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Environmental Impact Assessment of Geothermal Projects in Iceland

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ABSTRACT

There are some fundamental differences between energy projects in Iceland which have consequences for the efficiency and function of the EIA process. Most of the hydropower projects are well defined projects, i.e., the design, size and magnitude of the project is known when assessing the impact of the project. The characteristics of geothermal utilization can be very different. The utilization of geothermal energy is dynamic in nature, where the information is being gathered and processed continuously during the time of utilization. The paper discusses how the EIA Act and EIA process in Iceland function for geothermal projects and if it should be more flexible for such dynamic projects. The paper reviews geothermal projects, describing the main benefits and problems relating to the EIA process as well as the process of applying for consents and permits under various acts. The paper discusses possible solutions to the problems accounted for example using tools of planning, allowing more flexibility in the EIA, implementing more consultation among interest parties and agencies, and using area approach instead of structural approach.

1. INTRODUCTION

Since the year 1993, the legislation and the process concerning environmental impact assessment (EIA) in Iceland, have been evolving. During this period, much emphasis has been on projects like hydropower plants and roads. The last few years more emphasis on geothermal development has cast a new light on the EIA process its purpose. Some points have proven positive and some have raised questions about whether the current process suits projects with dynamic nature like in the geothermal exploration and development. The purpose of this paper is to give some insight into the Icelandic EIA process and how it has been employed in the geothermal field.

2. THE BACKGROUND OF ENVIRONMENTAL IMPACT ASSESSMENT (EIA) IN ICELAND

In the year 1993 the Icelandic government legalized the EU Directive number 85/337/EBE with the Environmental Impact Assessment Act no. 63/1993 (EIAA). In the year 2000 a new EU directive (Directive 97/11/EB) came into effect and changes in the Icelandic EIAA followed. In the year 2005 the EIAA was changed once again but this time exclusively on the initiative of the Icelandic government.

2.1 The Environmental Impact Assessment Act and the EIA Process

2.1.1 Geothermal Projects Subject to Assessment

Geothermal power stations and other thermal power installations with a heat output of 50 MW or more and other power producing units with an output of 10 MW_e or more are always subject to an EIA.

In the year 2000 a more fundamental screening process was implied as part of the EIAA. Projects which may have substantial impacts on the environment are assessed on a case-by-case basis, regarding the nature, size and location to determine whether they shall be subject to an environmental impact assessment. For geothermal projects that fit into that category are deep drilling, in particular drilling of production wells and exploration wells in high-temperature geothermal regions.

In addition projects which are subject to an environmental impact assessment and are planned in the same area or are contingent upon one another may be assessed jointly, e.g. geothermal power station subject to assessment and the adjacent power lines.

2.1.2 Scoping Document

If a project is subject to an impact assessment the developer shall submit a scoping document. A scoping document contains a description of the project, the project site and alternatives which could be considered. The scoping document also proposes which aspects of the project and of the environment will be illustrated and what data will be gathered.

2.1.3 Initial Environmental Impact Statement (IEIS)

Following a scoping document the developer publishes a report on the project's environmental impact assessment. This report, the initial environmental impact statement, has to be consistent with the scoping document.

In the IEIS the project's possible environmental impacts, cumulative and synergic, direct and indirect are discussed.

2.1.4 Environmental Impact Statement (EIS)

An Environmental impact statement is the final report of the environmental impact assessment for a project. The statement is based on the IEIS and the consultation, opinions and comments from governmental agencies, municipalities and the public.

2.1.5 Review

All the previous steps are subject to review by the public, public agencies and authorities. Within four weeks of receiving the environmental impact statement, the National Planning Agency (NPA) shall deliver a reasoned opinion on whether the report meets the criteria of the EIAA and whether the environmental impact is satisfactorily described. The NPA's opinion shall explain the main premises of the assessment, including the quality of the data on which the assessment is based and its conclusions.

