Overseas Private Investment Corporation
Environmental Guidance
Renewable Energy – Geothermal Projects

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These guidelines were developed with the technical support of:

Knight Piésold and Co.

1999 Broadway, Suite 600
Denver, Colorado 80202 USA
Telephone:(303) 629-8788
Facsimile:(303) 629-8789
E-mail: denver@knightpiesold.com

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Section 1.0 - Introduction

1.1 Project Definition

These guidelines apply to projects that involve the development of energy by harnessing power from high subsurface temperatures in regions of increased volcanism. Geothermal energy is a very reliable, predictable, easy to regulate renewable energy source, if proper controls are implemented. There are three geothermal power plant technologies being used to convert hydrothermal fluids to electricity. These are dry steam, flash, and binary cycle. The type of technology used depends on the state of the fluid (steam or water) and the temperature of the fluid.

Type of Plant	Subsurface Temperature [°C]	Unit Size – Installed Capacity [MWe]	Average Power Rating of Unit [MWe]
Single-flash steam	200°-260°	3-90	28
Double-flash steam	240°-320°	5-110	30
Dry steam	180°-300°+	15-120	39
Binary cycle plants	85°-200°	1-10	1.8

Sources:
1. E. Barbier, (2002): Geothermal energy technology and current status: an overview, Renewable and Sustainable Energy Reviews, issue 6/2002, 3-65.
2. R. DiPippo, (2005): Geothermal Power Plants: Principles, Applications and Case Studies, Elsevier, Oxford, ISBN: 1-85617-474-3.

Flash steam power plants first vaporize ("flash") the hydrothermal fluids. The resulting vapor then drives the turbine, which drives the generator. In a "double-flash system" any remaining fluids are flashed again to extract more energy. Flash plants also discharge excess steam and minor amounts of gases to the atmosphere. Spent hydrothermal fluids ("brine") are discharged to evaporation ponds or reinjected in disposal wells.

Dry steam power plants are the oldest technology and use hydrothermal fluids that are primarily steam. The steam goes directly to a turbine, which drives a generator to produce electricity. Dry steam plants discharge excess steam and minor amounts of gases to the atmosphere. Spent hydrothermal fluids ("brine") are discharged to evaporation ponds or reinjected in disposal wells.

Hot geothermal fluids are used to heat a secondary fluid with a much lower boiling point in binary cycle plants. The heat exchange causes the secondary fluid to vaporize and that vapor then drives the turbines. Because binary cycle plants are a closed loop system and virtually nothing is discharged to the atmosphere, binary cycle plants are the most environmentally benign technology currently in use.

The scope of geothermal projects also includes any associated infrastructure or ancillary facilities associated with the Project, including those that are not funded as part of the Project (funding may be provided separately), but whose viability and existence depend exclusively on the Project, and whose goods and services are essential for the successful operation of the Project. These may include pipelines, power transmission lines, access roads, and temporary-worker housing.

1.2 Summary of Significant Issues

These guidelines discuss the evaluation features most significant to geothermal projects and reflect the information contained in the International Finance Corporation's Environmental, Health and Safety Guidelines for Geothermal Power Generation, International Finance Corporation's General Environmental, Health and Safety Guidelines, International Finance Corporation's Performance Standards and other relevant standards and guidelines. These features include:

- Presence of critical or sensitive habitat on or adjacent to the site.
- Socio-cultural issues.
- Community issues.
- Air emissions.
- Impacts from well drilling and other operations.
- Impacts related to the construction of ancillary facilities including access roads and power transmission lines.
- Cumulative effects.

1.3 Scope of the Guidelines

These guidelines present potential environmental and social issues associated with geothermal projects, how OPIC may consider each of these issues when screening projects, applicable guidelines and standards, recommended measures to mitigate impacts, information needed to review a project, and monitoring recommendations.

These guidelines discuss the evaluation features that, in general, are most significant with respect to geothermal power generation projects, and therefore, require more emphasis while conducting environmental and social due diligence. As each project is unique, these guidelines may not capture the complete set of environmental and social issues related to geothermal projects. Each project is distinct and therefore will have environmental and social issues that are associated exclusively with that particular project.

It should be noted that these guidelines do not discuss typical impacts from construction and civil works such as erosion, impacts to water quality, solid waste disposal, and occupational health and safety issues. For additional guidance on these matters, please refer to IFC's General Environmental, Health, and Safety Guidelines, section 2.0: Standards and Guidelines (2007).

Section 2.0 - Standards and Guidelines

In addition to applicable host country requirements, geothermal projects are assessed using the following criteria:

- **OPIC's Environmental and Social Policy Statement**.
  http://www.opic.gov/sites/default/files/consolidated_esps.pdf
- **The International Finance Corporation's (IFC) Performance Standards on Social and Environmental Sustainability.**
  http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/pol_PerformanceStandards2006_full/$FILE/IFC+Performance+Standards.pdf
- **The IFC's Environmental, Health, and Safety Guidelines for Geothermal Power Generation**.
  http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_GeothermalPowerGen/$FILE/Final+-+Geothermal+Power+Generation.pdf
- Applicable provisions of the **IFC's General Environmental, Health and Safety Guidelines**, including the following:

1. Environment

   Section 1.1 Air Emissions and Ambient Air Quality
   Section 1.3 Wastewater and Ambient Water Quality
   Section 1.6 Waste Management
   Section 1.7 Noise

2. Occupational Health and Safety

   Section 2.1 General Facility Design and Operation
   Section 2.2 Communication and Training
   Section 2.3 Physical Hazards
   Section 2.4 Chemical Hazards
   Section 2.7 Personal Protective Equipment
   Section 2.9 Monitoring

3. Community Health and Safety

   Section 3.1 Water Quality and Availability
   Section 3.2 Structural Safety of Project Infrastructure
   Section 3.4 Traffic Safety
   Section 3.7 Emergency Preparedness and Response

