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ENVIRONMENTAL BASELINE STUDIES FOR GEOTHERMAL DEVELOPMENTS

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ABSTRACT

Environmental Baseline Study (EBS) is vital in predicting and evaluating potential environmental impacts of geothermal developments prior to any development. An EBS helps to understand existing environmental conditions thus defining the focus of the environmental impact analysis and resources that need protection through appropriate and viable mitigation measures. A number of national and international environmental policies and multilateral lending agencies regulations require description of existing environment that might be affected by potential development. The study process entails a scoping exercise by multi-disciplinary group of experienced specialists for the key environmental issues. Based on the valued ecosystem components, the study scope should cover, but not limited to issues such as climatic conditions, drainage and water resources, soils, flora, fauna, air quality, noise, land use, land tenure and socioeconomic aspects. Baseline environmental information is assembled through collection and analysis of existing data; carrying out specific field studies and community consultation programmes. Impacts arising from geothermal development could be physical, chemical, biological and socio-economic impacts. With such potential impacts, impact prediction process becomes relevant in both EBS and Environmental Impact Assessment Studies. Techniques used in impact prediction include: Checklists, Matrices, Networks and Flowcharts, Mathematical/Statistical Models, Maps and Geographical Information System (GIS) and Environmental Risk Assessment (ERA). With impacted predicted, mitigation measures should be in place to help avoid and minimize the potential impacts. Baseline monitoring is also required to provide effective feedback for specific environmental aspects. After the study the final EBS document need to be comprehensive, precise and accurate with uncertainties clearly stated.

1. INTRODUCTION

In order to predict and evaluate environmental impacts of geothermal development, it is critical to understand the baseline environmental conditions prior to development. This is achieved by carrying out Environmental Baseline Studies (EBS) during geothermal exploration. Understanding the existing environment serves to define the focus of the environmental impact analysis and resources that need protection through mitigation. Early collection of baseline data can help to guide the definition of the proposed geothermal project, including location of facilities. Significant impacts and development costs can be avoided if the location and nature of the sensitive resources are identified early in the geothermal development process. Best environmental management practices have also revealed that avoiding impacts through careful siting and project design is more desirable and cost effective than mitigating adverse environment impacts.

1.1 Environmental policies and regulatory requirements for EBS

A review of country and institutional environmental policies and regulatory frameworks indicate that all national regulations and multilateral financial institutions guidelines require an understanding of the existing environment that might be affected directly or indirectly by a proposed energy project (Hietter, 1995). The regulations and guidelines require that a description of the environmental baseline conditions should be included in the environmental impact assessment report to expedite project approvals for licensing and funding.

The following are examples of policies and regulations specific to geothermal developments:

- In USA, both the National Environmental Policy Act (NEPA, 1969) environmental review regulations and the Geothermal Resources Orders (GRO) No. 5, require baseline data collection for one year to describe existing conditions and to predict, monitor and evaluate environmental impacts of implementation of a proposed geothermal project.
- In Kenya, the Environmental Management and Coordination Act (EMCA) of 1999 and Environmental Impact Assessment and Audit Regulations require inclusion of a description of the environmental baseline conditions in an environmental impact study report.
- The World Bank OP 4.01- Guideline on Environmental Assessment: requires environmental baseline information as part of the Environmental Assessment report for energy projects, geothermal included, proposed for funding by the World Bank.

1.2 Definitions

The "environment" is broadly defined to include the natural, cultural, social and economic systems and their interrelations.

The term "baseline" refers to conditions existing before development against which subsequent changes can be referenced.

"Environmental Baseline Studies" generally include an entire range of pre-project studies and are carried out to:

- Identify key environmental factors, which may influence project design decisions (site lay-out, etc);
- Identify sensitive issues or areas requiring mitigation or compensation;
- Provide input data to impact prediction models; and
- Provide baseline data against which the results of future monitoring programs can be compared.

1.3 Objective

The main objective of EBS is to outline the existing environmental conditions to understand changes that may occur as a result of proposed geothermal development.

