



# The Geothermal Exploration Project

Project Document: ICE23066-1301

Sub-project of the Geothermal  
Compact in East Africa





# **The Geothermal Exploration Project**

Sub-project of the Geothermal Compact in East Africa

# Table of Contents

<b>ACRONYMS .....</b>	<b>5</b>
<b>SUMMARY .....</b>	<b>6</b>
<b>1. INTRODUCTION .....</b>	<b>7</b>
<b>2. RATIONALE .....</b>	<b>8</b>
<b>3. THE GEOTHERMAL EXPLORATION PROJECT .....</b>	<b>9</b>
3.1 MAIN OBJECTIVES.....	9
3.2. EXPECTED RESULTS (OUTPUTS) .....	9
3.3. PROJECT STRATEGY .....	10
3.4. PARTICIPATING COUNTRIES.....	12
3.5. PARTICIPATING AGENCIES AND POTENTIAL PARTNERS .....	12
3.6. CROSS CUTTING ISSUES.....	13
<b>4. IMPLEMENTATION .....</b>	<b>13</b>
4.1. ORGANIZATION AND ADMINISTRATION .....	13
4.2. INSTITUTIONAL ARRANGEMENTS .....	14
4.3. REPORTING, AUDITS AND EVALUATION .....	14
4.4. PROCUREMENT.....	15
<b>5. PROJECT TIME PLAN .....</b>	<b>15</b>
<b>6. PRELIMINARY COST ESTIMATES .....</b>	<b>16</b>
6.1. COST ESTIMATES FOR GEOTHERMAL EXPLORATION PROJECT.....	16
<b>7. RISKS .....</b>	<b>17</b>
<b>8. CONCLUSION .....</b>	<b>18</b>
<b>ANNEX 1: LOGICAL FRAMEWORK MATRIX .....</b>	<b>19</b>
<b>ANNEX 2: AN ILLUSTRATIVE COST SCENARIO FOR THE GEOTHERMAL COMPACT .....</b>	<b>22</b>
<b>ANNEX 3: DESCRIPTION OF THE 9 STAGES OF GEOTHERMAL DEVELOPMENT .....</b>	<b>23</b>
<b>ANNEX 4: SHORT NOTE ON THE HISTORY OF COOPERATION BETWEEN ICELAND AND EAST AFRICA .....</b>	<b>25</b>
<b>ANNEX 5: GEOTHERMAL DEVELOPMENT IN AFRICA - ICELAND AND WORLD BANK COOPERATION: AIDE MEMOIRE: NOVEMBER 3, 2011 .....</b>	<b>26</b>
<b>ANNEX 6: LETTER TO NDF FROM THE WORLD BANK .....</b>	<b>30</b>

## Acronyms

ARGeo	African Rift Geothermal Development Facility
AUC	African Union Commission
BADEA	Arab Bank for Economic Development in Africa
BGR	Bundesanstalt für Geowissenschaften und Rohstoffe
EARS	East African Rift Valley Countries
OS	Orkustofnun (National Energy Authority of Iceland)
ICEIDA	Icelandic International Development Agency
KfW	Kreditanstalt für Wiederaufbau
MoFA	Ministry of Foreign Affairs in Iceland
NDF	Nordic Development Fund
OFID	OPEC Fund for International Development
UNU-GTP	United Nations University – Geothermal Training Program
UNEP	United Nations Environmental Programme
UNDP	United Nations Development Programme
USAID	US Agency for International Development
EUEI PDF	EU Energy Initiative Partnership Dialogue Facility
WB	World Bank

## Summary

This document describes a project to partly address the great and increasing needs of East Africa Rift Valley countries for energy access through renewable, low emissions energy – with a focus on geothermal energy. The geothermal potential in this area is considered to be very promising and in parts of the region it is already known and utilized.

In 2011 The World Bank and Iceland started discussions on the possibilities of accelerating the geothermal development in the countries of the East African Rift Valley (EARS) by combining forces, and inviting other actors to join the cooperation. To this end a Geothermal Compact program has been formed, which includes a staged approach to research and investments, combined with parallel activities for institutional strengthening and capacity building in the respective countries and supporting institutions. The main objective of the Geothermal Compact program is to assist the East African Rift Valley countries to increase their access to green and renewable energy through geothermal energy development. In 2012, The World Bank started to explore with other donors the possibility of mobilizing additional concessional resources to fund test drilling programs, after the activities of the Geothermal Exploration Project are successfully completed. This initiative, the Global Geothermal Development Plan (GGDP) is led by ESMAP. Iceland supports the GGDP.

The Geothermal Exploration Project aims at assisting all EARS countries in completing the exploratory phase of geothermal development and build capacity and expertise in the field of geothermal utilization and related policy. The project will thus contribute to the overall objective of the Geothermal Compact. At the end of the project it is expected that: 1) All participating countries have a realistic assessment of potential geothermal sites, 2) plans for further action where applicable, and 3) capacity to move forward on the basis of those plans and submit drilling projects into funding pipelines.

The Geothermal Exploration Project is the initial phase of the Geothermal Compact partnership program, initiated jointly by Iceland and the World Bank. The Icelandic International Development Agency (ICEIDA) will act as the Lead Agency with joint co-financing from the Nordic Development Fund (NDF) and participation of others, as the case may be. The implementation of the project is demand-driven, responding to requests by governments and appropriate authorities. In addition to supporting and funding reconnaissance and geothermal exploration the project will also cover technical assistance and capacity building, as needed and requested within the scope of the project, including training through the UNU-Geothermal Training Programme.

The financial framework for the Geothermal Exploration Project is estimated at USD 13 million. The project could extend to all 13 countries in the East Africa Rift Valley. A separate project document will be prepared for activities in each country, including plans for geothermal exploration and capacity building.

# 1. Introduction

The preparation of this project was initiated following a visit of a World Bank Mission to Iceland in early November 2011. During the visit cooperation between the World Bank and Iceland was discussed, in particular how it would be possible to accelerate the geothermal development in Africa by utilizing the expertise and experience of Iceland in the field of renewable energy and combine that with the Bank's convening power and financial resources. The outcome of this visit was that the World Bank and the Ministry of Foreign Affairs (MoFA) in Iceland decided to continue the cooperation and formulate a plan to advance this concept. This entails that Iceland and Icelandic agencies will advance their work in order to bring countries towards exploration drilling. An Aide Memoire from the visit of the World Bank delegation to Iceland is included in Annex 5.

The chosen approach to organize this is based on a two-phase cooperation. Firstly, a generic partnership program has been sketched between Iceland and the World Bank, based on an exchange of letters, with invitation to other partners to join. The World Bank will play a lead role in providing general guidance for the direction of the Geothermal Compact partnership.

Secondly, under the umbrella of the Compact, individual or groups of agencies are invited to develop sub-programs/projects, which, for instance, may be implemented in the form of parallel co-financing. The World Bank has already invited the Nordic Development Fund (NDF) to join the partnership (see Annex 6). The Icelandic bilateral development agency, ICEIDA, will be the key actor on the Icelandic side.

Subsequently, ICEIDA and NDF decided to embark on a joint project under the Geothermal Compact, with a focus on the earlier stages of geothermal development, mainly the stages leading up to significant exploration drilling. In addition funding will be available for technical assistance and capacity building, including training through the United Nations University – Geothermal Training Programme.

The cooperation between ICEIDA and NDF is based on joint co-financing, with each agency primarily financing costs in specific countries, but under a joint program. ICEIDA will be the Lead Agency for NDF's participation.

The implementation of the project is demand-driven, responding to requests from the governments in the countries of the African rift valley. The project will seek good cooperation with other agencies supporting similar exploration activities and notes in particular the presence of BGR of Germany in certain ARGeo countries and the AUC/KfW Geothermal Risk Mitigation Facility (GRMF) which entails elements of potential support to surface exploration activities in Ethiopia, Kenya, Rwanda, Tanzania and Uganda.

A dialogue with, and guidance from, the chosen coordination platform among beneficiary countries will be given high priority in the implementation of the project. This includes cooperation and coordination with the AUC and ARGeo/UNEP. Political guidance for the project will also be sought from the AUC.