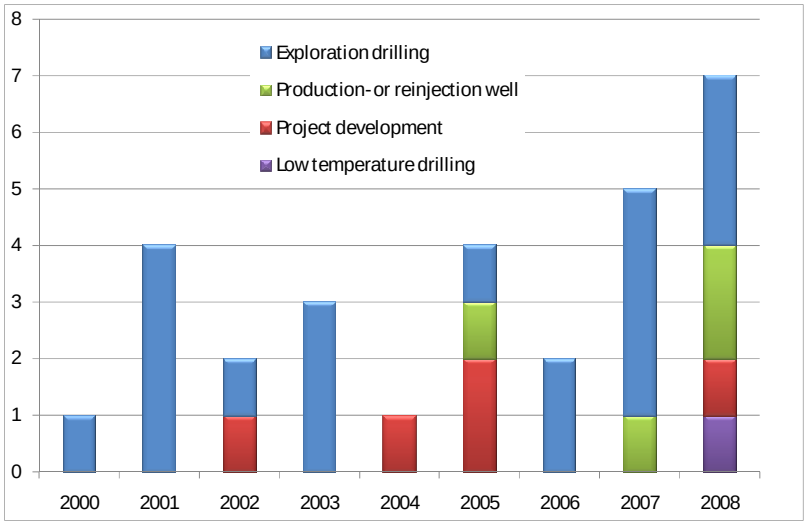

Figure 1: Number of geothermal development projects in Iceland assessed case-by-case whether they were subject to EIA 2000-2008.

2.2 Geothermal projects in Iceland and EIA

For the period 2000 to 2008, 29 geothermal development projects were assessed case-by-case whether they were subject to an EIA (**Error! Reference source not found.**). Six of these projects were subject to an EIA of which five were exploration drillings and one was due to changes in current project development. The projects are all situated in high temperature areas, on the southwest coast, Reykjanesskagi and Hellisheiði, and on the northeast coast, Krafla and Þeistareykir. One project of these 29 was situated in low temperature area.From the year 1994 to 2008, 14 geothermal projects were subject to an EIA and most of them during the last eight years. The first Icelandic EIA undertaken for a geothermal project dealt with exploration drilling. Some of the EIA cases are for one and the same geothermal development project, due to enlargement of an existing power plant or additional drilling of production wells or reinjection wells. Since the year 2000 geothermal projects are 13% of the total EIA cases in Iceland.

3. THE APPLICATION PROCESS FOR GEOTHERMAL PROJECTS IN ICELAND

For geothermal projects it is necessary to apply for various permits. The number of permits varies with the nature of the project, e.g. whether permits are applied for a power plant of some kind or for drilling production or exploration wells. Table 1 displays an overview of the application process for geothermal projects in Iceland, which permits are applied for and what legal body issues these permits. The process also includes changes in land use plans in the given area. The developer is responsible for applying for these permits.

4. THE NATURE OF GEOTHERMAL PROJECTS

Geothermal projects are different from most other projects that have to comply with the EIA act. Whereas for example hydropower plants can in a way been looked at as a static projects the geothermal projects are of a dynamic nature. This is due to:

- Difficulties in long term and even short term projection of the reservoir behavior
- Reinjection schemes, depending on a number of variables not known in the beginning of the exploration phase
- The exact location of facilities not exactly known and to a great extent depending on drilling results
- Number of drilling pads needed depending on the nature and evolution of the reservoir
- What impact earthquakes can have on the reservoir data not known
- Possible modifications of the steam/brine system and the power plant needed in case of steam cap development and/or effects of earth quakes
- Possible changes with time of the chemistry of the geothermal fluid

The information gathered in the exploration phase can have a significant effect on the size, location and the overall design of the project. Hence, the geothermal projects are dynamic not static as many other EIA projects such as hydropower projects, roads and aluminum smelters. Due to this, some have questioned whether the EIA process in Iceland takes into consideration this fundamental difference of the geothermal projects.

The time of preparation, exploration, research and engineering design of geothermal power plants is longer than for most other EIA projects. This is mainly due to the nature of the geothermal resource. Today it is common in Iceland that it takes 10 to 13 years to develop a geothermal green field project.

Due to the nature of the geothermal resource, the outcome of the different surveys undertaken at a very early stage of the project and which is the basic data for the EIA is just indicative for the real, short and long term impact the project imposes on the environment. The cost of the preparation and research is known to be considerable.