2. THE ENVIRONMENTAL BASELINE STUDY PROCESS

2.1 Scoping

The early EBS process starts with a scoping exercise for the key environmental issues. A multi-disciplinary group of experienced specialists (Meteorologist/Air Pollution Specialist, Geologist/Soil Engineer, Chemist/Water Pollution Specialist, Forester/Ecologist, and Social Scientist/Geographer) define a) the key environmental factors b) baselines for the key factors, and c) project alternatives, including "no project" option. Inputs from consultations with other public stakeholders and statutory institutions e.g. The Ministry of Energy, National Environmental Management Authority (NEMA) in Kenya, are also incorporated in the final scoping document. Based on the valued ecosystem components, the EBS scope should cover, but not limited to the following:

- **Climatic conditions** – Information on local meteorological conditions is important in future for assessing the dispersion of gaseous emissions from sources associated with the geothermal development. This entails review of data on wind, temperature, humidity, rainfall and evaporation.
- **Drainage and water resources –** This entails description of major water bodies (lakes), rivers, springs and swamps. These can be further categorized into surface (lakes, rivers, dams, water pans, swamps) and groundwater sources (boreholes).
- **Soils-** Data collection on sol physical properties which is very useful in explaining the prevalence of erosion and the principles of its control. The chemical properties of the soil are vital in determining the potential impacts on soil fertility associated with geothermal development.
- **Flora** – Description of existing vegetation of the area. This involves use of ecological checklists that will show the distribution of plant species over the proposed geothermal prospect area. It also involves characterization of vegetation and description of the major vegetation types, composition and associations.
- **Faunal studies** - This entail description of the fauna in the area. Acquisition of quantitative data and information with an aim of identifying unique and important habitats together with the spatial and temporal patterns of habitat use by the animals.
- **Air quality issues** – involves identification of matters, which are important in assessing the air quality impacts arising from the proposed geothermal development. Assessing the existing air quality by determination of ambient concentration of the main geothermal gas (hydrogen sulphide) from surface manifestations such as fumaroles.
- **Noise quality –** the potential for a noise to annoy depends on the loudness of the noise relative to the existing noise levels. Thus to undertake an impact assessment it is necessary to determine the existing noise environment in the absence of noise emissions from the proposed geothermal developments. Data on background noise levels are important from the point of view of noise impact assessment because it is the difference between the background noise and the proposed geothermal development related noise that most closely correlates with the perceived annoyance of noise.
- **Land use and Tenure systems –** It is the use of a stretch of land and involves interaction between the land and its user, which encompasses the relationship between biophysical features (geology, topography, soil, climate, flora and fauna) and socio-economic issues (land tenure, culture, community organization, income etc). Thus land use in any give area is always dynamic in any given time. Land tenure is the type of ownership i.e. freehold (individuals with title deeds), leasehold (for a given period of time usually 99 years) and communal ownership (community ownership).
- **Socio economic aspects** – administrative boundaries, demography (population estimate and projections), economic structure and labour, commercial sector, agriculture, tourism, community infrastructure (education and training, health services, housing, recreational facilities, security), transport, perceptions of local over the project, aesthetic/historical, cultural

and archaeological sites, energy sources, natural resources (economic minerals) and utilities (power, communication, water supply and quality etc).

A comprehensive work plan is then drawn outlining details of the key environmental aspects to be considered, methods to be used for baseline data collection, the various stakeholders to be consulted, estimated human and financial resources required and time allocation for the various components of the EBS.

2.2 Methods of baseline data collection

Baseline environmental information is assembled using 3 methods during energy development (Ontario Energy Consortium, 1992), geothermal exploration included:

- Collection and analysis of existing data;
- Carrying out specific field studies to acquire supplementary data to help in prediction of impacts of the proposed geothermal project and its alternatives, and to identify potential trade-offs in an Environmental Impact Assessment studies; and
- Community consultation programmes.

2.2.1 Review of existing data and sources

Before embarking on an extensive and costly field studies, maximum effort should be directed at determining the numerical and spatial data that already exist and can be used in describing the baseline environmental conditions in the proposed geothermal project area.

Existing data sources include:

- Government databases and routine monitoring programs – review scope and extent of these programs and re-focus studies to include areas and parameters relevant to EBS.
- Historical environmental studies in the area – review all available scientific and technical literature including unpublished information from academic and NGO groups active in the area of study for use in the EBS.
- Experience gained from similar geothermal projects – useful in focusing baseline studies on key issues of concern.
- Aerial photographs and satellite images – useful in determining the historical land use changes, which have occurred in the area and prediction of additional cumulative impacts of the proposed geothermal project development on various features of the landscape.
- Traditional knowledge – local communities possess profound and refined knowledge of the spatial and temporal distribution of wildlife and their ecological relations often lacking in scientific literature. This is useful in understanding social-cultural impacts of geothermal developments, which affect the subsistence economy and continuous relationship of the indigenous people to land.

2.2.2 Field studies

Field studies are required to fill in data gaps realized from review of the existing information or to provide more focused information for the EBS.