## 2. Rationale

The geothermal potential in Africa is mainly in the East Africa Rift Valley States (EARS) covering 13 countries from Eritrea in the north to Mozambique in the south. The total geothermal potential in this area is not known but estimates point to figures up to 14.000 MW. Countries are at very different stages in their geothermal development. Some, like Kenya, are already operating geothermal power plants while most of the countries are just beginning surface explorations and a few have not yet done comprehensive reconnaissance of likely geothermal locations. Most of the EARS countries lack detailed knowledge of the geothermal resources and in this context the project regards geothermal knowledge as a public good and aims to address chronic underinvestment in that field.

The demand for electricity in East Africa is assumed to grow rapidly in the coming years and decades, as these countries develop further. The 13 countries in the East Africa Rift Valley have a total population of about 340 million inhabitants. The present electricity consumption corresponds to around 6.600 MW, whereof only 216 MW is currently met by geothermal energy. A reasonable estimate of the total future need for electricity when these countries have reached developed country income levels, some decades from now, could be in the order of 340.000 MW.

All EARS countries suffer from low access to electricity. There are significant needs to provide better access in an environmentally sustainable manner. Each country requires additional electricity into its national grid as well as smaller, local solutions for increased electricity access in rural areas. Many of the countries are currently limited in their options, with polluting fossil fuel options being the easiest to implement, while more costly and less tested options in wind and solar energy are being explored as well.

Geothermal energy can, in appropriate locations, provide base load energy that is cost effective, based on proven technologies and low in emissions. In this context the project is in line with and contributes to the millennium development goal of environmental sustainability. The project will also contribute to the objectives of the Sustainable Energy for All initiative, of doubling the share of renewable energy in the global energy mix by 2030.

Even though a geothermal potential has been demonstrated, and the need for electricity is urgent, experience worldwide shows that severe barriers exist and frequently years pass without further action. These barriers for investors are mainly of three types: 1) High upfront investment costs, 2) drilling/reservoir risk and 3) long development time. Therefore, actions are needed to accelerate the development and mitigate and distribute the risk. This is the main rationale for the project described in this document.

## 3. The Geothermal Exploration Project

### 3.1 Main Objectives

The main objective of the overall partnership program, the **Geothermal Compact**, is to assist the East African Rift Valley countries to increase their renewable energy access through low emissions geothermal energy development. The ambition for an outcome is to see 200 MW of electricity or more added to the energy production in the EARS countries as a result of actions supported by the Compact within a time span of 7-15 years.

The main objective of the **Geothermal Exploration Project** is to contribute to the objectives of the Geothermal Compact by assisting all EARS countries in completing the exploratory phase of geothermal development and build capacity and expertise in the field of geothermal utilization and policy. The project support will extend up to (and possibly through) the stages of exploratory drilling, after which major infrastructure financing agents and/or commercial developers would step in to work with governments on further steps. An important aspect of the project includes support to the respective governments to move forward from positive exploration results and submit potential geothermal projects into funding pipelines for exploration drilling.

The specific objective (outcome) of the project is: *Enhanced geothermal knowledge and capacity that enables further actions on geothermal utilization in EARS countries.* The expected outputs are the necessary scientific data, reports and human resources to enable governments to take further actions on geothermal utilization. Where sufficient geothermal energy is discovered, such data will have significant market value in and of itself. Certain value is also attached in those cases where the explorations may eliminate fields previously thought to have potential. In both cases, an objective understanding of the geothermal potentials will be established in all participating countries, creating the necessary foundations for informed decisions regarding energy production.

### 3.2. Expected results (outputs)

#### 1. Scientific data and reports on geothermal resources

- 1.1. Reconnaissance studies conducted in respective EARS countries with recommendations for further action.
- 1.2. Geothermal explorations conducted and reported with recommendations for further actions.

#### 2. Improved and increased level of knowledge and capacity on geothermal utilization

- 2.1. Strengthened policy and legal framework for geothermal utilization.
- 2.2. Capacity building in the participating countries, including UNU-GTP.
- 2.3. Strengthened ability of development and financial institutions to engage and support the geothermal development process.

**3. Preparations for exploratory drilling are in place where applicable, including EIA, potential projects have entered funding pipelines.**

### 3.3. Project Strategy

A nine stage process is proposed for the geothermal development cycle discussed under the Geothermal Compact, which is a slight variation on the stages described in the World Bank Aide Memoire. The Geothermal Exploration Project will mainly cater to stages 1 and 2. If required, the project could potentially contribute towards stage 4 if funding allows. In parallel to the described stages the Project will offer financial support to parallel activities, mainly technical assistance and capacity building.

- Stage 1: Reconnaissance – Gathering of existing data
- Stage 2: Exploration
- Stage 3: Exploration drilling of 1-3 wells<sup>1</sup>
- Stage 4: Prefeasibility report
- Stage 5: Further drilling of wells – as needed
- Stage 6: Feasibility report
- Stage 7: Concept design and tender documents
- Stage 8: Detailed design and construction
- Stage 9: Testing, training and operations start-up

Based on geothermal reconnaissance studies and consultation in respective countries an appraisal will be conducted of the potential extent for further activities in the respective countries. A proposal for geothermal exploration may also be prepared on the basis of existing data and information, in cases where reconnaissance studies have previously been conducted. Such proposals will also be subject to an external appraisal. The preparatory process in each country includes the formulation of a project plan for geothermal exploration and capacity building.

The reconnaissance and explorations reports will be subject to appraisals by an external review panel of geothermal experts. Submitting reports and proposals to external review is expected to enhance the quality and relevance of the exploration work undertaken as well as the validity of the results.

Subject to positive exploration results at stage 2, it is also anticipated that considerable preparatory work for planning of exploratory drilling must take place in order to move potential projects into funding pipelines. This includes, institutional support, conducting an environmental and social impact assessment for the proposed exploration drill sites, submitting funding proposals to relevant financial institutions, and preparing drilling permits. It is anticipated that the exploration project will provide support towards these activities. Subsequent to positive exploration results, it is considered important to finalize all required preparations in order to facilitate a continuation to exploration drilling at stage 3.

To facilitate the drive towards the objectives of the Compact and the Exploration Project, the parties will provide financing and technical assistance to governments and their agencies, join hands in resource mobilization, and work together to strengthen the capacity within all participating institutions, for instance through the formation of a Community of Practice on geothermal

---

<sup>1</sup> In earlier outlines, e.g. the Aide Memoire between Iceland and the World Bank, stages 2 and 3 are presented as a single stage.

development, as outlined in the Aide Memoire from the World Bank. Parallel to the stages of geothermal exploration, the following activities, aimed at strengthening sector governance and capacity, will be carried out throughout the whole project period:

1. **Policy development and updates.** Legal and development framework for geothermal projects, business modeling, engagement of developers/sponsors, investors and financiers, with guidance from WB and technical support provided by the National Energy Authority of Iceland (OS) and other organizations.
2. **Capacity Building in the participating countries.** This includes training by UNU-GTP and other capacity building by the National Energy Authority of Iceland (OS). A geothermal human resource strategy should be prepared in each respective country which will guide these activities. The Reconnaissance study in each country will entail a human resource needs assessment. Regional capacity building efforts may also be considered for instance in cooperation with AUC and ARGeo.
3. **Strengthen the ability of development and financial institutions to engage and support the geothermal development process.** Various supporting initiatives will be launched, notably the creation of a Community of Practice on geothermal development for dialogue, learning and information sharing.

Parallel activities 1 and 2 focus on the partner countries in the EARS region, while parallel activity 3 is geared towards the external supporting agencies. It should be noted that USAID and the European Union are, separately, planning to offer technical assistance in Uganda and Rwanda that could overlap with some of parallel activities 1 and 2. Care will be taken to ensure activities are complementary and not overlapping.



Figure 1. Potential workflow of activities in the Geothermal Exploration Project.

### 3.4. Participating Countries

The 13 countries in the East Africa Rift Valley that this project covers are listed in table 1 together with an indication of the geothermal potential and the status of geothermal development in each country, based on an assessment report by ISOR for ARGeo.

While initial emphasis will be on assisting countries where full project development and financing appears more likely it is also considered important to address other countries in the initial stages. This will shorten the development time at a later stage, when international engagement options, including funding, may have changed for the better. Funding for geothermal exploration under the project is primarily geared towards areas which have not been designated as private concessions.

Table 1 shows the status of various EARS countries in their geothermal development. It outlines the current estimated potential in the country and the next relevant steps in the chain from reconnaissance to operations (marked with an X). ARGeo membership is indicated with an A in column A and whether it has a bilateral program with Iceland with an I in column B. NDF presence is indicated in column C.