4. Construction and Decommissioning

   Section 4.1 Environment
   Section 4.2 Occupational Health and Safety
   Section 4.3 Community Health and Safety

http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_GeneralEHS/$FILE/Final+-+General+EHS+Guidelines.pdf

Other guidelines relevant to ancillary infrastructure include applicable provisions of:

- **IFC's Environmental, Health and Safety Guidelines for Electrical Power and Distribution**.
  http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_ElectricTransmission/$FILE/Final+-+Electric+Transmission+and+Distribution.pdf

- **IFC's Environmental Health and Safety Guidelines for Toll Roads**.
  http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_TollRoads/$FILE/Final+-+Toll+Roads.pdf

- **Workers' Accommodation: Processes and Standards: A Guidance Note by IFC and the EBRD**.
  http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/p_WorkersAccommodation/$FILE/workers_accomodation.pdf

Note: International organizations, the United States Government and Industry groups periodically revise guidelines and standards to reflect technological advances and improved understanding of environmental, health, safety, and social risks. Completed applications that are received before the effective date of a new guideline or standard will be assessed using the guideline or standard that is in effect on the date of application, provided OPIC commitment for support is achieved within one year of the effective date of the new guideline or standard. If commitment is not achieved within one year after the effective date of the new guideline, the Project will be subject to the new guideline.

Section 3.0 - Screening

Based on information received from the Project applicant for the purposes of environmental, social, health and safety review, OPIC screens projects into one of three categories: Categorically Prohibited, Category A, and Category B.

3.1 Categorically Prohibited

Geothermal projects can result in adverse impacts and land disturbances that may preclude OPIC support. Project location is the primary determinant of eligibility. OPIC will not support the following types of projects:

- Projects that involve conversion or degradation of Critical Forest Areas or forest-related Critical Natural Habitats.
- Projects that require resettlement of 5,000 or more persons.
- Projects in or impacting natural World Heritage Sites (*http://whc.unesco.org/en/list*) unless it can be demonstrated through an environmental assessment that the Project (i) will not result in the degradation of the protected area and (ii) will produce positive environmental and social benefits.
- Projects in or impacting areas on the United Nations List of National Parks and Protected Areas (*http://www.unep-wcmc.org/un-list-of-protected-areas_269.html*) unless it can be demonstrated through an environmental assessment that the Project (i) will not result in the degradation of the protected area and (ii) will produce positive environmental and social benefits.
- Extraction or infrastructure projects in or impacting: protected area Categories I, II, III, and IV (Strict Nature Reserve/Wilderness Areas and National Parks, Natural Monuments and Habitat/Species Management Areas), as defined by the International Union for the Conservation of Nature (IUCN). Projects in IUCN Categories V (Protected Landscape/Seascape) and VI (Managed Resource Protected Area) must be consistent with IUCN management objectives

  (*http://www.iucn.org/about/work/programmes/pa/pa_products/wcpa_categories/*) (*http://www.iucn.org/about/work/programmes/species/red_list/*) unless it can be demonstrated through an environmental assessment that the Project (i) will not result in the degradation of the protected area and (ii) will produce positive environmental and social benefits.

If not prohibited, then the geothermal project is further screened as either Category A or Category B.

3.2 Category A or Category B

Category A geothermal projects are likely to have significant adverse environmental and social impacts that are irreversible, sensitive, diverse, or unprecedented. Category A projects require submission of an Environmental and Social Impact Assessment (ESIA) developed in accordance with IFC P.S. 1, an on-site due-diligence visit by an OPIC environmental analyst or a third-party consultant approved by OPIC and development and implementation of an Environmental and Social Action Plan (ESAP). Within three years of the execution of the contract with OPIC, Category A projects are required to conduct a third party audit.

Issues that require careful consideration in determining whether a project is Category A or B for geothermal projects include the following:

- Potential for significant habitat alteration or wildlife disturbance, including disruption of wildlife migration corridors.
- Potential for significant socio-cultural impacts related to land acquisition, land use, indigenous peoples, and cultural heritage.
- Potential for significant community impacts related to noise.
- Potential for significant occupational health and safety and/or community impacts from air emissions.
- Potential for significant environmental impacts resulting from well drilling and other geothermal operations.
- Potential for significant environmental and social impacts from ancillary features.
- Potential for significant environmental and social impacts due to cumulative effects.

If a project originally screened as a Category A project is subsequently found to result in major or unreasonable adverse impacts on the environment, health or safety, OPIC may decide to decline support.

Modifications of project design and advanced planning in siting may be used to avoid or significantly reduce adverse impacts of geothermal projects. A geothermal project may be screened as Category B if significant impacts are avoided, adequately mitigated and sufficient information is provided to assess such impacts, and there is no significant opposition to the Project by local stakeholders. Geothermal projects utilizing closed-loop technologies (such as binary cycle systems) are more likely to be screened as Category B projects.

Section 4.0 - Significant Issues and Mitigation Measures

This section describes environmental and social evaluation features associated with geothermal projects, how each of these features may affect screening determinations, and measures to mitigate impacts as provided in applicable guidelines and standards.

4.1 Presence of Critical or Sensitive Habitat on or Adjacent to the Site

Description of Impact. Geothermal resources are often located in seismically active areas with restrictive zoning, protected area status, or other land use restrictions designed to prevent extensive settlement in the area. Therefore, a significant impact often associated with geothermal power development is disturbance of natural or sensitive habitat.

Screening. OPIC cannot support projects that involve conversion or degradation of Critical Forest Areas or forest-related Critical Natural Habitats or projects located in or adversely impacting internationally recognized protected areas unless it can be demonstrated through an environmental assessment that the Project (i) will not result in the degradation of the protected area and (ii) will produce positive environmental and social benefits.

