2019). The energy sector is still predominantly driven by the fossil fuel consumption, accounting for 79.8% of total production in the country. The GHG emissions from electricity generation for the year 2017 was 2194.74 MtCO₂. Although this figure appears to be behemoth, according to the available data United States' share in this, including both direct emissions and indirect emissions associated with electricity use by the industries was 29.7% of the total. While, India continues to be the third largest emitter of greenhouse gases after China and the USA. The graph below shows the different modes of power generation across different countries (2016).

On the other hand, developed economies like China are spearheading by generating over 36.6% of their power by renewable resources (2017-18). Currently, they have the world's largest installed capacity of hydro, solar and wind power. America being the second largest consumer of electricity is lagging behind China in renewable resource generation as China doubles the current United States' share of alternative forms of energy. The next big investment they are putting into is in the solar energy sector. Although there has been great development in the scanning and identification of geothermal reserves with over 2700 hot springs occurring at the surface, no breakthrough in terms of application is seen yet. While we see that the United States of America started their operations in geothermal power generation in 1960s in California. As of 2015, 28% of worldwide geothermal power capacity are installed in the United States.

As already discussed, with the ever-growing population, a demand for cheap energy is high, and a drop in fossil fuel addictive economy is to be achieved. There needs to be an upgrading of technologies to provide clean and more efficient energy. To provide electricity to the remaining 7% of the population the country needs to invest around 701.5 billion dollars by the end of the next decade. This comes as one of the greatest private sector opportunities in achieving and maintaining universal access to electricity under the seventh SDG. The thing

to note here is that in India, most of the states have power distribution losses of over 50%. This would require double the global rate of improvement in energy efficiency.

To achieve these targets, Government of India has formed the Ministry for New and Renewable Energy (MNRE). Although we see a strong focus of the emerging sustainable ways of electricity production, we could see a lack of vision for the geothermal energy. The estimated geothermal potential for the country is around 10,000 Mega Watts. In India, the research and exploration for the geothermal fields began in 1970 and the Geothermal Survey of India identified 350 locations in the country. The country is mainly constituted of seven major geothermal provinces namely, Himalayas, Sohana, West Coast, Cambay, Son-Narmada-Tapi (SONATA), Godavari and Mahanadi. The potential applications of these reserves vary from power generation, cooking, space heating, crop drying to even use in greenhouse cultivation.

MEETING THE UNITED NATIONS SUSTAINABILITY DEVELOPMENT GOALS

India also seems to have boarded the train for sustainability by setting an ambitious target of producing 175 GW and 500 GW of energy using renewable energy sources by 2022 and 2030 respectively. By the current interests and investments done in the sector by the government of India, the country aims to have 275 GW from renewable energy by the turn of the next decade. By the current distribution of preferable substitutes of electricity production, we can clearly see that India is putting its bet on the solar energy sector which constitutes approximately 60% of the given proposal. The 2022 electrical power targets include achieving 227GW (earlier 175 GW) of energy from renewable sources - nearly 113 GW through solar power, 66 GW from wind power, 10 GW from biomass power, 5GW from small hydro and 31GW from floating solar and offshore wind power. The bidding process for the further additional 115 GW or thereabouts to meet these targets of installed capacity from January 2018 levels will be completed by the end of 2019-2020.

India has shown a keen interest in achieving the United Nation's Sustainable Development Goals. These goals address the global challenges we are facing around the world, including those related to poverty, inequality, climate change, environmental degradation, peace and justice. India held a firm stance on this, as said by the Prime Minister Narendra Modi, "Just as our vision behind Agenda 2030 is lofty, our goals are comprehensive. It gives priority to the problems that have endured through the past decades. And, it reflects our evolving understanding of the social, economic and environmental linkages that define our lives. The sustainable development of one-sixth of humanity will be of great consequence to the world and our beautiful planet." the words are overwhelming and so are the related efforts.