Countries	Stages			Potential	1	2	3	4	5	6	7	8	9
	A	B	C		Recon.	Exploration	Exploration drilling	Pre-feasibility	Drilling	Feasibility	Design	Constr.	Operation
1 Eritrea	A			High	X	X							
2 Djibouti	A			High	X	X	X	X					
3 Ethiopia	A		N	High	X	X	X					X	X
4 Uganda	A	I	N	Med	X	X							
5 Kenya	A		N	High	X	X	X		X	X	X	X	X
6 Rwanda			N	Med/ High	X	X		X					
7 Burundi				Med	X								
8 Tanzania	A		N	Med	X	X							
9 Zambia			N	Low/ Med	X	X							
10 Malawi		I	N	Low/ Med	X								
11 Mozambique		I	N	Low	X								
12 Congo				Unknown									
13 Comoros				Low/ Med	X								

**Table 1. Status of EARS countries in geothermal development.**

Two of the countries, Ethiopia and Kenya, already have geothermal plants in operation while at the same time there are undeveloped areas in both countries. Two other countries, Djibouti and Rwanda, are well on way towards the drilling stage. Most of the other countries are at the very beginning, either at Stage 1 (Reconnaissance) or Stage 2 (Exploration).

### 3.5. Participating agencies and potential partners

The Geothermal Compact and the Exploration Project envision a cooperation of several partners. In the table below the main agents are shown as well as the anticipated role of each agent. The core partnership concerning this project includes the World Bank, ICEIDA and NDF – in dialogue with the African Union and ARGeo, with input regarding training and capacity building from UNU-GTP and OS. The World Bank provides the overall leadership for the Geothermal Compact. In the countries in

which the World Bank has ongoing energy sector dialogue, implementation of the Geothermal Exploration Project will be aligned with this dialogue. The main actors and their role in geothermal development in the region are summarized in table 2 below.

Agents	Roles	Stages								
		1	2	3	4	5	6	7	8	9
		Recon.	Exploration	Exploration drilling	Pre-feasibility	Drilling	Feasibility	Design	Constr.	Operations
African Union	Political Guidance	X	X	X	X	X	X	X	X	X
ARGEO	Facilitator and coordin.	X	X	X	X	X	X	X	X	X
World Bank	Funding			X	X	X	X	X	X	X
MFA Iceland	Facilitator and funding	X	X	X	X					
ICEIDA	Lead agency Exploration	X	X		X					
NDF	Funding	X	X	X	X					
UNEP	Technical Assistance					X	X	X	X	X
OFID	Funding					X	X	X	X	X
BADEA	Funding					X	X	X	X	X
KfW	Funding					X	X	X	X	X
Other funds	Funding					X	X	X	X	X
BGD	Geological research	X	X	X	X					
IEA Iceland	Framework and capacity	X	X	X	X	X	X	X	X	X
UNU-GTP	Capacity building	X	X	X	X	X	X	X	X	X

Table 2. Main agents in the East Africa Rift Valley geothermal development.

### 3.6. Cross cutting issues

In accordance with NDF and ICEIDA policies, attention shall be paid to environmental and social aspects such as gender, land rights, resettlement issues and HIV/AIDS, during the planning and implementation phase of the project. These issues will also be given special consideration in the planning of policy level support.

## 4. Implementation

### 4.1. Organization and administration

ICEIDA will be the Lead Agency for NDF’s participation and provides administrative and technical oversight and management. Iceland has a well-established role in geothermal expertise and capacity building. This includes ICEIDA’s previous support to geothermal development regionally in East Africa and in particular countries. The cooperation between ICEIDA and NDF is based on joint co-financing, with each agency primarily financing costs in specific countries, but under a joint program. ICEIDA and NDF have entered into an agreement covering all relevant aspects of the cooperation, including, administration, financial and institutional arrangements, evaluation and procurement procedures.

Subsequent to an expression of interest from the respective countries, ICEIDA will meet with the relevant authorities and jointly assess the potential for engagement. Implementing agencies/authorities in the respective countries will be identified on a country to country basis. ICEIDA will enter into a cooperation agreement with the respective governments regarding the project support.

The project will be implemented in line with the Paris Declaration for Aid Effectiveness, and care will be taken that activities are complementary, not overlapping with other initiatives in the field of geothermal development. ICEIDA will undertake full coordination with other key stakeholders, such as AU and ARGeo, for instance through the provision of progress reports and participation in coordination and consultation meetings. ICEIDA has already participated in a collaboration meeting for development partners in geothermal development organized by the KfW in August 2012, where the importance of consultation and coordination among partners was highlighted.

Dialogue with, and guidance from, the chosen coordination platform among beneficiary countries will be given high priority. This includes cooperation and coordination with the AU and ARGeo. Good cooperation will also be sought with other agencies providing support, including KfW, BGR, UNEP, USAID and EDF.

## **4.2. Institutional arrangements**

All activities and implementation of the project will be demand-driven. Governments and/or appropriate geothermal authorities will be invited to express interest for support under the project. ICEIDA will be responsible for all legal and contractual arrangements with the involved governments. A process on engagement for interested EARS countries is established, including the process of seeking support from the Exploration Project and contractual formalization of exploration activities in each country. All approvals of requests for activities in stage 2 will be decided on in cooperation between ICEIDA and NDF, with NDF retaining a no-objection right.

ICEIDA will be the Lead Agency for the Geothermal Exploration Project, which will be the financial source for stages 1 to 2 – with possible extension into stage 4. ICEIDA will finance stage 1, reconnaissance, activities in all participating countries, while both NDF and ICEIDA will finance activities in stage 2, exploration.

The NDF financing will be directed to exploration in its cooperation countries. NDF funding will be the first option for activities in countries in NDF eligible countries. ICEIDA will provide financing for those countries where NDF cannot engage in and/or join as needed in the other countries.

In the stages following exploration the World Bank is expected to take over as the lead in mobilizing funding, in countries where the World Bank is having an ongoing energy sector dialogue, including through IDA and IFC resources, but also seeking engagement with other institutions, including OFID, BADEA and KfW.

The parallel activities will for the most part be funded by both NDF and ICEIDA. Decisions on financing for parallel activities will be done in consultation between NDF and ICEIDA, with NDF retaining a no-objection right to all such financing through its funding.

## **4.3. Reporting, audits and evaluation**

ICEIDA will provide NDF and the World Bank with bi-annual progress reports for all activities under the Geothermal Exploration Project, and will also furnish such additional information as the parties may reasonably request.

The project will be subject to financial audit by the Icelandic State Auditor in accordance with IFAC standards. The annual audited accounts of ICEIDA will be provided to NDF accordingly.

ICEIDA and NDF shall meet at least annually for discussions and to review progress. ICEIDA, NDF and WB will agree on a consultation process for the Geothermal Exploration Project and its linkages with the Geothermal Compact. An external mid-term evaluation of the project is scheduled 2014/15. A final evaluation of the project shall be conducted in 2018.

#### **4.4. Procurement**

Activities in stage 1 will follow ICEIDA's procurement rules and guidelines. Activities in phase 2 will be procured through international competitive bidding (or, alternatively, through bidding within the European Economic Area, as EEA rules stipulate for contracts of this size). Activities funded by ICEIDA will follow ICEIDA's rules and guidelines. Activities funded jointly by ICEIDA and NDF will follow NDF's rules and guidelines.

**Stage 1 - Reconnaissance.** Contracts for each reconnaissance study are estimated not to exceed 100.000 USD in each country.

**Stage 2 – Geothermal Exploration.** The geothermal exploration stage, subject to positive results of reconnaissance studies, is estimated at around USD 1 million in each country. It is expected that there will be one consultancy contract per country covering all exploration activities, subject to international competitive bidding. The procurement may be carried out by the respective governments, with technical support provided, or by ICEIDA, as the circumstances call for. In either instance, the procurement process shall be in line with ICEIDA and/or NDF rules and guidelines.

**Parallel Activities.** The parallel activities will for the most part be carried out within an institutional agreement with the UNU-GTP and the National Energy Authority of Iceland. Additional contracts which may be required to carry out these activities will follow NDF's and/or ICEIDA's guidelines.

### **5. Project Time Plan**

The development of geothermal energy takes long time. Geological, geophysical and geochemical research must be carried out and several exploration wells drilled before the main drilling takes place, see description of stages 1-4 in Annex 3. The total program horizon for the Geothermal Compact in each country is estimated to be 7 years from the first reconnaissance steps until start-up of operations, subject to geothermal potential. The table below gives an overview of this process, with major milestones for the Geothermal Compact marked with an X.

