Situation Analysis Study on Geothermal Development in Africa

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JAPAN INTERNATIONAL COOPERATION AGENCY

WEST JAPAN ENGINEERING CONSULTANTS, INC.

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Acronyms and Abbreviations

AAS	Atomic Absorption Spectrometry
ACP	African, Caribbean and Pacific Group of States
ADB	Asian Development Bank
ADF	African Development Fund
ADLI	Agricultural Development Led Industry
AFD	Agence Française de Développement
AMT	Audio-frequency Magneto Telluric method
ARGeo	African Rift Geothermal Development Program
ASC	ARGeo Steering Committee
AUC	African Union Commission
AfDB	African Development Bank
BGR	Bundesanstalt für Geowissenschaften und Rohstoffe
BOO	Build Own Operate
BRGM	Bureau de recherches géologiques et minières
CCM	Chama Cha Mapinduzi
CDM	Clean Development Mechanism
CEIF	Clean Energy Investment Framework
CERD	Centre de Recherche Scientifique de Djibouti
CF	Carbon Finance
CIDA	Canadian International Development Agency
CIF	Climate Investment Fund
CRMA	Climate Risk Management and Adaptation Strategy
CSF	Credit Support Facility
CTF	Clean Technology Fund
China EXIM	The Export-Import Bank of China
DCCSF	Development and Climate Change: A Strategic Framework for the World Bank Group
DGSM	Department of Geological Survey and Mineral Development
DNA	Designated National Authority
DOE	Department of Environment
DOE	Division of Environment
EA	Environmental Audit
EARS	East African Rift System
EEA	Ethiopian Electricity Agency
EEPCO	Ethiopian Electric Power Corporation
EIA	Environmental Impact Assessment
EIB	European Investment Bank
EIS	Environmental Impact Statement
ELC	Electroconsult
EMCA	Environmental Management Coordination Act
EMP	Environmental Management Plan
EMP	Environmental Management Plan
EPA	Federal Environmental Protection Authority
EPP	Emergency Power Provider
ERA	Electricity Regulatory Authority
ERB	Electricity Regulatory Board
ERC	Energy Regulatory Commission
ERS	Economic Recovery Strategy for Wealth and Employment Creation
ESI	Kenyan Electricity Supply Industry
ESIA	Environmental and Social Impact Assessment
ESPRIT	EPDC System Planning Program Reflecting Interconnection & Transmission
ET	Energy Tribunal
EU	European Union
EWCA	Ethiopian Wildlife Conservation Authority

EWURA	Energy and Water Utilities Regulatory Authority
EdD	Electricite de Djibouti
FEC	First Energy Company Ltd
FIP	Forest Investment Program
FISEA	Investment and Support Fund for Business in Africa
FIT	Feed In Tariff
FRUD	Front for the Restoration of Unity and Democracy
FS	Feasibility Study
GDA	Geothermal Development Associates
GDC	Geothermal Development Corporation
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GIS	Geographic Information System
GNI	Gross National Income
GPS	Global Positioning System
GRA	Geothermal Resources Act
GSE	Geological Survey of Ethiopia
GST	Geological Survey of Tanzania
GSU	Geological Survey of Uganda
GTZ	Deutsche Gesellschaft fur Technische Zusammenarbeit
GWDC	Great Wall Drilling Company
HIPC	Heavily Indebted Poor Countries
HRD	Hydrocarbon Resources Development
IAEA	International Atomic Energy Agency
IBRD	International Bank for Reconstruction and Development
ICEIDA	Icelandic International Development Agency
ICP-MS	Inductively Coupled Plasma-Mass Spectrometry
ICS-UNIDO	International Centre for Science and High Technology United Nations Industrial Development Organization
ICSID	International Centre for Settlement of Investment Disputes
IDA	International Development Association
IEA	International Energy Agency
IFC	International Finance Corporation
IGA	International Geothermal Association
IMF	International Monetary Fund
IPP	Independent Power Producer
ISOR	Íslenskar orkurannsóknir
JBIC	Japan Bank for International Cooperation
JEPIC	Japan Electric Power Information Center, Inc.
JETRO	Japan External Trade Organization
JGI	Joint Geophysical Imaging
JICA	Japan International Cooperation Agency
KETRACO	Kenya Electricity Transmission Company
KPC	Kenya Power Company
KPLC	Kenya Power & Lighting Company
KWS	Kenya Wildlife Service
KenGen	Kenya Electric generation Company
KfW	Kreditanstalt für Wiederaufbau
LRA	Lord Resistance Army
MDGs	Millennium Development Goals
MDRI	Multilateral Debt Relief Initiative
MEM	Ministry of Energy and Minerals
MEMD	Ministry of Energy and Mineral Development
MENR	Ministry of Energy and Natural Resources
MIGA	Multilateral Investment Guarantee Agency
MME	Ministry of Mines and Energy
MOE	Ministry of Energy
MT	Magneto Telluric
MoU	Memorandum of Understanding

N.A.	Not available
NCG	Non-condensable Gas
NDP	National Development Plan
NEDO	New Energy and Industrial Technology Development Organization
NEMA	National Environmental Management Agency
NEMC	National Environmental Management Council
NGO	Non-Governmental Organization
NIPA	National Investment Promotion Agency
NORAD	Norwegian Agency for Development Cooperation
NPES	National Poverty Eradication Strategy
NSGRP	National Strategy for Growth and Reduction of Poverty
NTF	Nigeria Trust Fund
OCT	Overseas Countries and Territories
ODA	Official Development Assistance
ODLC	Oserian Development Company Ltd
ODM	Orange Democratic Movement
OJT	On-theJob-Training
ONLF	Ogaden National Liberation Front
OP	operational policy
PA	Project Agreement
PASDEP	Plan for Accelerated and Sustained Development to End Poverty
PCF	Prototype Carbon Fund
PEAP	Poverty Eradication Action Plan
PHDR	Poverty and Human Development Report
PMO-RALG	Prime Ministers Office Regional Administration and Local Government
PMU	Project Management Unit
PNOC	Philippine National Oil Corporation
PNU	Party of National Unity
PPA	Power Purchase Agreement
PPCR	Pilot Program for Climate Resilience
PR	Project Report
PRDP	Peace Recovery and Development Plan
PROPARCO	Promotion et Participation pour la Coopération économique
PRS	Poverty Reduction Strategy
PRSP	Poverty Reduction Strategy Paper
PV	Photovoltaic
Pre-FS	Pre Feasibility Study
RAP	Resettlement Action Plan
REA	Rural Electrification Authority
REA	Rural Energy Agency
REB	Rural Energy Board
REF	Rural Energy Fund
REI	Reykjavik Energy Investment
RG	Reykjavik Geothermal
RMF	Risk Mitigation Fund
RPP	Rassemblement Populaire Pour le Progres
SCF	Strategic Climate Fund
SDPRP	Sustainable Development and Poverty Reduction Program
SIAP	Sustainable Infrastructure Action Plan
SIDA	Swedish International Development Cooperation Agency
SPPA	Standardized Small Power Purchase Agreement
SPPs	Zanzibar Electricity Corporation
SREP	Scaling Up Renewable Energy in Low Income Countries Program
SSA	Steam Supply Agreement
STM	Standardized Tariff Calculation Methodology
TAF	Technical Assistance Facility
TANESCO	Tanzania Electric Supply Company
TDEM	Time Domain Electro Megnetic
TDS	Total Dissolved Solid

TEDAP	Tanzania Energy Development And Access Project
TICAD	Tokyo International Conference on African Development
UAERA	Uganda Revenue Authority
UEB	Uganda Electricity Board
UEDCL	Uganda Electricity Distribution Company Limited
UEGCL	Uganda Electricity Generating Company Limited
UETC	Uganda Electricity Transmission Company
UETCL	Uganda Electricity Transmission Company Limited
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
UNU-GTP	United nations University-Geothermal Training Program
WB	World Bank
WBG	World bank Group
WDI	World Development Indicators
WFB	Wonji Fault Belt
XRD	X-Ray Diffract meter
ZECO	Zanzibar Electricity Corporation

Executive Summary

This report describes the current state of geothermal energy development in the East African Rift region, and discusses the future of development in the area and possible JICA support for it. In Sub-Saharan Africa, shortage of power is observed in many areas and hinders proper investment, creating severe barriers to sustainable socio-economic development. Given this situation, geothermal energy, with the advantage of a stable supply, is drawing widespread attention these days. Geothermal energy is also one of the clean and renewable energy sources that can facilitate our measures to cope with the global climate change issue. However, JICA has only very limited information on the geothermal potential of this region and the possibilities for its development. Therefore, it is rather difficult for JICA to draw up a basic strategy of how to assist geothermal energy development in this region and how to cooperate with other donor agencies working in this field. To mitigate these difficulties, this study has been planned to attain the objectives of “collecting comprehensive basic information on geothermal resources in the East African Rift region”, “analyzing the possibility of their development,” and “working out a blue print for a JICA strategy to assist geothermal development in the region.”

The East African Rift System is one of the major tectonic structures of the earth and extends for about 6,500 km from the Middle East in the north to Mozambique in the south. Using today’s technologies, the East African Rift region has the potential to generate about 15,000 MW of energy from geothermal power. In this region, Kenya is the leading country in using geothermal energy for power production, followed by Ethiopia. Kenya is generating a total of about 204 MW of electricity using geothermal energy. In Ethiopia, a pilot geothermal power plant of 7.3 MW has been installed. Following the lead of these two countries, Djibouti is carrying out an exploration survey of its geothermal resources. The development of geothermal energy is still in the initial stages in Tanzania and Uganda, with no exploration drilling to date. However, all these countries see geothermal power as one of the most promising candidate power sources to reduce their over-dependency on hydropower, which is vulnerable to drought, and to diversify their power sources.

For this report, basic information concerning such factors as the status of the power supply, the geothermal resource prospects, the level of technology, the energy policy and the environmental policy of each country has been collected and is described in Chapter 4 to Chapter 8 of Volume 1. In addition, the activities of other donor agencies in support of geothermal energy development in Africa are summarized in Chapter 9, and the existing information on each geothermal prospect is summarized in an Appendix.

In Volume 2, the Study Team describes its views country by country on how to proceed with geothermal resource development in the future. First of all, the expected role of geothermal power in fulfilling growing electricity demand by 2025 is discussed in Chapter 10. In Chapter 11, a schedule of

measures necessary to develop this capacity (a Road Map) is worked out through a thorough consideration of the resource situation. In addition, the importance of the governmental leading role in following these Road Maps is described in Chapter 12, and the necessity of enhancing the level of available technology is described in Chapter 13. Chapter 14 details the action by the governments that is necessary, and Chapter 15 shows the recommended JICA assistance projects . A summary of these chapters is as follows.

Chapter 10 describes the expectations for geothermal power in each country. These expectations are extracted from each country's power development plan and are examined by using simulation that considers the effect of the proposed interconnected system of the African Rift Valley region. Since the simulation results suggest an amount of geothermal power development very similar to that in each county's plan, it is thought that each country's development plan is appropriate. From a consideration of these results, it is thought that Kenya needs 1,600-2,000 MW of geothermal power by 2025. Similarly, Ethiopia needs 450-700 MW, Djibouti needs 60-80 MW, Tanzania needs 100 MW and Uganda needs 70-90 MW. A total of 2,300-3,000 MW of geothermal capacity needs to be developed in this region by 2025.

In Chapter 11, a development schedule to attain this development (a Road Map) is worked out for each country, and the required costs are estimated. In order to develop 2,000 MW by 2025, Kenya needs ambitious development of not only of the Olkaria fields but also of other prospects such as Menengai (6 phases), Silai (4 phases) and Paka (3 phases). In Ethiopia, the development of Aluto Langano, Tendaho, Corvetti and Abaya is necessary. In order to develop 700 MW, Ethiopia will need five other prospects as well, and a nationwide reconnaissance survey is necessary to chose promising prospects for this purpose. In Djibouti, the development of Asal field is necessary to achieve the 80 MW target. However, the Asal field has encountered technical problems such as high salinity. Therefore, an experimental, step-by-step approach is recommendable for the Asal field until appropriate operation conditions can be established. It would be wise to prepare for the development of other prospects in case Asal turns out not to be suitable for development. Therefore, a nationwide reconnaissance survey is necessary. Tanzania's target is about 100MW by 2025. To achieve this target, Tanzania needs to continue to develop the Mbeya prospect with the assistance of Germany (BGR). In addition it will need to develop three more prospects. To identify these prospects, it is appropriate to carry out a preliminary nationwide reconnaissance survey. Uganda needs to develop about 90 MW by 2025, and the Kibiro prospect there, from which the most promising data has been obtained, is expected to advance to development. In addition, the development of Buranga is expected to proceed with the support of Germany (BGR). Since one more prospect is needed in Uganda, a nationwide survey is also scheduled in the Road Map.

Chapter 12 shows the importance of government taking the leading role, since private companies are unlikely to participate in development of areas where there are no exploration wells. An effective remedy for this situation is for the government to undertake initial surveys. The government of Kenya is currently playing a leading role in its geothermal development in precisely this manner. Therefore, this "Kenyan model" is recommended as a paradigm of success for the rest of East Africa.

Chapter 13 shows the current number of engineers (including scientists) and the equipment available in each country, and discusses the necessity for technological improvements in the future. Kenya currently has 211 engineers, but will need a further 401 engineers over the coming ten years. Kenya also needs approximately USD 447 million to strengthen its equipment inventory, including through the accquisition of drilling rigs. Ethiopia currently has 72 engineers, but will need a further 285 engineers over the coming ten years. Ethiopia also needs approximately USD 131 million to acquire equipment. There are 22 engineers in Djibouti, and a further 57 engineers will be needed in the future. The estimated cost of bringing the equipment inventory to acceptable levels in Djibouti is about USD 7.5 million. Tanzania currently has 35 engineers, but will need a further 83 engineers over the coming ten years, while Uganda has 28 engineers and will need 77 more. Tanzania and Uganda both need approximately USD 7.6 million for equipment.

Chapter 14 details the expected action necessary for each government to follow its Road Map. In terms of policy framework, Kenya has already elaborated a wonderful development structure. This structure is designed to exploit geothermal energy under strong governmental initiative. The Kenyan structure is an admirable one for developing geothermal resources effectively, and can become a model for the other African Rift Valley countries. The first thing that Kenya has to do is to promote geothermal development according to its ambitious plan for GDC under this framework. On the resource development front, the Kenyan government should support GDC’s activities. The main challenge in the geothermal development of Kenya is how to procure the capital necessary to support ambitious geothermal development. Strong support from the donor agencies will be necessary in addition to Kenyan government funds. The second challenge is training the necessary geothermal engineers/scientists and technicians to support a positive geothermal development plan. To this end, GDC is utilizing training opportunities in UNU-GTP and is considering establishing its own training facility. It is necessary to accelerate the training strategy.

Ethiopia needs to formulate a clear development structure for geothermal development. Currently the Aluto Langano resource evaluation study is being financed by the WB and the Japanese and Ethiopian governments. As development proceeds, a new organization that is dedicated to geothermal development is desirable. Alternatively, a dedicated geothermal company could be formed to undertake geothermal exploration and power station operations. Geothermal development projects definitely require an organization and management system that can handle a large amount of money efficiently, and this is beyond the ability of a research institute such as the Geological Survey of Ethiopia. On the resource development front, strong promotion of resource surveys in Aluto Langano and Tendaho is needed. Exploration drilling is required in both fields to evaluate resource capacity. If the drilling results are favorable, power plant construction will be expected. Resource surveys in other promising prospects, such as Abaya and Corbetti, are also required. In addition, it is necessary to carry out a nationwide resource survey to select additional prospects for further development so that the Power Development Master Plan can include as many concrete geothermal projects as possible. As far as technology is concerned, the training of more technical professionals is indispensable. It is the Study Team’s estimation that it will be necessary to recruit nearly 280 engineers or more over the coming 10 years. It is crucial to take advantage of training courses in UNU-GTP and/or other facilities. Moreover, it is necessary to expand the equipment inventory and replace old equipment. In particular, the procurement of four (4) drilling rigs will be needed to achieve the proposed capacity expansion, as resource surveying progresses.

One of the barriers to geothermal development in Djibouti is the weak structure of the Ministry of Energy and Natural Resources. Currently, geothermal issues are dealt with by a single Secretary-General. With the renewed interest in geothermal development, there is a need to strengthen the Ministry of Energy and Natural Resources by creating a department to deal specifically with geothermal that has the appropriate qualified staff. This staff should work on geothermal policy and geothermal law that can allow both private and public participation in geothermal generation under a clear licensing mechanism. In addition, a decision should be made right now as to how the government will proceed with further geothermal development. This could initially involve the formation of a geothermal department at Electricité de Djibouti (EdD). Staff members can be transferred from the Centre de Recherche Scientifique de Djibouti (CERD), if necessary. Another option could be the creation of a new company that would undertake geothermal exploration and development on behalf of the government and sell power to EdD. This obviously depends on whether the government can get international donor support. On the other hand, the option reamins open of soliciting the services of an Independent Power Provider (IPP), because, fortunately, there is an IPP that has shown interest in developing Asal field. The problem is that the government seems not to be clear on what it wants to do or how to proceed. Currently, there seems to be a conflict between what price the government is willing to pay for the power and what the IPP is ready to accept. If the government wants to adopt development by IPPs, it should basically accept the price requested by the IPP after careful negotiation. If it chooses to go the IPP route, the government will certainly need advisory (Power Purchase Agreement (PPA) negotiations) and technical support during which local staff will work with consultants to acquire the skills necessary for negotiating project agreements and PPAs and supervising IPP performance. If the government does not accept the prices requested by the IPP, the government should take the option of creating a national geothermal developer, either EdD or a new company, and providing funds to develop the technological capacity of the national developer so that the developer can utilize low cost funds to make geothermal energy inexpensive. Further, by fostering this national geothermal developer into a local core developer, the government should aim at creating a local geothermal industry within its own country. The government should consider taking such a strategy.

On the resource development front, it is necessary for the Djibouti government to promote resource surveys in fields other than Asal. It is recommended that a nationwide resource survey first be carried out to identify the most promising fields. It is realistic to give CERD this responsibility, but if the government creates a new geothermal development entity, it would also be appropriate to let the new entity carry out these surveys. It is recommended that ODA funding be channeled into these surveys under government responsibility. On the technical front, the training of more Djibouti professionals is important. The Study Team estimates that Djibouti needs 57 engineers over the next 10 years. These engineers should be trained in UNU-GTP and/or other training facilities as soon as possible. Also needed is the expansion and renewal of the equipment inventory. It is necessary to undertake these measures in parallel with the resource surveys.

The first thing that Tanzania needs is to promote resource surveys. Currently, the resource survey in Mbeya is proceeding systematically under BGR. However, there are many other promising areas in Tanzania which have not been covered substantially. Therefore, a nationwide resource reconaissance survey is desired to select further promising areas for detailed surveys. Detailed exploration surveys with exploration well-drilling are also needed in the selected areas. On the policy front, in parallel with the nationwide resource assessment, a policy framework and development strategy should be elaborated. An institutional structure should also be developed which would be more effective in delivering a power station as programmed in the roadmap. Given that no geothermal power station has been commsisioned in Tanzania as yet, the Study Team sees the government of Tanzania and perhaps TANESCO or a special purpose company taking a leading role in this development and creating a good environment for future private sector participation as the resources are proven. As far as technical capacity is concerned, more professional staff must be recruited and trained.

Uganda needs a similar strategy and similar action to those recommended for Tanzania. The first thing the government should do is to facilitate resource surveys. Currently, the survey in Buranga is supported by BGR, but there are many other promising areas in Uganda, like Kibiro, Panyimur and others. Therefore it seems appropriate for JICA to support a resource survey in Kibiro. Since a resource survey requires exploration wells, a survey that includes drilling exploration wells is necessary. Moreover, a nationwide reconnaissance survey is also needed to select other promising areas. Detailed exploration surveys with exploration well-drilling will also be needed in the selected areas. A comprehensive policy framework to promote geothermal development is also required. In Uganda, privatization of the electric power sector is the most advanced in the region, and the power generation business is in the hands of private IPPs. If the government intends to retain this system, it should enact an appropriate geothermal law and regulations and work out incentives to attract private geothermal developers. However, the Study Team believes that it is difficult to expect private participation in Uganda in geothermal development under current conditions, since there is no geothermal power plant to demonstrate the viability of these resources. The Team recommends that the government strengthen the Geological Survey and Mines Department (or create an independent

Geothermal Development Department similar to the Petroleum Exploration Department) and take a leading role in the initial resource surveys. Once resource surveys are advanced enough and the results are promising, it will be possible to strengthen Uganda Electric Generation Company Limited (UEGCL) to undertake geothermal development under governmental initiative. This would be followed by private sector participation. Additional manpower and training are also required in order to advance geothermal development.

Chapter 15 proposes candidate projects in each country for JICA assistance. In this regard, the following three points should be kept in mind in extending assistance for geothermal development in Africa: "it is necessary for a technical training project to be followed by a large development project that employs the trainees", "Kenya should be promoted as a showcase for successful geothermal development in Africa", and "it is crucial to create a new assistance scheme that resolutely mitigates geothermal development risks." In particular, it is strongly recommended that JICA should expand the budget limitations of its Development Study scheme and should create a large-scale Development Study scheme that can accommodate initial surveys that include the drilling of several exploration wells. The budget limit for a large-scale Development Study is expected to be increased to USD 10-20 million for a three (3) to four (4) year program. Specific projects proposed for each country are as follows.

For Kenya, since the biggest issue is to secure financing for the activities of GDC, it is necessary for JICA to extend strong financial support, i.e. in the form of Yen Loans, to GDC so that Kenya becomes a showcase for success in Africa. Moreover, grant aid to large-scale Development Studies that include exploration drilling should also be considered for promising fields. Support for enhanced technology capacity building is also important. For Ethiopia, since the construction of a geothermal power plant in Aluto Langano is scheduled, financial support in the form of a Yen Loan is necessary. The second recommended support is for a large-scale Development Study of the promising prospects of Abaya or Corbetti. In addition, it would be wise to carry out a nationwide survey to find other promising fields. Support for enhanced technology capacity is also important. For Djibouti, the most important issue is the development of the Asal field. The Asal field suffers from the technical problem of high salinity and sulfide scaling. It is unknown whether present technology can solve this problem or not. However, a conclusion as to whether the field can be developed or should be abandoned cannot be reached until the exact characteristics of the steam and brine from the reservoir can be confirmed through more exploratory well drilling. Therefore, a resource survey including exploration well drilling to examine the possibility of the development is necessary. While development in the Asal field proceeds, a nationwide reconnaissance survey is also recommended to identify other promising areas. The strategy for Tanzania is to promote resource surveys in various promising fields. It is necessary to carry out a nationwide reconnaissance survey, and to select the most promising fields for further detailed surveys. For Uganda, it is recommended to carry out further MT surveys with exploration drilling in Kibiro. In order to find other promising fields, a nationwide reconnaissance survey is also recommendable.

The development of geothermal energy can stimulate the domestic economy and create employment in the local labor market of the countries where it takes place. Geothermal development in the African Rift region is expected to simultaneously bring a stable, renewable energy supply, economic development and environmental protection to the region, raising the standard of living for all.

Volume 1

Current Situation of Geothermal Energy Development in Africa

Chapter 1 Introduction

1.1 Objectives of the Study

In the Sub-Saharan region of Africa, a stable electricity supply is available only in limited areas, and the power shortages that can be observed in many other areas deter proper investment and are one of the severe barriers to sustainable socio-economic development in the region. In such a situation, geothermal energy has advantages in stable supply and in cost-competitiveness among power sources in the region and the world. Geothermal energy is also a clean and renewable energy source useful in coping with the global climate change issue. From these points of view, geothermal energy is gaining more attention than ever in the East African Rift region. In this region, Japan Bkan for International Cooperation (JBIC) has carried out a geothermal project formation study in Kenya, Uganda and Tanzania in the past. In these countries, however, some donor agencies such as the World Bank and German development Bank (KfW) are proactively supporting geothermal development. Therefore, it is important to update available information on the progress of the geothermal development in these countries. In other countries of the East African Rift region such as Ethiopian and Djibouti, where there is also large geothermal potential, Japan International Cooperation Agency (JICA) has little information on the geothermal potential and the possibility of its development. Therefore, it is rather difficult for JICA to draw up a basic strategy for assisting geothermal energy development in the East African Rift region that has recently become one of focal points of many donor agencies' activities. Since geothermal energy can be used not only as an electric power source but also as a heat and water source for local people, broad use of geothermal energy is expected to promote regional development and to create employment in the East African Rift region and therefore contribute to poverty reduction as well. In recognition of these basic facts, this study has been planned to attain the objectives of "collecting comprehensive basic information on geothermal resources in the East African Rift region", "analyzing the possibility of their development", and "working out a blueprint for JICA's strategy to assist geothermal development in the region."

1.2 Study Area

The East African Rift countries of Ethiopia, Djibouti, Tanzania, Uganda, and Kenya.

1.3 Study Contents

1.3.1 Study Fields

In this Study the objectives are to be approached in the following seven fields through collecting and analyzing information, integrating the analyzed results, and working out a blueprint for JICA's strategy

a Geothermal Development

b Energy Policy

c Local Technical Capacity
d Electric Power Sector
e Geothermal Resources
f Social and Environmental Policy / Direct-use Potential
g ODA (Official Development Assistance) Policy

To attain this purpose, one or two analysts were nominated in each study field.

1.3.2 Terms of Reference (TOR) of each Analyst

a. Leader/ Geothermal Development Analyst

- To manage the Study Team and to provide the team with a basic direction of study.
- In addition, to integrate the results of each analyst's findings, and to work out JICA's strategy.

b. Energy policy Analyst

- To investigate and analyze the energy policy executing system in each country, and to compile a report.
- To investigate and analyze the energy policy and geothermal promotion policy in each country, and to propose necessary arrangements to be made or measures to be taken to promote geothermal development.

c. Local Technical Capacity Analyst

- To investigate and analyze the local technical capacity of geothermal development organizations such as geological surveyors, electric power companies, and/or geothermal development companies, etc. from the viewpoint of current survey activities, human capacity, equipment, budget, etc.
- To propose necessary arrangements to be made or measures to be taken to enhance local technical capacity to promote geothermal development in each country.

d. Electric Power Sector Analysts

- To investigate and analyze the current situation of the electric power sector, including the electric power supply system, current power demand and supply, future power demand and supply forecast, long-term power plant development plans, IPP participation conditions, and electric power tariffs, etc. in each country, and to compile a report.
- To analyze the background and extent of geothermal energy's role in each country's power source mix.

e. Geothermal Resource Analysts

- To investigate and analyze the geothermal resource potential in each country and to evaluate the potential.
- To prioritize the promising fields, taking into account the resource potential, demand from electric power sector, the effects of development on socio-economic aspects, etc.
- To work out a Roadmap for geothermal development for each promising field.

f. Social and Environmental Policy / Direct-use Potential Analyst

- To investigate and analyze the system of envrionmental law related to geothermal development (environmental standards, procedures for EIA approval, relations between forest areas/environmental protection areas and promising geothermal fields, etc.).

- If data is available, to make maps which delineate forest protection areas and/or environmental protection areas in promising geothermal fields.
- To evaluate the demand for geothermal direct use (heat and condensed water) for local development.

g. ODA (Official Development Assistance) Policy Analyst

- To investigate and analyze the assistance of other donors to geothermal development in Africa.
- To make proposals as to JICA assistance policy in the geothermal sector.

1.4 Study Methodology

1.4.1 Collection of basic information

(i) In preparation work in Japan, data and material collection was carried out through of review of existing study reports, papers in related academic journals, and documents available via the Internet, etc.

(ii) In field surveys, the Study Team visited related organizations in each country and collected information and data through interviews.

(iii) Regarding information on the assistance of other donors, the Study Team visited the main donor organizations and obtained information through interviews and exchanges of views.

(iv) Obtained information and data was sorted out and arranged for reports.

1.4.2 Working out Roadmaps for prospective resources

(i) Evaluation of geothermal resources

The geothermal resources in prospective fields in each country were evaluated based on the obtained information and data. Theoretically promising geothermal resources require three favorable conditions, namely the existence of groundwater, the existence of a heat source, and the existence of a reservoir structure. Therefore, the study team examined these three factors in each field through examining existing data and/or documents and tried to evaluate the resource potential.

(2) Selection of prospective fields

The accuracy of the evaluation depended on the quality and quantity of existing data. The underground information would be more accurate if it was obtained through test well drillings. Also an MT survey would provide wide-range estimation of groundwater distribution. Therefore, the Study Team carried out the potential field analysis with a consideration of data sources and the survey methodology determining the existing study data. In addition, the evaluation also considered the available infrastructure of access roads, transmission lines and so on. The promising fields of each country were selected through these considerations.

(3) Drawing Roadmaps for development

Based on the analysis of barriers to geothermal development and appropriate countermeasures, the Roadmaps for development were drawn.

1.4.3 Proposal of a JICA assistance policy for geothermal development

Based on the analysis of all the available information including geothermal resources, local technical capacity, energy policy, and other donors' assistance, the Study Team has discussed JICA's basic strategy and has proposed possible assistance.

1.4.4 List of interviewees

For a study visit to the African Rift counties, the list of organizations interviewed was as follows;

Kenya	Ministry of Energy (MOE)
	Kenya Electric Generation Company (KenGen)
	Kenya Power & Lighting Company (KPLC)
	Geothermal Development Corporation (GDC)
	Energy Regulatory Commission
	Ministry of Environment and Mineral Resources
	Ministry of Forest and Wildlife
	National Environmental Management Authority (NEMA)
Ethiopia	Ministry of Mines and Energy (MME)
	Ethiopian Electric Power Corporation (EEPCO)
	Geological Survey of Ethiopia (GSE)
	Ethiopian Electricity Agency
	Environment Protection Authority
Djibouti	Ministry of Energy and Natural Resources (MENR)
	Electricité de Djibouti (EdD)
	Centre de Recherche Scientifique de Djibouti (CERD)
	Ministry of Housing, Urban Affairs, Environment and land Planning
Tanzania	Ministry of Energy and Minerals (MEM)
	Tanzania Electric Supply Company (TANESCO)
	Geological Survey of Tanzania (GST)
	Division of Environment, Vice President's Office
	National Environment Management Council
Uganda	Ministry of Energy and Mineral Development (MEMD)
	Uganda Electricity Transmission Company Ltd. (UETCL)
	Geological Survey and Mineral Development (GSMD, or simply Geological Survey of Uganda (GSU))
	National Environment and Management Authority (NEMA)

In a trip to donor counties, the list of organizations interviewed was as follows;

The U.S.A	The World Bank
	International Finance Corporation (IFC)
	Global Environment Facility (GEF)
Iceland	Ministry of Foreign Affairs
	United Nations University - Geothermal Training Program
	Reykjavik Energy Investment (REI)
	Reykjavik Geothermal
	Islandsbanki
Germany	Kreditanstalt fur Wiederaufbau (KfW)
	Federal Institute for Geosciences and Natural Resources (BGR)
Luxembourg	European Investment Bank (EIB)
France	Agence France de Development (AFD)
	United Nations Environment Protection (UNEP)
	Bureau of Research for Geosciences and Minerals (BRGM)

1.5 Process of the Study

The Study was conducted according to the Flow Chart shown in Fig.-1.5-1.

1.6 Work Schedule

The main schedule of the Study is as follows:

Preparation Work in Japan	Contract (March 9th)～end of April
Preparation Trip to Kenya (Leader)	March 13th ~ 19th
Preliminary Trip (Local Technical Capacity Analyst)	early April ~ middle April
Inception Report	April 12th
1st Field Trip (5 countries in Africa)	May 8th ～ 30th May (23days)
Intermediate Work in Japan	Early June ～ middle of July
2nd Field Trip (Donors)	July 14th ～ August 4th (22days)
Progress Report	August 23rd
Wrap-up Work in Japan	early August ～ early October
Final Report	October 15th
End of Work	November 5th

The work schedule is shown in Table-1.6-1.

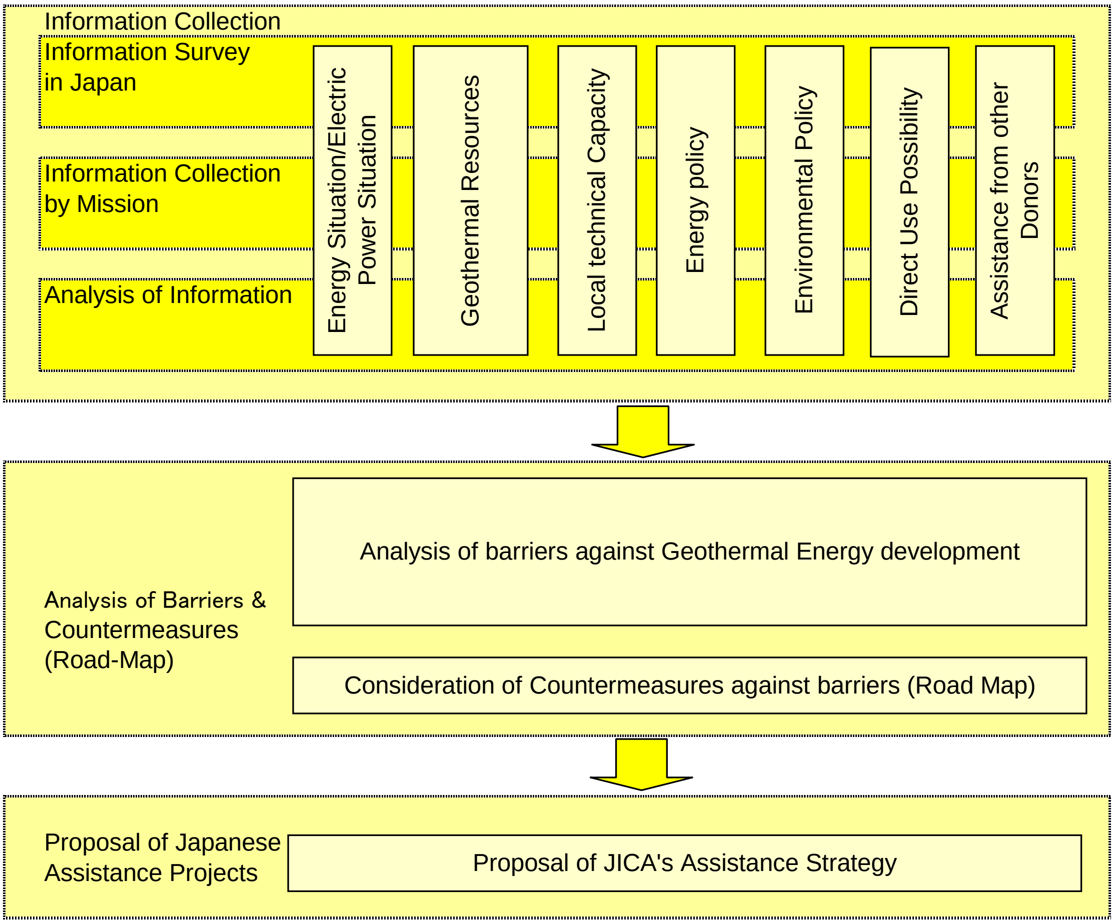


Fig.-1.5-1 Study Flow Chart

Table-1.6-1 Work Schedule

Work Schedule

Tasks \ Period	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
1. Preparation Work in Japan								
Preparation Meeting with Local Consultants (Leader/in Kenya)								
Data collection & Analysis								
Selection of Additional Data to be collected								
Survey by Local Consultant (Electric Sector)								
Preliminary Survey by Local Consultant (Local Technical Capacity)								
First Evaluation of Geothermal Resources								
Making Inception report								
Submission of Inception Report								
Preparation for 1st Field Trip								
2. 1st Field Trip								
1st Field Trip （Leader） （Kenya, Ethiopia, Djibouti, Uganda, Tanzania）								
1st Field trip （Energy Policy） （ditto）								
1st Field trip （Local Technical Capacity） （ditto）								
1st Field Trip (Geothermal Resources A) （Kenya, Ethiopia, Djibouti）								
1st Field Trip (Geothermal Resources B) （Uganda, Tanzania）								
1st Field Trip （Environmental and Social aspect/Direct use） （same as Leader）								
1st Field Trip report								
3. Intermediate Work in Japan								
Sorting out of Information								
Analysis of Challenges								
Considering of Countermeasures against Challenges								
Consideration of Geothermal Role in Electric Power Mix								
Second Evaluation of Geothermal Resources								
Selection of Promising Fields								
Making Progress Report								
4. 2nd Field Trip								
2nd Field trip （leader/Local Technical Capacity）								
2nd Field Trip (Energy Policy)								
2nd Field Trip (ODA Policy)								
Sorting out of information/ Making Report of 2nd Field Trip								
Making Progress Report								
Submission of Progress Report								
5. Wrap-up Work in Japan								
Integration of Results by Local Consultants （Cooperation Work in Japan）								
Integration of Challenges in each fields								
Final Evaluation of Geothermal Resources								
Selection of Promising Fields								
Making Road-Map for promising fields								
Consideration of JICA's Support								
Making Final Report								
Printing of Final Report								
Submission of Final Report								

Legend： Field Trip ■ Work in Japan □ Report ▽

1.7 Reports

The Study Team provides the following reports:

Inception Report

(i) Contents: Study methodology and the results of preliminary work

(ii) Timing: April 12th, 2010

(iii) Copies: 15 copies each in English and Japanese.

Progress Report

(i) Results of field surveys

(ii) Timing: August 23rd, 2010

(iii) Copies: 20 copies in Japanese.

Final Report

(i) Contents: All results of the study.

(ii) Timing: October 15th, 2010

(iii) Copies: 30 copies each in English and Japanese.

1.8 Team of Analysts

The Analyst list is as follows:

Table-1.8-1 List of Analysts

Name	In charge of
Masahiko KANEKO (Mr.)	Leader/Geothermal Development Analyst
Naotsugu IKEDA (Dr.)	Energy Policy Analyst
Martin N. Mwangi (Mr.)	Local Technical Capacity Analyst
Laban K. Kariuki (Mr.)	Electric Sector Analyst
Shigeru ONIKI (Mr.)	Electric Sector Analyst
Managu MOMITA (Mr.)	Geothermal Resource Analyst
Noriaki UCHIYAMA (Mr.)	Geothermal Resource Analyst
Tomoo AOKI (Mr.)	Environmental and Social Policy / Direct Use Analyst
Maiko SUGIMURA (Ms.)	ODA Policy Analyst

Chapter 2 Expectations for Geothermal Energy Development in Africa

2.1 Necessity to Support African Development

The world is now facing several global-scale problems such as climate change, the battle against terrorism and poverty, the security of indispensable supplies of energy, food and water, and so on. Many of these problems overlap with the problems that Africa is suffering now. The high proportion of the population living in extreme poverty in Africa creates instability in societies, and aggravates the threat of famine and of the spread of infectious disease. The occurrence of droughts and floods caused by climate change is adversely affecting African agriculture, which is the main industry of the continent. In addition, the soaring prices of food and energy in recent years are eroding the livelihoods of many poor people in Africa. To deal with these problems, international society set forth the United Nations Millennium Development Goals (MDGs) in 2001, and has promoted the sustainable development of Africa through a concentration of its assistance capabilities on important areas. However, it is expected that the MDGs in all eight fields will fail to be attained by 2015 in the Sub-Saharan region, if the current situation continues as it is. Although some emerging economies such as China, India, Brazil, and South East Asia are gaining power in international society, Africa is still left far behind as a region that suffers from many serious problems. Therefore, the development of Africa becomes a pressing and important issue for an international society that is strengthening the interdependence among regions.

In these circumstances, Japan, with its long-standing understanding of the importance of African development, has been playing the role of an opinion leader in international society. It reduced the debts of the highly indebted countries of Africa since the second half of 1980s. In addition, Japan also hosted the first Tokyo International Conference on Africa Development (TICAD) in 1993, and has made efforts to turn the eyes of international society towards Africa. As a result, the issue of African development has been a main agenda item of the G8 summit meetings every year since 2000, resulting in the promise from each member country during the Gleneagles G8 summit held in the United Kingdom in 2005 to raise its budget for African development. Moreover, in TICAD-IV held in 2008, Japan expressed its willingness to double its Official Development Assistance (ODA) allocation to Africa by 2012 and, in addition, to make efforts to encourage private sector investment in Africa. Through these activities, Japan is creating a constructive atmosphere in international society in support of the development of Africa.

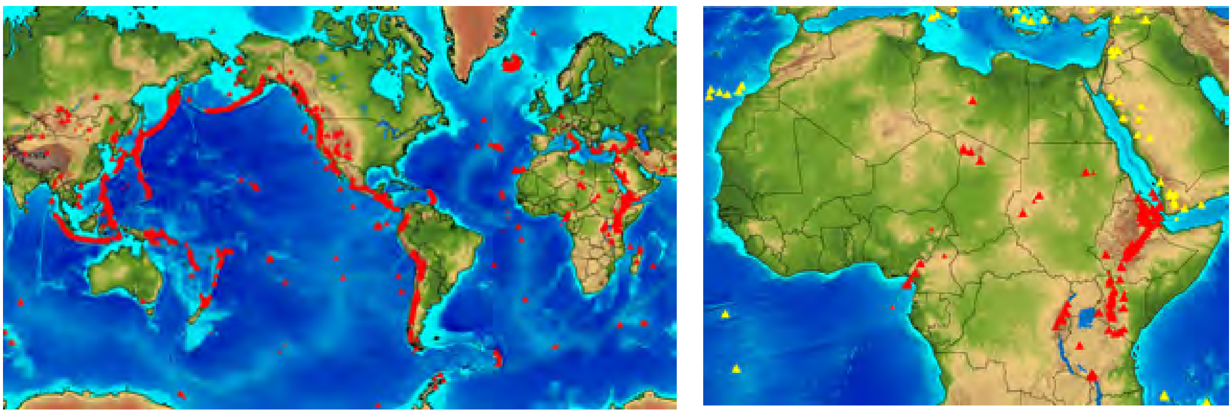
In the background of these activities, we can discern a basic recognition and outlook on the part of Japan. Japan believes that African development must contribute to the peace and prosperity of the entire world and therefore works to strengthen today’s global interdependence. Japan also believes that maintaining friendly relations with Africa, which consists of 53 countries and accounts for about 30 percent of United Nations member states, is in the national interest of a Japan that lays priority on

United Nations-oriented diplomatic policy. Strengthening economic relations with Africa, which has vast natural resources and the possibility of becoming a big market in the future, also greatly contributes to the social and economic development of Japan.

2.2 Expectation for Exploiting Geothermal Energy in Africa

Although Africa is still suffering from a lot of development problems, some positive signs can be recognized in some countries, such as the appearance of economic growth and the inflow of foreign direct investment as political stability is achieved. In order to make these indicators of development more widespread throughout the continent, continuous self-help efforts by Africa itself with the strong support of international society is indispensable.

The development of economic infrastructures such as roads and electric power networks is indispensable to assist the self-help efforts of Africa. Electric power, in particular, is essential energy for industrial activities and people’s lives. A stable supply of inexpensive electric power leads to socio-economic development through the expansion of industrial activities, the increase of foreign direct investment, the expansion of rural electrification, and the improvement of people’s standard of living. However, fossil energy resources are found only in some limited countries and not in every country in Africa. Many countries located in Sub-Saharan Africa do not possess enough fossil energy resources within their territories. Therefore, the power supply of many countries depends mainly on hydro power resources and diesel power that uses expensive imported fuel. However, the incidence of drought has been rising in step with climate change in recent years. Hydropower is not necessarily a stable power source in such circumstances. For instance, the hydropower plants in Kenya functioned at a greatly reduced level and caused serious electricity shortages due to severe drought in 2000 and 2009. Moreover, many countries that rely on imported energy are suffering from a deterioration in their balance of external payments caused by the surges in international oil prices in recent years.



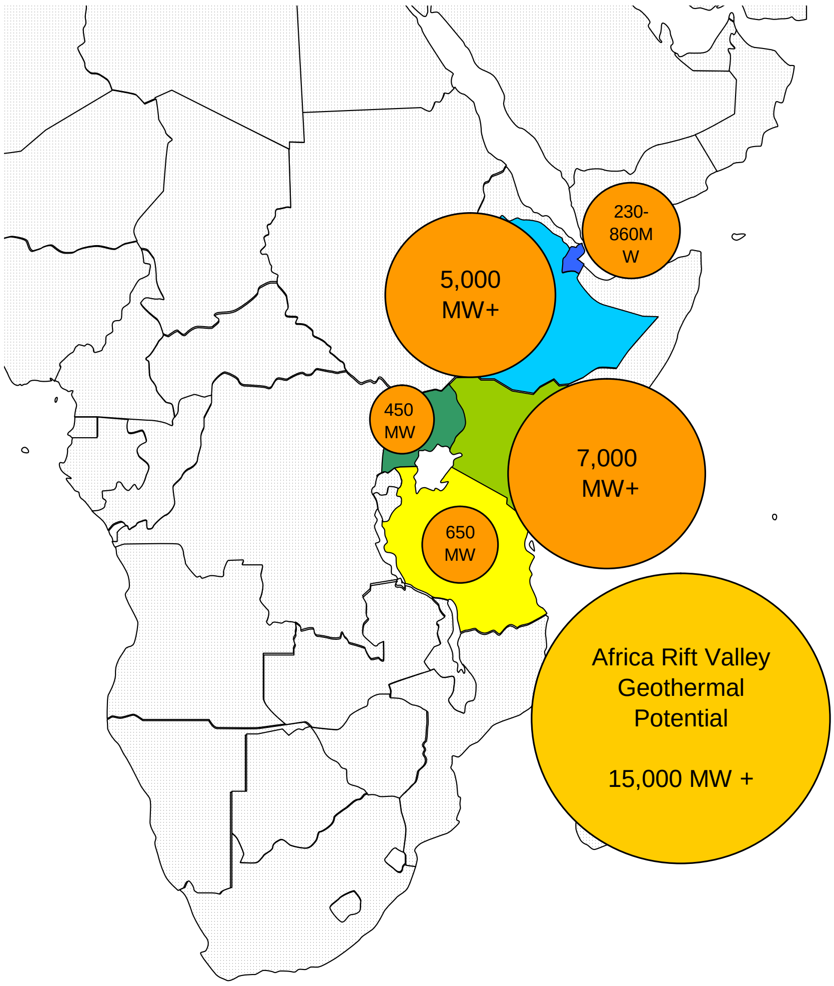
(Source) Smithsonian National Museum of National History

Fig.-2.2-1 Distribution of Volcanoes in the World

Table-2.2-1 Geothermal Resource Potential in the East African Rift System Countries

Country	Installed Capacity (MW) (a)	Estimated Geothermal Potential (MW) (b)	Geothermal Potential compared to Current Installed Capacity (c)=(b)/(a)	Current Geothermal Plant (MW) (d)
Kenya	1,097	7,000 +	6.4	204
Ethiopia	758	5,000 +	6.6	4
Djibouti	90	230-860	2.6-9.6	-
Tanzania	977	650	0.7	-
Uganda	355	450	1.3	-

(Source)
Geothermal Stakeholders' Workshop (2010), Country Report (for Kenya, Ethiopia, Tanzania, Rift Valley)
The Business Council for Sustainable Energy (2003) (for Djibouti, Uganda)



(Source) Geothermal Stakeholders' Workshop (2010), Country Report (for Kenya, Ethiopia, Tanzania, Rift Valley Total),
The Business Council for Sustainable Energy (2003) (for Djibouti, Uganda)

Fig.-2.2-2 Geothermal Potential in the East African Rift System Countries

Consequently, geothermal resources in the East African Rift System have been gaining attention in recent years. The African Rift System is a gigantic graben that runs through the Africa continent from north to south and is one of the plate boundaries where many volcanoes are found (Fig.-2.2-1). The width of the valley ranges from 35 to 100 km, and its total length is around 6,500 km. It is a normal fault and steep cliffs of more than 100 meters in height are found from place to place. The fault that runs from the Red Sea to Tanzania through Eritrea, Djibouti, Ethiopia and Kenya is called the East Rift System. The one that runs from Uganda to Malawi through the western part of Lake Victoria, Rwanda, and Burundi is called the West Rift System. The formation of the Rift System is related to the rising flow of mantle in the earth. This formation is considered to have started about 5 to 10 million years ago. Many promising geothermal resources exist in this Rift System, and the potential of these geothermal resources is thought to be 15,000 MW or more in terms of power generation capability (Teklemariam, 2010). This potential is expected to offer enough power to fulfill power demands in the Rift System countries (Table-2.1-1, Fig.-2.2-2).

Geothermal energy has the following characteristics:

(i) It is energy of high supply reliability

Geothermal power generation does not suffer from output fluctuations which may be caused by seasonal or weather conditions. Therefore it can be used around the clock throughout the year. Because of this, geothermal power boasts of a remarkably high capacity utilization rate, or plant factor, unlike other renewable energy sources. Therefore, geothermal power is characterized by its stable supply of large amounts of energy, and is a reliable power source for base-load demands.

(ii) It is domestically produced energy

Geothermal energy is purely domestically produced and utilized energy. For countries which do not domestically possess fossil fuel energy resources, utilization of geothermal energy will reduce the amount of fossil fuel importation, and for countries which export fossil fuels to other countries, geothermal energy will reduce domestic fossil fuel consumption and will increase the foreign exchange-earning potential of fossil fuel exports. If a 50 MW geothermal power plant is built, the effect is equivalent to the development of an oil field having an annual oil production of approximately 500,000 barrels. This amount of oil has a value equivalent to approximately USD 50 million at current oil prices, and the amount of oil saved by geothermal over a period of 30 years is estimated to be 15 million barrels, with a value of approximately USD 1.5 billion.[1]

(iii) It is stable energy

Although a geothermal power plant requires large amounts of up-front capital investment during the development stage, there are no fuel costs during the operating stage except for those associated with occasional makeup wells (1well, say, every 5 years). Therefore, the generation costs of a geothermal plant are not affected by increases in global oil prices or fluctuations of the exchange

[1] Crude oil price is assumed to be 100 USD/barrel.

rate of a country's own currency once the plant starts operation. This virtue of geothermal energy is drawing great attention at present, when global oil prices are soaring. Further, even in developing countries where currency values drop and oil importation prices rise, geothermal can supply energy at a stable price.

(iv) It is environmentally friendly energy

Since a geothermal power plant uses steam and hot water generated naturally underground, it is a power generation system which does not have a combustion process. Therefore, air-polluting substances such as sulfur oxide, nitrogen oxide and dust are not emitted, making this energy environmentally-friendly from the local perspective. From the global environmental perspective, a geothermal power plant also emits a very small amount of carbon dioxide compared with other power sources. For this reason, there are great expectations that geothermal energy will be developed as an effective climate change mitigation measure.

(v) It contributes to the local society

Hot water produced in a geothermal power plant can be effectively utilized as a heat source for horticulture, aqua-farming or local industry. For instance, Iceland widely uses hot water from geothermal power stations as a source for district heating in major cities. Kenya, a country in a tropical area, utilizes hot water as a heat source to control humidity in flower cultivation greenhouses. Through these direct uses, geothermal energy effectively combines energy development and regional development.

These characteristics of geothermal power are of remarkable importance when it is used as a power source in African nations. Specifically, the supply-reliability value mentioned in (i) contributes to the diversification of power sources in the Rift countries that depend mainly on hydro power. Geothermal power can supply energy irrespective of climate conditions, and therefore the energy supply becomes more secure when geothermal power is added to the power source mix. The value of having a domestic source of energy mentioned in (ii) is a big blessing for the Rift countries that are lacking in fossil energy resources. The value of resilience against economic fluctuations mentioned in (iii) will contribute to forming a strong energy source mix in the Rift countries in spite of the current volatile international energy situation. In addition, the environmentally friendly nature of geothermal mentioned in (iv) will make it a symbol of the fight against climate change, if African countries, which are vulnerable to climate change, exploit geothermal energy. Moreover, geothermal utilization can easily be turned into a CDM project, with the CO_2 credits providing benefits to both the host country and the supporting country. Additionally, in terms of the contribution to the local society mentioned in (v), a geothermal power plant can contribute to agricultural development by providing heat and condensed water to the host society. With such multiple uses of geothermal, the creation of job opportunities and the enhancement of farmers' incomes can be expected.

Attempts to use the hot water from geothermal power plants have already started in Kenya.

Large-scale flower cultivation is spreading in Naivasha, which is adjacent to the Olkaria geothermal power plants in Kenya. The floriculture export is the second largest foreign currency earner for Kenya following tourism. The Oserian farm, one of the large-scale farms producing roses and carnations in the area, uses geothermal power generation (4MW) for its farm uses in a complex of about 250 hectares (ha). Moreover, the farm uses the heat of geothermal water instead of chemicals to manage humidity control inside of the greenhouses at night time to prevent flower sickness and also uses CO2 from geothermal to boost plant growth . The farm has decreased its production costs by changing from fossil fuel to geothermal heat sources. The farm exports flowers to the European market, contributes to Kenya's foreign currency earnings and is employing more than 5,000 local people in the region. (Photo-2.2-1)



Photo-2.2-1 Multi-use of Geothermal Energy at Oserian Farm in Kenya
(left: Greenhouses for flowers, middle: Geothermal power plant, right : Inside of greenhouse)

The effective use of geothermal energy does not end there. The Eburru area is an arid zone located north of Olkaria at the top of Mt. Eburru, which is 2,600 meters high above sea level. The local people have difficulty securing drinking water for themselves and their domestic animals. However, they condense natural geothermal steam from fumaroles to produce water (Photo-2.2-2). Moreover, the farmers use geothermal steam to dry farm products (pyrethrum). This example shows that the effective use of geothermal energy can enhance local industry and living conditions.


Photo-2.2-2 Direct Use of Geothermal Energy in Eburru area, Kenya
（left: Facility condensing water from geothermal steam, right: A Drier house for agriculture products using geothermal hot water）

Chapter 3 Overview of the East African Rift Countries

3.1 Economic Overview

The five countries of the East African Rift region are among the least developed countries in the world. They are at relatively different stages of economic, social and institutional development. Table-3.1-1 shows economic indicators for the five countries.

Kenya is generally the most advanced of the five countries in terms of economic and institutional development. Its GNI per capita is the second highest in the list. Kenya is the trade and finance centre for East Africa and has pursued different economic reform programs, including a restructuring of the power sector in 1996. Currently, for example, IPPs provide 16 percent of the country's electricity production. Nevertheless, recent droughts have given rise to water and electricity rationing and a drop in agricultural output (which represents 1/3 of GDP). The current government (in place since 2002) has embarked on a wide poverty-reduction strategy and has pledged to promote economic growth.

Ethiopia is the most populous of the five countries. Nearly 50% of its economy is based on agriculture, which suffers because of drought, poor cultivation practices, and recently, war with Eritrea. In cooperation with international donors, Ethiopia has initiated multifaceted poverty reduction programmes, including the promotion of industrialization led by agricultural sector development.

Djibouti has a service-dominated economy based on its international shipping and refuelling port. The country has few natural resources and little industry aside from the port. Two-thirds of the country's inhabitants live in the capital port city (including immigrants and refugees). The rest of the population is made up mainly of nomadic herders. Unemployment is over 50%, and most sectors of the economy remain under state control. External assistance continues to play an important role in the Djibouti economy. Utility services for both water and electricity are relatively undeveloped and expensive, which exacerbates social living conditions and stymies the economic activity of small and medium enterprises.

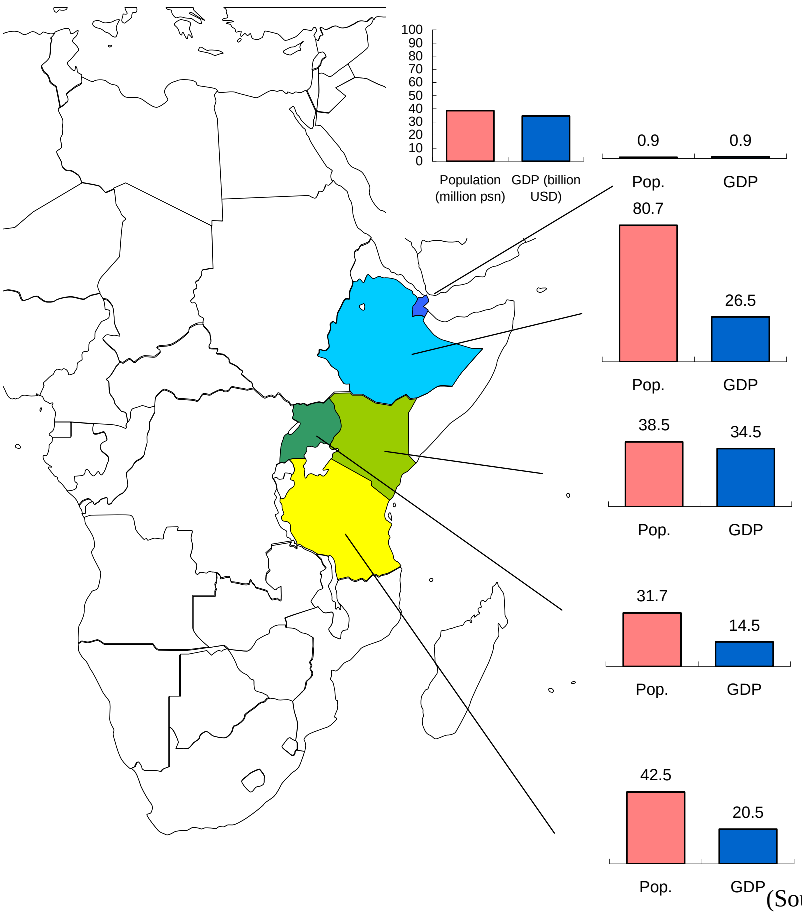
Finally, Tanzania and Uganda are both among the poorest countries in the world. Approximately half of Tanzania's GDP is dependent on agriculture, which occupies 80% of the large population. International donors have recently focused on the rehabilitation of the economic infrastructure and utilities. Macroeconomic growth has increased significantly since 2000, averaging 6.4% annually. Oil and gas exploration and development have contributed to this growth.

Uganda, like Tanzania, boasts a large population of which over 80% are employed in the agricultural sector. Coffee is the major export earner, but the country also has significant valuable mining resources (copper and cobalt). Significant economic reforms have been introduced since the 1990s, including measures to rehabilitate the infrastructure sectors. Macroeconomic growth since 1995 has averaged 6.7% per year.

Table-3.1-1 Economic Indicators for the East African Rift Countries

Country	Population* (2008) (million)	Pop. Growth* (2008) (% a.n.)	GDP* (2008) (billlion USD)	GDP Growth* (2008) (% a.n.)	GNI per Cap.* (2008) (USD)	Energy Consumption per Cap.** (2007) (kg Oil Eq.)	Electricity Consumption per Cap.** (2007) (kWh)
Kenya	38.5	2.6	34.5	3.6	770	132	133
Ethiopia	80.7	2.6	26.5	11.3	280	32	36
Djibouti	0.9	1.8	0.9	3.9	1,130	800	271
Tanzania	42.5	2.9	20.5	7.5	440	47	52
Uganda	31.7	3.3	14.5	9.5	420	28	28
Sub total	194.2	2.8	96.9	-	437	58	59
Sub-Sahara	818.0	2.5	987.1	5.0	1,082	672	542
World	6,692.0	1.2	60,587.0	2.0	8,613	1,795	2,674

(Source)
* World Bank, Key Development Data & Statistics
http://web.worldbank.org/WBSITE/EXTERNAL/DATASTATISTICS
** US Energy Information Administration, International Energy Profile
http://tonto.eia.doe.gov/country/country_energy_data.cfm?fips=UG



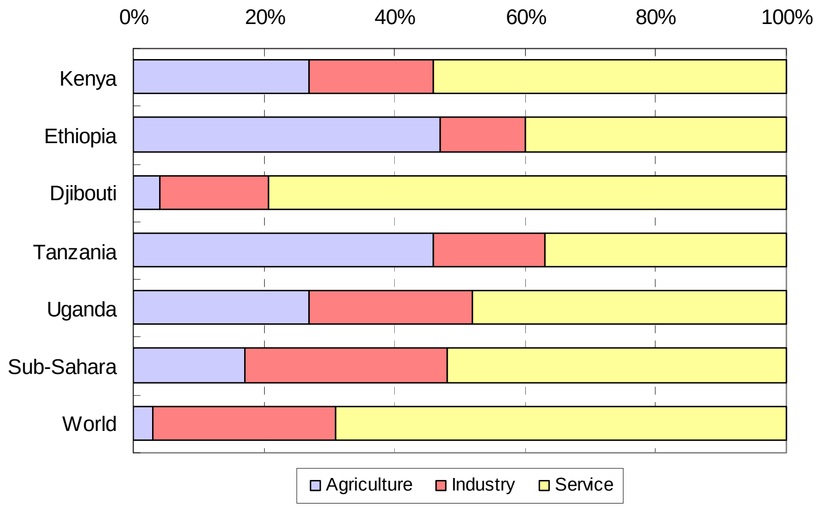
(Source) Same as Table-3.1-1

Fig.-3.1-1 Population and GDP of the East African Rift Countries (2005)

Table-3.1-2 Breakdown of GDP in the East African Rift Countries

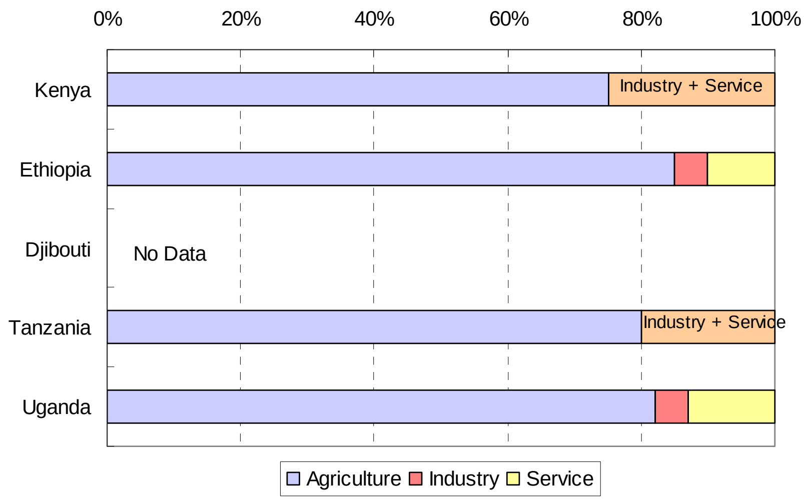
Country	GDP (2005) (billlion USD)	Agriculture (2005) (% of GDP)	Industry (2005) (% of GDP)	Service (2005) (% of GDP)
Kenya	18.8	27.0	19.0	54.0
Ethiopia	12.3	47.0	13.0	40.0
Djibouti	0.7	4.0	17.0	80.0
Tanzania	14.1	46.0	17.0	37.0
Uganda	9.2	27.0	25.0	48.0
Sub-Sahara	641.5	17.0	31.0	52.0
World	45,232.1	3.0	28.0	69.0

(Source)
World Bank, Key Development Data & Statistics
http://web.worldbank.org/WBSITE/EXTERNAL/DATASTATISTICS



(Source) Same as Table-3.1-2

Fig.-3.1-2 Breakdown of GDP of the East African Rift Countries



(Source) U.S. Central Intelligence Agency, The World Factbook

Fig.-3.1-3 Breakdown of Workforce of the East African Rift Countries

3.2 Energy Structure in the East African Rift Countries

The East African Rift countries have similar energy production and consumption characteristics. Combustible waste and biomass represents the largest category of energy produced, ranging from 70 to 90% of total energy production. All five countries import petroleum products mainly for transport use and electricity production. Renewable energy sources (hydro, geothermal, solar, etc) represent a small portion of total energy production, averaging 2% for hydropower, solar power and geothermal production combined.

Table-3.2-1 Total Primary Energy Supply in the East African Rift Countries (2007)

(unit: ktoe)

Country	Coal	Crude oil	Petroleum products	Gas	Hydro	Geothermal, Solar, etc.	Combustible/Renewable waste	Electricity	Total
Kenya*	68	1,607	1,907		300	877	13,548	-2	18,305
Ethiopia*			1,943		290		20,573		22,805
Djibouti**									
Tanzania*	52		1,346	446	216		16,188		18,278
Uganda**									

(Sources) *:IEA-International Energy Statistics 2007/ **:not reported

In terms of final energy consumption, combustible waste and biomass is the dominant category in the five countries. This is explained mainly by cooking and heating uses. Petroleum products, which represent the second most important category, are primarily used in the transportation sector. Electricity represents, on average, 2% of the energy consumed in the five countries and is supplied mainly in urban or semi-urban areas. Rural areas remain largely off-grid or un-electrified in the East African Rift countries.

Tabel-3.2-2 Total Final Energy Consumption in the East African Rift Countries (2007)

(Unit: ktoe)

Country	Coal	Petroleum products	Gas	Combustible, Renewable Waste	Electricity	Total
Kenya*	68	2,845		8,720	477	12,109
Ethiopia*		1,926		19,813	271	22,010
Djibouti**						
Tanzania*	20	1,365	72	14,081	267	15,806
Uganda**						

Sources: *:IEA-International Energy Statistics 2007/ **:not reported

With regard to electricity production, Kenya is the most advanced country in the group, with over 1,000 MW of total installed capacity. This represents approximately 10 times the installed capacity in

Djibouti and three times of that of Uganda.

Hydropower is currently the predominant source of electricity in the region, yet recent droughts and the silting of reservoirs raise questions concerning the reliability of these resources. Thermal production (mainly diesel generation) is present in most countries and is the only source of production in Djibouti. Volatile prices and high import costs make diesel generation a costly power source.

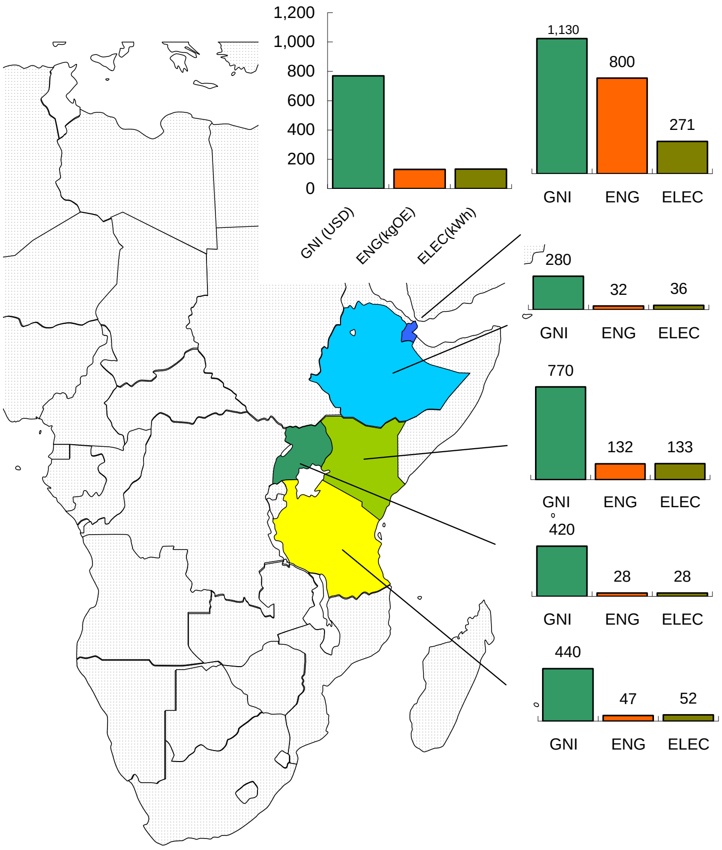
The amount of electricity used per capita in the East African Rift countries in 2005 was as follows: 133 kWh in Kenya, 36 kWh in Ethiopia, 271 kWh in Djibouti, 52 kWh in Tanzania and 59 kWh in Uganda. These values are far below the 542 kWh average for Sub Saharan African countries and are dwarfed by the 2,674 kWh global average (Table-3.1-1).

The current extent of electrification is low in most of the East African Rift countries, due to the relatively limited development of the infrastructure (in scope and depth) and the large populations. While urban centres have access to electricity grids (4–20%), the rate of electrification in rural areas is 1–2% for many of the countries. National development policies in most countries emphasize the promotion of local, independent or mini-grid electrification, yet the most likely source for this type of production (diesel generators) is made even more expensive by the costs of transporting fuel and spare parts to remote areas. Renewable options other than geothermal, such as solar and wind power, are also being explored in some countries.

Electricity demand growth is high in all East African Rift countries, averaging at least 3 to 5% per year. In relatively mature markets, such as Kenya, the reference baseline forecast for increases in consumption is 10.4% per year to 2020. In the more southern countries of the region, electricity demand is reportedly growing at 8.8% per year in Tanzania and at 6.1% per year in Uganda. High electricity demand growth underlines the need for adequate and diverse electricity production supply sources, including geothermal production.

Electricity prices in the five countries reflect the different production, transmission and distribution structures, with production costs varying between USD 0.035 and USD 0.3 per kWh. High technical and commercial losses as well as poor maintenance can significantly affect the selling price (as is the case in Djibouti). Electricity is provided by the national utilities in the urban, capital centres via the national grids. Outside of urban areas, there is little rural network coverage, and electricity (if it is supplied at all) is usually provided via small 5 – 10 MW diesel generation units run by cooperatives or other entities.

An outline of the power-sector system in the East African Rift countries is shown in Fig.-3.2-1. In Kenya, power generation is undertaken mainly by Kenya Power Generation Company (KenGen). In addition to KenGen, there are five private Independent Power Providers (IPPs) in the power generation sector. Kenya Power and Lighting Company (KPLC) is in charge of the transmission and distribution of electricity, and the newly established state-run Kenya Electricity Transmission Company (KETRACO) is in charge of new transmission lines built since 2008. At first, the government held 100% of the stock of KenGen and KPLC, but the government sold off some of the stock to the public in 2007. Currently the government holds 70% of KenGen stock and 49% of KPLC stock. In Ethiopia, the Ethiopian Electric Power Corporation (EEPCO) is in charge of power generation basically. However, a private IPP has entered the power generation business recently. The IPP is advancing construction of a hydroelectric power plant in Ethiopia. In Djibouti, a government-run company, Electricité de Djibouti, monopolizes power generation, transmission and distribution of power. In Tanzanian, while Tanzania Electric Supply Corporation (TANESCO) and IPPs are in charge of the power generation business, TANESCO monopolizes the business of power transmission and distribution. (Zanzibar Electricity Corporation (ZECO) supplies power in Zanzibar that it receives from TANESCO.) Privatization of electricity utilities is most advanced in Uganda. The Uganda Electricity Generating Company Limited (UEGCL) and five private companies are in charge of power generation, while the government-run Uganda Electricity Transmission Company Limited (UETCL) has a monopoly of the power transmission business. In distribution of power, Uganda Electricity Distribution Company Limited (UEDCL) supplies power outside of the metropolitan area, and a private company (UMEME), which borrows the UEDCL distribution network , supplies power in the metropolitan area.



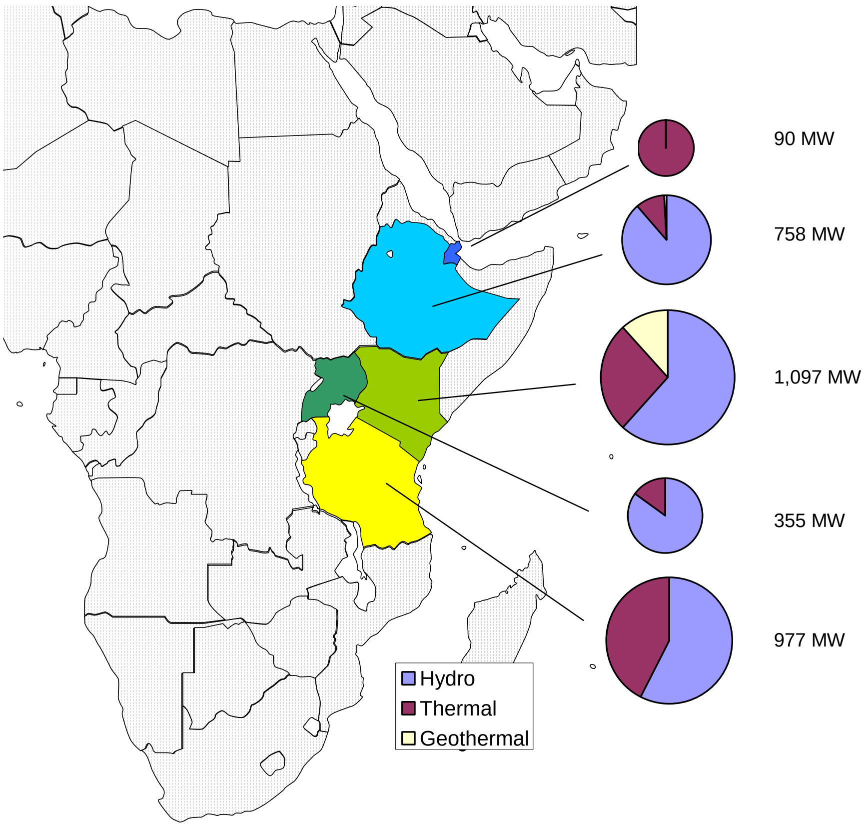
（Source） Same as Table-3.1-1

Fig.-3.2-1 GNI, Energy Consumption and Electricity consumption per Capita (2005, 2008)

Table-3.2-3 Profile of Electricity Sectors of the East African Rift Countries

Country		Kenya (Jun. 2006)	Ethiopia (2007)	Djibouti (2002)	Tanzania (Dec.2005)	Uganda (Dec.2005)
Electric Sector System						
Generation		KenGen/IPP	EEPCO/IPP	ED	TANESCO/IPP	Private Co.
Transmision		KPLC	EEPCO	ED	TANESCO	UETCL
Distribution		KPLC	EEPCO	ED	TANESCO	Private Co.
Installed capacity						
Hydro	MW	677	671	—	561	302
Thermal（GT・Die	MW	292	80	90	416	53
Geothermal	MW	128	7	—	—	—
Total	MW	1,097	758	90	977	355
Generated Eergy						
Hydro	GWh	3,025	2,837	—	1,778	1,856
Thermal（GT・Die	GWh	1,653	413	180	1,889	1
Geothermal	GWh	1,003	49	—	—	—
Total	GWh	5,681	3,299	180	3,667	1,857
Electricity Tariff						
Average tariff US ¢/kWh		10.5	N.A.	N.A.	7.1	6.5

(Source) Japan Electric Power Information Center, Inc.; Embassy of Japan in Ethiopia



(Source) Same as Table-3.2-3

Fig.-3.2-2 Installed Generation Capacity by Energy Source

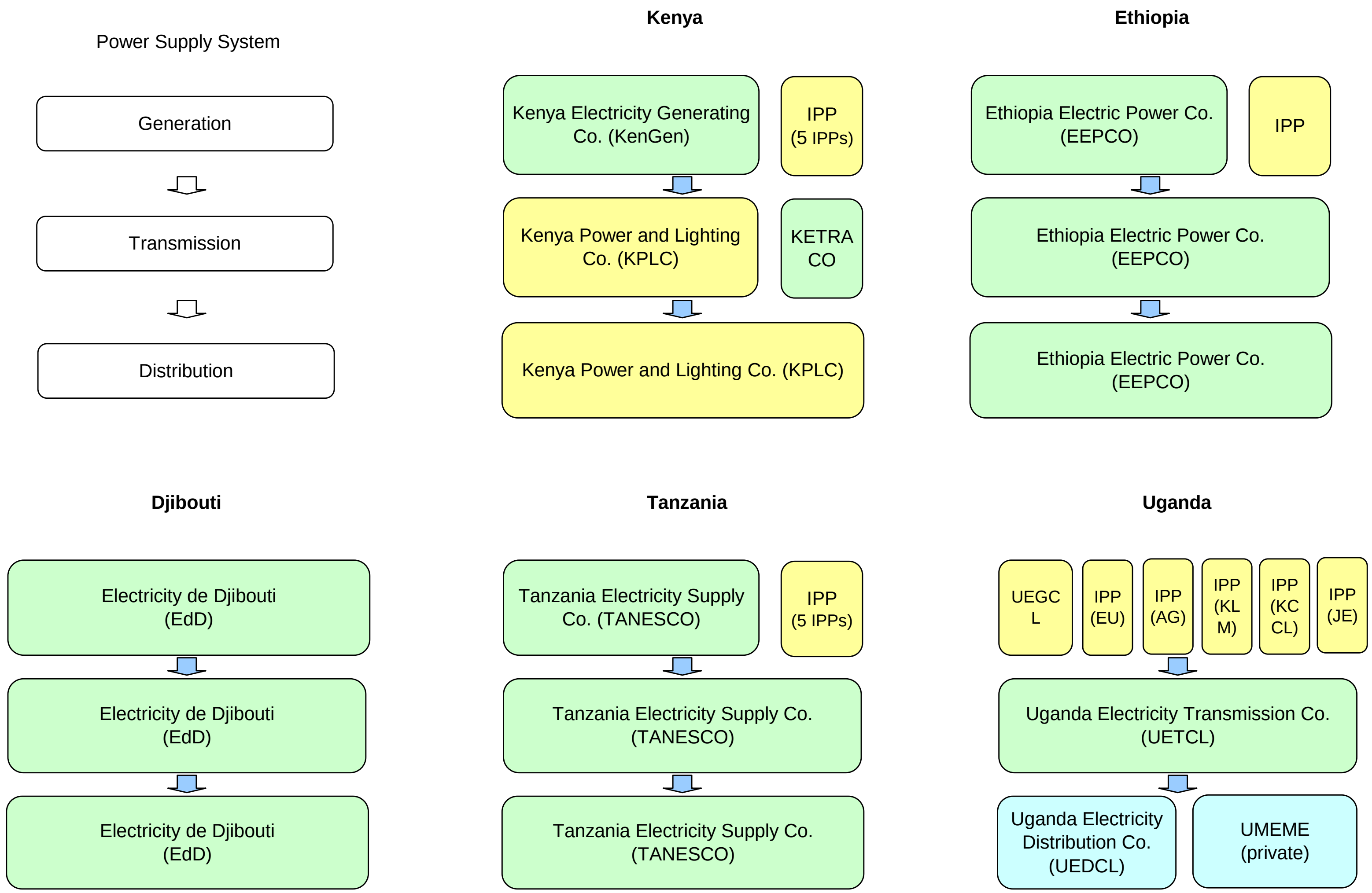


Fig.-3.2-3 Electric Power Supply System in the East African Rift Countries

3.3 Geothermal Resources in the East African Rift Countries

The East African Rift System is one of the earth's major tectonic structures, extending for about 6,500 km from the Middle East (Dead Sea-Jordan Valley) in the North to Mozambique in the south (Fig.-3.3-1). The Rift System is composed of two rift trends, the eastern and western branches. The eastern branch runs from north to south in Ethiopia and reaches south of Kenya. The western branch develops from Uganda throughout Lake Tanganyika, where it joins the Eastern branch, following the border between Rwanda and the Democratic Republic of Congo. The western branch, however, is much less active in terms of volcanism, although both branches are seismically and tectonically active today. The East African Rift System is one of the most important zones in the world where the heat energy of the interior of the earth escapes to the surface in the form of volcanic eruptions, earthquakes and the upward transport of heat by hot springs and fumaroles. As a consequence, the East African Rift System appears to possess a remarkable geothermal potential. The eastern branch that forms the Ethiopian and Kenyan rifts possesses by far the most extensive geothermal resource base in Africa and one of the most extensive in the world.