Projects that are not located in forest-related Critical Natural Habitats or Critical Forest Areas but that have the potential to result in significant habitat alteration or wildlife disturbance, including disruption of wildlife migration corridors, may be classified as Category A. The extent of impact and types of species located in or near the habitat or corridors should be considered in determining the classification of the Project.

Impact Mitigation. Mechanisms to reduce the amount of land clearing needed, thereby reducing impact on habitat and wildlife include:

- Using directional drilling for the establishment of numerous wells off a single or limited number of well pads.
- Aligning access roads and steam pipe placement to reduce the establishment of multiple rights-of-way.
- Sharing use of substations and transmission lines.
- Rapidly reestablishing native vegetation in cleared areas.

Additional mitigation measures to minimize impacts to habitat are described in IFC's Environmental, Health and Safety Guidelines for Electrical Power and Distribution and Toll Roads.

4.2 Socio-Cultural Issues

4.2.1 Land Acquisition and Land Use

Description of Impact. Most geothermal power plants only require 0.5 to 3.5 ha per MW, but this does not take into account land clearance required for the establishment of well pads, access roads, steam pipes, transmission lines, and sub-stations. Any project involving land acquisition can impact local communities and their livelihoods, current landowners and/or current land users. Land acquisition that results in involuntary resettlement can complicate the social impact of the Project. This is compounded when projects are located in countries where land tenure and ownership laws are tenuous and/or in situations where local communities or groups do not hold title to the land.

Screening. Land acquisition procedures, physical or economic displacement of people and/or impacts on their livelihood, and changes in land use are factors considered in screening projects as Category A or B. Information regarding actual land ownership, and in some countries, past ownership, as well as existing and adjacent land use, can assist in determining if effects in this area would result in a Category A or B

classification. Projects involving significant resettlement or impacts on livelihoods due to changes in land use are likely to be screened as Category A.

Impact Mitigation. Land should be acquired on a voluntary basis with current landowners and tenants and prices should be negotiated with current landowners at market rates. For projects that involve involuntary physical or economic displacement, land must be acquired in accordance with IFC's Performance Standard 5 (Land Acquisition and Involuntary Resettlement) and, where indigenous peoples are involved, IFC's Performance Standard 7 (Indigenous Peoples). The resettlement, compensation and community consultation processes and agreements must be clearly documented.

Land use patterns should be assessed to determine if there are currently existing land uses, such as agriculture or tourism, which could be diminished as a result of the establishment of a geothermal project. Although many geothermal power stations are located in remote areas, when necessary, site selection should consider proximity to local communities. Alternative locations that provide maximum separation distance between power plant structures and local communities are preferable.

4.2.2 Indigenous Peoples and Cultural Heritage

Description of Impact. Indigenous people may be particularly vulnerable if their lands and resources are transformed, encroached upon, or significantly degraded. Their languages, cultures, religions, spiritual beliefs and institutions may also come under threat.

Projects may be located in an area with the potential for containing tangible cultural resources. In addition, a geothermal project may impact the cultural heritage of the area by changing the landscape and possibly the type of economic activity in the area (IFC 2006).

Screening. Projects with the potential to adversely impact indigenous peoples are sensitive and as such are more likely to be screened as Category A. Projects with the potential to affect cultural heritage may be screened as Category A if impacts are determined to be significant.

Impact Mitigation. Projects should anticipate and avoid adverse impacts on communities of Indigenous Peoples, or when avoidance is not possible, to minimize and/or compensate for such impacts. For additional information on standards and requirements related to impacts on indigenous peoples, consult IFC's P.S. 7.

If a geothermal project has the potential to impact cultural resources, either tangible or intangible, mitigation measures found in IFC P.S. 8 should be implemented.

4.3 Community Issues

4.3.1 Noise

Description of Impact. Noise can result from drill rig operation, well testing activities and power station operations. Drilling rig equipment noise, well start-up and discharge through the separators can exceed 85–100 dB(A) (Mwangi, 2010; IFC 2007). Power station noises relate to the turbines, air receivers, and non-condensable gas ejectors.

Screening. If opposition to a project develops, the level of opposition can affect a project's classification as Category A or Category B.

Impact Mitigation. The WHO standard adopted in the IFC General EHS Guidelines section 1.7 on Noise Management defines the acceptable values for noise levels measured outdoors as follows (IFC, 2007; WHO 1999):

- For industrial and commercial facilities, not to exceed 70 dB(A) during both the day and night.

- For residential, institutional, and educational facilities, not to exceed 55 dB(A) during daytime and 45 dB(A) at night.
- For non-residential areas, not to exceed 85 dB(A) in close proximity to project operations and 70 dB(A) at property fence line.
- Noise levels should not exceed 55 dB(A) at the property line closest to the geothermal energy system during the day and not to exceed 45 dB(A) at night.

Exceptions for neighboring properties are allowed with the written consent of those property owners. This sound pressure level may be exceeded during short-term events such as well start-up periods. If the ambient sound pressure level exceeds 55 dB(A), the standard shall be ambient dB(A) plus 3 dB(A) at the nearest off-site receptor location (IFC, 2007; Weed, 2006).

4.3.2 Public Access

Description of Impact. Safety issues can arise when the public has access to geothermal generation facilities and substations, including physical hazards associated with the wells and related pipeline networks. In addition, hazards may result from contact with hot components, equipment failure, or the presence of active and/or abandoned well infrastructure.

Screening. Impacts due to public access to a project site can be mitigated to acceptable levels as laid out in IFC's Environmental, Health and Safety Guidelines for Geothermal Power Generation. Implementation of appropriate mitigation measures with respect to public access would assist in screening the Project as Category B.

