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Capacity Building for Fast Tracking Geothermal Development in Uganda (2012-2050)

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ABSTRACT

The peak demand on power generation capacity of Uganda for 2010 was about 550 MW. Electricity coverage in this period is 12% for the whole country and 6% for rural areas. It is evident that Uganda's population growth of 3.6 per annum is impacting negatively on the physical environment because of over dependence on biomass (over 90%) and fossil fuel for energy and electricity generation is lagging behind. In the short term, the construction of three large hydropower plants: Bujagali (250 MW), Karuma (750 MW) and Isimba (100 MW) including small Hydro's will certainly alleviate the energy crisis in the country. The annual demand for electricity in the urban areas of Uganda however, is growing at about 8% per year and is expected to increase with the current rate of infrastructure development, industry, housing estates, and city growth. Besides, hydro - electricity sites are more or less concentrated in one area (along the River Nile) resulting in long transmission distances and high energy losses. Uncertainties of continued availability of hydropower exist arising from climatic fluctuations and as such, there is a need to diversify energy sources. Geothermal energy remains an environmentally friendly energy source that has to be developed through capacity building in Uganda. It is a clean and reliable source for production of electricity. Uganda does not have a long history of geothermal resource exploration. Existing know how on the geology, geophysics and other geothermal manifestations from its prospective areas along the Ugandan Rift is sparse and inconclusive. The country has also very few professionals to support geothermal energy development. This paper addresses the capacity building needed to fast track geothermal development in Uganda.

1. INTRODUCTION

Highly reliable and affordable energy services have always played an important role in the development of human society. It is the essential ingredient to economic and social development, including eradication of extreme poverty as emphasized in the United Nations Millennium Development Goals (MDGs). Uganda, in this respect is not an exception. It imports petroleum products and intensively uses biomass, fossil fuels and hydroelectricity power generated from dams for electricity production and consumption. Recent growth in investment has shown that energy is not in pace with fast growing energy demand.

1.1 Gas Price Volatility and Energy Security

The energy sector in Uganda is characterized by high levels of imports of petroleum products accounting for a significant proportion of export earnings (AFREPREN, 2001). Such high imports increase the vulnerability of Uganda to external oil price shocks that have an adverse impact on balance of payments. During 1996, the total importation cost for gas products by the Ugandan Government, for example, was US$ 116 million, equivalent to about 15% of the total export earnings. Currently the annual importation cost of petroleum products is estimated to be more than US$ 212 million. In addition, the high petroleum tariffs in the country have also contributed to high costs on the local market. This has meant that the country has to spend a lot of its meagre foreign exchange on these products at the expense of other development programmes. Such gas price volatility and energy security is typical not only for Uganda but for all the countries surrounding the East African Rift System. Geothermal energy thus could play a vital role in minimizing fuel imports by providing an alternative to thermal-based electricity (Mbuthi, 2004). It offers diversification in energy generation, thus strengthening energy security.

1.2 Intensive Use of Biomass Energy

The lack of sufficient accessible, reliable and affordable energy is a major barrier for Uganda to achieve the MDGs by 2015. Biomass energy, mainly through wood, charcoal and agricultural residue, represents approximately 83% of the total energy consumption used by communities in both urban and rural areas of Uganda, and up to the equivalent of one third of the total household economy. Traditional fuels being burnt under inadequate conditions cause thousands of deaths per annum (mainly due to respiratory diseases caused by high concentration of particulate matter and the high level of carbon monoxide). Use of biomass as source of energy increases CO_2 emission, and the mismanagement of this resource leads to deforestation and desertification, poor carbon sequestration and aggravates climate changes. In recent years, the emphasis towards renewable sources of energy production has intensified. There is now a concerted international effort to develop and utilise carbon-free sources of energy in order to combat the potential causes of climate change.

