ENVIRONMENTAL IMPACT ASSESSMENT REPORT OF GEOTHERMAL ENERGY DEVELOPMENT

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Keywords: EIA, geothermal, environment

SUMMARY - Geothermal energy is often considered as one of green, renewable and alternative energy resources to fossil fuels for the supply of clean energy for the future. Geothermal energy is accepted as being an environmentally benign energy source, particularly when compared to fossil fuel energy sources. Geothermal fields contain heated fluids trapped beneath the earth, but the geological, physical and chemical characteristics of the geothermal resource can vary significantly at different sites. When these fluids are utilized for geothermal energy production, the environment of an area can be affected particularly air, water, land use and the aesthetic qualities of the landscape. A range of socioeconomic impacts are also important. These environmental factors can be addressed at different stages in the development of geothermal energy resources through environmental impact assessment (EIA) report in advance of development and through the implementation of an environmental management system (EMS) during the operation of geothermal energy utilization. All approaches to optimizing environmental impacts, management system, monitoring program and mitigation plans depends on the quality and the contents of EIA reports.

1 INTRODUCTION

Geothermal energy is energy derived from heat from the Earth's interior. This heat can be held in hot water or steam or in the rocks themselves and represents a potentially vast energy resource, estimated to be more than 300 times the energy held in fossil fuels (Armstead & Tester, 1987). In view of the greatly reduced emissions of CO_2 that are associated with geothermal energy when compared with the use of fossil fuels, geothermal energy is often described as a clean energy but there are still environmental impacts to consider in relation to its utilization.

The environmental assessment process has been defined differently everywhere. In fact, it appears that no two countries have defined it in the exactly same way. General blanket statements are often made that the developing countries are all behind the industrial countries in terms of environmental issues. It is interesting to note that the Philippines has required EIAs for certain projects since 1977. The Federal Republic of Germany started to do so nearly a decade later. In addition to the different approaches to the process, the wide variety of formats and methods for EIAs are available. This paper presents the states of geothermal energy development in the world and reviews the environmental impact assessment of geothermal energy through the contents of EIA reports.

2 GEOTHERMAL ENERGY UTILIZATION

As mentioned above, geothermal utilization is commonly divided into two categories, i.e. electricity production and direct application. Conventional electric power production is commonly limited to fluid temperatures above 180°C, but considerably lower temperatures can

be used with the application of binary fluids (outlet temperatures as low as 70°C). The ideal inlet temperatures into buildings for space heating is about 80°C (Fridleifsson et al. 2008), but by application of larger radiators in houses, or the application of heat pumps or auxiliary boilers, thermal water with temperatures only a few degrees above the ambient temperature can be used beneficially. There are quantified records of geothermal utilization in 72 countries. Electricity is produced from geothermal energy in 24 countries. The top fifteen countries producing geothermal electricity and using geothermal energy directly in the world in 2005 (in GWh/yr) are listed in Table 1.

Table 1: Top fifteen countries utilizing geothermal energy (GWh/yr) (Bertani, 2005).

electricity production		direct use	
USA	17,917	China	12,605
Philippines	9,253	Sweden	10,000
Mexico	6,282	USA	8,678
Indonesia	6,085	Turkey	6,900
Italy	5,340	Iceland	6,806
Japan	3,467	Japan	2,862
New Zealand	2,774	Hungary	2,206
Iceland	1,483	Italy	2,098
Costa Rica	1,145	New Zealand	1,968
Kenya	1,088	Brazil	1,840
El Salvador	967	Georgia	1,752
Nicaragua	271	Russia	1,707
Guatemala	212	France	1,443
Turkey	105	Denmark	1,222
France	102	Switzerland	1,175

Geothermal energy generally makes a small contribution to the energy needs of the major developed countries but makes a significant contribution in a number of developing countries, including the Philippines, Mexico, Indonesia, El Salvador and Kenya (Yousefi et al. 2007).

3 EIA OF GEOTHERMAL PROJECTS

Environmental Impact Assessment (EIA) is a relatively new planning and decision-making tool first established in the United States in the National Environmental Policy Act of 1969. It assists decision-makers in considering the proposed project's environmental costs and benefits. When the benefits sufficiently exceed the costs, the project can be viewed as environmentally justified.