While the time plan for stages 1 and 2 may only take a couple of years for a single country, ICEIDA and NDF expect the overall timeframe of the Geothermal Exploration Project to be up to 5 years. It is estimated that reconnaissance studies may commence in 2-3 countries each year for the first 3 years of the project, with subsequent activities to follow, as the case may be. It is also assumed that in certain countries, where prior reconnaissance studies have taken place, that exploration could commence directly. An indicative timetable for the exploration project is outlined in table 4.

Stages	Years	1	2	3	4	5	6	7
1	Reconnaissance	■						
2	Exploration		■					
3	Exploration drilling			■				
4	Prefeasibility				X			
5	Further drilling					■		
6	Feasibility						X	
7	Design/Tender						■	
8	Construction							■
9	Operations							X

Table 3: Estimated time plan for geothermal development under the Geothermal Compact

Years	1	2	3	4	5
Country 1	1	2	2.a		
Country 2	1				
Country 3	1	2	2		
Country 4	2	2	2.a		
Country 5	2	2	2.a		
Country 6		1	2	2.a	
Country 7		1	2	2	2.a
Country 8			1	2	2.a
Country 9			1	2	2
Country 10				1	2

Table 4: Indicative time plan for the implementation of the Geothermal Exploration Project. (2.a represents the preparatory stage for exploration drilling, including, EIA and preparations of funding applications.)

As discussed in section 4 above, parallel activities will be carried out throughout the whole 5 years program horizon. Capacity building and policy support is expected to commence after reconnaissance has taken place in each country.

## 6. Preliminary Cost Estimates

Geothermal investments are subject to great uncertainties. The outcome geothermal exploration or well drilling is never foreseen and the number of wells that are needed can vary much. Conditions can be very different from one geothermal area to another. Significant research and drilling expenses can result in a conclusion that a chosen field is not viable for further development. The cost estimates in this document are for the Geothermal Exploration Project – but an illustrative cost scenario for the broader Geothermal Compact is also provided in Annex 2 for information purposes.

### 6.1. Cost estimates for the Geothermal Exploration Project

It is assumed that under the Geothermal Exploration Project, stage 1 activities, reconnaissance, will be carried out in 10 EARS countries. An estimated total cost for these activities will be USD 1 million. Following that, it is estimated that activities under stage 2, explorations, will be carried out in 9 countries, under the assumption that in one of the countries reconnaissance will reveal insufficient geothermal potential to warrant investments in further explorations. The average exploration cost per country is estimated at USD 1 million, with a total of USD 9 million for the 9 countries.

The cost of responding to requests for technical assistance and capacity building in relation to parallel activities is estimated at additional USD 2 million. Other project related costs including management and administration are estimated at around USD 1 million.

The total cost of the Exploration Project would thus come to an estimated USD 13 million. While the unit costs in reconnaissance and exploration are reasonably well known the total costs are quite uncertain as they are the result of a) demand from individual governments and b) the outcome of stage 1 reconnaissance work in individual countries for the total number of stage 2 explorations that will be performed. The cost estimates should therefore be seen as a framework and an upper limit of available financing.

ICEIDA and NDF will each contribute up to USD 6.5 million (EUR 5 million). ICEIDA has approved funding for the project, with customary reservations regarding annual budgetary allocations for the agency. The Board of NDF has approved funding for EUR 5 million for the project.

## 7. Risks

Negative exploration results: As stated earlier, geothermal exploration is a probability activity. While all EARS countries have known potential, the most obvious sites, e.g. those in Kenya and Ethiopia, may already have been identified and explored. In this project the focus is on secondary potential countries and sites. It must, therefore, be contemplated that in some of the countries the results may be negative. That outcome has, nevertheless, a certain value as it removes uncertainty and allows energy planning to move forward at a more informed level.

Financing: While NDF can with certainty approve funding for the entire project, ICEIDA is bound by annual budgetary allocations from the Icelandic Parliament. Recent history, in which very significant cuts were made in funding for the agency, makes this risk a real one. In response commitments of funding will have to be made with the necessary reservations about available funding.

Rights and privileges agreements: Iceland has a general cooperation agreement with only a few of the EARS countries which are expected to benefit from the project. Agreements on the rights and privileges of those who implement the project in individual countries will, therefore, have to be negotiated at the project level with those countries where Iceland does not have an agreement. While it can generally be expected that countries will be forthcoming, it is conceivable that an agreement will not be reached in all cases. In those countries support would not be provided.

Project complexity: The Geothermal Exploration Project is somewhat complex as it comprises several small projects in separate countries, which means the involvement of several authorities in different countries and several different implementing agencies (which have not yet been identified). It is, however, expected that ICEIDA as lead agency can manage this complexity with several years of experience of working with geothermal energy in the EARS region. It is also envisioned that the ARGeo cooperation and/or AU may provide a regional collaboration platform, through which activities can be coordinated. Some support for strengthening the coordinating capacity of ARGeo may be considered. Furthermore, the project will not commence in all countries at the same time, this will, among other things, depend on when and if the project receives requests for support from the participating countries.

*Donor coordination:* There are several planned and on-going geothermal activities in the EARS region. For example the German KfW Development Bank and the African Union have developed a Geothermal Risk Mitigation Facility for surface studies and exploratory drillings in East Africa. ICEIDA has already been in contact with KfW to ensure that activities are complementary and not overlapping. The project will furthermore seek good cooperation and coordination with other agencies supporting similar exploration activities in the region, for example, UNEP, USAID, EUEI PDF, the Federal Institute for Geosciences and Natural Resources (BGR), Chinese drilling companies and the Geothermal Development Company of Kenya.

## **8. Conclusion**

The Geothermal Exploration Project is the initial phase of the Geothermal Compact partnership program, initiated jointly by Iceland and the World Bank. The main objective of the Geothermal Compact program is to assist the East African Rift Valley countries increase their access to green and renewable energy through geothermal energy development. The Geothermal Exploration Project aims at assisting all EARS countries in completing the reconnaissance and exploratory stages of geothermal development and build the related capacity. The project will thus contribute to the overall objective of the Geothermal Compact. At the end of the project it is expected that: 1) All participating countries have a realistic assessment of potential geothermal sites, 2) plans for further action where applicable, and 3) capacity to move forward on the basis of those plans and submit exploration drilling projects into funding pipelines.

The Geothermal Compact program has been presented here as a nine stage process, ranging over a seven years horizon, from reconnaissance and exploration to construction and operations start-up. The importance and necessity of this program is evident. Even though a geothermal potential has been demonstrated in the EARS countries, and the need for electricity is urgent, experience worldwide shows that severe barriers exists and frequently delay actions for many years. These barriers for investors are mainly of three types: 1) High upfront investment costs, 2) drilling/reservoir risk and 3) long development time.

Three activities of importance, on which action is lagging in most EARS countries or in supporting institutions, have been outlined: 1) establishing a policy, legal and geothermal development framework in each country, 2) building up capacity and expertise in the field of geothermal utilization and related policy, and 3) strengthening the capacity of supporting institutions. These activities will be carried out in parallel during the 5 year span of the Geothermal Exploration Project.

The Geothermal Exploration Project will help finance the early stages of the Geothermal Compact partnership program; the stages leading up to significant exploration drilling, thus reducing the initial risks. The World Bank has already indicated their willingness to raise additional support for the next stages, hence it is expected that the outcome of the exploration activities will lead to further geothermal investments in the EARS countries, increasing their use of renewable energy in the long run.