Impact Mitigation. Prevention and control measures to control public access include the use of gates on access roads, appropriate fencing, controlled locked access to the Project area and the posting of safety signage at the facility perimeters, at all access points and at all high voltage areas. Measures taken to avoid public access should include the initial siting of facilities away from any populated areas and inclusion of an established buffer zone around the perimeter of the geothermal facility. Hot surfaces should be shielded (and access limited) and thermal protection equipment should be issued to workers.

4.4 Air Emissions

Description of Impact. Potential air emissions from open loop geothermal power systems could contain hydrogen sulfide and mercury. Because non-condensable geothermal gases, including hydrogen sulfide, are heavier than air, the gases can accumulate in confined spaces and low-lying areas. Mercury is often found as a trace element in geothermal fluids. Due to its high volatility, mercury can be transferred to the environment in the vapor phase of non-condensable gases.

Screening. Projects that pose significant adverse environmental and social impacts that are irreversible, sensitive, diverse, or unprecedented may be classified as Category A. If it is determined that a geothermal project will result in high concentrations of hydrogen sulfide with the potential for significant adverse impacts on workers or nearby communities, a project may be classified as Category A.

Impact Mitigation. If levels exceed applicable health and safety standards, the Project should reinject byproduct gases or treat non-condensable gases to control hydrogen sulfide and mercury content. In open loop systems, activated carbon can be used to control gas phase mercury emissions.

Continuous monitoring of leaks is key to preventing morbidity and mortality of workers and area residents. High concentrations of hydrogen sulfide in the geothermal resource may require additional or more extensive mitigation measures.

The WHO air quality guideline for hydrogen sulfide is 150 $\mu g/m^3$ for an average concentration over 24 hours. The health end-point was eye irritation. To avoid odor annoyance, a 30-minute average

ambient air concentration not exceeding 7 μg/m^3 (5 ppb) is recommended (WHO, 2000). Other relevant guidelines for occupational exposure to H_2S include the following:

- OSHA: Permissible Exposure Limit (PEL) of 20-ppm averages over an 8-hour work shift and 50 ppm maximum peak, not to be exceeded during any 10-minute work period.
- NIOSH: Recommended Airborne Exposure Limit (REL) of 10 ppm, not be exceeded during any 10-minute work period.
- ACGIH: Threshold Limit Value (TLV) of 1 ppm averaged over an 8-hour work shift and 5 ppm as a short-term exposure limit.

4.5 Well Drilling and Other Operational Issues

4.5.1 Well Drilling Impacts

Description of Impact. Geothermal drilling relies on technology used in the oil and gas industry modified for high temperature applications and larger well diameters. Blowout prevention systems are similar to those found in the oil and gas industry. In contrast to oil and gas wells, which are often over-pressured and their pressures controlled by the weighted drilling fluids, geothermal wells are most often under-pressured. Although the probability of a blowout is reduced, drilling operations can encounter fractured or permeable strata where pore pressure is higher than the drilling fluid and loss of control may occur. In addition to well blowouts, pipeline failures can also occur in geothermal systems.

Screening. Impacts from well drilling can be mitigated to acceptable levels by applying mitigation measures laid out in IFC's Environmental, Health and Safety Guidelines for Geothermal Power Generation. Appropriate mitigation measures with respect to well drilling impacts would assist in screening the Project as Category B.

Impact Mitigation. Similar to what is required in oil and gas drilling operations, project design should carefully consider selection of casings, drilling fluids and drilling muds to reduce the potential for ground and surface water contamination. Adequate loss-of-well-control procedures and equipment must be in place to prevent loss of life, and equipment, including the drilling rig.

The IFC EHS Guidelines for Geothermal Power Generation recommend regular maintenance of wellheads and pipelines, use of blowout prevention equipment and development and implementation of emergency response plans to ensure containment of geothermal fluid spills.

4.5.2 Effluents

Description of Impact. The primary effluents from geothermal power plants are: drilling fluids and cuttings, spent geothermal fluids, cooling water, and domestic wastewater. Spent geothermal fluids may contain elevated levels of arsenic, boron, and molybdenum and therefore, improper disposal of these, as well as other effluents, can lead to adverse environmental and social impacts such as damage to water quality and aquatic habitat, which also potentially can affect surrounding communities.

Screening. Impacts from well drilling and geothermal power production can be mitigated to acceptable levels by applying mitigation measures laid out in IFC's Environmental, Health and Safety Guidelines for Geothermal Power Generation and IFC's General Environmental, Health and Safety Guidelines. Implementation of appropriate mitigation measures with respect to well drilling impacts would assist in screening the Project as Category B.

Impact Mitigation. To control discharge from drilling fluids and cuttings IFC recommends:

- Dedicated impervious storage tanks or sumps that are subsequently removed.
- Reuse of drilling fluid, where feasible.

- Reuse of water based drilling fluids or disposal into the borehole or landfill facility as appropriate, based on toxicity.
- Leak-proof well casings for acid treatment of wells in geological formations containing aquifers.

Spent geothermal fluids should be reinjected underground using leak-proof well casings, or if discharged, the effluent should be consistent with the receiving water body use as described in the General EHS Guidelines.

Discharged cooling water should meet local requirements with respect to the temperature of the discharge.

4.5.3 Water Consumption and Extraction

Description of Impact. Fresh water is used for drilling activities and certain cooling systems. Excessive groundwater or surface water use can have significant impacts on communities if they rely on the same water source.

Screening. Projects where the annual volume of groundwater abstracted to support drilling and worker housing amounts to 10 million m^3 or more are generally screened as Category A. If a project withdraws water from surface water and it is determined that, as a result, downstream users are significantly adversely impacted, the Project may be screened as Category A.

Impact Mitigation. Water should be recycled and reused to the maximum extent possible. Appropriate minimum flows in any source water stream should be identified and maintained.