Using today's technologies, East Africa has the potential to generate about 15,000 MW of energy from geothermal power according to the latest report (Teklemariam, 2010). East African countries using, or having carried out research on, geothermal resources include: Djibouti, Ethiopia, Kenya, Uganda, and Tanzania. Among these, Kenya is the leading country in using geothermal energy for electricity production, followed by Ethiopia. Kenya is generating a total of about 204 MW of electricity using geothermal energy resources. In Ethiopia, a geothermal pilot power plant with a total installed capacity of 7.3 MW was built. Initially, there was a disruption in power generation due to technical problems, but the problems have been addressed, and the plant is now achieving partial generation (4MW). Although geothermal plants have not been built yet, Djibouti is following the two lead countries in geothermal development. Several exploration wells have been drilled in Djibouti. Tanzania and Uganda are still at an initial surface survey stage.

Table-3.3-1 Geothermal Development Situation in Olkaria Field in Kenya

Area	Olkaria Ⅰ	Olkaria Ⅱ	Olkaria Ⅲ	Olkaria Ⅳ (Domes)	Oserian
Developer	KenGen	KenGen	IPP(Ormat)	GDC, KenGen	Oserian Dev. Co.
Plant Capacity	45MW (15MW×3) Unit-4,5 (140MWx2) (Planned)	105MW(35MW×3)	50MW	140MW	4MW (2MWx2)
Dev. Year	1981,82,85	2004,2010 (Unit-3)	2001	―	―
Cost	Unknown	174 m$（Unit-1,2） 87.5m$（Unit-3）	―	―	―
Donors	Unit-1,2,3 (WB,EIB) Unit-4,5 (WB, JICA, AfD)	Unit-1,2 (WB,KfW,EIB) Unit-3 (IDA,EIB)	―	KfW	―

(Source) KenGen

Table-3.3-2 Overview of geothermal Development in East African Rift Countries

Countries	Reconnaissance	Semi Detailed Survey	Detailed Survey	Drilling	Feasibility Study	Power Development	Remarks
Kenya	x	x	x	x		x	204 MW
Ethiopia	x	x	x	x		x	4 MW
Djibouti	x	x	x	x			
Tanzania	x	x	x				
Uganda	x	x					

(Source) Geothermal Stakeholders' Workshop (March, 2010) Nairobi, Kenya

Table-3.3-3 Geothermal Fields and Prospects in the East African Rift Countries

No.	Kenya	Ethiopia	Djibouti	Tanzania	Uganda
1	L. Magadi	Abaya	As Bahalto	South Mbeya	Buranga
2	Suswa	Corbetti	Allailou	L. Natron	Katwe
3	Longonot	Aluto Langano	Hanle	Luhoi-Rufiji	Kibiro
4	Olkaria	Tulu Moye	Gaggade	Kibo Crater (Mt. Kilimanjaro)	
5	Eburru	Gedemsa	Assal Rift	L. Manyara	
6	Menengai	Kone	N. of Ghoubbet el Kharab	Songwe River	
7	Arus/Bogoria	Fantale	S. of Ghoubbet el Kharab	Kilambo	
8	Baringo	Dofan	Arta	Mampulo and Kasimolo	
9	Korosi/Chepchuk	Meteka	Tamattako-nieille		
10	Paka	Danab	Obok		
11	Silali	Teo	South of Djibouti City		
12	Em urangogolak	Abe	NW of Kadda Alifita		
13	Namarunu	Tendaho	Alol-Sakallol		
14	Barrier volcano		Dora-Musa Ali		

3.3.1 Kenya

In the East African Rift region, Kenya was the first African country to tap geothermal energy for electric power generation. Its current status has partly been due to its limited hydro resources and the success that it has had in its staged geothermal development since 1981. Kenya's first electricity generating plant has been operating very reliably for around 30 years. This has encouraged Kenya to speed up its geothermal power development program.

The most explored and developed field in Kenya is the Olkaria geothermal field, which is divided into seven areas. The Olkaria I area has a 45 MW power plant based on three 15 MW units commissioned in 1981, 82 and 85, and the Olkaria II area has a 105 MW power plant commissioned in 2003 and 2010. These two plants and areas are owned by KenGen. The Olkaria III area with a 50 MW plant is owned by ORMAT (an IPP). The Olkaria IV area (locally referred to as Domes) has ten exploration wells drilled with temperatures up to 350ºC. A drilling operation is underway for expansion up to around 400MW output in the whole Olkaria geothermal field. Other geothermal areas such as Eburru, Longonot, Suswa, Menengai etc. are at a various stages of exploration (Fig.-3.3-2). The current estimated geothermal potential in Kenya is 7,000 MW. In the course of these development activities, Kenya has acquired considerable expertise in geothermal-related earth sciences and engineering.

It is notable that in Kenya, besides being used for electricity production, geothermal water and carbon dioxide are used in an extensive complex of greenhouses for growing roses. Rose exports from those greenhouses total USD 300 million per year.

3.3.2 Ethiopia

Ethiopia started a long-term geothermal exploration undertaking in 1969. Over the years, a good inventory of the possible resource areas has been built up, and a number of the more important sites have been explored in the Ethiopian Rift Valley. Of these areas, about sixteen are judged to have a potential for high-temperature steam suitable for electricity generation (Fig.-3.3-3). A much larger number are capable of being developed for direct utilization of geothermal heat in agriculture, agro-industry etc.

Exploration work peaked during the early to mid-1980s when exploration drilling was carried out at the Aluto-Langano geothermal field (Lakes District). Eight deep exploratory wells were drilled to a maximum depth of about 2,500m, and four were found to be productive, with a maximum geothermal reservoir temperature of about 350ºC. During the early 1990s exploration drilling was also carried out at Tendaho (Northern Afar). Three deep (2,100m) and three shallow wells (500m) confirmed the existence of a high-temperature (270ºC) reservoir.

The Aluto-Langano geothermal field was handed over to the Ethiopian Electric Power Company (EEPCO) for development in 1996, but utilization was delayed until 1998. The first 7.3 MW pilot power plant was built under a turnkey contract by the Israeli company ORMAT. Initially, there was a disruption in power generation due to technical problems. The plant is now achieving partial generation (4 MW).

Other geothermal prospect areas in the Ethiopian Rift Valley are at various stages of exploration that vary from reconnaissance to detailed geoscientific studies including drilling of temperature gradient (TG) wells. These include:.

(i) Tulu-Moye and Corbetti : Detailed geoscientific studies including drilling of TG wells

(ii) Abaya, Dofan and Fantale: Detailed geoscientific studies

(iii) Kone, Meteka, Teo, Danab, and L.Abhe: Reconnaissance investigations.

During the four decades that geothermal resource exploration work has been carried out in Ethiopia, a good information base and degree of exploration capacity have been developed. This is especially true in the human capacity and basic infrastructure development that will be critical in ensuring that future selected resource sites are advanced to the development phase much more rapidly than before.

3.3.3 Djibouti

Djibouti lies at the junction of three active, major coastal-spreading centers: (a) the East Africa Rift zone; (b) The Gulf of Aden Rift; and (c) and the Red Sea Rift (Fig.-3.3-4). This structural junction is unique in being the focal point of very high heat flux. According to a study by the Geothermal Energy Association (GEA, 1999), the geothermal potential in Djibouti is between 230-860 MW from a number of prospects including: (i) Lake Asal; (ii) Lac Abhe; (iii) Hanle; (iv) Gaggade: (v) Arta; (vi) Tadjourah; (vii) Obock and ; (viii) Dorra.

Much effort has been expended in Djibouti since the 1970s, in view of the fact that the country is deficient in indigenous energy resources. Djibouti's energy is currently produced from fossil fuels. The first concerted effort to assess and explore Djibouti's geothermal resources took place in the Asal area from 1970-83 and was funded by French government. About six exploratory wells were drilled in the Asal geothermal fields. While a very high-temperature system has been successfully located, problems related to the high salinity of the discovered fluids, which is due to the close proximity of the field to the Gulf of Aden, have delayed resource development and exploitation.

In 2000, Geothermal Development Associates (GDA) of USA completed a feasibility study for the development of a 30 MW geothermal power plant in the Lake Asal region.

3.3.4 Tanzania

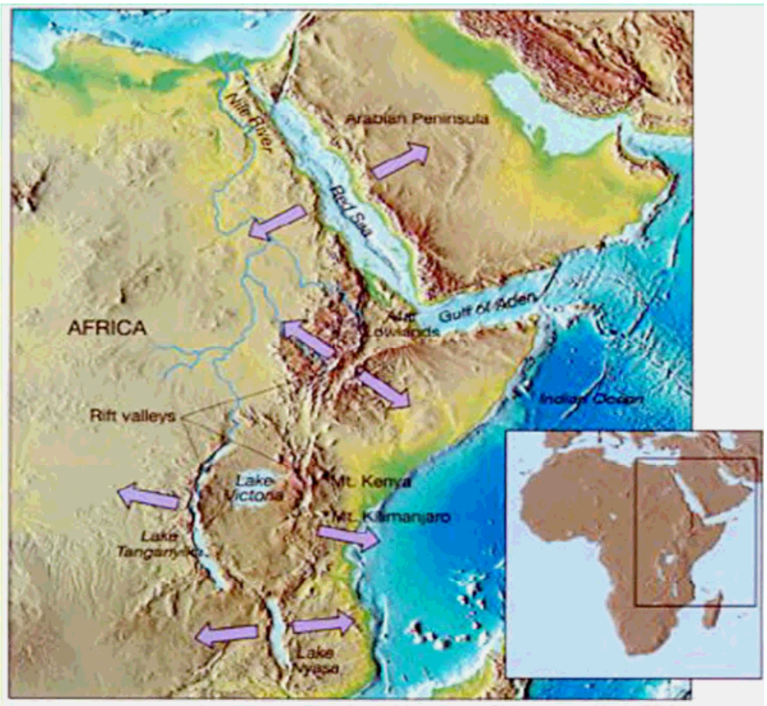
Geothermal exploration in Tanzania was carried out during 1976-79 by SWECO, a Swedish consulting group, in collaboration with Virkir-Orkint (Iceland), with financial support from the Swedish International Development Authority (SIDA). Reconnaissance studies for surface exploration were carried out in the north (near Arusha, Lake Natron, Lake Manyara and Maji Moto) and in the south (in the Mbeya region). Geothermal work in all locations in Tanzania is at the surface exploration stage.
Two potential target areas for geothermal exploration singled out so far are: (a) the Arusha region near the Kenyan border in the north; and (b) the Mbeya region between Lake Rukwa and Lake Nyasa in the southwest (Fig.-3.3-5). Another potential area (Luhoi) was prospected during 1998-2002 by First Energy Company (a local firm). It conducted important project definition and reconnaissance evaluation work. This area is located 160 km south of Dar es Salaam. The work conducted so far indicates the existence of a geothermal reservoir with a temperature greater than 200 degrees Celsius.

3.3.5 Uganda

Reconnaissance surveys have been carried out on geothermal areas of Uganda since 1935, when the first documentation of hot springs was made Bahati・Joshua (2002). Uganda recognizes the need to develop its geothermal resources to diversify its electricity generation, to support hydro and to improve electricity supply in the western part of the country. Recent geoscientific studies have focused on the three geothermal systems of Buranga, Katwe and Kibiro, all located in the active belt in the western Rift valley along the border of Uganda and the Democratic Republic of Congo (Fig.-3.3-6).

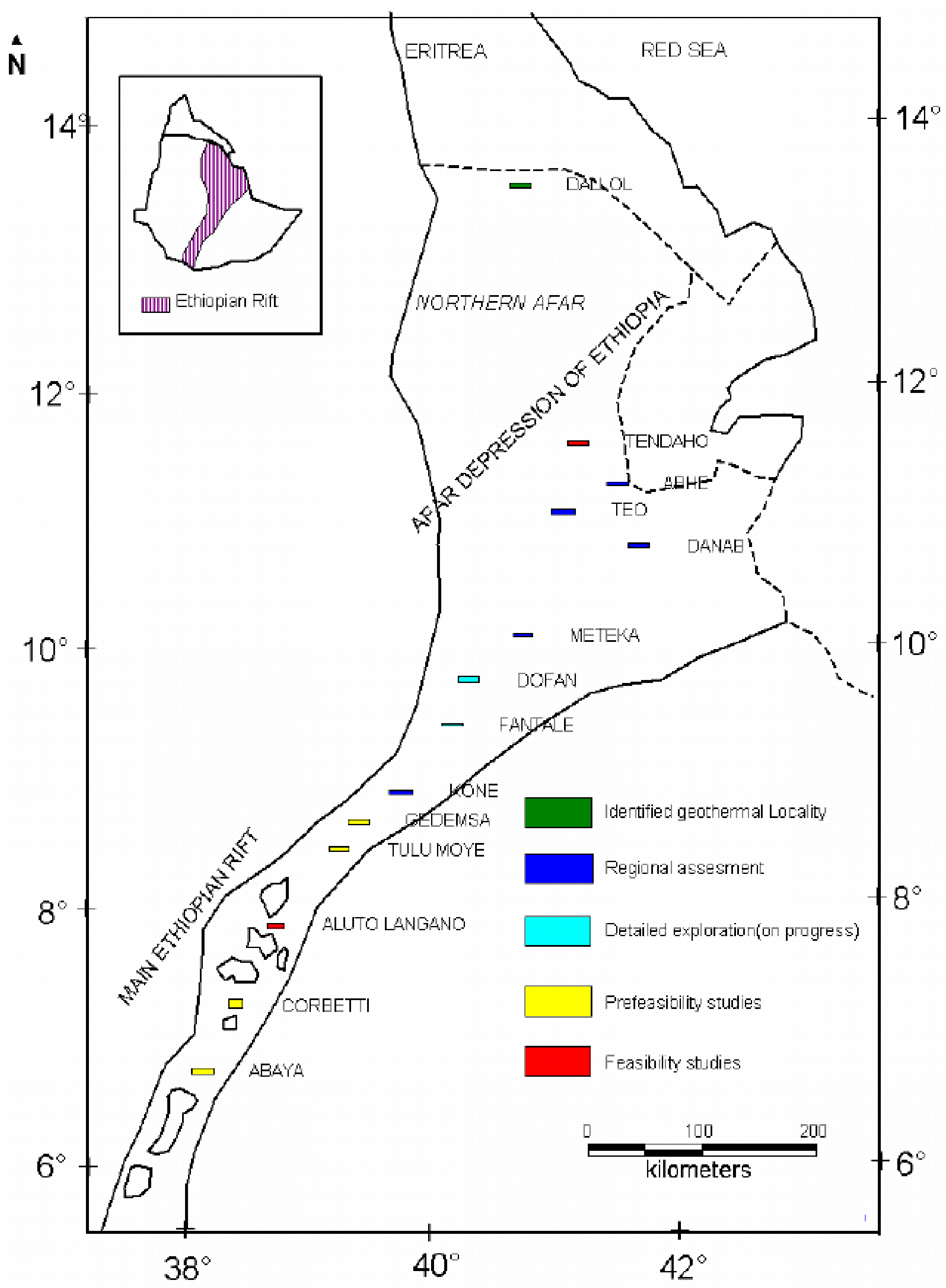
The three areas have been chosen for study because of volcanic and tectonic features that possibly indicate a powerful heat source and high permeability.

The African Development Bank (AfDB) conducted research at Katwe with the Uganda Alternate Energy Resource Agency (UAERA). The Icelandic International Development Agency (ICEIDA) has financed surface exploration survey at Kibiro, including geological and geophysical surveys. The ICEIDA has also completed the survey begun by UAERA in the Katwe geothermal prospect area. The German Geological Survey (BGR) has carried out a micro-seismic survey in the Buranga geothermal prospect area. In the Katwe and Kibiro geothermal prospect areas, shallow wells (200-300m) for temperature gradient measurement have been drilled. The temperature gradient measurement of shallow wells will prove the existence of the resource and update the geothermal model that will be a basis for the drilling of deep exploration wells.



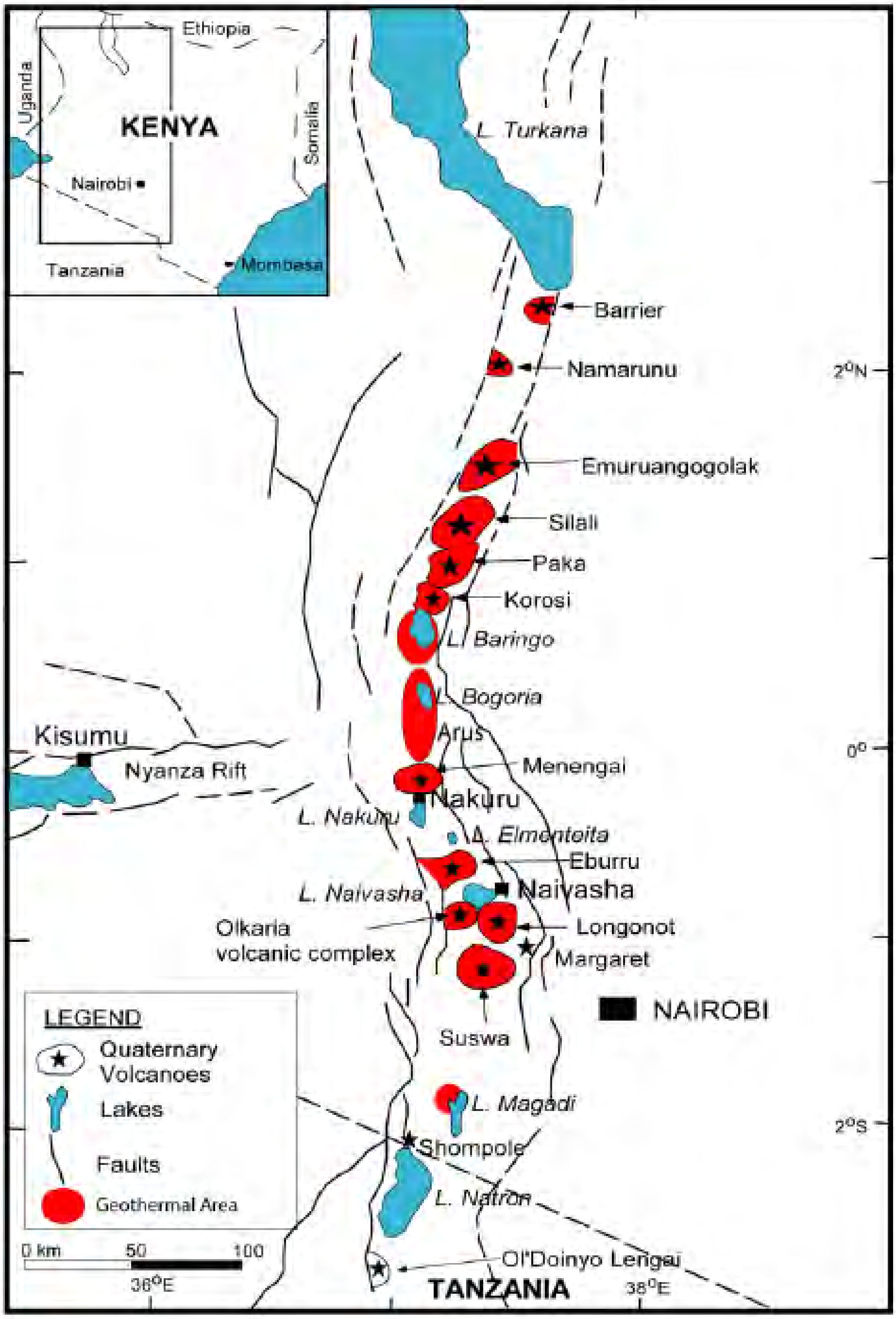
(Source) (Teklemariam, 2010)

Fig.-3.3-1 The Great East African Rift System



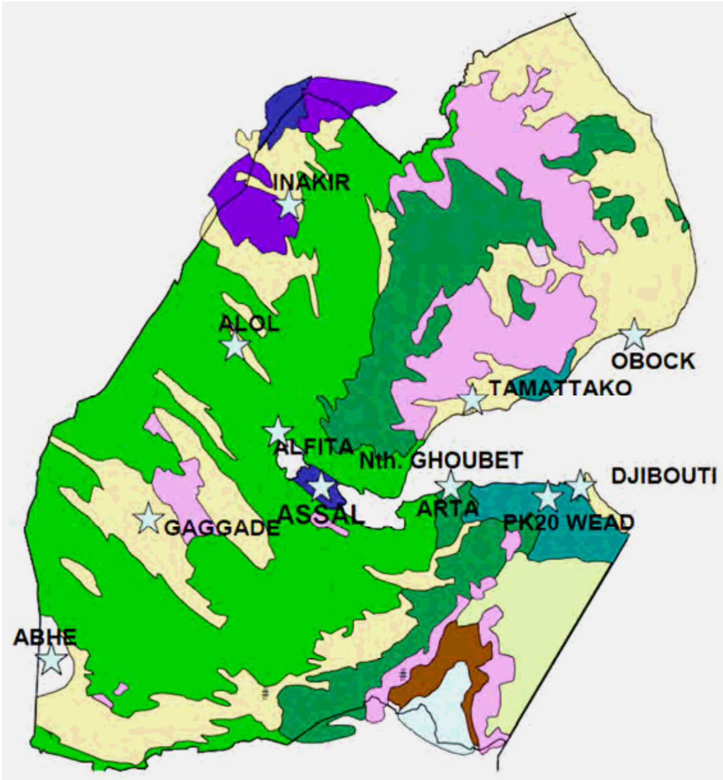
(Source) Peter(2010)

Fig.-3.3-2 Location of Geothermal Prospect areas in Kenya



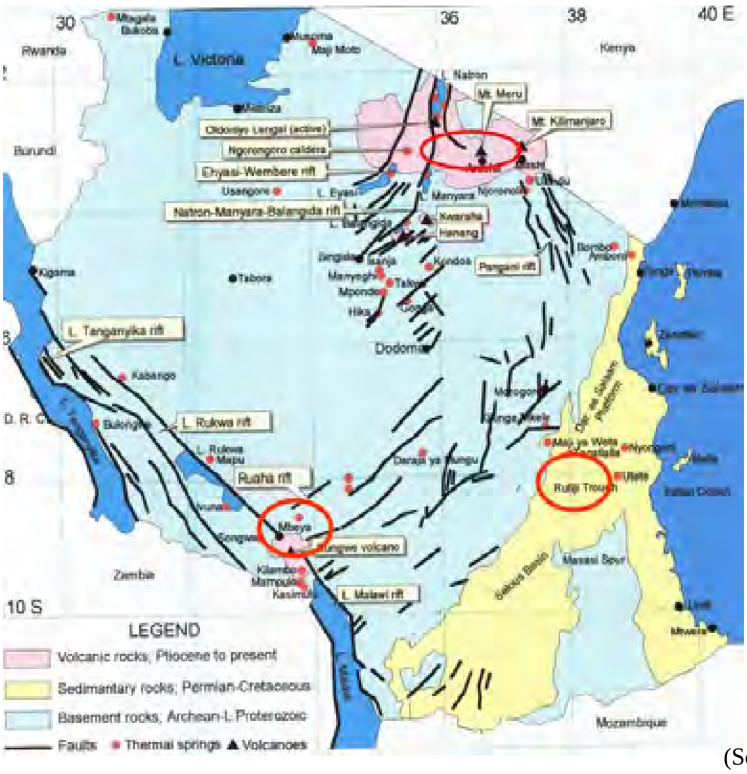
(Source) (Teklemariam, 2007)

Fig.-3.3-3 Location of Geothermal Prospect areas in Ethiopia



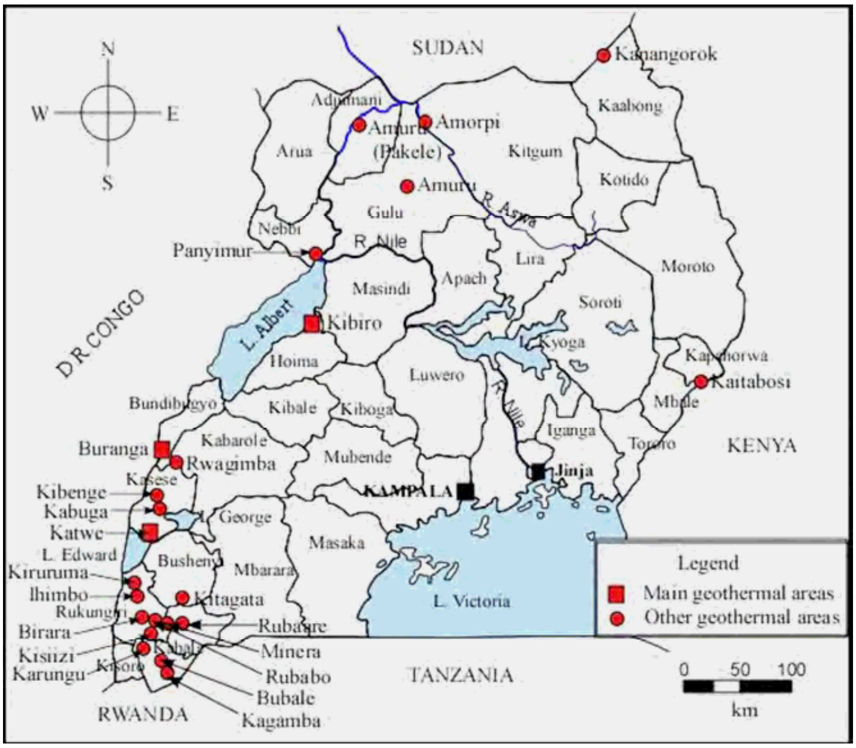
(Source) Ainan (2010)

Fig.-3.3-4 Location of Geothermal Prospect areas in Djibouti



(Source) JBIC (2008)

Fig.-3.3-5 Location of Geothermal Prospect areas in Tanzania



(Source) Bahati (2007)

Fig. 3.3-6 Location of Geothermal Prospect areas in Uganda

3.4 Situation of Japanese ODA to the East African Rift Countries

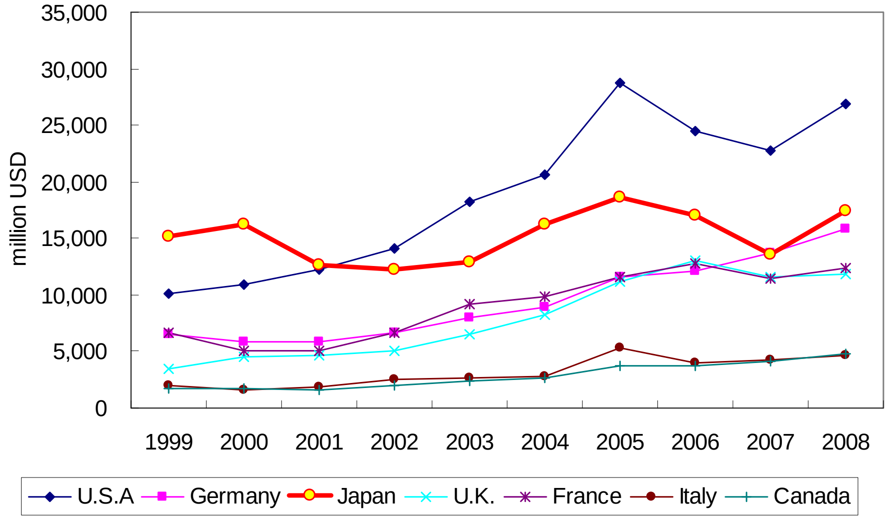
Many African countries are facing several problems such as food shortages, the spread of infectious diseases, prevailing poverty and so on. These problems threaten the daily lives of the local people. While international society is exerting utmost efforts towards attaining the Millennium Development Goals (MDGs), it is thought that the MDGs can hardly be attained in the Sub-Sahara region due to these intractable problems. Moreover, many Africa countries are also facing political challenges such as social instability, conflicts among ethnic groups, infringements of human rights, and the delay of democratization, etc. In order to settle these problems, sustainable socio-economic development is urgently needed in many African countries, and for this purpose, strong assistance from the international community is also necessary, especially in the fields of infrastructure maintenance, community development and the progress of democratization. As a part of the international community's efforts, Japan has been extending its assistance in the fields of economic growth, institutional development, capacity building, the spread of good governance and so on.

The total amount of the Japanese government's Official Development Assistance (bilateral assistance) to Africa is USD 1,701 million in 2007 (net disbursement base) and accounts for 29.1% of Japan's total bilateral assistance to all countries. This sum breaks down into USD 1,365 million grant aid (80.2%), USD 237 million technical cooperation (14.0%) and USD minus 85 million soft loan assistance (-5.0%, the amount of repayment exceeds the new disbursements).

The amount of Japanese ODA has been ranging between USD 12,000 million and USD 18,000 million (gross disbursement base) or between USD 6,000 million and USD 10,000 million (net disbursement base) for the last ten years due to the tight government budget situation. As a result, the amount of Japanese ODA has fallen to less than that of the United States, which has increased its ODA expenditures to fight against terrorism. Japan, which had been in the first place in ODA ranking between 1990 and 2000, is now in second place, just ahead of Germany, the United Kingdom, France, and others.(Fig.-3.4-1). Reversing a five-year trend of falling total ODA expenditures, the amount of Japanese ODA to Africa has increased greatly since 2005 (Fig.-3.4-2). At the same time, the amount of ODA to Asia, which had been the main traditional recipient region for Japanese ODA, has been reduced gradually, reflecting the recent great economic development in the region. As a result, after 2006, Africa became the number one recipient region for Japanese ODA, as shown in Fig-3.4-3. It is a sign of the Japanese government's recognition of the importance of supporting Africa.

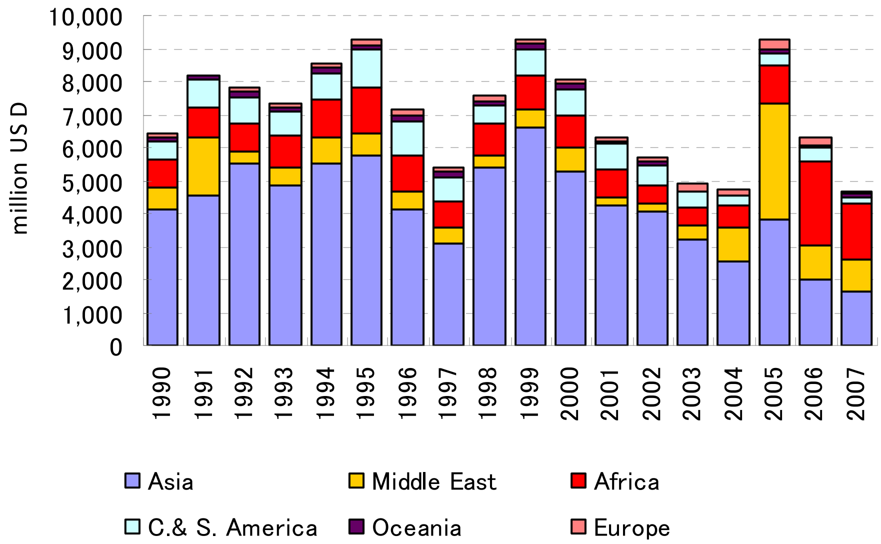
In the country by country breakdown of ODA expenditures, many East African Rift countries rank fairly high in the list of Japanese ODA recipient countries. Tanzania is the number one recipient country in Africa with USD 722 million, followed by Kenya with USD 57 million (4th place), Ethiopia with USD 36 million (8th place) and Uganda with USD 28 million (13th place). Djibouti places 37th, with USD 3.9 million in 2007.

As for cumulative ODA amounts in the recent ten-year period from 1998-2007, Tanzania has obtained USD 1,618 million and is the biggest recipient country (Table-3.4-1 and Fig.-3.4-5). Grant aid and technical cooperation are the main schemes of ODA to Africa. This is due to the fact that many African countries are not yet eligible for soft loans due to their governments' weak financial condition.



（Source） ODA Statistics, Ministry of Foreign Affairs

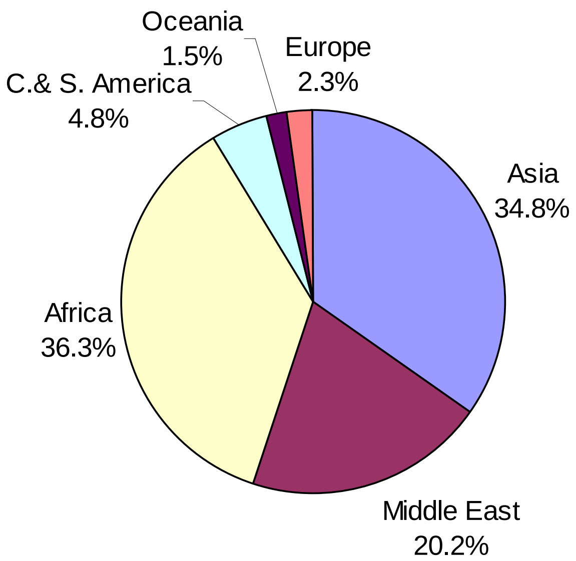
Fig.-3.4-1 Official Development Assistance of Major Donor Countries (gross disbursement base)



（Note） Total amount is not necessarily equal to the total ODA amount due to differences in counting method.

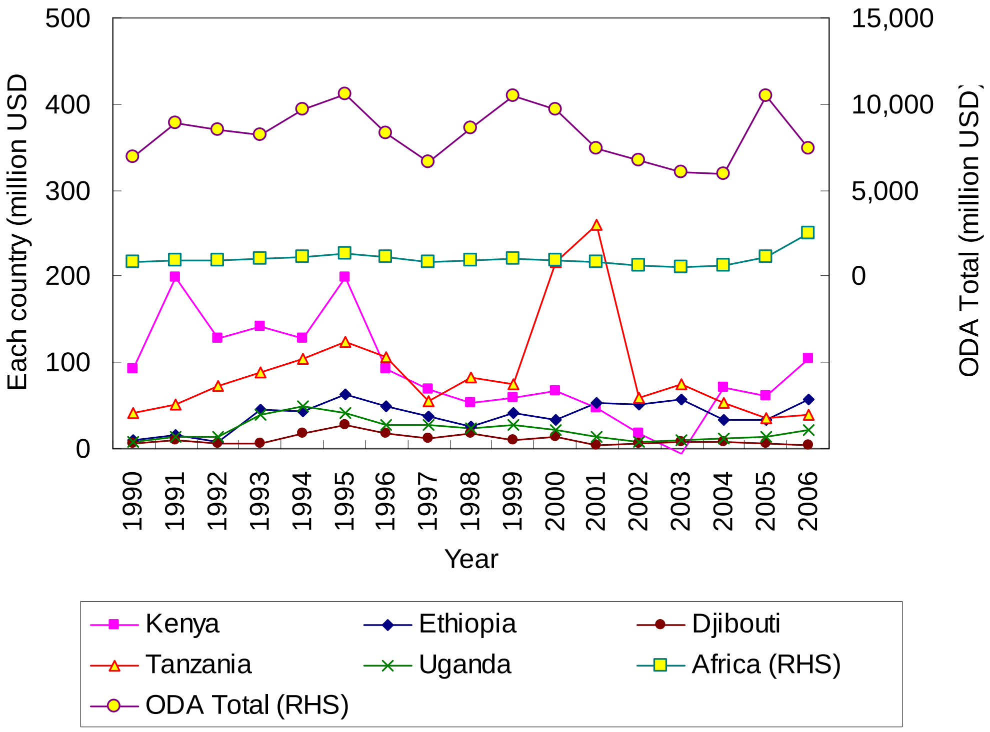
（Source） ODA Statistics, Ministry of Foreign Affairs

Fig.-3.4-2 Japanese ODA Amount by Regions (net disbursement base)



（Source） ODA Statistics, Ministry of Foreign Affairs

Fig.-3.4-3 Japanese ODA Amount by Regions in 2007 (net disbursement base)



(Note) RHS: Right Hand Scale （Source） ODA Statistics, Ministry of Foreign Affairs

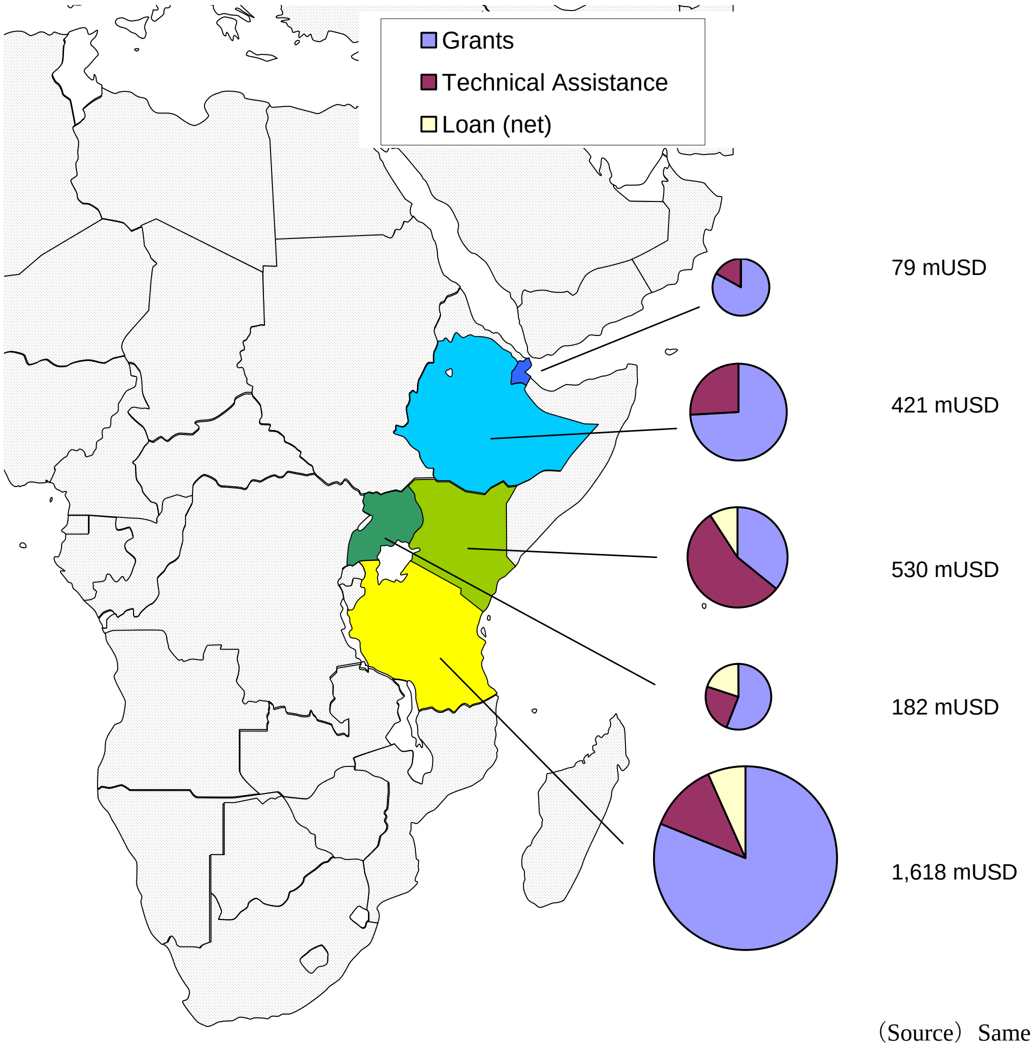
Fig.-3.4-4 Japanese ODA Amount to the World and the East African Rift Countries (net disbursement base)

Table-3.4-1 Cumulated Japanese ODA Amount to the East African Rift Countries (1998-2007)

(Net disbursement base: unit million USD)

Country	Grants			Loan	Grand Total
	Grants	Technical Assistance	Sub Total		
Kenya	186.0	286.6	481.3	48.2	529.5
Ethiopia	306.3	107.3	421.3	0.0	421.3
Djibouti	65.7	13.5	79.1	0.0	79.1
Tanzania	1,512.3	226.7	1,744.4	-126.3	1,618.1
Uganda	161.4	70.3	240.1	-57.8	182.3
Africa	10,508.2	2,171.8	13,015.4	-2,110.2	10,905.2
World	31,257.9	29,167.8	60,425.6	18,196.9	78,622.6

(Source) ODA Statistics, Ministry of Foreign Affairs
http://www3.mofa.go.jp/mofaj/gaiko/oda/shiryo/jisseki/kuni/index.php



（Source） Same as Table-3.4-1

Fig.-3.4-5 Cumulated Japanese ODA Amount to the East African Rift Countries (1998-2007)

3.5 Japanese ODA to Promote Geothermal Energy

As it is located on the Ring of Fire, Japan is rich in geothermal resources. The first Japanese geothermal power plant was built in 1966, and the current capacity of geothermal plants in Japan is 535 MW from 20 plants in 17 locations. Moreover, Japanese manufacturers are delivering approximately three quarters of the geothermal power plants in the world. Geothermal-related technology is one of technologies in which Japan is competitive in the global market. Backed by this technology, the Japanese government has positively supported several overseas geothermal projects through ODA schemes.

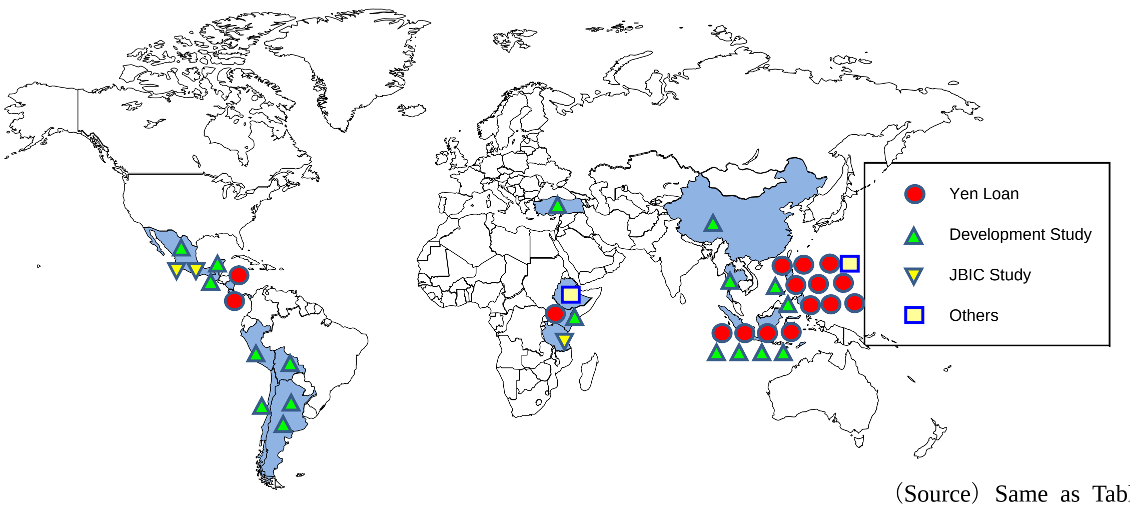
The Japanese government has extended soft loan assistance to 16 geothermal power plant projects amounting to JPY 199.2 billion to date. The Philippines and Central America had been the main recipient countries in the 1980s and 1990s. Since 2000, soft loans have been extended mainly to Indonesia. A soft loan of JPY 29.5 billion was provided to the Olkaria-I expansion (units 4 and 5) project in Kenya in 2010.

Development studies for geothermal resource development have been carried out since 1973. Up to the present, 16 development studies have been executed in 11 countries. Currently a master plan study for geothermal development is being carried out in Peru.

Under the expert dispatch scheme, 25 experts were dispatched to 10 countries between 1975 and 2001. Moreover, an international geothermal technology course was conducted at Kyushu University between 1970 and 2001, and the university trained 393 fellows from 36 countries.

In addition, there are two rare examples of support for geothermal development through ODA schemes. JICA supported Kyushu Electric Power Co. in carrying out geothermal exploration in Tanawan field in the Philippines in 2000 through a special JICA soft loan for the trial activities. The other example consisted of non-project-type grant aid to Ethiopia to support forest reservation activities and renewable energy development activities. Geothermal energy is also eligible for this non-project-type grant aid.

Recently, the Japanese government has been turning its eyes increasingly to geothermal development activities in Africa in addition to activities in traditional recipient countries such as the Philippines, Indonesia and Central and South America.



（Source） Same as Table-3.5-1

Fig.-3.5-1 Geothermal Projects funded by Japanese ODA

Table-3.5-1 Japanese Yen Loans for Geothermal Projects

Yen Loan

Country	Year	Project	Amount (100 million JPY)
Philippines	80	Tongonan GPP project	188.00
	81	Southern Negros GPP project	108.00
	83	Leyte GPP project (II)	160.70
	88	Palinpinon GPP (ii)	63.00
	92	Palinpinon GPP (ii) (Additional)	36.53
	94	Tiwi GPP Rehabilitation Project	70.56
		Mak-Ban GPP Rehabilitation Project	66.30
		Mount Labo GPP project (I)	107.56
	96	Nothern Negros GPP project	144.60
	Sub total		945.25
Nicaragua	77	Momotombo GPP project	75.00
	Sub Total		75.00
Costa Rica	85	Miravalles GPP Unit-1 project	135.47
	Sub Total		135.47
Indonesia	03	Lahendong GPP unit-3 project	58.66
	04	Ulubelu GPp unit-1&2 project	202.88
	05	E/S for expansion of Kamojang GPP	9.95
	09	Lumut Balai GPP unit-1&2 project	269.66
	Sub Total		541.15
Kenya	2009	Olkaria-1 GPP unit-4&5 expansion project	295.16
	Sub Total		295.16
Total (16 Projects)			1,992.03

(Source) Ministry of Foreign Affairs, ODA Statistics

Table-3.5-2 Japanese ODA for Geothermal Energy (other than Yen Loans)

Development Study

Country	Year	Project	Counterpart
Guatemala	1973-1977	Zunil fieled development study	INDE
Chile	1978-1981	Puchuldisa field development study	CORFO
Kenya	1974-1984	Rift Valley Eburru field development study	DOE
Philippines	1980-1982	Luzon Bugisu fieled development study	DOE
Indonesia	1979-1983	Lumpur field development study	MEMR
Indonesia	1986-1989	Kerinchi field development study	MEMR
Argentine	1982-1984	Northern Neuquen field development study	Min. of Planning
Philippines	1982-1985	Mak-Ban field development study	Energy dev. Dep.
Thailand	1982-1988	San Kamphaeng field development study	EGAT
Mexico	1984-1989	La Primavera field development study	CFE
Turkey	1985-1987	Dikili-Berbama field development study	MTA
Argentine	1987-1992	Neuquen field development study	EPEN
Guatemala	1997-2001	Amatitlan field development study	INDE
China	2001-2005	Yangbajain field development study	Electricity & Industry Dep.
Indonesia	2006-2008	Masterplan study for geothermal development	MEMR
Peru	2010-2012	Master plan study for geothermal development	Min. of Energy

(Source) Japan Geothermal Association, "Geothermal Annual book (2001)"

Dispatch of Experts

1975-2001	25 experts to 10 countries were dispatched

(Source) Japan Geothermal Association, "Geothermal Annual book (2001)"

Training

1970-2001	Kyushu Univ.	393 trainees from 36 countries were accepted

(Source) Kyushu University etc.

JICA Loan for Trial Development

Country	Year	Project	Recipient
Philippines	2000	Tanawan Geothermal Dev.	Kyushu Electric Co.

(Source) Kyoushu Electric Power Company

Non-project type Grant Aid

Country	Year	Project	Amount (100 million JPY)
Ethiopia	2009	Forest Reservation Project (RE dev.)	17.00

(Source) Ministry of Foreign Affairs, ODA Statistics

Chapter 4 Kenya

4.1 Country outline[1]

The political situation of Kenya is somewhat troubled at present. President Mwai Kibaki, the government party candidate of the Party of National Unity (PNU) defeated party leader Raila Odinga of the Orange Democratic Movement (ODM) and won re-election in the presidential election of December 2007. However, the confrontation between the ruling and opposition parties over the election results led to conflict between domestic tribes in this strongly tribal country, and developed into large-scale turmoil leaving about 1,200 people dead and more than 500,000 internally displaced. President Kibaki and ODM party leader Odinga accepted the mediation of a group of eminent Africans led by the former U.N. Secretary-General Kofi Annan. This mediation led to a February 2008 agreement between Kibaki and Odinga to form a PNU/ODM coalition government. This agreement was approved by Parliament in March 2008, and the grand coalition administration was initiated shortly after. The grand coalition administration continuously grapples with long-term problems such as the reform of the election administration committee, constitutional revision, the problem of tribal conflict, etc., though it is feared that progress will be slow.

On the economic front, agriculture centered around floriculture and tea cultivation is the predominant industry and accounts for about 21% (WDI, 2009) of GDP, although industrialization is more advanced here than in other East African nations. Steady growth has resulted from sound macro-economic policies and the structural reform undertaken in 2007, and the GDP real rate of growth rose from 6.4% (WDI, 2009) in 2006 to 7.0% (WDI, 2009) in 2007, recording its highest level ever. However, 2008 saw the economy impacted by sudden worldwide rises in the price of oil and food in addition to the effects of the rioting after the elections at the end of 2007 and the world economic recession, and the growth rate was sluggish at 3.6% (WDI, 2009).

Kenya formulated "Kenya vision 2030" in June 2008. This “Kenya vision 2030” strategy is designed to emulate the rising economic powers in Asia and provide a long-term development strategy for the Kenyan nation. The aim of the strategy is that Kenya should have a competitive edge worldwide, and be a prospering country with a high quality of life by 2030". This vision makes the economy, the society, and politics the pillars of the strategy and draws the image for all Kenyans. The targets are (a) for the economy: the achievement of an average economic growth rate of 10% a year, maintained until 2030, (b) for the society: that it should enable fair, impartial social development in secure surroundings, and (c) for politics: the achievement of democratic system with accountability. Based on this vision, 5-year medium-term plan was formulated, including the "Strategy 2008-2012 for 2030.”

[1] Source: International Cooperation Bureau, Ministry of Foreign Affairs, Japan: Official Development Assistance (ODA) countries data book 2009

4.2 Energy Resources

The primary energy supply of Kenya in 2007 amounted to 18,305,000 tones of oil equivalent (toe), of which 14,725,000 toe are indigenous energy (hydropower, geothermal power, firewood, etc.), 4,109,000 toe are imported (coal, oil, petroleum products, and electric power), and 391,000 toe are exported (IEA Energy Balance 2007). The final energy consumption is 12,109,000 toe, which breaks down to 794,000 toe for industrial use, 1,881,000 toe for transportation and 9,434,000 toe for other uses (household use, agriculture, etc.) (IEA Energy Balance 2007).

Though the government has been prospecting for oil and the gas for many years, there have been no big discoveries as of January 2009. The presence of oil has been confirmed on a small scale in the Great Rift Valley, but the reserves are uncertain. Kenya has been a pioneer in Africa for geothermal power development especially, and geothermal power plants with a total output of 204 MW have been commissioned, including IPP projects. It is presumed that there is a geothermal capacity of 7,000 MW or more awaiting development in the Rift valley region. Moreover, hydropower resources are estimated at 4,560 MW; 1,560 MW can be developed by power plants of more than 10 MW, and the remaining 3,000MW of capacity is suitable for plants smaller than 10 MW. Regions where a power plant of 30 MW or more can be constructed include the area around Lake Victoria and the Rift valley region, the Chia river valley, the Tana river valley, etc.

As for domestic hydrocarbon energy resources, some coal reserves have been identified, but no commercial coal mines have been developed so far. Therefore all the coal used in the country is imported. The users of this imported coal include cement factories in Mombasa. Currently, government agencies are conducting surface exploration in the Kwale and Klifi area in the Taru Basin as well as drilling exploration in the Mwingi and Kitui districts of the Mui Basin. In particular, a drilling rig for prospecting coal (purchased at 75 million Kenya Shillings (Ksh)) was utilized to drill 20 prospects in the Kitui district, and bituminous coal has been discovered so far in eight places. This coal is expected to be used for power generation. Further studies are being conducted to confirm the reserve in the Kitui area and to investigate the feasibility of its use for coal-fired power plants.

For domestic oil and gas, exploration efforts have so far not been successful in finding commercial resources so far. All fuel oil is imported and crude oil (90,000 bbl/day) is processed by the oil refinery in Mombasa.

Energy consumption from non-commercial sources accounts 74% of the total energy consumption (2007), most of which comes from traditional biomass such as fire wood. With population growth and the growing spread of poverty, it is expected that the energy consumption from non-commercial sources will also grow, raising serious concerns regarding environmental damage and deforestation.

In order to mitigate environmental destruction, the government is promoting the development and utilization of renewable energy, and trying to curb the consumption of energy from non-commercial sources. However, because of the delay in infrastructure development, in many areas commercial energy is simply not available, and for regions where commercial energy is available, many people can not afford to enjoy the service for financial reasons. Due to financial constraints, rapid progress in the development and utilization of renewable energy cannot be expected.

Table-4.2-1 Reserves of energy resources in Kenya

Type of energy	Estimated reserve	Remarks
Hydro	Large hydro 1,560 MW	For hydro plants larger than 10MW, it is assumed that annual power generation of 6,600GWh is possible
	Mini hydro above 3,000MW	Hydroelectric power plant capacity below 10MW
Geothermal	Above 7,000MW Possibility of further increase using binary technology	Current geothermal generation capacity is 204MW.
Wood biomass (Firewood, charcoal)	Total reserve 1.8billion m^3 Average annual yield 24.30mil m^3	Annual consumption 40 mil. m^3
Bagasse	Power generation potential: 300MW	In the sugar industry, used for cogeneration. One of the seven companies (Mumias) supplies 2MW of surplus electricity to the transmission grid.
Wind	346 W/m^2	—
Solar energy	4～6kWh/m^2/day	140,000m^2 of solar thermal panels were in use as of 2003, and PV power is used by 200,000 households.

（Source）Ministry of Energy

4.3 Electric Power Situation

4.3.1 Electric Power Sector

The power sector has been undergoing restructuring since the mid-90s, transforming the power sector from a vertically integrated monopoly into a liberalized sector with key players comprising generation (KenGen) and distribution (KPLC) utilities partly owned by the state but quoted on the Nairobi exchange, a government-owned geothermal development company (GDC) and transmission company (KETRACO), five Independent Power Providers (IPPs) and one Emergency Power Provider (EPP), an Energy Regulatory Commission (ERC), an Energy Tribunal (ET), and a Rural Electrification Authority (REA). Underpinning these reform measures is the Electricity Act (1997), the Energy Act (2007), the Geothermal Resources Act and the Environment Management and Coordination Act, among others.

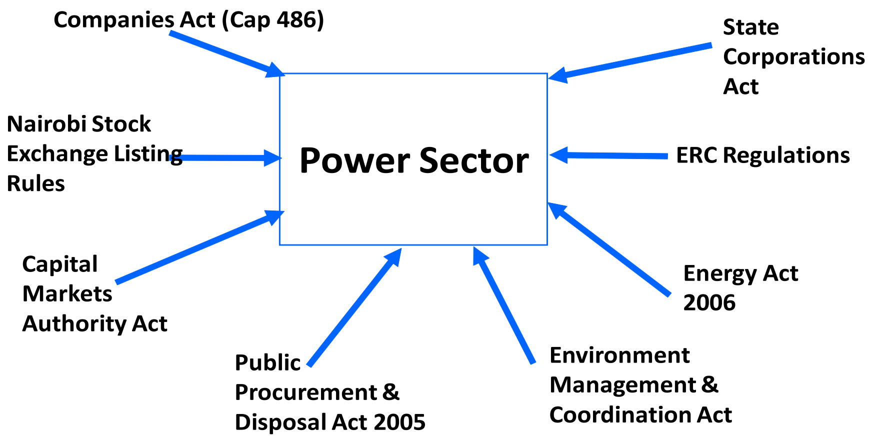
4.3.2 Power Sector Policy

A new national energy policy was approved by Parliament in 2004 and was followed by enactment of the associated law, the Electricity Act of 1997, later repealed by the Energy Act 2007. The policy set goals for the country in restructuring the sector from a monopolistic, vertically integrated utility into an unbundled, competitive generation business, transmission business and distribution and supply, with appropriate institutional and regulatory frameworks to enhance electric power development, as discussed in this report. The new law of 2007 facilitated the transformation of the Electricity Regulatory Board into the Energy Regulatory Commission and the establishment of the Rural Electrification Authority.

4.3.3 Legal Framework

Apart from the Energy Act, other laws governing the operations of the power utilities (KenGen, KPLC, KETRACO, GDC, IPPs, etc) include, among others, the Environment Management and Coordination Act and the Energy Regulatory Commission regulations. Fig.-4.3-1 below depicts the legal and regulatory environment.

LEGAL AND REGULATORY ENVIRONMENT



（Source）Study Team

Fig.-4.3-1 Legal and Regulatory Environment

4.3.4 Power Sector Investment Incentives

According to Sessional Paper No 4 of 2004 on Energy, the Government of Kenya proposes to make investments in the power sector more attractive to the private sector by reviewing in the medium-term the fiscal regime applicable to the energy sector, with a view, among others, to:

·Granting tax holidays for hydro, geothermal, renewable energy and domestic energy projects

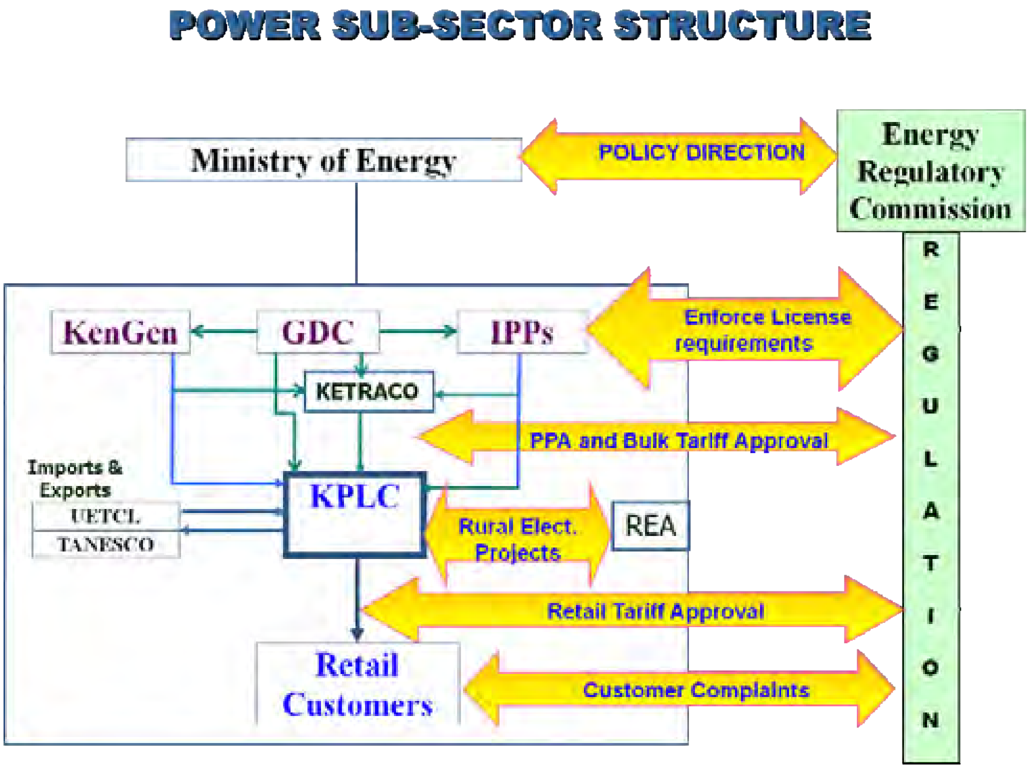
·Continuing the current fiscal policy of allowing the procurement of plant, equipment and related accessories for generation and transmission projects to be free of duty and taxes during project implementation.

This, together with the reforms undertaken in the sector covering legal, institutional and regulatory frameworks as well as electricity pricing and tariffs, has allowed a number of both IPPs and Emergency Power Providers to participate in Kenya's power sector development.

4.3.5 Institutional Framework

The institutional structure of the Kenyan power sector comprises the Ministry of Energy (MOE), the Energy Regulatory Commission (ERC), Kenya Electricity Generating Company (KenGen), the Kenya Power and Lighting Company (KPLC), the Rural Electrification Authority (REA), Kenya Electricity Transmission Company (KETRACO), Geothermal Development Company (GDC) and Independent Power Providers (IPPs). The policy thrust in the energy sector is articulated in Sessional Paper No.4 of 2004 on Energy and Energy Act No.12 of 2006. Both the policy and the law charge the Ministry of Energy with policy stewardship of the sector, including energy policy development and review. ERC has the statutory mandate to provide effective and efficient technical, economic and environmental regulation of the sector, including but not limited to approval of power purchase agreements and network service contracts; setting, reviewing and adjusting electric power tariffs; preparing indicative national energy plans and enforcing environment and health standards.

KenGen is a public electricity generator owned 70% by the Government and 30% by private shareholders. The company's power stations account for about 60% of the installed capacity from various energy sources that include hydropower, thermal, geothermal and wind. In addition, there are five IPPs generating electricity from fossil fuel-fired thermal, geothermal and biogases, collectively accounting for about 40% of the country's installed capacity. KPLC is the off-taker in the power market, buying power from all the power generators on the basis of power purchase agreements for onward transmission, distribution and supply to consumers. REA, KETRACO and GDC are special-purpose vehicles established under the Energy Act to respectively accelerate electricity access in rural areas; develop, own and operate new transmission systems in the country to allow for evolution of an open access system; and to accelerate geothermal exploration, exploitation and development. The GDC is expected to undertake surface exploration of geothermal fields; carry out exploratory, appraisal and production drilling; undertake early generation using well-head power generating units; develop and manage proven steam fields and enter into steam-to-energy sales agreements with KenGen and/or IPPs. Funding for REA, KETRACO and GDC is to be sourced from Government and other syndicated soft loans from multilateral and bilateral lending institutions.



（Source）KPLC

Fig.-4.3-2 Current Kenya Power Sub-Sector Structure

Kenya is interconnected to Uganda via a double-circuit 132kV transmission line, through which KPLC and the Uganda Electricity Transmission Company Ltd (UETCL) sell power to or buy from each other. Kenya and Tanzania share cross-border electrification at two towns at 33kV, as result of which the Tanzania Electricity Supply Company (TANESCO) currently supplies electricity to KPLC at Lunga Lunga and buys from KPLC at Namanga.

4.3.6 Regulatory Framework

The objective of regulation is to bring about desirable social outcomes, which are otherwise unattainable due to market failures. Such outcomes, including environmental conservation and high safety standards are public goods by nature and are therefore more efficiently supplied through state intervention rather than by the unfettered market mechanism. Furthermore, operations of some power sector activities, such as transmission and distribution networks, are by nature monopolistic and require an independent regulator to safeguard the interests of the stakeholders. Regulation therefore comprises state activities aimed at inducing economic agents to act in ways that are compatible with the social good.

The ERC was established under the Energy Act 2007 to regulate the generation, transmission and distribution of electric power in Kenya. The ERC is empowered to set and review tariffs, enforce environmental, health and safety regulations, investigate consumer complaints, ensure competition and approve power-purchase, transmission, as well as distribution-service contracts.

4.3.7 Energy Pricing

As part of the reforms undertaken from 1994, basic electricity tariffs were adjusted in phases to their long run marginal costs by 1999 to reflect the cost of supply. In addition to the basic electricity tariff, customers pay the following price adjustment charges, levies and taxes:

·Foreign exchange adjustment to compensate the Electricity provider for changes in operational costs resulting from fluctuations in exchange rates from the assumed base

·Fuel cost adjustment to compensate the Electricity provider for the extra running costs of thermal generation over and above those originally assumed in the computation of tariff rates

·Value Added Tax at 16% of the tariff charges

·Electricity Regulatory Commission levy

·Rural Electrification levy

The net effect of these additional charges is that the nominal price for electricity changes from time to time depending on hydrology, fuel prices and growth in electricity demand.

According to the Energy Policy stipulated in Sessional Paper No 4 of 2004 on Energy, where the market structure permits, energy prices will be determined by market mechanisms. However, where it is necessary to regulate prices because of the nature of the energy services, such as with electricity transmission and distribution networks, which are by nature a virtual natural monopoly, the regulator ensures efficiency pricing and a fair return on investments.

Electricity tariffs will reflect the cost of supply and also be efficient. In addition, consumer tariffs must also meet the social equity objective of affordability for the underprivileged members of the population.

4.3.8 Financing Framework

Electric power development by its very nature is capital intensive, and the volume of funds needed to implement a power generation project can hardly be mobilized entirely from local sources.

Over the years, generation and network capacity expansion has been financed primarily through Concessional Loans procured by the Government of Kenya from multilateral and bilateral development agencies and on-lent to the utilities, contributions by the utilities (tariff revenue) and exemptions from duty and VAT by the Government of Kenya. The response by the private sector in this area since liberalization of the power generation segment in 1996 has been lukewarm, attracting only a few players and bringing relatively higher costs.

According to Sessional Paper No 4 of 2004 on Energy, the Government of Kenya proposes to make investments in the power sector more attractive to the private sector by reviewing in the medium-term the fiscal regime applicable to the energy sector with a view, among others, to:

· Granting tax holidays for hydro, geothermal, renewable energy and domestic energy projects

· Continuing the current fiscal policy of allowing procurement of plant, equipment and related accessories for generation and transmission projects free of duty and taxes during project implementation.

· Promoting biomass-based power generation projects

4.3.9 Existing Generation Capacity

The interconnected system in Kenya has a total installed capacity of 1,564MW against an effective capacity of 1,531 MW as of June 2010. This includes 140 MW of emergency power contracted to ameliorate the impacts of capacity shortfalls occasioned by poor hydrology due to drought. Table-4.3-1 gives a summary of the installed and effective generation capacity including the Government-owned isolated grid power stations, while Table-4.3-2 shows the ownership and percentage contribution of different generation plants.

Table-4.3-1 Installed and Effective Capacity as at 30th June 2010

Sources	**Installed Capacity (MW)**	**% Share**	**Effective Capacity (MW)**	**% Share**
Hydro	761	53.4	748.3	53.8
Thermal	419.6	29.5	401.1	28.8
Geothermal	198	13.9	198	14.2
Cogeneration	26	1.8	26	1.9
Wind	5.45	0.4	5.45	0.4
Isolated Grid	14.2	1.0	12.5	0.9
Sub-Total Permanent	1,424.25	100	1391.35	100
Emergency Power Plant	140		140	
TOTAL	1,564.25		1,531.35	

（Source） KPLC

Table-4.3-2 Power Generation Market Shares

	Installed Capacity (MW)	**% Share**
<u>KenGen</u>		
Hydro	761	48.6
Thermal	153.7	9.8
Geothermal	150	9.6
Wind	5.45	0.3
Sub-Total KenGen	**1,070.15**	**68.3**
<u>REP</u>		
Isolated Thermal	**9**	**0.6**
<u>IPPs</u>		
Iberafrica	108.5	6.9
Tsavo Power	74	4.7
Mumias Sugar	26	1.7
OrPower4	48	3.1
Rabai Power	88.6	5.7
Sub-Total (IPPs)	**354.1**	**22.1**
<u>EPP</u>		
Aggreko	140	8.9
Grand Total	**1,564.25**	**100.0**

(Source) KPLC

4.3.10 Transmission and Distribution System

The existing transmission network consists of 220kV and 132kV high-voltage transmission lines, while the distribution network consists of 33kV and 11kV medium-voltage lines, as well as 66kV sub-transmission lines around Nairobi. Table-4.3-3 shows the growth of transmission and distribution circuit length in kilometers for the last six years.

Table-4.3-3 Transmission and Distribution Line Circuit Length (2004-2009)

(As of June 30th) (unit: km)

Voltage	2004	2005	2006	2007	2008	2009
220kV	1,323	1,323	1,323	1,323	1,323	1,331
132kV	2,035	2,035	2,035	2,085	2,085	2,112
66kV	600	600	630	632	632	649
40kV	58	58	58	29	29	29
33kV	5,973	6,570	7,826	11,163	12,633	13,031
11kVe	15,267	16,794	18,532	21,918	23,573	24,334
Total	25,256	27,380	30,404	37,149	40,274	41,486
% Increase P.A	10.2%	8.4%	11.0%	22.2%	8.4%	3.0%

(Source) KPLC Annual Accounts 2008/09

4.3.11 Existing Customers

The number of customers has registered double-digit growth over the last three years (2007-2009) in response to ongoing economic recovery and the implementation by the government of the accelerated electricity access program through the Rural Electrification Authority, as seen in Table-4.3-4 The trend is likely to continue as incomes of ordinary people continue to improve, enabling them to afford the connection charges.

Table-4.3-4 Number of Customers by Tariff Category (As of June 30th)

Tariff	Main Type of Customers Covered by this Tariff	2004	2005	2006	2007	2008	2009
DC only	Domestic KPLC REP	444,785 59,750	482,812 65,439	534,743 72,794	626,099 91,672	724,283 114,820	873,764 150,964
DC & IT	Domestic KPLC REP	50,290 319	50,843 325	52,338 338	54,284 358	55,573 367	57,678 1,002
SC only	Small Commercial KPLC REP	90,727 33,190	93,021 35,874	97,236 37,412	103,617 40,752	111,446 46,010	124,251 53,185
SC & IT	Small Commercial KPLC REP	1,134 82	1,162 80	1,146 75	1,150 185	1,149 71	1,167 72

B0	Irrigation Load KPLC REP	251 2	226 2	225 2	213 3	196 3	--
B1	Medium Commercial and Industrial KPLC REP	3,006 76	2,863 46	3,291 78	3,208 53	3,412 55	--
B2	Medium Commercial and Industrial KPLC	61	66	68	65	68	-
B3	Medium Commercial and Industrial KPLC	1	4	2	2	4	-
CI1	Large Commercial KPLC REP	269 1	287 1	305 1	317 2	321 2	2,250 37
CI2	Large Commercial and Industrial KPLC	135	142	155	168	177	233
CI3	Large Commercial and Industrial KPLC	19	16	18	18	16	23
CI4	Large Commercial and Industrial KPLC	0	0	1	1	1	14
CI5	Large Commercial and Industrial KPLC	1	1	1	1	1	13
IT only	Off-peak KPLC REP	918 9	734 8	705 10	677 8	659 9	631 9
SL	Street lighting KPLC REP	1,156 13	1,178 14	1,291 14	1,462 14	1,723 17	1,887 18
TOTAL (KPLC)		592,753	633,355	691,525	791,282	899,029	1,061,911
TOTAL (R.E.P.)		93,442	101,789	110,724	133,047	161,354	205,287
GROSS TOTAL		686,195	735,144	802,249	924,329	1,060,383	1,267,198
% INCREASE P.A.		6.7%	7.1%	9.1%	15.2%	14.7%	19.5%

(Note) REP: Rural Electrification Program (Source) KPLC Annual Accounts 2008/09

4.3.12 Electricity Tariffs

The Policy on the review and setting of electricity tariffs was formulated by ERB in 2005 with stakeholder participation.

The objectives of the Tariffs' Review Policy are to:

· establish an open, fair and transparent regulatory framework that results in competitive, cost-effective, efficient and equitable tariffs;

· protect consumers while ensuring that the licensees remain viable and are given incentives to operate efficiently;

· ensure the financial viability of the power sub-sector and promote efficient load management
· promote efficient use and equitable provision and expansion of electricity services
· promote the optimal growth and evolution of the Kenyan Electricity Supply Industry (ESI)
· guide consumers, licensees and potential investors with regard to regulations and regulatory decisions on sub-sector tariffs and tariff reforms.

Key elements of the Retail Electricity Tariffs Review Policy, as summarized in the Policy's Executive Summary, include the following:

· The Board shall allow just, fair and reasonable Rates of Return in order to: attract and compensate prospective investors adequately for the investment risks borne; and to yield sufficient income for the utility over its capital base.
· The allowed Rate of Return shall be computed using the Weighted Average Cost of Capital.
· The off-taker's Revenue Requirements shall be determined using the book value of the company's assets used in providing the regulated services i.e. the Regulatory Asset Base.
· The demand for electricity over the review period shall be based on a forecast made by the off-taker and which shall be consistent with the forecasts in the latest version of the Least Cost Power Development Plan.
· The subsidy provided in the Life-Line Tariff block shall be prudentially targeted so that it benefits only vulnerable consumers.
· In targeting the Life-Line Tariff, considerations shall be given to minimizing its impact on consumers and the off-taker.
· Medium and large commercial / industrial categories shall be based on the voltage level of service.

4.3.13 Electricity Demand Forecast

The peak power demand of the interconnected system stands at 1,106 MW in 2009. This, however, is considered suppressed and the real demand is estimated to be 1,205 MW. Against the effective capacity of the 1,531 MW in the interconnected system, which includes 140MW of emergency power plants, the registered demand leaves a reserve margin of 27% and only 15% without the EPP. The desired reserve margin used for planning in the past has been 15% but the Government has directed that the margin be increased to 30% by 2015.

Three main scenarios, namely reference, low, and high, were prepared based on different GDP growth assumptions. The tariffs are expected to grow at the same rate under all the three scenarios. The scenarios were defined to reflect both the current and future economic outlook, taking into account the economic development path defined in Vision 2030. The GDP assumptions used in developing the scenarios are shown in Table-4.3-5 below.

Table-4.3-5 Graduated GDP Growth Scenarios

Year	Low Scenario	Reference Scenario	High Scenario
2009	3.5	3.5	3.5
2010	4.0	5.0	6.0

2011	5.0	6.0	7.0
2012	6.0	7.0	8.5
2013-2030	8.0	9.0	10.0

(Source) KPLC

The GDP growth scenario for the low forecast reflects the pessimistic case taking into consideration the performance of the economy in the first quarter and second quarter of 2009, which was estimated to have shown annualized growth of 4.0% and 2.1% respectively. The main assumption under this scenario is that the domestic economy will grow, but at a slower pace than anticipated in the Vision 2030.

The reference scenario assumes a more realistic GDP growth path that is based on the current and probable future economic growth outlook. This scenario assumes that economic growth will gradually gather momentum, but will initially be constrained by the macro-economic disruptions occasioned by the recent internal and external shocks.

The high scenario is based on the economic growth aspirations encapsulated in Vision 2030 of attaining a sustainable economic growth rate of at least 10% per annum from 2013, based on the expectation that the full benefits of the economic restructuring program articulated in Vision 2030 will be realized. This scenario is the optimistic case.

Electricity tariffs are assumed to be stable and only escalate with the underlying inflation in the country, approximated at 5%. The month-to-month underlying inflation, excluding food items from the Consumer Price Index (CPI) basket, was estimated at 4.86% in November 2009 and 5.34% in December 2009.

Using the estimated coefficients, an electricity demand forecast was undertaken using GDP and tariffs projected on the basis of the graduated GDP growth scenarios enumerated above and assuming a 5% annual underlying inflation escalation factor for tariffs.

Based on these GDP assumptions and taking into account a projected reduction of system losses from 16.3% to 14.5% in 2013 and the implementation of an electricity scale-up project with a view to connecting at least one million new customers in the next five years, the capacity and energy load forecasts for the period 2009-2029 are shown in Table- 4.3-6 below. The peak load for the reference case rises from 1,205 MW in 2009 to 8,989 MW in 2029, while the energy increases from 7,391 GWh to 52,623 GWh over the same period.

Assuming a population growth of 2.8% over the 20 year period, the projected load growth would increase the current per capita electricity consumption of 182 kWh to 266 kWh/capita in 2015, 503 kWh/capita in 2021 and 1,302 kWh/capita in the year 2030. However, the per capita consumption will still be very low, at about half of the world's current per capita consumption of 2,752kWh/capita in 2009 (International Energy Agency, Key World Energy statistics 2009) and falling short of the projected per capita consumption of developing countries of 2,000kWh/capita by 2030. In 2009, the per capita consumption for Egypt was 1,468kWh/capita while that for South Africa was 5,013kWh/capita.

Table- 4.3-6 Electricity Demand Forecast 2009-2030

Fiscal Year	Low Scenario		Reference Scenario		High Scenario	
	Net Energy (GWh)	Net System Peak (MW)	Net Energy (GWh)	Net System Peak (MW)	Net Energy (GWh)	Net System Peak (MW)
2009	7,391	1,205	7,391	1,205	7,391	1,205
2029	44,173	7,543	52,623	8,989	57,406	9,809
Annual growth rate	9.4%	9.6%	10.3%	10.6%	10.8%	11.1%

(Source) KPLC

4.3.14 Generation Expansion Plan

The 20-year (2009-2029) least-cost power generation expansion plan for Kenya based on the reference load forecast is presented in Table-4.3-7. The first new project in the least-cost plan is a 2x70 MW geothermal plant scheduled for 2013 and a total of 2,746 MW plants that are to come on stream between 2013 and end of 2029. As for other sources, a total of 1,800 MW coal plants will be required in this period. These plants would serve as base-load generating units.