Geothermal developments need rather extensive exploration area as well as rather large area for production wells, reinjection wells and associated facilities. Today the tendency is to minimize the impact area as much as

possible. This has in some cases led to very unfavorable and difficult operation of the geothermal field.

Table 1: Permits and Processes for Geothermal Projects in Iceland.

	Permit/process	Institutions	When to apply
RESOURCE	Research permission	The National Energy Authority	Optional
	Utilization permission	The Ministry of industry, energy and tourism / The National Energy Authority	Optional
	Harnessing permit	The Ministry of industry, energy and tourism	When findings on the size of the project are out in the open and decisions have been made about building the project
LAND USE	Change in land use plan	Local authority	In the preliminary phase of the project
	Detail land-use plan	Local authority	When execution of the project is out in the open
EIA	Project subject to assessment	The National Planning Agency	When decision on project is on hand
	Scoping document	The National Planning Agency	
	Environmental impact statement	The National Planning Agency	
DEVELOPMENT	Development consent	Local authority	Granted when planning is ready and EIA is completed.
	Building permit	Local authority	When building- blueprints have been approved
	Operating license	Local health committee	Apply months before operating of the project begins
	Project in areas protected as natural phenomena	The Environment agency	If project disrupts protected natural phenomena

Geothermal projects are preferably developed in steps. The overall experience gained from the operation of a preceding step is the basis for the design of the succeeding step. In this way the evolvement with time of the geothermal reservoir and the technology is coped with. A succeeding step to one or several steps in operation can for example be increased steam production with associated increased reinjection for power generation or other industrial usage which in turn calls for more wells to be drilled and more facilities to be built. The very nature of geothermal projects is therefore dynamic in the sense that they are continuously evolving during the entire life span of the resource harnessed. In many cases these steps are also subject to an EIA.

5. ENVIRONMENTAL IMPACT OF GEOTHERMAL PROJECTS

Environmental impact resulting from geothermal development varies during the different phases of development and between sites. Kristmannsdóttir and Ármannsson (2003) have listed the main environmental issues involved in geothermal development:

- Surface disturbances
- Physical effects of fluid withdrawal
- Noise
- Thermal effects
- Chemical pollution
- Biological effects
- Protection of natural features

Geothermal exploration usually occurs in pristine areas characterized by volcanic activity, geothermal surface activity and geological formations. Ecosystems, both flora and fauna, are adapted to warm soils. Development includes roads, well pads and drilling of geothermal wells and groundwater and/or sea water wells. There is also deposition of waste soil and drill fluid including drill cuttings and mud. During flow testing of wells, steam and spray has shown to have temporarily adverse effect on the local vegetation with moss and grass being scalded. Noise follows flow testing of wells and can have negative effect on wildlife, tourists and local people.

If results from exploration are positive, development may continue. This can include more roads, well pads, pipelines, power plant, associated buildings and transmission lines.

Geothermal power generation usually causes air pollution due to the emission geothermal gas from brine flashing, particularly carbon dioxide (CO_2) and hydrogen sulfide (H_2S), carbon dioxide adding to the greenhouse gas effect and hydrogen sulfide being poisonous in high concentration.

Gas concentration in emission varies to a great extent from one geothermal site to another. During operation, subsidence and induced seismicity are possible effects as is change in geothermal surface activity. Discharge of hot water and/or geothermal fluid from geothermal power generation can cause problems whereas the fluid can contain high concentration of various chemicals which may cause threat to living organs.

6. EXPERIENCE OF THE EIA FOR GEOTHERMAL PROJECTS IN ICELAND

A few key issues should be noted from the brief history of EIA for geothermal projects in Iceland. This concerns the nature of geothermal projects, consultation in the EIA process, information and data concerning the key environmental factors affected by geothermal development and different vested interests in the geothermal development sites.

6.1 Consultation

6.1.1 Consultation Bodies

The EIA process for geothermal projects involves consultation with public agencies, local and governmental authorities, Non Governmental Organizations (NGO's) and other stakeholders. By consulting with bodies involved in the EIA process at the early stages of each project, different views emerge which can be discussed and resolved before the project is fully developed.

In geothermal projects the Environment Agency, the National Energy Authority, local authorities, local Health Inspectorates, NGO's and the Icelandic travel industry are considered as necessary consultation bodies. The National Planning Agency however plays a key role in the overall EIA process and should be consulted on regular basis.