An EIA will address the impacts of the exploration, construction and operational phases of the proposed projects. Indeed, the impacts associated with these different phases of the project might be significantly different. An EIA should include, short-, medium- and long-term impacts, local and global impacts, direct, indirect, secondary, cumulative, permanent and temporary, positive and negative effects of the project. Clearly, for a major geothermal energy development, the impacts are likely to be many, with local and global implications for the physical/chemical/biological and human environments (Yousefi et al. 2007).

3.1 EIA of geothermal utilization in Japan

Japanese government introduced the idea of EIA in 1972, when the cabinet approved guidelines under the title of "On the Environmental Conservation Measures Relating to Public Works".

There are about 200 Quaternary volcanoes in Japan including 83 active ones – 4% and 10% of those in the world, respectively; in the narrow territory of only 0.27% of the land area of the world. Therefore, Japan is blessed with extensive geothermal resources including hot springs. Moreover, hot water carried up from sedimentary basins is also abundant. There are many possible sources for both electricity production and direct use. Japan is sixth in the world for geothermal energy utilization.

There are several steps involved in geothermal energy development including exploration, feasibility studies construction of the power plant and operation. A law on EIA could make reference to land management, well drilling, water management, construction work, safety, and environment. Power plant construction, except in case of small ones, is subjected to a review in accordance with the Electric Power Development Pro-motion Law, and appropriate geothermal organizations, together with an assessment of environmental impact. The plans are inserted into the National Basic Electric Power Source Plan.

For constructing a geothermal power plant with a capacity in excess of 10 MWe, the plant owner has to carry out the whole procedure. The plant owner needs to present data based on the guidelines for geothermal power plant construction published in 1992, and submit a report which includes results of measurements, a prediction of its likely influence, and a mitigation plan, to the Ministry of International Trade and Industry (MITI). For operation of geothermal power plants, plant operators need not only the regulations regarding the Electric Utility Law, but also the regulations related to such environmental laws as the Air Pollution Control Act, the Water Pollution Prevention Act, the Effluvium Prevention Act, the Noise Control Act, and the Vibration Control Act.

3.2 Global environmental impacts of geothermal developments

With increasing concern about climate change associated with increasing atmospheric CO_2 concentrations that are due, at least in part, to the burning of fossil fuels, geothermal energy, along with other renewable energy resources, is considered to offer global benefits through the provision of clean energy with low associated CO_2 emissions. These global benefits are shown in Figure 1 and 2 base on the data for 2005 of the US, in which life cycle emissions of carbon dioxide (CO_2) and sulphur dioxide (SO_2) associated with a range of conventional fossil-fuelled electricity generation, are compared with emissions from geothermal electricity generation.

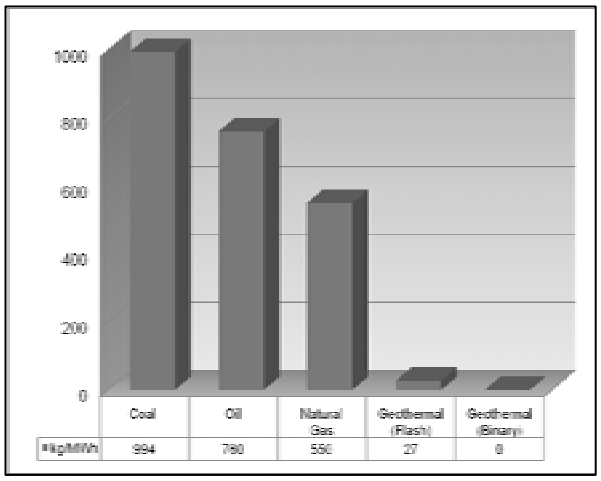

Figure 1: CO_2

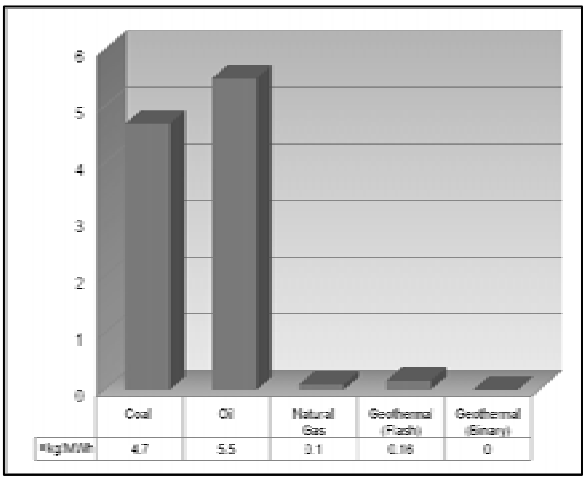

Figure 2: SO_2

It is clear from these comparisons that geothermal energy offers significant reductions in emissions of CO_2, the main greenhouse gas, and SO_2 which are toxic gas and major contributors to acid rain.