In the Goal 7 of the United Nation's Sustainable Development Goals, it is said about providing affordable and clean energy of the country. To have energy access over a large scale, it becomes crucial to first work on enhancing energy efficiency and to invest further into renewable energy. Since the past decade, Asia has been the driver of progress in this area. 72% of the increase in energy consumption from modern renewable sources between 2010 and 2012 came from developing regions, including parts of Asia namely China and India. Energy from renewable resources – wind, water, solar, biomass and geothermal energy – is inexhaustible and clean and works furthermore in becoming carbon neutral. Although the solution to energy's climate crisis lies off-grid, renewable energy currently constitutes only 15% of the global energy mix.

If we are to look closely at the expected output from the different forms of energies for the upcoming decade to fulfill the mentioned requirements of the country, we see that there is huge focus in creating massive infrastructural projects to gain massive outputs, but we fail to consider the low hanging fruits which can be cultivated with some innovation. In order to meet the exponentially growing demand, innovations in sustainable and efficient sources of energy is need of the hour. Considering climatic and geological conditions, India possess tremendous scope for Ground Source Heat Pump (GSHP) based low enthalpy heating and cooling systems.

GROUND SOURCE HEAT PUMPS

Ground Source Heat Pumps (GSHP's) provide one such economic way to reduce the dependency on the grid. It uses the earth's relatively constant temperature between 16 - 24°C which lies at a depth of 20 feet below the earth's surface to provide heating, cooling, and hot water for homes and commercial buildings. The scalability and effectiveness of it provides a cheaper and low power consumptive source for cooling or maintaining ambient temperature in office buildings or even community halls. GSHP harvests heat absorbed at the Earth's surface from solar energy via the soil over the day. 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 as a heat source during the winters or a heat sink during the summers to cultivate an ambient temperature throughout. GSHP's is effective in all kind of climate zones or can be deployed anywhere in India on 24 x 7 bases. This Technology is being used worldwide from last 50 Years.

The National Building Code 2016 has included new and energy efficient options for the better functioning while keeping the climate change in mind. The options include air conditioning, heating and mechanical ventilation, such as variable refrigerant flow system, inverter technology, hybrid central plant using chilled beams, radiant floor components, and geo-thermal cooling and heating systems. Heating Ventilation and Air Conditioning (HVAC) is generally responsible for a significant proportion of total building energy consumption. A typical system accounts for approximately 40% of total building consumption and 70% of base building consumption. The typical energy consumption breakdown of an office building, being 39% HVAC, 25% lighting, 22% equipment, 4% lifts, 1% domestic hot water and 9% other. Stakeholders, like the users of HVAC applications are encouraged to use geothermal heating/cooling under respective building projects as energy efficiency measures as this results in substantive reduction in costly electricity bills. This age-old proven technology has a payback period of 4-5 years and may be implemented by the interested stakeholders in market mode.

The principal objective of Geothermal heating and cooling systems is to reduce the consumption of electrical energy in domestic or commercial buildings. On an average, 40% of electrical energy is saved compared to the conventional heating and/or cooling systems.

The capital expenditure of such systems is higher than the conventional systems. However, due to significant energy savings operational expenditure is considerably reduced. The payback period of Geothermal systems is of the order of 3 years. Apart from reduced power consumption these systems have several other benefits. In GSHP systems, both the heating and cooling loops are closed loops, hence there is no water wastage compared to conventional cooling or heating systems where water is evaporated in open loop systems. Additionally, no greenhouse gases are emitted in such systems. Due to lower electrical consumption, utilization of fossil fuels is considerably reduced.

CAPACITY BUILDING FOR GROUND SOURCE HEAT PUMP ECOSYSTEM

Before we start with the implementation of GSHP at a large scale, a few things need to be kept in mind. One of the key factors for energy consumption is the building design, orientation and location. These are the physical characteristics of a building that have a significant impact on building loads and particularly the balance between heating and cooling. A building with very limited north and west glazing will generally have lower than average cooling loads, while a building with a large unshaded west facade will have high cooling loads, particularly in the afternoons. Once this is taken care of, the planning stage of implementation begins.