1.3 Hydroelectric Power Generated from Dams

This is the second major source of energy in Uganda. Apparently, the country also faces a major challenge in trying to achieve its development and social obligations because of inadequate modern energy services. The power generation capacity by 2010 was estimated as follows:

- Kiira / Nalubaale Power stations at Jinja: 150 – 190 MW
- Thermal Power Stations by Aggreko: 100 MW
- Thermal Power station by Jacobsen: 50 MW
- Co-generation by Sugar Plants: 25 MW
- Mini Hydros: 30 MW

Peak demand for electricity is about 550 MW. Electricity coverage is 12% for the whole country and 6% in rural areas. Electricity grid access in rural areas is largely limited to those towns and villages along major roads or near cities. Where the grid is available, only the wealthiest rural residents can afford connections and less than 5 per cent of rural areas are electrified (Davidson and Sokona, 2001). This energy divide can breed poverty, constrain the delivery of social services, limit opportunities for women, and gradually wear away environmental sustainability at the local and national levels. Annual demand for electricity is growing at about 8% per year and is expected to increase with the current rate of infrastructure development, industry, housing estates, and city growth. To offset the demand, the Government on a short to medium term has initiated the construction of three large hydropower plants: Bujagali hydropower dam (250 MW), Karuma (700 MW) and Isimba (130 MW). On a long term (2012-2025), the Ugandan Government has a plan to develop large hydro-power sites at Ayago (700MW), Arianga (400MW) and Uhuru (300MW) (Government of Uganda, 2007). Uganda's target is 3885 MW by 2015 and 8601 MW by 2020.

In times of environmental awareness and oil price volatility alternatives are also being investigated by the Government of Uganda (GoU) that include geothermal energy. The latter is considered to be one of the most promising and environmentally friendly energy source that is secure, clean, sustainable and reliable source for production of electricity, that is not affected by short-term fluctuations in the weather or world producer prices of oil.

Several interventions towards geothermal energy development in Uganda were undertaken in the past that include (Source: Geological Survey of Uganda):

- 1935: 46 hot and/or mineralized springs in Uganda were listed.
- 1952: Lava flows in the craters of Kyemengo and Lake Kitagata was reported as the evidence for the source heat for the Katwe - Kikorongo area.
- 1954: Drilling carried out in Buranga and project abandoned.
- 1972: The chemical analysis of the Katwe-Kikorongo thermal waters by UN inferred a reservoir temperature of 190^0C and the field was recommended for economic exploitation.
- 1973, an attempt was made to initiate a geothermal project with the United Nations support, but this did not materialise.
- 1982: Geothermal resources estimated at about 450 MW in the Ugandan Rift System.
- 1993-1994: Geothermal Energy Exploration I (UGA/92/002); Geochemical and geological investigation on three areas Katwe, Buranga and Kibiro. The aim of the project was to estimate subsurface temperatures and select promising areas for detailed surface exploration and exploration drilling, financed by the GoU and Iceland, UNDP and OPEC.
- 1999 to 2003: Isotope Hydrology for Exploring Geothermal Resources I. The aim of the project was to delineate flow characteristics of geothermal waters and identify their recharge areas, financed by the GoU and IAEA.
- 2002-2003: Uganda Alternative Energy Resources Assessment and Utilization Study (UAERAUS) - carried out geological, geochemical and the first geophysical surveys in Katwe, financed by the GoU and AfDB. The aim of the project was to delineate the spatial extent of the geothermal reservoirs and locate sites for exploration drilling.
- 2003 – 2007: Isotope Hydrology for Exploring Geothermal Resources II. The aim of the project was to refine the geothermal model of the study areas based on hydrological information from chemical and isotopic investigations, financed by the GoU and IAEA.
- 2004: Geological and first geophysical surveys in Kibiro, financed by the GoU& Iceland (ICEIDA).
- 2005-2007: Detailed surface studies (geological, geochemical and geophysical survey) of Buranga, financed by the GoU and BGR.
- 2005-2007: Further detailed geological and geophysical surveys and temperature gradient measurement in Katwe and Kibiro, financed by the GoU, WB and ICEIDA.

Unfortunately, the existing information on the geology, geophysics and other geothermal manifestations from these prospective areas is sparse and inconclusive. Mapping of hot springs, fumaroles and other geothermal surface manifestations has not been carried out in any systematic or comprehensive manner. The limited observations and surface geochemical work carried previously at hydrothermal springs in the western part of the country (Figure 1) has resulted in the licensing of two promising areas:

- Katwe in 2010 to COZUMEL Energy Ltd. to carry out a feasibility study for a duration of 3 years; and
- Buranga in 2011 to GIDS Consult Ltd to carry out a pre-feasibility study for a duration of 3 years.