Table-4.3-7 The Least-Cost Power Generation Plan – Planned New Capacity

Year	Configuration				Capital Cost (Mln USD)	Type	Added Capacity MW	Total Capacity MW	System Peak MW	Reserve Margin MW	Reserve Margin as %age of Total Capacity
2008								1,204	1,086	118	10%
2009	-1	×	8	OLK3		Geothermal	-8				
	-1	×	4	OLK3		Geothermal	-4				
	2	×	24	OLK3		Geothermal	48				
	3	×	8.33	COGN		Cogeneration	25				
	10	×	5.25	IBA1		MSD	52.5	1,317	1,172	146	11%
2010	-2	×	72	KIAM		Hydro	-144				
	2	×	82	KIAM		Hydro	164				
	-2	×	2.6	TAN1		Hydro	-5.2				
	-2	×	4	TAN2		Hydro	-8				
	2	×	4.3	TAN1		Hydro	8.6				
	2	×	5.5	TAN2		Hydro	11				
	9	×	10	RBD1		MSD	90				
	6	×	0.85	WIND 2		Wind –Aelous	5.1				
	30	×	1.65	WIND 1		Wind –Ngong 2	49.5	1,488	1,279	209	14%
	8	×	10	MSD1		MSD	80				
2011	-1	×	10	FIAT		GT	-10				
	0	×	0	MASI		Hydro	0				
	1	×	35	OK23		Geothermal	35				
				TRNS	196.8	Msa-Nbi Line		1,593	1,401	192	12%

2012	2	×	10.3	SAHP		HYDRO	20.6				
	1	×	20	KIND		HYDRO	20				
	5	×	10	MSD	65	MSD	50	1,684	1,540	144	9%
2013				TRNS	68.5	Line					
				TRNS	65.3	Line					
				TRNS	433	Ethio-Kenya Line					
	1	×	200	IMP1		IMPORT	200				
	2	×	70	GEOT	462	Geothermal	140				
	1	×	2.5	GEOT	50	Geothermal	2.5	2,027	1,715	312	15%
2014	-1	×	15	OLK1		Geothermal	-15	2,012	1,905	107	5%
2015	1	×	200	IMP1		IMPORT	200				
				TRNS	43.7	Msa-Nbi Reactors		2,212	2,112	99	4%
	-2	×	15	OLK1		Geothermal	-30				
2016	1	×	70	GEOT	231	Geothermal	70				
	2	×	70	GEOT	462	Geothermal	140				
	60	×	1.67	WIND 3		Wind – Marsabit or Turkana	100	2,491	2,339	153	6%
2017	1	×	230	IMP1		IMPORT	230	2,721	2,586	136	5%
2018	2	×	70	GEOT	462	Geothermal	140				
	1	×	150	IMP1		IMPORT	150				
				TRNS	41	Olkaria-Nairobi Line		3,011	2,856	155	5%
2019	-6	×	12.5	KIP1		MSD	-75				
	2	×	150	C150	742.5	Coal	300				
				TRNS	21.8	Msa -Nbi Line capacitors					
	1	×	50	IMP1		IMPORT	50	3,286	3,151	135	4%
2020	-10	×	5.66	IBA1		MSD	-56.6				
				TRNS	265.4	Olkaria-Nairobi Line					
	1	×	370	IMP1		IMPORT	370	3,600	3,474	126	3%
2021	1	×	70	GEOT	231	Geothermal	70				
	1	×	260	IMP1		IMPORT	260	3,930	3,828	102	3%
2022	-7	×	10.57	KIP2		MSD					
	1	×	330	IMP1		IMPORT	330				
	2	×	70	GEOT	462	Geothermal	140				
				TRNS	41	Line		4,400	4,215	185	4%
2023	3	×	70	GEOT	693	Geothermal	210				
	-1	×	30	KGT1		GT	-30				
	-1	×	30	KGT2		GT	-30				
	2	×	150	C150	492.5	Coal	300	4,850	4,638	212	4%
2024	2	×	70	GEOT	462	Geothermal	140				
	2	×	70	GEOT	462	Geothermal	140				
				TRNS	41	Olkaia-Nairobi Line					
				TRNS	262.3	Msa-Nbi Line					
	1	×	90	G90M	73.9	GT	90				
	1	×	90	G90K	73.9	GT	90	5,310	5,102	208	4%
2025	2	×	70	GEOT	462	Geothermal	140				
	3	×	70	GEOT	693	Geothermal	210				
				TRNS	41	Olkaia-Nairobi Line					
	4	×	20	MSD	104.3	MSD	80				
	1	×	90	G90K	73.9	GT	90	5,830	5,611	219	4%
2026	2	×	150	C150	492.5	Coal	300				
	3	×	70	GEOT	693	Geothermal	210				

	4	×	20	MSD	104.3	MSD	80				
	2	×	150	C150	492.5	Coal	300	6,720	6,168	552	8%
2027	2	×	70	GEOT	462	Geothermal	140				
	2	×	70	GEOT	462	Geothermal	140				
	2	×	70	GEOT	462	Geothermal	140				
				TRNS	41	Line					
	5	×	20	MSD	130.4	MSD	100				
	1	×	90	G90L	73.9	GT	90				
				TRNS	41	Olkaia-Nairobi Line		7,330	6,779	551	8%
2028	2	×	150	C150	492.5	Coal	300				
	-2	×	24	OLK3		Geothermal	-48				
	-3	×	8.33	COGN		Cogen	-25				
	3	×	70	GEOT	693	Geothermal	210				
	2	×	150	C150	492.5	Coal	300				
				TRNS	41	Olkaia-Nairobi Line		8,067	7,449	618	8%
2029	2	×	70	GEOT	462	Geothermal	140				
	4	×	20	MSD	104.3	MSD	80				
	1	×	90	G90E	73.9	GT	90				
	2	×	70	GEOT	462	Geothermal	140				
				TRNS	41	Olkaia-Nairobi Line					
	2	×	150	C150	738.6	Coal	300	8,817	8,183	633	7%

(Source) KPLC

The total new capacity added to the system over the study period will be 7,470 MW, comprising 2,746 MW of new geothermal, 224 MW of new Hydro, 1,800 MW of new coal units, 541 MW of new medium-speed diesel units, 1,530 MW of Imports, 155 MW of wind, 25 MW of cogeneration and 450 MW of new gas turbines. The level of penetration of geothermal is constrained by the slow pace of the exploration and implementation of the projects, which is largely dictated by funding available to obtain steam for conversion to power by KenGen and IPPs.

4.3.15 Role of IPPs in the Generation Expansion Plan

As mentioned before and as indicated in Table-3.5.10-2 above, there are currently 5 IPPs operating in Kenya, with total installed capacity of 354.1MW, with three owning thermal plants, one a geothermal plant and the other a bagasse-fired plant. IPP operations in Kenya date back to 1997, when two stop-gap plants on 7-year PPAs were commissioned. One 44MW medium-speed diesel plant in Nairobi running on heavy fuel oil was owned by Iberafrica and the PPA was extended in 2004 for 15 more years at a substantially reduced tariff. The second plant was a barge-mounted 43MW gas turbine in Mombasa running on kerosene or gas condensate and owned by Westmont of Malaysia, which was decommissioned upon expiry of the PPA in 2004.

KPLC has negotiated or is currently negotiating long-term PPAs with several IPPs. The main ones are:

·Lake Turkana Wind Power for 300 MW in Marsabit

·Gulf Power for an 84 MW HFO-fired MSD plant in Athi River

·Triumph for an 80.9MW HFO-fired MSD plant in Kitengela

·Melec Powergen for an 87MW HFO-fired MSD plant in Thika

·Aeolus Kenya for a 60MW wind plant in Kinangop
·Aeolus Kenya for a 100MW wind plant in Ngong
Several other private companies are carrying out feasibility studies for projects, especially involving renewable energy.

4.3.16 Geothermal Energy in the Generation Expansion Plan

Geothermal activities in Kenya are concentrated in the East African Rift, which is associated with the worldwide rift system and is still active. The East African Rift system has been associated with intense volcanism and faulting which have resulted in the development of geothermal systems. Over fourteen geothermal prospects have been identified in Kenya, namely: the Suswa, Longonot, Olkaria, Eburru, Menengai, Arus-Bogoria, Lake Baringo, Korosi, Paka, Lake Magadi, Badlands, Silali, Emuruangogolak, Namarunu and Barrier geothermal prospects. The Government, acting through the Ministry of Energy, KenGen and other partners, has undertaken detailed surface studies of some of the most promising geothermal prospects in the country. Evaluation of these data sets suggest that more than 7,000MW can be generated from the high-temperature resource areas in Kenya.

Geothermal is currently the most promising indigenous resource for the development of power. At present, the country has an installed capacity of 204MW, and a geothermal development plan is being implemented by the Geothermal Development Company (GDC). Geothermal projects typically progress through the stages of reconnaissance, surface exploration, exploratory drilling, appraisal drilling and feasibility study, with various decision points along the way. The stages listed above normally involve a high upfront cost. Carefully implemented regional reconnaissance surveys can, however, lead to a sound prioritization of target areas by the filtering out of less promising prospects. Good exploration surveys of targeted prospect areas have shown that they deliver high success rates for exploration drilling.

Geothermal power projects are characterized by high capital investment for exploration, appraisal drilling, production drilling and installation of plant. Such expenditures, required to prove the geothermal resource capacity, involve some risk. High upfront costs result in a long payback period, compared to fossil-fuel power plants, but longer term economic benefits accrue from the use of geothermal. Reservoir management requires continuous assessment of resource size and production capacity to ensure reasonable levels of certainty are maintained. This necessitates significant resource monitoring to ensure optimal production capacity.

As can be deduced from Table-4.3-7 above, geothermal plants are projected to contribute 2,746 MW, equivalent to 36.8%, out of a total of 7,470 MW of committed and planned capacity between 2009 and 2029.

4.3.17 Transmission Capacity Expansion

Additional transmission lines are planned to connect the new power plants to the grid and to reinforce transmission capacity to load centers, as shown below.

Table-4.3-8 Planned Expansion of Transmission Network

Year	Line
2009	Sondu-Kisumu 132kV line
2009	Mombasa-Nairobi 330kV line
2015	Arusha-Nairobi 330kV
2016	Olkaria-Nairobi 220kV line
2017	Mombasa-Nairobi 330kV line
2021	Olkaria-Nairobi 220kV line
2022	Mombasa-Nairobi 330kV line

(Source) KPLC

Regional interconnections are progressively evolving with the expected planned transmission lines linking countries in the region that are likely to be implemented under the Eastern Africa Power Pool (EAPP), the Nile Basin Initiative and the Nile Equatorial Lakes Subsidiary Action Programme. These lines include the Kenya (Isinya)-Tanzania (Arusha) 400kV line, a second Kenya (Lessos)-Uganda (Jinja) 220kV line, the Kenya-Ethiopia 500kV DC line and a 132kV cross-border electrification line to Moyale town from Ethiopia.

4.3.18 Conclusion

Despite the gains made from the reforms undertaken to date, the power sector in Kenya still faces many challenges in improving reliability of supply and efficiency of service delivery, including promotion of conservation, increasing access to affordable electricity for most of the rural population and lowering the cost of electricity to the economy and ordinary customers.

The measures the power industry is taking to address these challenges include prioritization of geothermal as a strategic resource and hence mobilizing financial and other resources from private and public sectors to implement geothermal development, other capacity expansion and rural electrification programs; to refurbish and upgrade system facilities ; to plan and implement least-cost system reinforcement, to undertake capacity expansion projects and power exchanges (interconnections) and to implement performance improvement programs.

Kenya requires investment from both the public and private sectors to implement an ambitious power capacity and network expansion to meet current deficits and satisfy the rising electricity demand. Private sector investments are likely to continue to be attracted to mid-range thermal power plants burning HFO and to renewable energy projects connected to the grid or installed as off-grid isolated power systems.

4.4 Geothermal Resources in Kenya

Kenya is endowed with vast geothermal resource potential along the Kenya Rift that transects the country from north to south. Exploration reveals that geothermal potential exceeds 7,000 MW and is capable of meeting all of Kenya's electricity needs over the next 20 years. Kenya Electricity Generating Company Ltd (KenGen) and Geothermal Development Company Ltd (GDC), in collaboration with the Ministry of Energy (MOE), have undertaken detailed surface studies of most of the prospects along the Kenya rift, which comprises the Suswa, Longonot, Olkaria, Eburru, Menengai, Lake Bogoria, Lake Baringo, Korosi and Paka volcanic fields (refer to Fig.-4.4-1). The Least Cost Power Development Plan (2009-2029) prepared by the Government of Kenya indicates that geothermal plants have the lowest unit cost and are therefore suitable for base load power and can be recommended for additional expansion. Growth in electric power demand in Kenya currently stands at over 8% annually. In order to meet the anticipated growth in demand, the Kenyan Government, working through the newly formed utility GDC, has embarked on an ambitious generation expansion plan to install additional 2,746 MW by 2029 from geothermal sources. The planned geothermal developments require over 1,000 wells to be drilled and about 38 large power stations of about 70 MW each to be built at a total cost of over USD 8 billion, inclusive of wells and steam gathering systems.

Exploration for geothermal energy in Kenya started in the 1960's with surface exploration that culminated in two geothermal wells being drilled at Olkaria. In early 1970's more geological and geophysical work was carried out between Lake Bogoria and Olkaria. This survey identified several areas suitable for geothermal prospecting, and by 1973 drilling of deep exploratory wells at Olkaria commenced with funding from UNDP. The Government, through the Ministry of Energy, GDC, KenGen and other partners, has undertaken detailed surface studies of some of the most promising geothermal prospects in the country. The areas that have been studied in detail include Suswa, Longonot, Olkaria, Eburru, Menengai, Arus-Bogoria, Lake Baringo, Korosi and Paka. Other areas with less detailed studies include Lake Magadi, the Badlands, Silali, Emuruangogolak, Namarunu and Barrier geothermal prospects. Evaluation of these data sets suggests that over 7,000 MW can be generated from the high-temperature resource areas in Kenya. The Ministry of Energy is keen to continue exploration and drilling in the areas of high potential.

4.4.1 OlkariaGeothermal Field

Currently, in Kenya, geothermal energy is being utilised in Olkaria field only. Three of the seven Olkaria sectors, namely the Olkaria East field, Olkaria West field and Olkaria Northeast field, are generating a total of 204 MW. The proven geothermal resource in the greater Olkaria geothermal field is more than 450 MW, and accelerated development is envisaged in the near future. The evaluation sheet for the Olkaria geothermal field is shown in Annex-1-1.

(1) Olkaria I Power Plant

The Olkaria I power plant located in the Olkaria East field (Fig.-4.4-2) is owned by Kenya Electricity Generating Company Ltd (KenGen) and has three turbo generating units, each generating 15 MW. The three units were commissioned in 1981, 1983 and 1985, respectively. The plant has therefore been in operation for around thirty years. Olkaria East field, which supplies steam to Olkaria I power plant has thirty-three (33) wells drilled. Thirty-one (31) of them were connected to the steam gathering system and 9 of them were drilled as makeup wells. Currently, twenty-six (26) of them are in production, while the rest have become uneconomic producers due to the decline in output over time. Some of these are earmarked to serve as reinjection wells or to be deepened. Currently, studies are underway to determine the viability of increasing generation by adding a 70 MW Unit IV.

(2) Olkaria II Power Plant

Olkaria II is located in Olkaria northeast field (Fig.-4.4-2), where the construction of 2 x 35 MW Olkaria II geothermal power station started in September 2000 and was completed November 2003. The plant is more efficient than Olkaria I, with a specific steam consumption of about 7.2 t/hr per MW as opposed to the 9.2 t/hr for the Olkaria I plant. As a result of the efficiency of the equipment there is excess steam available in this field. Consequently, KenGen decided to make use of the existing excess steam to add a 35 MW 3rd unit to Olkaria II. The construction of the Olkaria II 3rd unit has commissioned in 2010.

(3) Olkaria IV (Olkaria Domes)

Surface exploration was carried out in 1993-1994, and a working model for drilling exploration wells was conceptualized. In 1998-1999, 3 exploration wells were drilled and all encountered a geothermal system. In June 2007, the drilling of appraisal wells commenced using a rig hired from Great Wall Drilling Company Ltd (GWDC) of China. Currently, 6 appraisal wells have been drilled, 5 of which are directional and 1 of which is vertical. The capacities of the wells range from 4-13MW.

Production drilling is currently underway utilizing 2-3 rigs hired from GWDC, and a total of 15 production wells will be drilled. Two 70 MW power plants totaling 140 MW will be constructed in Olkaria Domes and are expected to be commissioned in the year 2012 and 2013, respectively.

(4) Olkaria III Power Plant

The Olkaria III project is the first private geothermal power plant in Kenya. A 20-year Power Purchase Agreement (PPA) was awarded to Orpower 4 Inc. by Kenya Power and Lighting Company (KPLC) under a World Bank-supervised international tender for the field development of up to 100MW. The first phase of the project included drilling of appraisal wells and construction of a 12 MW pilot plant. The first 8 MW was put into commercial operation in September 2000, and the other 4 MW in December 2000. The appraisal and production drilling commenced in February 2000 and was completed by March 2003. After drilling a total of 9 wells (with depths ranging between 1850-2750 m), adequate steam was proved for total development of 48 MW over the PPA period of 20 years. The 50 MW power plant was commissioned in 2008.

(5) Oserian Plant

Oserian Development Company Ltd (ODLC) constructed a 2.0 MW binary plant in Olkaria Central with Ormat as OEC to utilise fluid from a well (OW-306) leased from KenGen. The plant, which is supposed to provide electrical power for floricultural operations, was commissioned in July, 2004.

ODLC, which grows cut flowers for export, is also utilizing steam from a 1.28 MW well to heat fresh water through heat exchangers, enrich CO_2 levels and to fumigate the soil. The heated fresh water is then circulated through greenhouses. The advantage of using geothermal energy for heating is that it results in a drastic reduction in operating costs.

4.4.2 Eburru Geothermal Field

Eburru volcanic complex (Fig.-4.4-1) is located to the north of Olkaria. KenGen carried out detailed surface studies between 1987-1990 that culminated in the drilling of six exploration wells in Eburru between 1989 and 1991. Further infill MT surveys done in 2006 revealed that the Eburru field is able to support up to >60 MW. The results from the exploration wells indicate that the field showed temperatures of over 300°C, possibly due to localized intrusion.

The chemistry of discharge fluid from the wells indicates that the reservoir is non-boiling, with high-salinity brine and a high amount of non-condensable gases (NCG). Despite the almost similar geology, the chloride level of EW-I (956 to 1976 ppm) is higher than the Olkaria average. As compared to Olkaria, the reservoir permeability is moderate (KPC, 1990). The maximum discharge temperature was 285°C and the total output from the two wells that discharged (EW-1 & EW-6) was 29 MWt (Ofwona, 1996). The area has a fairly well-established infrastructure, and for this reason a 2.5 MW binary pilot plant is planned for commissioning in 2010. The evaluation sheet for the Eburru geothermal field is shown in Annex-1-2.

4.4.3 Suswa Volcano

Suswa is the southernmost Quaternary volcano in the central Kenya rift. The latest magmatic activity in Suswa is estimated to have occurred about 200 years ago within the annular trench in the caldera. The phonolitic nature of the lava implies a medium-level magma chamber, which could provide the present heat source for the system. The presence of a degassing magmatic body is also indicated by the presence of solfatara within the annular trench. The Low pH of fumarole condensates also suggests close proximity to a magma body or up-flow of a geothermal system. Magnetotelluric (MT) data recorded to the north of the inner caldera indicate that the interpreted heat source is about ten km deep. Gravity surveying indicates a northeast-southwest high-Bouguer anomaly directly under Suswa caldera in the region of Ol' Doinyo Nyoke volcano. The body is at a depth of more than four to eight km and could be the heat source of the geothermal system.

KenGen carried out detailed scientific studies in this prospect between 1992 and 1993 that included geology, geophysics and geochemistry. The studies identified the volcano, which may possibly have a shallow heat source under the caldera, as a good prospect. The studies resulted in the siting of three wells within the main caldera floor. Exploration drilling will be carried out after the drilling at Longonot, and it is estimated that more than 200 MW can be produced from the Suswa resource. The evaluation sheet for the Suswa geothermal field is shown in Annex-1-3.

4.4.4 Longonot Volcano Caldera

Longonot Volcano Caldera is located east of Olkaria geothermal field on the floor of the rift valley (see Fig.-4.4-1). Development of the precursor of Longonot caldera started 800,000 years ago with the development of a broad shield volcano. Volcanism continued and culminated in a caldera collapse about 9,000 years ago. Subsequent volcanism occurred in the center of the caldera and resulted in the building of a trachytic massif and deposition of thick pumice deposits within the caldera and on the flanks. It is estimated that the most recent volcanism at Longonot occurred about 200 years ago within the summit crater and along a north-northwest trending volcano-tectonic axis.

KenGen conducted surface exploration work of Longonot geothermal prospects in 1998 that involved geological, geochemical, geophysical and environmental surveys (KenGen, 1998). The presence of hydrothermally-altered lithics indicates that the geothermal system under the volcano must have attained temperatures of more than 250°C. Resistivity studies indicate an anomaly on the southern slopes of Longonot crater. These results have been used to site the first exploration well south of the volcano bound by the caldera structure. Scientific data show that the prospect area is more than 60km^2 and, if proven, is enough to generate more than 200 MW. Drilling will commence once funding is secured. The evaluation sheet for the Longonot geothermal field is shown in Annex-1-4.

4.4.5 Menengai Caldera

The heat source for the prospect is probably associated with a hot magmatic body that underlies the caldera structure at Menengai and a similar but probably older heat source is likely to be associated with a geothermal area to the north of Menengai. A positive magnetic anomaly that is coincident with low resistivity indicates the presence of a magmatic body at shallow depth. Seismic data indicate that the magmatic body is at a depth of about 12 km. The geothermal reservoir at Menengai is hosted within the fractured brittle trachytic lavas of the rift floor and welded pyroclastics that underlie the volcanic pile. At shallow levels, the paucity of geothermal manifestations is due to the self-sealed widespread pyroclastics and layered welded pyroclastics.

The main recharge is associated with the adjacent eastern and western rift escarpments. These high altitude ridges often have high rainfall. The extensive fault network that is evident in the rift provides hydraulic connection and flow towards the rift floor. The rift floor in this area is at a very low altitude relative to the rift scarps. The most fractured zone is probably along the Solai Axis, which may also be a major channel for groundwater flow along the rift axis.

Based on resistivity tests, the prospect is estimated to cover an area of more than 90 km2, which, if proven, can generate more than 200 MW. The top of the reservoir is estimated to be at 1000 masl, which is similar to the Olkaria area. The low resistivity anomaly at this depth is interpreted to represent a reservoir with temperatures in excess of 220°C. The evaluation sheet for the Menengai geothermal field is shown in Annex-1-5.

4.4.6 Lake Bogoria and Arus Geothermal Prospects

Arus-Lake Bogoria is an area of volcanic rocks without any clear observable volcanic centers. The rocks largely occur as lava sheets that were probably erupted through fissures on the rift floor during the Mio-Pliocene epoch. A large positive magnetic anomaly occurs in the area, which suggests the existence of rocks in the subsurface at high temperatures. Seismic surveys indicate shallow high activity to the east of Lake Bogoria along the Marmanet fault.

Geothermal manifestations are abundant in the area around Lake Bogoria and fluid geothermometry indicates moderate subsurface temperatures in the region of 145 to 245°C, while temperatures at Arus are at lower (170 to 192°C). The hot springs typically have elevated boron concentrations that suggest deep circulation of fluids. The geothermal system in the Bogoria-Arus area is, therefore, a product of deep circulation of meteoric water along the rift flank and rift floor faults. Deep circulating water would then gain temperature due to both deep circulation and mining of heat along the fault planes. The presence of geysers at Lake Bogoria indicates a good hydrological connection between the recharge and up-flow, which is mainly along the rift floor faults. The geothermal reservoir is expected to be small, discrete and confined to the immediate vicinity of fault zones. However, more than 20 MW can be generated from the resource using binary system technology. The evaluation sheet for the Bogoria geothermal field is shown in Annex-1-6.

4.4.7 Lake Baringo

Lake Baringo geothermal prospect is in the northern part of the Kenyan rift (refer to Fig.-4.4-1). Surface manifestations include fumaroles, hot springs, thermally altered hot grounds and anomalous groundwater boreholes. The Kenya Government and KenGen carried out surface studies in 2004 (Mungania et al, 2005). The geology indicates occurrence of trachyte and trachy-phonolites, basalts and alluvial and fluvial deposits on the lower parts. Lack of a centralized volcano or a caldera in this prospect suggests that its reservoir characteristics may be different from those of the prospects mentioned above.

Resistivity at sea level indicates occurrences of fault-controlled, discrete possible resource areas west of the Lake. Fluid geothermometry indicates a reservoir temperature of over 200ºC near the Chepkoiyo well, west of Lake Baringo. The prospect is not associated with a centralized volcano and the heat sources are probably deep dyke swarms along the faults. The estimated low to intermediate reservoir temperatures are ideal for direct uses and binary cycle electricity generation technologies. The evaluation sheet for the Baringo geothermal field is shown in Annex-1-7.

4.4.8a Korosi Volcano

The latest volcanic activity associated with Korosi was characterized by a basaltic composition and occurred a few hundred years ago. The last silicic volcanism, however, occurred about 10,000 years ago, implying that the heat source for the geothermal system is long-lived. A positive magnetic anomaly is also associated with the volcano. If a geothermal system occurs under Korosi, then it probably extends to the northern part of Lake Baringo as determined from low shallow seismic velocities in the region. The wide distribution of surface manifestations indicates that the geothermal area is large and extends from Lake Baringo to Korosi.

The main heat source for the geothermal system is probably located under the volcanoes of Korosi and Ol Kokwe. However, in both cases, basaltic magmatism is characteristic of the latest activity. The hydrogeology of the prospect is probably strongly controlled by Lake Baringo, which is located to the south of Korosi. The lake water would then flow down and northward as determined by the hydrological gradient. The outflow of the geothermal system is also northward. Gas geothermometry indicates that temperatures of more than 250°C are present in the reservoir. Therefore, it is possible that a high-temperature geothermal system is found under Korosi volcano and extends southward. More than 100 MW can be generated from this prospect. The evaluation sheet for the Korosi geothermal field is shown in Annex-1-8.

4.4.8b Chepchuk Geothermal Prospect

The heat source here is probably associated with the old caldera at Chepchuk and some outflow from the Paka geothermal system. However, the antiquity of the last volcanic activity (dated at about 1.2 million years ago) suggests that high temperatures may no longer exist in the geothermal system. Also, the minimal intensity of geothermal manifestations, despite the major faults passing through the geothermal area, signifies reduced activity in the system. Fumarole condensate chemistry, particularly the high ammonium concentrations, suggests that low temperatures are associated with the geothermal system. Despite the low estimated temperatures in the reservoir, the geothermal system should be able to support a ten to 20 MW power plant utilizing binary technology. The evaluation sheet for the Chepchuk geothermal field is shown in Annex-1-8.

4.4.9 Paka Volcano

Paka volcano is built of trachyte and basalt lavas and pyroclastic deposits that culminated in the formation of a caldera about 10,000 years ago. Younger, fissure-controlled basaltic and intermediate lava eruptions indicate that the magmatic system is probably still active and might store a great deal of heat. A Positive magnetic anomaly suggests the presence of high temperatures. Seismic studies indicate shallow events directly under Paka, suggesting that a hot body exists below at a depth of about 2.5 to 5 km. This hot body could be the heat source for the geothermal system associated with Paka volcano.

The area covered by intense geothermal manifestations at Paka is more than 45 km2. The broad distribution suggests that the heat source could be large and is probably located directly under the volcano, where the hottest fumaroles occur. Fluid geothermometry indicates that temperatures in the geothermal reservoir could exceed 300^{o}C. The hydrogeology of the area is characterized by recharge mainly from the east rift shoulder and also from the south and a discharge both to the north and northwest. The highest potential area for detailed studies is within the caldera and the massif in general. The evaluation sheet for the Paka geothermal field is shown in Annex-1-9.

4.4.10 Silali Caldera

Silali caldera measures 7.5 km by 5 km in area and was formed about 7,000 years ago. The latest activity was basaltic in composition and erupted about 200 to 300 years ago. The young activity associated with the volcano indicates that the magmatic body under the volcano could still be hot and could drive a geothermal system. The presence of a positive magnetic anomaly that is coincident with the dimensions of the caldera is further proof of the presence of a hot body under the caldera. Seismic studies indicate high activity in the east and southeast parts of the caldera floor, which could be related to a geothermal system.

Silali has some of the largest hot springs within the Kenya rift, indicating with a high likelihood that there is a geothermal system under the volcano. It is estimated that Kapedo, which is one of the hot springs associated with Silali, discharges 1,000 liters per second of water at 50 to 55°C. This translates into about 100 MW from this region alone. Fluid chemistry, however, indicates that the fluids are not directly from the upflow but have undergone interaction with shallow groundwater. The model for the system can be explained in terms of an upflow within the caldera with a resource area being probably more than 75 km2 in extent. The fluid then outflows mainly to the west and north through formational contacts and faults and fractures, discharging on the surface at Kapedo springs and other manifestations in the area. The resource in the prospect is estimated to amount to more than 300 MW for 25 years. The evaluation sheet for the Silali geothermal field is shown in Annex-1-10.

4.4.11 Emuruangogolak Caldera

Emuruangogolak caldera measures 5 km by 3.5 km in area and occupies the top of a shield volcano. The latest activity was of trachytic volcanism that occurred about 100 years ago on the southern upper slopes of the volcano. The young trachytic magmatism signifies the presence of a large and hot magma body under the caldera. A positive magnetic anomaly centered on the volcano further attests to the presence of a hot-body temperature. Geothermal manifestations, some of which are at boiling point, suggest the presence of a geothermal system which gas geothermometry indicates to be at temperatures of 200°C to 350°C. An abundance of fumaroles at higher temperatures on the eastern half of the caldera floor may imply a better geothermal system in that segment.

It is anticipated that the recharge of the geothermal system will prove to be good, as suggested by the occurrence of hot springs on the eastern flanks of the volcano. Modelling suggests that the geothermal fluid flows up within the caldera floor and immediate environs and flows out largely to the north and west. This geothermal prospect is capable of supporting more than 200 MW for 25 years. The evaluation sheet for the Emuruangogolak geothermal field is shown in Annex-1-11.

4.4.12 Namarunu Geothermal Prospect

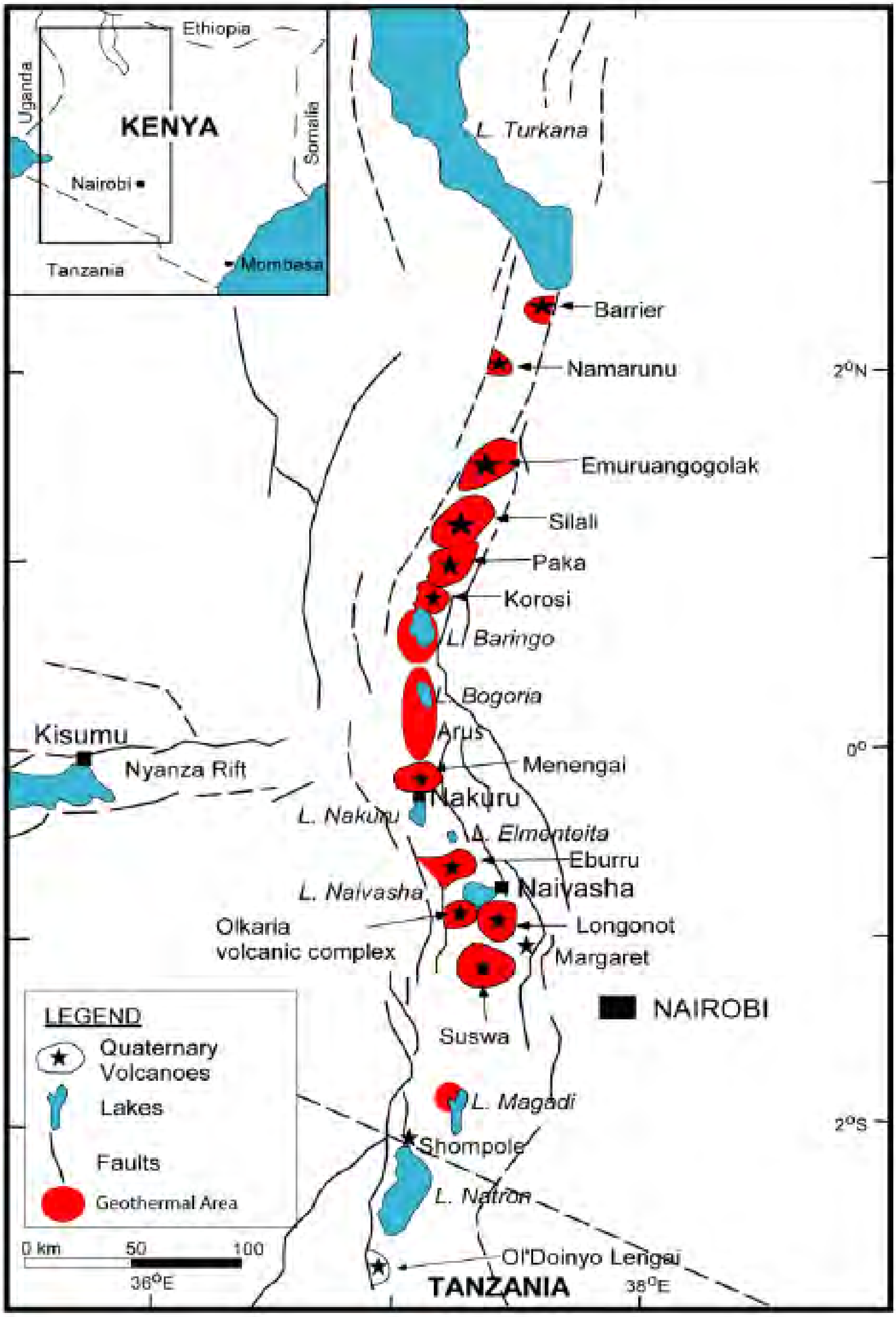
Namarunu geothermal prospect lies within an area of Plio-Pleistocene volcanic activity with the latest basaltic eruptions dating to 500,000 years ago. Other basaltic scoria cones dot the Namarunu volcanic field.

Fumaroles at temperatures ranging from 30 to 100°C occur at the foot of eastern and western fault scarps. Fluid geothermometry indicates a reservoir at temperatures of more than 200°C. The hottest springs occur along the eastern fault. Hydrological flow patterns indicate that recharge for the Namarunu prospect is largely from the east and south. The hot springs on the west are probably directly associated with a geothermal system in the south and south-east of Namarunu volcanic area. The area is capable of generating more than 20 MW using binary technology. The evaluation sheet for the Namarunu geothermal field is shown in Annex-1-12.

4.4.13 Barrier Volcanic Complex

This complex consists of three volcanoes, of which Kakorinya is the most promising in terms of geothermal potential. Kakorinya is a silicic volcanic center whose caldera formation was accompanied by a collapse about 92,000 years ago and followed by resurgence activity about 58,000 years ago. A caldera association implies that the volcano developed a shallow magma chamber whose heat could still drive a geothermal system. Recent basaltic activity at Teleki's volcano (100 years ago) is a strong indicator that new magma injections still occur, which could raise the local geothermal potential. Developing a geothermal model for the prospect is complicated by the lack of geophysical data and conflicting geochemical information. Low H2 and CH4 in the fumaroles and springs indicate an indirect path between the discharges and the heat source suggesting that the potential for the area is low. In contrast, high gas geothermometric temperatures (218 to 328°C) suggest proximity to an upflow.

It is likely that a high temperature geothermal system is present under the Kakorinya volcano. Sulphur deposits occur within the caldera that are indicative of shallow, degassing magmas, a further indication that there is a large heat source under the volcano. Preliminary indications are that the resource is capable of generating more than 100 MW. The evaluation sheet for the Barrier geothermal field is shown in Annex-1-13.



(Source) Peter (2010)

Fig.-4.4-1 Location of Geothermal Prospect areas in Kenya

(Source) KenGen

Fig.-4.4-2 Map of the Greater Olkaria geothermal area showing the locations of the fields

4.5 Technical Capacity

4.5.1 Ministry of Energy (MOE)

MoE is responsible for policy formulation and determining electric power feed-in tariffs. It also issues the Geothermal Authority permits, which allow an IPP to explore for geothermal resources, and Geothermal Licences, which allow geothermal energy exploitation under the Geothermal Act of 1982 and related regulations.

Whereas most of the Eastern African countries have a single ministry dealing with energy and minerals or energy and natural resources, Kenya has a dedicated ministry of energy. When exploration for geothermal started in the early 70s with assistance from UNDP, staff were seconded to the project from the Mines and Geology Department of the Ministry of Natural Resources, and some from the Kenya Power and Lighting Company. When the decision was made to proceed with the construction of Olkaria I geothermal power station, the government then mandated Kenya Power Company (KPC), which is now KenGen, to develop geothermal power stations. In addition, the exploration activities, including exploration drilling, which were recognized to be the government's responsibility, were delegated to KPC. This consolidated full responsibility for geothermal development under one parastatal organization. Any funding for surface or exploration drilling from donors was channeled to KPC by the government. Whenever the government did not have money to channel to KPC, KPC would be authorized by the government to use its own funds for this purpose. However, loans for power station construction were on-lent to KPC by the government at a much higher rate of interest than that demanded by the donors.

In the late 90s, when KPC was busy with activities at Olkaria and Eburru, the Ministry of Energy decided that it could take over the surface exploration work previously undertaken on its behalf by KPC. To this end, it employed several scientists and engineers and trained them for this purpose. The staff were also involved in the regional geothermal resource assessment covering a large part of the rift system which was funded by UNDP and the British government through the Overseas Development Administration (ODA). The UNDP project covered the Suswa, Longonot and Menengai areas, including part of Olkaria, and included geological, geochemical and geophysical studies. The ODA project (Dunkley et al 1993; Clark et al. 1990) concentrated on geology, geochemistry and hydrogeological aspects without any geophysical surveys. The Ministry of Energy had also acquired a small rig with the intention of carrying out exploration drilling. However, it was found that the rig was not suitably designed for this purpose, and it was abandoned after being tested at Olkaria. The Ministry staff employed to operate the rig were later absorbed by KPC.

At the end of these two projects in 1993, the government decided to leave the exploration work to KPC and downsized its geothermal staff. The are currently five (5) staff members at the MoE, as shown in Table-4.5-1. A large number of staff, except for the newly recruited ones, have been trained in Iceland. The staff remaining at the MoE after the downsizing have always been involved in the surface exploration work with KenGen, particularly in prospects outside of Olkaria. This is because the work in these fields is usually done by KenGen on behalf of MoE with funding mainly from MoE. A list of equipment currently owned by MoE is provided in Table-4.5-2.

Table- 4.5-1 Available skilled professional manpower in Kenya

Organisation	MOE	KenGen	GDC	Orpower4	ODCL	Total
Geologist	2	3	3	0		**6**
Geochemist	1	2	3			**5**
Geophysicist	1	4	1			**5**
Reservoir Engineer		9	1			**10**
Drilling Engineer		21	3			**24**
Power Station Engineer		8	1	3	2	**14**
Environmental Scientist	1	6	4	1		**11**
Financial Planner/Modeller		2	0			**2**
GIS Scientist		3	2			**5**
Drillers		5	0			**5**
Technicians		84	0	16	19	**119**
Total	**5**	**147**	**18**	**20**	**21**	**211**

(Source) Study Team

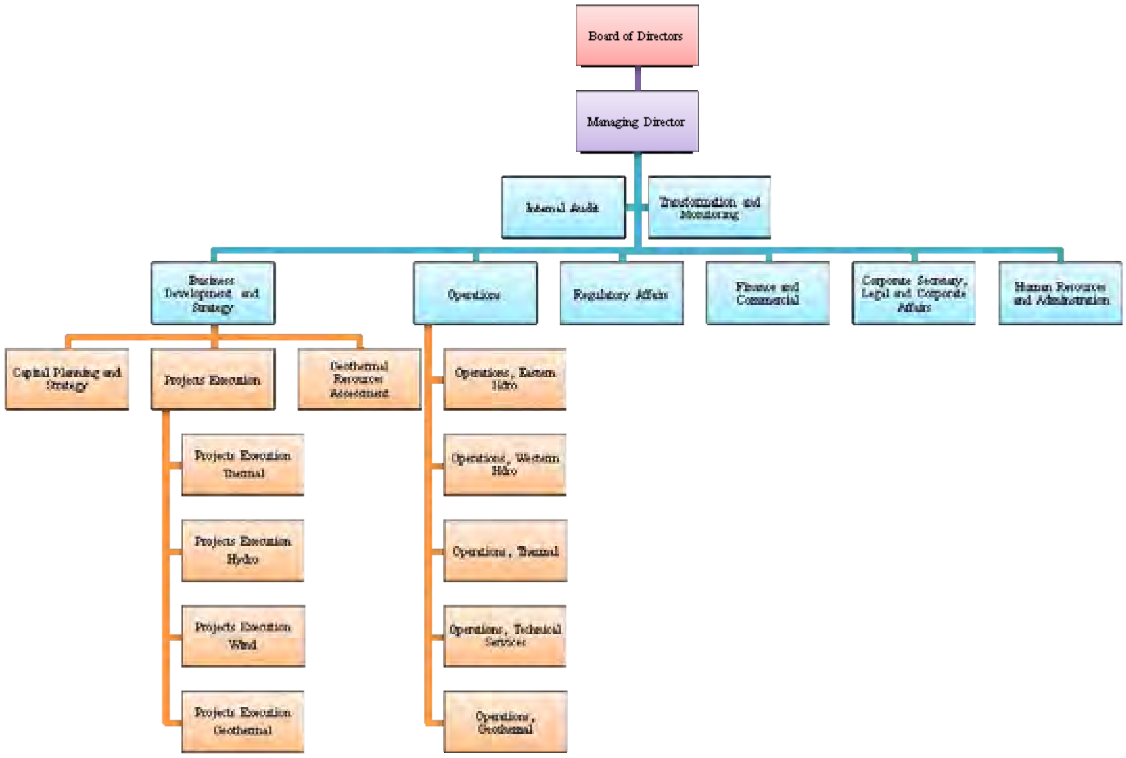
Table-4.5-2 Available equipment in Kenya

	KenGen	GDC		KenGen	GDC		KenGen	GDC		KenGen	GDC
Equipment Description	**Available**	**Available**	**Equipment Description**	**Available**	**Available**	**Equipment Description**	**Available**	**Available**	**Equipment Description**	**Available**	**Available**
Geological			**Geochemical**			**Geophysical**			**Drilling**		
Simple GPS	0	2	Simple GPS	1	2	Differential GPS	0	2	Complete Rig	1	0
Digital Thermometer	0	3	Digital Thermometer	1	2	Simple GPS	2	6	Water supply system(pumps,	2	0
Fluid Inclusion Heating-freezing stage	1	0	pH meter	2	2	TEM	1	2	Site preparation equipment (dozer, grader, tipper trucks)	1	0
Binocular Microscope	2	2	Conductivity Meter	2	2	MT	5	10	Small rig	0	0
Petrographic Microscope	2	2	Water Sampling Kit	1	0	Gravimeter	2	0	**General**		
X-Ray Diffractometer	1	0	Gas Sampling Kit	70	100	Magnetometer	2	0	4x4 field vehicles	40	10
X-Ray Flourescence	0	0	AAS	1	0	Portable seismometer	4	0	GIS System	1	0
ICP-MS	1	0	Ion Chromatograph (IC)	0	0	**Reservoir Engineering**			Total station	1	0
Thin sectioning equipment	2	0	Gas Chromatograph	2	0	Kuster gauge Tools set	2	10	Complete weather station	1	1
			Mass Spectrometer for stable Isotope	0	0	Kuster TPS with SRO	1	1			
			Tritium Scintillation counter & C14 analyser	0	0	Logging Winch	2	1			
						Logging Truck (K10)	1	2			
						Discharge Silencer	7	4			

(Source) Study Team

4.5.2 KenGen

Until the recent formation of GDC, KenGen had driven geothermal development in Kenya, bringing it to its current state. As mentioned above, KenGen was the government agent for geothermal exploration and advised the government in all matters related to geothermal development. Fig.-4.5-1 shows the current structure of KenGen as revised since 2008. The surface exploration, drilling and reservoir management is done by the Geothermal Resource Assessment group headed by the Geothermal Development Manager under the Business Development and Strategy Division. The geothermal power stations are constructed under the supervision of Project Execution within the same division. KenGen owns two power stations, Olkaria I and Olkaria II, with a current total installed capacity of 150MW. The geothermal power stations are managed by the Operations Manager within the Operations Division. Before this new structure, both the power station operations and geothermal resource assessment were in one Geothermal Division under one Chief Manager who reported to the Managing Director.



(Source) KenGen

Fig.-4.5-1 KenGen Organizational structure

Over the years, KenGen has trained many staff members in all areas of geothermal development other than the design of power stations. One staff member has a PhD degree in geophysics and a good number have MSc degrees. Two staff members are currently pursuing PhD degrees in Environmental studies in Iceland.

KenGen's more recent efforts have been to prepare tender documents and supervise power station construction by working with consultants. Some of the staff have been trained in steam pipeline design and reservoir simulation. The actual designs are undertaken by consultants, and the civil and power station construction has been done by local companies supervised jointly by KenGen and consultants. The most recent installation of the third unit at Olkaria II was done under EPC contract, with KenGen and consultants supervising.

KenGen has also acquired a great deal of scientific equipment and has some of the best scientific laboratories in the region. The staff are capable of carrying out detailed exploration surveys, including EIA studies up to the licensing stage. Some of the MT geophysical equipment procured with GEF funding under the Joint Geophysical Imaging (JGI) project has been used in Zambia, Rwanda, Djibouti and the Comoros under the regional cooperation initiative mooted under ARGeo. The staff are capable of doing a bankable feasibility study on their own, if project financiers allow them to.

Wells were drilled with two rigs and later one rig (N370). Drilling was initially done using KenGen staff supervised by foreign consultants, but numerous problems led to very long drilling times. However, CIDA provided technical assistance to KenGen for six years to supervise drilling and train staff on the job and in a special KenGen training school. Some of the staff were trained in Canada. This arrangement was so successful that KenGen staff took over drilling operations without further supervision from consultants and achieved world drilling standards.

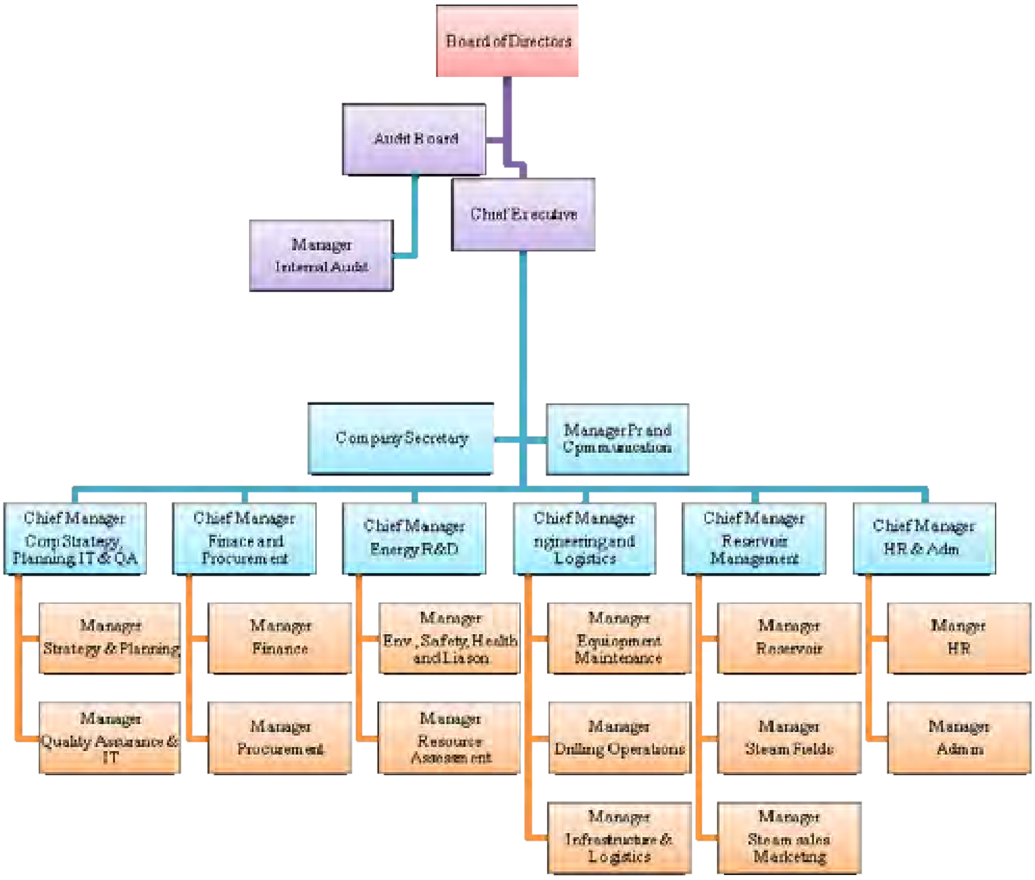
Because of the age of the rig and the limiting factor that the KenGen rig (N370) could not drill directional wells, a Chinese contractor was engaged in 2006 to drill appraisal wells in Olkaria Domes field and the contract has been extended to the drilling of production wells for an accelerated geothermal expansion of 280MW. The management of this contract from tender document preparation to evaluation and now supervision has been carried out very effectively by KenGen staff. In the contract, KenGen procures all the drilling materials.

Power station operations have been very good, with an average plant availability of 98%. KenGen staff are fully competent to operate and maintain the power plants without outside help. Operations and maintenance engineers are routinely trained in either Auckland or Iceland or in both places. The original two engineers, who were previously operations engineers for steam turbines in Mombasa were trained in Japan by Mitsubishi Heavy Industries, which had been given the contract to supply the 3 x 15MW turbines for Olkaria I.

One particular aspect of staff training at KenGen is to build in specialized training in procurement of equipment and project procurement. In this way, technological transfer is effectively enabled.

4.5.3 Geothermal Development Company (GDC)

GDC was established in 2008 by the Government as a special purpose company to accelerate geothermal development in Kenya. GDC is mandated to explore, drill for and sell steam to KenGen and any other company that may be interested for either power generation or industrial use. In so doing, GDC will undertake the risk of drilling both the exploration and production wells and therefore encourage private sector participation in geothermal power development. This mandate will cover all the geothermal areas not currently licenced to either KenGen or IPPs.



(Source) GDC

Fig.-4.5-2 GDC Organizational structure

Fig.-4.5-2 shows the organizational structure of GDC, and Table-4.5-1 shows the current professional staff at GDC. As mentioned previously, GDC has recruited very experienced management staff from KenGen who will manage the company. Two of these staff members, including the CEO, have PhD degrees in geothermal technology. However, GDC still requires a lot of new operational staff who will need to be trained very quickly. GDC will also need to train its staff in Steam Sales Agreement (SSA) documentation and negotiations, which has not been done before in Kenya.

Table-4.5-2 shows the equipment GDC has recently acquired. According to its business plan (GDC 2010), GDC intends to acquire 12 rigs and the various pieces of scientific equipment needed to explore for steam and test the wells. Two rigs are currently on order and will commence operation from late 2010. The two rigs will initially be commissioned and operated by the supplier, who will train GDC staff for one year.

4.5.4 IPPs

Two Kenya IPPs have built and operated geothermal power stations in Kenya.

OrPower4, Inc.

Orpower4 Inc is a subsidiary of Ormat International. In 1998, it acquired by competitive bidding a geothermal licence to develop up to 100 MW in the Olkaria West area. Olkaria West had previously been explored and appraised by KenGen using government funds. In 2000, Orpower4 installed 12 MW of its own binary plant technology on a pilot basis while it undertook further appraisal/production drilling. After successfully drilling about 9 wells with a contractor, it obtained enough steam to install an additional 36 MW which was commissioned in late 2008. Orpower4 has a 20-year PPA to sell electricity to KPLC**.**

Table-4.5-1 shows that about 20 professional technical staff operate and maintain the plant. Testing of the wells is contracted to either KenGen or overseas consultants. The installation of the generating plants has been carried out by Ormat home office staff assisted by local civil and installation engineering companies.

Oserian Development Company(ODCL)

Oserian is a flower-growing company located at Olkaria very close to both KenGen and Orpower4 facilities. Oserian currently owns and operates two small geothermal power stations capable of producing about 4MW. The first one is a binary 2MW plant procured from Ormat and operates from a single well leased from KenGen. The second one is driven by a back-pressure turbine supplied by Geothermal Development Associates of USA. It also runs on steam supplied by KenGen. Oserian also utilizes steam from a third well leased from KenGen to heat greenhouses in which it grows flowers for the export market. The geothermal operations and maintainance employ about 21 professional engineers and technicians (Table-4.5-1) in addition to other support staff. The installations were done by local engineering companies supervised by Ormat or GDA engineers. The power generated by ODCL is only for the use of its farm.

4.5.5 Consultants

The following professionals have been working in geothermal for many years and are available for individual consultancy services (Table-4.5-3):

Table -4.5-3 Individual consultants in Kenya

	Name	**Profession**	**Area of Consultancy**
1	Martin Mwangi	Geophysicist	Geothermal Exploration and Development
2	Francis Nganga	Engineer	Power Engineering
3	Joseph Nganga	Drilling Engineer	Drilling and Project Management
4	Samuel Maina	Engineer	Power Engineering
5	Laban Kimani	Engineer	Planning and Power Engineering
6	Zack Muna	Geochemist	Geothermal Exploration and Development

7	Stephen Onacha	Geophysicist	Geothermal Exploration
8	William Ambusso	Reservoir Engineer	Reservoir management
9	Prof Tole	Environmental Scientist	Environmental Impact Assessment (EIA)

(Source) Study Team

4.5.6 Short Course training in Naivasha, Kenya

In 2005, KenGen and UNUGTP started a short, 1-4 week course in geothermal as part of the ARGeo initiatives which is held annually in Naivasha. The course is co-organized by UNU-GTP in Iceland and KenGen (Fridleifsson 2010). The first course targeted decision makers and lasted 1 week but subsequent courses targeted the technical staff, and the duration was increased to 4 weeks. The 4-week course starts with a week of field trips with KenGen instructors followed by lectures and project work at Naivasha. The teachers are usually from UNU-GTP in Iceland or are KenGen staff, many of whom are former UNU Fellows, and also include several experts from neighboring countries. This creates an East African cooperation which seems to work very well. The course in Kenya has been particularly useful because Kenya has seen all the various activities involved, from exploration to power station operation, and therefore creates a good opportunity to learn all the aspects of geothermal development. In 2009, UNU-GTP, KenGen and GDC collaborated in putting on this course. One hundred and twelve (112) students had taken the course from Djibouti, Ethiopia, Kenya, Tanzania, and Uganda, although students from other countries like Eritrea, Rwanda, Burundi, Zambia, DR Congo, Yemen and the Comoros were also included. Some of the students who attend the short courses are given an opportunity to attend the 6-month UNU-GTP course in Iceland.

GDC has indicated its desire to establish a permanent geothermal training school for the benefit of its staff and the East African Region. This might replace the current short course school in Naivasha. Clear plans for this training school are not yet available.

4.6 Energy policy

Kenya adopted a "National Energy Policy (National Energy Policy and Investment Plan)" in 1987. The objective of the energy policy is to maintain stable economic growth while reducing external debt by pursuing a policy aiming at the reduction of oil imports as well as the promotion of energy security.
Since 1987, the economy had shown steady growth until 2000, when there were major back-to-back droughts in 2000 and in 2001. This was a major set-back to economic activity because of the resulting long-term severe power shortages. These long-term power shortages highlighted the need for an energy policy based on comprehensive perspectives, and a working group consisting of electric utility staff and DOE officials (KPLC, KenGen, ERB, etc.) was formed in 2001, initiating a study to formulate a new "National Energy Policy". Four subgroups under the working group, concerned with "renewable energy", "power", "biomass", and "oil" were established. This initiative resulted in the

formulation of a "National Energy Policy (Sessional Paper No. 4 of 2004 on ENERGY)", which was revised in 2004.

The purpose of the "National Energy Policy" is to achieve a stable, cost-effective supply of environmentally friendly energy, in the proper quantity and quality in order to promote economic growth. The gist of the policy is: 1, to secure a stable supply of high quality energy; 2, to review the various energy prices; 3, to revitalize local economies through a revitalized national energy supply; 4, to promote resource development; 5, to promote energy development while focusing on the environment, health, and safety; and 6, to promote energy efficiency and conservation.

Aiming at achieving poverty reduction, in 2003 the Kenyan government, developed its “Economic Recovery Strategies (Economic Recovery Strategy for Wealth and Employment Creation 2003-2007: ERS)", which positioned the energy sector as the third pillar of economic recovery.

The Kenyan government's power development policies can be found in the power policy law of 1997, in their policy deployments during the period 2004 – 2007, and in the energy law of 2006. The central themes of these policies are to encourage competitive markets by dismantling the vertically integrated power structure, to promote private investment and to contribute to the healthy development of the power industry through proper elaboration of the electric rate structure.

Furthermore, the development of the power industry in this way is intended contribute to the achievement of the millennium development goals, such as eradicating poverty and the related environmental goals. Energy development is recognized as a major impetus to achieving the goals listed above.

Thus, in order to promote renewable energy, in March, 2008 the government formulated a feed-in-tariff policy (a fixed-price purchasing system) for power generation projects using wind, biomass, small hydro, geothermal, biogas or solar power, which was revised in January 2010. The intention is to buy electric power generated from renewable energy sources at some fixed prices for 20 years until the cumulative capacity called for under the scheme reaches its predetermined maximum.

This scheme, which specifies different fee arrangements depending on type of the renewable energy source, reflects the fact that the development and operation costs for the wide range of renewable energy sources are different, and that consequently power costs will vary. Thus, the cost of power plant construction, maintenance, fuel, financing and return on investment for each type of renewable energy, as well as the expected life of the electricity generation facilities, are taken into account in setting criteria for Feed-in-Tariffs. Thus, the Feed-in-Tariffs are based on generation costs, but also take into account avoided costs, Feed-in-Tariffs in other parts of the world, and the specific socio-economic conditions in Kenya. Feed-in-Tariffs include the grid connection cost. In other words, this purchase price includes the cost of electricity sub-station equipment for the power delivery point.

(1) The Feed-in-Tariff for Wind Energy Resource Generated Electricity is a fixed tariff not exceeding US Cents 12.0 per Kilowatt-hour of electrical energy supplied in bulk to the grid operator at the interconnection point. This tariff shall apply to individual wind power plants (wind farms) whose effective generation capacity is above 500kW but does not exceed 100

MW. The tariff shall apply to the first cumulative 300 MW capacity of Wind power plants developed in the country under this tariff policy.

(2) The Feed-in Tariff for Biomass Energy Resource Generated Electricity is a firm-power fixed tariff not exceeding US Cents 8.0 per Kilowatt-hour of electrical energy supplied in bulk to the grid operator at the interconnection point. This tariff shall apply for 20 years from the date of the first commissioning of the Biomass power plant. Where biomass is used together with fossil fuels for the purpose of producing firm power, biomass shall contribute not less than 70% of the annual fuel consumption, otherwise the non-firm power tariff shall apply. The firm power tariff shall apply to the first 200MW of firm power generated by biomass-based power plants developed in the country.

(3) For non-firm Biomass power plants, a non-firm power fixed tariff willl apply, not exceeding US Cents 6 per Kilowatt-hour of electrical energy supplied in bulk to the grid operator at the interconnection point. This tariff shall apply for 20 years from the date of the first commissioning of the Biomass power plant. The non-firm power tariff shall apply to the first 50MW of non-firm power generating, biomass based power plants developed in the country. The tariffs shall apply to individual biomass power plants whose effective generation capacity is above 500kW but does not exceed 100MW for non-firm Biomass power plants and co-firing Biomass power plants.

(4) The Feed-in Tariff for Small Hydro Power Resource Generated Electricity will apply to small hydro power plants defined as hydro based power plants whose installed capacity is greater or equal to 500kW but less than or equal to 10 MW. A stepped fixed tariff for small hydro power generated electricity not exceeding the prices shown in the Table 4.2.2 below shall apply on electrical energy supplied in bulk to the grid operator at the interconnection point. The tariffs shall apply for 20 years from the date of the first commissioning of the small hydro power plant. The firm power tariff shall apply to the first 150MW of small hydro, firm-power generating stations developed in the country. The non-firm power tariff shall apply to the first 50MW of small hydro non-firm power generating stations developed in the country.

Table 4.6-1 Kenya's Feed-in Tariff for Small Hydro Power Resource Generated Electricity

Power Plant Effective Generation capacity (MW)	Firm Power Tariff (US ¢ /kWh)	Non-Firm Power Tariff (US ¢ /kWh)
<1	12.0	10
1-5	10.0	8.0
5-10	8.0	6.0

(Source) Ministry of Energy

(5) The Feed-in Tariff for Geothermal Energy Resource Generated Electricity is a fixed tariff not

exceeding US Cents 8.5 per Kilowatt-hour of electrical energy supplied in bulk to the grid operator at the interconnection point. This tariff shall apply for 20 years from the date of the first commissioning of the geothermal power plant. This tariff shall apply to the first 500 MW of geothermal power capacity developed in the country under this tariff policy. The tariff shall apply to individual geothermal power plants whose effective generation capacity will not exceed 70 MW.

(6) The Feed-in Tariff for Biogas Energy Resource Generated Electricity is a fixed tariff not exceeding US Cents 8 per Kilowatt-hour of electrical energy supplied in bulk to the grid operator at the interconnection point. This tariff shall apply for 20 years from the date of the first commissioning of the Biogas power plant.. This tariff shall apply to the first 100MW of power generated using biogas.

(7) The Feed-in Tariff for non-firm power Biogas Energy Resource Generated Electricity is a non-firm power fixed tariff not exceeding US Cents 6 per Kilowatt-hour of electrical energy supplied in bulk to the grid operator at the interconnection point. This tariff shall apply for 20 years from the date of the first commissioning of the Biogas power plant. This tariff shall apply to individual biogas power plants whose effective generation capacity is equal to or above 500kW and does not exceed 40MW. The non-firm power tariff shall apply to the first 50MW of non-firm power generating, biogas-based power plants developed in the country.

(8) The Feed-in Tariff for Solar Energy Resource Generated Electricity is a fixed tariff not exceeding US Cents 20.0 per Kilowatt-hour of electrical energy supplied in bulk to the grid operator at the connection point. This tariff shall apply for 20 years from the date of the first commissioning of the Solar power plant. This tariff shall apply to individual solar power plants whose effective generation capacity is equal to or more than 500kW but does not exceed 10MW, and shall apply to the first 100 MW of power generated using solar resources.

(9) The Feed-in Tariff for non-firm power Solar Energy Resource Generated Electricity is a non-firm power fixed tariff not exceeding US Cents 10.0 per Kilowatt-hour of electrical energy supplied in bulk to the grid operator at the connection point. This tariff shall apply for 20 years from the date of the first commissioning of the solar based power. The non-firm power tariff shall apply to individual solar power plants whose effective generation capacity is equal to or more than 500kW but does not exceed 10MW, and shall apply to the first 50MW of non-firm power generating, solar based power plants developed in the country.

As for geothermal policy, Kenya has implemented a policy which could be a model for others. Their policy assumes that responsibility for downhole resource studies such as pre feasibility studies and/or full scale feasibility studies rests with the government. The results of these publicly funded studies are open to private developers for the purpose of encouraging the participation of the private sector (Section 6.4.1 (i) - (iv) of Sessional Paper No. 4 of 2004 on Energy). Furthermore, if private developers undertake feasibility studies themselves, they may use the study results when negotiating

PPAs with KPLC. Kenya has also enacted a Feed-in Tariff program for renewable electricity for the purpose of encouraging private sector participation in geothermal development.

Constructing a rational legal and regulatory framework is regarded vital to the geothermal development. The Geothermal Resources Act-1982 (GRA), which was enacted in 1982, a year after the inception of the first geothermal production in the country, is the principal Law governing Geothermal Resource Development in Kenya. As the years have passed, supplementary laws and regulations have been put in place, such as the Regulations of 1990. Excerpts of the provisions set out in the GRA-1982 are as follows:

(1) Geothermal Resources are vested in the Government.

(2) Declaration of GR areas is authorized by the Minister for Energy

(3) Unauthorized use of GR without authority or license is forbidden.

(4) Authorization to search for geothermal resources through surveys, investigations, tests, measurements, boreholes and any related activity is given by the Minister for Energy. Authorization is subject to the following conditions :

  a. Authorization lasts for one year and is not transferable

  b. Authorization is renewable for one year

  c, Authorization may be revoked due to non-compliance with the Act, effect on other boreholes, overriding public interest

(5) Conditions for Geothermal Resource Licenses granted by the Minister for Energy.

  a. They are for a period not to exceed 30 yrs

  b. They are renewable for a period not to exceed 5 yrs

  c. They are not transferable without the Minister's authorization

  d. Annual rent is to be paid 3 months prior to due date, or a 10 % penalty will apply

(6) Cessation of work for 6 continuous months without consent or breach of any of the provisions may lead to forfeiture of license.

(7) Rights under the license are as follows:

  a. The license-holder may enter the geothermal resource site

  b. The license-holder may drill and construct necessary boreholes & undertake any necessary associated activities.

  c. The license-holder may construct and maintain buildings and machinery

  d. The license-holder may utilise the geothermal resources

  e. The license-holder may construct and maintain roads and other communication means

The other laws related to geothermal activities in Kenya are Electric Power Act no. 11 of 1997, the Environmental Management and Co-ordination Act, the Water Act (CAP372) of 1972, repealed in 2000, the Factories Act (CAP 514) of 1972, the Local Government Act, CAP 265, the Public Health Act (CAP242) of 1986, the Wildlife Conservation and Management Act (CAP 376), the Restrictive

Trade Practices, Monopolies & Price control Act, CAP 504, the Standards Act, CAP 496, and the Forest Act (CAP 385).

Kenya is also involved in an active geothermal development program. The Least Cost Power Development Plan 2009-2029 sets a development goal of building additional capacity of 1,569 MW by 2025. Assuming the development cost of the geothermal energy is USD3K per kilowatt-hour, the program will require financing of nearly 5 billion dollars in total. This will impose a huge financial burden on the government if the investment is carried out by the public sector alone. However, it is not desirable to impose huge restrictions on the other vital investments or policies of the government. Therefore, for successful long-term geothermal power development, the Kenyan government regards the participation of the private sector as essential for the country's power development, including the geothermal energy. Thus a policy has been set of introducing IPPs in such a way that the government takes responsibility for the steam development while leaving low-risk energy conversion to the private sector.

In other words, what has become the biggest obstacle to geothermal development is underground resource risk, which requires expensive drilling investigation in order to determine the amount of geothermal resources. To enter a business with resource risk is extremely difficult for private companies, and they agree to take on risk only in exchange for high compensation, which would push up the cost of geothermal power projects. During the geothermal exploration and investigation stage, no banks will finance a project, meaning that all the costs have to be funded from equity. In any case, funding the project would be very expensive. Drilling work under private developers would likely be carried out by expensive overseas drilling contractors, which necessitates expensive transportation of the drilling equipment and personnel. Upon analyzing these factors and the business models, the Kenyan government decided to form a state-owned company, GDC (Geothermal Development Company), through which the government collectively takes responsibility for the risk of geothermal resource development in Kenya. GDC shall employ its own drilling rigs and drilling engineers, thereby effecting a reduction in development costs, as drilling will be conducted using their own equipment and personnel. Since GDC also remains a state-run company, they will be eligible for low-cost financing, as they can obtain funding from international organizations.

Since the resource risk is now removed, with the steam supplied by the state-owned steam development company, the barriers to IPP participation are considerably reduced. In other words, the IPP can focus solely on the energy conversion business. In this way, the Kenyan government hopes to encourage the participation of private power producers in the conversion business, which accounts for about half of the development costs.

4.7 Environmental Policies

4.7.1 EIA and Environmental Legislations

(1) EIA system

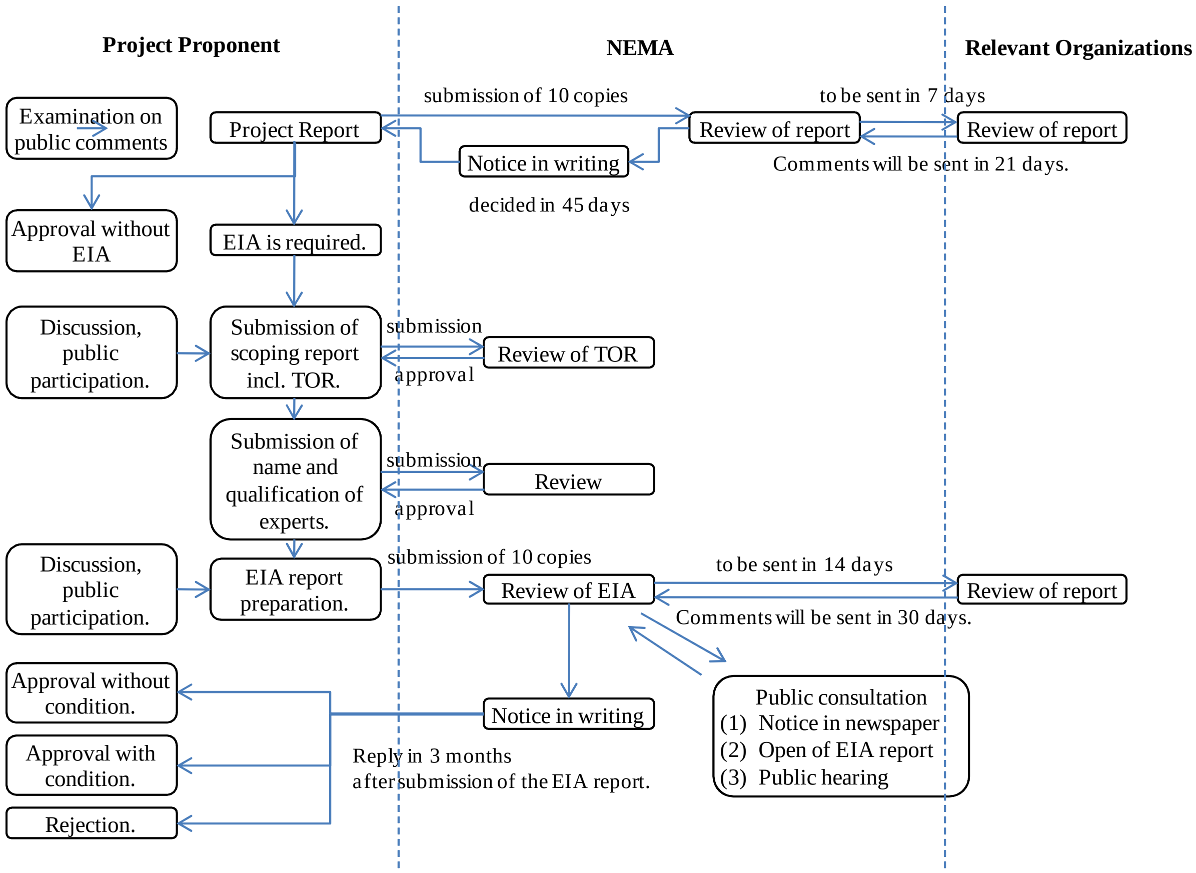
EIA system in Kenya is prescribed in Environmental Management Coordination Act of 1999 (EMCA) and Environmental (Impact Assessment and Audit) Regulations of 2003. Projects subject to the EIA are stipulated in Second Schedule of the EMCA and also EA is stipulated in Chapters 68 and 69 of the EMCA.

Process of EIA report preparation and its review are conducted based on the draft EIA Guidelines and Administrative Procedures of 2002, which was prepared by the National Environmental Management Agency (NEMA) as shown in Fig.-4.7-1. Legislations on EIA are shown in Table-4.7-1.

Since types of the project subject to the EIA as stipulated in the Second Schedule of EMCA are not clearly mentioned with quantitative criteria, NEMA decides if the project is subject to the EIA process based on the Project Report (PR) submitted by the project proponent. In the case of the geothermal power development project, it is supposed that EIA is required since the geothermal power development project is fallen in the category of "(a) power generation facility of the item No. 9 Electrical infrastructure" in the Second Schedule of the EMCA.

In the case of the existing Olkaria geothermal power development project, EAIS report was approved by NEMA with the following conditions.

- Compliance of requirements in EIA such as implementation of EA and compliance of the environmental management plan,
- Compliance of MOU with KWS related to the construction of infrastructure facilities in the Hell's Gate National Park,
- Compliance of the environmental legislations such as noise and vibration, water quality, waste, labor safety and sanitation,
- Implementation of management program for oil and hazardous materials, and
- Design of pipeline which does not disturb wildlife movement.



(Source) Prepared based on the EIA and Environmental Audit (2003) and draft EIA Guidelines and Administrative Procedures (2002)

Fig.-4.7-1 EIA Report Preparation and Approval Process

Table-4.7-1 Legislations on EIA

No.	Name of Legislations
1	Environment Management and Co-ordination Act (EMCA), 1999
2	Environmental Impact Assessment and Audit Regulations, 2003
3	(Draft) Environment Impact Assessment Guidelines and Administrative Procedures, 2002
4	Wildlife Conservation and Management Act Cap 376

(Source) Each legislation

(2) Relevant Environmental Legislations

Environmental Regulations and Standards Related to the Geothermal Power Development Project in Kenya are shown in Table-4.7-2.

Table-4.7-2 Environmental Regulations and Standards Related to the Geothermal Power Development Project in Kenya

No.	Name of Regulations and Standards	Outline
1	Environmental Management and Coordination (Water Quality) Regulations of 2006	Water quality standards on domestic water use, discharge into public water area, sewerage discharge, irrigation water, and recreation use
2	Environmental Management and Coordination (Noise and Excessive Vibration Pollution) (Control) Regulation 2009	Noise standards on ambient noise level, road side noise level, construction noise are stipulated. Not exceed 0.5[cm/s], 30 m from the source is stipulated for the vibration.
3	Occupational Safety and Health Act (OSHA) 2007	Labor environment conservation, safety in machinery operation, safety in chemical use, and penalty in violation are stipulated as safety and sanitation for the labors.
4	Environmental Management and Coordination (Waste Management) Regulations of 2006	License and environmental audit on waste management including collection, transportation, and final disposal is stipulated.

(Source) Each legislation

(3) Implementation Process of Environmental Audit

Environmental Audit (EA) is implemented based on the Environmental Management Plan (EMP), which is submitted with the EIA. There are 3 types of the EA; Initial-EA conducted by external organization, Self-EA conducted by the project proponent, and Compliance-EA conducted by NEMA.

(4) Other permissions

Based on the experience in the existing Olkaria geothermal power development project, the following environmental permissions are required in addition to the EIA. Permissions on emission gas, noise, drainage, and borrow pit are included in the ESIA. Permission on waste disposal site has to be obtained in the timing of its necessary after the project starts.

- Permission on water use from Water Resource Management Agency (WARMA)
- Permission on national park and wildlife protected area by MOU with Kenya Wildlife Service (KWS)
- Permission on waste disposal site

4.7.2 Legislations on Land Acquisition and Resettlement

(1) System of Resettlement and Relevant Organizations

In Kenya, national policy and legislations on the land acquisition and resettlement have not been well prepared. There are only relevant legislations on the land acquisition. In the case where preparation of the resettlement action plan (RAP) is required such as donor's financed project, the Operational Policy on Involuntary resettlement of the World Bank (OP 4.12) has been referred. In addition, the project proponent is required to submit the RAP to NEMA with ESIA report, even there is no regulation to submit the RAP.

(2) Legislations on Land Acquisition

Legislations on land acquisition are shown in the following table.

Table-4.7-3 Legislations on Land Acquisition

No.	Name of Legislations
1	The Constitutions
2	Government Land Act Cap 280
3	Land Titles Act Cap 282, 1908
4	Registration of Titles Act Cap 281
5	Land (Group Representatives) Act Cap 287, 1970
6	The Trusts of Land Act Cap 290, Revised edition 1982
7	Land Control Act 302, Revised Edition 1989 (1981)
8	Land Planning Act Cap 303, Revised Edition 1970
9	Land Acquisition Act, Cap 295
10	Valuers Act Cap 532
11	Rating Act Cap 267, 1963
12	Energy Act

(Source) Each legislation

4.7.3 Practice of Environmental and Social Consideration in Olkaria Geothermal Development Project

Since the Olkaria geothermal power plant is located in the Hell's Gate National Park, various environmental protection measures have been implemented. In addition, the power plant is located adjacent to the Naivasha Lake, which is the Ramsar Convention site. Therefore, all used hot water is returned to the underground. According the ESIA report on No. 4 and No. 5 facilities of the Olkaria power plant, H_2S has been monitored in 18 sites as an air quality monitoring program for the existing Olkaria power plants No. I and No. II.

Domestic waste is disposed through entrusting to the private company. Recyclable waste is collected by the recycle waste company. For the sludge discharged from cooling tower and condenser, the sludge is disposed in the closed space as an appropriate treatment.

Regarding the soil contamination, heavy metal has been monitored in 7 locations such as power plant, exploitation well, residential area, and Naivasha Lake. As and Zn are exceed the WB and NEMA standards according to the ESIA report. On the other, since soil contamination has not been detected according to the EA report in 2007 for the Olkaria No. I and No. II, it is considered that there is no serious impact at present.

As for the noise level, the noise level has been monitored by the KenGen at sixteen sites as a noise monitoring program for the Olkaria No. I and No. II, according to the ESIA report. Since the power plant is remote from the residential area, it is considered that there is no noise impact to the residential area, based on the monitoring results.

As environmental impact to the wildlife and livestock, dividing habitat area is considered. For the mitigation, pipelines located in such habitat area, shape of the pipeline is formed to make the animal pass under the pipeline.

4.8 Direct Utilization of Geothermal Energy

4.8.1 Utilization of Hot water in Olkaria Geothermal Development Project

KenGen has contracted with the Oserian Development Company to provide hot water to keep appropriate temperature in the green house of the Oserian Development Company to grow ornamental flowers, and also provide CO_2 to accelerate the growth. This is considered as a successful case.