The value chain needs to be broken into phases to gain a maximum utility. The preplanning phase should cover the demand forecasting of the geographies, including the factors such as the daily payload on the grid the building in consideration. This should be done to check the impact on the traditional resources of energy generation and how much does a GSHP actually helps in bringing it down. The major areas that could utilize from the implementation of GSHPs on a larger scale are the Tier I cities of India. It is observed that cities like Chennai, Mumbai, Kolkata and Delhi are with the highest electricity consumption for the cooling purposes. Being located on the tropic of Cancer, India faces diverse climatic conditions, and the mentioned states with the ever-growing population and humid makes the use of Air Conditioner a necessity. The other factors include the extent of urbanization. The downtowns, commercial office zones and urban residential areas have the least green cover and provide the most continuous need for cooling systems in India. Cities tend to be hotter than the rural areas as buildings housing the people, appliances and machinery – including equipment for cooling – generate heat when they use energy. Buildings and other hard physical structures can also absorb and store heat, slowly emitting some of that heat during the night and contributing to higher temperatures. Apart from this, the age demographic of the area is also an important factor. Older people are less heat tolerant than the young ones. Heatwaves can greatly increase mortality rates in the short term. Almost 15 000 more people than usual are estimated to have died during the August heatwave of 2003 in France, 80% of them over 75 years old.

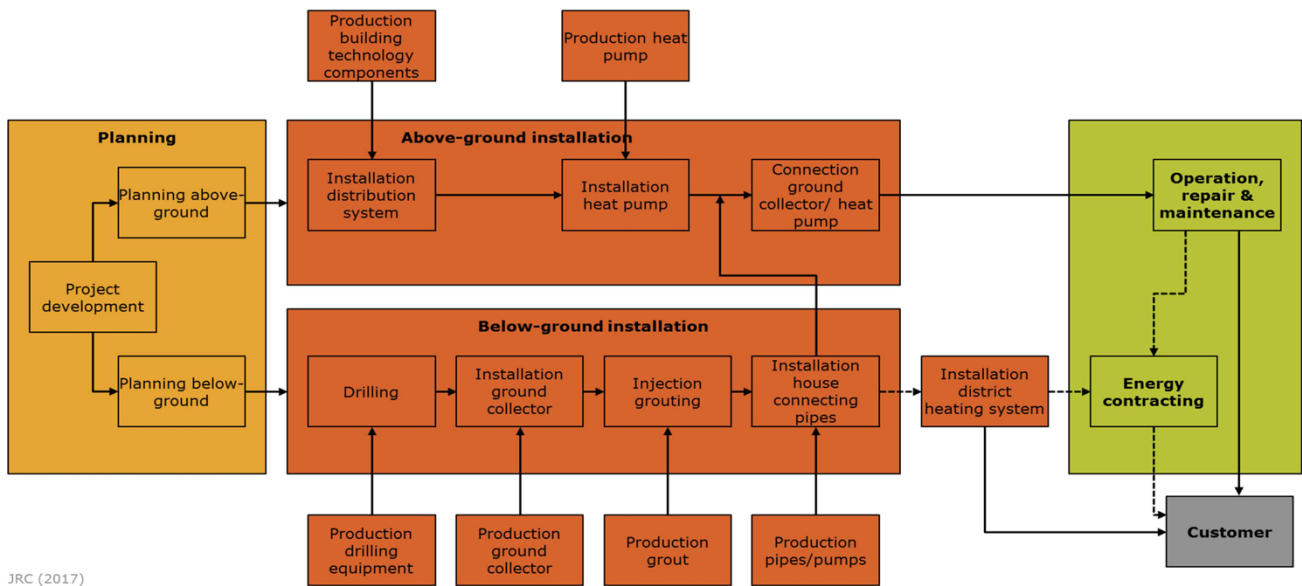


Figure 1: Flow Chart for Implementation of GSHP Systems on Large Scale

After gaining data about the required demand and supply ratio and zoning the places according to the factors mentioned above, we can start with the planning phase. The first parameter to be taken care of is the peak capacity of the building and the atmospheric conditions of the area. With proper forecasting with the existing data over the decade, we need to set an optimal temperature suited to the climate. The cooling capacity needs to be planned in advanced to meet the requirements upto the change of the decade. This project development phase is divided into major areas, the first one being the planning that is required below the ground, which is regarding the selection of the location to be earthed out and the installation of necessary equipments. While the other part talks about the the planning above the surface level.