## Annex 1 – Logical Framework Matrix

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Assumptions/Risks
<b>Overall Objective (Impact) (Geothermal Compact)</b>			
Increased access to renewable energy through low emissions geothermal energy development in East African Rift Valley countries.	<ul style="list-style-type: none"> <li>• 200 MWs of geothermal energy produced in „EARS“ countries as a result of activities under the Geothermal Compact (10-15 years).</li> </ul>	<ul style="list-style-type: none"> <li>• Installed capacity of geothermal power plants.</li> </ul>	
<b>Specific Objective (Outcome) (The Geothermal Exploration Project)</b>			
Enhanced geothermal knowledge and capacity enables further actions on geothermal utilization in EARS countries. <i>(Completing the exploratory phase of geothermal development)</i>	<ul style="list-style-type: none"> <li>• Plans in place (drill permits prepared) for exploratory drilling in (4-7) respective countries.</li> <li>• Funding proposals submitted to relevant financial institutions for exploratory drilling in (4-7) countries.</li> </ul>	<ul style="list-style-type: none"> <li>• Documentation for drilling permits</li> <li>• Funding applications</li> </ul>	<ul style="list-style-type: none"> <li>• Requests for assistance</li> <li>• Agreements for rights and privileges</li> <li>• Geothermal potential</li> <li>• Favorable funding policies</li> <li>• Political commitment for geothermal energy development</li> <li>• Political stability</li> </ul>
<b>Expected Results (Outputs)</b>			
<b>1. Scientific data and reports on geothermal resources produced.</b>			
1.1. Reconnaissance studies conducted in respective EARS countries with recommendations for further action.	<ul style="list-style-type: none"> <li>• Reconnaissance reports with recommendations on further studies.</li> <li>• External appraisals</li> </ul>	<ul style="list-style-type: none"> <li>• Final reports for Reconnaissance studies</li> <li>• Appraisal</li> </ul>	<ul style="list-style-type: none"> <li>• Requests made for assistance</li> <li>• Required research permits available</li> </ul>
1.2. Geothermal explorations conducted and reported.	<ul style="list-style-type: none"> <li>• Exploration report with recommendations on potential exploration drill sites, if warranted.</li> <li>• External appraisals</li> </ul>	<ul style="list-style-type: none"> <li>• Exploration reports</li> <li>• Appraisal</li> </ul>	<ul style="list-style-type: none"> <li>• Positive results from Reconnaissance study</li> </ul>
<b>2. Improved and increased level of knowledge and capacity on geothermal utilization.</b>			
2.1. Strengthened policy and legal framework for geothermal utilization in respective countries.	<ul style="list-style-type: none"> <li>• Updated policy and legal framework for geothermal utilization in each country.</li> </ul>	<ul style="list-style-type: none"> <li>• Updated policy and regulations.</li> </ul>	<ul style="list-style-type: none"> <li>• Political will and support for geothermal energy development.</li> </ul>
2.2. Capacity building in the participating countries, including UNU-GTP training.	<ul style="list-style-type: none"> <li>• # number of participants trained by the UNU-GTP (by country, gender, field, and level of training).</li> </ul>	<ul style="list-style-type: none"> <li>• Training reports, diplomas, papers published.</li> </ul>	<ul style="list-style-type: none"> <li>• Human resources with required qualifications are available.</li> </ul>

2.3. Strengthened ability of development and financial institutions to engage and support the geothermal development process.	<ul style="list-style-type: none"> <li>• Community of Practice is in place.</li> <li>• Amount of funding available for geothermal explorations/drilling.</li> </ul>	<ul style="list-style-type: none"> <li>• Funds available for geothermal development</li> </ul>	<ul style="list-style-type: none"> <li>• Willingness of agencies and institutions to engage in dialogue regarding geothermal development.</li> </ul>
<b>3. Preparations for exploratory drilling are in place.</b>			
3.1. Environmental and Social Impact Assessment conducted for exploratory drill sites where applicable.	<ul style="list-style-type: none"> <li>• EIA report produced</li> </ul>	<ul style="list-style-type: none"> <li>• EIA reports</li> </ul>	<ul style="list-style-type: none"> <li>• Exploration work has identified areas viable for exploration drilling.</li> </ul>
3.2. Applications in place for exploration drillings	<ul style="list-style-type: none"> <li>• Exploration drill permits prepared</li> <li>• Funding applications prepared</li> </ul>	<ul style="list-style-type: none"> <li>• Drill permits</li> <li>• Funding applications submitted</li> </ul>	<ul style="list-style-type: none"> <li>• Geothermal potential</li> </ul>
<b>Activities and processes</b>	<b>Input</b>	<b>Means of Verification</b>	<b>Assumptions</b>
<b>1. Geothermal explorations</b>			
<b>1.1. Reconnaissance studies</b>			
1.1.1. Introduction of the program to respective governments and authorities.	<ul style="list-style-type: none"> <li>• ICEIDA/NDF/WB/MFA/ARGeo</li> </ul>	Official letters	Expressed interest from respective countries.
1.1.2. Request/expression of interest	<ul style="list-style-type: none"> <li>• Respective country</li> </ul>	Letter	
1.1.3. Reply to request	<ul style="list-style-type: none"> <li>•</li> </ul>	Letter	
1.1.4. Delegation visit to respective country for further discussions and preparations.	<ul style="list-style-type: none"> <li>• ICEIDA (NDF/WB)</li> <li>• ARGeo</li> </ul>	Mission report	
1.1.5. Agreements made with respective governments for support.	<ul style="list-style-type: none"> <li>• ICEIDA</li> </ul>	Agreement	
1.1.6. Delineation of Reconnaissance study and preparation of Term of Reference.	<ul style="list-style-type: none"> <li>• Respective government/ICEIDA</li> </ul>	ToR	
1.1.7. Inception meetings for reconnaissance studies	<ul style="list-style-type: none"> <li>• ICEIDA, Consultants, Respective governments</li> </ul>	Meeting minutes	
1.1.8. Reconnaissance studies carried out	<ul style="list-style-type: none"> <li>• Consultants</li> </ul>	Report	
1.1.9. Debriefing for reconnaissance	<ul style="list-style-type: none"> <li>• Consultant, local agency, ICEIDA</li> </ul>		
1.1.10. Appraisal of findings.	<ul style="list-style-type: none"> <li>• External reviewers</li> </ul>	Appraisal report	
1.1.11. Consultation, present findings and discuss appraisal	<ul style="list-style-type: none"> <li>• ICEIDA, Respective government</li> </ul>	Meeting minutes	
1.1.12. Decision on further work	<ul style="list-style-type: none"> <li>• ICEIDA/NDF</li> </ul>	Minutes	
1.1.13 ToR for preparation of project plan	<ul style="list-style-type: none"> <li>• ICEIDA</li> </ul>	ToR	
1.1.14. Preparation of project plan for sub-project in each country	<ul style="list-style-type: none"> <li>• Respective governments Consultants</li> </ul>	Project plan	
<b>1.2. Geothermal Exploration</b>			
1.2.1. Procurement documents for exploration prepared in each country.	<ul style="list-style-type: none"> <li>• Respective government/ICEIDA/Consultants</li> </ul>	<ul style="list-style-type: none"> <li>• Procurement documents</li> </ul>	
1.2.2. International competitive bidding for explorations in each country and selection of consultants.	<ul style="list-style-type: none"> <li>• Respective government/ICEIDA/NDF/Consultants</li> </ul>	<ul style="list-style-type: none"> <li>• Advertisement</li> </ul>	
1.2.3. Inception meeting for geothermal exploration	<ul style="list-style-type: none"> <li>• Consultants, ICEIDA, Exploration consultants</li> </ul>	<ul style="list-style-type: none"> <li>• Meeting minutes</li> </ul>	
1.2.4. Geothermal explorations conducted	<ul style="list-style-type: none"> <li>• Consultants - explorations</li> </ul>	<ul style="list-style-type: none"> <li>• Progress reports</li> </ul>	
1.2.5. Monitoring of quality and progress of exploration	<ul style="list-style-type: none"> <li>• Consultants</li> </ul>	<ul style="list-style-type: none"> <li>•</li> </ul>	
1.2.6. Exploration report finalized with	<ul style="list-style-type: none"> <li>• Consultants - explorations</li> </ul>	<ul style="list-style-type: none"> <li>• Exploration report</li> </ul>	