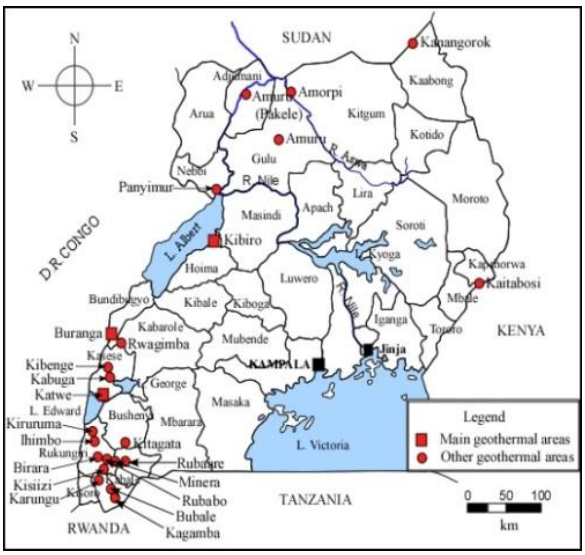

Figure 30: Location of the identified 23 geothermal sites in Uganda.

Current geothermal energy potential for Uganda is estimated at 450 MW. With the technology of today, the GoU believes that it has the potential to generate many thousands of megawatts of electricity, from geothermal power by the year 2050. This development will put enormous demands on the requirements for manpower with knowledge on geothermal, and thus the need for capacity building. The country has very few professionals to support geothermal energy development. Currently, the universities in Uganda give basic trainings in geoscience and engineering but none of them are equipped to provide dedicated courses geared to geothermal technology education and training. For supporting geothermal development in Uganda, therefore, capacity building to fast track geothermal development need to be designed within Universities with a prime objective of providing work programs for national and local governments, state-owned and private enterprises in developing and utilizing geothermal-based power. This include the development of teaching curricula, site specific case studies, a plan for direct use, setting a comprehensive publicly accessible database and an assessment of future enhanced geothermal sites.

2. JUSTIFICATION FOR GEOTHERMAL CAPACITY BUILDING IN UGANDA

• Education and training in earth science and engineering field is given at universities such as Makerere but dedicated geothermal technology education or courses critical to geothermal energy development is lacking and these institutions with the responsibility to champion applied courses and research in this field have not been successful in developing workable curriculum.

- The Geological Survey and Mines Department within the Ministry of Energy is responsible for all surface geothermal exploration in Uganda. It has some geothermal staff trained at the United Nations University in Reykjavik, Iceland, New Zealand, Austria, China and the Philippines mainly on surface exploration techniques. Geothermal companies will need earth scientists that have good geothermal exploration and exploitation knowledge and other skills.
- Uganda has skeleton capacity to carry out surface exploration activities for geothermal energy. However the country lacks the capacity to design, install and operate a geothermal power plant. Skilled personnel are needed in drilling, well tests and reservoir monitoring. A large number of personnel/staff will also be needed by geothermal companies to deal with legal, land, data management, forest and environmental management.
- In addition to university-level personnel, technician-level personnel will also be needed.

3. EDUCATION AND TRAINING IN GEOTHERMAL TECHNOLOGY

Education and training are among the most important components of a Geothermal Capacity Building Program. They should be seen as a catalyst for human resources development within universities and other institutions of higher education, as shown in Table 1.

3.1 Human Resources Development for Fast Tracking Geothermal Development

Education and training are meant to upgrade the teaching standard of the staff by injecting new mapping and geothermal exploration and exploitation approaches and modelling techniques. They may be conducted through various ways, among others, through academic program at local universities or overseas or through trainings or short courses.

In addition, applied research as witnessed in Europe is mostly carried out by universities. This is missing in Africa. Often lack of infrastructure and know-how arise and opportunities are missed by these universities, because the knowledge of the African experience necessary for organizations to function most effectively in research is absent both inside and outside these institutions. The BSc, MSc and PhD courses in geothermal technology will both academically and in an applied context try to enhance the country's ability to meet its objectives.

While Universities form the backbone of education, training and research, other institutions such as industries (Table 2), government (Table 3) and professional associations (Table 4) have also a task in offering short courses and seminars to fast track capacity building in geothermal technology. The main objectives of the short courses are awareness building and enhancing basic knowledge. The mechanism to do that is shown in Table 5.