4.8.2 Plan of Utilization of Hot Water

In addition to the utilization of the surplus hot water in the Olkaria geothermal development project as mentioned above, a Demonstration Center with area of 4.5 ha, which utilizes surplus hot water from the Olkaria Power Plant II, is planned to start construction next to the main gate (next to the training school) from June 2010. Construction of the center is about USD 133,000.

In the Demonstration Center, temperature of the hot water is declined through the three hot water pools and hot spring can be enjoyed in the third pool. The center is supposed to be utilized by visitors of the power plants with free of charge. Regarding water quality of the hot water, it has been confirmed that it was no problem for the hot spring purpose. Used hot water is planned to be returned in the underground. Capacity of the pool is about seventy persons and 20 - 100 visitors/day are expected.

In the Olkaria geothermal development project, though food processing, alcohol processing, grain dry, flour milling and concentration, indoor heater and cooler are considered for future utilization of the geothermal energy, there is no concrete development plan at present.

Chapter 5 Ethiopia

5.1 Country Outline

On the political front, in 1974, the long-reigning emperor Haile Selassie was deposed by a military junta led by Mengistu Haile Mariam, who established a one-party communist state known as the People's Democratic Republic of Ethiopia. Years of drought, famine, ethnic conflict and war followed, until Mengistu was overthrown in 1991. In December 1994, Ethiopia's constituent assembly approved a new constitution for the Federal Democratic Republic of Ethiopia, featuring a two-chamber federal parliamentary system. The current government led by Prime Minister Meles Zenawi, took office after the first elections under the new constitution in 1995. The number one concern of this administration has been poverty reduction and the establishment of food security.
[1]

Following the May 2005 elections, there was widespread unrest as several opposition groups claimed that the elections had been fraudulent, although opposition groups did increase the number of seats they held in the parliament from 12 (in the first-ever multi-party elections of 2000) to 200. The government party won victory again in the regional elections and the by-elections that were held in April 2008. A coalition of opposition parties was formed in 2009 to challenge the rule of Zenawi's party in the general election scheduled for May 2010, but the ruling EPRDF party won a landslide victory.

On the economic front, farm production has been going well thanks to an easing of drought conditions, investment from emerging donors such as China, India, and Turkey has been increasing, and the GDP growth rate of 2005-2007 achieved an annual average of about 11% (WDI 2009). This is the highest growth rate among non-oil producers in sub-Saharan Africa. The government is making an effort to maintain this high economic growth over the long term. Moreover, it is assumed that natural resources such as oil and scarce metals are also abundant, and Ethiopia's potential for development is therefore high. A large river such as the Blue Nile offers enormous hydroelectric potential, which is presently still underdeveloped. In the agriculture sector, which accounts for about 85% of employment and about 45% of GNI, poverty reduction and the establishment of food security remain important goals. Though the government is following a policy of Agricultural Development-Led Industry (ADLI), and has strengthened its measures to reduce poverty, inflation has been adding to the numbers of the urban poor. In addition, excessive economic dependence on exports of primary commodities like coffee has led to low foreign currency reserves and a large external debt.

On the development front, Ethiopia has been recognized as a Heavily Indebted Poor Country (HIPC)

[1] Source: International Cooperation Bureau, Ministry of Foreign Affairs, Japan: Official Development Assistance (ODA) countries data book 2009

by the World Bank, and drafted its first poverty reduction plan, the Sustainable Development and Poverty Reduction Program (SDPRP), in 2002 as a condition for receiving further development support. The Plan for Accelerated and Sustained Development to End Poverty (PASDEP) is Ethiopia's second poverty reduction plan, and targets the five years beginning in 2005-6. The execution of this policy in the light of the Millennium Development Goals (MDGs) remains a common challenge for donors and for the Ethiopian government.

The main policies of PASDEP involve the following:

- A large-scale effort to accelerate economic growth
- A strategy that considers geographic characteristics
- A response to the population problem
- Opening up economic opportunity for Ethiopian women
- Strengthening of key infrastructure
- Management of crises and instability
- Strengthening of measures to achieve the MDGs
- Job creation

5.2 Energy Resources

The primary energy supply in Ethiopia in 2007 totaled 22,805 thousand tons of oil equivalent (toe), consisting of 20,862 thousand toe of indigenous energy (hydro: 290 thousand toe, firewood and the like: 20,573 thousand toe) and 1,984 thousand toe of imported energy (oil, petroleum products), with no exports (IEA Energy Balance 2007). The final energy consumption was 22,010 thousand toe. In the breakdown by uses, industrial use accounted for 566 thousand toe, transport use for1,150 thousand toe and other uses (household/commercial, agricultural, etc.) for 20,294 thousand toe (IEA Energy Balance 2007).

In Ethiopia, as in many other East African countries, most primary energy sources consist of traditional biomass fuels, and, in particular, the energy on which households are dependent is mostly derived from biomass. As a result, it is estimated that 40 million tons of wood fuel, as well as 8 million tons of agricultural waste, are consumed annually. Disappearance of vast forest areas due to wood harvesting for firewood has caused environmental degradation. And excessive use of agricultural residue and animal manure as fuel has prevented their use as fertilizer, which has consequently caused a decline in soil fertility.

The majority of the oil fuel is consumed in the transport sector. National oil reserves discovered in Ethiopia are small and none of commercial scale has been found so far. Natural gas remains undeveloped, although 25 billion cubic meters of natural gas reserves have been confirmed in the country. As for oil development, Malaysia's Petronas has been working aggressively in recent years.

Despite a tragedy in which Ogaden National Liberation Front (ONLF) guerrillas were said to have killed 74 workers in 2007, including eight Chinese drilling workers, causing a temporary suspension of their venture, they resumed work in 2010 in the Ogaden region. Petronas is using one of the major oil service companies, Weatherford, as the drilling contractor this time. Petronas is said to have already invested more than USD100 million in oil development in Ethiopia (BBC news, 2007, Energy-Pedia, 2009). Since 1997, when the Assab refinery facility was shut down, all petroleum products have been imported. Overland oil imports from Sudan started in January 2003. Under the COMESA agreement, imports of oil from Sudan are exempt from customs duties.

Regarding coal resources, on the other hand, coalfields have been identified in the Delbi, Moye and Yayu areas in the western part of the country (with reserves estimated to be about 70 million tons in total). There were development plans in the past for these coal resources, but they have been suspended due to economical and environmental concerns.

As for other renewable energy resources, EEPCO has collected wind data across the country with the help of Germany's GTZ, and based on their study, a wind farm project is under development in Tigray state.

5.3 Electric Power Situation

5.3.1 Electric Power Sector

The power sector covers electricity generation, transmission and distribution, including rural electrification. The Ministry of Minerals and Energy is responsible for overall policy for the development and operation of the sector in Ethiopia. A new national economic policy was introduced in 1991 to guide the economic development of Ethiopia, including the management of the electric sector. The dominant player in the sector has been the Ethiopian Electric Power Corporation (EEPC), a vertically integrated utility responsible for generation, transmission, distribution and supply of electricity in the country. Initiated through various proclamations on electricity from 1997, the liberalization of the sector has seen the opening up of the sector to private investment in the generation and distribution/supply business areas, the establishment of a regulator - the Ethiopian Electricity Agency (EEA) - in 1997 and the promulgation of an investment law and environmental law to help attract investment in the sector. These are discussed in the sections of the report that follow.

5.3.2 Power Sector Policy

In its preamble, The National Energy Policy document states that Ethiopia is endowed with vast energy resources - 30,000MW of hydropower resources, 1387 million TOE of biomass resources, 17.5 million TOE of agricultural residue, over 100 billion cubic meters of natural gas, 4,000 MW of geothermal energy, 40.3 million tons of coal and oil shale, and vast resources of solar and wind energy - but has not been able to develop, transform and utilize these resources for optimal economic development. Therefore, the Government believes it is imperative to provide the economy with the necessary energy inputs at the right time and at affordable prices to speed up economic development and help the country attain the objectives of the Economic Reform Program the government has adopted. Towards this end the government has formulated a comprehensive national energy policy which directs the development of the energy sector in a coordinated manner that at the same time ensures that energy development is benign to the environment.

Among the Policy objectives is the placing of a high priority on the development of the abundant hydropower resource, the provision to the private sector of the support and incentives necessary to ensure its participation in the development of the country's energy resources, and the focussing of due and close attention on ecological and environmental issues during the development of energy projects. The National policy provides the basis on which the legal framework has been developed.

5.3.3 Legal Framework

To underpin the reforms in the power sector the following key laws have been promulgated over the last 10 or so years.

· Electricity Law Proclamation no. 86/1997 relating to electricity
· Proclamation no. 9/1995 on the environment
· Proclamation no. 146/1998, the Privatization of Public Enterprises Proclamation
· Council of Ministers Regulation no. 49/1999 to provide for the regulation of electricity operations
· Regulation no. 84/2003 on investment incentives and investment areas reserved for foreign and domestic investors.

The effect of these laws is to end the monopoly of EEPCO in electricity operations and provision, to establish a regulator (the EEA), to open up electricity sector to private investment, to create incentives to attract private investment into the development of the power system, and to create an environmental agency to oversee the sustainable and environmentally friendly development and operation of power resources.

5.3.4 Power Sector Investment Incentives

The objectives of the law related to investment in the electricity sector include helping to mobilize financial resources and technical expertise for sustainable exploitation and development of the natural resources. The law also creates wide employment opportunities for nationals by fostering the transfer of technical know-how, managerial skills, and the introduction of appropriate technologies in the sector.

The transmission and supply of electrical energy through the Integrated National Grid System is exclusively reserved for the Government. All other areas of investment in the electricity sector are open to foreign investors, as specified by Regulation No. 84/2003 issued by the Council of Ministers.

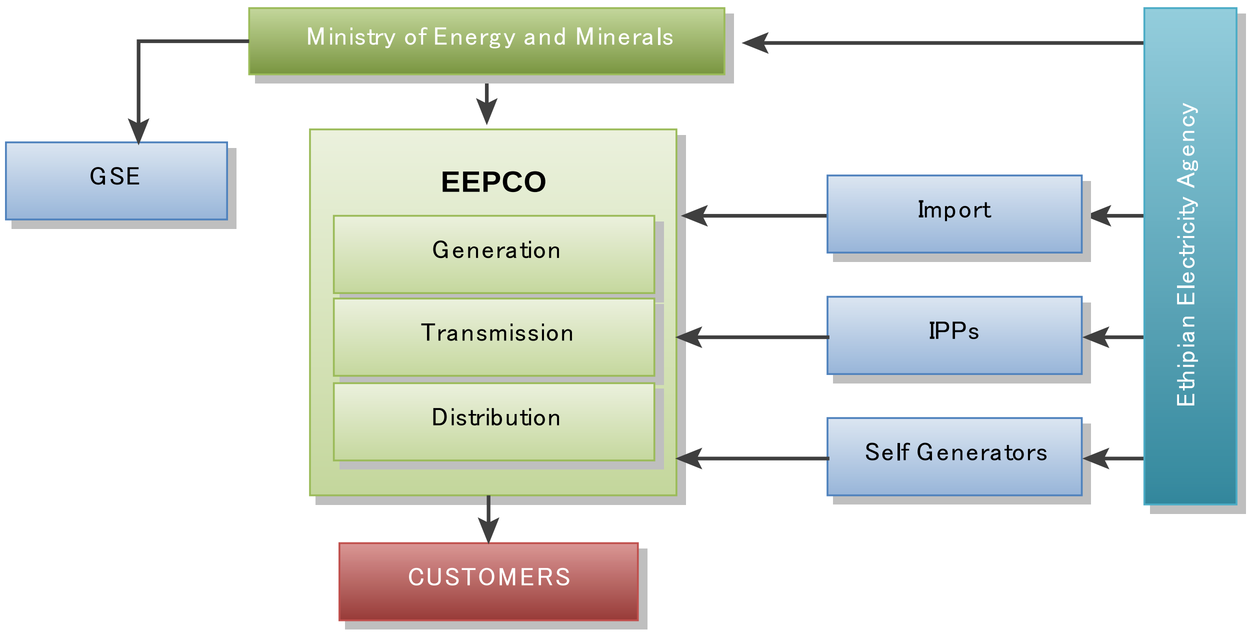
An investor shall be allowed to import duty-free those capital goods and construction materials necessary for the establishment of a new enterprise or for the expansion or upgrading of an existing enterprise, unless they are not produced locally in adequate quantity and quality at a competitive price.

An investor eligible for duty-free importation of capital goods shall be given the same privilege for spare parts whose value is not greater than 15% (fifteen percent) of the total value of the capital goods to be imported. It is worth noting that capital goods imported free of customs duty must not be transferred to third parties not entitled to similar duty-free privileges, unless prior payment of the customs duty is made.

5.3.5 Institutional Framework

EEPCO is vertically integrated and responsible for the generation, transmission, distribution and supply of electricity in Ethiopia. There are no immediate plans to unbundle any of the generation, transmission or distribution operations as in other countries. However, the law allows independent private developers on their own or through public- private partnerships to participate in development of the huge indigenous resources of the country, such as hydro or geothermal, for power generation.

As discussed above, the players in the sector include the Ministry of Energy and Mines, Ethiopian Electric Power Corporation (EEPCO), the Ethiopian Electricity Agency (EEA), the Ethiopian Environmental Agency, the Geological Survey of Ethiopia (GSE) and a host of other bodies that manage isolated systems throughout the country. There is no body charged with the development of geothermal power, although GSE is responsible for geothermal exploration as part of the mineral exploration of the country.



(Source) Study Team

Fig.-5.3-1 Electric Power Sector Players in Ethiopia

As observed above, Ethiopia has no institution devoted to the promotion and development of geothermal resources for power generation.

5.3.6 Regulatory Framework

Electricity Proclamation No. 86/1997 of June 1997 made way for the establishment of the Ethiopian Electricity Agency (EEA) as an autonomous federal government organ. The EEA has been in operation from the beginning of 2000.

The EEA is accountable to the Ministry of Infrastructure and is charged with the following duties:

·To supervise and ensure that the generation, transmission, distribution and sale of electricity are carried out in accordance with Electricity Proclamation No. 86/1997, the regulations and relevant directives;

·To determine the quality and standard of electricity services and ensure their implementation;

·To issue certificates of professional competence to electrical contractors;

·To issue, suspend and revoke licenses for the generation, transmission, distribution and sale of electricity in accordance with the relevant laws;

·To study and recommend tariffs and, upon approval, supervise its implementation;

·To cooperate with technical training institutions in the field of the development of electricity;

·To perform such other activities as may be necessary for the attainment of its objective.

Additionally, the EEA has put in place the following comprehensive strategies in its strategic and management plan:

·To build the Agency's capacity;

·To regulate the power sector so as to improve the reliability and quality of electric services;

·To study and regulate electricity prices and tariffs to improve efficiency

·To introduce and acquaint the public with the authorities and responsibilities of the Agency.

5.3.7 Energy Pricing

According to “Pricing procedure for small and very small self-contained systems (SCS) no 2/2005” and “Pricing procedure for inter-connected system (ICS) and large isolated systems no 1/2005”, the electricity price structures shall reflect costs and price levels will be based on short-term marginal/average costs, and be updated at no more than four-year intervals. Electricity law Proclamation No. 86/1997 sets out the pricing principles for electricity generation, transmission, distribution and supply. Electricity pricing shall be based on the principle of efficient allocation of resources, where customers and producers bear and receive the true costs associated with consuming and producing each unit of energy, respectively. Tariff structures shall be kept simple enough to avoid or minimize implementation difficulties. Prices for supplying energy and power to retail or bulk customers shall be determined on the basis of the system marginal cost, subject to adjustments to meet financial requirements to be defined as necessary, and optimum system planning. Where the marginal cost approach is inappropriate, such pricing shall be based on the average cost of supply and an acceptable rate of return on investment.

With regard to generation pricing within the national grid system, the most efficient generation facility identified to meet the system’s peak demand shall constitute the base for marginal generation capacity costs, while the most efficient generation facility identified to meet the system’s base load shall provide the base for the computation of energy prices. The marginal energy cost shall, in the case of hydropower plants, be computed on the basis of the cost which is not attributed to capacity, while the generation cost of thermal plants and the wholesale purchase price of power and energy shall be computed on the basis of planned generation.

With regard to generation pricing outside the national grid system, the most efficient generation facility used to meet the system demand shall constitute the base for determining the marginal generation capacity cost, and the marginal energy cost shall be computed for each generation facility. For small hydropower plants, a similar approach may be used as for large hydropower plants in the national grid system, while the generator's specific prices shall be spread over the system generation price on the basis of planned generation within the system and, where appropriate, shall be reviewed frequently by the regulator.

Appropriate incentive and penalty mechanisms shall be incorporated in the pricing process to secure a higher level of availability of thermal generation facilities. The price of bulk energy and power from private producers shall be determined in accordance with power purchase agreements approved by the Agency, and shall be directly transferred to customers. The system marginal transmission capacity cost shall form the base for transmission pricing within the national grid system. However, the system's transmission capacity cost outside the national grid system shall be determined on the basis of estimated or actual accounting costs and an acceptable rate of return on investment. System marginal distribution capacity cost shall form the base for distribution pricing within the national grid system, while, for distribution outside the national grid system, the system's distribution capacity cost shall be determined on the basis of estimated or actual accounting costs and an acceptable rate of return on investment. Generation and transmission costs at the appropriate voltage level shall be added on top of the distribution cost to form the tariff applicable to customers.

Energy and power metering costs and billing costs shall form the base for determining marginal customer-related costs. The payment of connection charges shall be related to additional costs resulting from supplying new demand. Charges on reactive power consumption shall be related to the capacity cost that the reactive power consumption applies to the system, at the voltage level at which consumption is provided. Other appropriate charges may be levied in accordance with contractual agreements between licensees and customers.

5.3.8 Financing Framework

The power sector is less liberalized compared to other Eastern African countries, of which Uganda is the most liberalized. The power sector supply chain of generation, transmission, distribution and supply continues to be dominated by EEPCO.

However, a legal framework has been put in place to attract private participation to the development of the sector.

5.3.9 Existing Generation Capacity

Currently (in 2010), EEPCO operates an interconnected Contained System (ICS) which has an installed capacity of 1,686.1 MW, comprising 1,566.6MW of hydro, 112.2MW of diesel and 7.3MW of geothermal plants as indicated in Table-5.3-1. Hydro comprises approx 93% of the total. This excludes 60MW of rented emergency diesel plant installed in 2009 at the height of power rationing and 37.1MW of off-grid systems (self contained systems or SCS).

Table-5.3-1 Installed Capacity in Ethiopia of ICS and SCS systems in 2010

Plant Name	*Hydro*	*Diesel*	*Geothermal*	*Total*	*Commissioning year*
Koka	43.2			*43.2*	1960
Awash II	32			*32*	1966
Awash III	32			*32*	1971
Finchaa	134			*134*	1973, 2003
Melka Wakana	153			*153*	1988
Tis Abay I	11.4			*11.4*	1964
Tis Abay II	73			*73*	2001
Gilgel Gibe	184			*184*	2004
Tekeze	300			*300*	2009
Gilgel Gibe I	184			*184*	
Glgel Gibe II	420			*420*	2010
Aluto Langano			7.3	*7.3*	1999
Sub Total	1566.6	0	7.3	*1573.9*	
Alemaya		2.3		*2.3*	1958
Dire Dawa		4.5		*4.5*	1965
Adigrat		2.5		*2.5*	1992, 1993,1995
Axum		3.2		*3.2*	1975, 1992
Adwa		3		*3*	1998
Mekele		5.7		*5.7*	1984, 1991,1993
Shire		0.8		*0.8*	1975,1991, 1995
Jimma		1		*1*	NA
Nekempt		1.1		*1.1*	1984
Awash 7 Kilo		35		*35*	2004
Kaliti		14		*14*	2004
Dire Dawa		38		*38*	2004
Ghimbi		1.1		*1.1*	1962, 1984
Sub Total		112.2		*112.2*	

ICS Total	1566.6	112.2	7.3	*1686.1*	
SCS Total	6.1	25.5		*31.6*	
Total (ICS and SCS)	1572.7	137.7	7.3	*1717.7*	

(Source) EEPCO

As can be observed from Table-5.3-2, Power Supply Data for Ethiopia 2005-2009, electricity demand registered positive growth over the previous years, but due to drought, the available capacity of the predominantly hydropower system was inadequate to meet demand, resulting in power rationing. EPPCO procured 60MW of rented emergency power to reduce the severity of power rationing as the ongoing implementation of new major hydro projects was completed.

Table-5.3-2 Power Supply Data for Ethiopia 2005-2009

Description	Years						
	Unit	2005	2006	2007	2008	2009	2009
Hydro	GWh	2,536	2,846	3,291	3,374	3,296	88.4%
Thermal	GWh	51	44	40	158	418	11.2%
Geothermal	GWh					14	0.4%
Total Production	GWh	2,587	2,890	3,332	3,532	3,728	100.0%
Total Sales	GWh	2,095	2,408	2,799	2,966	3,131	84.0%
System Losses	GWh	492	482	533	566	597	16.0%
System Losses %		19%	17%	16%	16%	16%	
System Peak Demand		521	587	625	674	673	
System Load Factor		57%	56%	61%	60%	63%	

(Source) EEPCO

5.3.10 Transmission and Distribution System

According to data in the “Extract of master plan 2007” the transmission system that year comprised a total of 7,132 km of transmission lines. About 2,194 km of these are at the 230kV level, 2,743 km at the 132kV level, 1,537 km at the 66kV level and 399 km at the 45kV level in the interconnected system.

5.3.11 Existing Customers

The number of customers over the period 2005 – 2009 (about 40% of whom are located in the capital Addis Ababa) is indicated in Table-5.3-3.

Table-5.3-3 Number of Customers over the Period 2005 - 2009

Year	2005	2006	2007	2008	2009
No of Customers	953,007	1,126,785	1,396,093	1,677,335	1,830,052

(Source) EEPCO

5.3.12 Electricity Tariffs

The current retail tariffs are designed to recover fixed costs, capacity costs, energy costs and power factor-related capacity costs. An increase of about 22% was made across the board in tariff charges for these categories of costs in 2006, bringing the tariff at that time up to the marginal cost of supply. The tariff rates adopted in 2006 are indicated in Table-5.3-4 and Table-5.3-5. However, due to inflation and the depreciation of the Ethiopian Birr, the current tariff charges have declined as seen in the equivalent tariffs in USD for 2006 and 2010 shown in above tables. This may be corrected by introducing a forex adjustment surcharge and periodical review to adjust for inflation.

Table-5.3-4 Energy charges for various tariff categories

	Consumption per month	Birr/kWh	US¢/kWh	US¢/kWh
Domestic			2006	2010
1st Block	0-50	0.273	3.1	2.2
2nd Block	51-100	0.356	4.0	2.9
3rd Block	101-200	0.499	5.6	4.0
4th Block	201-300	0.550	6.2	4.5
5th Block	301-400	0.567	6.4	4.6
6th Block	401-500	0.588	6.7	4.8
7th Block	above 500	0.694	7.9	5.6
Equivalent rate for Domestic		0.475	5.4	3.9
General				
1st Block	0-50	0.609	6.9	4.9
2nd Block	Above 50	0.694	7.9	5.6
Equivalent rate for General		0.672	7.6	5.4
Low Voltage Industry			0.0	0.0
Peak		0.743	8.4	6.0
Off Peak		0.544	6.1	4.4
Equivalent rate		0.578	6.5	4.7
High Voltage Industry 15kV				
Peak		0.509	5.8	4.1
Off Peak		0.393	4.4	3.2
Equivalent rate		0.409	4.6	3.3
High Voltage Industry 132kV				
Peak		0.474	5.4	3.8
Off Peak		0.366	4.1	3.0
Equivalent rate		0.381	4.3	3.1
Street Lighting		0.484	5.5	3.9
Summary				
Average tariff		**0.530**	**6.0**	**4.3**
Exchange Rate USD 1= Ethiopian Birr 16.38			8.8401	12.340

(Source) EEPCO

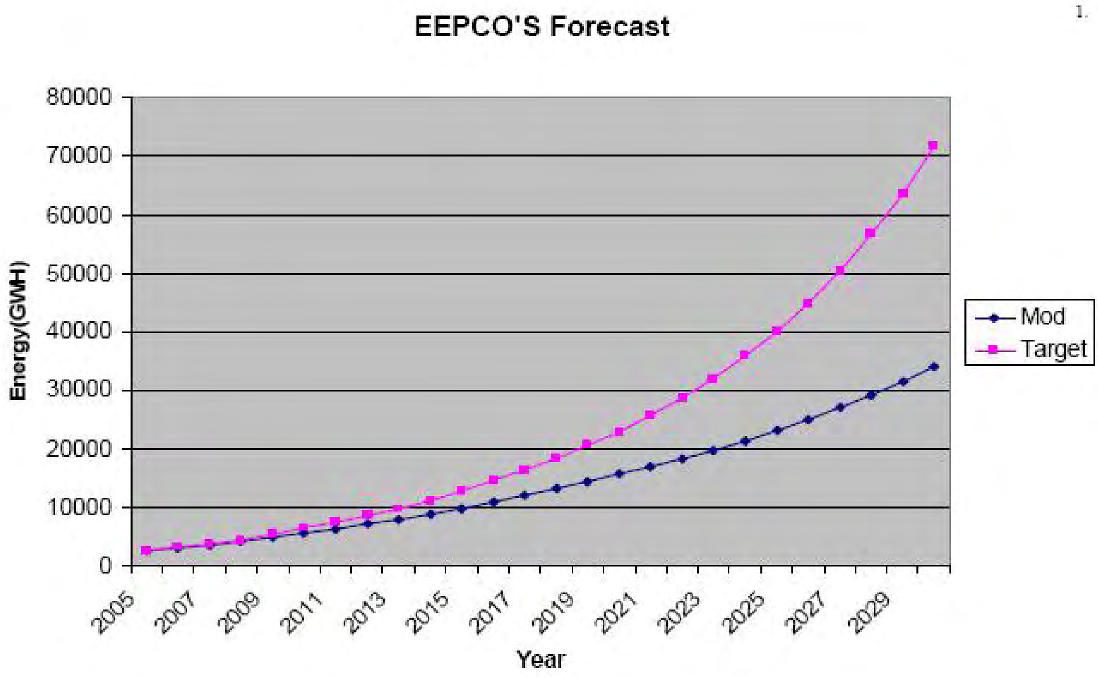
Table-5.3-5 Service (fixed) charges for various tariff categories

Tariff Category		Service (Fixed) charge Birr/month	Service (fixed) charge USD/month	Service (fixed) charge USD/month
Domestic	Consumption per month			
	0-25	1.708	0.19	0.14
	25-50	3.404	0.39	0.28
	51-105	6.82	0.77	0.55
	106-300	10.236	1.16	0.83
	above 300	13.652	1.54	1.11
	Three-phase	17.056	1.93	1.38
	Active/Reactive loads	37.564	4.25	3.04
General				
Single-Phase		14.494	1.64	1.17
Three-Phase		22.558	2.55	1.83
Active/ Reactive		35.258	3.99	2.86
Low Voltage Industry		-	-	-
High Voltage Industry 15kV				
Three-phase		54.009	6.11	4.38
High Voltage Industry 132kV				
Three-Phase		54.009	6.11	4.38
Street Lighting				
Single-Phase		14.494	1.64	1.17
Three-Phase		22.558	2.55	1.83
Active/ Reactive		35.258	3.99	2.86
Exchange Rate USD 1= Ethiopian Birr 16.38			8.8401	12.34

(Source) EEPCO

5.3.13 Electricity Demand Forecast

Analysis of historical sales and GDP data for the period 1973 to 2007 reveals that the electricity demand has an elasticity of 2.15 to changes in the overall GDP. If an economic growth rate of 7-10% can be achieved in the coming years, it could translate to an electric energy demand growth rate of about 17% (as projected in the target scenario), based on the above elasticity estimate depicted in Fig.-5.3-2 below:



(Source) EEPCO (2007)

Fig.-5.3-2 EEPCO Projected Electricity Demand

5.3.14 Generation Expansion Plan

To meet the projected country electricity demand and bulk export commitments to the neighboring countries of Djibouti, Kenya and Sudan, the Government is implementing an ambitious hydro capacity expansion program through EPPCO, with two initial projects commissioned in 2009/2010 adding over 720 MW to the national grid. Other projects under construction or committed to according to the EEPCO Strategic Plan Summary of December 2009 (citing the power system master plan EEPCO 2007) are indicated in Table-5.3-6 below.

To meet the projected demand, expansion of generation and transmission capacity is planned and is being implemented by EEPCO. Table-5.3-7 below shows the unit energy costs for committed and candidate generation projects. The unit cost refers to the cost at the generation point calculated with a 10% discount rate.

Table-5.3-6 Committed and candidate project details

Project	Status 2009	CAP MW	Energy GWh	unit cost of energy Euro cents/kWh	Commissioning Year
Hydro					
Tekeze I	Completed	300	960	3.5	2009
Gibe II	completed	420	1,680	3.2	2009
Beles	95% completed	460	1,860	3.11	2010
Gibe III	35% completed	1,870	6,400	3.1	2013
Fan	45% completed	100	212	5.14	2013
Helele Werabesa	Tendering	422	2,233	2.65	2015
Chemoga Yeda	Contract signed	278	1,250	3.06	2015
Gibe IV	MOU signed	1,472	7,500	3.25	2015
Genale III	Contract signed	258	1,200	2.64	2014
Genale VI	Tendering	256	1,000	3.82	2015
Geba I & II	Tendering	366	1,788	2.84	2015
Gojeb	Tendering	150	450	5.56	2015
Sub Total Hydro		6,352	26,533		2015
Wind					
Ashegoda wind	Construction under way	120	417	4.90	2012
Adama Wind	Contract Signed	51	162.7	5.75	2011
Messobo Wind	MOU Signed	42	155	5.85	2012
Ayisha Wind	MOU Underway	300	1,314		2012
Debre Birhan Wind	MOU Underway	100	389		2013
Assela Wind	MOU Underway	100	389		2013
Adama II	Under study	51	162.7		2013
Sub Total Wind		764	2,989.4		2013
Geothermal					
Aluto Langano Geothermal	Pre feasibility	75	525.6		2012
Tendaho Geothermal	Pre feasibility	100	700.8		2018
Corbetti Geothermal	Pre feasibility	75	525.6		2018
Abaya Geothermal	Pre feasibility	100	700.8		2018
Tulu Moya Geothermal	Pre feasibility	40	280.32		2018

Table-5.3-6 Committed and candidate project details (cont'd)

Dofan Geothermal	Pre feasibility	60	420.48		2018
Sub Total Geothermal		450	3,153.6		2018
Grand Total		7,566	32,676		

(Source) EEPCO (2007)

Table-5.3-7 Committed and Candidate Project Details

No	Project	Capacity	Energy	Unit costs
		MW	GWh	Euro Cts/kWh
1	Tekeze I	300	960	3.16
2	Gibe II	420	1,680	2.62
3	Beles	460	1,860	2.43
4	Wind	120	450	4.8
5	Gibe III	1,870	6,400	2.86
6	Fan	100	212	5.14
7	Hallele-Werabessa	422	2,233	2.65
8	Tekeze II	450	1,750	3.31
9	Gibe IV	1,900	7,500	3.25
10	Genale III	258	1,200	2.64
11	Genale IV	256	1,000	3.82
12	Geba I&II	366	1,788	2.84
13	Keradobi	1,600	8,600	2.96
14	Boarder	1,200	6,000	2.63
15	Mendaya	2,000	12,100	2.24

(Source) EEPCO (2007)

5.3.15 The Role of IPPs in Generation Expansion Plan

There are no IPPs operating in Ethiopia, but the legal framework is in place for private sector investment in power generation.

5.3.16 Geothermal Energy in the Generation Expansion Plan

Directive for Maximum Duration of License for Non-Hydropower Generation Plants for Commercial Purposes No. 1/ 2005, issued by the Ministry of Infrastructure pursuant to the authority vested in it by Article 18(2) of the Electricity Operations Council of Ministers Regulation No. 49/1999 sets a maximum limit on the duration of a license for non-hydropower generation plants for commercial purposes as follows:

· Thermal Power Generation license..... 30 years

· Geothermal Power Generation license..... 25 years
· Biomass Power Generation license.... 20 years
· Wind Power Generation license.... 20 years

A 5 MW geothermal plant is currently in operation at Aluto Langano. Exploration, appraisal and feasibility studies of the geothermal prospects would provide the planning inputs necessary to facilitate consideration of geothermal candidates in the master plan.

5.3.17 Transmission Capacity Expansion

The "Power master plan study 2007" covered Ethiopia's main transmission and sub transmission voltage levels and also interconnections with neighboring countries. The results showed that, in order to cope with the changes in the power system, EEPCO needs to install 304 km of 66kV, 1,844 km of 132kV, 3,486 km of 230kV and 1,210 km of 400kV lines by 2015, as indicated in Table-5.3-5.

The study further indicated that transformers in almost 100 substations have to be upgraded, voltage-controlling reactors and capacitors of about 1,046MVar and 1,100MVar are also needed for proper operation of EEPCO's future system.

Table-5.3-8 Proposed Transmission System Expansion

From	To	Voltage Level	km	In Service Year
Kombolcha	Aksta	132	82	2008
Tekeze	Mekele	230	2x 90	2008
Mekele	Alamata	230	141	2008
Alamata	Combolcha	230	121	2008
Combolcha	Cotebe	230	294	2008
Cotebe	Kality	230	20	2008
Finchaa	Ghedo	230	93.6	2008
Ghedo	Gefersa	230	134	2008
Combolcha	Samara	230	180	2008
Samara	Ditchato	230	63	2008
Gonder II	Shehidi	230	2x 135	2008
Gilgel Gibe II	Gilgel Gibe I	400	30	2008
Gilgel Gibe II	Sabata II	400	185	2008
Sebeta II	Sebeta I	230	2x 20	2008
Gonder	Humera	230	323	2008
Beles	Bahar Dar III	400	2x 65	2009
Bahar Dar III	Debremarkos	400	200	2009
D.Markos	Sululta	400	230	2009
Sululta	Cotebe	230	2x 22	2009

Tekeze	E/Selase	230	249	2009
Melka Wakena	Ramo	230	287.5	2009
Ramo	Gode	230	325	2009
Melka Wakena	Yadot	132	100	2009
Dire Dawa	Dj. Border	230	201	2009
Ramo	Fik	132	250	2009
Sawla	KeyAfer	132	120	2009
Addis Nort Tap	Addis North	230	5	2009
Aksta	Alem Ketema	132	100	2009
Nekemte	Gutin	132	67	2009
Bedele	Yayu Coal	230	48	2010
Yayu	Metu	230	42	2010
Bedele	Metu	230	90	2010
Metu	Gambela	230	150	2010
Kaliti I	Addis Center	132	14	2010
CotebeI	CotebeII	132	10	2011
GGIII	W.Sodo	400	2x 80	2011
W.Sodo	KalityI	400	2x 270	2011
GGIII	GGII	400	150	2011
Kality I	Kality North	132	3	2011
Kality I	Bole Weregenu	132	19	2011
Halele	Werabessa	230	30	2014
Werabessa	Werabessa Tap	230	2x 5	2014
Werabessa	Ghedo	230	2x 79	2014
Yirgalem	W.Sodo	132	60	2015
G.Gibe old	Jimma	132	71	2015
Mesobo	Mekele	132	25	2015
Kality I	D.Zeit	132	30	2015
Chemoga Yeda 1	D Makos	230	2x 36	2015
Chemoga Yeda 2	Chemoga Yeda 1	230	2x 9	2015

(Source) EEPCO (2007)

5.3.18 Conclusion

The major challenges include (1) the need to raise the huge financial resources required for ongoing major hydro projects and (2) the need for diversification of generation sources to minimize hydro risks to the economy by developing the environmentally friendly geothermal resources of the country.

Ethiopia has an ambitious program of hydropower development that, when complete, will provide adequate energy for its domestic use and for export to neighboring countries. To minimize hydro risks and thereby improve the reliability of supply, there is a deliberate policy to diversify the energy sources by developing geothermal power. This requires financial resources that are currently committed to the primary hydropower development. Also, reforms to the legal, regulatory and institutional framework lag behind other Eastern African countries. However, the putting into place of a pricing policy based on cost-reflective tariffs and marginal cost, and the establishment of environmental law is helpful to government efforts to attract private investment to the sector.

5.4 Geothermal Resources in Ethiopia

Ethiopia is one of the few African countries with a significant amount of geothermal resources. These resources are found in the Ethiopian Rift Valley and in the Afar depression, which are both part of the Great East African Rift System. Three geothermal prospective zones were identified in Ethiopia: the Lakes District, Northern Afar, and Southern Afar. Within these zones, 16 geothermal prospects have been identified as potential prospects for electricity generation. It is believed that Ethiopia could probably generate more than 5,000 MW of electric power from geothermal resources alone.

The Precambrian rocks are the oldest and constitute the basement rocks in Ethiopia. They are more than 600 million years old (refer to Fig.-5.4-1). The rocks are impermeable, but highly fractured. Major groundwater resources are associated with these fractured zones. They appear especially in the south and in the western part of the country. The Precambrian rock is mainly composed of metamorphic and granitic rocks. The high degree of metamorphism of these rocks reflects the high temperatures to which they have been subjected since their deposition. The Precambrian rocks contain a lot of economically exploitable minerals. After the end of the Precambrian, uplift occurred in the Paleozoic. The Paleozoic deposits are mainly shale and of glacial origin. The Mesozoic is characterized by subsidence, with the deposition of mudstone and limestone. Outcrops of Mesozoic rock are observed in the west of the country. Volcanism started from the Mesozoic (shield volcanoes with alkali basalts and fragmental material) and has persisted in the Quaternary, especially in the Afar area, within small eruptive centers. The recent volcanic activities are associated with the development of the Rift Valley. The Quaternary is represented by conglomerate, sand clay and reef limestone, which are found in the Afar depression. Geothermal activity is associated with Cenozoic deposits. Also, the Cenozoic deposits contain the groundwater resources of Ethiopia (Warden and Kazmin, 2009).

The Main Ethiopian Rift (MER) extends some 400 km NNE from latitude 6^{o}N to latitude 9^{o}N. The MER has an average width of 70 km and is bounded by large normal faults with displacements of as much as 1000 m. (Di Paola, 1972). Tectonic fragmentation of the rift floor formed the Wonji Fault Belt (WFB) (Fig.-5.4-2). The WFB has been active since the early quaternary (Mohr, 1967) and has a system of dextral en echelon displacements.

The Aluto-Langano geothermal field was allocated to the Ethiopian Electric Power Company (EEPCO) for development in the year 1996, but utilization was delayed until 1998. The first 7.3 MW pilot power plant was built under a turnkey contract by the Israeli company ORMAT. Initially, there was a disruption in power generation due to technical problems, but the plant is now achieving partial generation (4 MW).

Other geothermal prospect areas in the Ethiopian Rift Valley are at various stages of exploration that vary from reconnaissance to detailed geoscientific study including drilling of temperature-gradient (TG) wells. These include:

(i) Tulu-Moye and Corbetti : Detailed geoscientific study, including drilling of TG wells

(ii) Abaya, Dofan and Fantale: Detailed geoscientific study

(iii) Kone, Meteka, Teo, Danab, and L.Abhe: Reconnaissance investigations.

During the four decades that geothermal resource exploration work has been carried out in Ethiopia, a good information base and degree of exploration capacity has been developed. This is especially true of the human capacity and basic infrastructure development that will be critical in ensuring that future selected resource sites are advanced to the development phase much more rapidly than before.

5.4.1 Aluto Langano geothermal field

The Aluto-Langano geothermal field is located on the floor of the Ethiopian Rift Valley about 200 km south east of Addis Ababa (Fig.-5.4-3). In the Aluto-Langano geothermal field, eight deep exploratory wells were drilled to a maximum depth of 2500m between 1981 and 1985, of which four are potentially productive. The maximum reservoir temperature encountered in the productive wells is about 350ºC. A feasibility study was conducted by the Italian firm Electroconsult between 1983 and 1986 (ELC, 1986), indicating that the resource is capable of generating 30 MW for 30 years.

With a view to assessing the production capacity of the existing production wells, geochemical monitoring, well testing and reservoir engineering studies have been carried out since then. However, due to lack of financial resources, further full-scale exploration was halted and the field was handed over to EEPCO for it to utilize the already existing wells and evaluate the reliability of the resource using a pilot plant.

The 1986 Italian feasibility report was reviewed by GENZL (Geothermal Energy development New Zealand Limited Company) in 1995, which recommended starting development of the field by installing a 5 MW condensing turbine power plant.

A 7.3 MW pilot geothermal plant was installed in 1998 utilizing the exploration wells that had been drilled. As mentioned earlier, the plant has not been fully operational due to factors that have to do with the lack of operational experience. Steps are being taken to identify the problems and rehabilitate the plant.

The evaluation sheet for the Aluto Langano geothermal field is shown in Annex-2-1.

5.4.2 Tendaho geothermal field

Geothermal exploration was carried out in the Tendaho area between 1979 and 1980 with economic and technical support from Italy. Between 1993 and 1998, three deep wells (to a maximum depth of

2100m) and three shallow exploratory wells (up to 500m) were drilled, confirming a temperature of over 270ºC. The Italian and Ethiopian governments jointly financed the drilling operations in the field. A preliminary production test and techno-economic study indicated that the shallow productive wells, which were believed to be drilled along the outflow zone, could supply enough steam to operate a power pilot plant of about 5MW, while the potential of the deep reservoir is estimated to be about 20 MW (Aquater, 1996).

Based on this and further studies, the Ministry of Mines is currently in the process of designing a work- plan at Tendaho to progress towards development. The recent upgrade of a trunk highway through the Tendaho area will help facilitate such exploration and development. In addition, the Ethiopian government plans to extend the country's main 230 KV transmission line to Semera, which is within ten km of the drilled wells at Dubti.

The evaluation sheet for the Tendaho geothermal field is shown in Annex-2-2.

Other than these two advanced survey areas mentioned above, six prospects have been subjected over the years to surface investigation of their geology, geochemistry and geophysics, including drilling of shallow temperature-gradient (TG) wells.

5.4.3 Corbetti geothermal prospect area

The Corbetti geothermal prospect area (Fig.-5.4-3) is located about 250 km south of Addis Ababa. Corbetti is a silicic volcano system within a 12 km-wide caldera that contains widespread thermal activity such as fumaroles and steam vents. Detailed geological, geochemical and geophysical investigations conducted in the Corbetti area indicate the presence of potential geothermal reservoirs with temperatures in excess of 250°C. Six temperature-gradient wells have been drilled to depths ranging from 93-178m (Kebede, 1986). A maximum temperature of 94°C was recorded. No further work has been carried out since then. The data shows the probable existence of a deep reservoir with a temperature in excess of 250 °C.

A 132 KV power transmission line passes within 15 km of the prospect and is the main trunk line to Southern Ethiopia, to towns along the two branches of the highway to Kenya.

The evaluation sheet for the Corbetti geothermal field is shown in Annex-2-3.

5.4.4 Abaya geothermal prospect area

Abaya is located on the northwest shore of Lake Abaya, about 400 kms south by road from Addis Ababa (refer to Fig.-5.4-3). The Abaya prospect exhibits widespread thermal activity mainly characterized by hot springs, fumaroles and altered grounds. Hot spring temperatures are as high as 96 °C with a high flow rate. Integrated geoscientific studies (geology, geochemistry and geophysics) have identified the existence of a potential geothermal reservoir with a temperature in excess of 260°C (Ayele et al., 2002). Further geophysical study including drilling of shallow temperature-gradient wells is recommended here.

The 132 KV transmission line to Arba Minch is located about 40 kms to the NNW of the prospect. This raises the prospects for development of the resource once it is adequately explored and

exploratory drilling has been carried out.
The evaluation sheet fo the Abaya geothermal field is shown in Annex-2-4.

5.4.5 Tulu Moye- Gedemsa geothermal prospect area

This area is characterized by volcanism dating from Recent (0.8 –0.08 Ma) to historical times. Volcanism in the Tulu Moye-Gedemsa prospect area involved the extrusion of peralkaline felsic lava associated with young tensional and transverse tectonic features dating from 0.1 -1.2 Ma, with abundant silicic peralkaline volcanic products (Di Paola, 1976). This suggests the existence of a deep-seated magma chamber that has persisted for a long time. The area is highly affected by hydrothermal activity, with the main hydrothermal manifestations being weak fumaroles, active steaming grounds (60-80°C) and altered grounds. The weakness of the hydrothermal manifestations is explained as being the result of the relatively high altitude of the prospect area and the considerable depth to the ground water table. During 1998-2000, integrated geological, geochemical and geophysical studies including shallow temperature-gradient surveys (150-200m) have confirmed the existence of a potential geothermal reservoir with a temperature of about 200°C (Ayele et al., 2002) and have delineated target areas for further deep exploration wells.
This prospect area is located close to the Koka and Awash II and III hydro-electric power stations, and the associated 230 and 132 KV substations and transmission lines.
The evaluation sheets for the Tulu Moye geothermal field and the Gedemsa geothermal field are shown in Annex-2-5 and Annex-2-8, respectively.

5.4.6 Dofan geothermal prospect area

Geological, geochemical and geophysical investigations in the Dofan geothermal prospect show that the area is characterized by a complex volcanic edifice which erupted a considerable volume of pantelleritic lava from numerous eruptive centers between 0.5-0.2 Ma (Cherinet and Gebreegziabhier, 1983). The presence of several hydrothermal manifestations (fumaroles and hot springs) within the graben together with an impervious cap indicate that this field should be given a high priority for further detailed exploration and development. Given these indications and the estimated reservoir temperature of more than 200°C (Teclu, 2002/2003), the Geological Survey of Ethiopia is carrying out detailed geological, geochemical and geophysical investigations in order to delineate and select target areas for deep exploration wells.
The area is located about 40 km from the high voltage substation in Awash town.
The evaluation sheet for the Dofan geothermal field is shown in Annex-2-6.

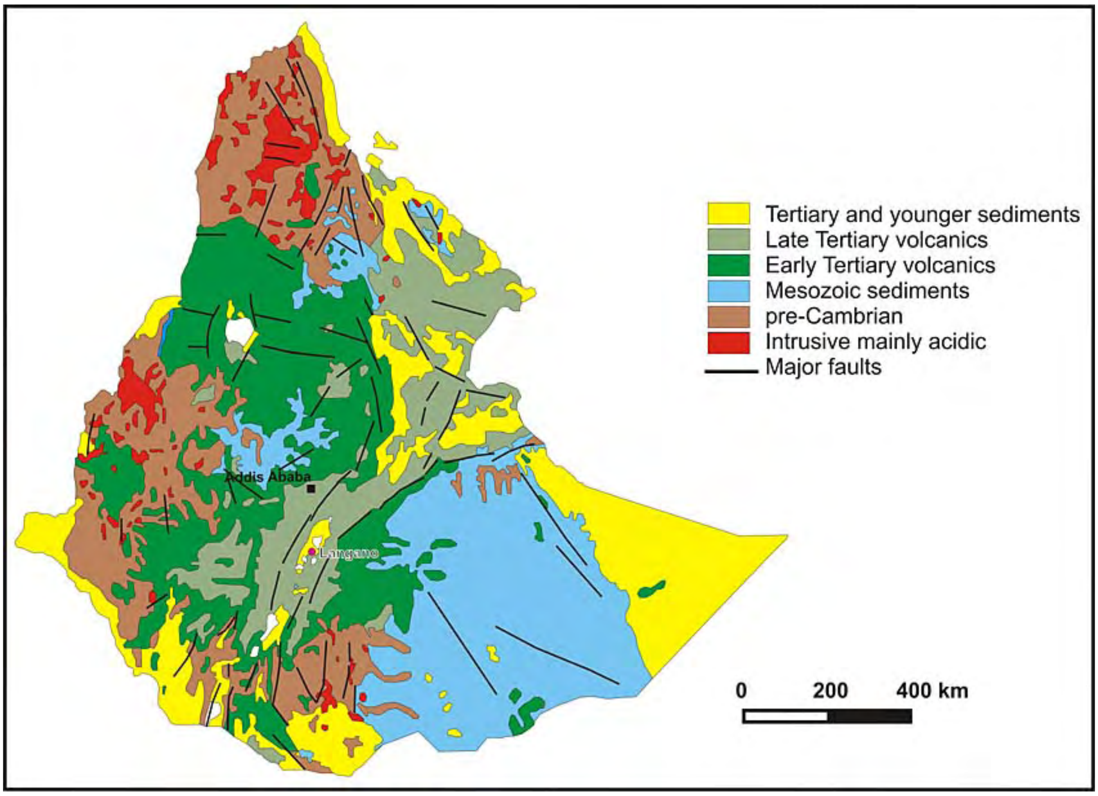
5.4.7 Fantale geothermal prospect area

The Fantale geothermal prospect is characterized by felsic lava extrusions in the caldera floor and widespread fumarolic activity, suggesting the existence of a shallow magma chamber. Active tensional tectonics form fissures up to 2m wide near the volcanic complex. Ground water discharge to the system is assured by the proximity of the area to the western escarpment. The results of an integrated interpretation of previous data suggest that the area is potentially prospective for future detailed geothermal resource investigation. Therefore, due to the presence of an impervious cap rock, the western part of the prospect, in particular, deserves to be investigated through a more detailed geothermal exploration programme. To this end, the Geological Survey is carrying out detailed geological, geochemical and geophysical investigations in order to delineate and select target areas for deep exploration wells.

The evaluation sheet for the Fantale geothermal field is shown in Annex-2-7.

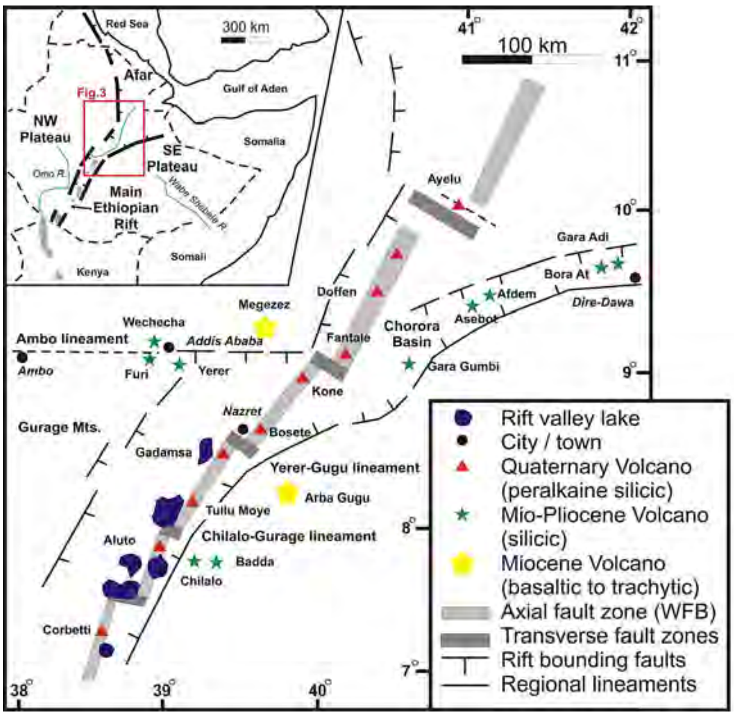
5.4.8 Prospects at reconnaissance level (Wendogenet, Nazreth, Meteka, Teo, Danab, Damali, Boina and .Dallol areas)

During the 1980s, reconnaissance geological, geochemical and geophysical investigations were conducted in these areas and revealed the existence of young volcanic features and active surface thermal manifestations. Meteka and Teo hold promise for the discovery of economically exploitable geothermal resources at high temperatures and warrant detailed surface investigation followed by exploratory drilling. Detailed exploration studies will be conducted in the near future to test the presence of economically exploitable geothermal resources in these fields.



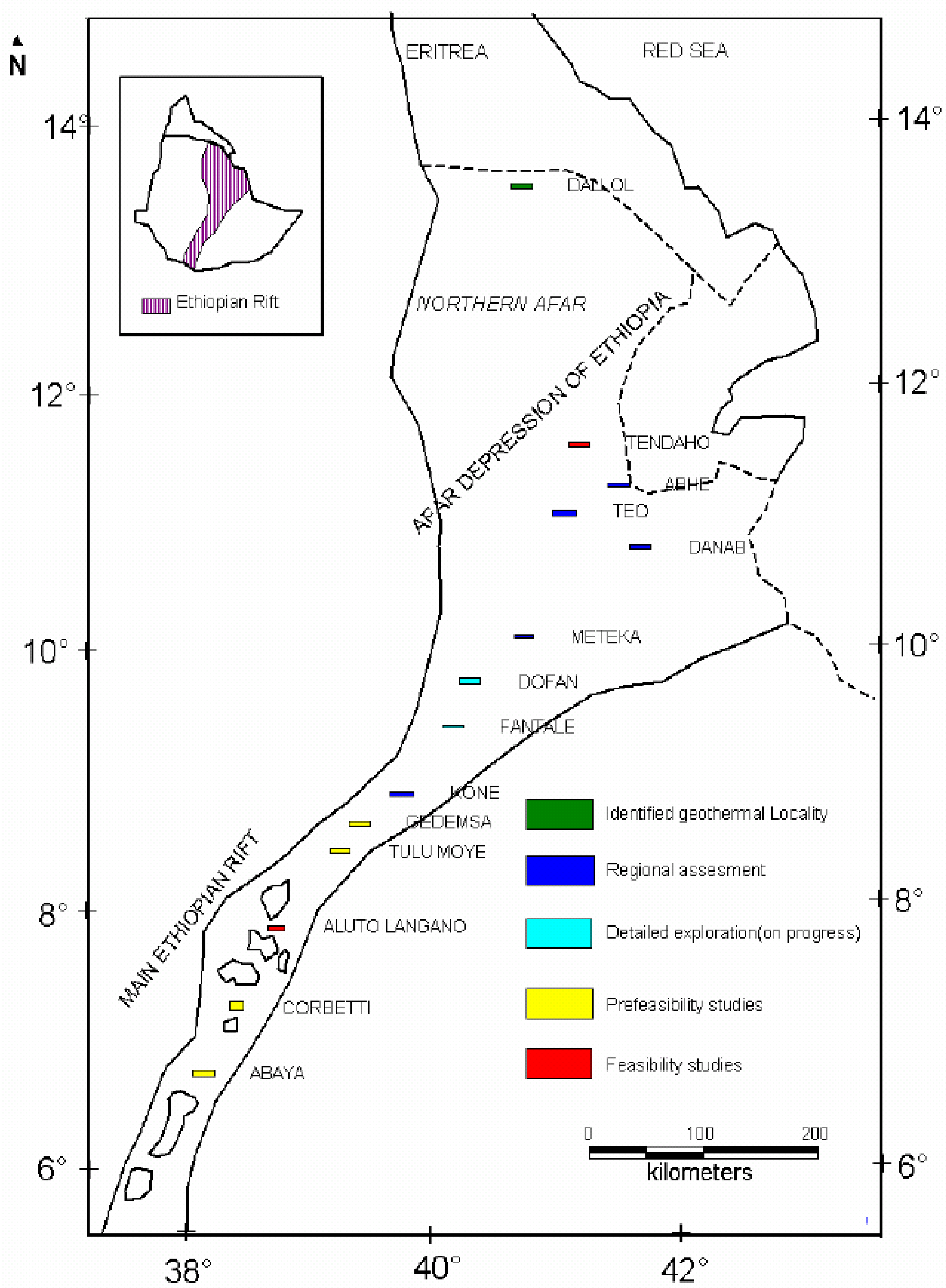
(Source) Geological Survey of Ethiopia

Fig.-5.4-1 Geologic Map of Ethiopia



(Source) Geological Survey of Ethiopia

Fig.-5.4-2 Regional Geological Structure in Ethiopian Rift Valley



(Source) (Teklemariam, 2007)

Fig.-5.4-3 Location of Geothermal Prospect areas in Ethiopia

5.5 Technical Capacity

5.5.1 Ministry of Mines and Energy (MME)

The Ministry of Mines and Energy is responsible for geothermal development in Ethiopia through the Geological Survey of Ethiopia (GSE) headed by its Director-General. There are no staff at the Ministry dealing specifically with geothermal activities.

5.5.2 Geological Survey of Ethiopia (GSE)

GSE has been involved with geothermal exploration since the work started with reconnaissance surveys in the Ethiopian Rift Valley between 1969 and 1973 funded by UNDP. It is currently responsible for all the scientific exploration work, including the drilling and testing of wells. EEPCO then takes over the power station construction and operation. This is the model used for the development of the Aluto- Langano and Tendaho fields.

Table-5.5-1 shows the staff currently working at the GSE and Table-5.5-2 indicates the equipment available, which includes a well-established geochemical laboratory and two deep drilling rigs. GSE also has a small rig which can be used to drill for groundwater for use in drilling and for other operational purposes. With the exception of Kenya, GSE has the most qualified and well-trained staff. At the peak of its operations, GSE staff were capable of carrying out detailed surveys and drilling and testing of the wells. Unfortunately, GSE has also been losing a large number of its trained staff because the development of geothermal in Ethiopia has not moved ahead in tandem with the training.

Table-5.5-1 Available skilled professional manpower in Ethiopia

	MME	GSE	EEPCO	Total
Geologist	0	2		**2**
Geochemist		4		**4**
Geophysicist		4		**4**
Reservoir Engineer		3		**3**
Drilling Engineer		2		**2**
Power Engineer		0	4	**4**
Environmental Scientist		0	0	**0**
Financial Planner/Modeller		0	1	**1**
GIS Scientist		2	0	**2**
Drillers		24		**24**
Technicians		12	14	**26**
Total	**0**	**53**	**19**	**72**

(Source) Study Team

Table-5.5-2 Available equipment in Ethiopia

Equipment Description	Available	Equipment Description	Available	Equipment Description	Available	Equipment Description	Available
Geological		**Geochemical**		**Geophysical**		**Drilling**	
Simple GPS	3	Simple GPS	1	Differential GPS	0	Complete Rig	2
Digital Thermometer	0	Digital Thermometer	1	Simple GPS	0	Water supply system(pumps, pipelines, tanks)	1
Fluid Inclusion Heating-freezing stage	0	pH meter	1	TEM	0	Site preparation equipment (dozer, grader, tipper trucks)	0
Binocular Microscope	2	Conductivity Meter	1	MT	0	Small water Rig	1
Petrographic Microscope	3	Water Sampling Kit	1	Gravimeter	1	**General**	
X-Ray Diffractometer	1	Gas Sampling Kit	70	Magnetometer	1	4x4 field vehicles	40
X-Ray Flourescence	1	AAS	1	Portable seismometer	0	GIS System	
ICP-MS	0	Ion Chromatograph (IC)	1	**Reservoir Engineering**		Total station	
Thin sectioning equipment	1	Gas Chromatograph	1	Kuster gauge Tools set	0	Completer weather station	0
		Mass Spectrometer for stable Isotope	0	Kuster TPS with SRO	0		
		Tritium Scintillation counter & C14 analyser	0	Logging Winch	0		
		UV-SP	0	Logging Truck (K10)	0		
				Discharge Silencer	0		

(Source) Study Team

5.5.3 The Ethiopian Electric Power Corporation (EEPCO)

EEPCO is wholly owned by the Government of Ethiopia and is responsible for power generation, transmission and distribution. However, the power sector has been liberalized, allowing independent power generators to get into the regulated power sector. EEPCO currently owns and operates the Aluto-Langano geothermal binary plant, which was originally producing 7.3 MW, but is currently only producing about 4 MW due to plant and well problems. A staff of eighteen (18) operates and maintains the plant. EEPCO’s experience in operating and maintaining geothermal power plants is therefore limited to Aluto Langano, which has operated very poorly so far because of problems which started one year after commissioning. However, the need to train engineers and technicians will increase with an increase in generation capacity.

5.5.4 Independent Power Providers (IPPs)

So far, although the power sector in Ethiopia is liberalized and a regulator is operational, there is to date no IPP licenced to generate power.

5.5.5 Local Consultants

There is no major company that provides geothermal consultancy, but the following individuals (Table 7.19) are available for consultation:

Table-5.5-3 Individual consultants in Ethiopia

Name	Profession	Areas of Expertise
Getahun Demissie	Geologist	Exploration management and policy, legislation and negotiations
Molla Belaineh	Geologist	Exploration management
Teshome Abera	Drilling	Drilling management

	Engineer	
Negussie Mekuria	Geochemist	Exploration Geochemistry
Abebe Ayele	Geophysicist	Exploration Geophysics
Meseret Teklamariam	Geochemist	Exploration management
Markos Melaku	Reservoir Engineer	Steam field operations

(Source) Study Team

5.5.6 Other facilities

It was noted that the University of Addis Ababa has stable isotope equipment, but it is not working and cannot be repaired.

5.6 Energy Policy

The Ethiopian government has established a National Energy Policy, according to which they will plan energy resource development while aiming to improve the quality of life of Ethiopian people and enhance industry. At the same time, they also aim to develop an energy sector which will be able to provide a sufficient amount of energy, while retaining such features as high reliability, environmentally friendliness, and superior efficiency that limits the commitment of foreign exchange reserves. The development strategy makes hydropower the highest priority in Ethiopia, followed in importance by the policy of shifting from traditional biomass to modern energy. Other high-priority goals are to promote energy conservation and efficiency, to promote capacity building for the energy sector and to promote participation of the private sector in energy development.

In order to promote private investment in energy development, including in renewable energy, the government has established an investment licensing system. In accordance with the Declaration of investment No.280/2002, No. 375/2003 and their amendments, developers to whom licenses are issued are granted ① import duty exemption for certain goods, ② permits for land acquisition , ③ permits to access the project location, and ④ permits to carry out Feasibility Studies. The licenses pertaining to this investment law are of two types, namely investment licenses and operation licenses. Licensees envisaged by this law include individuals, corporations, public companies and foreign companies. Up to the present, 4 solar, 28 hydro , 5 wind power, 1 geothermal, 1 solar, 1 methane gas, 2 internal combustion, and 2 other projects for a total of 44 projects have been approved. The licensees are 5 individuals, 1 overseas company, 3 joint entities, EEPCO (with 29 licenses) and 6 private companies. Among these licensed projects, 35 have been completed to an operational stage, 9 have been suspended and 1 has been abandoned.

As part of the development of indigenous energy resources including renewable energy, the government has been studying the adoption of a Feed-in Tariff program(fixed-price buyback program) in the hope of attracting private investment into energy development. According to the third draft of the program issued in October 2009, in order to promote domestic energy resources (hydro, biomass, wind, geothermal, bagasse, coal, oil shale, and natural gas), projects facilitating that indigenous energy development and having a private investment component of more than 50% are entitled to a fixed-price buy-back program for electricity generated by the project.

The cumulative amount of power generation eligible for this program is limited to 300MW for the country. A purchase price plan has been prepared, varying according to the size of each type of generation facility and the type of energy. For example, hydropower generation facilities are divided into 6 categories, and in each size range there is a further division into guaranteed output or non-guaranteed output. In principle, transmission facilities to the point of connection to the grid under the Feed-in Tariff program are the responsibility of the power producer.

Table 5.6-1 Feed-in Tariff proposal for hydroelectric power in Ethiopia

Plant size	Guaranteed output US ¢ /kWh	Non-guaranteed output US ¢ /kWh	Program term	Remarks
100kW – 500kW	8	6	20 years	Substation provided within 5 km
100kW – 2.5MW	7.5	5.5	ditto	-
2.5MW – 5MW	7	5	ditto	-
5MW – 10MW	6.5	4.5	ditto	-
10MW – 25MW	6	4	ditto	-
25MW – 40MW	5.5	3.5	ditto	-

（Source）EEA, MOME(2009)

Table 5.6-2 Feed-in Tariff proposal for Biomass electric power in Ethiopia

Plant size	Guaranteed output US ¢ /kWh	Non-guaranteed output US ¢ /kWh	Program term	Remarks
＜500kW	10	8	15 years	Biomass content>= 70%
500kW – 2.5MW	9.5	7.5	ditto	ditto
2.5MW – 5MW	9	7	ditto	ditto
5MW – 10MW	8.5	6.5	ditto	ditto
10MW – 25MW	8	6	ditto	ditto
25MW – 40MW	7.5	5.5	ditto	ditto

（Source）EEA, MOME(2009)

Table 5.6-3 Feed-in Tariff proposal for wind-generated electric power in Ethiopia

Plant size	Wind speed<7.5m/s US ¢ /kWh	wind speed >=7.5m/s US ¢ /kWh	Program term	Remarks

200KW - 500kW	10	9	15 years	Substation provided within 5 km
500kW – 2.5MW	9	8	ditto	ditto
2.5MW – 5MW	8	7	ditto	ditto
5MW – 10MW	7	6	ditto	ditto
10MW – 25MW	6	5	ditto	ditto
25MW – 40MW	5	4	ditto	ditto

（Source） EEA, MOME(2009)

Table 5.6-4 Feed-in Tariff proposal for geothermal electric power in Ethiopia

Plant size	Guaranteed output US ¢ /kWh	Non-guaranteed output US ¢ /kWh	Program term	Remarks
500kW – 2.5MW	10	8	20 years	
2.5MW – 5MW	9.5	7.5	ditto	
5MW – 10MW	9	7	ditto	
10MW – 25MW	8.5	6.5	ditto	
25MW – 40MW	8	6	ditto	

（Source） EEA, MOME(2009)

Table 5.6-5 Feed-in Tariff proposal for Bagasse electric power in Ethiopia

Plant size	Guaranteed output US ¢ /kWh	Program term	Remarks
100kW – 500kW	10	15 years	-
500kW – 2.5MW	9	ditto	-
2.5MW – 10MW	8	ditto	-
10MW – 15MW	7	ditto	-
15MW – 25MW	6	ditto	-
25MW – 40MW	5	ditto	-
40MW – 50MW	4	ditto	-

（Source） EEA, MOME(2009)

Table 5.6-6 Feed-in Tariff proposal for coal, oil shale and natural gas electric power in Ethiopia

Plant size	Guaranteed output US ¢ /kWh	Program term	Remarks
500kW – 5MW	6	15 years	
5MW – 10MW	5	Ditto	
10MW – 40MW	4	Ditto	

（Source） EEA, MOME(2009)

In recent years, EEPCO has successfully developed a series of large hydroelectric power projects, which has boosted their experience and confidence in conducting large scale power development programs. Their interest is not limited just to mainstream hydro projects but also includes geothermal, wind, international power trading and the fiber-optic telecommunications business utilizing OPGW lines.

5.7 Environmental Policies

Environmental and social considerations under the Federal Environmental Protection Authority (EPA) cover physical, biological, and social aspects. Therefore, EIA covers social considerations including the resettlement issue. The opening of the EIA report to the public and receipt of comments from the public are not conducted.

There are sectoral EIA guidelines and relevant standards as shown in the following tables. However, there is no environmental guideline on geothermal development.

Table-5.7-1 Relevant Environmental Legislations and Standards in Ethiopia

No.	Name of Legislations and Standards
1	Environmental Policy of Ethiopia (Issued year is not known)
2	Regulation No. 159, Council of Ministers Regulation to Provide for the Prevention of Industrial Pollution
3	Proclamation No. 295-2002, Proclamation Provided for the Establishment of Environmental Protection Organs
4	Proclamation No. 299-2002, Environmental Impact Assessment Proclamation
5	Proclamation No. 300-2002, Environmental Pollution Control Proclamation
6	Proclamation No. 513-2007, Solid Waste Management Proclamation
7	Council of Ministers Regulations to Provide for Wildlife Development, Conservation and Utilization (Council of Ministers Regulations No. 163/2008), 2008

(Source) EPA and EWCA

Table-5.7-2 Sectoral EIA Guidelines in Ethiopia

No.	Name of Guidelines
1	Environmental And Social Impact Assessment Guidelines for Dams and Reservoirs, EPA, 2004
2	Environmental Impact Assessment Guideline on Crop production, EPA, 2004
3	Environmental Impact Assessment Guideline on Pesticides, EPA, 2004
4	Environmental Impact Assessment Guideline on Fisheries, EPA, 2004
5	Environmental Impact Assessment Guideline on Forestry, EPA, 2004
6	Integrated Environmental And Social Impact Assessment Guidelines on Hydropower Production, Transportation And Distribution, EPA, 2004
7	Environmental Impact Assessment Guideline on Fertilizer, EPA, 2004
8	Environmental Impact Assessment Guideline on Irrigation, EPA, 2004
9	Integrated Environmental And Social Impact Assessment Guidelines Livestock And Rangeland Management, EPA, 2004
10	Environmental Impact Assessment Guideline on Road and Railways, EPA, 2004
11	Integrated Environmental And Social Impact Assessment Guidelines on Water Supply, EPA, 2004

(Source) EPA

Table-5.7-3 Environmental Guidelines in Ethiopia

No.	Name of Guidelines
1	Technical Guidelines on the Environmentally Sound Management of Biomedical and Healthcare Wastes, EPA, 2004
2	Guidelines on Composting, EPA, 2004
3	Guidelines to Prepare Environmental and Social Management Plan, EPA, 2004
4	Guideline Ambient Environmental Standards for Ethiopia, EPA, 2004
5	Environmental Assessment Reporting Guide, EPA, 2004
6	Check lists for major key projects, EPA, 2004
7	Environmental and Social Management Framework for Productive Safety Net Programme, EPA, 2004
8	Guidelines On Soil Conservation On Cultivated Land, EPA, 2004
9	Technical Guidelines On Households Waste Management, EPA, 2004

(Source) EPA

In environmental and social considerations for development project, both socio-economic boundary and biological boundary are considered. Since high priority is put on the consultation with project-affected community in the development project, consultation is conducted mainly by local government in all of the project stages.

In the case where EEPCO is project proponent, EIA is conducted by internal or external resources of EEPCO. After the EIA report is reviewed by the Ministry of Mines and Energy, the EIA report is submitted from the Ministry of Mines and Energy to EPA. Period of EIA approval is within 15 days after receipt of the EIA report by EPA.

Though there was a case that EIA approval was rejected after the review process, EIA approval has been issued with conditions in general due to necessity of the development project. According to EPA, a coal development project was rejected since the project is located in an important area for biodiversity conservation.

On the other, environmental protected areas such as national park and forest protected area are under jurisdiction of the Ministry of Culture and Tourism. Wildlife Protected Areas in Ethiopia have four categories; National Park, Wildlife Sanctuary, Wildlife Reserve, and Controlled Game Area. Implementation of the development project in the protected area requires EIA approval.

Ethiopian Wildlife Conservation Authority (EWCA) under the Ministry of Culture and Tourism makes comments on the development project located in the protected area, parallel to the EIA process. As long as adequate measures are confirmed even in the case where some impacts are expected due to the development project, implementation of the project is not always rejected. Relevant information on the protected areas are shown in the Web site of EWCA.

5.8 Direct Utilization of Geothermal Energy

As an example of direct utilization of the geothermal energy in Ethiopia, it is mainly bathing swimming facility using geothermal energy, mainly in Addis Ababa, including the Sheraton, Filowh, Ghion, and Hilton hotels, the National Palace, Greek Community, and St. Joseph School (Lund et al (2010)). On the other, surplus hot water from the geothermal power plant has not been conducted yet.

Chapter 6 Djibouti

6.1 County Outline[1]

Though it is a small country of 830,000 people (WDI 2009), Djibouti occupies a geopolitically strategic position at the entrance to the Gulf of Aden dominating the main shipping route between Europe and Asia through the Suez Canal, and providing a key link between the African continent and West Asia and beyond. The government is relatively well-established and is a factor for stability in the Horn of Africa. The French army and the U.S. military are stationed in Djibouti to ensure the stability of the region and carry out counter-terrorism operations. Moreover, the Self Defense Forces of Japan and other members of the international community based in Djibouti are grappling with the Somali coast piracy problem, and an EU maritime force is also based in Djibouti.

After Djibouti achieved independence from France in 1977, there was much conflict occurring against a background of tribal confrontation, and repeated efforts were made towards national reconciliation. In 1991, civil war broke out between the government forces and the insurgent forces of FRUD (the Front for the Restoration of Unity and Democracy), but in 1994 the government and FRUD signed a peace agreement, bringing an end to over three years of civil war. In 1997, in the first elections to the national assembly following the peace agreement, the ruling coalition of the Rassemblement Populaire pour le Progrès (RPP) and FRUD won all the seats, and a new government was inaugurated. In the 1999 Presidential election following the resignation of President Goured, his replacement, Ismail Omar Guelleh, the administration's Chief Cabinet Secretary, defeated the opposition candidate and won the Presidency. In 2000, the new government and FRUD concluded a Peace Framework Agreement, and in 2001 final terms of peace were agreed. In the general election of January 2003, the ruling alliance won all of the seats in Parliament, and in the April 2005 Presidential election following the expiry of his first term, Guelleh was re-elected as President. In addition, the ruling party won a landslide victory in the local elections of March 2006.

The land of Djibouti is mostly desert, and agriculture remains undeveloped. Since it is also poor in mineral resources, the service sector, which accounts for 80% of GDP is the heart of industry, and the country relies on income from the rail transport of exports to Ethiopia, entrepôt trade, the provision of port services, services associated with the French and U.S. military bases, and foreign assistance. Djibouti is one of the gateways to Africa for the Arab nations, and investment has been increasing in recent years. A number of infrastructure projects, such as the container terminal at Doraleh (which opened for business in February 2009), have been completed or are in the execution or planning stages.

[1] Source: International Cooperation Bureau, Ministry of Foreign Affairs, Japan: Official Development Assistance (ODA) countries data book 2009

On the development front, the May 2004 Poverty Reduction Strategy Paper (PRSP) proposed a program resting on the four pillars of economic growth (improvement of the legal framework to encourage investment and the stability of the domestic economy, etc.), human resource development (education, insurance, social security), regional development (improvement of basic infrastructure, environmentally aware conservation of resources) and strengthening of governance (strengthening of public financial management, promotion of local devolution, capacity building).

6.2 Energy Resources

Prospective fossil fuel resources such as oil, natural gas, and coal are not found in Djibouti. Therefore, it relies on imports for all its energy needs, and the value of these imports is estimated to be more than USD 200million per year[2]. The port of Djibouti is an important oil terminal with extensive storage facilities. Moreover, the majority of the countryside of Djibouti is barren and agriculture is undeveloped. Therefore, there is little in the way of agricultural waste and biomass resources, etc that could be developed. Djibouti is an arid zone with few rivers, and there are thus few hydropower resources, as well.

It is thought that there is a geothermal resource potential of 50MW-150MW around Lake Asal and other locations. Though air stream investigations confirming a sufficient wind resource have not been carried out, it is said to be promising in five places (Ghoubet, Ali Sabiah, Djibouti Ville, Egralyta and Bada Wein) (World Bank, 2009). Wind power could be important in Djibouti, where other energy resources are scarce. The potential of solar energy has not yet been adequately evaluated.

6.3 Electric Power Situation

6.3.1 Electric Power Sector

Djibouti is characterized by its lack of fossil resources (oil and gas) and hydroelectric potential. The country therefore currently has a strong dependency on imported oil products - mostly imported from nearby Saudi Arabia and Dubai – which leads to a high cost of energy. Djibouti currently has installed electricity generating capacity of 137MW, all of which is thermal (diesel or gas/oil). In January 2001, U.S.-based Geothermal Development Associates (GDA) announced that it had completed a feasibility study on the development of a 30MW geothermal power plant in Djibouti. The study, which commenced in August 2000, established the commercial viability of the proposed generating facility, to be located in the Lake Asal region west of the capital. It was proposed that the plant be constructed under a build-own-operate (BOO) financing scheme. However, the project has not been implemented.

6.3.2 Power Sector Policy

Djibouti National Electricity Policy is not articulated in a single document, but different aspects of

[2] This number is estimated from oil import of 8,470 barrel per day and the average oil price of 72.3 USD/barrel in 2007.

government policy concerning the sector are covered in different policy documents, including the power master plan. During the Study Team's visit in April 2010, the Ministry indicated that the Government is committed to the expansion of energy services to facilitate economic growth through investment in such areas as infrastructure, mining and minerals processing, as well as through investment in economic activities that promote social well-being, such as education, health care, and the provision of access to clean water, among others.

6.3.3 Legal Framework

According to the U.S. State Department's 2010 Investment Climate Statement, Djibouti does not have laws that would discourage incoming foreign investment. In principle there is no screening of investment or other discriminatory mechanisms. Certain sectors, however, most notably public utilities, are state-owned and are not currently open to investors. Djiboutian laws guarantee the right of foreign and domestic private entities to establish and own business enterprises, and to engage in all forms of remunerative activity. Legally established private-sector companies have the same access to markets, land ownership, credit, and other business facilities as do public enterprises. Although restrictions on private enterprises are minimal, competitive equality with public enterprises, namely public utilities, remains limited.

The Electric law provides for the operation of the state electricity utility, Electricité de Djibouti, a vertically integrated utility responsible for generation, transmission and distribution. Although there are no Independent Power Providers (IPPs) in the power sector, the law does not prevent their participation in power generation. The Ministry of Energy and Natural Resources regulates the power sector.

6.3.4 Investment Incentives

The U.S. State Department's 2010 Investment Climate Statement for Djibouti (the most recent annual report on the country) noted that "the Government of Djibouti recognizes the crucial need for foreign investment for the economic development of the country. Djibouti's assets include a strategic geographic location, an open trade regime, a stable currency, substantial tax breaks, and other incentives." It also notes that "Djibouti offers significant incentives to private-sector individuals and corporate investors, but obstacles to foreign investment include a small domestic market, and high labor and energy costs."

Djibouti's National Investment Promotion Agency (NIPA), created in 2001, promotes private-sector investment, facilitates investment operations, and works to modernize the country's regulatory framework. NIPA has been mandated to encourage and facilitate foreign investment by assisting with all administrative procedures. Its ultimate goal is to serve as a one-stop shop for investors. NIPA identifies fishing, banking, insurance, tourism, health, and manufacturing as priority sectors for investment. In July 2008, the government of Djibouti named a Minister of Investment Promotion, a new cabinet level position. The Minister of Investment Promotion oversees NIPA.

Djibouti has no foreign exchange restrictions. There are no limitations on converting or transferring funds, or on the inflow and outflow of cash. The Djibouti franc, which has been pegged to the U.S. dollar since 1949, is stable. The fixed exchange rate is 177.71 Djibouti francs to the dollar.