recommendations on potential exploration drilling if warranted.			
1.2.7. Appraisal of exploration report	<ul style="list-style-type: none"> <li>External reviewers</li> </ul>	<ul style="list-style-type: none"> <li>Appraisal report</li> </ul>	
1.2.8. Consultation, findings presented and decisions on further actions.	<ul style="list-style-type: none"> <li>Respective government/ICEIDA/NDF</li> </ul>	<ul style="list-style-type: none"> <li>Meeting minutes</li> </ul>	
<b>2. Improved and increased level of knowledge and capacity on geothermal utilization.</b>			
2.1.1. Geothermal policy and regulatory review conducted in each country.	<ul style="list-style-type: none"> <li>Consultants/OS</li> <li>AUC, ARGeo</li> </ul>	<ul style="list-style-type: none"> <li>Policy Review report</li> </ul>	
2.1.2. Preparation of plans for appropriate support at the policy level.	<ul style="list-style-type: none"> <li>Consultants/OS</li> <li>AUC, ARGeo</li> </ul>	<ul style="list-style-type: none"> <li>Report</li> </ul>	
2.1.3. Support to policy and regulatory development according to plans.	<ul style="list-style-type: none"> <li>Consultants/OS</li> <li>AUC, ARGeo</li> </ul>	<ul style="list-style-type: none"> <li>Progress reports</li> </ul>	<ul style="list-style-type: none"> <li>Political commitment for geothermal development</li> </ul>
<b>2.2. Capacity building</b>			
2.2.1. Needs assessment conducted for geothermal capacity building in respective countries.	<ul style="list-style-type: none"> <li>Consultants</li> <li>UNU-GTP, OS</li> <li>ARGeo</li> </ul>	<ul style="list-style-type: none"> <li>Needs assessment report</li> </ul>	
2.2.2. Geothermal human resource strategy prepared in each country.	<ul style="list-style-type: none"> <li>Consultants</li> <li>UNU-GTP, OS</li> <li>ARGeo</li> </ul>	<ul style="list-style-type: none"> <li>Human resource strategy</li> </ul>	
2.2.3. Identification of suitable candidates for the UNU-GTP and registration.	<ul style="list-style-type: none"> <li>UNU-GTP</li> </ul>	<ul style="list-style-type: none"> <li>Diplomas and degrees awarded to participants (Gender based)</li> </ul>	
2.2.4. Based on human resource strategy, local training courses planned and carried out accordingly.	<ul style="list-style-type: none"> <li>UNU-GTP</li> <li>OS</li> <li>AUC, ARGeo</li> </ul>	<ul style="list-style-type: none"> <li>Training reports</li> </ul>	
<b>2.3. Strengthen the ability of development and financial institutions to engage and support geothermal development.</b>			
2.3.1. Presentation of program activities at meetings and seminars.	<ul style="list-style-type: none"> <li>ICEIDA/MFA/WB</li> </ul>	<ul style="list-style-type: none"> <li>Progress reports</li> </ul>	
2.3.2. Establish geothermal community of practice.	<ul style="list-style-type: none"> <li>ICEIDA/MFA/WB</li> </ul>		
2.3.3. Introduce program activities and plans for finance and development institutions.	<ul style="list-style-type: none"> <li>ICEIDA/MFA/WB</li> </ul>	<ul style="list-style-type: none"> <li>Progress reports</li> </ul>	
2.3.4. Hold collaboration meetings with relevant/potential stakeholders. Present findings and updates.	<ul style="list-style-type: none"> <li>ICEIDA/NDF/MFA</li> </ul>	<ul style="list-style-type: none"> <li>Meeting minutes/reports</li> </ul>	
2.3.5. Status and updates/ briefs disseminated to relevant/potential stakeholders.	<ul style="list-style-type: none"> <li>ICEIDA</li> </ul>	<ul style="list-style-type: none"> <li>Briefs disseminated</li> </ul>	
<b>3. Preparation for exploration drilling in place</b>			
3.1.1. EIA produced for exploration drilling sites, if applicable.	<ul style="list-style-type: none"> <li>Consultants</li> </ul>		<ul style="list-style-type: none"> <li>Exploration studies have identified potential exploration drill sites.</li> </ul>
3.2.1. Plan prepared to enter funding pipelines for exploration drilling.	<ul style="list-style-type: none"> <li>Respective governments, consultants</li> </ul>	Documentation	
3.2.2. Permits for exploration drilling prepared.	<ul style="list-style-type: none"> <li>Respective government/Consultants</li> </ul>	<ul style="list-style-type: none"> <li>Drilling plans and permits</li> </ul>	<ul style="list-style-type: none"> <li>Exploration studies have identified potential exploration drill sites.</li> </ul>
3.2.3. Funding applications for exploration drilling prepared.	<ul style="list-style-type: none"> <li>Respective government/Consultants</li> </ul>	<ul style="list-style-type: none"> <li>Funding applications</li> </ul>	

**Annex 2: An illustrative cost scenario for the Geothermal Compact**

The following cost scenario for activities supported by the Geothermal Compact should be regarded as preliminary rough averages, and mainly for demonstration purposes. The great variability and uncertainty should be kept in mind. Partly therefore, it has been found sensible to maintain cost estimations at a multi-country level, in order to even out such variations.

The estimates are based on the following general assumptions:

The total investment cost including exploration and drilling (but not the parallel activities) for a 50 MW geothermal plant is assumed to be 3,8 MUSD/MW installed.

Similar figure for a 10 MW plant is 5,3 MUSD/MW and for 5 MW plant 6,2 MUSD/MW. For very small plants, e.g. in the 1 MW vicinity, the costs per MW would be correspondingly higher, possibly in the 10 MUSD/MW. As this shows, investment costs per installed MW increase significantly as the effectiveness of the source falls. The distribution of these costs over the 9 stages is outlined as follows:

1	2	3	4	5	6	7	8	9
Reconn	Explor	Explor	Prefeas	Drilling	Feasib	Concept	Constr	Op Start
<b>0,04%</b>	<b>0,52%</b>	<b>7,31%</b>	<b>0,10%</b>	<b>39,16%</b>	<b>0,10%</b>	<b>0,16%</b>	<b>52,21%</b>	<b>0,39%</b>

**Table 5: Assumed development cost distribution (50MW plant):**

Even if Reconnaissance (stage 1) is carried out in all EARS countries, there is no guarantee that this activity will lead to a decision to move to stage 2, Exploration. Similarly, after Exploration, there is no certainty that activities will proceed to Exploration Drilling. The criterion which form the basis of the cost scenario presented here are is as follows:

- Stage 1, Reconnaissance is carried out in 10 of countries.
- 9 countries continue to Exploration in stage 2.
- On basis of the results of the exploration, stage 3 Exploration Drilling and stage 4 Prefeasibility Study is done in 7 of the countries.
- Stage 5 Production Drilling is started in 6 countries leading to the final result that 4 countries end with a 50 MW geothermal power plant running, one with 10 MW and one with 5 MW.

This scenario for the Geothermal Compact would end with 215 MW installed in 6 countries after 7-15 years, which would double the geothermal electricity production in the EARS region. The total preliminary cost estimate of this Geothermal Compact Scenario is around USD 870 million (not including the parallel activities, which would not change the overall cost estimates notably). Assuming that the Exploration Project leads to the presented scenario investments of close to \$ 900 million, the leverage ratio would be 90 to 1.

Smaller plants, including 1 MW or smaller, my well be a part of the outcome. This investment option has not been investigated. Analysis of this option in comparison with other renewable energy choices, including wind and solar, could be carried out as a part of this project.

## **Annex 3 – Description of the 9 stages of geothermal development**

### **Stage 1: Gathering of existing data/ Reconnaissance**

Geothermal and other available information is collected, including information on geology, geophysics and geochemistry of the presumed resource, including but not limited to:

- Study of the available information on the geothermal field, reservoir assessment, characteristics of existing wells etc.
- Chemical analyses of the fluid from surface manifestations and wells if available.
- Gathering of all maps, reports and literature regarding the presumed geothermal field.
- Outline which data are missing and which additional (existing) data are to be obtained.
- Site visit for first estimate of the field and meetings with local scientists for additional information.
- Recommendations for further exploration and/or drilling

### **Stage 2: Exploration**

In the exploration stage a research program is carried out as follows:

- Geological, geothermal and structural mapping.
- Chemical analyses and interpretation of fluids from the geothermal springs and fumaroles.
- Surface geophysical methods including TEM (Time Domain Electromagnetics) and MT (Magnetotellurics) resistivity survey, micro seismic studies, gravity measurements etc.
- Environmental Impact Assessment for exploratory drilling if applicable 3

### **Stage 3: Exploration drilling of 1-3 exploration wells**

- Designing, siting, supervision and the drilling of 1-3 exploration wells. Sampling and well testing.
- Volumetric assessment of presumed resource.

### **Stage 4: Prefeasibility report**

The prefeasibility report will be based on evaluation of existing data and includes:

- Evaluation of field capacity.
- Basic process design, i.e. flash turbine and/or binary.
- Treatment of the geothermal fluid and recommended field operation.
- Preliminary cost estimate for the investment and operational costs and cost pr. kWh delivered to the grid.
- Environmental impact study for further drilling
- Recommendations for next step

### **Stage 5: Further drilling of wells**

The location and number of additional exploration/confirmation wells will be based on recommendations from the pre-feasibility report.