Table 1: University Education

Academic Program (BSc, MSC and	1	Build in a number of geothermal related courses in the curriculum of undergraduate and post-graduate program such as: geology, geophysics, mining engineering, petroleum engineering, mechanical engineering, physics, electrical or other related majors.

PhD degrees)	2 Initiate geothermal training program at Makarere University, Kyambogo University and Nkumba University. These programs provide integrated education, covering exploration, exploitation, utilization, feasibility analysis, economic and environmental analysis. 3 Strengthen the North-South and South-South cooperation so as to foster junior faculties to pursue programmes in other countries such as New Zealand, Iceland, Japan, Netherlands, Germany, Norway, Sweden, Finland and Indonesia that offer scholarship to prospective students trying to pursue PhD research in geothermal technology.
Geothermal Seminars	Improve the quality of lecturers through geothermal seminars and discussions held regularly at the university, minimum once a month, to enable students to take up knowledge from geothermal experts, either from geothermal service companies, exploration companies, government institutions, other universities, research organizations. Seminars may also help universities to improve networking, partnership and acquiring new knowledge on current geothermal technology.
Field Excursion	Conduct field trip regularly to introduce the students to field works, field measurements, wells and production facilities as well as power plant facilities.
	Build in geothermal field camp programme in the curriculum. It should contain about 50% field work in a selected geothermal area, 50% data interpretation and theory in the class on results of field work.
Geothermal Research	Establish research program to improve current techniques or methodologies that lead in reducing risk, increase efficiency, production sustainability.
	Develop collaboration works/industrial research with geothermal companies.
Community Development	Provide short introductory courses or training in basic skills or deepening skills; among others in geology, geochemistry, geophysics, reservoir engineering, drilling engineering, production engineering, steam field operation, power plant technology, direct uses of geothermal energy, feasibility analysis, project economic analysis, environmental analysis, and many others.
Collaboration with other Universities	Establish joint degree program, collaborative research, student exchange and sabbatical programs with the objective of facilitating technology transfer through visiting scholars in strong partnership with other institutions, in particular with international institutions.
Improve quality of lectures	Improve educational materials and quality of faculty through the "train the trainers program".

Table 2: In-house Training by Industries

In-house Training/Assignment	Improving human resources competencies in order to carry out activities of exploration/exploitation/utilization of geothermal energy, feasibility study, project economic analysis, environmental analysis as well as analyzing and solving problems related to geothermal field/technology.

Table 3: Short Course Training by Government Institutions

Training/ Short Courses	<u>Ministry of Energy and Mineral Development</u>: • Training to increase the competence of human resources, to support the implementation of preliminary survey activities of exploration, to understand the process of project work areas, to approve exploration plans, budget approval, feasibility study, exploitation and utilization plans, supervision and improve/complement the provisions of geothermal legislation and standardization. • To train and advice people working in small scale mining activities basically grouped in cooperatives. <u>National Forestry Authority and the Ministry of Water and Environment:</u> • Training to provide understanding about the utilization of geothermal activities, ranging from exploration to utilization, and also knowing the potential environmental impacts and mitigation. <u>Ministry of Finance Planning and Economic Development:</u> • Training to provide understanding about the utilization of geothermal resources, ranging from exploration to utilization, the amount of investments, economic and project risks.

Table 4: Training Courses and Seminars by Professional Associations

Training/Courses	Trainings to provide members of a yet to be formed Uganda Geothermal Association (job seekers) and those involved in the Corporate Social Responsibility (CSR); with basic knowledge in support

	of geothermal energy, geothermal regulations, standardizations, and competencies.
Seminar/discussion/ Symposium	Provide members of the future Uganda Geothermal Association additional knowledge to improves networking and partnership.

