

Report on the social and environmental impact of geothermal energy

[Sociology](#), [Population](#)



Introduction

Geothermal energy refers to natural heat stored underground beneath the earth's crust. On the ground surface the energy is evident in form of hot and altered ground, hot springs and fumaroles. The energy is tapped by sinking geothermal wells underground. The high temperature and pressure fluid is extracted and through carefully built wells and designed network of pipes and channels the hot steam to the plant turbine to generate electricity. The steam and water are extracted at very high pressure and temperature. The application of geothermal energy has gained popularity globally because of its environmental friendliness. There are various technologies available and applied right from the exploration, development and exploitation of the resource. However, social and environmental considerations and impacts are vital in making geothermal the preferred form of energy [CITATION MDu04 | 2057].

Geothermal Energy Technology and Development

There are various technologies available and applied right from the exploration stage to the development and exploitation of the geothermal energy. The installation and utilisation of geothermal power applies three major methods and technologies: dry steam, flash steam and binary cycle system. The type of technology used depends on underground pressure and temperature of the geothermal reservoir. The process involves drilling of wells to tap the hot fluid from underground. There are two common drilling methods in use; directional drilling and perpendicular drilling. The pipes are then build and or installed down to the source (reservoir) of the fluid (gas

and liquid states)[CITATION Wor98 I 2057].

The immense pressure underground naturally pushes the liquid up to surface in which the two phase- liquid and gas are separated using a steam separator. The pure steam then is directed to the turbine to generate electricity. The phenomenon of re-injection where the steam and water are either naturally or artificially replenished to the underground reservoir ensures that the resource is virtually undeletable. Naturally a geological conduit or loop is formed and ensures continuous supply of steam and hot water[CITATION Wor94 I 2057]. Artificially water from the surface is re-injected down through an injection well, it passes through hot rocks then rises to the surface via a recovery well and the steam is directed to the turbine to generate electricity.

The energy flow is such that potential energy in the wells is transformed into kinetic energy. It turns the turbines as mechanical energy and through electromagnetic induction method electrical energy is produced. The geothermal wells occur at different depths ranging from hundreds of metres to as far as eight kilometres underground. The geothermal installations are exceedingly effective, operating consistently at 95-98% availability. They are not prone to fluctuation in season or daily weather changes like the hydropower, wind and solar[CITATION Msj09 I 2057].

The socioeconomic consequences of geothermal energy and mitigation strategies

The energy source often occurs in land owned by indigenous communities thus has both negative and positive social consequences. The exploration, development and exploitation of geothermal in a certain area depend on the

agreement between the developer and the community in which the resource is based. The community and the developer agree on specific measures that will guarantee safety, sustainability, social cohesion and social benefit to the locals[CITATION CBS02 | 2057]. However the local communities are always ignored thus they stand on the losing end when such projects are set up. In most cases they may end up losing land and becoming displaced leading to socioeconomic disturbance. Another effect of geothermal energy related to the community has to do with the health impact of the project. This mainly results from inhalation of injurious gases such hydrogen sulphide (H₂S) from the wells.

Geothermal resources normally occur in the rural, isolated and sometimes very scenic environments that have other socioeconomic importance that should be considered[CITATION PFA04 | 2057]. In other words the conflict between the exploitation of geothermal energy and other economic functions is an important consideration. A classical example is wildlife and tourism sector which may be affected by geothermal installations; for instance interference with breeding areas and migration routes, animal accidents, effluent disposal, loss of habitat, harassment of animals, odour and noise[CITATION Wor89 | 2057]. The construction of the geothermal plant infrastructure (piping network, roads and buildings) modernises an otherwise natural eco-system. There is also an aspect of Aesthetic and visual impacts in which establishment of geothermal plants may cause visual intrusion, an interference if not planned carefully.

Mitigation of the socioeconomic effects of geothermal energy

In order to reap the maximum benefits of geothermal energy all stakeholders must formulate and implement certain measures to reduce the adverse socioeconomic effects of the geothermal projects. The government ought to put in place the necessary policy framework to protect the interest of the public or the community where the project is being undertaken. The framework should balance the interests of the community and the needs for energy development by ensuring that the community is adequately compensated for any socioeconomic disturbances. The framework should provide opportunity for negotiations between the local community and the resource developer. The developer should be legally bound to make clear social and communal benefits which the society will accrue. At the very onset of the project developers should be legally bound to carry out an impact assessment on all aspects.

The developers should also be legally bound to protect and guarantee the health and safety of the community and the workers with regard to the plant. Local baseline surveys of health and disease incidences at every stage of the project, even before the project, should be conducted. Often developers establish a health centre to take care of physical accidents and other ailments of the staff on the site. The developer may also come up with an insurance cover for the workers and other associated parties. A clear relationship should be established between Water requirements of the local community and whether this will be affected by the development of the project. The relationship between surface water masses and deep underground water masses should be studied and established in order to

avoid contamination of surface water[CITATION SGo00 | 2057].