Djibouti's Investment Code stipulates that "no partial or total, temporary or permanent expropriation will take place without equitable compensation for the damages suffered". Given the government policy of promoting private investment, no expropriations are expected. In December 2007, Djibouti and France signed a bilateral agreement regarding bilateral promotion and protection of investment, which, inter alia, extends legal protections to French investments in Djibouti.

Performance requirements are not a pre-condition for establishing, maintaining, or expanding foreign direct investment. Incentives do, however, increase with the size of the investment and the number of jobs created. Tax benefits and incentives fall under two categories detailed in the investment code. Investments greater than USD 280,000 which create a number of permanent jobs may be exempted from license and registration fees, property taxes, taxes on industrial and commercial profits, and taxes on the profits of corporate entities. Imported raw materials used in manufacturing are exempted from the internal consumption tax. These exemptions apply for up to a maximum of ten years after production commences. Investment matters fall under the jurisdiction of the national investment board, which approves all investments.

Djibouti offers significant incentives to private-sector individuals and corporate investors. One U.S. firm that recently established a branch in the Free Zone hailed the speed and efficiency of the process. Establishing a local company outside the Free Zone is, reportedly, significantly more time-consuming. The Djiboutian investment code guarantees investors the right to freely import all goods, equipment, products, or material necessary for their investments; to display products and services; to determine and run marketing policy and production; to choose customers and suppliers; and to set prices. Foreign investors are also free to determine their own hiring and firing policy as long as it remains within the structure of the labor code.

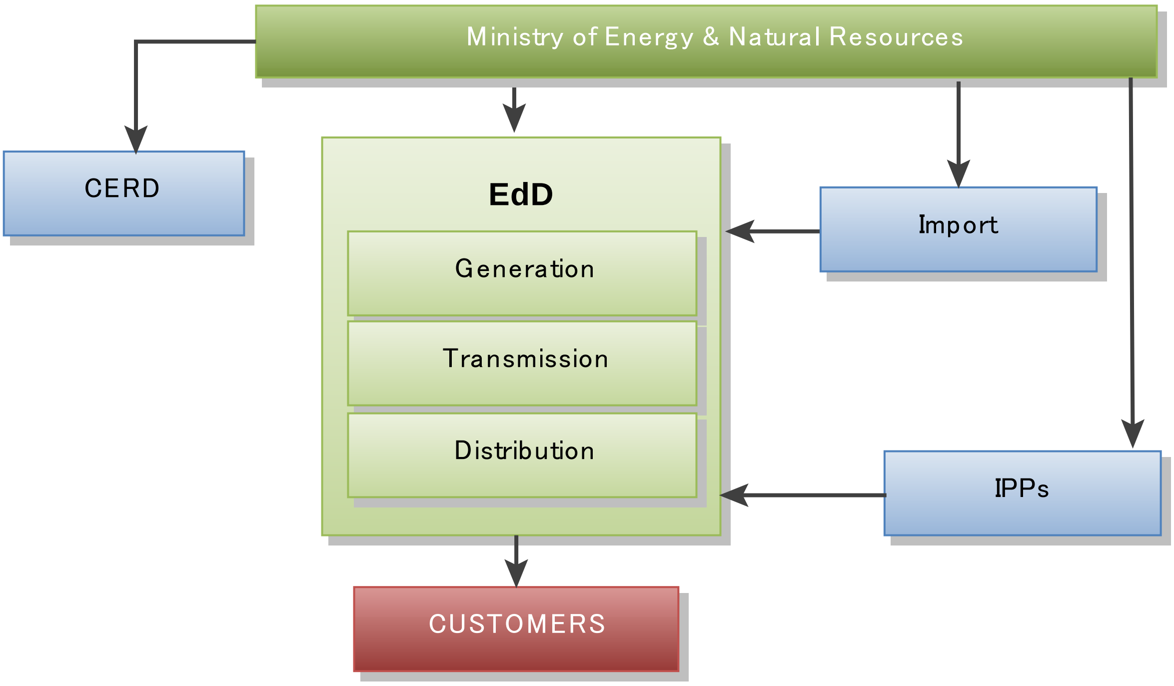
6.3.5 Institutional Framework

The state-owned Electricité de Djibouti (EdD) is the national electric company, responsible for generation, transmission and distribution of electricity, and reporting to the Ministry of Energy and Natural Resources. Other stakeholders in the sector include the Centre d'Etudes et de Recherche (CERD) and power exporters (EEPCO).

As observed above, Djibouti has no institution devoted exclusively to the promotion and development of geothermal resources for power generation.

6.3.6 Regulatory Framework

The electricity sub-sector of Djibouti has no appointed regulator. EdD, the main national electricity company, reports to the Ministry of Energy and Natural Resources. The Ministry carries out all regulation of the sector.



(Source) Study Team

Fig.-6.3-1 Power Sector in Djibouti

6.3.7 Energy Pricing

The pricing policy consists of full cost-recovery tariffs for electricity services at the retail level and Power Purchase Agreements (PPA) for power producers selling in bulk to EdD that are based on cost-reflective tariffs and a fair return on investment.

6.3.8 Financing Framework

The power development implemented by EdD has been largely financed through public funding from the Government and development partners. New power projects, such as the development of geothermal, are likely to include private investment in their financing frameworks.

6.3.9 Existing Generation Capacity

The interconnected system currently has an installed capacity of 122.6MW, comprising diesel-fired generation plants mainly from two stations named Boulaos and Marabout. Other small units include four small diesel-fueled generating stations, with a combined capacity of 7.3MW that serve the southern and northern region. Two small diesel plants with a combined nominal installed capacity of 3.3MW serve the Southern region, while the 2.2MW Tadjoura plant and the 1.8MW Obock plant serve the northern region. Table-6.3-1 below shows the main generation facilities (2 plants).

Table-6.3-1 Boulaos and Marabout Diesel Plant Details

Plant	Type	Installed Capacity (MW)	Effective Capacity (MW)	Fuel
Boulaos				
G11	Medium Speed Diesel	6.5	4	HFO
G12	Medium Speed Diesel	6.5	6.5	HFO
G13	Medium Speed Diesel	4.5	4.5	HFO
G14	Medium Speed Diesel	4.5	4.5	HFO
G15	Medium Speed Diesel	4.5	4.5	HFO
G16	Medium Speed Diesel	4.5	4.5	HFO
G17	Medium Speed Diesel	6.5	6.5	HFO
G18	Medium Speed Diesel	6.5	6.5	HFO
G21	Medium Speed Diesel	13.4	10	HFO
G22	Medium Speed Diesel	15	15	HFO
G23	Medium Speed Diesel	6.5	6.5	HFO
G24	Medium Speed Diesel	6.5	4.5	HFO
G25	Medium Speed Diesel	13.4	13.4	HFO
G31	Medium Speed Diesel	4.7	4.7	HFO
G32	Medium Speed Diesel	4.7	4.7	
Total		108.2	100.3	
Marabout				
M1	Medium Speed Diesel	2.4	2.4	Gas oil
M2	Medium Speed Diesel	2.4	2.4	Gas oil
M3	Medium Speed Diesel	2.4	2.4	Gas oil
M4	Medium Speed Diesel	2.4	2.4	Gas oil
M5	Medium Speed Diesel	2.4	2.4	Gas oil
M6	Medium Speed Diesel	2.4	2.4	Gas oil
Total		14.4	14.4	
Grand Total		122.6	114.7	

(Source) Study Team compiled from EdD data

6.3.10 Transmission and Distribution System

The transmission system in Djibouti is currently limited to a 63kV inter-connector between the main substations of Marabout and Boulaos and two 20kV transmission circuits from Djibouti town to the village of Arta, some 40km away. There is also a 20kV circuit between Dikhil and Ali Sabieh in the south of the country.

The distribution system comprises 20kV radial circuits emanating from the main substations. Most customers are supplied at low voltage (LV) via distribution substations.

Whereas technical system losses are reasonable at about 12%, the non-technical losses, at about 15%, are excessive and need to be reduced to less than 1%. See the losses from 2005 to 2008 in Table-6.3-2 below.

Table-6.3-2 System Losses in the Djibouti Power System

Year		2005	2006	2007	2008
Energy delivered	GWh	286,364	294,927	308,795	313,381
Technical Losses	GWh	32,159	34,536	37,241	37,762
Percent of Energy delivered		11.23%	11.71%	12.06%	12.05%
Non-Technical Losses	GWh	42,296	42,145	33,782	46,850
Percent of Energy delivered		14.77%	14.29%	10.94%	14.95%
Total Losses	GWh	74,455	76,681	71,023	84,612
Percent of Energy delivered		26.00%	26.00%	23.00%	27.00%

(Source) Study Team compiled from EdD data

6.3.11 Existing Customers

The customer base has registered moderate growth over the last 10 years, as evidenced by Table-6.3-3 showing unit sales and the number of customers.

Table-6.3-3 Unit Sales and Customer Data

Category	Social	Domestic	LV Djibouti	Public Lighting	Temporary supplies	MV Djibouti	LV Interior Districts	MV Interior Districts	Total
Sales									
	GWh	GWh	GWh	GWh	GWh	GWh	GWh	GWh	
1996	20.1	46.3	31.5	2.6	1.1	57.4	5.3	1.3	165.6
1997	20.1	52.4	30.2	2.4	0.9	56.6	4.9	1.3	168.9
1998	12.7	32.5	24.2	1.2	1.3	45.0	5.0	1.1	123.0
1999	17.2	40.3	32.8	1.8	0.6	47.5	4.4	1.2	145.8
2000	18.6	51.6	40.9	1.8	0.9	58.8	4.8	1.1	178.5
2001	15.8	62.0	40.1	1.4	0.7	70.0	4.9	1.2	196.1
2002	18.8	62.7	43.0	2.0	0.7	66.1	4.8	1.5	199.7
2003	19.0	63.7	46.9	2.0	0.9	74.3	6.3	1.7	214.8
2004	20.2	63.9	44.4	2.4	1.1	83.0	5.8	4.5	225.1
2005	20.4	63.2	50.3	2.3	1.3	83.3	6.6	0.8	228.2
2006	21.3	64.1	50.3	2.2	1.2	92.5	6.7	0.9	239.2
2007	22.4	68.4	51.3	2.7	3.7	96.9	7.2	2.1	254.7
2008	25.0	69.1	63.0	2.7	2.3	80.5	7.3	1.8	251.8
Number of Customers									

1996	11,562	8,335	3,049	168	86	665	2,215	58	26,138
1997	12,580	9,875	3,113	168	87	114	2,366	10	28,313
1998	12,347	8,377	3,089	168	81	109	2,371	10	26,552
1999	12,997	9,501	3,183	169	76	107	2,362	10	28,405
2000	12,083	11,628	3,234	169	82	108	2,315	9	29,628
2001	12,462	11,933	3,247	169	71	110	2,344	9	30,345
Sales									
	GWh	GWh	GWh	GWh	GWh	GWh	GWh	GWh	
2002	13,254	11,950	3,316	169	74	110	2,424	11	31,308
2003	13,964	12,004	3,413	173	63	109	2,542	11	32,279
2004	14,876	11,928	3,276	174	64	123	2,507	12	32,960
2005	15,115	12,206	3,477	175	76	114	2,869	10	34,042
2006	16,034	13,049	3,668	177	94	111	3,043	10	36,186
2007	16,582	13,773	3,740	177	105	132	3,247	10	37,766
2008	17,222	14,191	3,957	187	111	136	3,430	12	39,246

(Source) Study Team compiled from EdD data

6.3.12 Electricity Tariffs

The retail electricity tariff rates are high, reflecting the high cost of the fuel used for power generation. Table-6.3-4 shows the retail tariffs from 1996 to 2008 for different customer categories.

Table-6.3-4 Electricity Prices for Different Customers 1996 to 2008

Categories		1996	2000	2004	2008
Social	US$/kWh	0.17	0.23	0.20	0.28
Domestic	US$/kWh	0.21	0.21	0.24	0.29
LV Djibouti	US$/kWh	0.84	0.97	1.35	0.39
Public Lighting	US$/kWh	0.21	0.21	0.26	0.33
Temporary supplies (construction etc)	US$/kWh	0.31	0.30	0.36	0.45
MV Djibouti	US$/kWh	0.21	0.21	0.23	0.36
LV Interior Districts	US$/kWh	0.24	0.24	0.20	0.33
MV Interior Districts	US$/kWh	0.30	0.31	0.21	0.42

Exchange rate DJF1= USD 173.64

(Source) Study Team compiled from EdD data

6.3.13 Electricity Demand Forecast

The demand forecast will depend on the pace of growth in the mining and mineral processing industry and on other commercial and industrial loads that may result from investment in those sectors in the coming years. The projected demand based on planning data available in 2009 is given in Table-6.3-5.

Table-6.3-5 Projected Electricity Demand

Year	Peak Demand MW	Generation sent out GWh
2008	56.9	325.6
2009	68.0	379.4
2010	74.5	420.8
2011	83.8	475.8
2012	99.7	572.7
2013	116.3	662.6
2014	128.2	726.8
2015	137.6	775.3
2016	148.6	832.6
2017	153.3	859.2
2018	158.1	886.3
2019	161.6	907.0
2020	165.2	928.1
2021	167.9	944.2
2022	170.6	960.9
2023	173.5	978.0
2024	176.4	995.6
2025	179.9	1,016.0
2026	183.4	1,036.1
2027	187.0	1,056.7
2028	190.8	1,077.9
2029	194.6	1,099.7
2030	198.5	1,122.1
2031	202.3	1,143.8
2032	206.2	1,166.1
2033	210.2	1,188.9
2034	214.3	1,212.3
2035	218.5	1,236.3

(Source) Study Team compiled from EdD data

6.3.14 Generation Expansion Plan

Djibouti has no hydropower sites, but it does show good potential for geothermal. A lot of preliminary exploration work has been carried out, but further up-front testing is needed, which will be expensive. Until a complete investigation of that resource has been undertaken, it is not possible to know the exact size of plant that could be supported, nor what the final investment costs will be. However, a Memorandum between the Government of Djibouti and the Icelandic Reykjavik Energy Invest Ltd

(REI) has recently been signed, paving the way for further drilling and laying out the tentative terms for an IPP arrangement, should exploitation prove to be possible and profitable.

Wind power offers promising short- and medium-term opportunities, as comprehensive wind data and feasibility work for one site in Arta is already available, while there is partial data and pre-feasibility work for about 10 other sites, some of them showing very good wind conditions.

Ongoing investment in the electric interconnection with Ethiopia (AfDB project) should fulfill a significant proportion of the demand for energy in the mid-term. Renewed momentum on the development of geothermal (with the support of ARGeo, IGA, Proparco and IFC among others) should fulfill demand in the longer term. The short-term remains highly uncertain. Djibouti's power generation expansion is therefore dominated by heavy fuel-oil-fired diesel power plants. The development plan is outlined in Table-6.3-6.

Table-6.3-6 Least Cost Power Development Plan (2009)

		Net Capacity added MW	Net Cumulative additional Capacity MW
2013	2xDiesel HFO 12MW	24	24
2014	1xDiesel HFO 7MW	7	31
2015	2xDiesel HFO 12MW	24	55
2019	1xDiesel HFO 7MW	7	62
2020	1xDiesel HFO 12MW	12	74
2022	1xDiesel HFO 12MW	12	86
2024	1xGT 7MW	7	93
2026	1xDiesel HFO 12MW	12	105
2029	1xDiesel HFO 7MW	7	112
2030	2xDiesel HFO 12MW	24	136
2031	1xDiesel HFO 12MW	12	148
2032	1xDiesel HFO 7MW	7	155
2033	1xDiesel HFO 7MW	7	162
2034	1xDiesel HFO 7MW	7	169
2034	1xGT 15MW	15	184

(Source) Study Team compiled from EdD data

6.3.15 Geothermal Energy in the Generation Expansion Plan

As mentioned above, geothermal energy is a promising electricity energy source for Djibouti. A sensitivity analysis of the potential role for geothermal power, undertaken under the Power Master Plan, indicated that the long-term development of the electricity system relying only on liquid fuel represented the most expensive alternative. Any development of geothermal that displaces energy otherwise generated by diesel plants is economically attractive. At the cost and performance parameters assumed for the master plan study, 60 MW of geothermal power generation would form part of the long-term least cost expansion plan for the system.

Energy imports displacing peak thermal generation complement geothermal generation as base load power. The master plan therefore considered a scenario in which the geothermal resources are assumed to be proven, allowing the development of three 20MW units of geothermal capacity that contribute, together with up to 700GWh of energy imports over the Ethiopia-Djibouti interconnector, to satisfying the growing power demand. For that scenario, a minimum of 25MW of diesel generation until 2016 was assumed, and it was assumed that the first geothermal plant would be commissioned in that year. From 2016, minimum MW generation was assumed to incorporate that geothermal plant capacity plus 15MW of diesel generation, as depicted in Table-6.3-7 below

Table-6.3-7 Likely Generation Expansion Plan with Geothermal and Power Imports from Ethiopia

.		Net Capacity added MW	Net Cumulative additional Capacity MW
2013	2xDiesel HFO 12MW	25	25
2016	1xGeothermal 20MW	20	45
2019	1xGeothermal 20MW	20	65
2022	1xGeothermal 20MW	20	85
2030	1xDiesel HFO 15MW	15	100

(Source) Study Team compiled from EdD data

6.3.16 Transmission Capacity Expansion

According to the Least Cost Electricity Master Plan, Djibouti (2009) an interconnector between Ethiopia and Djibouti is due to begin operation in 2011. At present there is a Power Purchase Agreement (PPA) between EEPCO and EdD governing the conditions of use for the soon-to-be-built interconnector. The fundamental basis of this PPA is that the supply will, in general, be from Ethiopia to Djibouti and that the supply will be in the form of energy only and have no capacity element. To this end the supply is based on four periods. These periods are shown below in Table-6.3-8.

Table-6.3-8 Availability of Interconnector Supply as per PPA

Season/Time of Day	Peak Period (18:30 to 21:30)	Off-Peak Period (21:30 to 18:30)
Wet (July 1 to Nov 7)	Supply available	Supply available
Dry (Nov 8 to June 30)	No contractual Supply	Supply available

(Source) Study Team compiled from EdD data

The power purchase agreement (PPA) currently states that the amount of energy that can be supplied by the interconnector on an annual basis is limited. The PPA estimates that energy available from the interconnector could range from between 180GWh per annum up to a maximum of approximately

300GWh per annum. Recent discussions between EdD and EEPCO, however, have indicated that the level of energy transfer available via the interconnector may potentially exceed 300GWh per annum. One of the numerous clauses within the PPA requires EdD to continue maintaining its existing power generation capacity and to carry on investing in new generating capacity such that EdD is able to cope with outages, unforeseen or planned, and/or with planned contract interruptions.

Table-6.3-9 Transmission Reinforcements

2015	2nd Marabout-Boulaos 63kV Cable Circuit
	2nd PK-12 63/20kV 40MVA Transformer
	2nd and 3rd Marabout 63/20kV 36MVA transformers
	3rd PK-12 230/63kV 63MVA Transformer
	3rd Boulaos 63/20kV 36MVA Transformer
	2nd PK-12 - Palmeraie OHL Double Circuit (AAAC Aster Conductor)
	2nd Palmeraie-Boulaos Cable Circuit (2 X 400 mm^2)
	2nd Palmeraie-Marabout Cable Circuit (2 X 400 mm^2)
	Boulaos Reactive Compensation - 40MVAR Capacitor Bank (4 x 10 MVAR)
2020	Palmeraie 63/20kV Substation
	3rd PK-12 63/20kV 40MVA Transformer
	PK-12 Reactive Compensation - 30MVAR Capacitor Bank
	Marabout Reactive Compensation - 10MVAR Capacitor Bank
2035	4th PK-12 63/20kV 40 MVA Transformer
	PK-12 20kV Reactive Compensation - Additional 20MVAR Capacitor Bank/SVC
	PK-12 63kV Reactive Compensation - 90MVAR Capacitor Bank/SVC

(Source) Study Team compiled from EdD data

6.3.17 Conclusion

Generation capacity is currently (2010) inadequate to meet demand in summer or when plant is out due to maintenance or breakdown. The price of power from diesel power plants is the highest among the five countries studied, since Djibouti has no hydro contribution. To increase capacity in an affordable manner, Djibouti needs to develop geothermal resources, which are the only available cheaper source of energy in the country. This requires the mobilization of funds to exploit this resource.

6.4 Geothermal Resources in Djibouti

The Republic of Djibouti is one of several African countries located on the East African rift system where geology is also affected by the two other oceanic ridges of the Red Sea and Gulf of Aden. Such a particular geodynamical situation puts the area in a remarkable position for the development of geothermal energy. Effectively, the underground heat sources are expressed on the surface by numerous hot springs and fumaroles mainly distributed in the Western part of the country and along the Gulf of Tadjourah ridge. In spite of the significant geothermal studies and the deep drilling exploration conducted since 1970 on several geothermal prospect zones, geothermal energy in Djibouti remains to be developed.

A volcanic series overlies the basement rocks (Jurassic limestone and Cretaceous sedimentary rock) as a result of the triple junction system of the Red Sea, Aden gulf and East African rifts, related to plate tectonic movements in the last 25-30 Ma. Adolei basalts characterize the first rupture movement within the Arabo-Nubian block, which occurred during the later Miocene period (Fig.-6.4-1). During these first movements the area was under an Ethiopian rift tectonic pattern with a N-S extension fault system (Gaulier・Huchon,1991). There then followed a period of slow expansion during which the Mabla rhyolites outcrop formed (15 Ma) in a large senestral shear zone. The oldest Ethiopian structures oriented N-S to N20°E were reactivated as senestral strike-slip faults. After an interval during which these rhyolites were eroded, the Dalha basalts were laid down with an angular unconformity (3.4 - 9 Ma). The Somali basalts outcrop was formed practically contemporaneously in the eastern part of the region. A N160°E extension links to early movements during the emplacement of Dalha basalts. Progressively this extension became oriented to N20°E. Between 3.4 and 1.5 Ma, the Stratoid basalts and Gulf basalts poured out as the Gulf of Tadjourah opened (Black et al., 1974; CNRS-CNR 1973). At the early stage of the opening of the Gulf of Tadjourah, the western border of Ali Sabieh horst acted as a wide dextral strike-slip zone with a related N-S to N20°E extension which became oriented to N40°E. Recent volcanic formations are mainly located in the Asal rift and the Manda Inakir rift.

Geothermal prospecting was begun in Djibouti in 1970 by the French Bureau de Recherche Géologiques et Minières (BRGM) and continued until 1990. Then, since 2007, Reykjavik Energy Invest was awarded a concession in the most promising Asal area to build an initial geothermal power plant of 50 MW. But all these investigations failed to galvanize the start of geothermal power production. The exploration areas are in different stages of exploration, which are summarized in Table-6.4-1 (update of Houmed, 1984). All those above areas and some smaller geothermal fields in the Republic of Djibouti are represented in Fig.-6.4-2.

6.4.1 Asal Geothermal Field

The Asal geothermal system is located in the isthmus between Lake Asal and Ghoubet al Kharab (Fig.-6.4-1) at a distance of about 120 km from Djibouti city. Altitudes range from -151 m at Lake Asal to +300 m at the highest point of the rift valley floor. The area is bounded by the high plateaus of Dalha to the north (above 1000 m high) and by 400 to 700 m high plateaus to the south, which separate Asal from the Gaggade and Hanle sedimentary plains (Fig.-6.4-2).

The region is arid with an average rainfall of 79 mm per year. Hydrogeological studies of the region show a general groundwater flow toward Lake Asal, which is the lowest point of the area and is occupied by a salt lake saturated in sodium chloride and calcium sulphates. The area is controlled by tectonic faults, still active at present.

A total of six deep wells have been drilled in the area, the first two in 1975 and the last four in 1987 and 1988. Well Asal 2 was damaged, wells Asal 4 and Asal 5 were impermeable although very hot, but wells Asal 1, 3 and 6 have produced extremely saline fluids from depths of 1000-1300 m, where the aquifer temperature is about 260°C (Daher, 2005). The temperature profiles of A3, A4 and A5 are shown in Fig.-6.4-3. Well test data from wells Asal 3, 4 and 6, including injection test data, draw-down test data, pressure build-up data and pressure interference data, have been analyzed in order to estimate the reservoir properties of the Asal geothermal system.

From November to December 2007, a field survey consisting of geological and geophysical studies was conducted in the Asal area. The survey was led by ISOR, Icelandic Geosurvey, a consulting and research institute. Finally, a preliminary conceptual model combining the old available data (on geochemistry, geology, well-drilling) has been proposed (Fig.-6.4-4). It reveals the presence of three independent geothermal reservoirs, designated simply as Fiale, Gale le Goma and South of Asal Lake.

The evaluation sheet for the Asal geothermal field is shown in Annex-3-1.

6.4.2 Hanle-Gaggade geothermal field

The prospect site is located in the southwestern region of the country where stratoid basalts circumscribe a succession of high plateaus and sedimentary plains between lake Abhé and lake Asal (Fig.-6.4-2). Within this wide zone, several fumerolles and hot springs are identified in the lake Abhé area, where the temperature of the hot springs can exceed 60°C.

The first part of the exploration began with three gradient wells about 450 meters deep in Hanlé plain (Teweo1, Garabayyis 1 and Garabayyis 2) in order to confirm the hydrogeological settings and to assess the temperature gradients before carrying on with the deep drilling (GEOTHERMICA 1985; GENZL 1985). They showed heterogeneous sedimentary sequences comprising sandy aquifers overlying a stratoid basalts aquifer. Temperature measurements gave a maximum of 87°C on Garabayyis 2, and the estimated temperature gradients are between 1.3°C/100m and 2°C/100m.

Two deep wells (Hanlé 1 and Hanlé 2) realized in the Hanlé plain reached 1623 m and 2038 m, respectively (AQUATER 1989). Hanlé 1 recorded a maximum of 72°C at 1420m. After the lacustrine deposits, the well crosses a rhyolitic complex between 94 m and 307 m overlying a monotonous sequence of basaltic flows. Permeable zones are encountered in the rhyolitic complex, at the contact with the basalts and in the scoriaceous layers. The well is impervious below 800 m. The maximum temperature in Hanlé 2 was 124°C at 2020 m. The lithological sequence is represented mainly by basalts. Highly permeable levels are found down to 450 m (fluid TDS 2 g/l) and the rest of the well remains impervious (AQUATER 1989; Jalludin 2003). On the basis of these results on permeability and temperature, the Hanlé prospect site was revealed to be unsatisfactory for geothermal purposes.

The evaluation sheet for the Hanle-Gaggade geothermal field is shown in Annex-3-2.

6.4.3 Nord-Goubhet geothermal field

The Nord-Goubhet area is located northeast of but close to the Asal rift. Goda mountain and Makarassou region are found in the northern part of the area and the study zone is limited by the sea in the South. Compared to the Asal rift, the area is more elevated, at altitudes of up to 500 to 600 meters. The geology is marked by the Dalha basalt outcrops covered by the more recent Gulf basalts and pleistocene sediments. The fracture network is well-developped. The area is situated between different zones of different tectonic patterns and is therefore affected by several tectonic trends: Asal rift NW-SE faults, Makarassou N-S trends (Tapponnier et Varet 1974) and old trends identified in the Goda mountain.

Along the scarped valleys of the wadis, several fumaroles and one boiling spring are found at the bottom of the volcanic cliffs. Different methods applied to the chemical data from the condensate of the fumaroles give differenet estimations for the possible reservoir temperature: 220°C and 170°C (Geothermica 1987).

Three geophysical surveys have been conducted in the area of Nord-Goubhet: gravimetric, AMT and electric (rectangle method) (BRGM 1983). The results from the three geophysical surveys cannot be completely intercorrelated. However, findings from the gravimetric and the geoelectrical methods open up an interesting insight into the underground structures underlying the surface hydrothermal activities, insight that can guide drilling exploration.

The evaluation sheet for the Nord-Goubhet geothermal field is shown in Annex-3-3.

6.4.4 Arta geothermal field

This geothermal prospect zone is located on the Southern shore of the Gulf of Tadjourah and 45 km west of the town of Djibouti. The geological formations are mainly represented by the miocene Dalha basalts, while other units comprise Mabla rhyolites, stratoide basalts and Gulf basalts. The plain is filled with coarse quaternary sediments. The zone shows a particularly intensive fracture network controlled by strike-slip faulting and, more recently, by normal faults (Arthaud et al. 1980).

Geochemical studies of shallow wells and springs have determined two main chemical types. One type is alkaline-bicarbonated, characterizing superficial groundwater with typical recharge from wadi beds during run off. The geochemical temperature is slightly under 75°C (Geothermica 1982). The second type is alkaline-chlorine as an effect of sea water intrusion and the probable influence of underlying high-TDS waters, which have been demonstrated in the country (Bouh 2006; Jalludin et al. 2006). The geochemical temperatures range from 75 to 95°C.

The geophysics of the Arta area has been explored with with gravimetry and geoelectric methods. The gravimetric survey delineates an upwelling zone with positive anomaly that likely represents a rhyolitic dome. The underground structures shown by the mapping of the anomalies seem to corroborate one of the main fracture trends, the NE-SW trend. The main finding from the geoelectrical soundings is the presence of a conductive layer several hundreds of meters thick. Within the scope of the geological situation of the area, this might be related to highly altered volcanic rocks, most likely Dalha basalts, as is observed also elsewhere in the field. Consequently, from the geothermal reservoir

standpoint, this analysis reinforces the likely presence of a cap rock of relatively elevated thickness.
In future geothermal reservoir exploration in the Arta region, Geothermica (1982) suggests that the objective will not be found at shallow depth, but that exploration drilling might need to go to a depth of two thousand meters to possibly tap a deep geothermal reservoir. The evaluation sheet for the Arta geothermal field is shown in Annex-3-4.

6.4.5 Obock geothermal field

The Obock prospect zone is close to the town of Obock located on the northern shore of the Gulf of Tadjourah at its eastern limit. This geothermal site was selected based on the upwelling of several hot springs and the presence of one fumarole on the beach. Some hot springs can be identified only during low tide. The outcrops close to the hydrothermal manifestations are formed of quaternary madrepores covered by the alluviums that are found all over the Obock plain. In the upstream side, volcanic rocks are found that are dominated by intensely fractured Mabla rhyolites in the form of mountains and scarped reliefs. The fractures in the quaternary plain area are observed exclusively close to the shore as E-W open fissures in the madrepores. Based upon marine geophysical and tectonic studies, the surface hydrothermal activity appears to be related to the nearby Gulf of Tadjourah ridge, whose fault system reaches the Obock site (Manighetti 1993). Some geophysical prospecting has been undertaken for the purpose of groundwater development and also for geothermal development, but the results are not significant, as they are limited in investigation depth or incomplete. These are electrical soundings with short AB lengths (CGG 1965) and magnetic surveying with insufficient points (Essrich and Brunel 1990). Geochemical analysis reveals alkaline-chloride dominated waters in relation with sea water. Geothermometers found a possible reservoir temperature of 210°C (Houssein 1993). The evaluation sheet for the Obock geothermal field is shown in Annex-3-5.

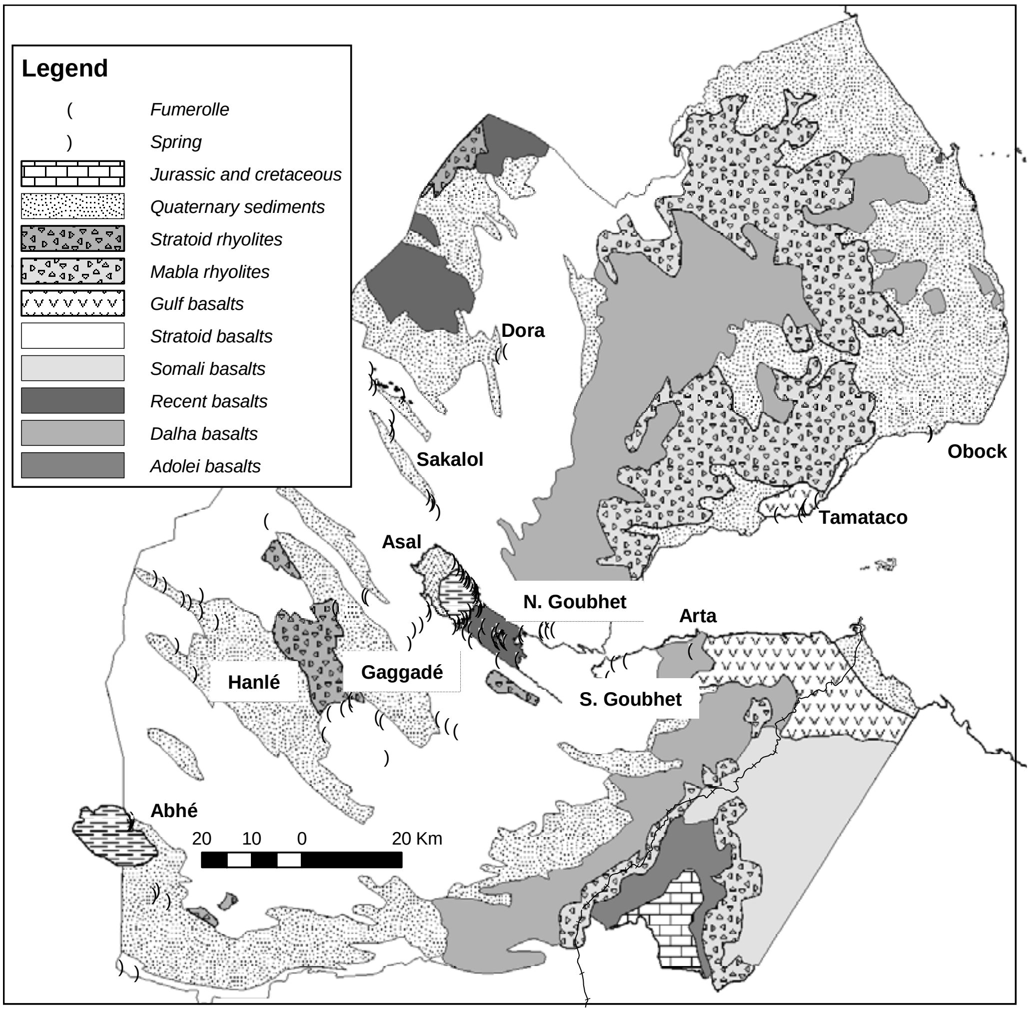
6.4.6 Lac Abhe geothermal field

The Lac Abhe zone is located in the southwestern region of the country, on the border with Ethiopia. This hypersaline lake is at the western end of the Gobaad plain and the eastern end of the downstream valley of the Awash river coming from the Ethiopian plateau. The geology is characterized by the stratoid basalt plateaus limited by the E-W faults configuring the Gobaad plain, filled by quaternary and probably late pliocene sediments. The lake area is particularly rich in surface hydrothermal manifestations, with fumaroles and hot springs, but also travertine constructions, some of them reaching more than 60m above ground level. The travertines are aligned on the main fracture trends. Fumaroles are located on those travertines, and the hot springs occur at the bottom of these travertine chimneys. The temperature of the hot springs is generally higher than 90°C. Only preliminary geochemical studies have been conducted for this prospect, and they reveal mainly two types of waters. Most of the hot springs are alkaline-chloride-sulfated, and a few of them present also a bicarbonated type as a result of surface water mixing. The surface hydrothermal manifestations are spread over an area of about one hundred square kilometers. This suggests that in the Lac Abhe zone there is an important thermal anomaly representing a potential geothermal reservoir. The evaluation sheet for the

Lac Abhe geothermal field is shown in Annex-3-6.

6.4.7 Other potential geothermal zones

In addition to the above-mentioned geothermal zones which have been explored by advanced surface studies and, for some of them, by drillings, there are several other potential geothermal development sites of interest in the Republic of Djibouti. The following geothermal sites are characterized by surface hydrothermal activities, hot springs and fumaroles, and also groundwater with abnormally elevated temperatures: Sakkalol, Tamataco, Wead (Djibouti plain), North of lake Asal, South-Goubhet and Dora (Fig.-6.4-2).



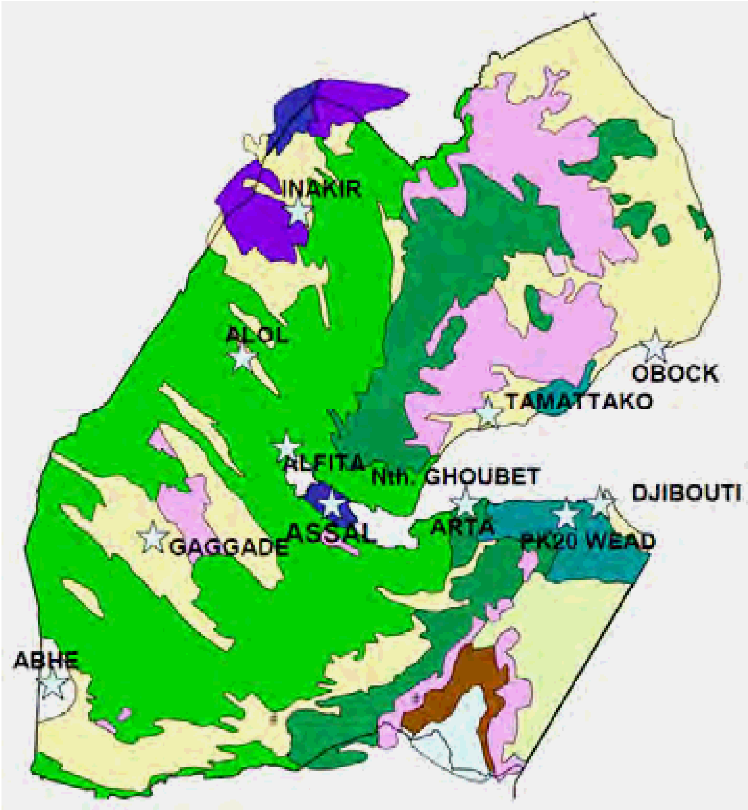
(Source) Jalludin (2006)

Fig.-6.4-1 Geology and hydrothermal activity of the Republic of Djibouti

Table-6.4-1 Actual stage of exploration and intensity of surface exploration of various geothermal fields in Djibouti

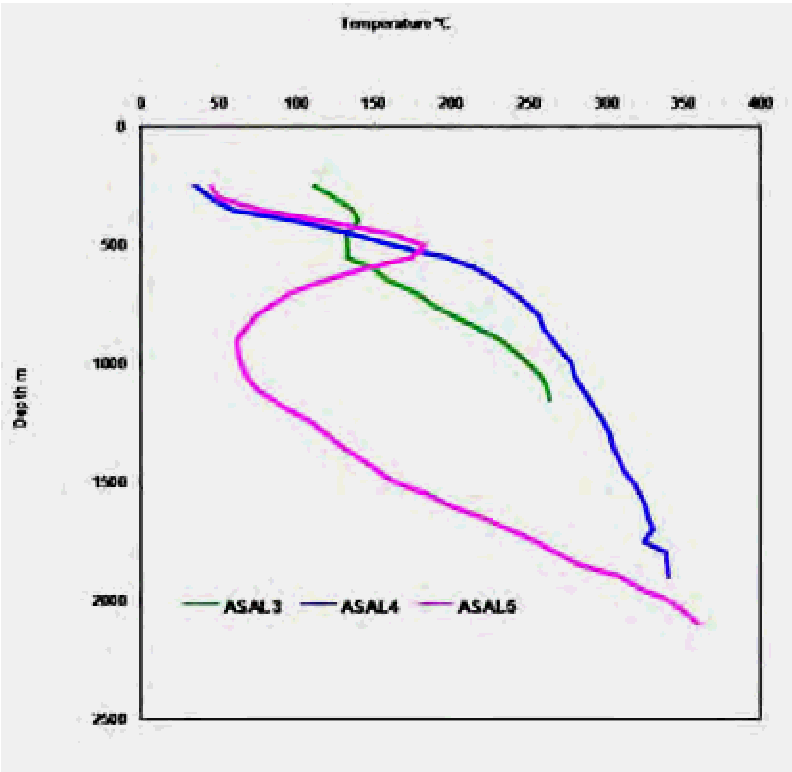
	Exploration stage				Surface manifestations	
Area	Geology	Geochemistry	Geophysics	Exploration drilling	Hot springs	Fumaroles
Lake Asal	+++	++	+++	++	++	+
North Goubbet	++	++	++		+	+
Gaggade	++	++			+	+++
Hanle	++	++	++	+		++
Lake Abbe	++	+			++	++
Arta	++	++	++			+
Obock		++			+	+
Alol	+	+			++	+

(Source) Houssein (2010a)



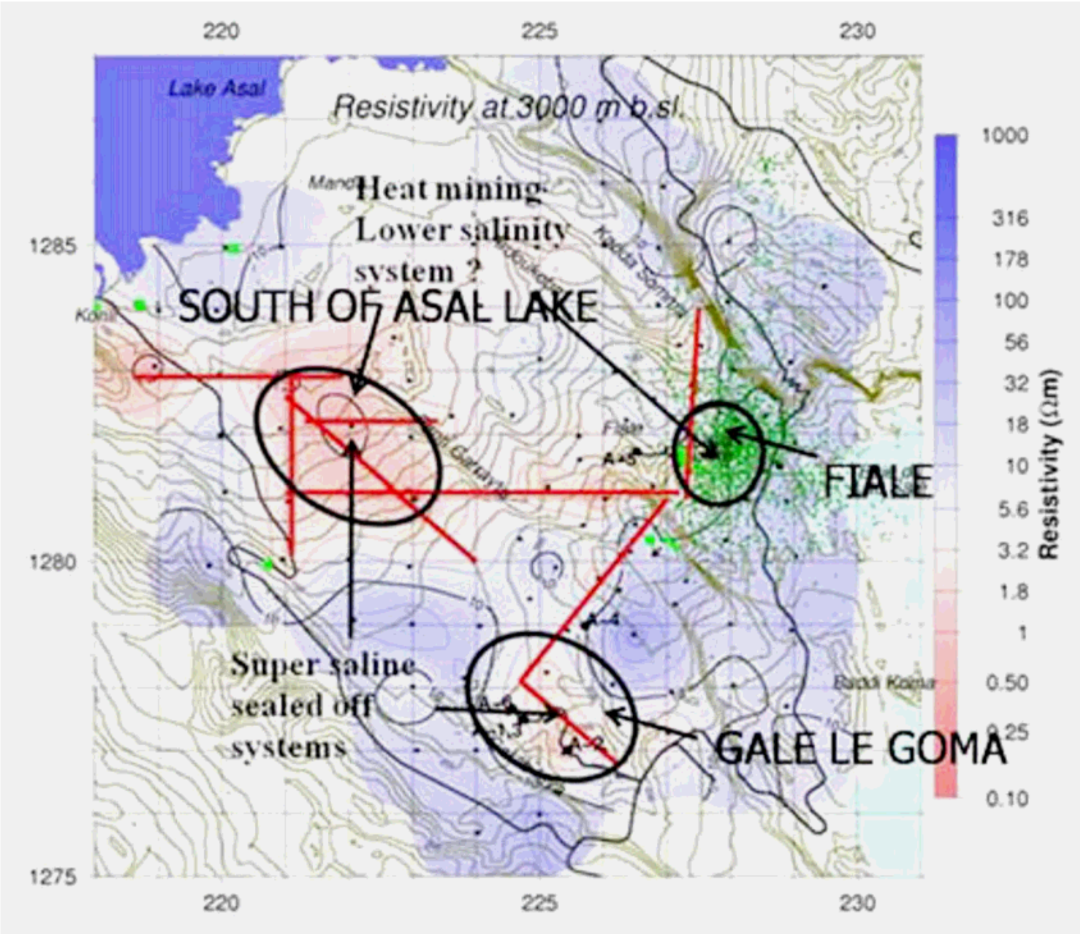
(Source) Ainan (2010)

Fig.-6.4-2 Location of Geothermal Prospect areas in Djibouti



(Source) Houssein (2010b)

Fig.-6.4-3 Temperatures profiles of well Asal-3, Asal-4 and Asal-5



(Source) Houssein (2010a)

Fig.-6.4-4 A conceptual model of geothermal activity in the Asal rift

6.5 Technical Capacity

6.5.1 Ministry of Energy and Natural Resources (MENR)

Geothermal development activities in Djibouti are coordinated through the Ministry of Energy and Natural Resources. The current chief executive of the Ministry of Energy is Farah Ali Ainan, who is the Secretary-General and an Engineer by profession. The Ministry of Energy and Natural resources negotiates and issues geothermal concessions, for example the one issued to Reykjavik Energy Invest for the development of Asal geothermal field in 2007. It is also responsible for the formulation of the energy policy. Mr. Ainan is the only person in the Ministry who deals with geothermal matters and has no staff with a specialist geothermal background to assist him. During this study, Mr Ainan made it clear that one form of assistance he would like to have is the provision of a technical advisory team of one or several geothermal professionals who could advise and assist him in the formulation of a geothermal development strategy and act as the owner's engineer during exploration drilling in Asal or any other field under development by IPPs.

6.5.2 EdD

Currently, EdD is the only power company in Djibouti. It is a vertically integrated state-owned enterprise responsible for generating, transmitting and distributing electric power in the country. EdD does not have any mandate to develop geothermal power, although it is ready to undertake this task if the government directs it to do so. EdD understands the usefulness of the development of geothermal power in Djibouti, as the country is currently wholly dependent on thermal power which it generates itself until it starts to import power from Ethiopia through the almost-completed 220kV double circuit interconnector. EdD is a strong supporter of geothermal development, even though it does not have a mandate to undertake and finance exploration work. In 1997, the Director-General of EdD conducted a serious campaign in the US to seek interested IPPs to develop the Asal Field. Following this campaign, Geothermal Development Associates (GDA) of US signed a Memorandum of Understanding (MoU) for the development of Asal. EdD then took on board a geologist previously working with CERD on the Asal project and created a geothermal department in anticipation of power purchases from GDA. The geologist is very experienced, but he is the only staff member coordinating geothermal undertakings with other renewable energies like solar and wind power that EdD is involved with.

6.5.3 Centre d'Etudes et de Recherche de Djibouti (CERD)

CERD is currently responsible for conducting all the scientific investigation of geothermal in Djibouti and has been involved with this activity right from the beginning. It was formerly known as ISERT until 1979 when the name was changed.

CERD is a semi-autonomous scientific research body in the Office of the President. It is headed by a Director-General and has seven departments - Earth Sciences, Life Science, Social Sciences, Languages, New Technologies, Strategy and Political Sciences and Medical Research. Geothermal activities are located within the department of Earth Sciences.

Table-6.5-1 indicates that there are about 21 technically qualified CERD staff engaged in geothermal work. However, these staff also work in other areas like hydrogeology, and geological mapping depending on the projects under implementation and the funding available. Seven staff members have been trained in geothermal science in various places, including Naivasha, Kenya. One reservoir engineer is currently undertaking a PhD in Reservoir Engineering in the US after completing an MSc at the University of Iceland. According to CERD’s projections 23 more staff will be recruited and trained in order to continue detailed surface investigations and be involved in drilling, particularly during exploration.

Table-6.5-1 Available professional skilled manpower in Djibouti

	MENR	CERD	EdD	Total
Geologist		2	1	**3**
Geochemist		2		**2**
Geophysicist		2		**2**
Reservoir Engineer		1		**1**
Drilling Engineer		0		**0**
Power Engineer				**0**
Environmental Scientist		10		**10**
Financial Planner/Modeller		0		**0**
GIS Scientist		3		**3**
Drillers		0		**0**
Technicians		1		**1**
Total	**0**	**21**	**1**	**22**

(Source) Study Team

Table-6.5-2 shows the equipment currently available at CERD and the additional equipment they plan to acquire. One (1) set of TDEM equipment and one (1) set of MT equipment will be procured this year through a groundwater survey project to be financed by UNESCO. Some of the equipment, like the mass spectrometer for stable isotopes and a logging truck may not be required immediately. The civil equipment and water supply infrastructure may not be required until the development strategy developed and adopted by Djibouti is more clearly defined and it becomes clear whether it is the government or IPPs that will lead the way.

Table-6.5-2 Equipment available by CERD

Equipment Description	Available	Equipment Description	Available	Equipment Description	Available	Equipment Description	Available
Geological		**Geochemical**		**Geophysical**		**Drilling**	
Simple GPS	4	Simple GPS	1	Differential GPS	0	Complete Rig	0
Digital Thermometer	1	Digital Thermometer	1	Simple GPS	1	Water supply	0
Fluid Inclusion Heating-	0	pH meter	2	TEM	1	Site preparation equipment	0
Binocular Microscope	2	Conductivity Meter	1	MT	1	Small water rig	0
Petrographic Microscope	2	Water Sampling Kit	1	Gravimeter	1	**General**	
X-Ray Diffractometer	0	Gas Sampling Kit	0	Magnetometer	0	4x4 field vehicles	1
X-Ray Flourescence	0	AAS	1	Portable seismometer	0	GIS System	1
ICP-MS	0	Ion Chromatrograph (IC)	1	**Reservoir Engineering**		Total Station for land survey	0
Thin sectioning equipment	0	Gas Chromatograph	0	Kuster gauge Tools set	0	completer weather station	0
		Mass Spectrometer for	0	Kuster TPS with SRO	0		
		Tritium Scintillation counter	0	Logging Winch	0		
				Logging Truck (K10)	0		
				Discharge Silencer	0		

(Source) Study Team

CERD has a budget of about US$2.8million to be utilized over the next three years. They intend to utilize about US$200,000 to undertake geophysical surveys in several geothermal prospects. The areas targeted for these detailed surveys are the Obock, Gaggade, and Inakir areas. Lake Abhe will be developed by Hydrocarbon, an Indian IPP that already holds a geothermal concession. UNESCO is also providing some funds for groundwater surveys which will be used to procure TDEM and MT equipment for that work and which can later be used for geothermal exploration as well.

6.5.4 IPPs

Currently there are no IPPs in the power sector. Initially, Geothermal Development Associates (GDA) from the US was interested in developing Asal field and signed an Memorandum of Understanding (MOU) with the government for the development of 30MW of geothermal power in 1998. GDA carried out a feasibility study in 2000, but unfortunately the project did not take off. In 2007 Reykjavik Energy Invest (REI) from Iceland obtained an exclusive license from the Djibouti government, also to develop Asal. In April 2008, Heads of Terms for the Project Agreement (PA) and Power Purchase Agreement (PPA) were signed. Prefeasibility studies were carried out between 2007 and 2008 for a 50MW power development. The drilling of 4 exploration wells was planned to take place in 2009, but did not, presumably due to the financial crisis that hit the Icelandic economy. Negotiations for a final PA and an amended PPA took place in January 2010, but an agreement could not be reached. At this stage, the agreement reached earlier has expired and the Djibouti government is looking at other alternatives to proceed with the project.

Hydrocarbon Resources Development (HRD) was also issued an exclusive license for Lake Abhe in 2008. HRD, which has recently changed its name to Hydrocarbon, was to start its prefeasibility work at the end of 2009, but has not yet started as of this time (2010).

6.6 Energy Policy

Djibouti is dependent on oil imports for nearly all of its domestic energy consumption, which amounts to 12,500 barrels/day (U.S. Energy Information Administration). Currently under construction are international power transmission lines through which cheap hydroelectric power is expected to be fed from Ethiopia to mitigate dependence on imported oil. The primary attention in terms of energy policy will remain focused on reducing expensive oil imports (and thus preserving foreign exchange reserves) and exploiting the development of a stable supply of indigenous energy.

The electricity market is small, as the country and population are also small. Currently EdD (Electricité De Djibouti), which was established in January 1960, is the country's only vertically integrated system operator. There is no plan to privatize or divide EdD, or to liberalize the market. Djibouti does not have an independent electricity regulatory body which oversees EdD activity. The Ministry of Energy and Natural Resources is the only body which has the obligation to supervise all projects related to electric power in Djibouti.

In the past, electric power generation has depended entirely on imported fossil fuels. As the economic development of East African countries is expected to progress steadily, the business activity associated with Djibouti port, as well as the power demand is expected to grow in the future. In order to accommodate the increasing demand for electricity, fossil fuel imports are expected to continue growing further. Therefore, the Djibouti government has shown keen interest in the development of renewal energy resources such as geothermal, wind and solar energy, which are the only indigenous energy resources available in the country. Among them, geothermal energy has been held up as a resource of great promise.

The government of Djibouti has been engaged in a series of studies related to geothermal resource development with help both from multilateral donors such as the World Bank and the United Nations, and from bilateral donors such as the United States, France and Iceland. The Asal geothermal field has been cited as the most promising geothermal prospect. Since the first major studies conducted under the United Nations Development Programme and by the French government in the 1980s, the development of this field has been a focus of efforts for many years. ARGeo, the East African regional scheme for promoting geothermal energy, has also adopted Asal as a regional development priority

However, located adjacent to lake Asal, which is highly saline, the Asal geothermal resource exhibits adverse characteristics such as reservoir fluid of very high salinity and the precipitation of various types of scaling, especially iron sulfide scaling. These conditions are expected to raise both technical and economic barriers to development of the resource. Based on an agreement concerning the Asal geothermal development, Reykjavik Energy Invest (REI) of Iceland has carried out a feasibility study and environmental assessment. They have submitted a project proposal with a view to concluding a PPA, which the Djibouri government has been reluctant to accept. Information obtained from interviews with the Djibouti government, REI, the World Bank and the International Development Corporation (IDC) has thrown some light on the matter. Specifically, it appears that the price level of the PPA is the heart of the trouble, with the final proposal according to the Djibouti side being USD 19 cents/kWh, while the other side claims that the final figure was lowered to USD 12 cents/kWh. The actual situation is unclear to outsiders.

6.7 Environmental Policies

According to the Department of Environment (DOE) under the Ministry of Home, Urbanism, Environment and Land Planning, EIA is prescribed in Décret n°2001-0011/PR/MHUEAT. On the other, relevant legislation on EIA and guidelines have not been prepared. Though there are previous cases of the EIA such as the Asal geothermal development, there is no detailed rules and regulations on the EIA. In addition, environmental standards such as water quality, air quality, and noise and vibration have not been prepared.

Required period for the EIA approval is between one and two months after EIA report is submitted to DOE, according to DOE. Expenses on the EIA approval process are not prescribed and the procedures are conducted with free of charge.

There is no registration system for entrepreneurs who conduct the EIA-related study in Djibouti. In addition, since there is no adequate entrepreneur capable to conduct the EIA-related study in the country, foreign firm has conducted the EIA-related study. In the case of large-scale project, there is case where ad hoc review committee is formed.

DOE is also in charge of the environmental protected area. Although there is a list of the protected areas in the Web site of DOE, exact boundary of the protected area has not been fixed due to unavailability of map which shows exact location of the protected areas. In the case where the project is located in the protected area, same EIA procedure is required to be taken.

6.8 Direct Utilization of Geothermal Energy

There is no geothermal use in Djibouti at present (Lund et al (2010)). Since climate of Djibouti is rather hot throughout the year, different from the neighboring rift valley countries, utilization of the hot water for heating use is not expected for residential area. In addition, utilization of the hot water for industry is less expected, since industrial activity is limited in Djibouti.

Chapter 7 Tanzania

7.1 Country Outline[1]

On the political front, Tanzania is one of the most stable countries in East Africa. President Nyerere was the founding father of the country, and held the presidency from 1962-1985. Subsequently, there has been an orderly transition of power every ten years. President Mwinyi served from 1985 to 1995, President Mkapa followed from 1995-2005, and then-Foreign Minister Kikuwete was elected as the new president with over 80% of the vote in the presidential election of December, 2005. Since the shift in May 1992 from one-party rule by the revolutionary party Chama Cha Mapinduzi (CCM) to a multiparty system, CCM has always maintained its position as the government party. In semi-autonomous Zanzibar, which is the base of the main opposition party, CUF, confrontation between the ruling and opposition parties continues, although there has been a movement towards better relations under Kikuwete.

On the economic front, although Tanzania has pursued steady macroeconomic policies since the latter half of the 1990s, GNI per person is still at a Least Developed Country level of US$400 (WDI2009), and the agriculture sector accounts for about 80% of the workforce and about 40% or more of GDP. Sightseeing, mineral resources (gold and diamonds, etc.), and the communications industry are performing well, and the economic growth rate over the past five years has been over 6% (6.7% in fiscal year 2006, 7.1% in 2007, and 7.8% (presumed) in 2008). Although inflation had been 5% or less since 2002, a long-term drought in 2006 brought food shortages and shortages of electricity derived from hydropower, and inflation rose to 7.3%,. In 2008, a sudden rise in the price of the raw materials etc. drove inflation up to 10.3%. The key challenge facing the current government is that high economic growth rates are a condition of poverty reduction, and thus various reforms and policies fostering poverty reduction are being advanced, while partnerships with development donor expand, and ODA to Tanzania increases every year.

On the development front, the Tanzanian government formulated a "National Poverty Eradication Strategy (NPES)" as a national development strategy in 1997, presenting a framework for poverty reduction, and in 1999 announced its "Tanzania development vision 2025", outlining initiatives for the development of the country (to improve the quality of life, to encourage good governance, to ensure the rule of law, and to foster a competitive economy). On the basis of this strategy for development, a Poverty Reduction Strategy (PRS) was formulated in 2000, and in July 2007, as a second PRS, these national development strategies were formulated into a "National Strategy for Growth and Reduction of Poverty (NSGRP)" known by the alias MKUKUTA (and the developmental strategy for Zanzibar, MKUZA, was formulated in January 2007).

[1] Source: International Cooperation Bureau, Ministry of Foreign Affairs, Japan: Official Development Assistance (ODA) countries data book 2009

The second PRS is an inclusive five-year policy framework aiming at poverty reduction and economic growth. In this framework, national initiative is valued, and a results-oriented approach across all fields has been adopted, with three elements contributing to growth and poverty reduction: "Growth and the reduction of poor incomes", "Improvement of the quality of life and social welfare", and "Governance and accountability". Also, monitoring continues from a perspective valuing growth, and a Poverty and Human Development Report (PHDR) reporting progress in the MKUKUTA development indicators has been published.

7.2 Energy Resources

The primary energy supply in Tanzania in 2007 amounted to 18,278,000 tonnes of oil equivalent (toe), with16,902,000 toe of indigenous energy (coal, natural gas, hydropower, firewood, etc.), 1,498,000 toe of imported energy (oil and petroleum products) and no exports (IEA Energy Balance 2007). The final energy consumption was 15,806,000 toe, which breaks down to 2,013,000 toe for industrial uses, 1,005,000 toe for transportation and 12,788,000 toe for other usess (household, agriculture, etc.) (IEA Energy Balance 2007).

Tanzania possesses resources such as hydropower, natural gas, coal, and renewable energy (solar energy, wind power, geothermal power and biomass). The hydropower potential is 5,000MW, there is up to 45 billion m^3 of natural gas, about 300 million tons of coal, and 187kW/m^2 of solar power (Table-7.2-1). Geothermal power is being investigated now.

Table-7.2-1 Energy resource potential in Tanzania

Type	Resource Amount	Remarks
Hydro	5,010MW	10MW or more : 4,700MW Less than 10MW : 310MW Rufiji river water system : 1,200MW Ruhudji river water system : 358MW Rumakali river water system : 222MW Upper Klhanshi : 120MW
Natural gas	45 billion m^3	Songo Songo gas field：80 billion m^3 Mnazi Bay gas field : 15 billion m^3
Coal	304 million ton (proven resources〉	Estimated resources 1.2 billion tons (The main coal fields are as follows:) Muchuchuma coal field 1.2 billion tons (bituminous coal) Mhukura coal field 150 million tons (sub-bituminous coal) Kiwira coal field 1.14 billion tons

		(bituminous coal) Mbalawara coal field 100 million tons (bituminous coal)
Solar	187kW/m^2	Estimated resources 215MW
Wind	―	Four existing wind power generation sites
Geothermal	―	Under investigation
Wood biomass	1.8 billion m^3	Firewood, charcoal, etc.
Residue biomass	―	Dung, bagasse, fruit, etc

(Source) JEPIC (2010)

As for natural gas, development around Songo Songo island in the Indian Ocean is progressing, and the production of the Songo Songo gas fields began in 2004 with financing from the World Bank, European Investment Bank (EIB: Europe Investment Bank), and Swedish International Development Cooperation Agency (SIDA). The development of the natural gas project is led by the Songas Co. (with 20 companies or more, such as Canadian and Tanzanian enterprises, investing), and Songas also carries out power plant repair work and pipeline construction in addition to its gas field development activities. The 186 MW power plant connected with this project was completed before the pipeline was constructed in 2002, and used jet fuel at first, but has been using natural gas ever since the pipeline from the gas field to the power plant was completed in 2004.

7.3 Electric Power Situation

7.3.1 Electric Power sector

The electricity sector in Tanzania comprises the Ministry of Energy and Minerals (MEM), Tanzania Electric Supply Company (TANESCO), the Rural Energy Board (REB), the Rural Energy Agency (REA), the Rural Energy Fund (REF), and the Energy and Water Utilities Regulatory Authority (EWURA). Tanzania Electric Supply Company Limited is 100% wholly owned by the government, and falls under the Ministry of Energy and Minerals.

TANESCO was established early in the 1930s as two companies, one private and one government entity, but by 1957, under the Electricity Ordinance, the government had acquired all shares in TANESCO, making it a 100% state-owned power utility. TANESCO is a vertically integrated company providing generation, transmission, distribution and sale of electricity on the Tanzanian mainland. TANESCO is the sole bulk supplier of electricity on the Tanzanian mainland. Starting in 1980, TANESCO began supplying bulk power via a 38km, 45MW, 132kV submarine cable to Zanzibar Electricity Corporation (ZECO), which is solely responsible for the distribution of electricity in Zanzibar and Pemba,.

TANESCO's monopoly position was ended in June 1992 to allow private sector participation in the power business. To date, a number of independent generation facilities and other supply initiatives have been established in the country, and a number of others are being planned. In addition, there have been several distribution and supply initiatives, including missions and cooperatives. The Artumas Group has developed an initiative for the supply, transmission, distribution and sale of electricity in the Mtwara and Lindi regions.

Some local industries are generating their own electricity. These include SAO Hill and TANWAT in the Iringa Region that use biomass. There is also community-based generation, transmission and distribution. Religious institutions and Environmental Protection Organizations have initiated mini-power generation plants in their localities.

7.3.2 Power Sector Policy

The first National Energy Policy for Tanzania was formulated in April 1992. Since then, the energy sub-sectors as well as the overall economy have gone through structural changes, where the role of the Government has changed, markets have been liberalized and private sector initiatives encouraged. Hence, the policy document was revised in 2003, taking into account the structural changes in the economy and political transformations at the national and international levels. The national policy objectives for the development of the energy sector remained unchanged: to provide funding to the development process that establishes efficient energy production, procurement, transportation, distribution, and end-user systems in an environmentally sound manner and with due regard to gender issues. The revision, therefore, focused on market mechanisms and the means to reach the objective of achieving an efficient energy sector with a balance between national and commercial interests. Specifically, the revised energy policy takes into consideration the need to:

- have affordable and reliable energy supplies in the whole country;
- reform the market for energy services and establish an adequate institutional framework, which facilitates investment, expansion of services, efficient pricing mechanisms and provides other financial incentives;
- enhance the development and utilization of indigenous and renewable energy sources and technologies;
- adequately take environmental considerations into account in all energy activities;
- increase energy efficiency and conservation in all sectors; and
- increase energy education and build gender-balanced capacity in energy planning, implementation and monitoring

The policy objectives of the revised Energy Policy 2003 were desgined to ensure the availability of reliable and affordable energy supplies and their use in a rational and sustainable manner in support of national development goals. The policy identified improving electricity supply and distribution as one of the challenges facing the sector. The policy document noted that the generation of electricity was expected to triple during the next twenty years (to 2023) to meet the projected increase in demand from industry, agriculture, commerce and the general population. Although significant investment had been made in generation facilities during previous years, in the medium term, the policy identified the need to promote and enhance private investment in electricity generation, transmission and distribution to meet the projected growth in demand.

7.3.3 Legal Framework

The legal framework for the power sector includes the Electricity Act of 2008, the EWURA Act of 2001, the REA Act of 2005 and the Gas Bill of 2009.

The Electricity Act of 2008 provides for the facilitation and regulation of generation, transmission, transformation, distribution, supply and use of electric energy in order to encourage cross-border trade in electricity and rural electrification and related matters. Under the Act, the Minister shall provide supervision and oversight in the electricity supply industry and shall to that end:

·develop and review Government policies in the electricity supply industry;

·prepare, publish and revise policies, plans and strategies for the development of the electricity subsector;

·take all measures necessary to reorganize and restructure the electricity supply industry with a view to attracting private sector and other participation, in such parts of the industry, phases or time frames as the Minister deems proper;

·through the Rural Energy Agency, prepare, revise and publish a Rural Electrification Plan and Strategy;

·promote the development of the electricity sub-sector, including the development of indigenous energy resources;

·take measures to support and promote rural electrification in accordance with the Rural Energy Act, including the provision of funds to the Rural Energy Fund;

·formulate policy by which electricity may be imported or exported;

· conduct inquiries into accidents or disasters caused by electricity; and

·carry out any other functions as the Minister may deem necessary

7.3.4 Institutional Frameworks

TANESCO is vertically integrated and responsible for generation, transmission, distribution and supply of electricity in Tanzania. Under the ongoing reforms, the Government of Tanzania plans to ultimately un-bundle TANESCO into separate generation, transmission and distribution entities, as a prelude to its privatization. In the current power sector situation, the Government of Tanzania has opted to adopt the recommended option of creating and ring-fencing, within TANESCO, generation, transmission and distribution business units which in the long run will be privatized. These units will compete with IPPs or other electricity suppliers under the supervision of the regulator in delivering electricity services to Tanzanians.

7.3.5 Regulatory and Institutional Frameworks

The Electricity Act of 2008 established the Energy and Water Utilities Regulatory Authority (EWURA), a multi-sectoral regulatory authority responsible for the technical and economic regulation of the electricity, petroleum, natural gas and water sectors in Tanzania. EWURA has the power to:

- award licenses to entities undertaking or seeking to undertake a licensed activity;
- approve and enforce tariffs and fees charged by licensees;
- approve licensees' terms and conditions of electricity supply; and
- approve initiation of the procurement of new electricity supply installations.

The functions of the Authority in relation to the electricity supply industry shall be to protect customer's interests through the promotion of competition; promote access to, and affordability of, electricity services, particularly in rural areas; promote least-cost investment and security of supply for the benefit of customers; promote improvements in the operational and economic efficiency of the electricity supply industry and efficiency in the use of electricity; promote appropriate standards of quality, reliability and affordability for the electricity supply; take into account the effect of the activities of the electricity supply industry on the environment; protect the public from dangers arising from the activities of the electricity supply industry; and finally to promote the health and safety of persons employed in the electricity supply industry in the working environment.

(1) System Operator

The Authority shall designate a person to be a System Operator and license such a person to:

- co-ordinate the power supply system to ensure instantaneous balance between generation and consumption of electricity;
- be responsible for dispatching electricity from all generation installations connected to transmission facilities;
- co-ordinate planned generation and planned transmission outages;
- monitor the cross-border trade in electricity;
- recommend amendments to the Grid Code; and
- perform such other functions as may be prescribed in its license or in rules issued by the Authority.

The System Operator shall update on an annual basis a Power System Expansion plan, taking into consideration the policies, plans and strategies for the electricity sub-sector and proposed developments in generation and demand. In the performance of his licensed activities the System Operator shall abide by the Grid Code.

(2) Market Operator

The Authority shall designate a person to be a Market Operator and license such person to:-

- administer the operations of the wholesale electricity market;
- admit members to the wholesale electricity market, and require the lodging of securities from such members;
- receive bids and offers to buy and sell electricity in the wholesale electricity market;
- clear, reconcile and settle the wholesale electricity market;
- collect such contract and metering information as may be required for licensing; and
- recommend amendments to the market rules.

The Market Operator shall, at all times abide by the market rules in the performance of licensed activities.

(3) Rural Energy Agency

The Rural Energy Act of 2005 establishes the Rural Energy Agency and Rural Energy Fund. The responsibility of the Agency and EWURA is to prepare a Rural Electrification Plan and Strategies for Mainland Tanzania, and periodically amend and update the plan. The Minister for Energy and Minerals shall submit annually to the National Assembly a report on the progress and achievement of the Rural Electrification Plan and Strategies.

To promote development of power projects by the private sector, the Rural Energy Agency has developed three documents that guide investors in Small Power Plants (SPPs) in Tanzania:

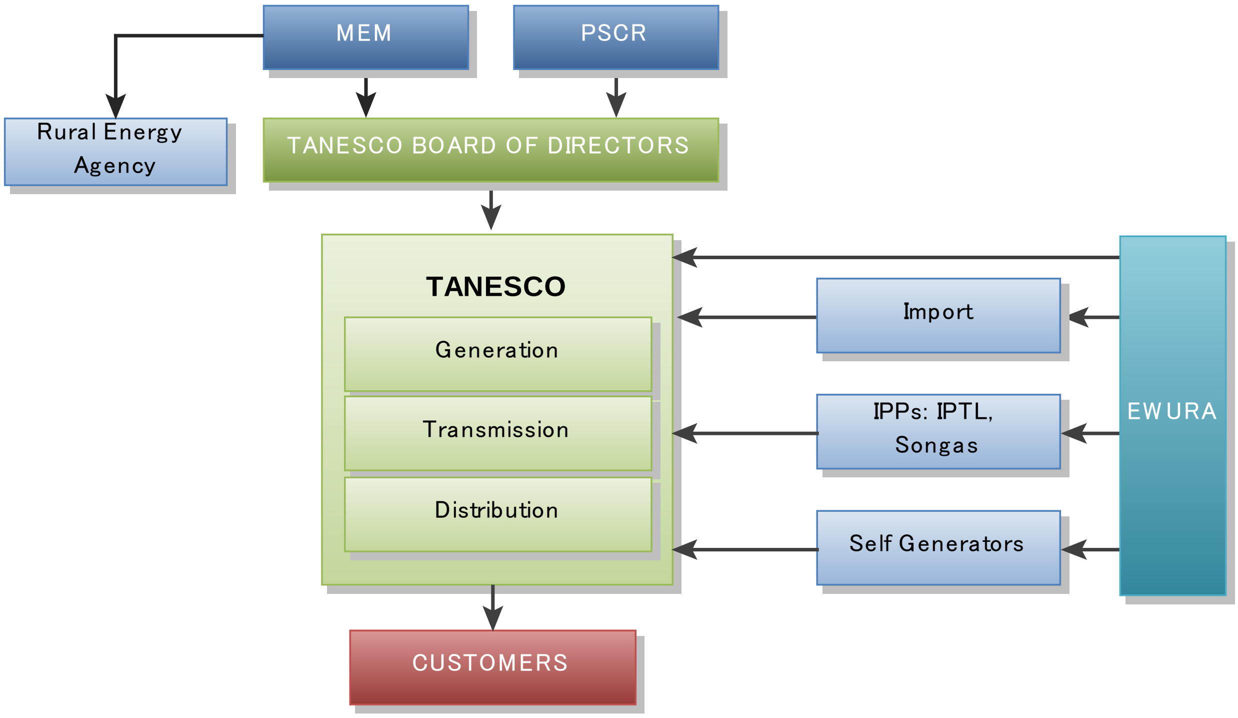
- Standardized Small Power Purchase Agreement (SPPA) for the Main Grid, 2008
- Standardized Tariff Calculation Methodology (STM) for the Main Grid, 2008
- Detailed Tariff Calculations under the SPPA for the Main Grid for year 2008

SPPs are embedded in the distribution system and require interconnection to the existing network with relatively short medium-voltage lines that will not unduly affect the service quality to customers on the distribution lines. Considering the sizes of renewable energy-based power plants awaiting development, and the configuration and voltage levels of the Tanzanian electricity network, an SPP is defined as a power plant using a renewable energy source or waste heat, or cogeneration of heat and electricity, with an output capacity of up to ten (10) MW. These could include pilot geothermal power plants installed as part of an exploration and appraisal program or simply as a final installation in a less productive field.

(4) Reorganization of the Electricity Market

The Minister may, in consultation with the Minister responsible for finance and EWURA, restructure the electricity supply industry in order to foster competition to increase efficiency, enhance development of private capital investment and promote regional electricity trading. The Minister shall within one year after the Act of 2008 comes into force, prepare and publish a policy for the reorganization of the electricity market stipulating the parts of electricity market that shall be subject to competition; the form of competition that shall be introduced in each relevant part of the electricity market; and the timeframes for the introduction of competition. In formulating the policy, the Minister shall take into consideration international best practices regarding competition policies in the electricity sector; the effects of competition on customer services, investment and private sector participation; the size and nature of the electricity market in mainland Tanzania; any need there may be to restructure existing entities in the electricity supply industry to create effective competition; and the views of EWURA, the Fair Competition Commission, consumers and licensees. The Minister may, in consultation with EWURA, the Fair Competition Commission, consumers and players in the electricity supply industry, amend the policy at any time.

The institutional structure during transition from the vertically integrated utility to the envisaged power market is likely to be as shown in Fig.-7.3-2 below.



(Source) Study Team

Fig.-7.3-1 Tanzanian Transition to an Emerging Market

As observed above, Tanzania has no institution devoted exclusively to the promotion and development of geothermal resources for power generation.

7.3.6 Energy Pricing

Under the Electricity Act of 2008, EWURA may regulate:

· tariffs for the sale of electricity by licensees to other licensees, unless the electricity is sold in markets determined by the Authority to be competitive;

· tariffs for the sale of electricity by licensees to customers other than eligible consumers;

· charges for connection to, and the use of any transmission system;

· charges for connection to, and the use of any distribution system;

· prices and charges in respect of goods and services provided by licensees determined by the Authority to be subject to tariff regulation

· Cross border licenses under electricity Tariffs regulation

EWURA shall be guided by the principles that tariffs should reflect the cost of efficient business operation; that tariffs should allow licensees to recover a fair return on their investment, provided that such investments have been approved by EWURA; that costs covered by subsidies or grants provided by the Government or donor agencies shall not be reflected in the costs of business operation; that tariff adjustments shall, to the extent possible, ensure price stability; that access charges for use of a transmission or distribution system shall be based upon comparable charges for comparable use; that no customer class should pay more to a licensee than is justified by the costs it imposes upon such a licensee; and that tariffs should enhance efficiency in electricity consumption and should encourage supply that is adequate to satisfy demand.

Regulated tariffs and charges may include automatic tariff adjustments, as approved by EWURA to reflect periodic changes in the cost of fuel; changes in the cost of power purchases or the rate of inflation; and currency fluctuations. EWURA may, however, prescribe maximum tariffs of a generic nature or employ simplified tariff methodologies for special licensees or persons such as those involved in renewable energy technologies.

7.3.7 Financing Framework

According to the National Policy of 2003, the energy sector represents a substantial part of the national economy. The Government shall therefore strike a balance between the use of the energy sector for revenue generation and the need for affordable energy, by limiting the impact of high taxes, levies and other duties on energy production costs. This balance could include strict cost pricing in the markets of major energy products, as well as measures to meet the requirements of the sector for subsidies, incentives and other costs, which need to be covered within the sector itself or by the national state budget. The cost of energy represents a significant part of the total cost structure of companies. Consequently, it affects the competitiveness of products in domestic as well as export markets. Cost effectiveness in the production and supply of energy may be achieved through continued opening up and liberalization of energy markets and further introduction of competition at all levels of the sector. The elimination of cross-subsidization from large energy consumers to households and other smaller consumers will go a long way towards improving product competitiveness in the marketplace.

7.3.8 Existing Generation System

TANESCO operates an interconnected grid system comprising hydropower and thermal generating units. The hydro capacity is comprised of six TANESCO hydro plants with a total nameplate capacity of 561 MW. The installed capacity of thermal generating equipment within the Tanzanian grid totals 478 MW, for a total nameplate capacity of 1,039 MW.

Table-7.3-1 Tanzanian Hydro and Thermal Installed Capacities

Plant name	**Nominal Capacity MW**	**Installation year**
HYDRO		
Mtera	80	1988
Kidatu	204	1975
Hale	21	1967
Kihansi	180	2000
Pangani Falls	68	1995

Nyumba Ya Mungu	8	1968
Subtotal	561	
THERMAL		
SONGAS I (2 units)	40	2004
SONGAS II (3 units)	120	2005
SONGAS III (1 units)	40	2006
Tegeta IPTL (4)	100	2002
Ubungo Wartsila	100	2007
Ubungo Diesel	34.37	1980
Zuzu Diesel	7.44	1980
Iyunga Diesel	13.90	1980
Tabora Diesel	10.20	1980
Nyakato Diesel	12.5	1980
Subtotal	478.41	
Grand Total	1,039.41	

(Source) Tanzania Power Sector Master Plan

In the dry year the hydro capacity is reduced, leading to deficits that are met by expensive diesel emergency power plants or power rationing.

7.3.9 Existing Transmission and Distribution System

In December 2009, the transmission network down to 66kV was as shown in Table-7.3-2. The total electricity access then was estimated at 10%, with urban and rural access at 14% and 1% respectively.

Table-7.3-2 Transmission Lines in km

	2006	**2007**	**2008**	**2009**
220kV Line	2,624	2,624	2,624	2,624
132kV Line	1,435	1,435	1,435	1,435
66kV Lines	546	546	546	546
Total number of customers	721,538	905,816	1,030,362	

(Source) Study Team compiled from TANESCO data

7.3.10 Existing Customers

The increase in the number of connected customers has averaged over 10% per annum in the period 2004 to 2008, as shown in Table-7.3-3. This trend is likely to continue as more investment is made in rural electrification, as a part of the poverty reduction strategy.