Table 5: Human Resources Development through Short Courses

Awareness	**Basic Knowledge**	**Basic Skill**	**Knowledge & Skill Deepening**	**Advanced Skill Deepening**
Objective: To train non-technical professionals to promote awareness and knowledge understanding	Objective: To prepare a workforce that is capable of taking up new technologies so as to support geothermal exploration and development	Objective: Improving basic skills, including the use of a range of hardware and software resources and tools.	Objective: Knowledge application, complex problem solving, use of complex tools	Objective: To prepare participant to become independent practitioners
Trainers: Ugandan Experts	Trainers: Ugandan Experts	Trainers: Majority Ugandan Experts	Trainers: Ugandan and International Experts	Trainers: Ugandan and International Experts

3.1 Human Resources Development at Universities

Universities are the centers of learning and sustainable institutions worth empowering as they are considered the nation's pride. Unless there is lack of students to attend a specified course, the tendency is that they will run as an institution, funded by the national government for many years to come. By empowering universities therefore, sustainability is guaranteed. Taking the University of Makarere as an example, statistics show that over 300 students join the Faculty of Science every year out of which, around 200 students graduate with a BSc Degree. Training the trainer therefore, is a big asset to the development of the country and there is no other institution to replace that.

The programme will have multiplier effects at various levels in relation to its target groups:

• The university staff involved will be available to teach hundreds of students over the years, through the new courses. They also might induce interest about their new skills plus internet-based teaching methodologies amongst their co-faculty members;
• The students trained by the freshly trained faculty staff will introduce the skills and experiences obtained in their future work environment and share it with their future professional colleagues;
• Once the expertise is developed, Ugandan partner institutions will participate actively in the activities of the National platforms on sustainable geothermal energy program, where their experiences will help drive the national geothermal energy agenda;
• The educational programme will increase possibilities for other Ugandan universities to set up more linkages with institutes in Europe and to catch up with international trends in their respective fields.

Furthermore, the programme will multiply its effects by:

• An effective communication strategy, dissemination of publicity material, etc.
• Active linkages to other initiatives, such as other future regional or continental geothermal projects.

As outlined above, currently no university education geared towards geothermal technology exists in Uganda or in the region. The Government of Uganda is committed to developing geothermal energy in its policy documents (Government of Uganda, 2007). To support geothermal activities in the country therefore, aggressive human resources development programme must be initiated at universities. The geothermal technology programme should build on already existing earth science, engineering, environment, management and economic courses and capacity and avoid duplication at all cost. We propose below the creation of new curriculum that is built on existing Earth Science education that will incorporate geothermal exploration, exploitation and utilization including business, management and environmental modules and techniques. The geothermal technology education in mind will develop a set of post-graduate diploma, and MSc courses including PhD research on geothermal related fields (e.g., exploration/exploitation/and utilization techniques and models). This includes updating the knowledge and teaching skills of partner faculty, developing resource materials for these courses, having the courses formally approved and offered, and publicising the courses. Critical equipment gaps and needs in partner institutions will be identified and filled where necessary.

3.2 Geothermal Technology Education - Proposal for Curriculum Development (Modified after Suryantini, Unpublished PowerPoint Presentation, 2011) Human Resources Development at Universities

In the following tables we propose curricula on geothermal trainings.

Table 6: Exploration modules/trainings

	Basic Exploration Training		Basic Skill Exploration Training			Deepening Exploration Training		Advanced Exploration Training	
AWEC Geothermal Energy for everyone	BKE01	Remote Sensing & GIS	Earth Science	BSE01	Remote Sensing	DSE01	Integrated Geological, geophysical & geochemical mapping; Data enhancement, Interpretation, Integration & analysis.	AEE01	Advanced image processing, Modelling
				BSE02	GIS				
	BKE02	Introduction to Geothermal Systems and Technologies	Geology	BSE03	Volcano-stratigraphy	DSE02	Surface Exploration	AEE02	Petrography for Volcanic Rock and Alteration
	BKE03	Volcanology its Implication to Geothermal System		BSE04	Hydrothermal Rock Alteration	DSE03	Geothermal Field Camp Program: Survey, Data Acquisition and Analysis		
	BKE04	Concept and Methods in Geological Exploration for Geothermal		BSE05	Mineral-Fluid Equilibrium				
			Geochemistry	BSE06	Fluid and Soil Geochemistry	DSE04	Integrated Geological-Geophysical Analysis for Determining Reservoir Geometry		
	BKE05	Concept and Methods in Geochemistry Exploration for Geothermal		BSE07	Gas Geochemistry				
				BSE08	Isotope Geochemistry	DSE05	Integrated Geological-Geochemical Analysis to Identify Reservoir Fluid Properties		
	BKE06	Concept and Methods in Geophysical Exploration for Geothermal	Geophysics	BSE09	Geo-electrical Survey			AEE03	MT Data Processing
				BSE10	Gravity Survey	DSE06	Integrated G-G-G Analysis for Resource Assessment		
				BSE11	MT-TDEM	DSE07	Geothermal GGG Integrated Analysis for Well Targeting		
				BSE12	Geology-Geophysical Well Logging				
				BSE13	Micro earthquake (MEQ)	DSE08	G-G-G Modeling		
				BSE14	Structure and Geo-mechanic	DSE09	Geophysical Analysis		
						DSE010	Rock Properties		