Measures must also be taken to ensure that the development of geothermal energy is not in conflict with other socioeconomic activity. Agricultural activities should not be adversely affected by geothermal. This can be achieved by constructing the pipes and all other installation in a manner that protects agricultural fields. It is also worth mentioning that the Agricultural sector may benefit from steam specifically used in horticultural farming. The geothermal wells and plants can be designed to suit natural environments through creation of conformity and game proof fencing. The plant developers should take measures to establish and protect wildlife breeding grounds and migratory routes. The infrastructure can be painted with wildlife colours, the piping network can be re-designed to avoid causing wildlife accidents like tapping the steam and installing the plants outside the parks and tourist sceneries, fencing around wells and along the steam lines[CITATION AJe10 | 2057]. The visual absorption capacity (VAC) of a region should be carefully and clearly understood from the planning stage. The project can be established in a region with a high VAC due the topographical nature. This requires the use of neutral equipment, non-reflective colour that blends with the environment and mostly surrounding rocks, use of trees that have less visual effect. The cost of mitigating these effects must be considered from the initial stages of a geothermal project.

Certain socioeconomic benefits may be derived from the development of the geothermal energy. Geothermal projects, like any development project, stimulate creation of additional economic activities, direct and indirect employment opportunities. The project creates jobs during drilling,

exploration, buying of plant equipments and operations. Through economic multiplier effect the wages earned are used to generate additional income and create employment in the wider economy. A general rule is the tapping and maximisation of local labour. Other local communities' benefits include access to electricity, improved access to essential services, income and transport services. As part of corporate social responsibility geothermal developers often build schools and health centres for the community. Geothermal energy boosts the national economy in relation to energy by reducing energy gaps and triggering economic activities thus reducing poverty[CITATION Cow05 | 2057].

Environmental considerations in geothermal development

The environmental monitoring parameters are quantitative units employed and laid down in order to indicate any minimal changes and adjustment in surrounding conditions. The indicators are continuously monitored during exploration, drilling, construction and operation of a geothermal plant. These parameters include; water and gas chemistry measurements, land subsidence measurements, extent of soil erosion considerations, air pollution and precipitation chemistry quantification, noise level measurements, ecosystem (plants and animals both aquatic and terrestrial), soil and vegetation elements concentration, water elements concentration, Geo-hazard monitoring, Seismic monitoring, and Ground water chemistry levels. Geothermal energy is highly rated in terms of air emission as compared to other sources. Its effect on air cannot be underestimated at community level. Therefore monitoring of gaseous emissions should be conducted periodically.

During drilling fumes mainly emanate from diesel generators and dust from moving vehicles. During well testing, hot steam vents out and nearby plants and air quality are affected due release of H₂S. Hydrogen sulphide (H₂S) is a major significant geothermal gas, occurs in the range of 0.03 to 6.4 g/kWh from power plants. It has awful pungent rotten-egg like smell. When the project is operational, H₂S is constantly monitored by quantifying the fraction of non-condensable gas (NCG) in the steam and by sending gas to the main geochemistry laboratory for analysis. Typically gas analysis is conducted frequently in the early years of the project and frequency is reduced in the later years as the reservoir is stable. Classically, NCG decline over time. Table 1 below summarises the effects of H₂S on humans and wildlife. The air pollution modelling is tool used to asses concentration levels of gases during operation the plant. It helps to monitor ground concentrations of gas to mitigate health and nuisance effects.

Another environmental consideration in utilization of geothermal energy is noise pollution. The noise pollution in geothermal occurs at different stages of the project. The steam releases noise during well testing at high pressure, the noise is comparable to a large jet engine. The overall impact is dependent the number of wells under testing. Construction is another source of noise, mainly from graders, trucks, bulldozers and cranes for the period of construction. Noise during the operation of the plant is from the gas ejectors, powerhouse and cooling towers. To mitigate noise levels silencers are installed and earmuffs are provided to workers. The notices showing places with high levels of noise are indicated.

The main waste from a geothermal plant is brine solution. The disposal of waste water is via deep constructed trenches and a natural drainage. Waste water can also be disposed by deep re-injection. Brine is considered toxic by any standards. However, depending on geothermal reservoir chemistry brine may pose certain risks. For example brine can pollute water when it occurs with certain metals like Lithium, lead, Zinc, Mercury, Boron and Arsenic. The viscous fluid consisting of grease, oil, cement, cuttings, additives and drill mud may also pollute surface water but they are often re-injected back during drilling. Proper well casing, cementing and deep reinjection is one-stop answer to prevent geothermal waste water from mixing with shallow water table. Separators and proper drains are used to curb other waste water.