3.3 Local environmental impacts of geothermal developments

Despite the emissions reductions that can be achieved by utilizing geothermal as opposed to conventional (fossil) energy sources, the local environmental impacts can sometimes be significant, especially with regard to air and water pollution.

3.2.1 Air pollution

Although emissions of CO_2, SO_2 and NO_X are lower for geothermal energy than for conventional fossil fuels, there are still important gaseous emissions associated with geothermal energy utilization. These gaseous pollutants include traces of ammonia, hydrogen, nitrogen, methane, radon and the volatile species of boron, arsenic and mercury, though generally in very low concentrations and can affect only the local environment. The important gas of these group is the emission of hydrogen sulphide (H_2S), which can represent an odor nuisance at low concentrations but it is toxic at concentrations above 0.001% v/v (Heath, 2002).

3.2.2 Water pollution

Both local surface waters and ground waters can be affected by geothermal energy developments. The most important potential impacts on the water environment are associated with the management and disposal of wastewaters, notably geothermal brines, which are commonly disposed of by reinjection into wells where they can contaminate groundwaters or by storage in holding ponds from which they can leak into surface waters.

Contamination of shallow groundwater reservoirs can also be caused by drilling fluids and as a result of well casing failure, which might also affect groundwater levels. In addition to water quality impacts, the abstraction of geothermal waters can impact on groundwater levels. The most important consequence of this is ground instability and subsidence, but lowering the water table can also affect local water supplies (Heath, 2002).

The pollution impacts on the water environment can be mitigated through effluent treatment, the careful storage of waste water and its reinjection into deep wells and through careful monitoring of the condition of holding ponds and well casing (Yousefi et al. 2007).

4 GEOTHERMAL ENVIRONMENTAL IMPACTS ASSESSMENT REPORT

According to the environmental impact assessment Law and related regulations, the need for an EIA is determined by the scale of the planned project. However, assessment is required for a small to medium project as well, if the project is expected to have great impact on the environment. In case of geothermal projects, although the range of adverse impacts is low but most scientists consensus that the EIA report and monitoring is needed for the sustainable development.

Generally, studies of physical, chemical, biological and socioeconomic impacts are carried out for an EIA. These parameters are differently defined in different countries. For these parameters, some countries use different EIA evaluation criteria. Also, monitoring is important

for checking the results of an EIA. An environmental impact assessment report for geothermal utilization should contain the information presented in Figure 3.

5 CONCLUSIONS

Although there certainly are environmental impacts associated with geothermal energy developments, they are generally more benign than those associated with other energy generation technologies, particularly fossil and nuclear.

Generally the environmental impacts of geothermal power generation and direct use are minor, controllable, or negligible. There must be full compliance with environmental regulations, which may vary from country to country. In any case the effects must be monitored and documented (often over long periods), rated and, if necessary, reduced.
Geothermal energy offers considerable advantages over conventional fossil fuelled electricity generation through greatly reduced CO_2 emissions with global implications with regard to climate change along with lower SO_2 and NO_X emissions with implications for local air quality and the generation of acid rain (Heath, 2002). Despite the global environmental benefits that can be claimed for geothermal energy, there may be important local impacts on the atmosphere, notably through the emission of H_2S and other minor gaseous pollutants, and on surface and groundwater, mainly through the disposal of contaminated waste water.

The impacts of geothermal energy utilization can be managed and minimized through their careful consideration as an environmental impact assessment (EIA) prior to site development and through the implementation of an environmental management system (EMS) during the operation of the scheme. Socioeconomic impacts are also important and can be optimized through the involvement of local communities in the development of geothermal resources (Heath, 2002).

Figure 3: the contents of geothermal EIA report

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