4.6 Ancillary Features

Description of Impact. Ancillary features, including pipelines, access roads and transmission lines to the main grid, can result in significant land use disturbances, visual intrusions, and wildlife impacts. In addition, because sites for geothermal projects can sometimes be located in remote areas or the required skilled workers do not live near the Project site, workers' accommodations may be needed. Workers' accommodations require consideration of siting issues as discussed above, provision of potable water and availability of wastewater and solid waste disposal services.

Screening. The significance of the impacts that ancillary facilities may have and their potential cumulative effects need to be considered during the screening process as they could have an effect on a project's category classification. The length and route of a pipeline, transmission line, or access road, outside the Project boundary, and their impact on the siting criteria discussed above, will determine if effects related to ancillary facilities would result in a Category A or B classification.

Potential social impacts that may result from worker housing should be considered including impacts on community infrastructure, health, and safety. Depending on the size, duration and potential risks associated with workers' accommodations, impacts from workers' accommodations may be considered during classification of a project as Category A or Category B.

Impact Mitigation. For access roads and transmission lines, IFC's EHS Guidelines for Toll Roads and for Electric Power Transmission and Distribution should be consulted and recommendations applied.

For workers' accommodations, projects should adhere to international standards for worker housing such as "Workers' Accommodation: Processes and Standards: A Guidance Note by IFC and the EBRD" (*http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/p_WorkersAccommodation/$FILE/workers_accomodation.pdf*).

4.7 Cumulative Effects

Description of Impact. Because geothermal power facilities are often developed in stages to manage reservoir-life it is important to identify any planned future expansion or the presence of other geothermal facilities in the Project area of influence. Open loop geothermal facilities located in close proximity to each other can result in significant adverse cumulative impacts with respect to noise, ambient air quality and visual impacts. Cumulative effects can also result from the additive effects of other activities from different projects in a region, or secondary development that is likely to occur as a result of project development, each of which taken individually may not create significant impacts, but taken together could result in considerable impacts.

Screening. Having more than one geothermal facility within the same area or community can significantly exacerbate environmental and social impacts. Cumulative impacts from ancillary features should also be considered. If there are potential significant adverse impacts to the environment or nearby communities due to cumulative effects, a project may be classified as Category A rather than Category B.

Impact Mitigation. The potential for cumulative impacts should be identified during the Project's environmental and social assessment process. Opportunities exist to reduce land-clearance impacts through shared use of power transmission lines, substations and access roads. Monitoring plans and procedures for air emissions and noise should take into account the cumulative effect of these impacts.

Section 5.0 - Information Needed from Project Applicant

Information that can be supplied by a project applicant that would assist OPIC in the screening and review of any proposed geothermal project includes:

Project technology

- A description of the power generation process and technology.
- Information regarding separators, non-condensable gas ejectors, cooling towers, waste ponds, reinjection wells, pipes.

Project site

- Exact location including latitude and longitude coordinates.
- Current land use of the site including whether or not there are existing structures on the site that will need to be removed.
- Presence of protected/endangered plants or animals on the site.
- Presence and/or proximity to wildlife migration corridors.
- Proximity to important wildlife habitat areas including Special Protected Areas (SPAs) and statutorily designated or qualifying International or National sites for nature conservation including Natura 2000 sites.
- Proximity to protected area or area of cultural significance.
- Proximity to closest residence/neighborhood, particularly proximity of residents/neighbors to significant hydrogen sulfide emissions sources.
- Description of procedures for measuring and monitoring noise and potential impact on nearby residents and any controls that will be required on the equipment to minimize noise.
- Information regarding physical or economic displacement of any person or persons.
- Information regarding potential impacts on indigenous peoples.
- Information regarding how the land for the Project was acquired.
- Any public meetings held with nearby residents and issues that arose.
- Information relating to the surrounding topography.
- Information regarding planned expansion or presence of other geothermal facilities, existing or planned, in the Project area of influence.

Project impacts

- Whether steam production and reinjection wells will be constructed as part of the Project, and if so, how the drill fluids and tailings will be treated and disposed of.
- Whether drilling fluids will be reused.
- How oils present in the oil-based drilling fluids will be treated and stored.
- How spent geothermal fluids will be handled and treated before discharge.
- How air emissions, particularly for hydrogen sulfide and mercury will be managed and monitored.
- Whether scrubbers will be used to abate hydrogen sulfide and mercury emissions.

- Information regarding water consumption and extraction, specifically water use numbers for processes and sanitary use; source of water, any studies that have been done to determine impacts of water use, and what monitoring will be in place.
- Information regarding types of hydrogeological modeling and water balance assessments that have been conducted to support the Project and to determine impacts on nearby aquifers.
- How solid wastes will be managed including sludge from the cooling towers, air scrubber systems, if applicable, turbines, and steam separators as well as construction waste and everyday trash.
- Description regarding emergency procedures in the event of a well blowout or pipeline failure.
- Whether or not a social and environmental impact assessment, social and environmental management plan, social and environmental policy and grievance mechanism have been prepared for the Project.
- Whether or not an Occupational Health and Safety plan has been prepared for the construction and/or operational phase of the Project.
- Description of maintenance procedures that will be employed to minimize the likelihood of well blowouts and pipeline failures.
- Information regarding construction impacts, such as: measures to control erosion, plans for solid and sanitary waste disposal during construction, provision of potable water for construction workers and hazardous materials storage, handling and disposal.

Connection to the electrical grid and other related infrastructure needed for the Project

- Description of any on-site substation to be constructed.
- Complete description of how the Project will tie into the existing transmission system including whether or not there will be construction of a transmission line, its length, its route and who is responsible for the construction of the line.
- Whether or not roads will be constructed for the Project and their length, width, and route (whether in exising right-of-way or not).
- Description of any other ancillary features, including: substation, construction lay-down areas, or access roads.
- Whether or not there will be worker housing needed on-site and the plans for the construction of that housing.