- Exploration/confirmation well design and a test procedure for each well to be presented.
- Drilling, testing and evaluation of test results.

### **Stage 6: Feasibility report**

The feasibility report includes:

- Evaluation of field capacity.
- Process design, i.e. process flow, instrumentation and control diagram (PF&ID).
- Control system will be specified.
- All main equipment will be specified.
- Cost estimate for investment and operational cost and cost pr. kWh delivered to the grid.
- Environmental impact report for the project.
- Recommendations for next step.

### **Stage 7: Concept design and tender documents**

Drawings and documents of this stage include:

- Layout drawings of steam gathering systems, separators, power plant and reinjection system.
- Specification and tender documents for main equipment including control system, eventually EPC (Engineering, Procurement and Construction) contract.
- Design of production- and reinjection wells
- Specification and tender documents for drilling of production and reinjection wells.

### **Stage 8: Detail design and construction**

- Detail design based on concept design
- Supervision of detail design
- Tender documents for civil construction
- Production drilling
- Supervision of drilling
- Manufacturing, delivery and installation of equipment
- Civil construction
- Supervision of construction

### **Stage 9: Testing, training and operations start-up**

- The system is tested to specification from equipment manufactures.
- The power plant is started up (commissioned) and starts producing energy to the grid.
- Training of operators of the plant during the first weeks/months of operation.

While the above describes a common division into stages and sequence, there may be variations and a different delineation might be applicable in individual countries. Further description of requirements in each country and the sequencing involved may be described in a Project Document prepared for planned activities in each country.

#### **Annex 4: Short note on the history of cooperation between Iceland and East Africa**

The history of utilization of geothermal energy in Iceland goes back to 1930 when the first houses in Reykjavik were heated this way. Today more than 90% of houses in Iceland are heated with geothermal hot water, and around 26% of Iceland's electricity is generated from geothermal sources. Iceland has for a long time played a leading role in the world in geothermal expertise and capacity building. In 1979 The Geothermal Training Programme of the United Nations University (UNU-GTP) was established and located in Iceland.

The Icelandic International Development Agency ICEIDA is presently operating bi-laterally in three African countries, Malawi, Mozambique and Uganda. Besides, the Icelandic Ministry of Foreign Affairs (MoFA) has multi-lateral cooperation with a number of agencies and countries. The following list of examples of activities gives an idea of the involvement of Iceland in geothermal development programs in East Africa in the past:

- Reconnaissance study of geothermal sources in Burundi was carried out by Icelandic geoscientists from the Icelandic Energy Authority IEA in 1982.
- ICEIDA facilitated in 1990-1992 financial and technical support through UNDP for a study of geothermal possibilities in Kenya and Uganda.
- Prefeasibility studies of three prospect geothermal areas in Uganda, Katwe, Buranga and Kibiro in Uganda by ICEIDA 2004-2008.
- Professional training and provision of equipment for geothermal research to the government of Uganda, ICEIDA 2004 – 2008.
- Technical and financial support to the ARGeo project, ICEIDA 2005-2011.
- Compilation of a report on geothermal sources, status of exploitation, human resources and equipment inventory in a custom built web-based database in ten EARS countries through ARGeo, ICEIDA, 2010-2011.
- Geothermal research in í Alid in Eritrea, facilitated by ARGeo and carried out by ISOR, Iceida, 2008.
- 400+ geothermal professionals from developing countries trained through the UNU-GTP in 33 years of operation.

## **Annex 5: Geothermal Development in Africa - Iceland and World Bank Cooperation: *Aide Memoire: November 3, 2011***

**Geothermal Development in Africa**  
Iceland and World Bank Cooperation  
*Aide Memoire: November 3, 2011*

A Geothermal Learning and Partnership Mission from the World Bank visited Reykjavik from October 31 to November 3, 2011. The mission led by S. Vijay Iyer, Director Sustainable Energy, comprised Messrs. Fridrik Jonsson, Advisor to the Executive Director, World Bank (Nordic and Baltic countries), Magnus Gehringer, Sr. Energy Specialist, ESMAP, World Bank; Raihan Elahi, Somin Mukherji and Paul Baringanire (Sr. Energy Specialists, Africa Energy, World Bank); and Pascal Ndayishimiye, Director, REGIDESO Burundi. The Icelandic delegation led by Benedikt Höskuldsson, Head of Energy, MFA comprised Hermann Örn Ingólfsson, Director General for International and Security Affairs and for International Development Cooperation, Engilbert Guðmundsson, Director General, the Icelandic International Development Agency, (ICEIDA), Guðni A. Jóhannesson, Director General, National Energy Authority, Árni Helgason, Director Energy&Fisheries (ICEIDA), Jónas Haraldsson, Advisor, MFA. The objective of the mission is to find ways to accelerate geothermal energy development in Africa via the Icelandic experience and enhance the sharing of their considerable knowledge, expertise and resources in this area for the benefit of African countries.

The World Bank is very grateful for the kind courtesies and hospitality extended by the Government of Iceland, Ministry of Foreign Affairs; National Energy Authority; ICEIDA; ISOR; UNU Geothermal Training Program, and a number of Icelandic institutions, companies and individuals. The interactions were substantial and productive and contributed to the positive results of the mission.

Iceland's journey from being a developing country up until the seventies to a modern, vibrant and developed economy is marked by the development of its considerable geothermal potential for energy, heating and a variety of economic applications. In the process, it has achieved global leadership in geothermal technology and business in all its manifestations. Iceland has an installed geothermal generation capacity of 665 MW, a remarkable achievement for a country with only about 300,000 inhabitants. While 74% of Iceland's electricity is generated from hydropower, around 26% comes from geothermal resources. Iceland also is a leader in low temperature geothermal use and the utilization of waste heat from geothermal power plants for various purposes and industries, including the deployment of district heating systems providing over 90% of all buildings with low cost heating. Given the world wide push now on accelerating energy access and development of sustainable energy solutions, geothermal potential where available, provides a renewable and affordable resource of choice. Iceland is keen to expand its role in enhancing the possibilities of geothermal development especially in sub Saharan Africa. The World Bank seeks to harness all possible efforts and resources to achieve its mission of addressing energy poverty. The basis for this partnership between Iceland and the Bank is thus this convergence of goals. Together we believe that geothermal energy, together with hydropower and natural gas could meet the energy needs of African countries (particularly the Rift Valley countries).

Iceland is a valuable partner of the World Bank in energy, and a contributing member to the ESMAP. It is also providing knowledge, capacity building, exploration and advisory services to a number of Rift Valley Countries. Icelandic companies are engaged in developing projects and investments. The main

**Geothermal Development in Africa**  
Iceland and World Bank Cooperation  
*Aide Memoire: November 3, 2011*

outcome of the mission is a compact between Iceland and the World Bank to deepen the cooperation and enhance the possibilities of accelerated geothermal expansion.

**Geothermal energy potential in Africa**

6000 KM African Rift Valley covering Djibouti, Ethiopia, Uganda, Eritrea, Kenya, South Sudan, Tanzania, Malawi, Mozambique, Burundi, Rwanda, Zambia and Somalia. 14,000 MW of geothermal resource potential in these countries can power the needs of over 150 million people. It can provide affordable, continuous power and heat, and enable diversification of supply with hydro, gas and wind resources. Geothermal power alone can provide at least a quarter of the energy needed in these countries by 2030.

Besides providing stable power to anchor supply, its possibilities range from grid and off-grid systems for rural and urban communities, to multiple uses such as heat for food processing, industrial applications and other economic applications.

(For a detailed status of development by country please see Annex 1)

At the conclusion of the visiting program, a meeting was convened with Mr. Össur Skarphéðinsson, Minister for Foreign Affairs of Iceland to discuss a possible outcome of the visit. At the meeting discussions focused around the efforts to develop geothermal resources in Africa being challenged by the need for a consistent approach and the sustained availability of financial resources, technical know-how and skilled human resources. Against this background, Iceland and World Bank reached the following understandings to promote geothermal energy development in Africa.

1. Given the following seven stages for geothermal development that each country has to pass through, currently countries in Africa are at different stages in this development cycle. Kenya is well advanced and is in Stage 7 whereas Burundi and Malawi are at preliminary phase and entering into Stage 1. Annex 1 gives a snapshot of the status of each country.