Table-7.3-3 Number of Customers 2004 – 2008

	2004	2005	2006	2007	2008
Total number of residential connections	605,796	662,140	719,505	903,862	1,028,197
Total number of commercial (or medium voltage) customers	1,455	1,478	1,519	1,613	1,849
Total number of industrial (or high voltage) customers	341	349	356	374	390
Total number of connections	607,545	663,909	721,538	905,816	1,030,362

(Source) Study Team compiled from TANESCO data

7.3.11 Electricity Tariffs

A review of the tariff structures shows that there have been several major changes in structure during the last 20 years with the objective of making the prices reflect the cost of supply. In 1995, the structure was changed significantly with the introduction of a new T 1 Tariff (General Use) grouping together the loads from the previously separate residential, small commercial and light industrial categories; the introduction of a new T 2 Tariff (Low Voltage Supply) and a new T 3 Tariff (High Voltage Supply) bringing together the previously separate categories of High Voltage Supply and High Intensive Supply Energy. In 2003, Tariff T 1 was split into D 1 (domestic low usage) and T 1 (general use), to which public lighting was added. In 2008 only the tariff rates changed. The level of tariffs has also registered increases to close the gap with the marginal cost of supply.

The current tariff (2010), extracted from the TANESCO website, is summarized in Table-7.3-4 below:

Table-7.3-4 TANESCO Tariffs in Equivalent US Dollars
(Exchange rate US$ 1 = TSh 1,393.14 on 20 June 2010)

	Domestic Low Usage	General Usage	Low Voltage Max	High Voltage Max	
	(D1)	(T1)	(T2)	(T3)	Zanzibar
Low Energy (0-50kWh) - per kWh	0.04				
Low Energy (0-50kWh) - per kWh	0.11				
Service Charge per Month		1.65	6.13	6.10	6.13
Demand Charge per kVA			6.71	6.22	3.41
Energy Charge per kWh		0.09	0.06	0.06	0.05

NOTE: All the charges above exclude VAT and EWURA charges

(Source) http://www.tanesco.co.tz/index.php?option=com_content&view=article&id=63&Itemid=205

7.3.12 Electricity Demand Forecast

Electricity demand has continued to register positive growth of about 6.4% per annum over the last eight years. Due to drought, the available capacity has been inadequate to meet demand, resulting in the substitution of expensive emergency power to meet the shortfalls. Table-7.3-5 below gives a summary of demand and energy production forecasts.

Table-7.3-5 Electricity Demand

Year	Peak demand MW	Energy GWh
2010	900	5,319
2015	1,471	8,570
2020	2,202	12,761
2025	3,177	18,283
2030	4,726	26,969
2033	6,047	34,511

(Source) Study Team compiled from TANESCO data

7.3.13 Generation Capacity Expansion

The Power Sector Master Plan of 2009 identifies an expansion program dominated by hydro, imports, and coal or gas-fired plants, as shown in Table-7.3-6 below.

Table-7.3-6 Capacity Expansion Plan

Year	Plant	Fuel	Type	Addition	
				MW	GWh
					Firm
2009	Tegeta GT (October)	Gas	GT	41	70
2010	Tegeta IPTL	Gas	Diesel	100	701
	Tegeta GT	Gas	GT		212
2011	Mwanza MS diesel	Biomass,	Diesel	60	420
	Cogen Ubungo	Gas	Steam	40	280
	EPP	Gas	GT	100	701
2012	Wind	Wind	Wind	50	217
2013	Kiwira	Coal	Steam	200	1289
	Kinyerezi Gas	Gas	GT	240	1648
2015	Rusumo Falls	Hydro	Hydro	21	129 1
	Interconnector I	Import	Import	200	374
2016	Ruhudji	Hydro	Hydro	358	1,333
	Igamba 2	Hydro	Hydro	8	260
2017	Mnazi Bay	Gas	GT	300	2,060
	Mtwara	Gas	GT	12	82
2018	Rumakali	Hydro	Hydro	222	908
2020	Stieglers Gorge I	Hydro	Hydro	300	1,908

2021	Interconnector II	Import	Import	200	1,374
2022	Retire Tegeta IPTL	Fuel	Diesel	(100)	(687)
2023	Stieglers Gorge II	Hydro	GT	600	855
	Retire Kinyerezi Gas	Gas	GT Diesel	(240)	(1,648)
	Kinyerezi HFO	Fuel		240	1,648
2024	Ngaka 1 and 2	Coal	Steam	400	2,579
	Retire Songas 1+2+3	Gas	GT	(187)	(1,284)
2025	Mchuchuma 1 and 2	Coal	Steam	400	2,579
2026	Stieglers Gorge III	Hydro	Hydro	300	646
2027	Nyasa coal	Coal		200	1,374
	Kakono	Hydro	Hydro	53	335
2028	Masigira	Hydro	Hydro	118	810
	Local gas	Gas	GT	200	1,374
	Mpanga	Hydro	Hydro	144	464
2029	Retire Ubungo GT	Gas	GT	(100)	(687)
	Local coal	Coal	Steam	300	2,060
2030	Retire Tegeta GT	Gas	GT	(41)	(282)
	Coastal Coal I	Coal	Steam	300	2,102
	Ikondo -Mnyera	Hydro	Hydro	340	1,316
2031	Coastal Coal II	Coal	Steam	300	2,102
	Retire Mwanza Ms Diese	Fuel	Diesel	(60)	(420)
	Retire Ubungo EPP	Gas	GT	(100)	(687)
	Retire Cogen	Biomass	Steam	(40)	(275)
	New Cogen	Biomass	Steam	40	275
	Taveta – Mnyera	Hydro	Hydro	145	622
2032	Coastal Coal III	Coal	Steam	300	2,102
	New Wind	Wind	Wind	50	217
	Retire Wind	Wind	Wind	(50)	(217)
	Coastal Coal IV	Coal	Steam	300	2,102
2033	CC LNG	Coal	Steam	174	1,219
	CC LNG	LNG	CC	174	1,219
	CC LNG	LNG	CC	174	1,219
	Retire Kinyerezi	Gas	GT	(240)	(1,648)
	TOTAL ADDITIONS 2009-2033			6,546	36,354

(Source) TANESCO (2009)

7.3.14 Role of IPPs in the Generation Expansion Plan

Following liberalization of the sector, a number of IPPs are participating in the oil or gas-fired thermal plant generation market. There is therefore experience available that could help in enhancing the participation of the private sector in the implementation of the power master plan.

7.3.15 Geothermal Energy in the Generation Expansion Plan

The Power Sector Master Plan refers to a rural electrification study, indicating that 20 potential geothermal sites had been previously assessed, and that the study identified three sites as most promising and proposed more detailed investigations of them. These are:

· Lake Natron in the Arusha region

· Songwe river basin in the Mbeya region

· Luhoi Spring area in the Lower Rufiji Valley, Utete district.

The Luhoi Spring site is under concession to a developer (First Energy Company). The report concluded that the Luhoi site was very promising, with a potential for plant sizes of 50 to 100 MW, and that the Songwe site had similar potential. The Lake Natron site was judged to have less potential. There is insufficient information to specify a geothermal site as a firm candidate for the short-term or midterm in The Power Sector Master Plan. However, given the importance of using indigenous Tanzanian resources, the report says that the next Power Sector Master Plan update could include a 100 MW geothermal plant as a candidate for 2025 or later. Generic or typical generation and cost data based on the Kenyan experience could be used.

7.3.16 Transmission Capacity Expansions

The Power Sector Master Plan of 2009 further identifies transmission additions required to connect planned generation facilities to the grid and for load transfers, as presented in Table-7.3-7.

Table-7.3-7 Transmission Line Expansion Plan (2010 – 2033)

From	To	kV	No. of Circuits	Length (km)
Shinyanga	Singida	400	3	200
Singida	Dodoma	400	3	210
Dodoma	Iringa	400	3	130
Morogoro	Tanga	400	2	200
Arusha	Tanga	400	2	335
Kiwira	Mbeya	220	2	120
Kinyerezi	Ubungo	220	1	15
Babati	Arusha	400	2	162
Singida	Babati	400	2	150
Iringa	Mufindi	400	3	130
Mufindi	Makambako	400	1	73
Ubungo	Stieglers	400	1	200
Mbeya	Rumakali	220	1	150
Makambako	Rumakali	220	1	200
Mufindi	Ruhudji	220	1	100
Kihansi	Ruhudji	220	1	150
Bulyanhu	Geita	220	2	150

Geita	Nyakanzi	220	2	133
Nyakanzi	Rusumo	220	1	95
Mwanza	Shinyanga	400	2	140
Mbeya	Makambako	400	1	147
Makambako	Mchuchuma	400	1	200
Mufindi	Mchuchuma	400	1	220
Stieglers	Dar-2	400	1	160
Dar-2	Morogoro	400	2	179
Stieglers	Mtwara	400	2	400
Ubungo	Dar-2	400	1	50
Rusumo	Kakono	220	1	150
Rusumo	Kyaka	220	1	168
Masigira	Makambako	220	2	180
Taveta	Ikondo	400	2	5
Ikondo	Mufindi	400	2	150
Kihansi	Mpanga	220	2	40
Arusha	Kenya Borders	400	2	150
Zambia Borders	Mbeya	400	2	120

(Source) Tanzania: Power Sector Master Plan update 2009

7.3.17 Conclusion

The major challenges facing the power sector include the need for diversification of generation sources to minimize the risks of fluctuating hydropower to the economy; the need to address poor reliability of supply; the need to mitigate the high generation costs faced by IPPs and other thermal plants (being mitigated by conversion from fuel to gas); the need to remedy the low access to electricity of the citizens; and the need to mobilize huge financial resources for capacity expansion over the medium and long term.

The data for Tanzania indicate a huge potential for private sector participation in the development of the country's least-cost power resources to meet rising demand and increase electricity access to most of the population as part of the national effort to reduce poverty and attain the MDGs (Millennium Development Goals) by 2015.

Although interest in geothermal has been expressed in the context of renewable technologies for meeting the increased demand and enhanced electricity access targets, the present level of exploration is such that no geothermal plants are included in the least-cost development plan.

7.4 Geothermal Resources

There are more than 15 geothermal areas in Tanzania, but a nationwide survey has not yet been carried out. Thus, the geothermal potential in Tanzania is only conjectured to be about 650MW (McNitt, 1982) based on UNDP research conducted by an American organization in the 1980's. Tanzanian power supply public corporation (TANESCO) has 5 main geothermal fields to develop, whose order of priority and current state of surveying is shown for each field in Table-7.4-1. The Mbeya region, where the priority is the highest and where investigations have progressed to the Pre-FS stage in five areas, is described in detail below.

Table-7.4-1 Current state of the survey of geothermal fields in Tanzania

Site	Order*	Geology	Geophysics	Geochemistry	Remarks
Mbeya (Songwe-Rungwe) Complex	1.	Re	Pre-FS	Pre-FS	Geotherm(2008)
		Re	Re	nil	Decon/Sweco (2005)
		nil	nil	Re	Mnzava et al. (2004)
		nil	nil	Re	Hochstein et al. (2000)
		Re	Re	Re	Sweco and Virkir (1978)
Rukwa Block	2.	nil	nil	Re	Hochstein et al. (2000)
		Re	Re	Re	Sweco and Virkir (1978)
Kisaki & Rufiji Block	3.	Re	nil	Re	MEM,GST,REA+Tanesco(2009)
		nil	nil	Re	Hochstein et al. (2000)
		Re	Re	Re	Sweco and Virkir (1978)
Eyasi - Ngorongoro – Natron Block	4.	Re	Re	nil	Decon /Sweco (2005).
		nil	nil	Re	Hochstein et al. (2000)
		Re	Re	Re	Sweco and Virkir (1978)
Dodoma – Singida – Kondoa Block	5	nil	nil	Re	Hochstein et al. (2000)
		Re	Re	Re	Sweco and Virkir (1978)
Potential sources outside rift valley	6	nil	nil	Re	Hochstein et al. (2000)
		Re	Re	Re	Sweco and Virkir (1978)

*Order of priority for future development
Re: Reconnaissance
Pre-FS: Pre Feasibility Study

(Source) TANESCO (2009)

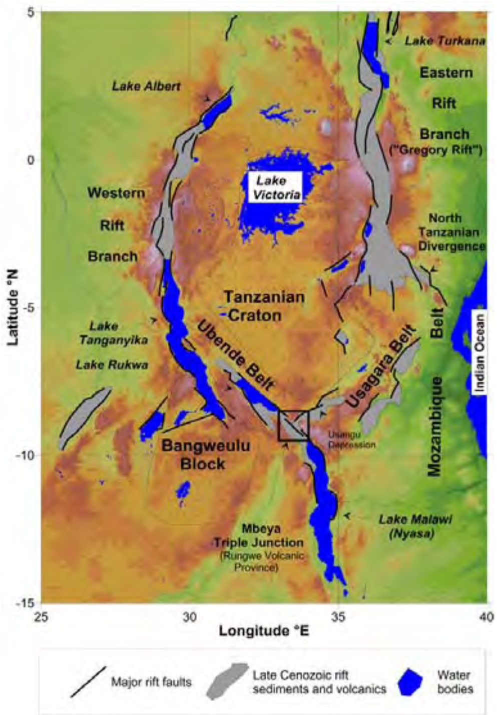
7.4.1 Mbeya geothermal field

The Mbeya region was investigated by BGR (BGR, 2008). It is located in the Rungwe volcano State Mbeya district, southwest of Tanzania (Fig.-7.4-1). Based on the measurement of the geological age of the Songwe travertine, geothermal activity in the main region is thought to have begun about 360,000 years ago with volcanic activity. Today, there are a lot of faults, hot springs, and volcanoes in the field (Fig.-7.4-2). The chemical content of hot spring water shows a mixture of deep geothermal water and shallow water near the surface (Fig.-7.4-3 and 4). The reservoir temperature is calculated to be 200^{o}C or more, based on the chemical analysis of hot spring water (Fig.-7.4-4). In terms of geophysical exploration, a TEM investigation has been executed (Fig.-7.4-5), and the subsurface structure has been clarified. Moreover, a fluid flow model and a geothermal structural model have been constructed on the basis of these surface survey results (Fig.-7.4-6 and 7). Geothermal fluid is thought to be stored under the Poroto mountains, including Nzogi volcano, and is thought to outflow to the west or northwest into the Songwe valley through a crack with a good permeability.

However, no geothermal wells have yet been drilled, nor has the geothermal potential been estimated, so a development plan has not been decided yet.

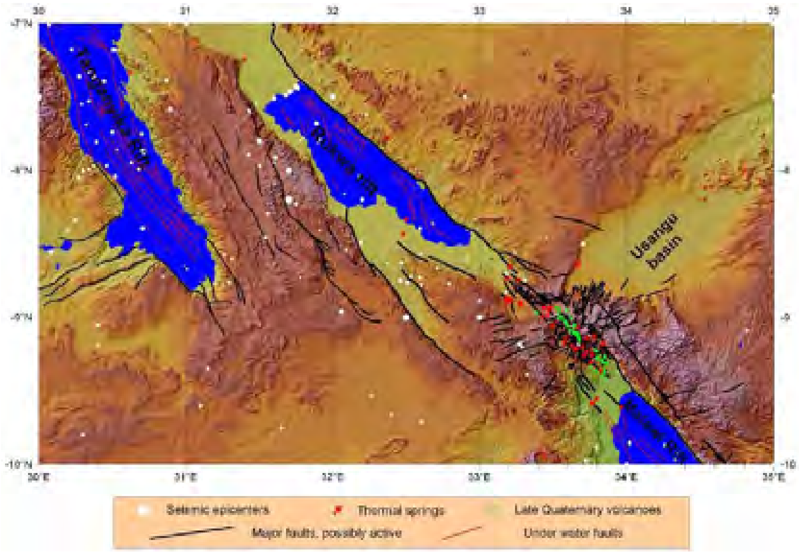
It should be noted that an MT survey will be conducted by BGR late in 2010.

The evaluation sheet for the Mbeya geothermal field is shown in Annex-4-1.



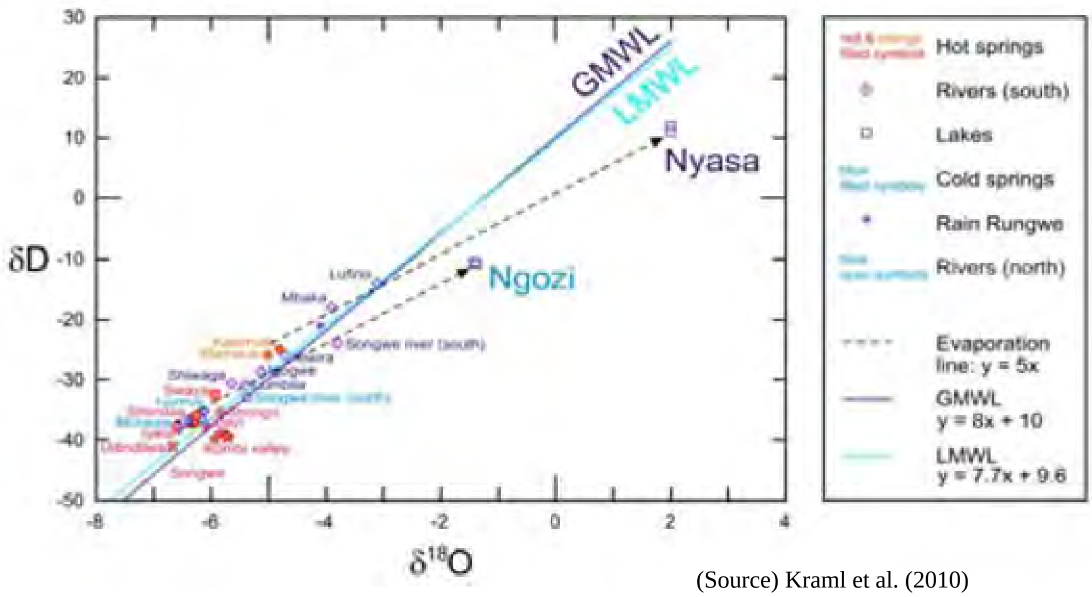
(Source) Delvaux et al. (2010)

Fig.-7.4-1 Location of Mbeya (Tanzania) geothermal field



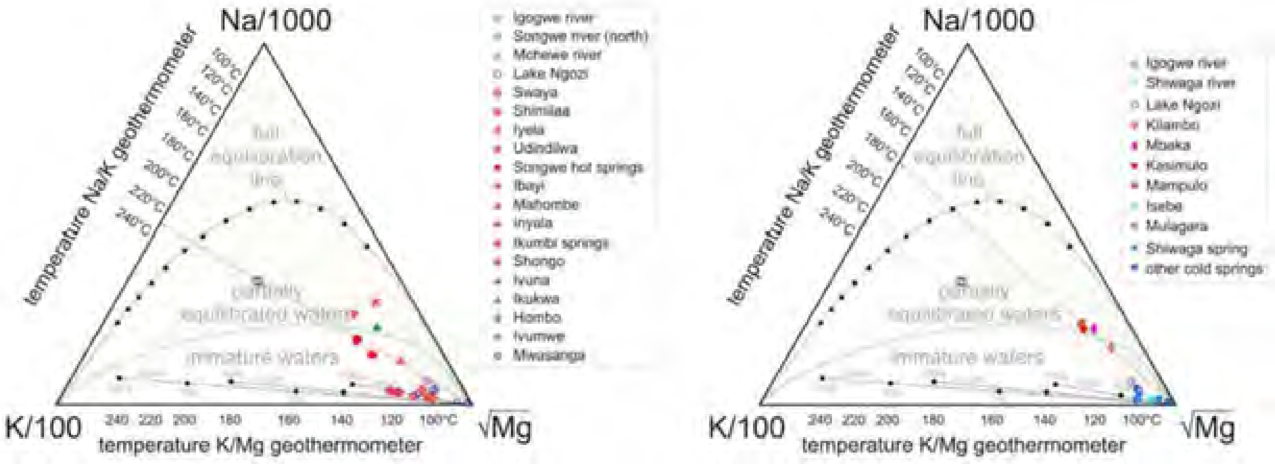
(Source) Delvaux et al. (2010)

Fig.-7.4-2 Distribution of faults, hot springs and volcanos in the Mbeya region



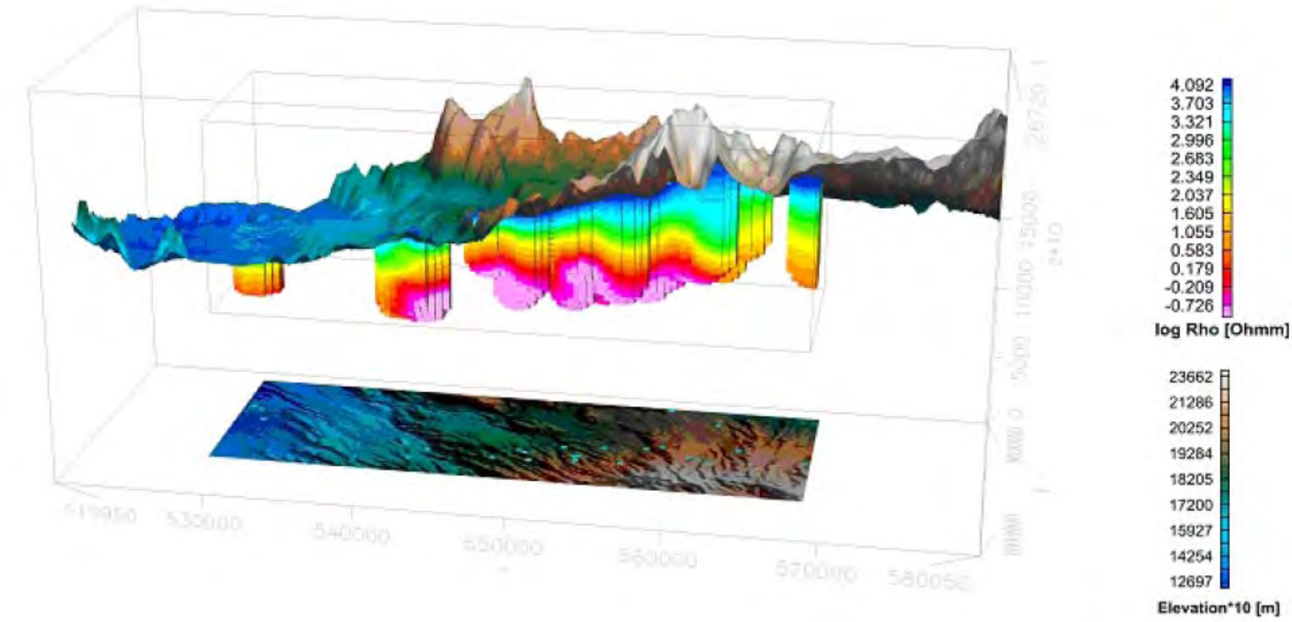
(Source) Kraml et al. (2010)

Fig.-7.4-3 Delta-D / Delta ^{18}O diagram of hot spring water in Mbeya region



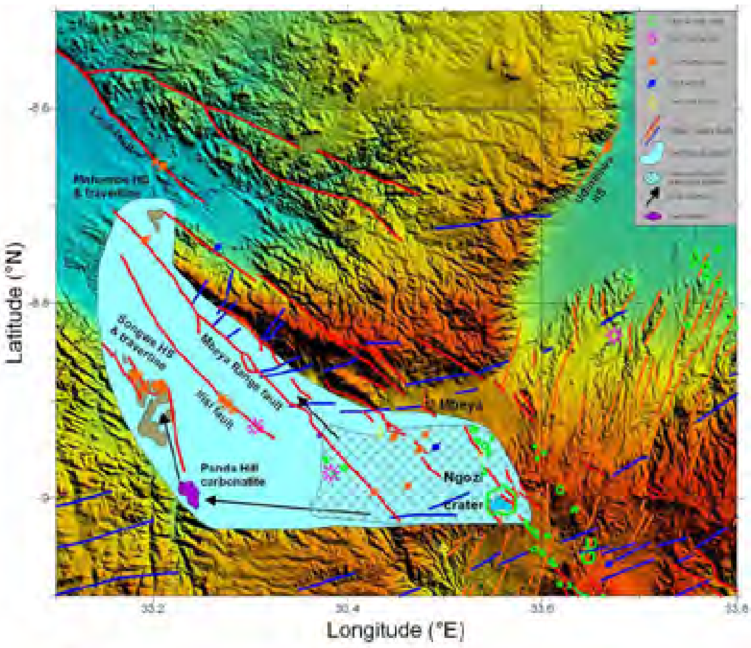
(Source) Kraml et al. (2010)

Fig.-7.4-4 Trilinear diagram of Na-K-Mg of hot spring water in Mbeya region



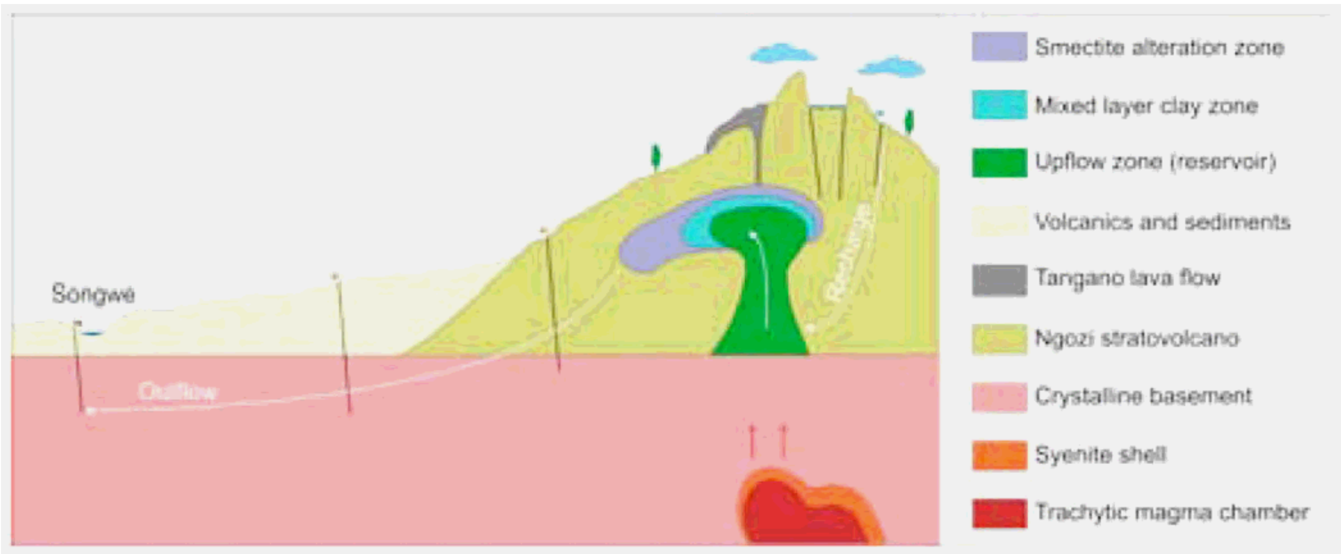
(Source) Kalberkamp et al. (2010)

Fig.-7.4-5 TEM survey result in Mbeya region



(Source) Delvaux et al. (2010)

Fig.-7.4-6 Fluid flow model (plain) of Mbeya region



(Source) Kalberkamp et al. (2010)

Fig.-7.4-7 Geothermal conceptual model (section) in Mbeya region

7.4.2 Other geothermal fields

In addition to Mbeya, the Rukwa, Kisaki & Rufiji, Eyashi-Ngorongoro-Natron, and Dodoma-Singida-Kondoa geothermal fields have been the subject of general geological, geochemical, and geophysical surveying. In these areas, new volcanic activity and geothermal manifestations are reported, but detailed surveys of these data- poor areas will be necessary to confirm the geothermal potential for development.

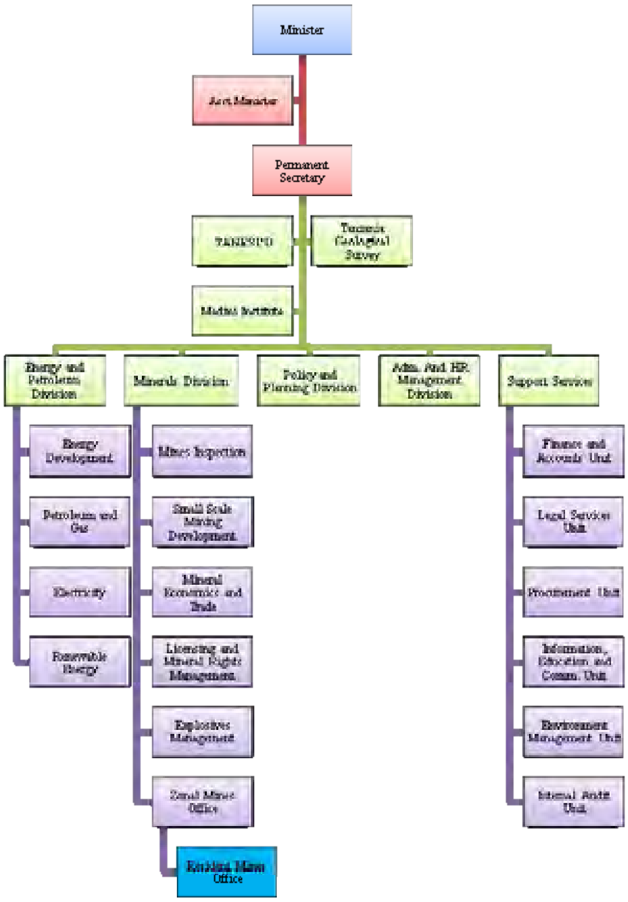
7.5 Technical capacity

7.5.1 Ministry of Energy and Mineral Resources

Fig.-7.5-1 shows the organizational structure of the Ministry of Energy and Minerals in Tanzania. Geothermal activities within the Ministry are handled by the Energy and Petroleum Division, specifically its Renewable Energy Section. The Renewable Energy Section is headed by an Assistant Commissioner and has five subsections, namely Geothermal, Solar, Wind, Small Hydro and Biomass. Currently there are two Geologists who are responsible for geothermal activities in the Ministry. One geologist has taken the UNUGTP course in Iceland and the other has taken the 4-week Naivasha short course in Kenya. About seven other staff have been previously trained in geothermal in New Zealand, Pisa and Iceland, but six of them are working in other areas and one has recently retired from the Geological Survey of Tanzania (GST). One staff member has a PhD degree in Geophysics, but is no longer working in geothermal, although she is still in the Ministry in a different department.

7.5.2 The Geological Survey of Tanzania (GST)

GST is located in Dodoma, about 600km from Dar es Salaam, and is responsible for carrying out the actual technical surface exploration work in Tanzania. The organizational structure of GST is given in Fig.-7.5-2. The staff involved in geothermal exploration work is members of the Applied Geology Section. Geochemical and geological laboratory assistance services are provided by the Laboratory Services Section. The laboratory was established to study mineral chemistry rather than water and steam geochemistry. Therefore the relevant equipment for chemical analysis of geothermal gas and water is required. Table-7.5-1 shows the professionals involved in geothermal, although it should be noted that they are utilized in other areas whenever there is no geothermal work for them. Currently one geologist has been working towards a PhD degree in Italy since 2009.



(Source) Study Team

Fig.-7.5-1 Ministry of Energy and Minerals of Tanzania Organizational structure

Table-7.5-1 Available professional skilled manpower in Tanzania

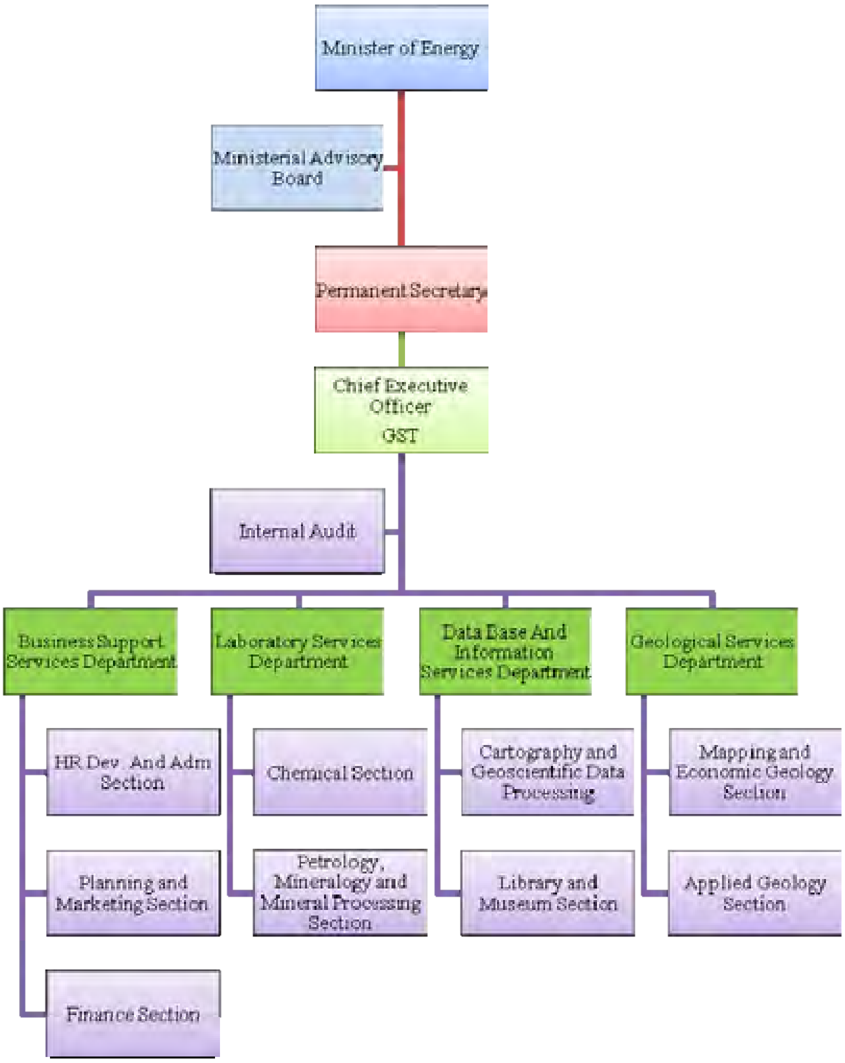
	MEM	GST	TANESCO	TOTAL
Geologist	2	4	2	8
Geochemist	1	1		2
Geophysicist	1	6		7
Reservoir Engineer		1		1
Drilling Engineer		0		0
Power Engineer				0
Environmental Scientist		3		3
Financial Planner/Modeller				0
GIS Scientist		1		1
Drillers				0
Technicians		13		13
Total	4	29	2	35

(Source) Study Team

Table-7.5-2 Available equipment in Tanzania

Equipment Description	Available	Equipment Description	Available	Equipment Description	Available	Equipment Description	Available
Geological		**Geochemical**		**Geophysical**		**Drilling**	
Simple GPS	5	Simple GPS	1	Differential GPS	0	Complete Rig	0
Digital Thermometer	0	Digital Thermometer	0	Simple GPS	1	Water supply system(pumps, pipelines, tanks)	0
Fluid Inclusion Heating-freezing stage	0	pH meter	1	TEM	1	Site preparation equipment (dozer, grader, tipper trucks)	0
Binocular Microscope	1	Conductivity Meter	1	MT	0	Small water rig	0
Petrographic Microscope	2	Water Sampling Kit	0	Gravimeter	0	**General**	
X-Ray Diffractometer	1	Gas Sampling Kit	0	Magnetometer	1	4x4 field vehicles	2
X-Ray Flourescence	0	AAS	2	Portable seismometer	0	GIS System	0
ICP-MS	1	Ion Chromatograph (IC)	0	**Reservoir Engineering**		Total station	0
Thin sectioning equipment	2	Gas Chromatograph	0	Kuster gauge Tools set	0	Complete weather station	0
		Mass Spectrometer for stable Isotope	0	Kuster TPS with SRO	0		
		Tritium Scintillation counter & C14 analyser	0	Logging Winch	0		
				Logging Truck (K10)	0		
				Discharge Silencer	0		

(Source) Study Team



(Source) Study Team

Fig.-7.5-2 Geological Survey (Ministry of Energy and Minerals) of Tanzania Organizational structure

Table-7.5-2 shows the equipment currently available for field surveys and laboratory work. Several pieces of equipment are critically required, for example water and gas sampling apparatus, iron and gas chromatographs, MT equipment, a gravimeter and microseismic equipment. If the geothermal surveying proceeds to the feasibility stage, well-testing equipment will be required as well.

7.5.3 TANESCO

TANESCO has two Engineering Geologists in its Department of Research and Environment. One of these geologists has been trained in Iceland, and the other has attended the short course in Naivasha, Kenya. They have no equipment of their own, but they are usually involved in geothermal exploration work as a part of the Geothermal Working Group together with the staff of GST and the Renewable Energy Section at the Ministry of Energy and Minerals. TANESCO has no mandate to develop geothermal resources and does not have an annual budget for this purpose.

7.5.4 Rural Energy Authority

Although they do not have staff for geothermal exploration, the Rural Energy Authority (REA) has been interested in the development of geothermal, particularly small size power plants for rural electrification. They believe that geothermal offers the best opportunity for this type of plant. DECON, SWECO and Inter-consult (2005) carried out some preliminary studies on geothermal resources in Tanzania in 2005 for a Master Plan for Tanzania Rural Electrification Study. The study was financed by the African Development Bank (AfDB). The study recommended further detailed work in the Mbeya area, which was later undertaken by BGR in their Geotherm I programme. Later, in 2009, the Rural Energy Authority prepared a Concept Note in collaboration with MEM, GST, the University of Dar es Salaam and TANESCO to solicit funding from the World Bank for exploration drilling (Rural Energy Agency 2009). There has not been any further progress on this proposal to date.

7.5.5 IPPs

The local company known as First Energy Company Ltd (FEC) was licenced by the government to explore for geothermal resources at Ruhoi in the Rufiji trough area (Business Council for Sustainable Energy 2003). FEC has carried out preliminary investigations, reviewing the available literature, geophysical information and petroleum well data, from which they established that the area has potential for geothermal development. Unfortunately, they have not found any local or overseas investors who could support their project. Our attempt to have a meeting with FEC was not fruitful and email communication has remained unanswered.

7.5.6 Consultants

There are no local or foreign consulting companies or individuals involved in geothermal work.

7.6 Energy Policy

The Tanzanian government promulgated "The Tanzania Development Vision 2025" as a national development strategy in 1999. This strategy was designed to achieve the following three aims: (1) improvement in the quality of life, (2) formulation of healthy and balanced policy and law, and (3) establishment of a competitive economy. In addition, the development strategy for each sector was presented. As for infrastructure development, the energy sector was given the second-highest development priority, following only the road sector and one item of the strategy is that it is important to attract investment not only from government but also from domestic and foreign investors. Currently, the energy policy has been formulated in accordance with this strategy.

The first National Energy Policy for Tanzania was formulated in 1992. Since then, energy sub-sectors, as well as the overall economy, have gone through structural changes, and hence, in February 2003, a revised "National Energy Policy" was published, reflecting structural changes in the economy and political transformations at the national and international levels. Specifically, the revised energy policy takes into consideration the need to

(1) have affordable and reliable energy supplies in the whole country.
(2) reform the market for energy services and establish an adequate institutional framework to facilitate investment, expansion of services, efficient pricing mechanisms and to offer other financial incentives.
(3) enhance the development and utilization of indigenous and renewable energy resources and technologies
(4) adequately take environmental considerations into account for all energy activities
(5) increase energy efficiency and conservation in all sectors
(6) increase energy education and build gender-balanced capacity in energy planning, implementation and monitoring

According to the Tanzania National Energy Policy of 2003, the policy objectives are to ensure the availability of reliable and affordable energy supplies and their use in a rational and sustainable manner in order to support national development goals. The national energy policy, therefore, aims to establish efficient energy production, procurement, transportation, distribution and end-use systems in an environmentally sound and sustainable manner.

The challenges to be addressed are,

(1) to meet the requirement for an expanded electricity supply and distribution infrastructure by inviting private investment.
(2) to promote petroleum development through private sector participation.
(3) to strengthen regional interconnection.
(4) to promote rural electrification for the purpose of achieving balanced socio-economic growth for all.
(5) to improve energy supply to rural households, especially to reduce the burden on women and to

reverse deforestation through energy efficiency in cooking and lighting.

As the actual implementation program to achieve the goals, the following goals are being pursued:

(1) to introduce a market economy in the energy sector

(2) to establish an independent regulatory system

(3) for the government to assume an appropriate role in the market

(4) to develop international interconnection transmission lines

(5) to improve energy conservation and energy resource efficiency

(6) to implement environmental management by addressing issues and hazards noted in the environmental impact assessments for energy projects.

(7) to encourage women to get involved at all levels of the energy sector

(8) to eliminate subsidies on energy through liberalization of a competitive market while balancing the need for revenue generation and need for affordable energy.

(9) to develop and apply appropriate technologies

(10) to formulate a comprehensive regulatory framework

For the power sector, the policy is aimed at the following objectives:

(1) to provide affordable and reliable electricity

(2) to promote rural electrification

(3) to promote private investment in development projects and open the generation business fully to IPPs

(4) to promote regional co-operation and integration to ensure reliable supply, exploit low-cost energy and balance the erratic availability of hydro-based power.

(5) to develop the domestic power generation capacity based on indigenous resources

(6) to implement environmental measures

The Energy and Water Utilities Regulatory Authority (EWURA), whose vision is “Quality, affordable and sustainable energy and water services for all”, is an autonomous multi-sectoral regulatory authority established by the Energy and Water Utilities Regulatory Authority Act, Cap 414. It is responsible for technical and economic regulation of the electricity, petroleum, natural gas and water sectors in Tanzania pursuant to Cap 414 and sector legislation. Since the beginning of its operation, EWURA’s biggest challenge has been setting up the office and taking up its main regulatory functions, like setting up the rules and licensing.

According to the EWURA website, the functions of EWURA include, among others: licensing, tariff review, monitoring performance and standards with regard to quality, safety, health and the environment. EWURA is also responsible for promoting effective competition and economic efficiency, protecting the interests of consumers and promoting the availability of services in the regulated sectors to all consumers, including low-income, rural and disadvantaged consumers.

In order to encourage the development of its vast renewable energy resources, Tanzania offers attractive financial terms to potential investors. It has simplified the procedures for investing in solar, wind and micro-hydro projects and has introduced a 100% depreciation allowance in the first year of operation and an exemption from excise duty and sales tax and concessionary customs duty on the first import of materials used in renewable energy projects. In addition extensive guarantees are provided to investors under the investment promotion center's certificate of approval, such are guarantees concerning property rights, the dispensation of assets, and the repatriation of income. Tanzania is also a member of multilateral agencies able to arbitrate in disputes concerning investors, notably the World Bank's Multilateral Investment Guarantee Agency (MIGA) and the International Center for Settlement of Investment Disputes (ICSID).

Also relevant to the development of renewable energy in Tanzania, the Rural Energy Agency and Rural Energy Fund were established under Rural Energy Act No.8 of 2005. REA is governed by a Board of Directors (the Rural Energy Board) from the Ministry of Finance, PMO RALG, Private Sector Foundation, Tanzania Bankers' Association, Consumers' Association, Civil Society, the Ministry of Energy and Minerals and Development Partners. The role of agency/fund is:

(1) to promote, coordinate and facilitate private and public sector initiatives and entrepreneurship in rural energy supply;
(2) to ensure continued electrification of rural commercial centers and households;
(3) to promote the accessibility and affordability of modern energy services for low-income groups;
(4) to continue the research, development and application of appropriate rural energy solutions;

Tanzania Energy Development Access Project (TEDAP) provides two types of subsidies to project developers, which are (1) Performance grants and (2) Matching grants. These grants are provided to bring down developers investment costs.

Projects eligible for a Performance Grant are the following:

(1) Grid-connected mini-grids;
(2) Isolated/green-field mini/micro-grids;
(3) Solar Photo-Voltaic (PV) Systems;
(4) Off-grid energy investments including hybrid systems,
(5) Other non-electric energy sources (biomass, biogas, and improved stoves).

Funds cannot be used for the financing or acquisition of existing assets (including land) or refinancing of existing debts or accrued interest.

Eligible project developers are; (1) Any private enterprise, (2) NGOs, (3) the community, (4) co-operatives, (5) individuals operating in Tanzania, registered as a legal entity, and having the capacity to enter into a binding contract under the laws of the United Republic of Tanzania, with sufficient technical, financial management and procurement capacity to implement the proposed project.

Products eligible under the scheme are

(1) Power generators using renewable energy,
(2) Transmission and distribution networks and consumer connections to serve consumers on the

mini-grids

(3) Solar photovoltaic systems ranging from solar lanterns to larger systems to meet household and institutional requirements.

The current subsidies provided under the Tanzania Energy Development Access Project (TEDAP) to support facilities of project developers are as follows:

For Mini-grid projects

(1) USD 500 for each new connection in rural energy projects under mini-grids, and green-field areas;

(2) Maximum amount up to 80% of total investment cost for Commercial PV

(3) An average of USD 2 per Watt-peak for solar PV installations

The payment procedure for the subsidies is as follows:

For Mini-grids, the payment modalities are:

(1) 40% at mobilization and after signing;

(2) 40% after delivery of goods on site;

(3) 20% after approval of customer acceptance receipts by REA

“Matching Grants” are offered for the purpose of providing technical assistance to: (1) Government Institutions (MEM, REA, EWURA, Project Developers), (2) Financial institutions, and (3) Other stakeholders. The eligible forms of assistance provided are training and consultancy services, and the disbursement process is as follows:

(1) First payment after at least fifty percent of the counterpart contribution (in cash) from the project promoter for the assignment has been disbursed and proof of this cleared by REA

(2) First payment is an amount equal to fifty percent (50%) of the agreed level of support

(3) The remaining balance of 50% will be released when a completion report acceptable to REA is submitted, together with supporting evidence of completion and achievement of agreed activities and supporting procurement documentation including TOR;

(4) Payments are based on agreed deliverables in the Grant Agreement

In relation to its promotion of renewable energy, Tanzania ratified the "United Nations Framework Convention on Climatic Changes (UNFCCC)" on April 17, 1996, and then the "Kyoto Protocol" on August 26, 2002. Also, in December 2004, the government designated the "Vice Presidential Department of the Environment (Division of Environment, Vice President's Office)" as the designated national authority (DNA) required by CDM program. The government is compiling the appropriate technology applicable to CDM scheme from the various sectors, including energy, agriculture, industrial processing, waste management, forestry and land use.

7.7 Environmental Policies

National Environmental Management Council (NEMC) under Division of Environment (DOE), which was established based on the National Environmental Management Act (2004), is in charge of enforcement of environmental related legislations and EIA approval. DOE was established in 1994 under Ministry of Natural Resources and Tourism and was placed under the Vice President Office in 1994 to play a inter-ministerial role. Main roles of DOE are to prepare governmental policy on environmental conservation and to provide guidance/guidelines to relevant organizations. DOE is planning to establish Regional Offices. Most of local governmental offices has Environment Coordinator at present. Though NEMC has Zone Offices, it is not functioned enough according to NEMC.

According to NEMC, EIA Act in 2004 and EIA guidelines in 2005 are the latest. There is no plan to revise those. In addition, though there is no sectoral guidelines, there are sectoral checklist (The checklists have not obtained during the study.).

Required period for EIA approval process must not exceed 3 months between submission of EIA report from project proponent to NEMC and issue of approval. Expenses for the EIA approval process is differ depending on the number of the Technical Committee members (10 - 12 members on average. Concrete cost has not been obtained during the study.). Only local entrepreneur who register in NEMC can conduct the EIA study. In the case where foreign firm jointly conducts EIA study with local firm, 200,000 Tanzanian shilling has to be paid to NEMC.

In the case of the EIA for the development project located in the environmental protected area, Tanapa, Tanzania Wildlife Research Institute and Tanzania Forest Research Institute under Ministry of Natural Resources and Tourism are involved. Management of the environmental protected area is differ based on category of the protected area; Fishery Dept. in the case of Marine Protected Area, Division of Nature (Ministry of Natural Resources) in the case of Nature Protected Area, and Division of Forestry (Ministry of Natural Resources) in the case of Forest Protected Area.

Summary of the EIS report in English and Swahili is opened to the public in the occasion of the public hearing. Main locations of the dissemination are NEMC office, District office, and Project office. Up on request, original volume of the EIS report is opened. Period and frequency of the environmental monitoring are determined as per features of the project. Public consultation under EIA procedure means consultation with project-affected persons. According to DOE, though the consultation is supposed to be conducted one time after the EIS review, additional consultation can be conducted in the timing of EIA scoping process per the JICA environmental guidelines.

Approval process of the EIA is the following steps; 1) application of EIA by the project proponent with submission of EIS report, 2) NEMC’s advise to DOE based on review, 3) Review by DOE, and 4) EIA approval by Minister of State.

Though EIA approval for small-scale development project is supposed to be conducted by local government, capacity for the review is not enough at present. There were cases where villagers objected to the project after the EIA approval. In such cases, DOE has advised to the project proponent to have adequate communication with villagers.

Land acquisition and resettlement is under jurisdiction of Ministry of Land and Human Settlement Development. Land acquisition process is enforced based on the Land Act. There was a court case in a shrimp culture project due to resettlement issue.

According to DOE, there are many active environmental NGOs in Tanzania in cooperation with DOE. NGO requires to register in Formal Affairs.

7.8 Direct Utilization of Geothermal Energy

There is no information on current utilization of the direct utilization of the geothermal energy in Tanzania. Since geothermal power development has not been implemented in Tanzania, there is no case on utilization of surplus hot so far. There would be potential of direct utilization of the geothermal energy such as hot water in future in Tanzania, like that in Kenya, since climate condition in Tanzania is relatively similar to that in Kenya.

Chapter 8 Uganda

8.1 Country Outline[1]

On the political front in Uganda, following independence in 1962, there was a series of coups d'état that plunged the internal affairs and the economy of the country into turmoil, but after 1986, the political situation stabilized and has remained stable under the long-lasting administration of President Yuseri Museveni. In 2005, a referendum led to the restoration of multi-party politics in time for the February 2006 Presidential elections, in which Museveni won a landslide. Campaigning for the 2011 elections has already begun.

There were some undemocratic irregularities in the 2006 election that had an effect on foreign donor support, but since then relations between the administration and donors have been quite good. Although the government has been making efforts to improve governance through civil society participation in planning and budgetary decisions, the creation of anti-corruption courts, and the strengthening of the auditing of government expenditures, there is increasing pressure both from inside and outside the country for greater transparency in the conduct of elections and a more forceful approach to the problem of deep-seated corruption.

The activities of the anti-government insurgency known as the Lord's Resistance Army in the northern part of the country over a twenty-year period at one time produced as many as two million internal refugees, but these activities are coming to an end, and the security situation in the country has been greatly improved with the progress in peace negotiations since 2006, with the result that today the number of internal refugees living in camps has fallen to about 600,000 (2009, "UN Consolidated Appeal Process"). To deal with the challenges of ensuring the early return of the remaining internal refugees and providing support to returned refugees for recovery and development, a serious Peace, Recovery and Development Plan (PRDP) for northern Uganda was launched in July 2009.

On the economic front, as a result of the positive acceptance of the various structural adjustment programs conducted by the IMF and the World Bank since the latter half of the 1980's, the economic reforms carried out by the Ugandan government have succeeded, and since the 1990's the macroeconomic situation has been stable. In May 2000, as a part of the completion of Uganda's HIPC status, Uganda's main creditors forgave many of its debts, with Japan leading the way by forgiving a 6.247 billion yen loan. In addition, on the basis of the Multilateral Debt Relief Initiative agreed at the 2005 Glen Eagles G8 summit meeting, measures for Ugandan debt relief were taken, and the ratio of public foreign debt to GDP fell from 57% to 13% over a two-year period.

[1] Source: International Cooperation Bureau, Ministry of Foreign Affairs, Japan: Official Development Assistance (ODA) countries data book 2009

At present, the country is working hard towards steady macroeconomic management. Although there has been no change in Uganda's status as a poor, low-income country, the government has launched a policy of "Prosperity for All", the income of farmers is improving, and the government is aiming at private sector-led economic growth through the encouragement of trade and investment. As a result of these efforts, since 2000 the GDP growth rate has reached an annual average of 7.8%, although due to the effects of the worldwide economic recession since 2008, a growth rate of 6% was anticipated for 2009. It should also be noted that about 77% of the workforce is engaged in agriculture, which in 2008 accounted for 11% of GDP and 38% of exports. In addition, the population growth rate is a high 3%, and in 2007 31% of the population lived in poverty.

The "Poverty Eradication Action Plan (PEAP)", an inclusive poverty reduction strategy that the Ugandan government formulated in 1997, was recognized by the World Bank and IMF as the first Poverty Reduction Strategy Paper (PRSP) in the world, and debt reduction based on the HIPC initiative was carried out in Uganda in advance of any other country (from March 2000). Subsequently, the third PEAP, announced in December 2004 (and applicable until June 2009), emphasized macroeconomic management; production, competitiveness and raising incomes; security, conflict resolution and disaster management; good governance; and human development.

The successor to the PEAP plan that began in 2010/2011, the five-year National Development Plan (NDP), takes a policy line giving greater emphasis to economic growth, makes its theme "Employment and Growth for Prosperity", and focuses on the important tasks of ameliorating the social, economic and trade infrastructure, and improving the standard of living.

8.2 Energy Resources

Because it is adjacent to Lake Victoria, the third largest lake in the world and the main source of the White Nile and other rivers that flow through the country, Uganda is rich in hydropower resources. Hydropower plants developed as of February 2009 total only 320MW in output (about 15% of the available water power), and so a great deal of room for development remains, since hydropower resources were estimated to be about 2,200MW as of the end of 2008.

Moreover, because oil had been discovered in neighboring Kenya (in the Rift Valley Belt in the west) in the 1980's, oil exploration was also carried out in Uganda. As a result, oil was discovered in 1998, and oil development has advanced in several places since then. A joint venture company (Heritage Oil Co.) between the government and Chinese enterprises (China Nationa1 Petroleum Co., China Petroleum & Chemical Co. and China National Offshore Oil Co.) has been mining in the Tullow point area (Block 1 and Block 2) around Lake Albert since 2008. As of February 2009, it is presumed that there are about 600 million barrels of reserves in the same area. However, oil deposits for the whole country have not been determined.

The Ministry of Energy and Mineral Development (MEMD) plans to set up an oil refinery on the shores of the Lake Albert (near the oil mining point in the Hoima district) to reduce the amount of imported petroleum. After the oil refinery is completed, crude petroleum, diesel fuel, kerosene, etc. are scheduled to be produced (in volumes of 40,000-60,000 barrels in total per day).

It is planned to export oil to overseas nations beginning with Kenya, and the possible construction of a pipeline of about 1,500km to the Mombasa port in the eastern part of Kenya is being considered if oil production takes off. Moreover, MEMD has scheduled the construction of an oil-fired power plant (50MW-100MW) in the oil region to mitigate the power supply shortage, and the construction of a power line from the petroleum area to the capital, Kampala.

Table-8.2-1 Potential of renewable energy in Uganda

Type	Potential	Remarks
Hydro	2,200MW	Medium-scale hydro 2,000MW Small hydro 200MW
Biomass	1,650MW	Mainly agricultural waste
Geothermal	450MW	Under investigation in Katewe-Kikorongo, Burnga etc.
Solar	200MW	Promotion as local electrification resource
Others	800MW	Mainly Wind power
Total	5,300MW	

(Source) JEPIC (2010)

In addition, the use of agricultural waste biomass is scheduled to be attempted because Uganda is a farming nation. The potential of renewable energy sources such as hydropower and biomass is estimated to be 5,300MW in total, according to the National Renewable Energy Strategy (Table-8.2-1).

8.3 Electric Power Situation

8.3.1 Electric Power sector

The sector covers electricity generation, transmission and distribution, including rural electrification. In 1999, following approval by Cabinet of the Power Sector Reform and Privatization Strategy and enactment of a new electricity law (The Electricity Act, 1999), the Electricity Regulatory Authority (ERA) was established to regulate the industry. Thus, while the Ministry of Energy and Mineral Development (MEMD) is responsible for policy, the ERA regulates the industry independently of the Ministry. The Uganda Electricity Board (UEB), the national utility company lost its monopoly in the sector with the passage of this Act.

As part of the Power Sector Reform process, UEB was unbundled to create separate business entities for generation, transmission and distribution, Uganda Electricity Generation Company Limited (UEGCL), Uganda Electricity Transmission Company Limited (UETCL) and Uganda Electricity Distribution Company Limited (UEDCL), respectively. The generation and distribution businesses were leased out to private operators Eskom and Umeme Limited, respectively, on long-term concessions, while transmission remains a public function. Under the concession arrangement, the existing assets remain in public ownership, while Eskom and Umeme operate and maintain the assets. New generation capacity is being developed by Independent Power Providers (IPPs) in partnership with the Government. The characteristics of the sector are discussed later in this report.

8.3.2 Power Sector Policy

According to the Uganda Renewable Energy policy of 2002, the main policy goal in the energy sector is to meet the energy needs of the Ugandan population for social and economic development in an environmentally sustainable manner. Specifically the energy policy seeks to increase access to modern affordable and reliable energy services as a contribution to poverty eradication, to improve energy governance and administration, to stimulate economic development, and to manage energy-related environmental impacts. The Policy paper noted that although geothermal energy exploitation has not been established in Uganda, there is evidence of the existence of the resource. It noted further that the potential geothermal resources were estimated at about 450MW in the Ugandan Rift Valley System. Apart from basic studies of the geological and geochemical characteristics of several geothermal anomalies, no detailed studies have been carried out to establish the economic resource potential.

8.3.3 Legal framework

The Electricity Act Chapter 145 of 1999 (the Electricity Act) was enacted at a time when the Government and its various stakeholders had reached a consensus that the electricity sector in Uganda needed to liberalize and attract greater involvement of the private sector.

The Act provides for the establishment of an electricity sector regulator, an Electricity Disputes Tribunal, a licensing process, regulatory mechanisms, rural electrification and the re-organization of the Uganda Electricity Board (UEB) into its respective successor companies. Since the enactment of the Act some of the supportive statutory instruments adopted include:

- The Electricity (License Fees) Regulations 20 of 2003
- The Electricity (Tariff Code) Regulations 23 of 2003
- The Electricity (Safety Code) Regulations 22 of 2003
- The Electricity (Quality of Service Code) Regulations 21 of 2003
- The Electricity (Primary Grid Code) Regulations 24 of 2003

The Act allows for the entry of private players into the electricity sector through a detailed licensing mechanism overseen by the ERA and generally also provides for the liberalization of the sector, the principle objective being the introduction of competition and achievement of efficiency. The ERA may issue Generation, Transmission, System Operator, Distribution, Sale and Export and Import licenses. When granting or rejecting a license, ERA takes into account Government of Uganda policies, among other considerations. The holders of distribution and transmission licenses are obliged within the limits of technical feasibility, to offer access to other existing or potential users of their networks.

The Act permits the holding of several licenses, except where this may impede electricity sector efficiency and fair competition, or is inconsistent with the Electricity Policy. For instance, in the medium term, it will be a single-buyer market, with UETCL acting as the sole buyer from generators, except in the case of rural off-grid systems, which may be vertically integrated.

8.3.4 Power Sector Investment Incentives

In accordance with the Renewable energy policy of 2007, the Government has put in place legal and institutional frameworks to permit renewable energy programs to work. Some specifics of theses frameworks are:

- Providing a Standardized Power Purchase Agreement to private sector project developers who want to feed power into the grid. The significance of this type of PPA is that it makes the business predictable by removing market uncertainty, facilitates negotiations with the developers, and dramatically reduces transaction costs. This will also help to attract a larger number of investors to renewable energy generation.
- Establishing a Feed-in-Tariff, based on the principle of avoided cost pricing, in accordance with the provisions of the Electricity Act of 1999. The tariff should translate into cash revenue that will not require the investor to resort to a capital subsidy. The Feed-in-Tariff is part of the Standardized PPA. The feed-in tariff is structured to differentiate between peak, shoulder and off-peak prices to reflect the higher value of power in the peak period, and to differentiate between short- to medium-term prices and long-term prices, to reflect the higher risk of load shedding in the short to medium-term. In terms of price levels, the following principles shall apply:
  - Wheeling of power over third-party networks, will be charged for in accordance with rates set and published by ERA.
  - All Government authorities who provide the various consents (including permits, licenses, approvals, etc) must grant them in a well-coordinated and expeditious manner.
  - To increase investor comfort, private sector investors must be granted access to either of the two existing financial facilities that will allow them to hedge their long-term borrowing from local financial institutions. These facilities are the Refinance Facility at the Bank of Uganda and the Credit Support Facility (CSF) (a Public Trust entity). The detailed operational modalities of these facilities can be assessed from the various legal documents that established them.
  - The roles of various institutions in the development of renewable energy projects should be harmonized.

8.3.5 Institutional Framework

Until 31 March 2001, the Uganda power sector was vertically integrated under the monopoly of the Uganda Electricity Board (UEB). This government-owned statutory corporation operated and maintained the main generation, transmission and distribution network facilities in Uganda. The key activities performed by Government of Uganda were:

- Formulating power sector policy;
- Ensuring the financial, legal and environmental due diligence of UEB;
- Maintaining an inventory and valuation of UEB assets and liabilities;
- Analyzing distribution and transmission network investment needs;
- Carrying out financial and tariff modeling;
- Drafting and issuing licenses, regulations, concession and power sale agreements.

With the enactment of the new Electricity Act in 1999, UEB was unbundled into three independent companies, namely: Uganda Electricity Generation Company Limited (UEGCL), Uganda Electricity Transmission Company Limited (UETCL), and Uganda Electricity Distribution Company Limited (UEDCL).

Uganda Electricity Generation Co. Ltd (UEGCL) owns the two major hydropower plants at Nalubaale (180MW) and Kiira (200MW). Uganda Electricity Transmission Co. Ltd (UETCL) owns and operates the transmission infrastructure above 33kV. Uganda Electricity Distribution Co. Ltd (UEDCL) owns and operates the distribution network at 33kV and below. Uganda Electricity Board (Statutory Corporation) remained in place in order to wind up its operations.

The ownership of UETCL, that serves as the power superhighway, remained with the Government. UEGCL & UEDCL were privatized through long-term concessions.

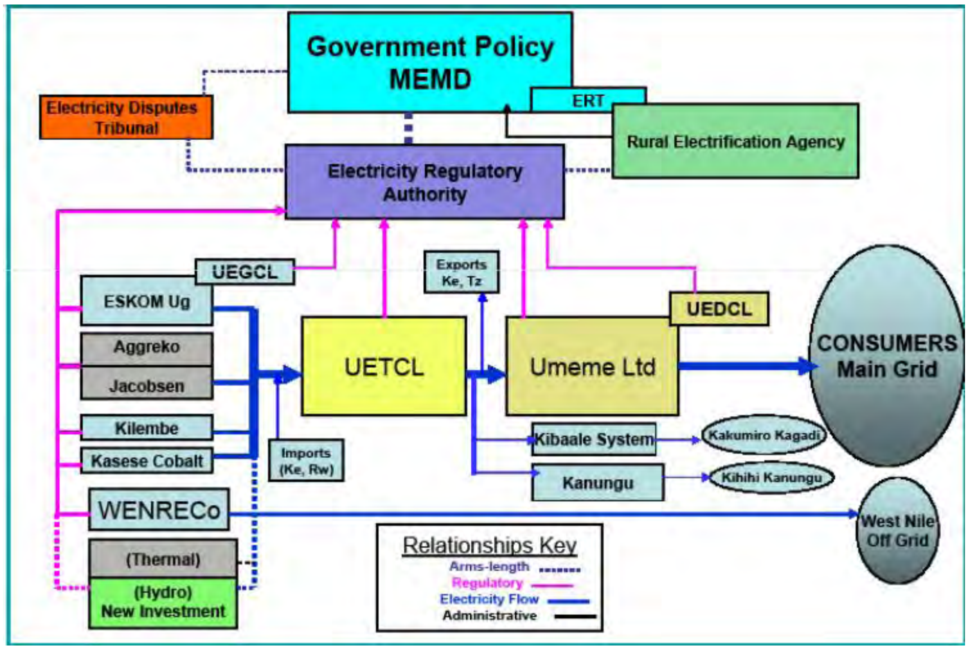
A 20-year concession was granted to Eskom (U) Ltd (the concessionaire) to maintain and operate the Kiira and Nalubaale hydroelectric power stations owned by UEGCL. A new concession company, Umeme Ltd., was established by a Consortium formed by Globeleq and Eskom Enterprises to maintain and operate the distribution business owned by UEDCL.

8.3.6 Regulatory Framework

The Electricity Act establishes the Electricity Regulatory Authority (ERA), whose mandate includes inter alia:

- the issuance, modification and revocation of licenses for the generation, transmission, distribution or sale of electricity and for electricity exports and imports;
- the establishment of tariff structures;
- the development and enforcement of performance standards and
- the review of the organization of companies or other legal entities engaged in the generation, transmission and distribution of electricity in order to ensure efficiency and competition in the electricity sector.

The ERA is empowered to act independently in the performance of its functions and duties. It is, however, subject to direction by the Minister responsible for energy on policy matters that do not adversely affect or interfere with the exercise of its powers and performance of its functions.



(Source) ERA, 2009

Fig.-8.3-1 Power Supply Situation in Uganda

8.3.7 Energy Pricing

Under the Electricity Act the tariff structure and terms of supply are prescribed by the ERA. The licensees make applications for the tariff they wish to charge and ERA reviews the applications based on total revenue requirement. After approval of an application, the licensee may, on a quarterly basis, apply for revisions based on inflation and foreign exchange rate fluctuations. Wide stakeholder consultations, including public hearings, are conducted during the review process.

To implement its energy pricing policy, ERA has published “Tariff Determination in the Uganda Electricity Sector October 2006” and “Regulatory Framework for Uganda Report 22/01 May 2001”. These Reports propose tariff methodologies and formulas for deriving various electricity sector supply tariffs, as summarized from the Regulatory Framework Abstract below.

The Electricity Regulatory Authority’s approach to regulation of electricity prices in Uganda is intended to balance incentives for improved operation with investment incentives. The process of awarding concessions for generation and distribution requires the regulatory framework to be presented to potential investors. The challenge of regulation of the power sector in Uganda is to reward investors fairly, yet to provide adequate incentives to minimize costs in the industry. This involves allowing for a reasonable return on investment, while ensuring that operating and investment efficiencies are achieved.

The reports propose price adjustment formulae and show exactly how adjustments will be made. The reports also provide for incentive elements in regulation and guaranteed rates of return; price reviews; generation tariffs; bulk supply tariff; and end-user tariffs.

8.3.8 Financing Framework

As is the case in other Eastern African countries, the Uganda power sector requires large capital inflows from both the public and private sectors to implement capacity expansion programs comprising renewable (mainly hydro) energy projects and, in the short-term, thermal plants to address the current shortages. There is also a need for investment in expanding electricity access for the rural population by developing off-grid systems. Most of these could be mini-hydro or other renewable energy projects.

8.3.9 Existing Generation Capacity

The installed generation capacity in the country is 380MW, comprising Nalubaale (180MW) and Kiira (200MW) hydro plants, located at Jinja. They share the same water and are connected to the same supply point in the grid. The declining water level in Lake Victoria has reduced output from Nalubaale and Kiira plants, necessitating severe power rationing.

Additionally, Uganda has thermal installed capacity of 150MW and cogeneration of 17 MW. Other small hydro generating plants operated by Kilembe Mines limited and Kasese Cobalt Company limited account for a further 14.5MW of capacity. There are also a number of off-grid generation plants delivering a total of 2.4 MW. Table-8.3-1 summarizes the existing generation plants in the country.

Table-8.3-1 Existing Generating Plants

Plant Name	No of Units	Unit Capacity (MW)	Installed Capacity (MW)
Hydro			**394.5**
Kiira	5	40	200
Nalubale	10	18	180
Kilembe Mines	2	2.55	5
Kasese Cobalt	3	3.15	9.5
Thermal			**150**
Aggreko - Kiira	1	50	50
Namanve (Jacobson)	1	50	50
Aggreko - Mutundwe	1	50	50
Other			**17**
Kakira Sugar Works	1	12	12
Kinyara Sugar	1	5	5
Total			**561.5**

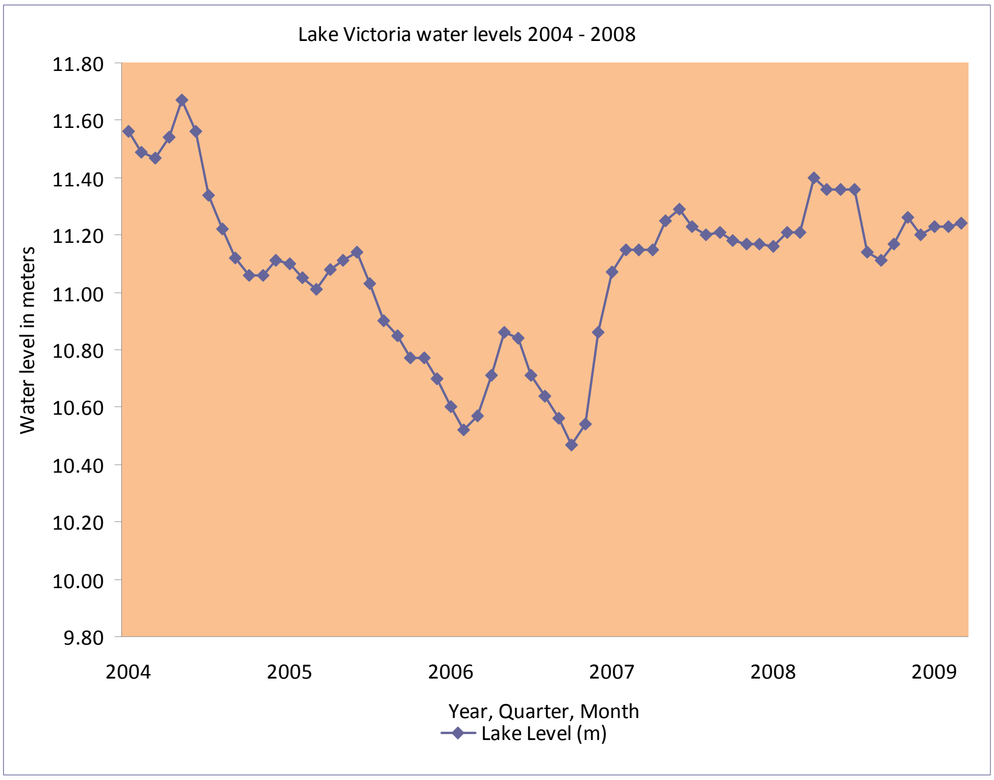
(Source) UEGCL, 2009

The generation capacity and production is heavily dependent on the two main hydro plants, Kiira and Nalubale, which rely on the water levels of Lake Victoria. Due to drought in the lake’s catchment areas in Kenya, Tanzania and Rwanda, the levels have at times been very low (refer to Fig.-8.3-2), reducing available energy. For instance, over a 5-year period, the combined output of the two plants ranged from a low of 1,178GWh in 2006 to a high of 1,896GWh in 2004, a variance of about 60 %. Table-8.3-2 gives the generation output of these 2 plants in the period 2004-2009, part of which is also covered in Fig.-8.3-3.

Table-8.3-2 Energy Generated from Hydro Plants on the White Nile (2004-2009)

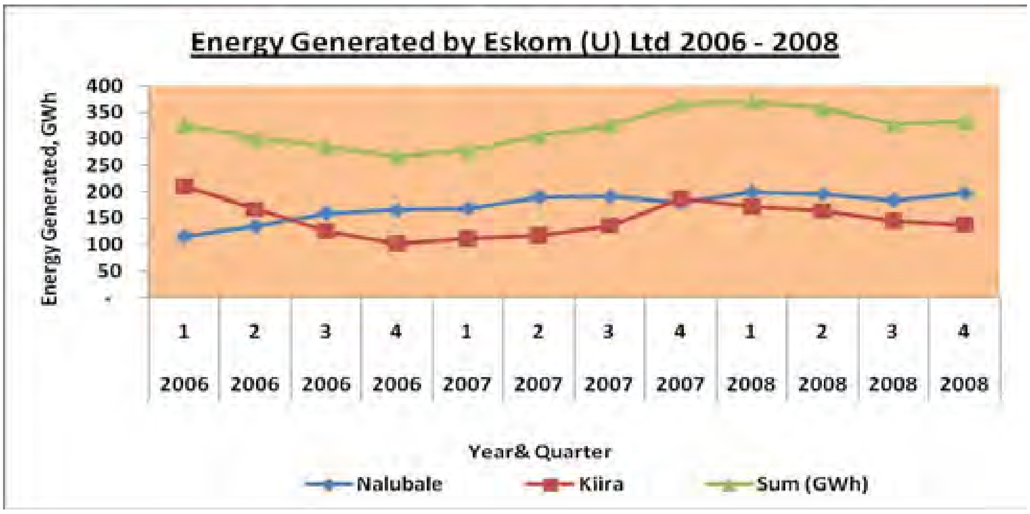
Year	Nalubale	Kiira	Total
	(GWh)	(GWh)	(GWh)
2004	937	959	1,896
2005	772	974	1,746
2006	573	605	1,178
2007	728	550	1,278
2008	774	618	1,392
2009	769	496	1,265

(Source) Study Team compiled from UEGCL data



(Source) Study Team compiled from Eskom (UEGCL) data

Fig.-8.3-2 Fluctuations to Lake Victoria Water Levels 2004 ― 2009



(Source) Study Team compiled from Eskom (UEGCL) data

Fig.-8.3-3 Fluctuations in Energy Generated by Eskom 2006 – 2008

8.3.10 Transmission and Distribution System

Uganda has a total of 1,425 km of 132kV high voltage transmission lines and 54 km of 66kV lines in the country. The main lines in operation by 1998 are indicated in Table-8.3-3. The distribution facilities included 3,258 km of 33kV lines, 3,443 km of 11kV lines and 6,496 km of low-voltage lines.

Table-8.3-3 Main Transmission Lines in Operation by 1998

No	Name	System Voltage	Length (km)	Type	Year of energizing
1	Owen Falls - Tororo	132kV	2x119.6	steel	1954
2	Tororo - Malaba	132kV	2x 10.6	steel	1954
3	Owen Falls - Kla North	132kV	2x 68.8	steel	1954
4	Kampala North – Mutundwe	132kV	2x8.9	steel	1959
5	Mutundwe - Kabulasoke	132kV	84.5	wooden	1963
6	Kabulasoke - Nkonge	132kV	134	wooden	1963
7	Nkonge - Nkenda	132kV	75	wooden	1963
8	Kabulasoke - Masaka West	132kV	59.5	wooden	1963
9	Tororo - Opuyo	132kV	119.5	wooden	1963
10	Opuyo - Lira	132kV	141.2	wooden	1963
11	Owen Falls - Lugazi	132kV	35.2	steel	1963
12	Masaka West - Kyaka	132kV	85	steel	1994
13	Masaka West - Mbarara North	132kV	129.6	steel	1995
14	Lugogo - Kla North	132kV	2x5.5	steel	1997
15	Lugogo - Mutundwe	132kV	2x10.4	steel	1997
16	Owen Falls - Lugogo	132kV	2x75	steel	1998

(Source) Study Team compiled from UETCL data

8.3.11 Existing Customers

The distribution network provides power to 33 of the 54 districts in the country. Uganda's electrification rate is very low, with grid access of only 5% for the whole country, dropping to less than 2% in rural areas. Electricity is consumed by the residential (55%), commercial (24%) and industrial (20%) sectors and for street lighting (1%), as per UMEME limited performance indicators report. The number of customers as at 31st Dec 2009 was 317,394, breaking down as indicated in Table-8.3-4.

Table-8.3-4 Existing Number of Customers (As of Dec-09)

Domestic (Small General 10.1)	292,348
Commercial (Small General Service 10.2)	23,654
Industrial (Large Industrial 30 & 32)	200
General (Medium Industrial 20 & 22)	983
Street Lighting (50)	209
Total	317,394

(Source) UMEME (2009)

In addition to internal (Uganda) customers, through UETCL Uganda has the following export contract obligations to neighboring countries: Kenya (30MW), Tanzania (9MW) and Rwanda (5MW). However, the 30MW to Kenya is supplied only during off-peak hours, and only 6MW and 3MW in exports go to Tanzania and Rwanda, respectively.

8.3.12 Electricity Tariffs

Over the last 10 years the ERA has presided over phased increases in retail tariffs, as indicated in Table-8.3-5. The objective has been to adjust retail tariffs to reflect the cost of supply while taking into account the very poor customers who benefit from cross-subsidies within the domestic tariff structure.

Table-8.3-5 Electricity Retail Tariff 2001 – 2006 (unit: Uganda Shillings)

Code	Type of Charge	Rate per	Jun 01	Sep 02	Jun 03	Mar 04	Jun 05	Dec 05	Jun 06
Domestic (Code 10.1)	1-5 kWh	kWh			50	50	50	50	50
	>15 kWh	kWh			170.1	171.4	212.5	216.9	298.2
	1-30 kWh	kWh	50	50					
	>30 kWh	kWh	189.8	168					
	31-200 kWh	kWh							
	>200 kWh	kWh							
Commercial (Code 10.2/10.3)	Average Unit Charge	kWh	189.8	168	170.1	164.8	204.4	208.3	286.8
	Peak	kWh				196.8	259.9	265.9	327.6

	Shoulder	kWh				162.8	200.5	204.3	287
	Off-Peak	kWh				104.3	100.8	100.6	223.9
	Standing Service Fee	Month	1,000	1,000	1,000	1,000	2,000	2,000	2,000
Industrial (Code 20)	Average Unit Charge	kWh	171.6	152.4	155.1	150.3	178.9	182.8	261.5
	Peak	kWh				75.3	116.3	119.6	148.3
	Shoulder	kWh				59.4	82.5	84.6	123.5
	Off-Peak	kWh				32.9	34.1	34.3	91.2
	MD Charge	kWh	5,000	5,000	5,000	5,000	5,000	5,000	5,000
	Standing Service Fee	Month	10,000	10,000	10,000	10,000	20,000	20,000	20,000
Large Industrial (Code 30)	Average Unit Charge	kWh	104.4	93.5	89.4	60.4	71.9	73.6	120.8
	Peak	kWh				180.2	232.1	238.2	300.9
	Shoulder	kWh				148.3	175	178.8	261.8
	Off-Peak	kWh				94.5	80.2	80	201.9
	MD Charge	kVA							
	MD up to 2000 kVA	kVA	3,300	3,300	3,300	3,300	3,300	3,300	3,300
	MD above 2000 kVA	kVA	3,000	3,000	3,000	3,000	3,000	3,000	3,000
	Standing Service Fee	Month	15,000	15,000	15,000	15,000	30,000	30,000	30,000
Street Lighting (Code 50)	Average Unit Charge	kWh	176.4	153	155	162.5	201.5	205.3	282.8
	Peak	kWh				130.1			
	Shoulder	kWh				113.1			
	Off-Peak	kWh				87.7			
	Standing Service Fee	Month	4,000	4,000	4,000				

(Source) Study Team compiled from UMEME data

For bulk tariffs between UETCL and UMEME and under PPAs between UETCL and IPPs and Eskom, ERA reviews the tariffs agreed between the parties for conformity with its established tariff policies and pricing guidelines, and approves the tariff or requests an adjustment.