Section 6.0 - Recommended Monitoring

Because each project and site is unique, monitoring requirements should be determined on a project-by-project basis and should be largely based on the significant issues that were identified during the environmental and social impact assessment of the Project.

In general, monitoring for a geothermal project may include the following:

- **Construction phase**
  - Monitor that occupational health and safety measures are carried out in accordance with IFC's General Environmental, Health, and Safety Guidelines.
  - Monitor that impacts from construction such as erosion and sedimentation, solid and sanitary waste disposal, hazardous materials (including fuels and lubricants) management, are being mitigated in accordance with IFC's General Environmental, Health, and Safety Guidelines Erosion.
  - If applicable, monitor that any cultural heritage that may be found or affected during construction is treated in accordance with IFC P.S. 8.
  - Respond to and record community grievances.
  - If applicable, monitor habitat and species impacts in accordance with IFC P.S. 6 and/or the Project's biodiversity management plan.
  - If applicable, monitor that temporary worker housing is constructed and maintained in accordance with Workers' Accommodation: Processes and Standards: A Guidance Note by IFC and the EBRD.
- **Operation Phase**
  - If cooling water is discharged to streams, resulting temperature changes in the receiving stream should be evaluated.
  - Corrosion and leak detection monitoring by qualified inspectors.
  - Seismic monitoring to determine if there are any effects associated with removal of pressure or water, or from reinjection back into the formation.
  - Monitor how spent geothermal fluids are being handled and disposed of.
  - Monitor the use and control of drilling fluids.
  - Monitor air emissions where appropriate (i.e. when hydrogen sulfide gas and mercury are expected to be present).
  - Monitor water use.
  - Monitor noise levels.
  - Cumulative effects, if applicable.

Section 7.0 - Resources

Presence of Critical or Sensitive Habitat **Socio-Cultural Issues** **Community Issues** **Air Emissions** **Impacts from Well Drilling and Other Operations** **Impacts Related Construction of Ancillary Facilities** **Cumulative Effects**	Berkeley Lab, ESD. Energy Resources Program Research Area: Geothermal Energy Exploration and Development *http://esd.lbl.gov/research/programs/er/research_areas/geothermal_energy.html* Blankenship, D. and Finger, J. (2010): Handbook of Best Practices for Geothermal Drilling, Sandia National Laboratories, Albuquerque, NM and Livermore, CA, December 2010 *http://www1.eere.energy.gov/geothermal/pdfs/drillinghandbook.pdf* Crossley, B. and Thomson, T. (2008): Granite Power: Review of Environmental Factors for Exploration Geothermal Borehole at Bulli-1, Umwelt, February 2008 *http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/223310/20080212-EL-6360-REF-GranitePower-Geothermal-Expl-Bulli-1.pdf* Gawell, K. and Bates, D. (2004): Geothermal Literature Assessment: Environmental Issues. Geothermal Energy Association, Washington, D.C., May 2004. *http://www.geothermal-biz.com/GeothermalLiterature.pdf* IFC, (2007). Environmental, Health, and Safety Guidelines: Genral EHS Guidelines: Environmental Air Emissions and Ambient Air Quality, April 30, 2007 *http://www.ifc.org/ifcext/enviro.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_GeneralEHS_1-1/$FILE/1-1+Air+Emissions+and+Ambient+Air+Quality.pdf* IFC, (2007). Environmental, Health, and Safety Guidelines for Geothermal Power Generation, April 30, 2007 *http://www.ifc.org/ifcext/enviro.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_GeothermalPowerGen/$FILE/Final+-+Geothermal+Power+Generation.pdf* Kagel, A, (2008): The State of Geothermal Technology Part II: Surface Technology. Geothermal Energy Association, Washington, D.C., 2010 *http://www.geo-energy.org/reports/Geothermal Technology - Part II (Surface).pdf* ová, M, (2009): Feasibility Study of Binary Geothermal Power Plants in Eastern Slovakia: Analysis of ORC and Kalina power plants, University of Akureyri, February, 2009 *http://www.res.is/static/files/ThesisReports/Martina_Kopunicova.pdf* Lundin, J., et al (2006): EUSUSTEL WP3 Report: Geothermal power production. Uppsala University, Sweden, 2006. *http://eusustel.be/public/documents_publ/WP/WP3/WP3_Geothermal_energyFINAL.pdf* Mwangi, M, (2010): Environmental and Socio-Economic Issues of Geothermal Development in Kenya. Geothermal Resource Council: Bulletin, vol. 39, No.2: pp24-35 *http://www.geothermal.org/10MarApril24.pdf*

	National Grid Corporation of the Philippines (NGCP) and the Green Core Geothermal, Incorporated (GCGI). (2011): Order: In the Matter of the Application for Approval of the Ancillary Services Procurement Agreement Between the National Grid Corporation of the Philippines and Green Core Incorporated: Prayer For Provisional Authority, Pasig City, PI, May, 2011. *http://www.ngcp.ph/documents/ERC_2011-065_RC_order_and_notice_of_public_hearing.pdf* Nemzer, M. (2011): Geothermal Education Office (GEO). 664 Hilary Drive Tiburon, CA 94920, USA *http://geothermal.marin.org/* SKM. (2005): The Geothermal Resources of Victoria: The Sustainable Energy Authority of Victoria, Monash University, February 2005 *http://www.sustainability.vic.gov.au/resources/documents/SKM_Geothermal_Report.pdf* Taylor, M, (2007): The State of Geothermal Technology Part I: Subsurface Technology. Geothermal Energy Association, Washington, D.C., November, 2007 *http://www.geo-energy.org/reports/Geothermal Technology Part I - Subsurface Technology (Nov 2007).pdf* United States Department of Energy. (2011): Final Environmental Assessment: Ormat Nevada Northern Nevada Geothermal Power Plant Projects. U.S. Department of Energy Loan Guarantee Program Office, Washington, D.C., August 2011 *http://energy.gov/sites/prod/files/EA-1849-FEA-2011.pdf* United States Department of Energy. (2011): Federal Interagency Geothermal Activities: Working Draft. Geothermal Technologies Program, Office of Energy Efficiency and Renewable Energy, Washington, D.C., June 2011 *http://www1.eere.energy.gov/geothermal/pdfs/ngap.pdf* Enhanced Geothermal Innovative Network for Europe (ENGINE). (2008): ENGINE Coordination Action. Best Practice Handbook for the Development of Unconventional Geothermal Resources with a focus on Enhanced Geothermal System. Orleans, FR, 2008 *http://engine.brgm.fr/Documents/ENGINE_BestPracticeHandbook.pdf*