Land Subsidence may occur due continued withdrawal exceeding the natural recharge of the reservoir during exploitation. Net outflow may cause rock collapsing particularly in areas with clay sediments. The drop in reservoir pressure during fluid withdrawal, the presence of highly compressible geological rock formation above reservoir and occurrence of high permeability path between formation and reservoir and between ground surface and reservoir are the major causes of subsidence. Another common environment consequence of geothermal energy is the occurrence of high levels of metals in soil and vegetation, due to surface disposal of waste water from the wells[CITATION SGo00 I 2057].

Advantages of geothermal over other energy sources

There are various advantages of geothermal energy in comparison to other conventional source of energies. Geothermal energy can be comfortably established along other land use activities and it requires little space to establish a geothermal plant. The installations can be built in farmlands and typical share land with local wildlife. Geothermal energy is a renewable source on the basis of measured recharge and extraction rate. The recharge rate of the reservoir should be higher than the extraction rate. Using re-injection technology the recharge rate has been increased to more than double making geothermal reservoir more sustainable. The sustainability is further qualified by reservoir flow monitoring [CITATION KAP00 I 2057].

Geothermal plants do not produce operational wastes. In fact some geothermal fluids contain by-products that mostly have valuable minerals that can be recycled and recovered for industrial use. For example silica solid are used in cosmetic production and salts can be crystallized, for industrial use, like in the blue lagoon in Iceland. Harmful dissolved minerals are usually re-injected back to the reservoir. The isolated and condensed hot water from the turbine is routinely re-injected to the ground minimising the release of hot water and steam to the surrounding.

The development of geothermal does not result in emission of green house gases which is in agreement with the Kyoto protocol on climate change and the recent Copenhagen agreement on greenhouse gas emissions. However generation geothermal energy is associated with limited amounts of SO₂, CO₂, and no amount of nitrogen oxides in comparison to fossil fuels. This amounts of the said gases are however not as a result of the energy

production but exist naturally and are thus within the safe and acceptable limits. According to a survey by International Geothermal Association (IGA) the gases will finally vent into the atmosphere, naturally, though at very low rates. The composition of CO₂ measured in geothermal area globally is between 4g/kWh and 740g/kWh on weighted average of 122g/kWh. While a mean of CO₂ content in the Non Condensable Gases is at 90.4%. Despite the presence of this high level of CO₂ the type of geothermal technology applied limits the amount of Non Condensable Gases (NCG) released to the air. The binary plant system emits no gases since it is totally looped and uses the heat exchanger, this means no gases finds its way out of the loop. However where the binary system is not applied vapour containing these gases is emitted by dry steam and flashed steam technology. The re-injection technology is applied to minimise emissions into the atmosphere. In addition CO₂ containing geothermal fluids at low temperature can be used as a growth booster in horticulture. Research has shown that CO₂ in the normal range of 300ppm to 1000ppm can boost growth by 15% [CITATION AJe10 | 2057]. Therefore based on emission of green house gases (GHG) geothermal Energy is one of the cleanest forms of energy and is on the Clean Development Mechanism (CDM) of the Kyoto protocol. The CDM requires that developed countries (countries emitting a lot of GHG) to pay for their Green House Gas (GHG) emission to countries that engage in emission reduction projects. Through use of geothermal energy the overall goal of reducing GEG emissions globally is achieved with minimal investment. Table 2 below gives comparison CO₂ emissions by geothermal plant and fossil fuels plants.

There is minimal ground and surface water pollution as compared to other fossil fuels that always release waste heat into the water masses. The technology of harnessing and utilizing geothermal energy has been carefully developed to minimize ground water pollution. Geothermal plants have cooling towers that release excess heat to the atmosphere while cooling water used in fossil fuel plants is directly release into water bodies. The extraction and recharge wells are lined with steel and cemented to separate geothermal fluids from contact with environmental and ground water resources. Sonic logging measurement is continuously done on cement and on casing to ensure no leakage takes place[CITATION Vanpp I 2057]. The low cost of operating cost, the minimal environmental impacts, the renewable and the inexhaustible nature of geothermal energy source thus make it sustainable.

Conclusion

Geothermal energy is tapped by sinking geothermal wells to the underground. The high temperature and pressure fluid is extracted through carefully build wells and network of pipes that channels the hot steam to the plant turbine to generate electricity. The generation and utilization of geothermal energy has several socioeconomic and environmental implications. However there are certain mitigation strategies for the said negative impacts. Geothermal energy is considered to be a superior form of energy due to certain socioeconomic and environmental benefits/advantages. In summary geothermal energy is cheaper to produce, environmentally friendly, renewable, virtually inexhaustible and sustainable.

Geothermal energy is one of the Clean Development Mechanism (CDM) project according to the Kyoto protocol[CITATION MsJ09 I 2057].

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