6.1.2 Consultation during Scoping

Scoping document should be prepared in close consultation with the above mentioned parties. This is to ensure that all available data is included and that necessary research is planned for. Not doing so can cause delay and increase the cost of the project whereas research is time consuming and, in some instances, can only take place at a specific point in time of the year. This applies especially to ecological research. During preparation of scoping document meetings should be held where maps are presented and preliminary information regarding the project development is introduced, including energy output and input, effluent treatment, construction plans and available information on the development area.

Experience reveals that consultation does not need to be formal. Meetings can be informal but minutes of meetings are essential. These meetings can open up potential moments for deliberation. Matters discussed at consultation meetings should be addressed in the environmental impact statement.

6.1.3 Consultation for Environmental Impact Statement

After reviewing research and exploration results and other gathered data for a geothermal site, meetings with consultation bodies should be arranged as often as considered necessary. This allows for deliberation concerning development of the overall project and probable effects on the environment. This working procedure usually raises questions at a point in time in the development process when it is still possible to make adjustments and plan for mitigation measures.

Developers and consultation parties do not always agree on what to emphasize on in the EIA but it is very important to address all those points at an early stage. The purpose of the EIA process is not halting the development of a project but to help public officials and the developer to make informed decisions that are based on an understanding of environmental consequences and take proper action before necessary permits are granted.

6.1.4 Consultation and Participation

The main objective of public participation in the EIA process is that different views emerge and that all stakeholders are involved in the decision-making. This does not necessarily lead to decisions that are beneficial for the environment but can help reaching reconciliation.

Public participation in the EIA process is developing in Iceland as well as elsewhere (Isaksson, 2009). A detailed framework does not exist on how this is best accomplished. Two geothermal EIA cases in Iceland show great disparity in public participation and interest.

The first case is the development of a new 135 MW_e geothermal power plant in Hellisheidi area in year 2007. The proposed development is located in a scenic area with much geothermal activity on the surface. Gas emissions may cause negative impact on air quality and debate is on whether the harnessing can be considered sustainable. The EIA process sparked a lively discussion about the project. During the development of the environmental impact statement (EIS), a total of 675 individuals commented on the content of the document or the process of which 564 were unanimous. In addition a number of news articles were published.

In contrast during the EIA process for an 80-100 MW_e enlargement of an existing geothermal power plant in Reykjanes in year 2009 no comment was given by the general public on the proposed project. This development was also intended in a scenic area with much geothermal surface activity, popular as tourist destination.

The reviewing process for both cases revealed a number of remarks from public agencies, local and governmental authorities including serious comments from the National Energy Authority.

The reason for this huge difference in public involvement is not clear but something sparked the interest in one case but not the other. It remains unclear whether many comments from the public deliver better grounds for making decisions concerning individual projects. Additionally, it can be questioned whether the EIA process is the right venue for such extensive paperwork. On the other hand, some have argued that the Icelandic public is prevented from influencing decisions regarding big projects which may affect the quality of their lives.

This experience gives reason and basis for development of a framework for public participation in the Icelandic EIA process. Its purpose should be a smooth development pathway, not to halt but to streamline a project. This framework could also take into consideration the different nature of projects.

The yes or no answer to a geothermal development question should be answered in a master plan, on national or regional basis and through strategic environmental assessment process (SEA). Land use policy should not be the challenge for the developers of individual projects.

6.2 Information

The issuing of geothermal research exploration permits and utilization permits must be based on reliable and detailed information about the projected impact the proposed project may have on the environment (Goff, 2000).

6.2.1 Geothermal Data and Sustainability

The management of geothermal energy as a natural resource is a vital issue in the EIA process. The assessment of sustainable use is a difficult task and controversy is among scientists, government agencies and developers how this is best accomplished. The conventional approach for the operation of a geothermal power plant is to increase steam production in steps while monitoring the effects on the reservoir. Developers' point of view may be that in order to find out the long term capacity, fluid dynamics and thermodynamics of the reservoir it is necessary to tap the reservoir to such an extent and for a long enough period of time in order to get reliable response of reservoir variables for adjusting the reservoir model. Whereas this exercise is based on actual field trials for a long period of time with, in a way unforeseen results and uncertainty, it raises the question how to define a sustainable harnessing of the reservoir. Government officials, issuing permits, need to base their decisions on data at a very early stage of the project. They are responsible for the criteria for sustainable resource management. Presented with data, that shows pressure decline in the geothermal reservoir and pressure rise in the upper part of the system i.e. development of a steam cap, have created debate between parties on how and if to harness the geothermal reservoir.