Section 8.0 - Glossary of Terms - Geothermal

Categorically Prohibited Project - A project of the type listed in Appendix B of OPIC's Environmental and Social Policy Statement where potential adverse environmental or social impacts of the Project preclude OPIC support.

Category A - Category A projects are likely to have significant adverse environmental and/or social impacts that are irreversible, sensitive, diverse, or unprecedented. In the absence of adequate mitigation measures, Category A projects are considered higher risk.

Category B - Category B projects are likely to have limited adverse environmental and/or social impacts that are few in number, generally site-specific, largely reversible and readily addressed through mitigation measures. Category B projects are considered medium risk. For these reasons, the scope of OPIC's environmental and social assessment for a Category B project is narrower than that required for Category A projects.

Closed Loop - In closed-loop systems gases or fluids removed from the well are not exposed to the atmosphere but are injected back into the ground after a significant portion of the heat has been removed.

Critical Forest Areas - A type of Natural Forest that qualifies as Critical Natural Habitat. Critical Forest Areas include, but are not limited to, primary Forests and old growth Forests that may serve as critical carbon sinks.

Critical Natural Habitats - (i) Existing internationally recognized protected areas, areas initially recognized as protected by traditional local communities (e.g., sacred groves), and sites that maintain conditions vital to the viability of protected areas (as determined by the environmental assessment procedure); and (ii) Sites identified on supplementary lists by authoritative sources identified by OPIC. Such sites may include areas recognized by traditional local communities (e.g., sacred groves), areas with known high suitability for biodiversity conservation and sites that are critical for vulnerable, migratory or endangered species. Listings are based on systematic evaluations of such factors as species richness, the degree of endemism, rarity, and vulnerability of component species, representativeness, and the integrity of ecosystem processes.

Cultural Heritage - Tangible property or sites having archaeological (prehistoric), paleontological, historical, cultural, artistic and religious value, as well as unique environmental features that embody cultural values, such as sacred groves. Cultural Heritage also includes intangible forms of culture, such as cultural knowledge, innovations, and practices of communities embodying traditional lifestyles.

Drilling Mud - Different types of clays and other minerals in suspension making a base or as additives to formulate mud compositions resistant to high temperature and brine environment for use in geothermal wells. Drilling mud is used when water is encountered and air alone cannot lift the geothermal fluid anymore (Umran, S. (2000) *Investigation on Geothermal Drilling Muds with High Temperature Stability)*.

Economic Displacement - Loss of assets or access to assets that leads to loss of income sources or means of livelihood.

Environmental and Social Action Plan (ESAP) - A systematic program designed to prevent, mitigate and monitor anticipated environmental and related human impacts of prospective and ongoing activities. An ESAP is required on all Category A projects.

Environmental and Social Impact Assessment (ESIA) - A comprehensive analytical body of work designed to evaluate environmental impacts of major projects having the potential to have significant, diverse, and irreversible impacts on the natural environment and on humans dependent on that environment. An ESIA is required for all Category A projects involving new ("greenfield") developments or significant expansion of existing facilities.

Environmental and Social Management System (ESMS) - Part of a project's overall management system that includes the organizational structure, responsibilities, practices and resources necessary for implementing the Project-specific management program developed through the environmental and social assessment of the Project.

Forest - An area of land not less than 1.0 ha with a tree crown cover (or equivalent stocking level) of more than 10 percent that has trees with the potential to reach a minimum height of 2 meters at maturity *in situ*. A Forest may consist of either closed forest formations, where trees of various stories and undergrowth cover a high proportion of the ground, or open Forest. Young natural stands and all plantations that have yet to reach a crown density of 10 percent or tree height of 2 meters are included under Forest, as are areas normally forming part of the forest area that are temporarily destocked as a result of human intervention such as harvesting or natural causes but that are expected to revert to Forest. The definition includes Forests dedicated to forest production, protection, multiple uses, or conservation, whether formally recognized or not. The definition excludes areas where other land uses not dependent on tree cover predominate, such as agriculture, grazing, or settlements. In countries with low forest cover, the definition may be expanded to include areas covered by trees that fall below the 10 percent threshold for canopy density, but are considered Forest under local conditions.

Geothermal - Of, relating to, or utilizing the heat of the Earth's interior, originating from the Greek roots *geo*, meaning earth, and *thermos*, heat. *http://www.merriam-webster.com/dictionary*.

Geothermal Fluids - The water or steam that is used during the geothermal power process that can contain minerals; also known as mineralized fluids.

Industry Sector Guidelines - Technical reference documents issued by the International Finance Corporation with general and industry specific performance levels and measures.

Injection Wells - Any excavation that is cored, bored, drilled, jetted, dug, or otherwise constructed, whose depth is greater than its largest surface dimension and which is used, or intended to be used, for the injection of fluids or solids into the subsurface or groundwater. Injection

wells are designed to force water underground for the purpose of maintaining a steady supply of water in the geothermal system to an underground reservoir.