Table 7: Exploitation modules/trainings

	Basic Exploitation Training		Basic Skill Exploitation Training		Deepening Exploitation Training			Advanced Exploitation Training		
AW01 Geothermal Energy (for everyone)	BKE02	Introduction to Geothermal Systems and Technologies	BSE15	Applied Geothermal Reservoir Engineering	Reservoir	DSE11	Geothermal PTS Survey- Plan and Analysis	Reservoir	AEE04	Advanced Geothermal PTS Survey Analysis
AW02 Drilling (for everyone)	BKE07	Introduction to Geothermal Reservoir Engineering	BSE16	Introduction to Geothermal Reservoir Modeling		DSE12	Well Productivity and Production Enhancement		AEE05	Advanced Pressure Transient Analysis
	BKE08	Introduction to Geothermal Drilling Engineering	BSE17	Applied Geothermal Well Drilling		DSE13	Geothermal Subsurface Assessment		AEE06	Advanced Geothermal Reservoir Modeling
	BKE09	Introduction to Geothermal Production Engineering	BSE18	Geothermal flow measurement		DSE14	Applied Reservoir Management		AEE07	Naturally Fractured Reservoir
			BSE19	Geothermal Surface Flow Tracer		DSE15	Applied Geothermal Reservoir Tracer			
			BSE20	Geothermal Risk Mitigation	Drilling	DSE16	Well Control	Drilling	AEE08	Underbalanced drilling
			BSE21	Geothermal Reservoir Data Management		DSE17	Drilling Planning and Management			
						DSE18	Casing Design			
						DSE19	Well Cementing			
						DSE20	Drilling Fluid			
						DSE21	Well Walkovers			
					Production	DSE22	Geothermal Surface Tracer Applications	Production	AEE09	Corrosion and Scale Control
						DSE23	Wellbore Modelling		AEE10	Hydraulic Fracturing
						DSE24	Desain of Surface Facilities		AEE11	Pipeline Systems: EPC Supervision & Commissioning
						DSE25	Geothermal Pipeline design			
						DSE26	Steam Field Managment		AEE12	Optimisation of steam field system
	Basic Geothermal Utilization Training		Basic Skill Geothermal Utilization Training		Deepening Geothermal Utilization Training			Advanced Geothermal Utilization Training		
					Utilization	DSE27	Process Design	Utilization		
AW01 Geothermal Energy for everyone	BKE10	Geothermal Utilization Technology	BSE22	Geothermal Power Plant Technology		DSE28	Material selection for geothermal environment		AEE13	Optimization of Power Plant
	BKE11	Introduction to Geothermal Power Plants Engineering	BSE23	Direct Use of Geothermal Energy		DSE29	Power Plant Design			
						DSE30	Turbine, Manufacture and Design			
						DSE31	Management O & M of power plant			
						DSE32	Start up and commissioning			

Table 8: Business, Management and Environmental Trainings

Awareness	**Basic Knowledge**		**Basic Skill**		**Knowledge & Skill Deepening**		**Advanced Skill Deepening**
Prerequisite	**BUISNESS AND MANAGEMENT TRAININGS**						
					DSE32	Decision and Risk Analysis	
	BKE11	Geothermal Business	BSE24	Preparation of tender documents	DSE33	Portfolio Analysis and Optimisation	
BKE01 Introduction to Geothermal Systems and Technologies	BKE12	Geothermal Regulation	BSE25	Cost Estimation	DSE34	Project Financing	
	BKE13	WKP Bidding Process	BSE26	Economic Analysis	DSE35 DSE36	Project Management Evaluation of Feasibility of Geothermal Project	
			BSE27	Energy Service Contracts and Power Purchase Agreements for Geothermal Operations.	DSE37	Preparation of Feasibility Report	
Prerequisite	**ENVIRONMENTAL TRAININGS**						
BKE01 Introduction to Geothermal Systems and Technologies	BKE14	Environmental Issues of Geothermal Project	BSE28	Environmental Baseline Studies			
			BSE29	Advanced Social, Environment and Forestry impact assessment and management			