In the EIA process for geothermal projects, this debate has become a larger part of the EIA deliberation. The knowledge and expertise of the nature and utilization of geothermal fields is limited to few professionals but the EIA process is intended to give the public the opportunity to follow this discussion. Everyone can reveal their opinion on this issue during the EIA process but only few scientists have the grounds to build their opinion on. Therefore, the scientific data, presented in the EIA and the debate between the geothermal specialists, may cause difficulty for public officials to understand and to make an informed decision. This makes the point that for the purpose of public participation in the EIA process, data must be presented in a clear and simple way. But this may be difficult due to the dynamic and unpredictable nature of the geothermal reservoir, as noted in chapter 3.

Therefore, the dialogue on whether the proposed resource harnessing can be considered sustainable, can only reach a certain point in the EIA process. The decision on whether a utilization permit or a harnessing permit is granted is not based on the EIA process but is the result of the communication of the developer and the Ministry of industry, energy and tourism / National Energy Authority (table 1). A development permit however is based on the EIA and the land use planning.

6.2.2 Geological Formations

Geological formations have been a key environmental factor in the Icelandic EIA's for geothermal projects. This is due to the fact that geothermal activity is commonly associated with volcanic activity, which is the source or origin of geological formations. Many of these formations are protected by the Nature Conservation Act, as landscapes and ecosystems. This applies to volcanic craters, pseudo craters and lava fields, as well as surface geothermal deposits (sinter and travertine), 100 m^2 or more in area.

Most geothermal developments influence to a certain degree the countenance of the landscape, i.e. the broad appearance of the landscape changes due to the alien facilities installed. Roads, production well heads, surface pipelines and buildings are examples of these aliens in nature.

Thanks to a technical development, the directional drilled wells have increased the flexibility in site selection for drilling. During the EIA process, this enables discussions between developers and geoscientists about the optimum locations and optimum numbers of well pads with associated service roads in order to minimize the environmental impact of the project.

Harnessing geothermal reservoirs causing pressure decline can change geothermal activity on the surface, causing geysers and hot springs to disappear or be transformed into fumaroles (Kristmannsdóttir and Ármannsson, 2003). This man made impact can be hard to distinguish from natural changes and can also happen in the course of seismicity. In the EIA it has been classified as indirect effect and is subject to great uncertainty.

This indirect impact due to tapping geothermal fluid out of the reservoir has called for development of mitigation measures like reinjection of geothermal fluid, establishing controlled and balanced harnessing of on the one hand the fluid dominated reservoir and on the other hand the steam cap once it is developed and proper monitoring of surface activity.

6.2.3 Geothermal Ecosystems

Ecosystems in geothermal areas are different from the surrounding ecosystems. These ecosystems can be considered unique in terms of biological diversity. They contain rare species of plants and moss, the microbial life in hot springs is very diverse and this also applies to the invertebrate species. Warm creek, originating from a hot spring, is different habitat than a cold creek close by. Consequently it also has different species composition.

Geothermal development usually does not cause direct disturbance in these ecosystems. Directional drilling has also allowed for the protection of both fragile ecosystems as for rare geological formations. Nevertheless, the indirect effect on hot springs that may be caused by the geothermal harnessing, may lead to changes in these ecosystems.

In recent EIA processes much attention has been given to this derivative impact on geothermal ecosystems. It can be argued that due to great uncertainty in predicting the effect of geothermal operations on hot springs this should not be given much weight in the EIA. On the other hand, these ecosystems are very susceptible and can be considered very important as components in Earths' biodiversity.

It is also worth mentioning that the thermo files can be a valuable resource for the bio industry like the blue green algae, cultivated at the Blue Lagoon.