Natural Forests - Forest lands and associated waterways where the ecosystem's biological communities are formed largely by native plant and animal species and where human activity has not essentially modified the area's primary ecological functions.

Non-Condensable Gas (NCG) - Gas from chemical, petroleum processing units or geothermal power production (such as distillation columns or steam ejectors) that is not easily condensed by cooling; consists mostly of nitrogen, light hydrocarbons, carbon dioxide, or other gaseous materials and is always present in geothermal steam. NCG's cause power plant inefficiencies that result in increased steam consumption and ultimately higher plant costs. *McGraw-Hill Dictionary of Scientific and Technical Terms*, 6th edition.

NCG Ejectors - With a simple, standard heat exchanger (reboiler), the geothermal steam is condensed and its NCG components are discharged via the NCG ejectors.

Performance Standards - Technical reference documents issued by the International Finance Corporation with environmental and social impact management performance criteria.

Physical Displacement - Relocation or loss of shelter.

Project - All facilities owned or controlled within a physical project boundary that constitute a commercially viable business unit eligible for OPIC support.

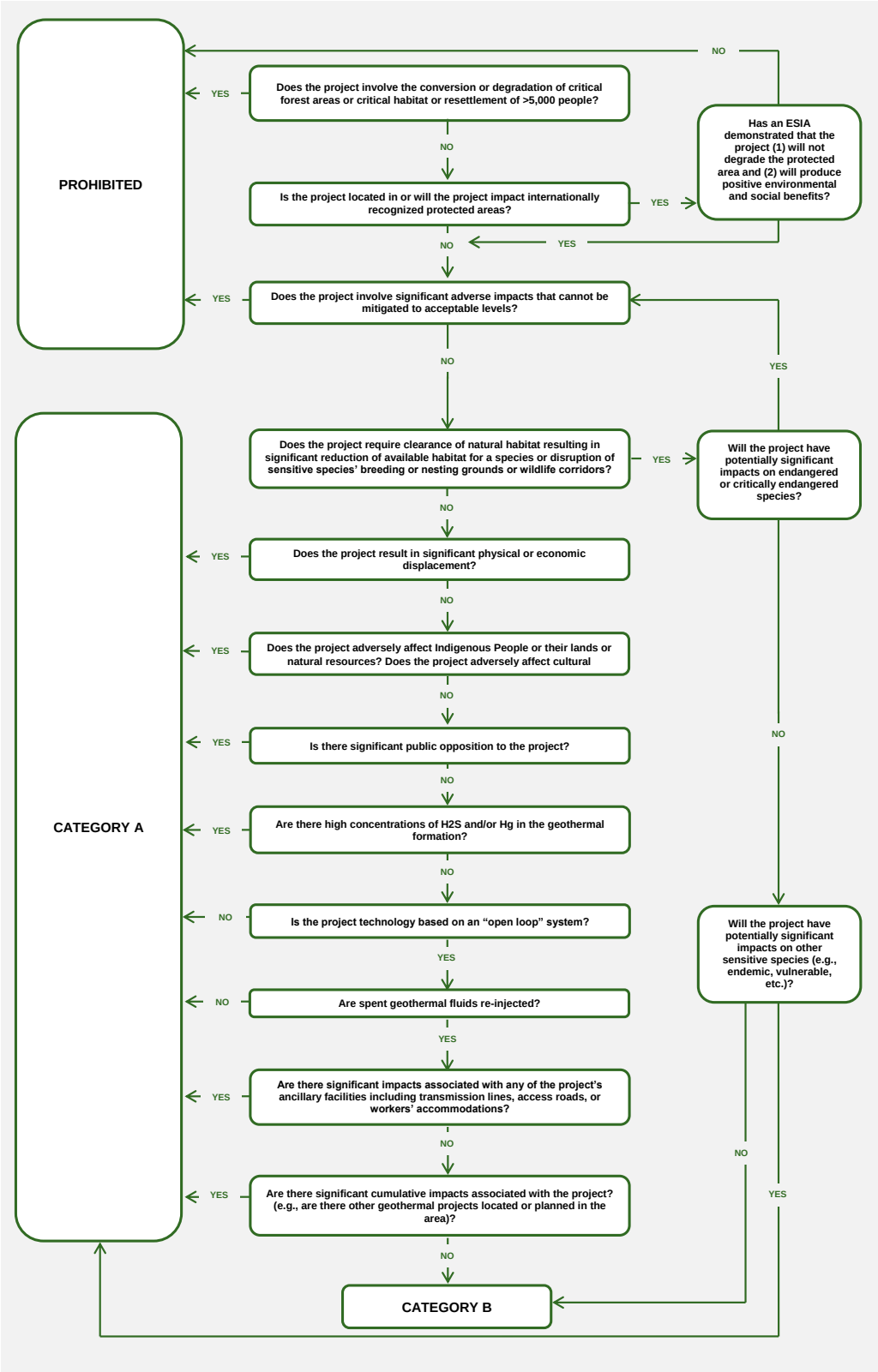
Project Affected People - Individuals, workers, groups or local communities, which are or could be affected by the Project, directly or indirectly, including through cumulative impacts. Emphasis should be placed on those who are directly and adversely affected, disadvantaged, or vulnerable.

Reinjection well - Any well or converted well constructed to dispose of geothermal fluids derived from geothermal resources into an underground reservoir.
http://www.oregonlaws.org/glossary/definition/geothermal_reinjection_well

Renewable Energy - Energy supplied from renewable energy sources, such as wind and solar power, geothermal, hydropower, and renewable biofuels/biomass not otherwise categorically prohibited, not including nuclear power.

Well Blowout - *A*n uncontrolled escape of fluids and gases from a geothermal well.
http://www.leg.state.nv.us/nac/NAC-534A.html - NAC534ASec031

Appendix A

Flowchart

Screening Flow Chart
Geothermal Projects.