Another factor that can be introduced is the use of solar power or any other renewable source of energy could be used to power the basic requirement of GSHP system to be it completely carbon neutral. The overall reduction of the electricity requirement by the households would reduce by approximately 35 to 40%. Not only this, it would also reduce the carbon emission as the heat coming from the ground has no such environmental impact. Combining this hybrid model with smart and energy efficient lighting systems in the buildings, we can easily achieve the target of net zero energy buildings.

One of the significant attributes needs to be focused is the use of data analytics tools. With the advent of different tools and technologies under the umbrella of Industry 4.0, energy consumption behavior of domestic, industrial and commercial establishments can be predicted in advance. This information can be used for accurate forecasting, which eventually be useful for manufacturing the components of GSHP systems.

A centralized data repository on national level is also an important aspect. The record of all the manufacturers, dealers, customers and investors in a centralized repository would ensure smooth coordination on national level, which is crucial for efficient implementation and to avoid delays, overbudgeting and wastages.

POLICY FRAMEWORK

India is also coming up with new policy on geothermal energy providing significant encouragement for GSHP installations. The geothermal policy envisages 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(thermal) and 20 MW(electrical) Geothermal Energy Capacity in the initial phase till 2022 and 10,000 MW(thermal) & 100 MW(electrical) by 2030. The demand of electricity requirement can be reduced by installing Ground Source Heat Pumps (GSHP'S) and retrofitting the existing HVAC systems with Geo-exchange-based system.

The Indian 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 are the key areas of interest. The adoption and proper enforcement of mandatory building energy codes and MEPS (Minimum Energy Performance Standards) for equipment and appliances must be at the heart of policies aimed specifically at energy use in buildings. Standards need to be expanded and strengthened as quickly as possible across all countries, drawing on extensive international experience and knowledge. Policies should account for capacity building, including appropriate training for skilled labor in the buildings sector to design, sell, install and operate more efficient cooling equipment.

SUMMARY

India's cooling/heating energy consumption is expected to grow by about double the current baseline in 2027 according to the Alliance for an Energy Efficient Economy. This target is difficult to achieve just by linearly upgrading on existing technologies even considering the advent of renewable energy sources. Along with expanding energy sources on the supply side, reducing consumption is equally important. This can be achieved partially by awareness and adopting sustainable practices. However, as the paper suggests, GSHP systems can significantly reduce the burden of energy consumption. The concept of GSHP is widely accepted across many countries. However, a tropical country like India, who is expected to double the energy consumption in the next decade needs immediate measures for large scale implementation of GSHPs across domestic, commercial and industrial establishments. In order to succeed in this mission a focused approach is necessary from policy makers, investors and other stakeholders. This paper provides a direction for the channelized approach. If India is able to succeed in this domain, along with replacing its entire fleet of commercial vehicles into electrical vehicles, will be a world leader in sustainable practices.

REFERENCES:

[HTTPS://IN.ONE.UN.ORG/PAGE/SUSTAINABLE-DEVELOPMENT-GOALS/SDG-7/](https://in.one.un.org/page/sustainable-development-goals/sdg-7/)

[HTTPS://MNRE.GOV.IN/GEO-THERMAL](https://mnre.gov.in/geo-thermal)

[HTTP://WWW.INDIAENERGYPORTAL.ORG/SUBTHEMES_LINK.PHP?TEXT=GEOTHERMAL&THEMEID=13](http://www.indiaenergyportal.org/subthemes_link.php?text=geothermal&themeid=13)

[HTTPS://WWW.YOUTUBE.COM/WATCH?V=TBOPF8w-554&t=58s](https://www.youtube.com/watch?v=TBOPF8w-554&t=58s)

[HTTPS://WWW.GOOGLE.COM/PUBLICDATA/EXPLORE?DS=D5BNCPPJOF8F9_&MET_Y=EG_USE_PCAP_KG_OE&IDIM=COUNTRY:IND:PAK:NPL&HL=EN&DL=EN](https://www.google.com/publicdata/explore?ds=D5BNCPPJOF8F9_&met_y=eg_use_pcap_kg_oe&idim=country:IND:PAK:NPL&hl=en&dl=en)