6.2.4 Tourism and Recreation

As mentioned above, geothermal exploration usually takes place in pristine areas characterized by volcanic activity. Many of these sites are categorized as of natural interest according to the Act of Nature Conservation and are popular as tourist destinations. Areas with good prospects for geothermal development are commonly popular as tourist destinations (Noorollahi and Yousefi, 2003). This has to some extent placed the tourist industry and the energy industry on opposite sides. The tourist industry claiming,

geothermal development, including noise, surface disturbances and pipelines, will cause negative impact in popular tourist destinations. The geothermal developers on the other hand claiming the effect above ground occupying relatively confined area will be minor and that the tourist industry can´t claim any land use rights in these areas. The developers argue that gained experience proofs that visitor centers with educating exhibitions of the power plants and professionally guided tours attract every year thousands of visitors and therefore the geothermal installations can support the tourist industry.

Through consultation and problem solving some of these disputes can be resolved in the EIA process. This has been done through mitigation measures like minimizing visibility of buildings and pipelines, placing well pads far away from hiking trails, drilling many holes from each well pad and improving tourist facilities and hiking trails.

Opinion poll conducted in the Reykjanes area in Iceland has revealed positive view among tourists and recreational people towards geothermal power plants (Guðmundsson, 2008). When asked about steam released from a geothermal power plant the response was also positive. On the other hand, when asked about well sites and pipelines, the view was rather negative.

Kristmannsdóttir and Ármannsson (2003) also point out that there are not only negative effects of geothermal utilization to tourism. One of the most striking examples is the Blue Lagoon in Svartsengi high-temperature field, where a geothermal effluent pond is now one of Iceland's most renowned tourist landmarks. Dumping water in this way would probably not be allowed today. Experience also shows that geothermal power plants attract tourists, scientists and students.

6.2.5 Uncertainty

As noted above there is certain degree of uncertainty regarding the imposed impact caused by harnessing of the geothermal reservoir on geothermal ecosystems and geothermal activity on the surface? The dynamic nature of the resource makes it even harder to identify human induces effects.

During the EIA process the ecosystems and the geothermal surface activity are usually identified and in the EIS it is stated that there may be some risk of negative impact caused by the project. In the recent projects, the developer is made fully accountable for this possible, indirect impact. This is partly based on the Precautionary Principle, which states that if an action or policy might cause severe or irreversible harm to the environment, in the absence of a scientific consensus that harm would not ensue, the burden of proof falls on those who would advocate taking the action. Instead of reaching consensus of lowering this risk by using mitigating measures like reinjection, this uncertainty has been used as grounds to halt further development. A study is being prepared to analyze and discuss how to apply uncertainty in the geothermal EIA cases.

7. CONCLUSION

The EIA process in Iceland is in continuous progress. Due to the dynamic nature of the geothermal resource, developers cannot at an early stage of development give decisive information on the scope of a given project, exact location of facilities and geothermal fluid extraction rate. Therefore one has endeavored to develop the projects in steps. This is not common for other EIA projects, and has caused some debate how to handle in the Icelandic EIA.

This also applies to the uncertainty of the environmental impact of geothermal development since all geothermal areas are dynamic in nature, causing natural fluctuations in surface activity and geothermal habitats.

The Icelandic EIA process needs to be further developed regarding geothermal development. Exploration zones must be defined in national and/or master plans so that adequate profile of the resource can be projected. Utilization zones also have to be defined adequately in master plans. This can include certain environmental conditions with regard to development, but must allow for some room for the developer to respond to information gathered from the reservoir.

The EIA process should evaluate the learning and experience gained from exploration and harnessing which can be of great value for research and development units, schools, educative tourism and the geothermal industry worldwide.

It must be looked into whether the grade scale used to assess the impact should be adapted further to fit for geothermal projects. A clear procedure must be set up how the grades are weighed together and how the weighted grade shall be used to arrive at the final decision in the EIS.

The EIA has created some vital benefits such as broad consultation and created new guidelines for the development of geothermal projects. It is important for all actors in the EIA process to learn from the experience gained from preceding steps and to improve the EIA process in general for geothermal projects, especially how to discuss and assess the uncertainty that is involved with all such projects and the complicated and diverse scientific data that the EIA decision is based on.

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