8.3.13 Electricity Demand Forecast

The actual electricity demand in Uganda is much higher than recorded in recent years due to persistent load shedding that has been taking place despite the procurement of emergency power. The Master plan has considered the most likely scenario (reference) and low/high scenarios in its capacity expansion planning. Table-8.3-6 gives the projected reference electricity demand over the next 15 years:

Table-8.3-6 Power and Energy Forecasts

Year	Base case - Total Sales GWh	Base Case - Max Demand MW
2010	1,868	535
2015	2,840	727
2020	4,174	967
2025	5,588	1,294
2030	7,177	1,662

(Source) PB (2009)

8.3.14 Generation Expansion Plan

In accordance with the national power master plan, the Government of Uganda places a high priority on the development of its huge indigenous power resources, particularly the hydropower resources on the White Nile, to meet growing electricity demand and facilitate regional trade. The hydroelectric power potential of Uganda is high and is estimated at over 2,000 MW, mainly along the White Nile.

Planned expansion projects in the plan include large hydro and mini hydro systems, as indicated in Table-8.3-7 below. In accordance with its renewables policy, the Government of Uganda plans to diversify the country’s power sources by developing geothermal. Many constraints plague the development of this resource by the government itself, including high capital costs and other competing financial priorities.

Table-8.3-7 Least Cost Power Development Plan

In Service by start of	Power plant	Net capacity MW
2009	AGGREKO Kiira	50
2010	AGGREKO Mutundwe Retired	-50
	Electromaxx	10
	INVESPRO	50
2011	AGGREKO Kiira Retired	-50
	Small hydro	40
2012	Electromaxx Retired	-10
	Invespro Retired	-50
2013	Peaking plant (Gas turbine)	25
	Bujagali	250

2014	Baseload plant (steam plant)	100
2016	Small hydro	37
2017	Karuma	250
2019	Isimba	100
2021	Geothermal 1	30
2022	Geothermal 2	30
2023	Geothermal 3	30
2024	Ayago	250
2025	Karuma	250
2025	Small hydro	7
2026	Ayago	250

(Source) PB (2009)

8.3.15 The role of IPPs in the Generation Expansion Plan

Uganda has privatized the generation and distribution business, as well as invited the private sector to partner in its generation capacity expansion projects under some form of public-private partnership (PPP) arrangement. The Government is concentrating public resources on rural electrification and transmission network operation and expansion. The necessary legal framework is in place to facilitate full participation of private investment in the development of the sector. Development of geothermal will require both the commitment and support of Government, development partners and the private sector. Each will have a role to play in ensuring the accomplishment of the desired goal of diversification of electricity sources and promotion of sustainable, environmentally friendly energy production technologies.

8.3.16 Geothermal Energy in the Generation Expansion Plan

The Rural Electrification Strategy and Plan covering the Period 2001 to 2010 identifies the promotion of renewable energy as another important element of the Government's Rural Electrification Strategy, which aims to facilitate a rapid rise in the use of renewable energy by removing or reducing existing barriers to market penetration. One of the goals of the Renewable Energy Policy for Uganda is to increase the use of modern renewable energy from the current 4% to 61% of total energy consumption by 2017. The Policy notes that the current level of investigations indicate that the three areas of Kibiro, Buranga and Katwe-Kikorongo have been selected as potential targets for geothermal development. The total geothermal energy potential is estimated to be 450 MW. The policy document sets out targets for the installation of 25MW and 45MW of geothermal generation by 2012 and 2017, respectively. Given that no exploration drilling has been done to date, it would be difficult to meet these suggested targets.

However, the Power Sector Investment Plan of Dec 2009 produced by PB Power includes the commisioning of 30MW of geothermal power plants in each of the years 2020, 2021 and 2022. The plan also includes 100MW of steam base-load plant in 2013, which could be displaced by geothermal in the next master plan update, if an intensive exploration and appraisal program were to prove the resource within the time-frame in which the system requires the additional power. In order to satisfy both the desire to achieve a renewable energy policy and the necessity of a power sector investment plan, it is suggested that between now and 2020 as much as geothermal power as possible be allowed to be brought into the system.

8.3.17 Transmission Capacity Expansion

The generation expansion program includes transmission lines to connect remote hydro sites to load centers. In addition, some transmission reinforcement is required to meet increasing load transfers between major load centers. Table-8.3-8 details the transmission expansion plan to 2018.

Table-8.3-8 Transmission Expansion Plan

Name/ Area of Project	Expected Commissioning Year
Bujagali Interconnection Project (BIP)	2011
Nkenda- Fort Portal-Hoima 132kV lines	2011
Owen falls – Lugazi 66kV transmission line Rehabilitation	2012
Kawanda – Masaka 220kV transmission line	2013
Mbarara– Nkenda 132kV Transmission Line	2013
Tororo – Opuyo –Lira 132kV Transmission Line	2013
Mutundwe – Entebbe 132kV Transmission Line	2013
Opuyo-Moroto 132kV line and substation	2013
Mbarara-Mirama (Uganda) -Birembo (Rwanda) 220 kV transmission line	2013
Bujagali-Tororo (Uganda) - Lessos (Kenya) 220kV transmission line	2013
Nkenda (Uganda)-Mpondwe – Beni (DRC) 220kV transmission line	2014
Mirama-Kabale 132kV line	2014
Masaka- Mwanza transmission line	2015

(Source) Uganda Medium Term Generation Expansion Plan and Renewable Energy Policy for Uganda 2007

8.3.18 Conclusion

The main challenges facing Uganda are to ensure adequate power supply capacity to compensate for hydropower shortfalls during drought seasons and to cater for load growth; to reduce the necessity for high-cost thermal power generation, especially from emergency power sources; to increase the low rate of electricity access in Uganda; and to mitigate budgetary constraints on renewable energy development and the high capital cost involved in the development of renewable technologies with the attendant high risk. According to the Renewable energy policy of Uganda of 2007 it is a government policy objective to develop renewable energy sources (mainly hydro and geothermal) as a means of addressing the challenges facing the power sector. Uganda therefore requires investment from both the public and private sectors to implement an ambitious power development program to meet current power deficits, rising electricity demand and contractual electricity export commitments to her neighbors Kenya, Tanzania and Rwanda, and to diversify its power sources, which are currently dominated by hydro. The necessary legal framework is in place and is being reviewed with a view to addressing weaknesses identified as the sector evolves.

8.4 Geothermal Resources

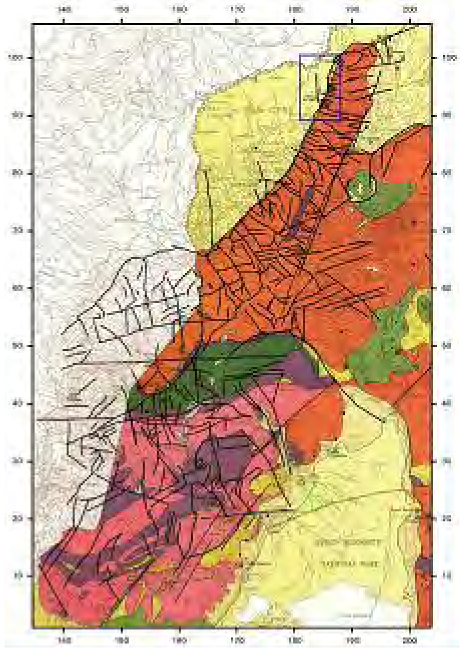
In Uganda, geothermal areas are located near the rift, but a nationwide survey has not yet been carried out. So the geothermal potential of Uganda is only conjectured to be about 450MW (McNitt, 1982) based on UNDP research carried out by an American organization in the 1980's. Geothermal surveying of 20 geothermal fields in the three main geothermal areas in Uganda (Buranga, Katwe-Kikorongo, Kibiro) has mainly been carried out by foreign entities.
It is also relevant to note that recent oil exploration in the Panymur area shows that the thermal gradient in that area is high, indicating possible geothermal potential.

8.4.1 Buranga geothermal field

The Buranga area has been surveyed by BGR (BGR, 2007). It is located in the Albertine rift (western branch of the east Africa rift) in the Bundibugyo district in western Uganda near the Congolese border (Fig.-8.4-1). This is a geologically active area, though there is no sign of volcanic activity (Fig.-8.4-2), and is thought to be of the fault-dominated type. There are hot springs flowing out naturally near the field. The highest hot spring temperature recorded is 98.3^{o}C, the pH of the waters is neutral, the Cl content is high at about 4,000 mg/kg (Table-8.4-1), and mixing of magma-derived fluid is supposed. The hot spring water is classified based on its major anion composition as SO_4 type, HCO_3 type or the middle type, Cl type water, suggesting the presence of a deep reservoir, is only found in an oil exploration field 20km away to the north-northeast (Fig.-8.4-3). The relation between the Cl and SO_4 content of the hot spring water shows that the hot spring water is a mixture of deep SO_4-Cl fluid and a diluted HCO_3 fluid (Fig.-8.4-4), and analysis of the ratio of the stable isotopes shows that the hot spring water originates in precipitation that falls on the high altitude area in the mountainous Rwenzori district (Fig.-8.4-5). Geothermometry based on the chemical composition of the hot spring water shows temperatures of 120～150^{o}C (Table-8.4-1) in the reservoir, although the actual measured temperature in the deepest heat flow hole (349m) is 66^{o}C. The thermal gradient there is only about 31^{o}C/km, and an anomalous high-temperature area is not confirmed. The heat source of this area is assumed to be an intrusive magma, and a geothermal conceptual model has been elaborated, as shown in Fig.-8.4-6 and Fig.-8.4-7. No other geophysical study has been conducted yet, and the geological and geothermal structure is unknown here. The geothermal potential cannot be estimated yet, and so the development plan remains undecided. There is no restriction on development in this area, though it is in Semliki national park (Bahati, personal communication).The evaluation sheet for the Buranga geothermal field is shown in Annex-5-1.

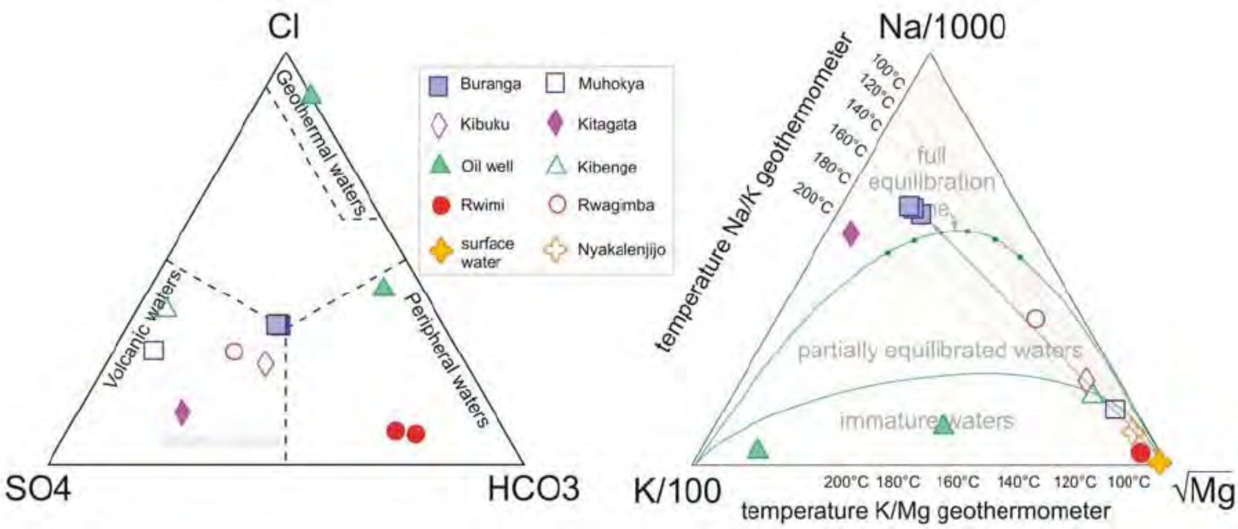
(Source) Bahati et al.(2010)

Fig.-8.4-1 Geothermal areas in Uganda (Katwe, Kibiro, Buranga)



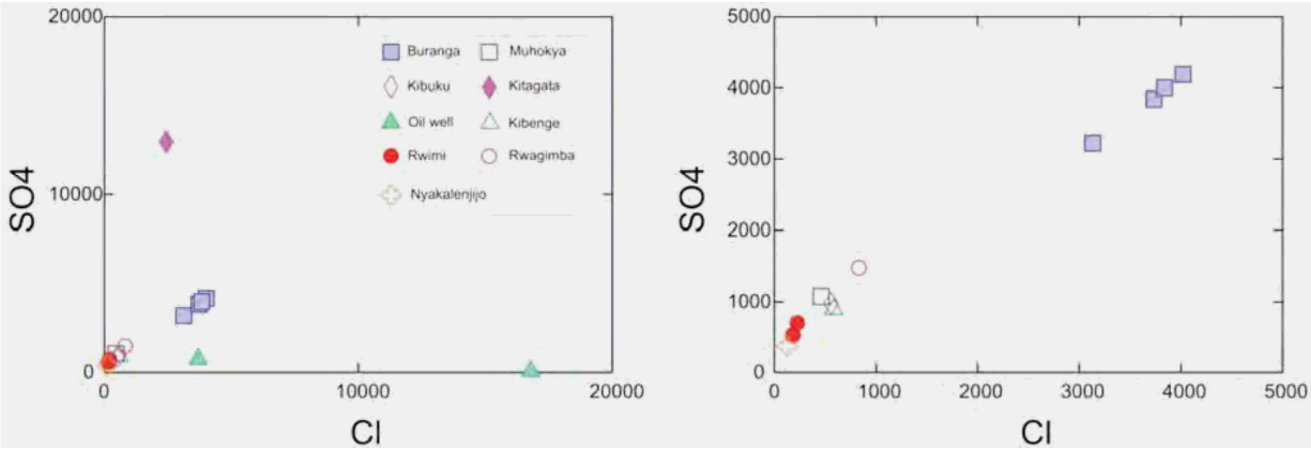
(Source) BGR(2007)

Fig.-8.4-2 Geological map and lineament map of Buranga area (Uganda)



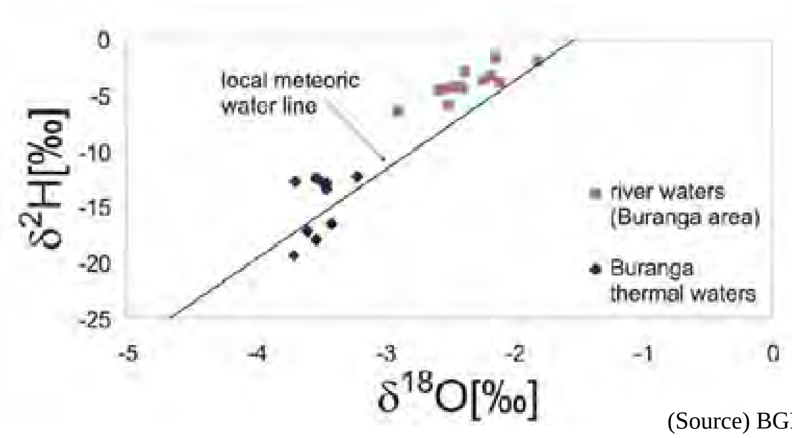
(Source) BGR(2007)

Fig.-8.4-3 Trilinear diagram of the major anions and Na-K-Mg of hot spring water in the Buranga area



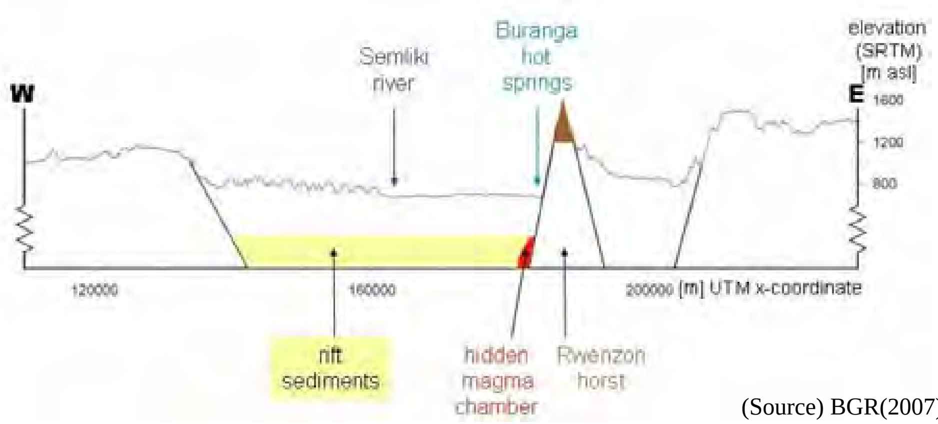
(Source) BGR(2007)

Fig-8.4-4 Cl-SO_4diagram of hot spring water in the Buranga area



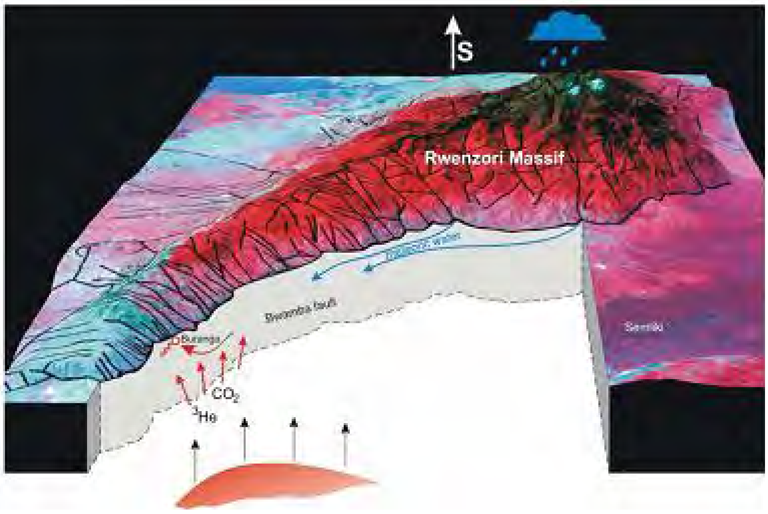
(Source) BGR(2007)

Fig.-8.4-5 Delta-D-Delta ^{18}O diagram of hot spring and river water in the Buranga area



(Source) BGR(2007)

Fig.-8.4-6 Geothermal conceptual model of Buranga area



(Source) BGR(2007)

Fig.-8.4-7 3-D model of the the Buranga area

Table-8.4-1 Chemical （mg/kg） and stable isotope （‰）analysis results for hot spring water in the Buranga

Location	Sample No.	Temp. (°C)	pH	CO_2	H_2S	SiO_2	Na	K	Ca	Mg	SO_4	Cl	B	Li	$\delta^{18}O$	δD	TDS
Mumbuga2	UG-93-09	93.4	7.87	2445	0	76.9	5320	195	2.45	2.13	3720	3580	4.3	1.34	-3.6	-17.1	14600
Mumbuga5	UG-93-10	93.6	7.73	2411	0	76.4	5160	190	2.56	2.27	3570	3490	4.2	1.3	-3.49	-12.8	14030
Nyansimbe9	UG-93-16	95.8	8.15	2638	0	87.7	5940	222	0.95	1.74	4180	4010	4.71	1.48	-3.21	-12.2	16250
Nyansimbe13	UG-93-11	80.3	7.61	2889	0	88.6	6160	230	2.1	2.63	4330	4160	4.96	1.51	-3.54	-12.4	17050
Nyansimbe17	UG-93-32	98.2	8.57	2635	0	85.1	6270	235	0.39	0.28	4400	4210	4.96	1.51	-3.45	-13.4	17080
Nyansimbe19	UG-93-13	85.8	7.81	2878	0	85.7	6300	234	2.04	1.98	4420	4240	4.8	1.54	-3.46	-12.9	17050
Kagoro20	UG-93-12	89	7.50	2798	0.3	81	5950	219	2.69	2.19	4160	4030	4.7	1.47	-3.69	-12.7	16400
R.Mungera	UG-93-15	21.8	7.52	57	0	37.2	11.1	3.7	11.2	3.61	1.7	1.8	0	0.008	-2.24	-3.7	74
Kyakatimba1	UG-93-17	23.8	7.54	197	0	36.3	21.2	8.1	54.7	14.3	27.6	2.1	0	0.034	-2.57	-4.6	208

(Source) Bahati et al.(2010)

Table-8.4-2 Geochemical temperature (^{o}C) of hot spring water of major geothermal field in Uganda

Area	Site	T_{qz} [a]	T_{KMg} [b]	T_{NaK} [c]	T_{NaKCa} [d]	$T_{S^{18}O_4 H_2{}^{18}O}$ [e]
Kibiro	Kibiro 5	160	148	217	220	137
	Kibiro 14	151	150	222	223	110
Katwe-Kikorongo	L.Kitagata 2	116[f]		145[f]		130
	L.Kitagata 5	134[f]		162[f]		140
Buranga	Kagoro 20	122[f]		111[f]		188
	Nyansimbe 17	104[f]		113[f]		189
	Mumbuga 5	117[f]		111[f]		212

[a] Fournier and Potter (1982).
[b] Giggenbach (1988).
[c] Arnórsson et al. (1983).
[d] Fournier and Truesdell (1973).
[e] Mizutani and Rafter (1969).
[f] Results from Ármannsson (1994).

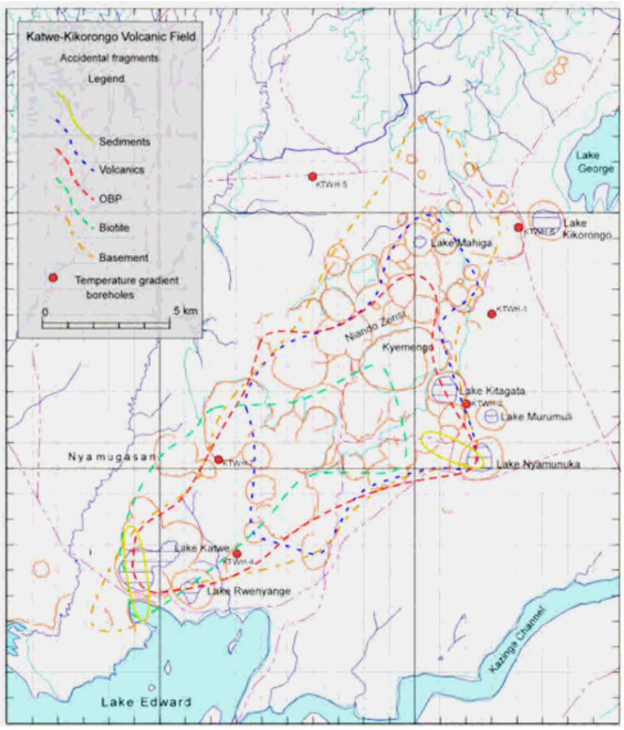
(Source) Bahati et al.(2010)

8.4.2 Katwe-Kikorongo geothermal field

The Katwe-Kikorongo area has been surveyed by ICEIDA (ICEIDA, 2009). It is located in Queen Elisabeth national park, with the mountainous Rwenzori district to the north and Edward lake to the south. (Fig.-8.4-1). This is a volcanic area with many steam explosion craters, but few signs of lava flow (Fig.-8.4-8). In addition, the results of geological surveys in this field indicate that ejected pyroclastics, tuffs with abundant granite and gneissic rocks from the basement dominate the area (Fig.-8-4.9). The volcanic activity has been estimated to have taken place in the Pleistocene to Holocene. The heat source of this field is assumed to be an intrusive magma. The geothermal manifestations in this field are a hot spring (70^{o}C) and a travertine (calcareous deposit rock) in the Kitagata Crater lake. The chemical composition of the hot spring water here is characterized by a very high concentration of HCO_3 (maximum 20,000 mg/kg) and SO_4 (maximum 100,000 mg/kg), and an extremely high concentration of Cl, which at 86,600 mg/kg is over four times the concentration in seawater (Table-8.4-3). The geochemical temperature of the hot spring water is 140～200^{o}C (Table-8.4-3). Moreover, the waters of Kitagata lake and Katwe lake contain 30 - 40ppm of H_2S, suggesting that the lake water is of volcanic or hydrothermal origin. The thermal gradient here is only about 30 – 36^{o}C/km, so a geothermal reservoir may be present at depth or far from the heat flow hole, based on the temperatures recorded for the heat flow hole (which was about 300m deep).

In terms of geophysical exploration, a TEM survey and a gravity survey have been conducted (Fig.-8.4-10). The thermal gradient well site was chosen based on the geophysical results (Fig.-8.4-11), and a geothermal structural model has also been elaborated. However, the geothermal potential has not been calculated, nor has a development plan been decided yet.

The evaluation sheet for the Katwe-Kikorongo geothermal field is shown in Annex 5-2.

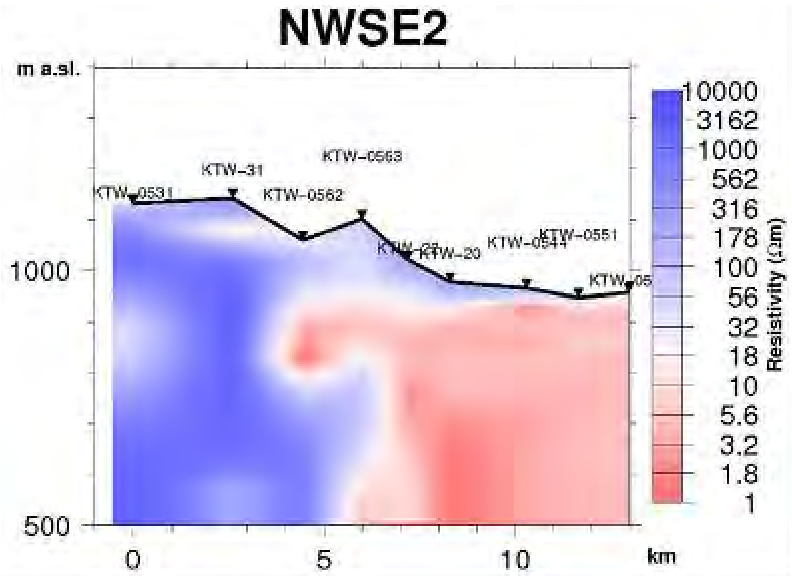


(Source) Bahatiet al.(2010)

Fig.-8.4-9 Geological map of Katwe-Kikoro area

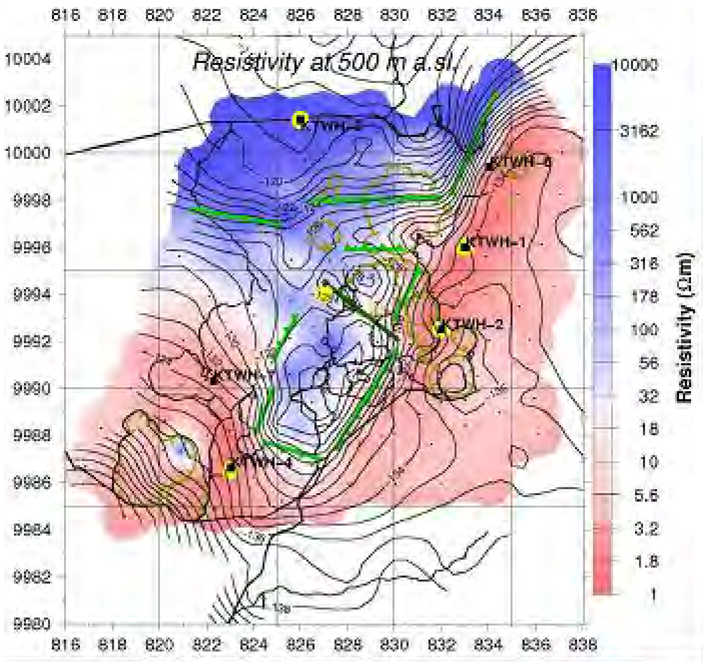
(Source) ICEIDA(2010)

Fig.-8.4-8 Craters in the Katwe-Kikorongo （Uganda） volcanic area



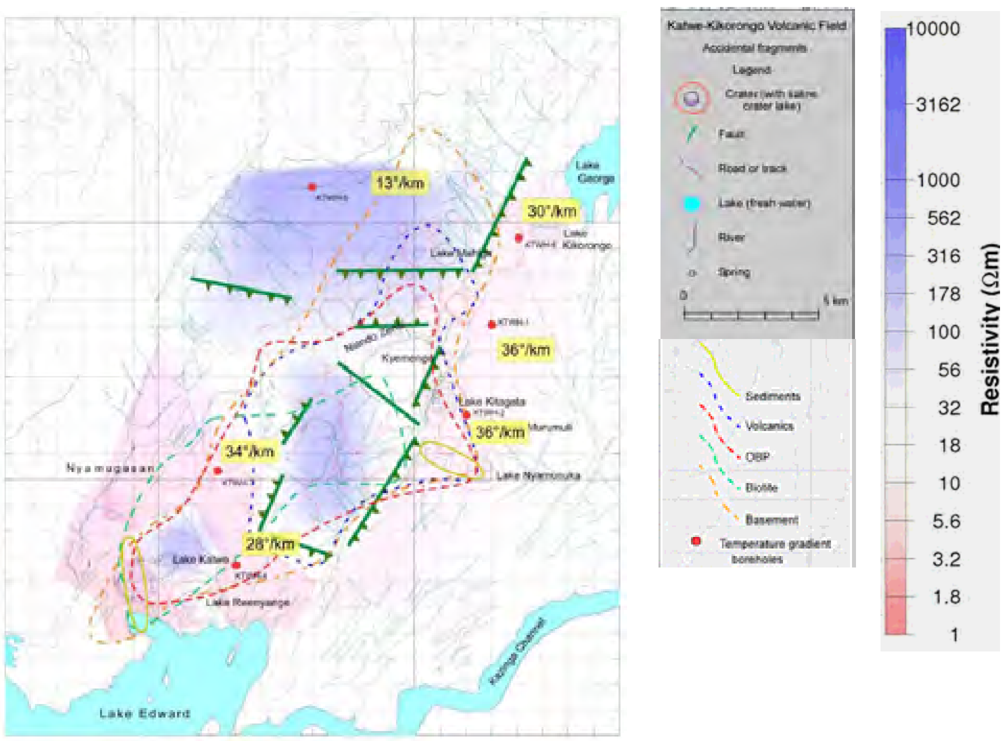
(Source) ICEIDA(2010)

Fig.-8.4-10 Resistivity map based on the TEM survey in the Katwe-Kikorongo area



(Source) ICEIDA(2010)

Fig.-8.4-11 Chosen heat flow hole points（yellow） and actual drilled points（black squares） in the Katwe-Kikorongo area



(Source) ICEIDA(2010)

Fig.-8.4-12 Geothermal structure of Katwe-Kikorongo area

Table-8.4-3 Chemical (mg/kg) and stable isotope (‰) analysis results
for hot spring water in the Katwe-Kikorongo area

Location	Sample No.	Temp. (°C)	pH	CO_2	H_2S	SiO_2	Na	K	Ca	Mg	SO_4	Cl	B	Li	$\delta^{18}O$	δD	TDS
LKatwe13	UG-93-01	28.6	7.61	156	0	29.3	44.7	35.1	10.1	5.92	7.0	3.9	0	0.003	-3.52	-9	132
L.Katwe6	UG-93-02	28.5	9.64	11316	5.3	88.6	25600	3500	0.1	0.95	9940	19000	1.9	0.067	1.9	-6	72000
L.Nyamunu1	UG-93-03	27.5	9.42	5523	0	32.2	8950	722	0.13	0.49	6450	3340	0.27	0.025	1.12	9.1	24690
L.Edward1	UG-93-04	23.3	8.55	223	0	18.2	83.7	41.5	16.8	27.3	18	20.2	0	0.01	2.52	22.1	254
Katunguru1	UG-93-05	26.6	6.95	1000	0	53.7	952	89.7	296	232	1800	723	0	0.023	-1.88	-8	4870
L.Kitagata5	UG-93-06	66.6	8.41	3105	0	91	9310	644	0.6	0.85	13400	2430	0.82	0.063	-0.73	0.5	27770
L.Kitagata2	UG-93-07	56.6	8.03	2544	0	105	6510	523	1.45	6.27	8970	1770	0.59	0.031	-0.6	3.2	19410
KazingaCh1	UG-93-08	26.2	8.28	108	0	21.5	38.5	7.8	22.9	11.2	11	10.3	0.06	0.005	0.98	12.6	180
L.Kitagata1	UG-96-06	61.1	9.33	10350	19.4	210	33600	1840	4.1	2	44000	8370	2.77	0.16	2.2	0	99515
L.KitagataW	UG-93-28	36	9.57	19470	0.3	389	87300	4780	4.3	1.47	110300	22200	6.9	0.08	10	24	256000
L.KatweW	UG-93-29	28	9.55	9008	4.8	237.6	124500	22500	5.3	32.5	71300	86600	17.5	0.11	9.6	24.5	372000

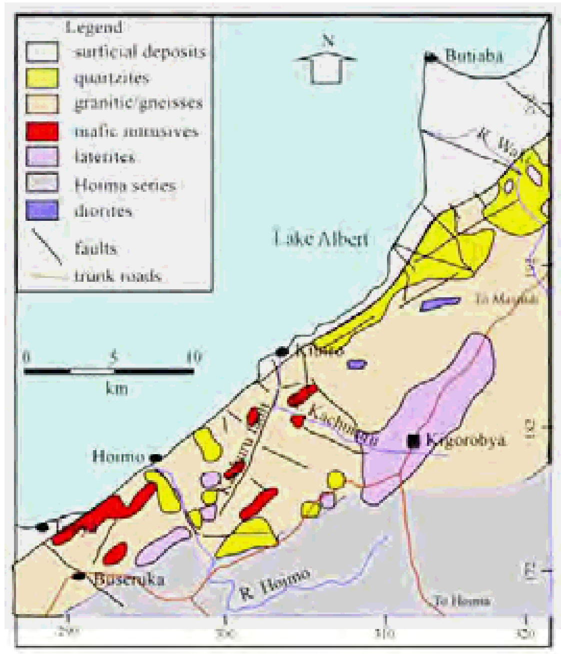
(Source) Bahati et al.(2010)

8.4.3 Kibiro geothermal field

The Kibiro area has also been surveyed by ICEIDA (ICEIDA, 2009). It is located in the west branch of the East Africa rift valley (Fig.-8.4-1). The Kibiro geothermal field is divided into two entirely different geological environments by an escarpment which cuts through the field from SW to NE (Fig.-8.4-13). To the east of the escarpment, the geology is dominated by Precambrian crystalline basement rock, characterized by granites and granitic gneisses that are mylonitic in the fault-controlled valleys. To the west lies an accumulation of thick sequences of Rift Valley arenaceous Kaiso and argillaceous Kisegi sediments at least 5.5 km thick, but without any volcanic rocks on the surface. (Fig.-8.4-14). The pH of the hot spring water is neutral, the Cl concentration reaches a maximum of 2,580 mg/kg, and the geochemical temperature of the hot spring water is 200～220°C (Table-8.4-3), though it is the lowest-lying of three major regions. The results of stable isotope analysis show that there are two separate origins for the hot waters, one in the east and the other in the south. Moreover, it has been suggested based on the tritium concentration in the hot spring water that the hot spring waters are mixed with low-temperature water. Oxygen and the sulfur isotope ratio of sulfate suggest the contribution of magma-derived fluid. In terms of geophysical exploration in this field, TEM and gravity surveys have been conducted (Fig.-8.4-15 - 17). An area showing both high gravity and also low resistivity is suggested the presence of intrusive rock, which is the heat source for this field. Six heat flow holes (about 300m deep) revealed a somewhat high thermal gradient of about 30°C/km around the cliff, although there was only 16°C/km on the east side of the cliff. This field is only in the Pre-FS stage, so the geothermal potential has not been estimated yet and the development plan remains undecided. The evaluation sheet for the Kibiro geothermal field is shown in Annex-5-3.

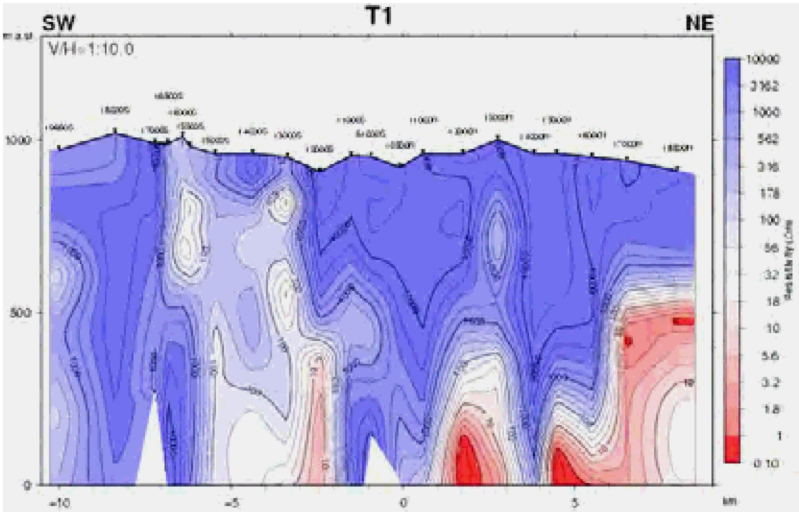
(Source) Bahati et al. (2010)

Fig.-8.4-13 Geology and geothermal manifestations in the Kibiro area（Uganda）



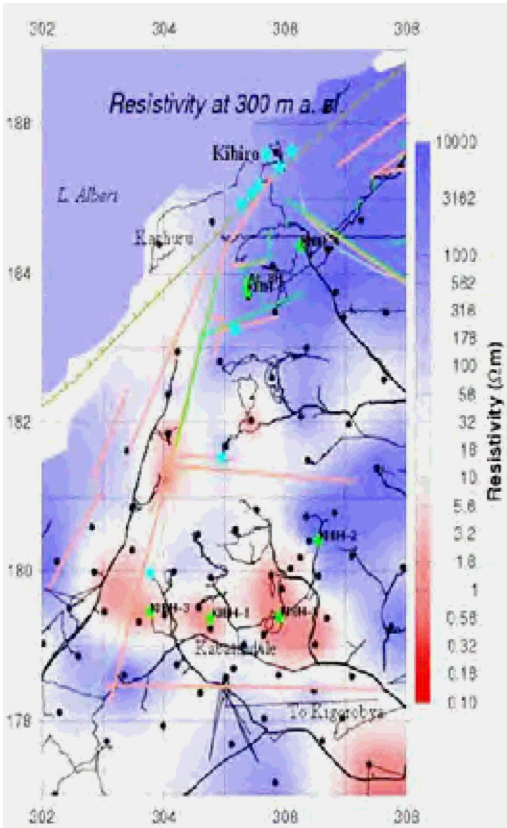
(Source) Bahati et al. (2010)

Fig.-8.4-14 Geological map of Kibiro area



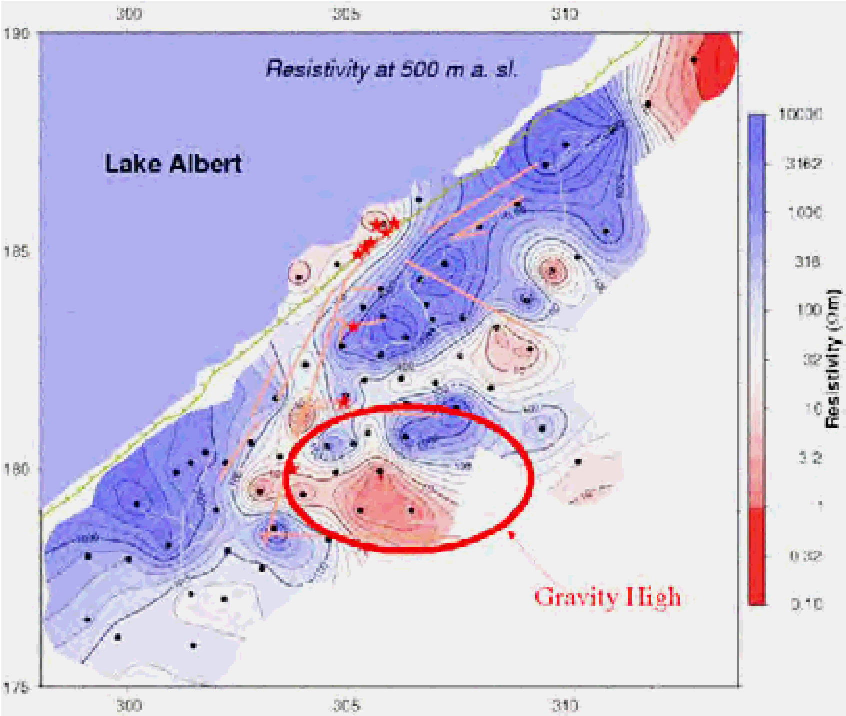
(Source) (ICEIDA, 2004)

Fig.-8.4-15 Resistivity map of the geothermal area based on the TEM survey in Kibiro



(Source) Bahati et al. (2010)

Fig.-8.4-16 Resistivity map of the geothermal area based on the TEM survey in Kibiro



(Source) (ICEIDA, 2004)

Fig.-8.4-17 Resistivity and gravity anomaly area map based on the TEM survey in Kibiro

Table-8.4-4 Chemical (mg/kg) and stable isotope (‰) analysis results for hot spring water in Kibiro

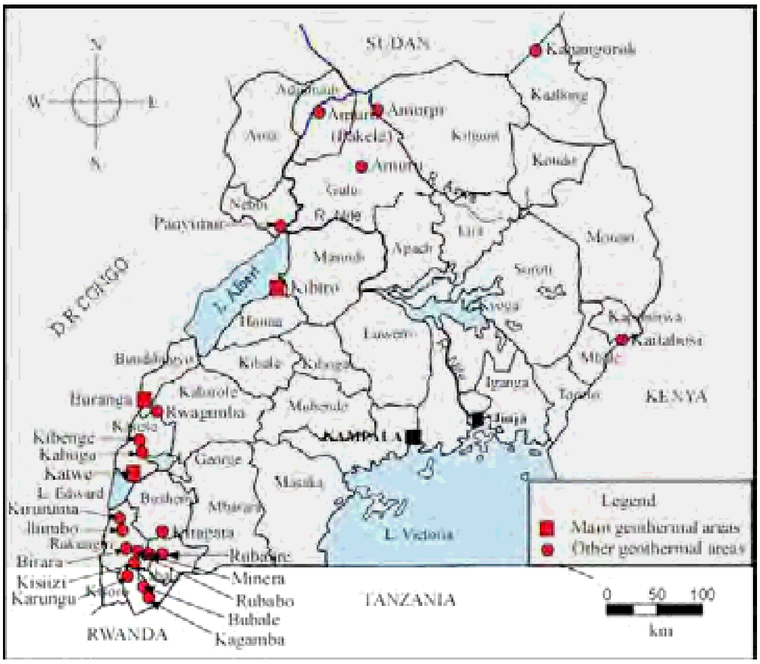
Location	Sample No.	Temp. (°C)	pH	CO_2	H_2S	SiO_2	Na	K	Ca	Mg	SO_4	Cl	B	Li	$\delta^{18}O$	δD	TDS
Mukabiga2	UG-93-19	86.5	7.06	146	10.4	129	1530	169	62	8.14	46.7	2500	2.26	1.5	-2.01	-11.3	4576
Mukabiga5	UG-93-20	81.1	7.14	155	13	125	1490	164	62.9	7.96	26.4	2450	2.23	1.48	-2.08	-11.8	4436
Mwibanda14	UG-93-21	71.8	7.14	155	17.3	122	1480	165	65.7	9.21	15.4	2440	2.21	1.46	-1.98	-10.6	4384
Muntere15	UG-93-22	39.5	8.05	115	0	135	1570	182	75.9	8.71	49.9	2580	2.47	1.53	-1.01	-3.9	4548
L.Albert	UG-93-23	30	8.93	236	0	0.5	72.3	49.4	9.75	27.3	19.3	24.2	0	0.012	5.47	39.8	338
Wantembo	UG-93-24	29.8	6.89	367	0	90.5	87.5	7.7	75.8	39.5	139	31.2	0	0.016	-3.58	-15.2	662
Kiganja1	UG-93-25	23.6	6.26	130	0	70.8	12.4	2.6	14.8	8.03	5.3	5.2	0	0.003	-1.57	-4.1	124
Ndalagi1	UG-93-26	24.9	6.72	232	0	76.1	50.6	7.5	138	39.5	227	123	0	0.015	-2.08	-5.2	680

(Source) Bahati et al. (2010)

8.4.4 Other geothermal fields

The recent oil exploration in the Panymur area shows the thermal gradient in that area is quite high at 80°C/km (Bahati, personal communication), and there are hot springs with a temperature of 35 – 58°C (Armannsson et al., year unknown), but no other surveys have been done in the Panymur area.

There are also hot springs in Kagamba, Karungu, Bubare, Rubaare, Kitagata, Ihimbo, Kanyinabarongo, Birara, Minera, Rubabo, Kiruruma, Kisiizi, Kabuga, Kibenge, Ndugutu (Bugoye), Rwimi, Rwagimba, Kanangarok, Kaitabosi, Amuru hot spring, and Amuru (Pekele) （Fig.-8.4-18）. Chemical analysis of the hot spring water has been carried out for these 21 hot spring areas by USGS（Armannsson et al., year unknown）



(Source) Bahati（2007）

Fig.-8.4-18 Location of geothermal areas other than major areas in Uganda

Table-8.4-5 Geochemical temperature of hot springs in other than major areas in Uganda

Location	Sample No.	Measured temp. ℃	Quartz temp. ℃	Chalcedony temp. ℃	Na/K temp. ℃
Kagamba	UG-05-15	35	73.9	41.8	338.9
Karungu	UG-05-16	65	101.1	70.7	153.9
Bubale	UG-05-17	34	62.6	30.3	194.7
Rubaare	UG-05-18	54	138.8	112.1	134.6
Kitagata	UG-05-19	66	120.1	91.4	136.1
Ihimbo	UG-05-20	70	83.8	52.2	96.0
Kanyinabarongo	UG-05-21	38	85.0	53.4	136.4
Birara	UG-05-22	63	136.1	109.1	155.8
Rubabo1	UG-05-23	58	125.0	96.9	136.2
Rubabo2	UG-05-24	60	123.2	94.9	137.0
Kiruruma	UG-05-25	36	108.2	78.4	183.9
Kisiizi	UG-05-26	30.1	58.6	26.4	n.a.
Minera	UG-05-27	58	126.8	98.8	128.1
Kabuga	UG-05-29	42	104.0	73.8	100.2
Kibenge	UG-05-30	48	97.5	66.8	121.6
Ndugulu	UG-05-31	22	79.7	47.9	141.3
Rwimi	UG-05-32	24	133.2	105.9	250.3
Rwagimba	UG-05-33	69.2	114.3	85.0	93.1
Kanangorok-1	UG-05-58	60	138.4	111.6	139.4
Kanangorok-2	UG-05-59	42	145.0	119.0	146.0
Kanangorok-BH	UG-05-60	38	144.9	118.9	153.2
Kaitabosi	UG-05-61	48	26.9	-3.1	93.7
Amoropii (Panyimur)	UG-05-62	58	111.3	81.8	98.5
Panyimur (Okumu)	UG-05-63	45	112.9	83.6	95.4
Panyimur (Avuka-2)	UG-05-64	35	104.6	74.5	139.6
Panyimur (Amuru)	UG-05-117	49	78.7	46.7	82.5
Amuru	UG-05-118	48	114.0	84.7	106.8

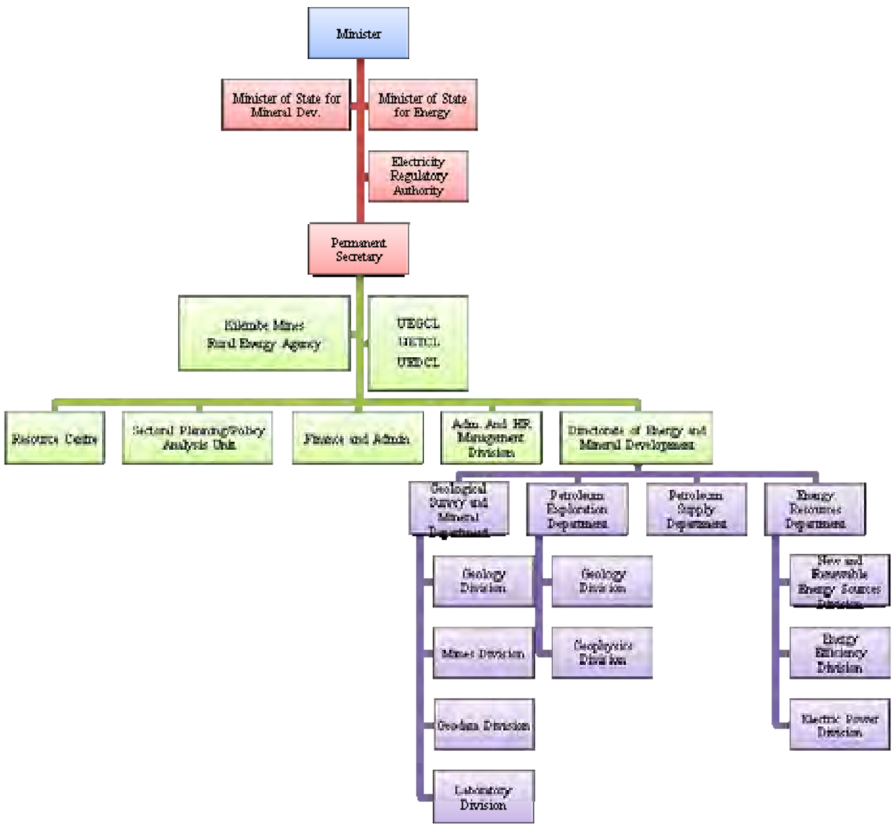
(Source) Armannsson et al.(Unknown)

8.5 Technical Capacity

8.5.1 Ministry of Energy and Mineral Development (MEMD)

The main duties and the role of the Ministry of Energy and Mineral Development (MEMD) consist principally of (1) energy policy formulation and implementation, (2) identification of the size of potential reserves of energy and mineral resources (implementation of studies and evaluation of technical data for the resources), (3) formulation of a regulatory framework for the development, supply and utilization of energy, and (4) supervision and evaluation of the performance of the private sector in their resource development, exploration and use.

The Directorate-General of Energy and Mineral Development of MEMD reports to the minister and the administrative vice minister and is organized into four department, the Energy Resources Department, Petroleum Exploration Department, Geological Survey and Minerals Department and Petroleum Supply Department. The Energy Resources Department has three sub-divisions, including an electric power division. The electric power division handles all matters related to power policy formulation, technical assistance to local governments, supervision of the operation of hydroelectric plants, and nuclear energy.



(Source) Study Team compiled from MEMD data

Fig.-8.5-1 Organizational structure of the Ministry of Energy and Mineral Development of Uganda

8.5.2 Department of Geological Survey and Mines (DGSM)

The DGSM, which is located in Entebbe, is the Department that is mandated to carry out all geothermal exploration in Uganda including exploration drilling. Responsibilities outside this mandate will be borne by ERD.

There is about 28 technical staff involved in geothermal work. A total of 27 people have been trained in different courses to date in Uganda (see Table-8.5-1). Only one person has an MSc degree, an MSC in Environmental Science from the University of Iceland.

Table-8.5-1 Available professional skilled manpower in Uganda

	MEMD	DGSM	PST	TOTAL
Geologist		9	0	9
Geochemist		8	0	8
Geophysicist		5		5
Reservoir Engineer		1	0	1
Drilling Engineer		0		0
Power Engineer		0	0	0
Environmental Scientist		1	0	1
Financial Planner/Modeller		0	0	0
GIS Scientist		0	0	0
Drillers		0		0
Technicians		4		4
Total	0	28	0	28

(Source) Study Team

Table8.5-2 shows the equipment currently owned by DGSM. Although there is a large geochemical laboratory, most of the equipment is old and needs replacement, and additional equipment is required. It was understood that there are plans to construct a new office block for DGSM in the near future.

Table-8.5-2 Available equipment in Uganda

Equipment Description	Available	Equipment Description	Available	Equipment Description	Available	Equipment Description	Available
Geological		**Geochemical**		**Geophysical**		**Drilling**	
Simple GPS	0	Simple GPS	1	Differential GPS	0	Complete Rig	1
Digital Thermometer	0	Digital Thermometer	1	Simple GPS	0	Water supply system(pumps, pipelines, tanks)	2
Fluid Inclusion Heating-freezing stage	1	pH meter	2	TEM	1	Site preparation equipment (dozer, grader, tipper trucks)	1
Binocular Microscope	2	Conductivity Meter	2	MT	0	Small water rig	0
Petrographic Microscope	2	Water Sampling Kit	1	Gravimeter	1	**General**	
X-Ray Diffractometer	1	Gas Sampling Kit	0	Magnetometer	2	4x4 field vehicles	0
X-Ray Flourescence	0	AAS	1	Portable seismometer	0	GIS System	0
ICP-MS	1	Ion Chromatograph (IC)	1	**Reservoir Engineering**		Total station	0
Thin sectioning equipment	2	Gas Chromatograph	0	Kuster gauge Tools set	0	Complete weather station	0
		Mass Spectrometer for stable Isotope	0	Kuster TPS with SRO	0		
		Tritium Scintillation counter & C14 analyser	0	Logging Winch	0		
				Logging Truck (K10)	0		
				Discharge Silencer	0		

(Source) Study Team

Although the current staff at DGSM are capable of conducting surface exploration, their biggest problem is the lack of a regular budget to do so. Mineral exploration seems to have more financial support, and most of the staff are required to work in the exploration and therefore cannot focus on geothermal exploration unless there is a ongoing project. The staff have previously been involved in surface exploration work financed and conducted by ICEIDA at Katwe and Kibiro, and more recently with the work financed by BGR at Buranga.

There is no clear entity or department charged with undertaking geothermal activities. The Assistant Commissioner of the Laboratory Division is unofficially the coordinator of geothermal activities. He is also the regional coordinator of isotope technical assistance from AIEA under ARGeo.

8.5.3 IPPS

There are no IPPs who have shown any interest so far in geothermal development in Uganda.

8.5.4 Consultants

There are no local geothermal development consultants.

8.6 Energy Policy

In the past, there was no long-term energy policy in Uganda, the only formal plan being the annual plan prepared by the Department of Energy for budgetary purposes. Therefore, it was hoped to establish a long-term energy policy, in part because it was deemed essential for attracting private investment into the energy sector. The report "Medium-Term Competitive Strategy for the Private Sector (2000-2005)" published in July 2000 also pointed out the need for a long-term energy policy. As a result, with the help of several donor agencies such as the World Bank (WB), the Norwegian Agency for Development Cooperation (NORAD), the Swedish International Development Cooperation Agency (SIDA), JICA, and others, the government adopted the "National Energy Policy (The Energy Policy for Uganda)", which was published in September 2002. Under this policy, "to provide the energy required by the people for the socio-economic development in an environmentally sustainable form" was established as the main target. The goals promulgated in the "National energy policy" and the plan of action the government should follow in order to achieve the goals are shown in Table-8.6.2.

With regard to renewable energy policy, the objective of the energy sector is to achieve the realization of the goal of providing the necessary energy to sustain the economic and social development of the people of Uganda in a way that is sustainable as well as eco-friendly ("Renewable Energy Policy" in 2002). The energy policy targets the following tasks: to contribute to poverty eradication in particular, to improve energy management and administrative work, to contribute to economic growth and to control the environmental impacts of energy exploitation. The constitution enacted in 1995 aims to achieve "the satisfaction of basic human needs" and one of the means envisaged to that end is to secure a "nation-wide energy supply".

In accordance with the clause 1 of Article 56 of the Electricity Act 1999 Cap145, Uganda Electricity Transmission Company (UETCL), which holds the only electricity transmission business license in Uganda, presented a standard Feed-In Tariff system for renewable electricity generation, based on instructions from the Electricity Regulatory Authority to set the purchase price to the grid for renewable energy generation facilities up to a limit of 20MW on the basis of the avoided cost. The Feed-In Tariff is designed to encourage the development of renewable energy . The FIT system in Uganda, however, applies only to small hydro and biomass among various renewable energy resources, and geothermal power is not included.

Table-8.6-1 Uganda's Feed-in Tariff for renewable energy

	Hydro Electric Power			Biomass Power		
Time of Use	Year 1 to 6	Year 7 to 20	Simple Weighted Average	Year 1 to 6 (Bagasse)	Year 7 to 20 (Bagasse)	Weighted Average
Peak (1800-2400hrs) (US Cents/KWh)	12.00	9.00	9.00	12.00	8.00	9.60
Shoulder (0600-1800hrs) (US Cents/KWh)	6.40	5.40	5.70	6.00	4.50	5.10
Off-Peak (0000-0600hrs) (US Cents/KWh)	4.00	1.50	2.25	4.10	4.00	4.04
Average Tariffs	7.20	5.33	5.89	7.03	5.25	5.96

(Source) Study Team compiled from Ugandan ERA data

Table-8.6-2 Government policy objectives and action plans

	Purpose of policy	Government activity
1	Consolidate potential reserves and demand for each energy resource	・ Construct comprehensive database for energy resources while studying trends in energy consumption ・ Train local experts who will collect and evaluate the data.
2	Establish national energy supply system with stable supply at affordable cost	・ Encourage private investment in the energy sector. ・ Promote competition among energy suppliers. ・ Promote market mechanisms for the energy sector. ・ Establish a rural energy supply. ・ Provide information, education, and technology to consumers. ・ Cooperate with financial institutions to build sustainable

		financing mechanisms
3	Improve energy sector management	・ Clarify the role and function of the various energy agencies (government, private sector, NGOs, etc.) ・ Create a regulatory framework with emphasis on transparency. ・ Develop human resources in the energy sector to divide implementation of policies and programs more equally between urban and rural areas. ・ enhance the capacity of regulatory agencies to a level where they can create a regulatory framework adapted to the changing environment. ・ Adopt appropriate measures to recruit good quality personnel in regions to ensure the participation of people in rural areas. ・ Formulate energy policies fair to all the stakeholders.
4	Promote economic development	・ Promote competition in energy markets ・ Take various measures to stimulate private investment in the energy sector ・ Enable a cheap and stable energy supply ・ Promote regional interchange of energy in East Africa.
5	Address environmental problems	・ Encourage the development of alternative energy and environmentally friendly energy use. ・ Educate consumers and suppliers on the environmental issues. ・ Reduce emissions of substances that cause environmental problems including global environmental issues (set wide range of targets.) ・ Promote the efficient use of energy. ・ Create the necessary capacity and organization to enforce environmental monitoring.

(Source) MEMD (2002)

Of relevance to the CDM approach is the Uganda government's ratification of the UN Framework Convention on Climatic Change (UNFCCC) on 8 November 1993 and the Kyoto Protocol on 25 March 2002. The government appointed the meteorological agency (Department of Meteology) as a focal point for participation in the UNFCCC. It is expected to streamline and make consistent the regulatory framework, while seeking to implement the plans of the Framework Convention. In addition, the Ministry of Lands, Water and Environment has been designated under the CDM as the Designated National Authority (DNA) which is authorized to approve projects. The World Bank's Prototype Carbon Fund (PCF) projects are the only CDM projects to have been implemented so far.

8.7 Environmental Policies

Regarding the EIA system in Uganda, there are Environmental Impact Assessment Regulation in 1998 and Guidelines for Environmental Impact Assessment in 1997 as main legislative documents. In addition to the EIA guidelines, sectoral guidelines for the EIA are currently under preparation. Draft EIA guidelines for the energy and mining sectors have been prepared and are now under review of the National Environmental Management Authority (NEMA). In the hearing to NEMA during the study in May 2010, the guidelines were supposed to be opened for the public review.

There is a list of the projects subject to the EIA in Annex 3 for the EIA guidelines. Related to the geothermal power development project, it is supposed that project category of the electrical infrastructure (item No. 11 in the list) is mainly applied and also mining (item No. 6 in the list) is included. However, since conditions on project scale are not prescribed in the list, necessity of the full-scale EIA is determined in the screening process of the EIA. The list is a kind of reference material. Therefore, necessity of the full-scale EIA is determined only in the screening process in the case of the project whose project type is not mentioned in the list.

Procedural flow of the EIA is shown in the following figure. During the EIA procedure, it takes 180 days at maximum to obtain the EIA approval after project proponent submits an EIA report to NEMA. On average, this period is shorter than 180 days. During the approval process, feedback comments are sent from NEMA to the project proponent within 21 business days in the case of IEE and 30 business days in the case of full-scale EIA. Expenses for the EIA procedures have to be paid based on the cost standard prescribed in the EIA regulation of 1998. Implementation of the EIA study is limited to entrepreneur registered under NEMA.

Review of the EIA is basically conducted in NEMA. The EIA report is sent to lead agency of the project and relevant district office to call for their comments as a part of the stakeholder consultation. In the case of controversial project, ad hoc technical committee is formed.

Public hearing is held in the case of controversial project. In the ordinary cases, summary of the EIA report is opened to the public for calling for the comments. The summary of the EIA report is translated into local language and opened in the NEMA library, public library, Makerere University, and Environmental Division of District Office.

Though aspects on land acquisition and resettlement are required to be covered as a social environmental issue in the EIA, there is no concrete description on the issue in the current EIA guidelines. Since there is no regulations/guidelines on the land acquisition and resettlement, which is separated from the EIA, the guidelines of the World Bank is referred in practice. District Land Board in the project area is mainly in charge of the land acquisition and resettlement.

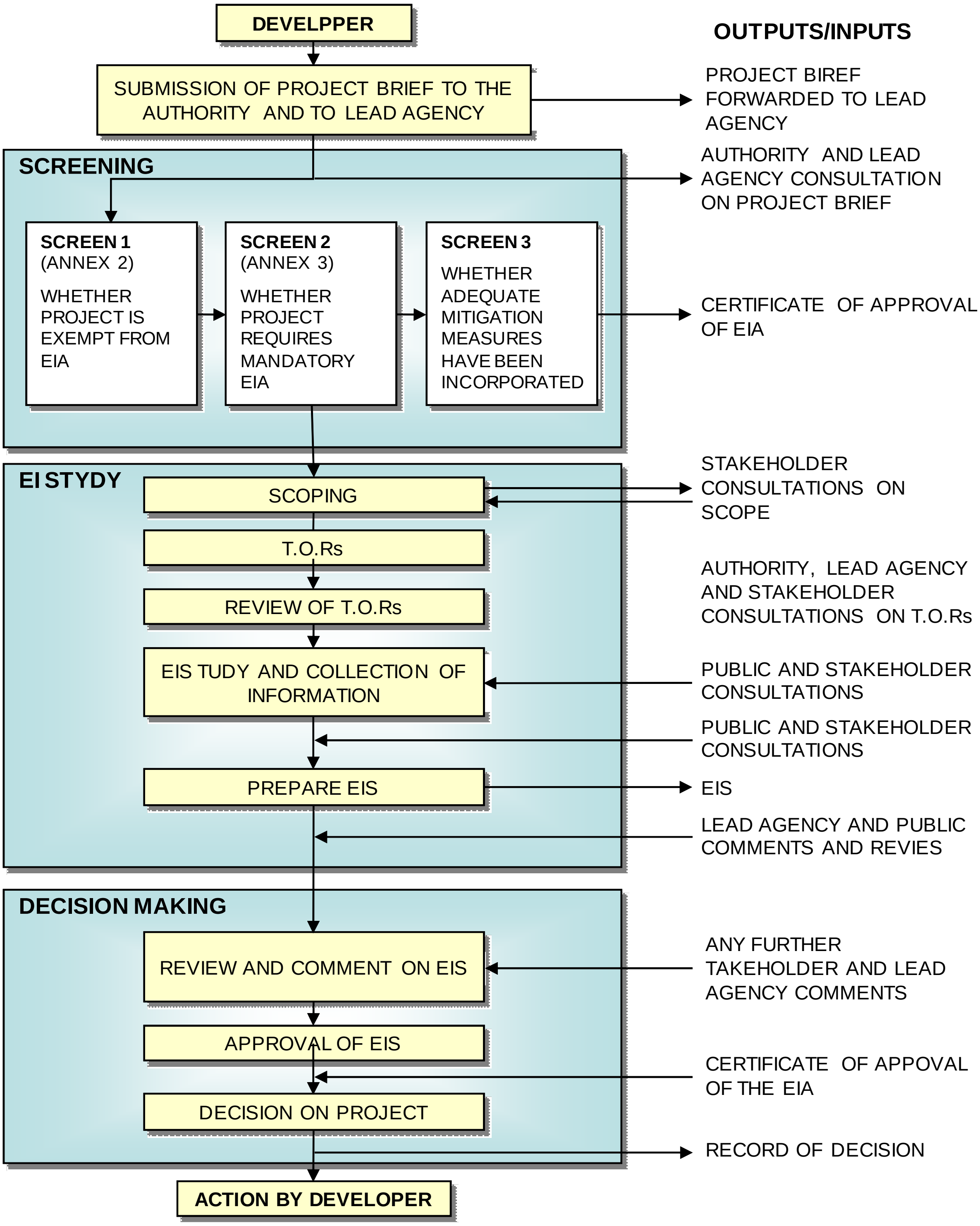
The number of the EIA which requires full-scale EIA have gone up and some 300 EIAs are applied for the approval process annually. Among those EIAs, around 30 projects are related to the energy sector, mainly oil exploitation.

Major environmental issues related to the development project are resettlement, pollution related health damage, and transboundary natural environmental impact. According to NEMA, though specific issues related to the geothermal development project are not known in NEMA, EIA procedure will be required project stages in well exploitation and power plant construction.

Table-8.7-1 Relevant Environmental Legislations and Standards in Uganda

No.	Name of Legislation
1	The National Environmental Act, Cap 153 (Commencement 19 May, 1995)
2	The Environmental Impact Assessment Regulation, S.I. No. 13/1998
3	Guidelines for Environmental Impact Assessment in Uganda, NEMA, 1997
4	Sectoral Guidelines for the Environmental Impact Assessment Process for the Mining Sector in Uganda (Draft under review process), NEMA
5	The National Environment (Standards for Discharge of Effluent into Water or on Land) Regulations, S.I. No 5/1999
6	The National Environment (Noise Standards And Control) Regulations, 2003
7	The National Environment (Hilly And Mountainous Area Management) Regulations, 2000
8	The National Environment (Management Of Ozone Depleting Substances And Products) Regulations 2001
9	The National Environment (Access to Genetic Resources and Benefit Sharing) Regulations, 2005
10	The Mining Act, 2003
11	The National Forestry and Tree Planting Act, 8/2003
12	The Water Act, Cap. 152

(Source) NEMA



(Source) NEMA (1997)

Fig.-8.7-1 Process of EIA Report Preparation and Approval Process

8.8 Direct Utilization of Geothermal Energy

There is no information on current utilization of the direct utilization of the geothermal energy in Uganda. Since geothermal power development has not been implemented in Uganda, there is no utilization of surplus hot so far. There would be potential of direct utilization of the geothermal energy such as hot water in future in Uganda, like that in Kenya, since climate condition in Uganda is relatively similar to that in Kenya.

Chapter 9 Assistance of Other Donor Organizations to Geothermal Development in the Region

There are various multilateral and bilateral donor organizations that are involved in supporting geothermal development in East African countries, such as the World Bank, the Global Environment Facility (GEF), KfW Entwicklungsbank (Germany), Agence Française de Développement (AFD) (France) and so on, so coordination and cooperation among these donor agencies will be very important for geothermal development in the region. These donor agencies utilize multiple schemes of cooperation, such as grants for surface exploration, technical assistance for training and capacity building, concessional loans, equity and loans to the private sector. The Risk Mitigation Facility of ARGeo merits special mention because the program provides technical and thus also financial assistance to the most difficult part of geothermal resource development, which is the drilling of exploratory wells. Currently KfW is also designing the structure of their own fund to finance exploratory drilling, and this should be implemented from the beginning of 2011.
In this chapter, the structure and function of ARGeo will be described in detail and then, the trend of assistance of principal donor organization for geothermal development in the region will be overviewed.

9.1 ARGeo（African Rift Geothermal Development Program）

9.1.1 Objective and Background

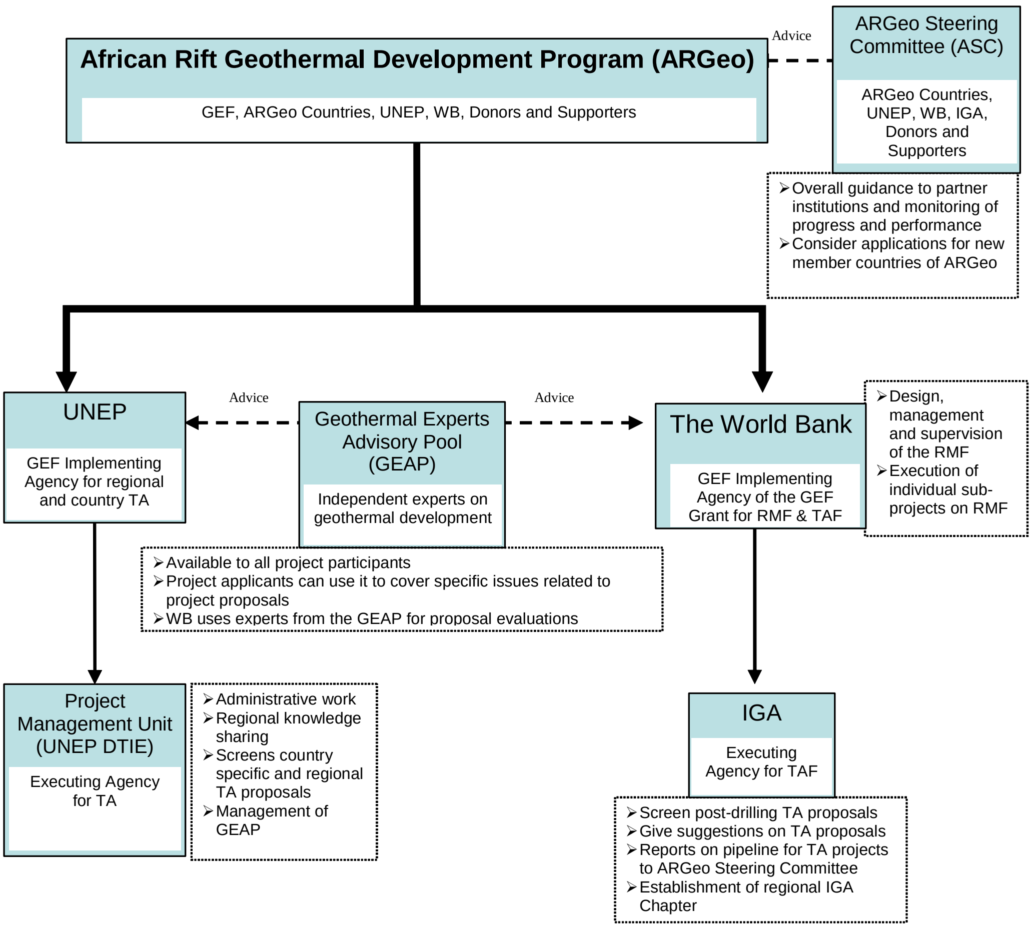
The ARGeo Program is a framework for partnership among international donor organizations and the countries in the region to promote the development and utilization of geothermal energy in the East African Rift Valley. ARGeo will contribute to a reduction of green-house gas (GHG) emissions and simultaneously to the diversification of the regional energy supply. The participating countries are Djibouti, Eritrea, Ethiopia, Kenya, Tanzania and Uganda. However, the Program will also be open to other African countries with confirmed resource potential interested in geothermal development. Preliminary interest has been expressed from the Comoros, Rwanda and Zambia.

The ARGeo intiative was launched with the leadership of UNEP and KfW and the East African countries at an international conference held in Nairobi in April 2003. Bilateral agencies such as Iceland’s ICEIDA, the Italian government and the German BGR joined these efforts, providing resources for the execution of Pre-F/S, training and the holding of regional conferences. The amounts provided by each organization were USD 249,542 from Iceland, USD 1,600,000 from BGR, and USD 150,000 from the Italian government. Since then, other donors such as the US government and French development agency (AFD) have committed their support to ARGeo. However, it has been taking a long time for the Executing Agencies to approve the ARGeo Programe itself. The original executing agencies were KfW and UNEP, but as the process unfolded, the World Bank and UNEP became the executing agencies of the program, and the program itself was finally approved by the beginning of 2010. Due to the delay in the implementation of the project, most of those co-financing resources once committed by the bilateral donors have to be reconfirmed at the present time.

9.1.2 Components and Implementation Structure of ARGeo

The GEF approved the USD 17.75 million in grants for the ARGeo program, which consists
of four components described in Table-9.1-1. All the components require co-financing. The World Bank manages the the Risk Mitigation Facility (RMS) component, the centerpiece of the ARGeo Program, and the Technical Assistance Facility component for project-related TA support. The components managed by UNEP consist of technical assistance with emphasis on regional knowledge sharing and technical assistance for the upstream pre-drilling stage. The objectives of each facility are independent, and a development project, whether private or public, can combine support from any of those facilities as appropriate.

The ARGeo Steering Committee (ASC) will provide overall guidance to the partner institutions and monitor progress and performance. The ASC includes nominated representatives of the participating countries, UNEP, the World Bank and the IGA (International Geothermal Association).
The Geothermal Experts Advisory Pool (GEAP) will consist of a regularly updated roster of reputable local and international experts, representing the various disciplines involved in geothermal development, including resource evaluation, drilling, reservoir engineering, geothermal power plant engineering, legal services, environmental management, etc. The GEAP will be available to all project participants. Maintenance and updating of GEAP is to be managed by UNEP staff of the ARGeo Program. To determine eligible experts for the roster, UNEP and the World Bank will each designate a mutually agreed geothermal expert as a selection panelist. The International Geothermal Association (IGA) will be the executing agency for the World Bank's Technical Assistance Facility (TAF). In the Risk Mitigation Facility (RMF), success/failure will be determined based on the measured values of the parameters as defined under the grant agreement of each project. The drilling process will be monitored by experts drawn from the GEAP hired by the World Bank. UNEP, the executing agency for the two components of regional networking and technical assistance, will create a Project Management Unit in the UNEP office in Nairobi as their "implementation agency".



(Source) GEF (2009)

Fig.-9.1-1 Stakeholders in ARGeo Program

Table-9.1-1 Components of ARGeo

Project Components	Investment or TA	Expected Outcme	Expected Outputs	GEF Financing ($)		Co-Financing ($)		Total
Risk Mitigation Facility (RMF)	risk insurance	Mitigate the geological risk element in exploration and drilling activities so that geothermal energy technologies become financially attractive in the Rifr Valley of East Africa	Four geothermal resource sites with confirmed energy potential through RCD confirmed	11,000,000	15.49%	60,000,000	84.51%	71,000,000
Technical Assistance Facility (TAF)	TA	Mitigate the capacity constraints of participating client countries and local utility project sponsors to proceed in GtPP devleopment and the post-drilling stage	1. Facilitate financial close of exploration drilling operations by providing post-drilling TA. 2. On the job training program for regional GtE staff to use regional expertise in the execution of exploration and drilling programme 3. Establishment of East African Regional Branch of IGA as a tool to create interest of and foster relationships with donors, bi-laterals, international organizations and national agencies and organizations outside the region	1,640,000	57.06%	1,234,000	42.94%	2,874,000

Regional network	TA	Strengthened technical and institutional capacity and information base through a regional network that will support and coordinate the implemetatoin of the activities	Increase the information base and technical capacity in the region. Raise awareness about appropriate policies and regulatory and legal frameworks for geothermal development. Fully operational informaion network hubs in each country.	1,550,000	24.45%	4,790,000	75.55%	6,340,000
Technical assistance	TA	Support to surface exploration to priority geothermal prospects. Adjustment to a favourable direction to geothermal energy development of the mining legislations of the diferent States	Confirmation of priority prospects, prefeasibility studies and bankable feasibility studies.	2,800,000	44.71%	3,462,600	55.29%	62,626,000
Projece Management WB				360,000	90	40,000	10	400,000
Project Management UNEP				400,000	100	0	0	0
Total Project Costs				17,750,000		69,526,600		87,276,600

(Source) GEF (2009)

http://www.thegef.org/gef/sites/thegef.org/files/repository/9-24-2009%20Council%20letter.pdf

The World Bank and UNEP will jointly implement the ARGeo program in coordination and with the support of the governments of Djibouti, Eritrea, Ethiopia, Kenya, Tanzania and Uganda. The counterpart agencies will be; The Ministry of Energy and CERD (Djibouti), Department of Mines, Ministry of Energy (Eritrea), Geological Survey of Ethiopia and the Ministry of Energy (Ethiopia), the Ministry of Energy and KenGen/GDC (Kenya), the Ministry of Energy and Department of Geological Survey and Mines (Uganda), and the Ministry of Energy and Minerals (Tanzania).

9.1.3 Risk Mitigation Facility (RMF)

The Risk Mitigation Facility, the centerpiece of the ARGeo program, is a grant-based compensation scheme which will partially mitigate the resource risk associated with geothermal exploration. The operation period of the fund will be 5 years and any of the public and private sponsors will be eligible to apply for RMF support. It is the assumption that the project sponsors will bring their own capital contribution and other resources to finance a large part of the project cost. That is to say, the RMF is intended to provide a discrete support to encourage public and private project sponsors to undertake investment in geothermal energy development and to build sustained market capacity to develop and finance geothermal projects on commercial terms using private capital. The project sponsors are also expected to pay for the initial phase of geological research, surveying and other pre-drilling exploratory activities out of their own budget.