- Stage 1: Preliminary studies comprising reconnaissance, surface exploration
- Stage 2: Appraisal studies including, subsurface investigations and drilling design
- Stage 3: Preparation of drilling program including siting, environmental assessments and mitigation plans and cost estimates
- Stage 4: Drilling, resource assessment, reservoir engineering, due diligence and project design
- Stage 5: Policy and Development Framework for project(s), business modeling, engagement of developers/sponsors, investors and financiers
- Stage 6: Construction and field development
- Stage 7: Operation, production and resource management

2. Iceland and Icelandic agencies are in a position to assist countries reach up to Stage 3. Various sources of funding and technical assistance will be pulled together, such as the ICEIDA support for Malawi and Mozambique, bilateral technical assistance in countries like Rwanda and Uganda, and World Bank financing under project assistance, for accelerating this effort. Once countries are at Stage 3, the

**Geothermal Development in Africa**  
Iceland and World Bank Cooperation  
*Aide Memoire: November 3, 2011*

main barrier to progress beyond is substantial funding needed to execute a sensible drilling program. The drilling of four exploratory wells (minimum recommended) costs nearly US\$20 million and is not capital that private companies are willing to provide.

3. A two part compact to take countries up this development ladder and hopefully to stage 7 and beyond in this decade is proposed.

Part 1 – This has two elements. Firstly, Iceland and Icelandic agencies will advance their work in order to bring countries to the end of Stage 3, i.e. have a viable drilling program ready to go. This would involve, working with the countries and their agencies to carry out a detailed analysis (stock taking) of the present situation and identify and support specific steps that each country has to take in order to reach stage 3. These would include geotechnical investigations of promising sites, detailed geophysical, seismic, environment and chemical tests including test drilling and assessments. Secondly, in parallel, World Bank and Iceland will collaborate with other partners and funding agencies to enable sourcing of grant and/or concessional financing that can part share the costs and risks of specific drilling programs in the target countries. This facility will build on the extensive learning and experience of agencies like UNEP and KfW, as well as countries like Kenya and Indonesia which have undertaken such drilling programs with public and donor funding in the recent past. All avenues including climate finance, private and concessional financing sources will be explored. This will cater to Stage 4. Beyond Stage 4, the World Bank and Iceland will continue to support the countries to establish the right conditions for investment and development of specific projects that result from successful results of the drilling program.

Part 2 – Expand the current program for capacity building and knowledge exchange in geothermal science and business practice, e.g. those being conducted by ISOR and UNU, both in the countries and in the institutions involved in supporting such development. The World Bank will be establishing a Community of Practice (COP) for geothermal development which initially will include staff that is engaged in this area globally. Once the COP is in place, it will be networked with country professionals, institutions and expert groups involved in geothermal development e.g. UNU Geothermal Training Program, ISOR, the respective country energy utilities, interested companies etc. to create a real time and dynamic platform for cutting edge knowledge generation and exchange. This will enable on the one hand, a collective enhancement of knowledge and capacity across the board in the geothermal development community, and on the other create a global community of practice where knowledge and practices can be actively exchanged.

4. Iceland and the World Bank propose to offer this Compact to the concerned countries and based on demand and interest, stand ready to move forward in actioning it. The Compact will be part of an outreach effort to other potential partners who might want to join and contribute to this effort.

**Geothermal Development in Africa**  
Iceland and World Bank Cooperation  
*Aide Memoire: November 3, 2011*

**Annex 1**

**Africa Rift Valley Countries  
Geothermal Development Program**

Country	Current Status	Support Requirement
Kenya	<ul style="list-style-type: none"> <li>• Is at an advanced stage of operations and further project development.</li> <li>• Power Plants of 209 MW total are in operation in the Olkaria geothermal field</li> <li>• A 280 MW plant is under construction</li> <li>• Capable of providing capacity building and knowledge sharing to other neighboring countries</li> </ul>	<ul style="list-style-type: none"> <li>• Development of new sites</li> <li>• South South knowledge exchange program</li> <li>• Advance technology</li> </ul>
Ethiopia	<ul style="list-style-type: none"> <li>• Surface exploration and reconnaissance studies carried out at several sites.</li> <li>• At couple of sites deep drilling exploration studies undertaken.</li> <li>• One power plant is operating at 7.3MW capacity.</li> </ul>	<ul style="list-style-type: none"> <li>• Establishment of appropriate legal, institutional and regulatory framework.</li> <li>• Financing of a sustainable drilling program</li> </ul>
Djibouti	<ul style="list-style-type: none"> <li>• Surface exploration and reconnaissance studies carried out at several geothermal sites</li> <li>• The main area is, however, the Assail field where exploration started in 1970/80 ties with surface exploration and drilling of 8 deep wells.</li> <li>• Exploration continued in 2007-2009, which pointed out promising drilling targets in other parts of the Assal field</li> <li>• Preparation underway to fund a drilling program.</li> </ul>	<ul style="list-style-type: none"> <li>• Establishment of appropriate legal, institutional and regulatory framework.</li> <li>• Financing of a sustainable drilling program</li> </ul>
Rwanda	<ul style="list-style-type: none"> <li>• Surface exploration and reconnaissance studies carried out in several fields and completed at one site.</li> <li>• Exploration drilling of 3 deep (2.5 km) wells in preparation</li> </ul>	<ul style="list-style-type: none"> <li>• Establishment of appropriate legal, institutional and regulatory framework.</li> <li>• Continue work on exploratory and reconnaissance studies.</li> <li>• Financing of a sustainable drilling program.</li> </ul>
Uganda	<ul style="list-style-type: none"> <li>• Surface exploration and reconnaissance studies at various levels at three sites (Libido, Kate and Baraga).</li> <li>• No deep drilling has been carried out but six shallow (&lt;300 m) wells have been drilled in Kibiro</li> </ul>	<ul style="list-style-type: none"> <li>• Establishment of appropriate legal, institutional and regulatory framework.</li> <li>• Continue work on exploratory and reconnaissance studies.</li> <li>• Financing of a sustainable drilling program.</li> </ul>
Burundi Malawi Zambia Mozambique Tanzania	<ul style="list-style-type: none"> <li>• Limited surface exploration and reconnaissance studies have done in these countries</li> </ul>	<ul style="list-style-type: none"> <li>• Reconnaissance and exploration studies to be initiated, leading to prepare and implement a drilling program</li> </ul>

## Annex 6: Letter to NDF from the World Bank

The World Bank  
Washington, D.C. 20433  
U.S.A.

S. VIJAY IYER  
Director  
Sustainable Development Department

April 5, 2012

Mr. Helge Semb  
Managing Director  
Nordic Development Fund (NDF)  
P.O. Box 185  
FIN-00171 Helsinki  
FINLAND  
Helge.semb@ndf.fi

Dear Mr. Semb:

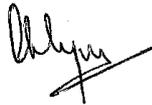
It was a real pleasure meeting you here at the World Bank headquarters during our Energy Days in February. Thank you for productive and informative discussions.

I am pleased to confirm that the World Bank would welcome NDF's participation in the partnership between the Bank and Iceland, as defined by the Bank's Aide Memoire of November 3, 2011 and the exchange of letters I had with the Minister of Foreign Affairs in Iceland, dated December 22, 2011.

It is my understanding that funding from NDF would be provided in a co-financing relationship with Iceida, as Lead Agency, jointly or in parallel, as the case may be. This would indicate that your funding would primarily be directed toward reconnaissance and explorations. It would also be available for technical assistance for parallel activities defined in the said Aide Memoire, including policy formulation, legal frameworks, business modeling, mobilization of sponsors and investors, and capacity building in the African countries involved.

Let me assure you of the Bank's commitment toward our common endeavor to strengthen energy access for the poor countries in the East African Rift Valley region, by utilizing a low emissions resource, which thereby also helps the world to address the problem of climate change. We see our own engagement primarily in the stages that follow reconnaissance and exploration. The focus by Iceida and NDF on the early steps would therefore be important in paving the way for the Bank's engagement. Moreover, the Bank is willing to raise additional concessional support to finance the next stages, and we would also like to continue discussing the possibility of NDF playing an active role in that effort.

Best regards,



cc: Mr. Benedikt Höskuldsson, Ministry for Foreign Affairs, Iceland



**Þróunarsamvinnustofnun Íslands (ÞSSÍ)**  
**Icelandic International Development Agency (ICEIDA)**

Þverholti 14

IS-105 Reykjavík

Tel: 354 545 8980

Fax: 354 545 8985

[www.iceida.is](http://www.iceida.is)