Field sampling programs for baseline studies is designed with an aim of providing sufficient information to assist in impact predictions and developing a reference base to guide and test future geothermal project monitoring programs. The level of detail and scope are tailored to meet the needs of the proposed geothermal project.

2.2.3 Community consultation programmes

The community consultation programs are aimed at creating awareness and ensuring early involvement and active participation of the local communities living in the precincts of the proposed geothermal project area and other stakeholders, which may be directly affected on implementation of the proposed geothermal project.

The consultations between community leaders and representatives of the geothermal project proponent should be confined to key issues of concern. The local people including administration, elders, women and the youth, should be consulted and given a chance to articulate their concerns, fears and offer environmental solutions for consideration in geothermal project planning, design, and implementation. An appropriate feedback mechanism on issues raised should be established and maintained to avoid suspicions and ensure smooth implementation of the proposed project.

Utilizing services of a Community Liaison person has proved successful during implementation of KenGen Hydroelectric projects and is recommended for geothermal developments.

2.3 Impact prediction

2.3.1 Impacts types

The potential impacts of geothermal developments fall in broad categories that include: physical, chemical, biological, and social economic impacts. The physical impacts may vary from soil erosion due to civil works, noise emissions, visual quality impairment, etc. The Chemical impacts may arise from the chemical discharges from waste brine (B, As, Hg), and Non condensable Gases (H_2S, CO_2, CH_4). The biological impacts may include loss of sensitive habitats and interference with animal migration routes. The socio-economic issues may range from provision of employment opportunities and constraints on available social amenities.

Impact prediction is therefore fundamental to EBS as well as Environmental Impact Assessments (EIAs) and should consider *direct or primary impacts* as a result of the geothermal project implementation, *indirect or secondary impacts*, which are knock-on effects in the same project location or other adjacent areas, *cumulative impacts* that accrue over time and space from many developments, and possible *impact interactions* between different impacts of a proposed project. In general, impacts may be *positive (beneficial) or negative (adverse)*, short-term or long-term, reversible or irreversible, permanent or temporary.

To be able to make logical impact predictions, a good understanding of the nature of the proposed geothermal project, similar projects including effectiveness of impact mitigation measures, and other projects that may cause interactive or cumulative impacts, is required. For example, the experience gained in Olkaria I geothermal field has been used widely as a model case while carrying out EBS, EIAs, monitoring and evaluation of impacts of geothermal developments in other fields located in the Greater Olkaria Geothermal Area, and prospects outside Olkaria.

2.3.2 Methods of impact prediction and significance evaluation

Impact prediction is not an exact science irrespective of the method used. The uncertainties should therefore be clearly stated in the final EBS document. Direct impacts are often easy to predict unlike indirect or cumulative impacts.

Several standard techniques to aid in impact predictions are available and include: *Checklists, Matrices, Networks and Flowcharts, Mathematical/Statistical Models, Maps and Geographical Information System (GIS) and Environmental Risk Assessment (ERA). Checklists and Matrices* are commonly used for most of the EBS conducted during geothermal exploration.

Statistical weightings of *impact magnitude, sensitivity and recoverability of relevant receptor* are used to quantitatively derive *impact significance*.

2.4 Mitigation and baseline monitoring

The mitigation measures are to avoid, minimize, remedy or compensate for the predicted impacts.

Examples:

- Alternative production techniques e.g. binary technology based on organic ranking process in place of conventional geothermal steam condensing systems, and site locations away from sensitive ecosystems (wetlands, habitats), etc.;
- Changes in construction time and methods e.g. avoiding night operations to minimize disturbances due to traffic and noise emissions;
- Changes in project design (few drill pads with 5-7 wells, wastewater re-injection systems, dispersion of NCGs through Cooling Towers), site boundaries, landscaping with local vegetation to maintain integrity of the existing ecological system, etc.;
- Off-site disposal of construction and operational waste (waste oil) to minimize both construction and operational impacts;
- Compensation for irreversible or permanent losses e.g., land, sensitive habitats; and
- Enhancement of positive impacts.

Baseline monitoring is necessary for effective feedback for specific environmental aspects e.g. faunal population and floral distribution. The monitoring program often lasts for many years to be able to establish the natural dynamic variations and not only "snapshots" of the environmental conditions at a particular moment in time.

2.5 Presentation of EBS Report and findings

The EBS report should be comprehensive, precise and accurate with uncertainties clearly stated. Impact predictions are critical and should include both potential negative and positive impacts of proposed geothermal development. Emphasis needs to be given to positive environmental impacts and ways of enhancement. Use of graphics in presentations is recommended.

REFERENCES

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