The RMF utilizes the same lending instrument as the GEF-supported GeoFund, which was operational from November 2006 in Europe and Central Asia. The GeoFund constituted a compensation scheme for risk mitigation of USD 10 million, provided technical assistance of USD 7 million, and also dispensed USD 8 million in the form of a grant. Since the World Bank was the Executing Agency for the GeoFund , the technical lessons learnt from the GeoFund were fully applied to the ARGeo program. In particular, the GeoFund provided a useful opportunity to acquire hands-on experience in how a risk mitigation instrument can be designed so that triggering events and payment claims can be defined and processed in a transparent manner.

The RMF is designed to provide geological risk insurance which requires a payout only in the event of failure. This design allows the use of scarce GEF funds on a revolving basis. The needed TA and capacity-building ensure a continuous project development in power plant design, construction and operation after successful drillings. In terms of investment, the ARGeo project has a multiplier effect of more than four. With a GEF investment of USD 17.75 million, a project may generate around USD 75 million of investment from its partners.

The applicable terms and conditions of the RMF will be determined for each project. However, normally the size of an individual commitment by the RMF will be up to USD 5 million per well. An example of the basic structure is as follows: for the drilling of three exploratory wells, the investment needed may be around USD 19 million (USD 5 million/well x 3, plus infrastructure and administration etc.). When the drilling of one or more wells results in failure, the RMF will pay compensation of up to USD 5 million or 85% of the actual drilling cost of each well. The risks to be covered will be limited to the geological ones. The technical, management and commercial risks in drilling will not be covered. Success/Failure of exploratory drilling will be determined based on the measured values of the parameters as defined under the grant agreement for each individual project. The parameters for success/failure will be determined under the grant agreement for each individual project. The drilling process will be monitored by the Bank-hired experts drawn from the GEAP on a continuous basis and the drilling date will be transmitted from the on-site drilling manager. Information about any major changes in the drilling plan or unexpected geological events which would potentially affect the outcome of the drilling activities will be readily communicated to the Bank experts and ultimately to the ARGeo task team of the Bank.

As a result of the response by the ARGeo countries to the initial project solicitation, there are 17 projects in the RMF project pipeline, of which 4 have been short-listed. The Assal project in Djibouti was expected to be the first project supported by the RMF, a project for which the International Finance Corporation (IFC) also intended to provide 20% of the equity for exploratory drilling, until the IPP negotiations between the Djibouti government and the project sponsor were suspended in practice. Table-9.1-2 shows the current RMF project pipeline. However, the pipeline will be updated regularly. The next updating may be done following upon project requests submitted during the next ARGeo Conference in November 2010 in Djibouti.

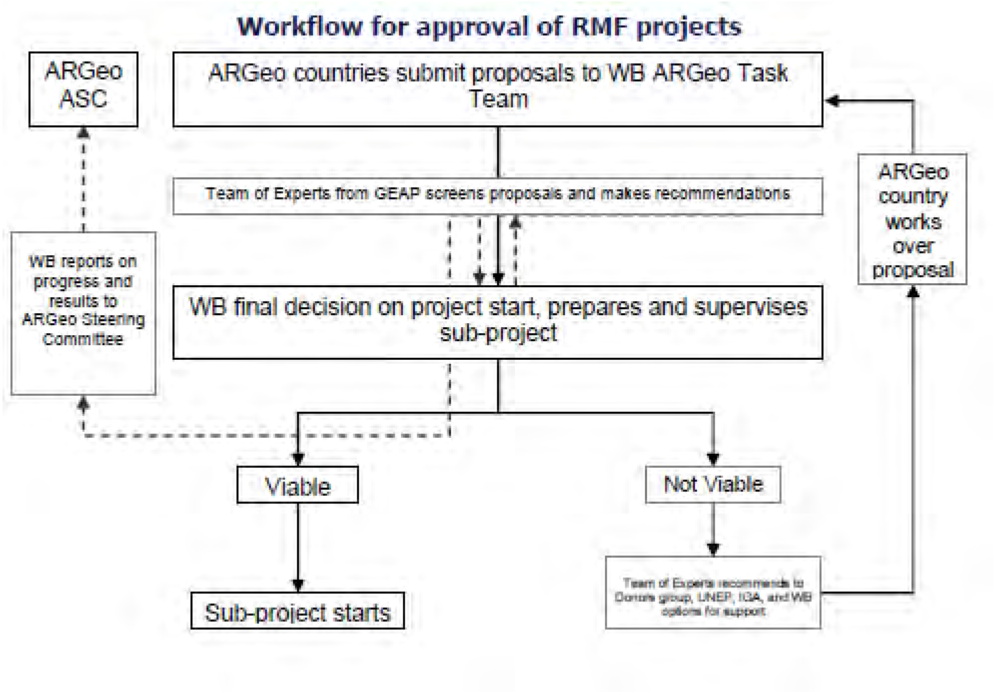
Table-9.1-2 RMF Project Pipeline

Project Name	Country	Resource Potential (MW)	Comments
Proposals Submitted to the independent proposal review panel			
Assal	Djibouti	100	Deemed ready for RCD*
Alid	Eritria	30	Request some additional scientific surface exploration work to qualify for RCD
Tendaho	Ethiopia	30	Deemed ready for RCD
Longonot	Kenya	70	Deemed ready for RCD
ARGeo Project pipeline of regional geothermal sites where surface exploration activities have started			
Obock	Djibouti	5	
Dikhil	Djibouti	10	

Nabro-Dubbi	Eritria	5	
Corbetti	Ethiopia	30	
Suswa	Kenya	200	
Menengai	Kenya	600	
Silali	Kenya	70	
Rufidji	Tanzania	6	
Natron-Manyara	Tanzania	5	
Mbeya	Tanzania	20	
Buranga	Uganda	10	
Katwe	Uganda	30	
Kibiro	Uganda	20	

*RCD: Resource Confirmation Drilling

(Source) World Bank (2009)



(Source) World Bank (2009)

Fig.-9.1-2 Workflow for approval of RMF projects

9.1.4 Technical Assistance Facility（TAF）

The Technical Assistance Facility (TAF) managed by the World Bank will provide project sponsors with the technical assistance needed in the preparation and implementation of geothermal energy projects. TAF will be executed by the International Geothermal Association (IGA) under the supervision of the World Bank. IGA has also been acting as executing agency for the TA activities of the GeoFund in Europe and Central Asia, also under the supervision of the World Bank. The IGA is a non-profit organization of experts, scientists and companies active in geothermal energy development around the world. It has more than 3000 members in 65 countries, has consultative status with the Economic and Social Council of the United Nations and the European Union, and is one of the founding members of the Renewable Energy Alliance (IREA). As part of the implementation of the TAF, IGA will establish an East African Regional Branch to provide a focal point linking the international geothermal community to the opportunities in the region.

TAF will particularly help to support the activities of the public sector in the post-drilling phase and play a complementary role to UNEP's technical assistance program, which focuses on support for preliminary geothermal resource assessment. Where other funding is not available, TAF could also support pre-drilling surface exploration activities. Thus, TAF post- and pre-drilling technical assistance, complemented by UNEP technical assistance, will provide a wide range of critical support during the exploration and implementation phases of a geothermal energy project. Technical, financial and commercial planning is particularly important for successful project implementation. However, many of the public sector project sponsors in East African countries are not adequately staffed with experienced professionals who can deal with project planning and management involving private sector investors and developers. Therefore, TAF will support feasibility studies, project implementation and business planning, financial analysis, bidding and contract preparation, negotiation, etc. TAF will also facilitate capacity-building in the area of geothermal generation technologies by financing an internship program designed to provide on-the-job training for managerial, technical and operations personnel that will be involved in power plant construction and operation as well as in well-field management and operation. Internships will be for a minimum period of one month and a maximum of 4 months.

9.1.5 Regional Networking and Technical Assistance

A Project Management Unit for technical assistance will be established at UNEP's office in Nairobi for the purpose of overall management and administration of ARGeo components implemented by UNEP. The centerpiece of UNEP tasks will be the creation of a regional knowledge sharing network which will manage geological information in a joint database accessible to all the ARGeo countries, building the capacity required to ensure that the information system will be maintained and updated appropriately even after the completion of the ARGeo program. In addition, UNEP will support activities of upstream surface exploration to minimize the possibility of the failure of exploration drilling compensated by the RMF. Also, awareness-raising through training concerning appropriate policies and the regulatory and legal framework for geothermal development, as well as support for the elaboration of bankable feasibility studies will be included in the technical assistance.

9.1.6 Monitoring Indicators for the ARGeo Program

The ARGeo Program will be implemented for a period of 5 years and will be monitored by the ARGeo

Steering Committee through the indicators shown in the Table-9.1-3.

Table-9.1-3 Arrangements for results monitoring

		Target Value				
ARGeo Program Outcome Indicators	Baseline	YR1	YR2	YR3	YR4	YR5
Actors with confirmed investments (Value of investments, or Projects invested, or Potential explored)	138MW	50-150MW (if drilling successful and no RMF called)		220MW	250MW	300MW
Amount of CO_2 emissions (in tonnes) that will be potentially mitigated	3.4 Mill	200,000-500,000		500,000	1,000,000	1,000,000
Intermediate Outcome Indicators						
Number of geothermal resource sites with energy potential con- firmed through RCD (Resource Confirmation Drilling)	0	1		2	3	4
Number of exploration drilling operations reaching financial close						
Number of post-drilling feasibility studies fi- nanced by the program, in the form of business planning, financial analysis, or bidding and contract preparation	0		1	2	3	
Nmber of regional GtE staff supported by IGA's on-the-job train- ing program	0	2	8	13	18	24
Establishment of East African Regional Branch of the IGA	0		East African Regional Branch established			

(Source) World Bank (2009)

9.2 World Bank Group

"Renewable energy" and "energy efficiency" will be vital solutions for the World Bank Group (including IBRD/IDA, GEF, Carbon Finance, IFC, and MIGA, and hereinafter referred to as WBG) in the face of global climate change and pressing need of energy for development. In fiscal 2008, total WBG financial commitments for "renewable energy", including hydropower of all sizes, and "energy efficiency" rose to USD 2.7 billion. This represents an 87 percent rise in financing for "renewable energy" and "energy efficiency" from USD 1.4 billion in fiscal 2007. Total commitments for "new renewable energy[1]"and "energy efficiency" were USD 1.7 billion. Ninety-five "renewable energy" and "energy efficiency" projects in 54 countries, as well as two cross-border projects, were supported in fiscal 2008. These projects accounted for 35 percent of total WBG energy lending commitments in fiscal 2007. Looking at the funding breakdown by organization, IBRD and IDA provided the largest funding for renewable energy and energy efficiency of all the WBG institutions, with USD 1.3 billion of combined commitments, among which USD 109 million was for "new renewable energy". GEF has been an important partner, contributing USD 145 million in co-financing for World Bank projects. IFC committed a total of USD 949 million, with USD 115 million going to "new renewable energy", USD 473 million to "energy efficiency" and USD 361 million to large hydropower projects.

Table-9.2-1 WBG Commitments for Renewable Energy and Energy Efficiency, Fiscal 2008

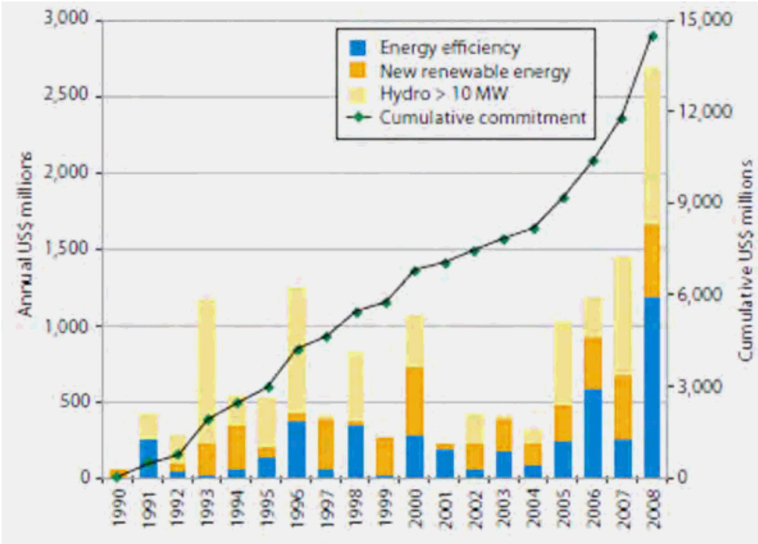
	Commitments in fiscal 2008 (millions of US$)			
Source of funds	*New RE*	*Hydro > 10 MW*	*EE*	*Total*
World Bank	272	625	719	1,616
IBRD/IDA	117	601	624	1,343
GEF	90	—	55	145
Carbon Finance	65	24	40	128
IFC	115	361	473	949
Own Funds	72	361	473	906
Carbon Finance	39	—	—	39
GEF	4	—	—	4
MIGA	88	21	—	110
Total	476	1,007	1,192	2,675

(Source) World Bank (2008)

At the Bonn International Conference on Renewable Energies in 2004, the WBG made a commitment to accelerate its support for new renewable energy and energy efficiency. It pledged to increase its financial commitments for "new renewable energy" and "energy efficiency" at a rate of 20 percent per year between fiscal 2005 and 2009 from a baseline commitment of USD 209 million (equal to the average of the previous three years). Thus, with the combined commitments of USD 1.7 billion for

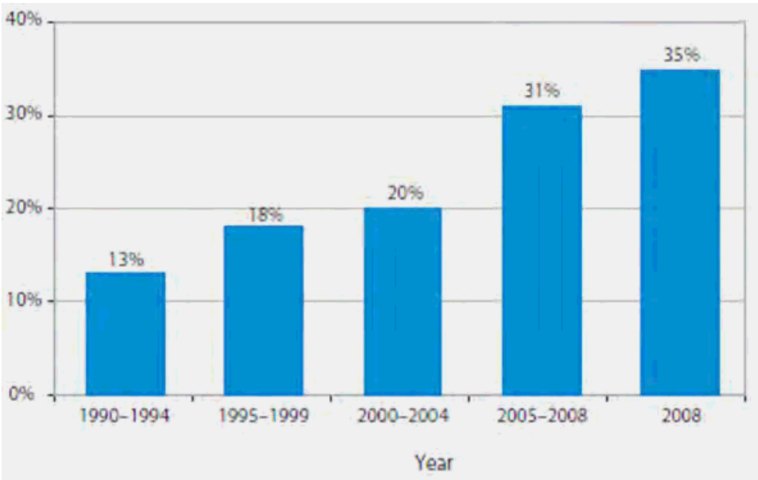
[1] New Renewable Energy comprises energy from solar, wind, biomass, and geothermal, as well as hydropower from facilities with capacities up to 10 MW.

"new renewable energy" and "energy efficiency" in fiscal 2008, the World Bank outperformed its Bonn Commitment by a wide margin, as in previous years.



(Source) World Bank (2008)

Fig.-9.2-1 WBG Renewable Energy and Energy Efficiency Commitments, Fiscal 1990-08



(Source) World Bank (2008)

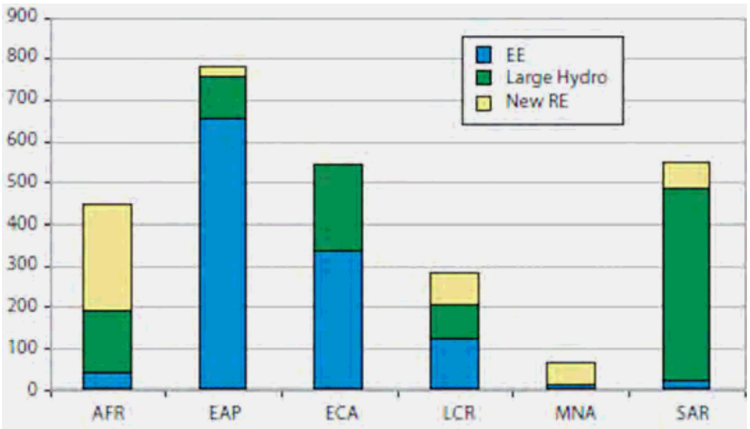
Fig.-9.2-2 Share of Renewable Energy and Energy Efficiency Relative to the WBG's Total Energy Commitment

East Asia and the Pacific received the largest share of total "renewable energy" and "energy efficiency" commitments in fiscal 2008, accounting for 783 USD million or 29% of total commitments. These commitments are largely dominated by "energy efficiency" projects (84%), followed by large hydropower projects (13%). Sub-Saharan Africa received USD 447 million in "renewable energy" and "energy efficiency" commitments, which accounted for 17 % of total "renewable energy" and "energy efficiency" commitments. The majority of these commitments were devoted to "new renewable energy" projects, reflecting their great potential for off- and mini-grid applications.

Table-9.2-2 Projects by Region, Fiscal 2008

Region	EE	Hydro > 10 MW	New RE	Total
AFR	4	5	13	22
EAP	13	1	5	19
ECA	17	5	1	23
LCR	7	1	7	15
MNA	2	0	2	4
SAR	4	2	6	12
Grand total	47	14	34	95

(Source) World Bank (2008)



(Source) World Bank (2008)

Fig.-9.2-3 WBG Renewable Energy and Energy Efficiency Commitments by Region, Fiscal 2008

A total of 34 projects that were "new renewable energy" projects in whole or in part were approved in fiscal 2008, including the geothermal projects Olkaria II in Kenya (MIGA), Asal in Djibouti (IFC, GEF, & CF) and three projects in Indonesia (IFC, GEF, & CF), and one project in Poland (CF).

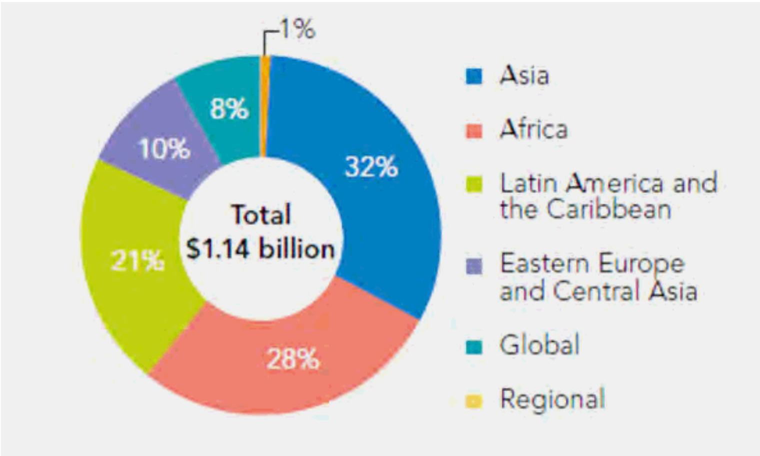
"Renewable energy" and "energy efficiency" feature prominently in the WBG strategy "Sustainable Infrastructure Action Plan (SIAP)" that was launched in 2008 and in its comprehensive "Development and Climate Change: A Strategic Framework for the World Bank Group (DCCSF)" that was endorsed in the same year. SIAP is a three-year plan with the objective of scaling up infrastructure investment in developing countries. SIAP calls for a renewal of the WBG core energy sector approach, to respond to the emerging trends in energy security and climate change and to close the energy access gap. DCCSF is designed to provide a framework to make effective climate action a part of core development efforts that are mainstreamed into all WBG operations. In an effort to reduce the resource gap in addressing these issues, the DCCSF includes funding sources in the form of the Climate Investment Funds (CIFs). which were created with the participation of various multilateral and bilateral donors in 2008. CIFs, managed by the World Bank, consist of two funds: the Clean Technology Fund (CTF) and the Strategic Climate Fund (SCF) to which applications may be made for various instruments such as grants, concessional loans and risk guarantees. Under the SCF, there is a Pilot Program for Climate Resilience (PPCR), a Forest Investment Program(FIP) and a Scaling Up Renewable Energy in Low Income Countries Program (SREP). SREP provides financing for renewable energy projects in developing countries which would improve the energy access gap. Geothermal projects are eligible for funding, and it is expected that East African countries like Kenya and Ethiopia will make requests under SREP. As of March 2010, six donor countries (Japan, the Netherlands, Norway, Switzerland, the UK, and the US) had pledged contributions to SREP in the total amount of USD 292 million.

The World Bank has articulated an Africa Energy Access Plan to provide a new and credible way to expand access to energy in Sub-Saharan Africa, a region where the rate of electrification is particularly low by global standards. With an aim to increase access in Sub-Saharan Africa to 47 percent by 2030, this plan is a partnership between the countries involved and the donor community. The commitment of the client countries is reflected in their development of realistic scale-up plans, an appropriate private-public mix and self-financing instruments. On the donor side, a programmatic, sector-wide strategy is being pursued that is in contrast to the project-by-project and donor-by-donor approach. It is estimated that an increase of funding on the order of USD 2-4 billion per year is needed to have a significant impact on the availability of modern energy services in Sub-Saharan Africa. Renewable energies, which lend themselves more readily to decentralized installations than do conventional sources of energy, can play a particularly important role in Sub-Saharan Africa in providing electricity to people who live far away from the urban centers.

The WBG has provided various project-based loans for the various Olkaria geothermal projects in Kenya. The World Bank is the lead donor with regard to the Energy Sector Recovery Project designed to enhance the policy, institutional and regulatory environment to favor private sector participation, to support efficient expansion of power generation capacity, and to increase access to electricity in urban and rural areas. Through this framework, the World Bank has supported and is supporting geothermal projects in Kenya. In Ethiopia, the World Bank has supported mainly hydropower projects, such as the financing of Gilgel Gibe hydropower plant through co-financing with the African Development Bank. Recently, the World Bank approved a IDA credit of USD 180 million in additional financing to scale up some components of the Energy Access Project. The Energy Access Project seeks to expand access to electricity, to improve the quality and adequacy of power supply, to improve energy end-use efficiency, to develop renewable energy sources and to strengthen institutional capacity. The additional financing of USD 180 million provided for the Energy Access project will support (i) upgrading the distribution network of seven major cities including Addis Ababa, (ii) expanding access to 50 new villages, (iii) evaluating and appraising the geothermal resource in Aluto Langano, and (iv) providing technical assistance and capacity-building to the sector entities. As part of component (iii), USD 10 million has been allocated for the purchase of drilling equipment and materials. Exploratory drilling for Aluto Langano geothermal project is a joint effort between the World Bank and the Japanese government, which committed to a donation of approximately USD 10 million for engineering services and the purchase of drilling equipment and materials.

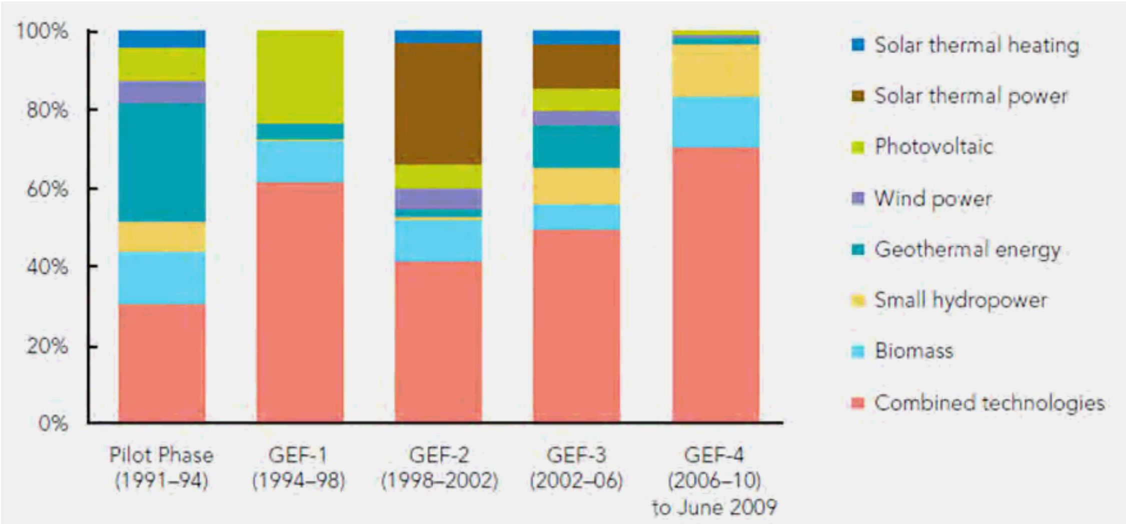
9.3 Global Environment Facility（GEF）

The Global Environment Facility (GEF) is a partnership among 178 countries created in 1991 as a financial mechanism of the United Nations Regional Framework Convention on Climate Change (UNFCCC). The GEF has provided USD 7.6 billion in grants and has leveraged USD 30.6 million in co-financing for more than 2,000 projects in more than 165 countries. Currently the GEF is in its fifth term, with the total amount of replenishment of USD 4.34 billion, of which USD 5 million was allocated for Kenya, USD 2 million to Djibouti, USD 6.59 million to Ethiopia, USD 7.86 million to Tanzania and USD 4.64 million to Uganda. Renewable energy has accounted for a significant portion of GEF’s portfolio, with projects amounting to about USD 1.14 billion. This GEF funding has been supplemented with USD 8.3 billion in co-financing. In terms of recipient regions, 32% of GEF funding is directed to Asia, followed by 28% to Africa. The 11 geothermal energy projects supported by GEF up to the present have required a total commitment of USD 65 million, which has been supplemented with USD 1.6 billion in co-financing.



(Source) GEF, Investing in Renewable Energy: the GEF Experience

Fig.-9.3-1 Regional Distribution of the GEF Portfolio in Renewable Energy, by Funding Level



(Source) GEF, Investing in Renewable Energy: the GEF Experience

Fig.-9.3-2 GEF Investment by Renewable Energy Technology

At the level of countries, geothermal projects have been supported by GEF in Armenia, Bulgaria, Djibouti, Eritrea, Ethiopia, Indonesia, Hungary, Kenya, Lithuania, the Philippines, Poland, Romania, the Russian Federation, Tajikistan, Turkey, Ukraine, Tanzania and Uganda. On the regional level, GEF supports the GeoFund project in Europe and Central Asia and the ARGeo project in East Africa.

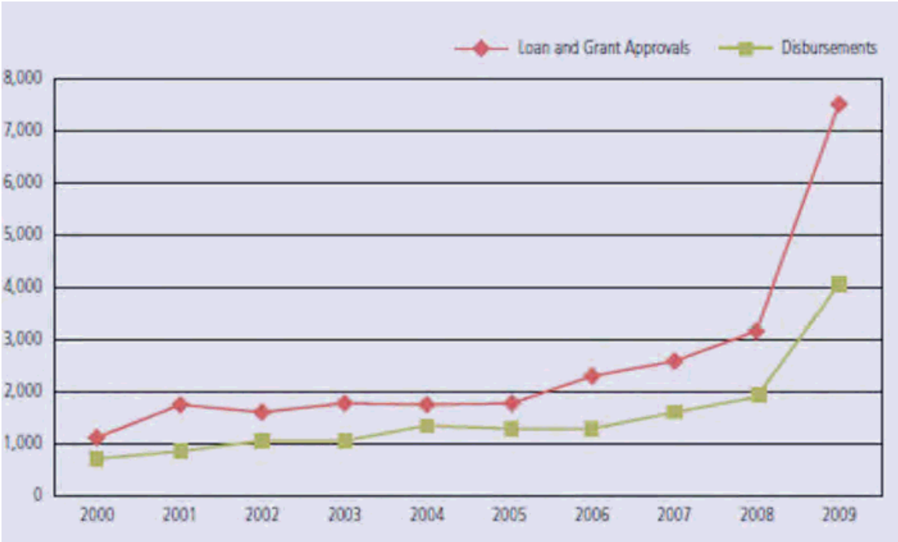
(Source) GEF, Investing in Renewable Energy: the GEF Experience

Fig.-9.3-3 GEF Renewable Energy Projects around the World

9.4 African Development Bank Group (AfDB)

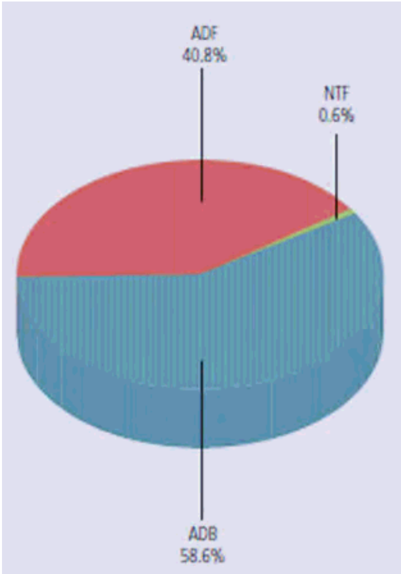
The African Development Bank Group (hereinafter referred to as AfDB), consists of the African Development Bank (ADB), the African Development Fund (ADF) and the Nigeria Trust Fund (NTF). Its primary objective is to contribute to the sustainable economic development and social progress of its regional members. This objective is met by financing a broad range of development projects and programs through public sector loans, private sector loans, equity investment, technical assistance, emergency assistance grants and so on. AfDB total loans, grants and other approved funding amounted to USD 8.06 billion in 2009.

The sectorial distribution of loans and grant approvals for AfDB operations continues to reflect the priorities of its Medium-Term Strategy (2008-2012), which are infrastructure, private sector development, governance, higher education, science and technology. By focusing on these areas, AfDB seeks to contribute toward the broader development objectives of improved agriculture and food security, human development, regional integration, and meeting the special needs of fragile states and middle-income countries. At the same time, the cross-cutting issues of gender, environment and climate change continued to be mainstreamed into areas of AfDB's operations. In terms of the sectoral distribution of loans and grant approvals for AfDB operations, the infrastructure sector has benefited the most, with an allocation of USD 3.91 billion (52.1%), of which power supply received the largest proportion (57.2%). Regionally, Sub-Saharan Africa received 45.2% of total funding, or USD 3.4 billion, North Africa received 16.6%, or USD 1.05 billion, with East Africa receiving 14.0%, or USD 515.6 million.



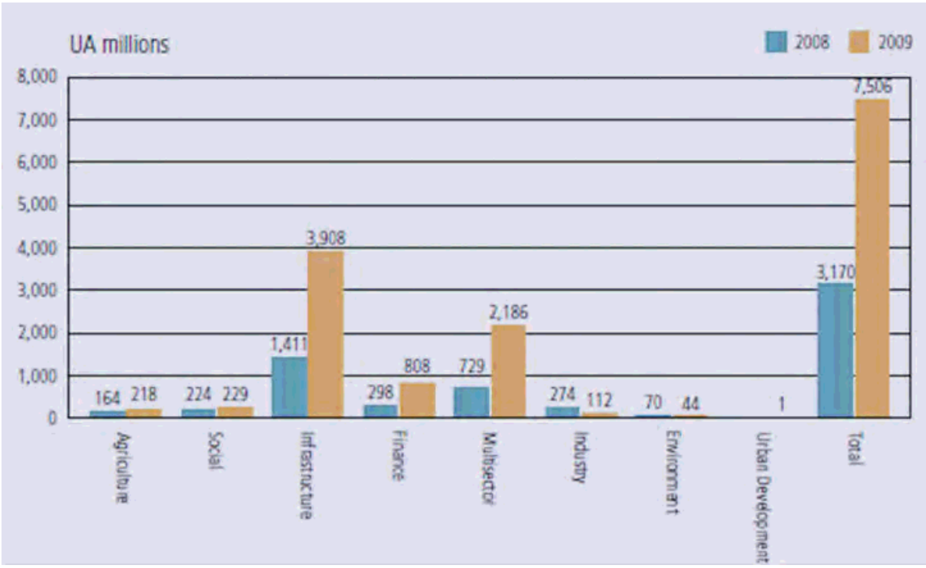
(Source) AfDB (2009)

Fig.-9.4-1 AfDB Loan and Grant Approvals and Disbursements, 2000-2009 (million USD)



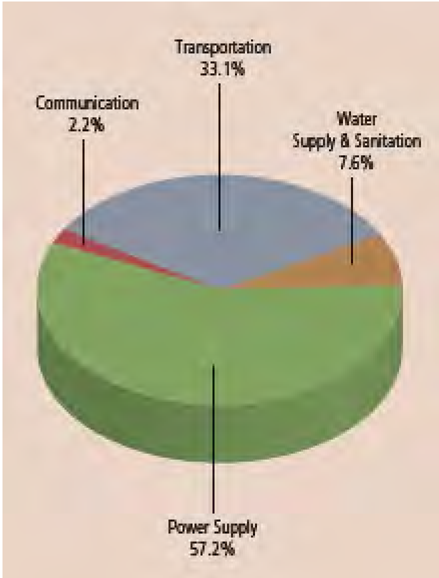
(Source) AfDB (2009)

Fig.-9.4-2 AfDB Loan and Grant Approvals by Institution, 1967-2009



(Source) AfDB (2009)

Fig.-9.4-3 AfDB Loan and Grant Approvals by Sector, 2008-2009



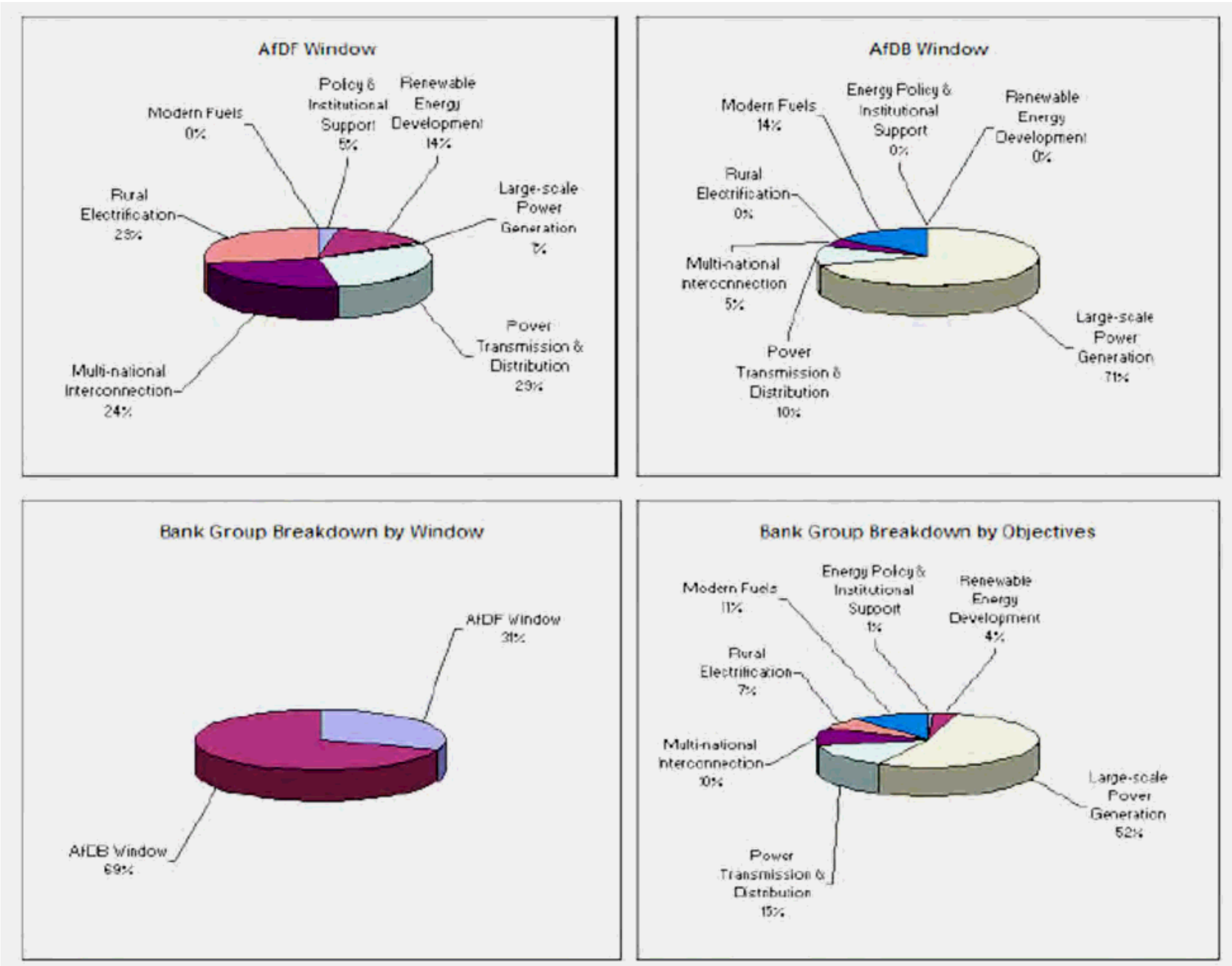
(Source) AfDB (2009)

Fig.-9.4-4 AfDB Subsectoral Distribution for Infrastructure, 2009

In 2008, AfDB produced the "Clean Energy Investment Framework (CEIF) for Africa: Role of the AfDB". According to this framework, the total investment required to implement the AfDB scenario for universal access by 2030 to reliable and increasingly cleaner electric power in all the 53 countries on the African continent is estimated at USD 547 billion.

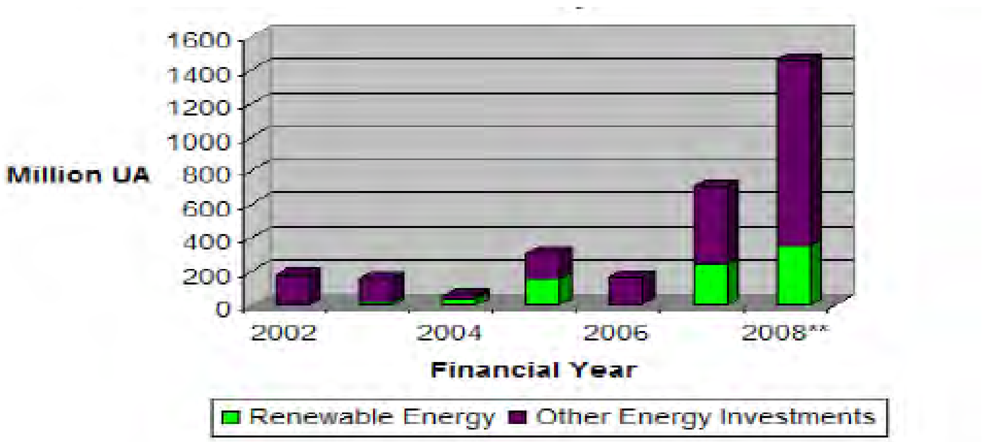
For the countries of Sub-Saharan African, the total capital requirement is estimated at USD 282 billion, or, on average, USD 12.3 billion per year. The role of renewable energy in expanding energy access will be large, particularly in East Africa with its enormous potential for hydro, geothermal, solar, and wind resources.

In 2009, AfDB approved the "Climate Risk Management and Adaptation (CRMA) Strategy" as a follow-up to the CEIF. Currently, the CEIF and the CRMA together constitute AfDB's policy on climate change.



(Source) AfDB (2008)

Fig.-9.4-5 Break-down of AfDB Group energy sector operations, 2002-2007



(Source) AfDB (2008)

Fig.-9.4-6 AfDB Renewable Energy Investments in the Overall Energy Sector Operations

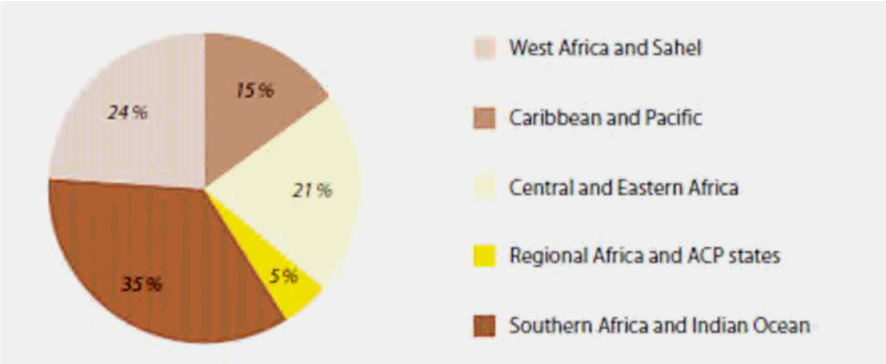
Up to the present, AfDB has not approved loans for geothermal energy projects. However, considering the increasing trend of the Bank's investments in renewable energy projects, it is very likely that the Bank will finance geothermal projects in the future.

9.5 European Investment Bank (EIB)

The European Investment Bank (EIB) is the European Union's long-term lending institution, a publicly-owned, policy-driven bank. The EIB supports mainly infrastructure projects that serve for the enhancement of regional integration and the improvement of industrial competitiveness, environmental conservation and energy supply, among others. The EIB is also guided by external regional mandates to support European policies abroad and finance development projects in the developing countries. Its operations outside the EU region extend to Africa, Latin America, the Middle East and Asia - practically all over the world. However, these account for less than 10% of all the EIB operations. In 2009, the EIB signed loans totaling EUR 79 billion, with 95 % of its financing destined for projects within the EU region. The total loan amount approved for African, Caribbean and Pacific Countries (ACPs) and the Overseas Countries and Territories (OCTs) was EUR 863 million.

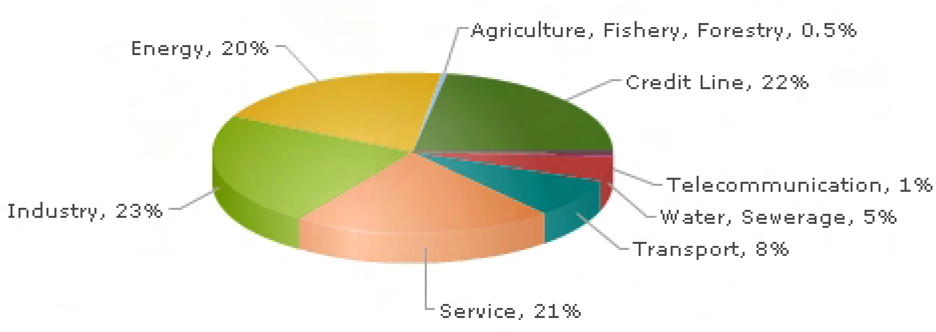
(Source) EIB, Regional Brocher: EIA in the African, Carribbean and Pacific Countries (ACPs) and the Overseas Countries and Territories (OCTs)

Fig.-9.5-1 Loans singed in ACPs/OCTs from 2000 to 2009



(Source) EIB, Regional Brocher: EIA in the African, Carribbean and Pacific Countries (ACPs) and the Overseas Countries and Territories (OCTs)

Fig.-9.5-2 Breakdown by region of EIB's lending activity in ACPs/OCTs from 1963 to 2007



(Source) EIB HP

Fig.-9.5-3 EIB's lending activity to the ACPs and OCTs by Sector from 2003 to 2009

In the sectoral breakdown of lending activity, the energy sector occupies a large share. In particular, the growth of the EIB's support for renewable energy projects has been quite a remarkable feature of its involvement in the energy sector. The approved amount for renewable energy projects constituted 43% of the approved amount for the entire energy sector in 2005, and expanded to 70% in 2009, with the sum of USD 4.2 billion being disbursed.

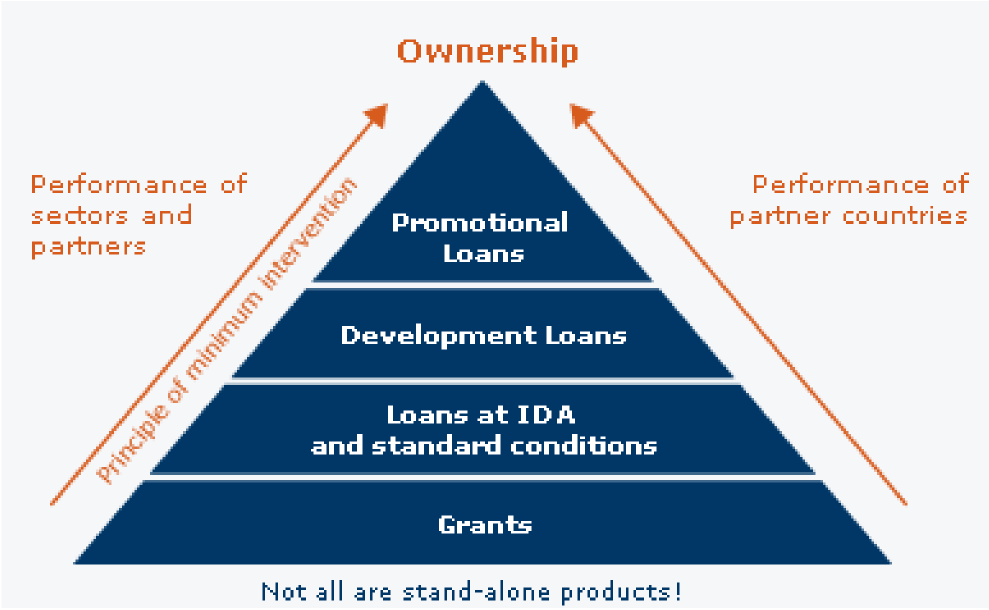
The EIB can provide with loans, guarantees and equity. Loans can be granted to programs or projects in both the public and private sectors and can cover up to 50% of the project cost, (normally EUR 100 million is a maximum limit). Also the EIB supports projects that are financially difficult but economically beneficial (such as environmental or social projects or the projects directly beneficial to low-income people) with interest rate subsidies (grants of up to 50% of the interest rate). Furthermore, the EIB offers a range of upstream technical assistance for project preparation, which includes feasibility studies for projects. For example, in Olkaria IV, the EIB made a loan of EUR 120 million for plant construction. At the same time, they provided a grant in the amount of EUR 25-30 million for drilling. Since it is a principle of the EIB not to bring distortion to a market, KenGen's plant portion of the project was financed with a loan offered under near-commercial conditions, and the drilling portion was supported with a grant to GDC. The EIB also supported other geothermal projects in Kenya (Olkaria I & IV, II, and II Expansion). However, due to their limited operations outside the EU region, they are not themselves conducting studies for project identification or formation in East Africa.

The EIB is the fund manager for the "EU-Africa Infrastructure Trust Fund", an instrument of the "EU-Africa Partnership on Infrastructure". The Secretariat of the fund is housed at the EIB headquarters. The fund supports infrastructure projects with regional characteristics through four types of grant support: interest rate subsidies, technical assistance, one-off grants for social environmental components of projects, and insurance premiums to cover country risks. The total financial commitment as of June 2008 is EUR 98 million, of which EUR 60 million is committed by the European Commission and EUR 38 million is committed by 11 EU Member States. The fund will provide a grant of EUR 30 million to the geothermal exploration risk mitigation scheme which is currently in preparation by KfW.

9.6 KfW Entwicklungsbank (KfW)

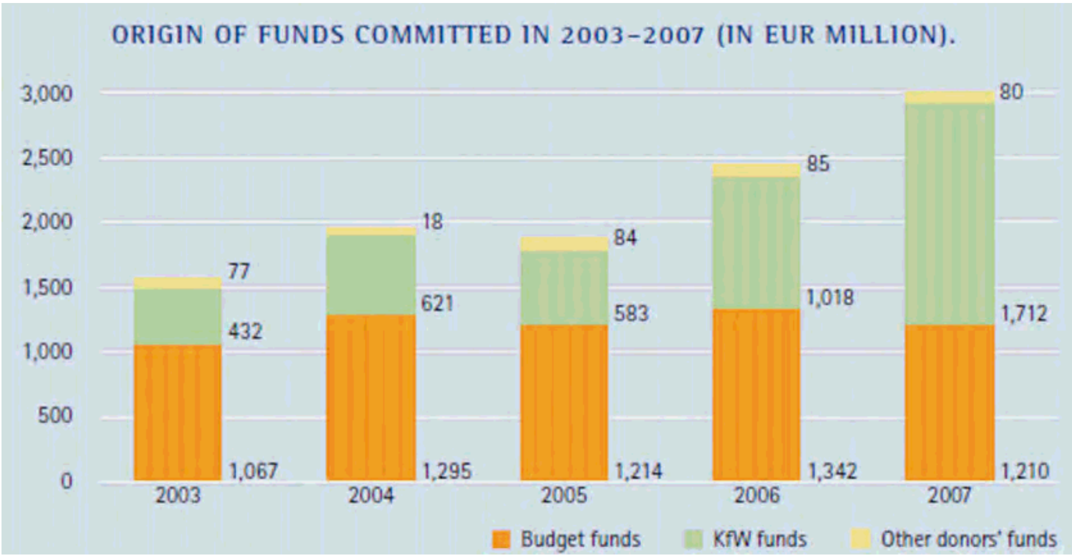
KfW Bank Group is a German government-owned development bank chartered to support the economic development in the country and also to carry out Financial Cooperation (FC) with developing countries on behalf of the German Government. KfW Entwicklungsbank (hereinafter referred to as KfW) is the entity in charge of FC with developing countries. At present, KfW sets the goals for FC with a view to moving from its position as a classic provider of grants and of financing for economic infrastructure to reposition itself as a competent strategic advisor, equipped with innovative promotional approaches and flexible financing instruments. Under this policy, in recent years, KfW has been actively participating in new forms of development cooperation, such as programme-based joint financing. The key strategic focuses of KfW in recent times have been climate protection and financial system development, as well as water supply and sewage disposal.

In 2007, the financing commitments of KfW amounted to EUR 3,002 million, of which Sub-Saharan Africa received a share of 32%.



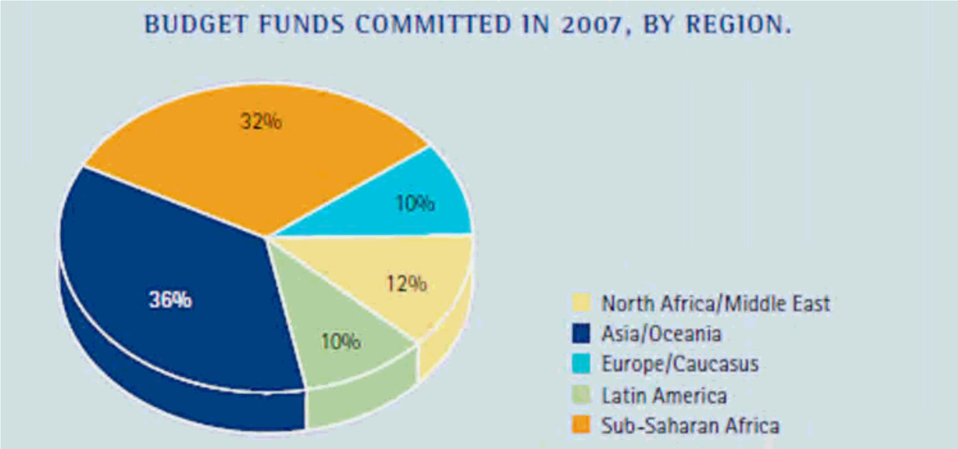
(Source) KfW Entwicklungsbank HP

Fig.-9.6-1 KfW Scheme of Financial Cooperation



(Source) KfW (2007)

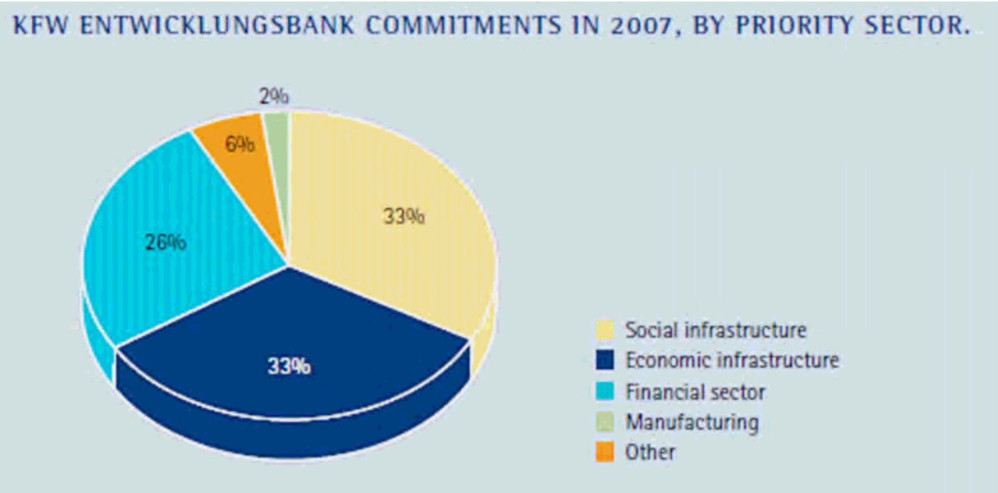
Fig.-9.6-2 Origin of Funds committed in 2003-2007



(Source) KfW (2007)

Fig.-9.6-3 Budget Funds committed in 2007, by Region

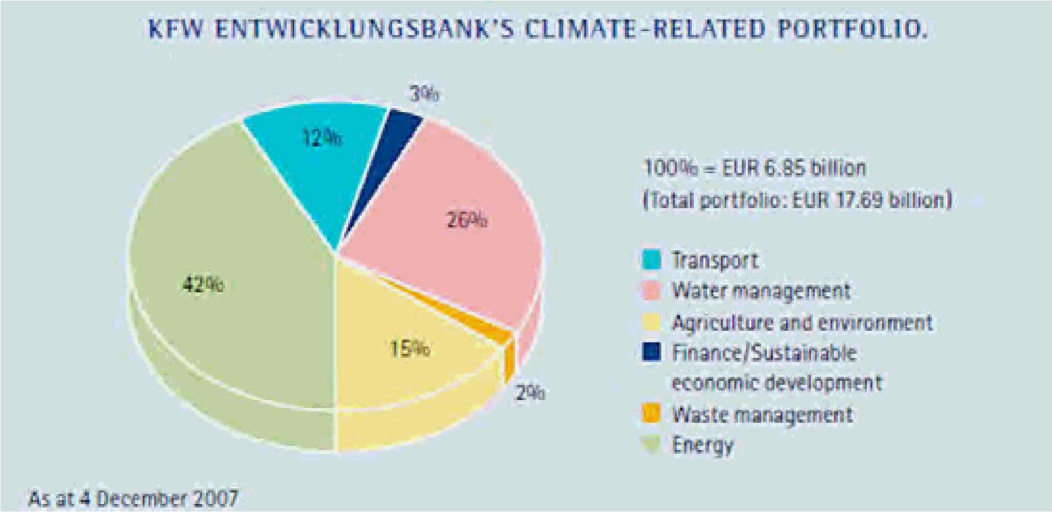
In the sectoral breakdown, the two highest priority sectors, social infrastructure and economic infrastructure, each received a 33% share of the new commitments.



(Source) KfW (2007)

Fig.-9.6-4 KfW Commitments in 2007, by Priority Sector

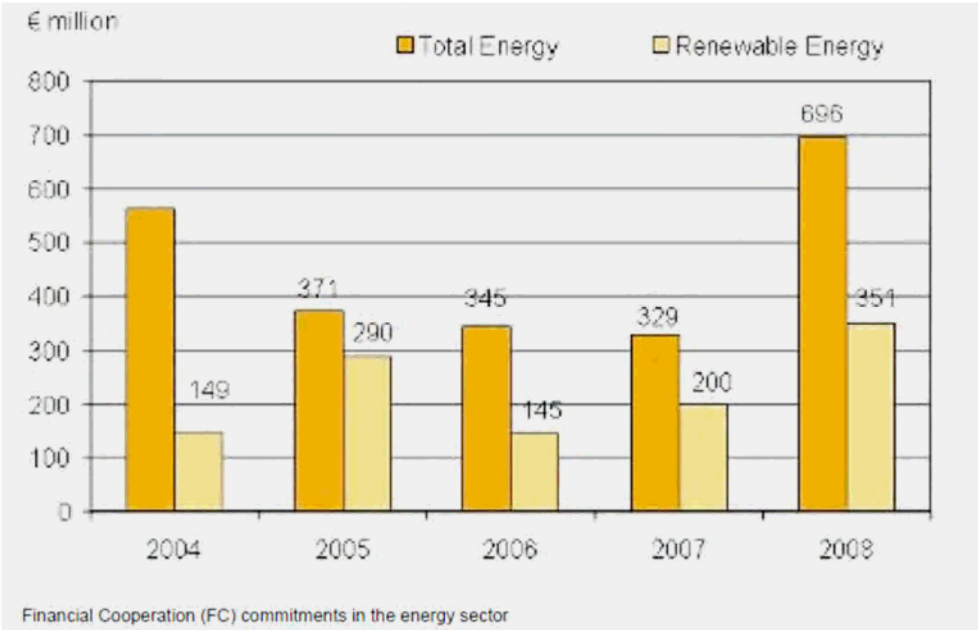
Over the past ten years, the KfW portfolio of projects related to climate change has increased, and in 2007, 42 % of KfW's climate-related portfolio was concerned with energy projects.



(Source) KfW (2007)

Fig.-9.6-5 KfW climate-related portfolio (2007)

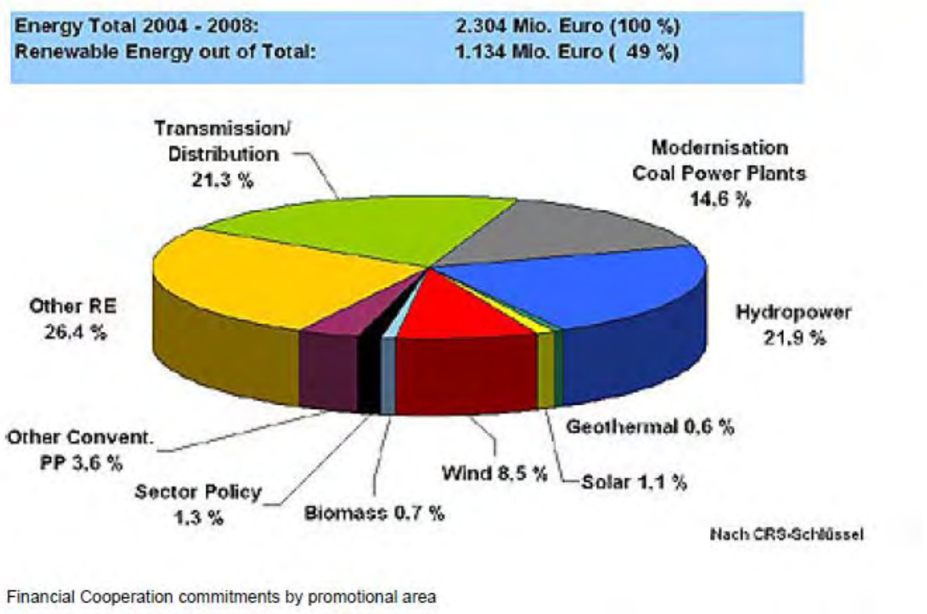
Over the five years from 2004 to 2008, KfW approved energy-related projects in the total amount of EUR 2.3 billion, which is equivalent to about 25 % of all its Financial Cooperation (FC) commitments. The energy sector is currently a key area in 16 countries: Afghanistan, Albania, Bangladesh, Bosnia and Herzegovina, Brazil, India, Kosovo, Mexico, Montenegro, Nepal, Pakistan, Senegal, Serbia, South Africa, Uganda and Ukraine.



(Source) KfW Entwicklungsbank HP

Fig.-9.6-6 KfW Financial Cooperation commitments in the energy sector

Among energy projects receiving funding from KfW, renewable energy projects are becoming increasingly important. In 2008, EUR 351 million (50% of total commitments in the energy sector) were allocated for renewable energies. This made KfW the largest financier of renewable energy sources in developing countries, even exceeding the World Bank Group.



(Source)KfW Entwicklungsbank HP

Fig.-9.6-7 KfW Financial Cooperation commitments in the energy sector by promotional area (2004-2008)

Against this background, KfW is highly committed to supporting geothermal development in the East African countries. KfW provided the finance for Olkaria II and Olkaria IV in Kenya, and also took a leadership role with UNEP for the early stages of the establishment of ARGeo, though at present KfW has decided to support geothermal projects independently of the ARGeo framework. Currently, KfW is preparing a grant-based risk mitigation scheme for exploratory well drilling, whose design will be completed before the end of 2010.

The main characteristic of KfW's risk mitigation scheme is that it provides a “bonus subsidy” for successful exploratory drilling as an incentive to further development, instead of providing “compensation” for the failure exploratory drilling, as the RMF of ARGeo does. A total of EUR 50 million (EUR 20 million from KfW and EUR 30 million from EU-Africa Infrastructure Trust Fund) will provided under the scheme. The scheme subsidizes 40% of the drilling cost of the first two exploratory wells, and when the drilling results in success, KfW pays a further 30 % of the cost. This will encourage a project developer lacking sufficient financial resources in the initial stage of development to reach the next stage of development. Also, the scheme is designed to avoid a situation in which disputes over a payment claim may arise because the definition of the success/failure of drilling is not usually very simple. “Success” of drilling will be recognized when (1) developer goes to the next development stage with the confirmed financial resources, or when (2) a developer returns a concession right, but presents a complete study report on the exploratory drilling in question with a perspective on further development that will enable another developer to take over the project.

9.7 The Federal Institute for Geosciences and Natural Resources (BGR)

The Federal Institute for Geosciences and Natural Resources (BGR) is a geoscientific research authority created under the German Federal Ministry of Economics and Technology. Energy and mineral resources, groundwater management, geotechnology, disposal of radioactive waste, and seismology among others are their main scientific focus, and they also carry out technical cooperation projects with developing countries in the geoscientific sector.

To promote the use of geothermal energy in developing countries with high geothermal potential, BGR started the Geotherm Program in 2003. Phase I (EUR 3.7 million) of the programme has been completed and they are currently entering on Phase II with a budget of EUR 2.9 million. The Geotherm Program has been focusing its activities on the East African countries because of their high geothermal potential and also because those countries have been a principal recipient of technical and financial cooperation from the German Federal government. However, the Geotherm Program is also implementing projects in countries in other regions, such as Chile, Yemen and Vietnam. The budget for Phase II of the program has been decreased slightly from that for Phase I. However, support for geothermal development around the world is increasing throughout the German government.

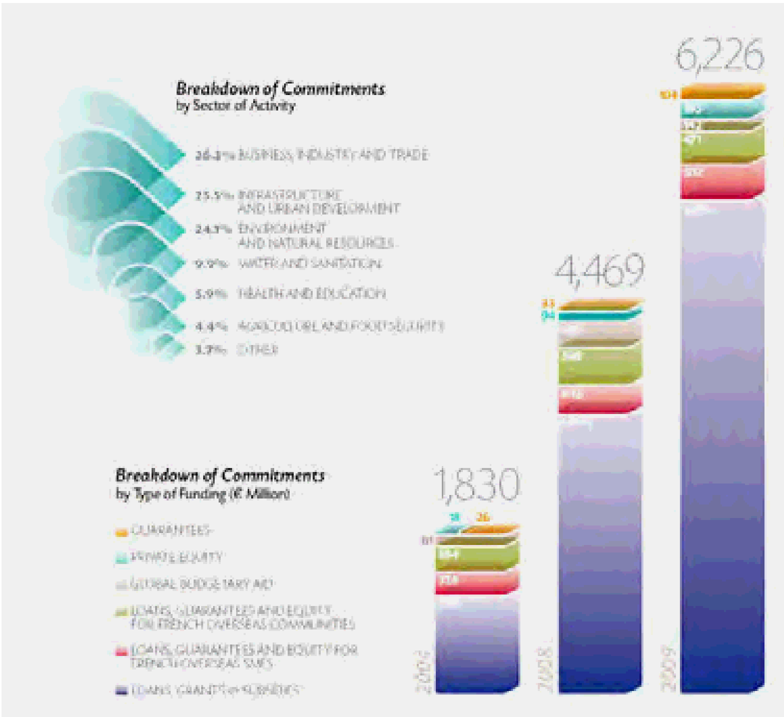
Phase I of the programme provided support for capacity-building and technical transfer though the implementation of pre-feasibility studies, support for the Geothermal Training Course at the United Nations University, support for the start-up of the ARGeo Program, support for the organization of the regional workshop in Ethiopia, and so on. During Phase I, pre-feasibility studies were also conducted in Tendaho (Ethiopia), Mbeya (Tanzania), Buranga (Uganda) and other fields in Chile, Rwanda and Yemen.

During Phase II, the programme will focus on greater involvement of the counterparts to raise awareness of policy and decision-making in order to assure continuous further development of geothermal projects after the completion of pre-feasibility studies. In this sense, BGR support may include the organization of meetings with investors and financial institutions during the study period, support for the elaboration of bankable documentation of exploratory drilling, and so on. Currently, projects are under implementation in Chile, Ethiopia, Tanzania and Yemen based on bilateral cooperation agreements. Requests have also been presented by Uganda, Kenya, and Rwanda. Djibouti is not eligible to participate in the Geotherm Program due to the lack of a bilateral cooperation agreement between the two governments.

Recently BGR has entered into a cooperation agreement with KfW. Combining the cooperation schemes of the two entities is expected to generate a synergistic effect in the geothermal development projects which they support.

9.8 French Development Agency (AFD)

The French Development Agency (AFD) is a bilateral development finance institution of the French Government, with a wide range of cooperation schemes offering grants, subsidies, technical assistance, sovereign loans and financing to governments, offering non-sovereign loans to public organizations, and also offering financing to the private sector through its subsidiary PROPARCO. The total amount committed in 2009 was EUR 6.2 billion, which reflects the remarkable and continuous growth of French ODA, compared to the commitments of EUR 1.5 billion in 2002.



(Source) AFD (2009)

Fig.-9.8-1 Breakdown of AFD Commitments by type of funding (million EUR)

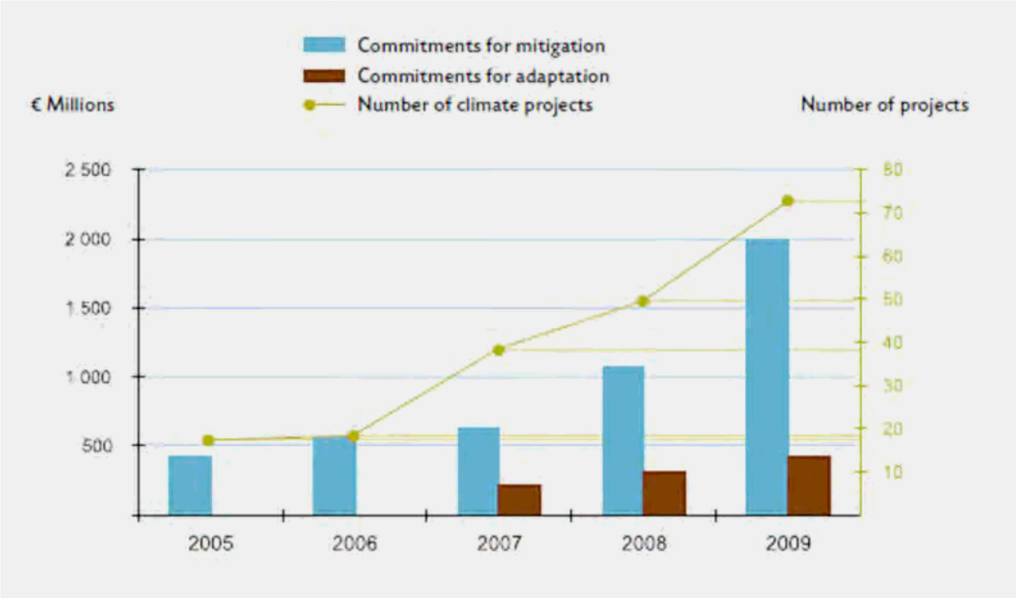
The regional breakdown shows that Sub-Saharan African countries are a priority for AFD. The commitment amount for this region in 2009 was EUR 2,071 million, representing 40% of its total annual funding for all countries. The commitment for countries in North Africa and the Middle-East was EUR 1,152 million, for Asian and Pacific countries, EUR 1,060 million, and for Latin America and Caribbean countries, EUR 622 million. In 2009, the French ODA to Sub-Saharan African countries increased by about 60% over the previous year. This is due to AFD's responsiveness to

President Sarkozy's "Cape Town Initiative," which aims to increase France's bilateral aid to sub-Saharan Africa to a total of EUR 10 billion between 2008 and 2012. PROPARCO also increased its 2009 financing to Africa to EUR 415 million, or 37% of its portfolio. In the same year, FIESA (the Investment and Support Fund for Business in Africa) was created to support economic growth and the generation of jobs. The fund is capitalized at EUR 250 million, with a majority stake held by AFD.

(Source) AFD (2009)

Fig.-9.8-2 Growth of AFD's financial commitments to Sub-Saharan Africa from 2005 to 2009

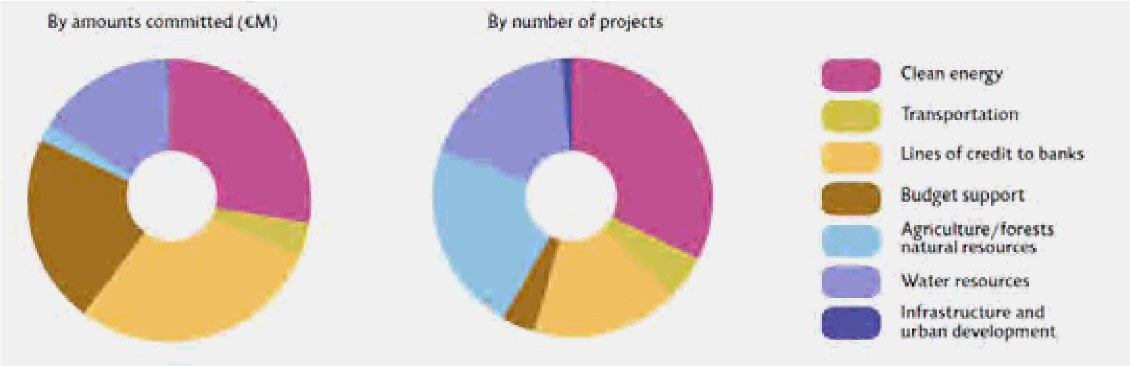
In 2009, AFD approved 71 projects contributing to the fight against climate change, which is becoming a strategic area of focus for the organization, disbursing an amount totaling 2.4 billion EUR. Cumulative commitments for the period 2005-2009 reached EUR 5.4 billion, making AFD one of the main donors to projects mitigating climate change. In 2008, AFD contributed over 10% of the total climate financing offered within the framework of Official Development Assistance around the world.



(Source) AFD and Climate Change

Fig.-9.8-3 Evolution of AFD's climate commitments

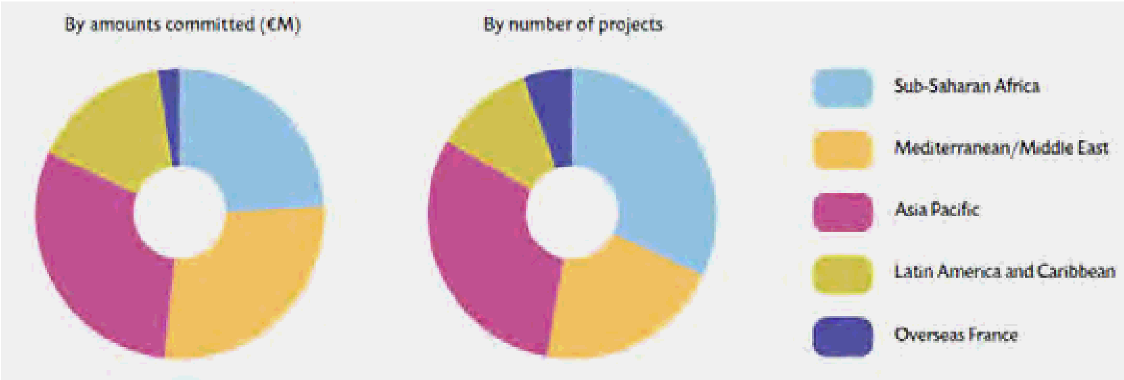
Among AFD's climate commitments, renewable energy represents approximately 30 % in terms of the number of projects.



(Source) AFD and Climate Change

Fig.-9.8-4 Climate projects financed by AFD in 2009: breakdown by sector

In the regional breakdown, sub-Saharan Africa represents approximately 30 % of AFD's climate commitments in terms of the number of projects.



(Source) AFD and Climate Change

Fig.-9.8-5 Climate projects financed by AFD in 2009: breakdown by geographical area

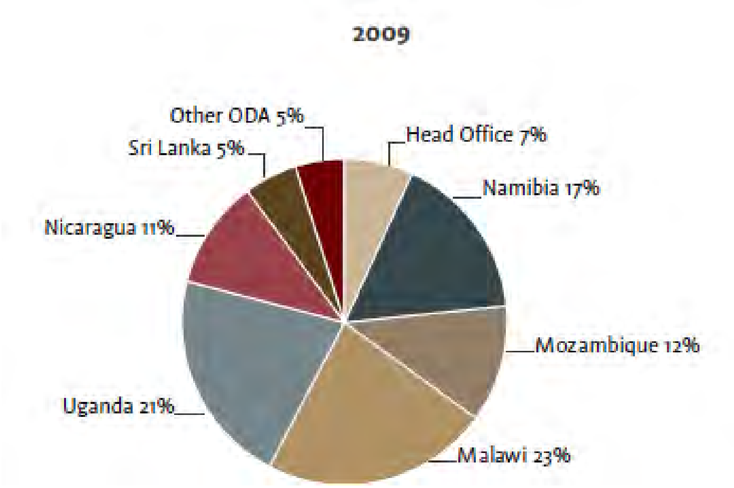
Most of AFD's assistance to geothermal development projects has been concentrated in Kenya, except for a feasibility study conducted in Dominica. In Kenya, AFD financed a syndicated loan for Olkaria II with EIB and the World Bank (with EUR 20 million of funding from AFD). PROPARCO financed the private sector development of Olakaria III, while AFD also provided co-financing for Olkaria I and IV with JICA, the World Bank, EIB and KfW (with EUR 150 million of funding from AFD). Also, AFD financed the purchase of a drilling rig by GDC in 2010 with funding of EUR 50 million, and provided a further EUR 6 million for capacity-building through a technical assistance facility, in which the elaboration of a Master Plan for the energy sector is also included. Furthermore, AFD is planning to implement a three-year technical cooperation agreement to support the planning of generation and transmission for the Kenyan Ministry of Energy, which includes renewable energy as one of its components. In Ethiopia, AFD is providing financing without a sovereign guarantee to EEPCO for a wind-power project. In Djibouti, a country that enjoys a close relationship with France, AFD may be interested in supporting geothermal energy development, though they have not become involved in it up to now.

9.9 Iceland

Historically, the Icelandic International Development Agency (ICEIDA) has been characterized by its support for fisheries and geothermal energy. In 2009, ICEIDA's contribution to bilateral cooperation was 14.1 USD million. Malawi is the biggest recipient of ICEIDA support, receiving 23 % of overall expenditures, or USD 3.2 million. The second largest amount was received by Uganda with 21 % of the total, or USD 3 million. Expenditures in Namibia, Mozambique and Nicaragua also accounted for a substantial portion of ICEIDA's support. In the breakdown of expenditures by sector, about half of the total went towards education and fisheries, 28% to education and 20% to fisheries. A further 10% went to the health sector, 11 % to social infrastructure, 14% to water supply and sanitation, and 8% to geothermal energy.

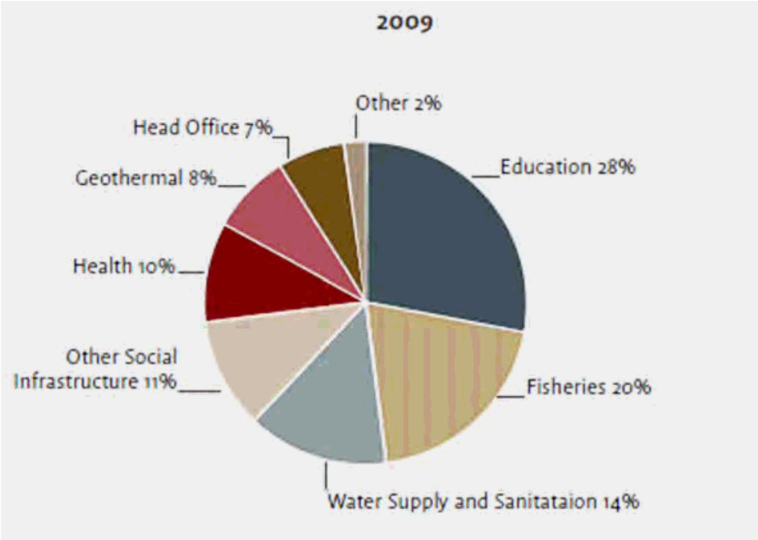
Among its geothermal energy projects, ICEIDA supported the surface study in Kibiro and Katwe in

Uganda. Also, with budget funds from the Icelandic Ministry of Foreign Affairs, they have been supporting the United Nations University's Geothermal Training Program for more than 20 years. The UNU-GTP has operated at the National Energy Authority (Orkustofnun) in Iceland since 1979 with annual six-month courses. More than 400 scientists and engineers from 43 countries have completed the courses between 1979 and 2008, 26% of them from Africa. The participants can undertake MSc studies under a cooperation agreement with the University of Iceland. The government of Iceland and the UNU are planning to increase the number of participants in the program and also to create regional training centers in Kenya and in Central America. However, confirmed financial resources for this undertaking are not in place. In October 2008, a short course on geothermal exploration was co-hosted by the UNU-GTP and KenGen. Also, in November 2008, a short course on geothermal project management and development was held in Uganda in connection with the ARGeo II conference.
ICEIDA is also providing technical assistance for the utilization of geothermal energy resources in Nicaragua, through a series of seminars for the evaluation of geothermal resource data, bringing in experts from Iceland and El Salvador.



(Source) ICEIDA (2009)

Fig.-9.9-1 ICEIDA Geographical Distribution of Expenditures (2009)



(Source) ICEIDA (2009)

Fig.-9.9-2 ICEIDA Distribution by Sector (2009)

At the same time, Reykjavik Energy Invest (REI), majority-held by the Reykjavik municipal government, has been actively participating in geothermal development projects outside the country. In Djibouti, REI signed an MoU for the Assal geothermal development projects with the government of Djibouti and they were planning to drill some exploratory wells with capital participation from IFC and also support from the Risk Mitigation Facility of the ARGeo program. However, the project has not advanced, since negotiations with the Djibouti government have been suspended. REI also organizes a graduate programme for research in sustainable energy, which every year sees the participation of about 30 students from outside the country.