Table 9: Other Trainings on Geothermal Energy

Awareness	**Basic Knowledge**		**Basic Skill**		**Knowledge & Skill Deepening**	
Prerequisite						
	BKE15	Introduction to Geothermal Monitoring	BSE30	Planning Environmental Monitoring	DSE38	Monitoring using Geophysical Method
			BSE31	Planning Monitoring for Baseline Purposes	DSE39	Monitoring using Geochemistry Method
					DSE40	Monitoring using Remote Sensing Method
Prerequisite						
	BKE16	Introduction to geothermal hazard and mitigation	BSE32	Volcanic and earthquake, hydrothermal eruption, hazard mitigation	DSE41	Volcanic and earthquake, hydrothermal eruption hazard assessment
Prerequisite						
BKE01 Introduction to Geothermal Systems and Technologies			BSE33	Introduction to computer software used in Geothermal Applications	DSE42	Advanced Course in computer programming for Geothermal Applications

4. OUTPUTS AND BENEFITS OF CAPACITY BUILDING

a) Universities in Uganda will have high quality geothermal training programmes and will be supporting the development of 23 geothermal areas (See Figure 1) in the country.
b) Post graduate and specialized geothermal training programmes based on Ugandan case studies will be available for building specialized engineers/ geothermal experts.
c) Trainings programs will be available not only for geothermal companies but also for Ministry Staff, such as Energy, Finance and Planning, Environmental, and Local Governments as well as for the general public.
d) Experts who have the capacity to develop and regularly update through remote sensing including satellite Sensing Measurements maps of Uganda "Hot Rocks".
e) Trained University staff with the capacity to identify a develop business plans for small and medium enterprises (SMEs) which make direct use of geothermal energy with low temperatures such as greenhouses, food processing and essential production enterprises.
f) Train local university staff and government officials to utilize publicly accessible geothermal data information system which can be used by local governments to provide reliable subsurface data in their tenders for new geothermal working areas.

5. CONCLUSIONS

a) Introducing geothermal training in Uganda will result in reducing the long term dependence on biomass (over 90%) and fossil fuel for energy as electricity generation is lagging behind.
b) Uganda needs support for promotion investment in clean energy sources to cut down CO_2 emission to meet the energy demand.
c) Geothermal energy remains an environmentally friendly energy source that has to be developed through capacity building in Uganda.
d) Fast Tracking Capacity building for Energy Projects in Uganda has to be supported by GoU, Private Sector and Development Partners.
e) Post graduate and specialized geothermal training programmes based on Ugandan case studies will be available for building specialized engineers/ geothermal experts.
f) Training programs being available not only for geothermal companies but also for government ministries.
g) Trained local university staff and government officials to utilize publicly accessible geothermal data information system which can be used by local governments to provide reliable subsurface data in their tenders for new geothermal working areas.

REFERENCES

AFREPREN 2001. African Energy Data Reference Handbook: AFREPREN Trimestrial Report, Volume. IV, Nairobi, Kenya.

Davidson O and Sokona Y (2002) "Think Bigger, Act faster", EDRC/ENDA, University of Cape Town, South Africa (Accessed 14 May 2012)

Government of Uganda (2007). The renewable Energy Policy for Uganda, http://etutoring.gayazahs.sc.ug/uploads/ebooks/1336063700.pdf - (uploaded 15 May, 2007)

Mbuthi, 2004; http://africa-toolkit.reeep.org/modules/Module2.pdf.

Suryantini N. (2011). Capacity building geothermal development in Indonesia in Association with the National Development Planning Agency (BAPPENAS), (Unpublished PowerPoint Presentation), IF Technology, Arnhem.

World Summit on Sustainable Development (2002). Plan of Implementation of the World Summit on Sustainable Development. United Nations, New York. www.un.org/esa/sustdev/documents/WSSD_POI_PD/English/WSSD_PlanImpl.pdf.

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Figure 11; proposed Model for Geothermal Development Projects for National &