Volume 2

Promotion of Geothermal Energy Development in Africa

Chapter 10 Expectations for Geothermal Energy in the Power Source Mix

10.1 Geothermal Components of Long-term Power Development Plans for each Country

Electricity utilities have a mission to supply electric power to the people and to industry in a stable manner and at an affordable price. Since supplying electric power is a long-term business, electric utilities should build an appropriate power source mix so that they can supply stable and affordable power over the long term that is resistant to disturbances by occasional fuel price fluctuations or an adverse economic climate. This “appropriate power source mix” is sometimes referred to as a “best mix of power sources.” The “best mix of power sources” is usually determined by such factors as economic considerations, the stability of the fuel supply, and technical aspects of power generation.

The economic considerations of power generation center on the power generating costs for each power plant. The ideal power source mix should attain the lowest generation cost possible. However, if an electric utility focuses exclusively on making the generation cost as cheap possible, it is likely to depend overwhelmingly on the cheapest fuel available at the moment. However, since the price of fuels is always fluctuating, what is the cheapest fuel at one time is not always the cheapest over the long term. Since it is difficult to forecast future fuel prices accurately, it is wise to diversify the power source mix and mitigate the risks of depending exclusively on certain fuels or power sources. Moreover, the stability of the power supply can be improved by utilizing domestic energy as much as possible. Therefore, the goal of achieving least-cost generation and the goal of guaranteeing a stable energy supply sometimes conflict. The “best mix” needs to harmonize these two conflicting goals.

Furthermore, the technical aspects of each power plant should also be considered in making the best mix. For example, a coal-fired power plant takes a longer time to start full operation from a stand-by condition than a gas-fired combined-cycle power plant or an oil-fired power plant. A coal-fired power plant cannot track the fluctuations in power demand as quickly as a gas-combined cycle plant or an oil-fired power plant can. Therefore, a coal-fired power plant is suitable for base load supply, and a gas-fired combined-cycle plant or an oil-fired power plant is suited for peak load supply or middle load supply. Moreover, since hydropower plants can proceed very quickly from a stand-by condition to full load operation, hydropower is suitable for peak load supply. On the other hand, a geothermal plant is not appropriate for tracking load fluctuation, since the steam flow from the ground is virtually stable all year round. Therefore, a geothermal plant is suited for base load supply. These technical characteristics of power sources should also be considered in striving to obtain an appropriate balance between least generation costs and the stability of the power supply.

The government and electric power companies of each country are always struggling to achieve the "best mix of power sources." Each country has its own philosophy as to how to balance the costs and the risks. Accordingly, the details of the "best mix" are different from government to government. The government usually works out a long-term electric power development plan as a guideline to attaining the “best mix” in the targeted years.

Many countries in the African Rift region have formulated long-term Electric Power Development plans. The position of geothermal energy in these plans has been described in Section 3 of Chapters 4 to 8. Here the particulars are summarized again in Table-10.1-1. This table shows that Kenya has the most positive geothermal development plan, i.e. to develop 1,578 MW by 2025 ("the Least Cost Power Generation Plan 2009-2029").

Ethiopia has an Electric Power Development Plan that centers on hydropower development. This country has huge hydropower resources. However, the government of Ethiopia recognizes the danger of depending too much on hydropower alone. Hydropower plants lose a significant amount of their generation ability due to decreased water flow when an abnormal drought occurs. Therefore the government of Ethiopia has the intention of developing geothermal energy to prepare for such a situation. According to the explanation provided in the power development plan, there are 450 MW of geothermal plants plan including 75 MW coming onstream at Aluto Langano in 2012 and 375 MW from other five (5) fields in 2018.

Table-10.1-1 Geothermal energy development plans in Electric Power Plans in the Rift Valley Region Countries

(Unit: MW)

	Kenya	Ethiopia	Djibouti	Tanzania	Uganda
2011	35				
2012		75			
2013	143				
2014					
2015					
2016	210		20		
2017					
2018	140	375			
2019			20		
2020					
2021	70				30
2022	140		20		30
2023	210				30
2024	280				
2025	350			(100)	
Total	1,578	450	60	(100)	90

(Source) Kenya KPLC (2008)
Ethiopia EEPCO (2009)
Djibouti EdD (????)
Uganda MEMD (2009)
Tanzania TANESCO (2009)

Djibouti has a plan to develop three (3) geothermal plant units of 20 MW between 2016 and 2022.

Uganda has a Power Sector Investment Plan that expects three (3) geothermal plant units of 30 MW between 2021 and 2023.

Tanzania has natural gas and coal resources. The Power System Master Plan of Tanzania has a power supply plan that makes use of these resources. However, the plan also explains that there is insufficient information to allow a geothermal site to be a firm candidate for the short- or mid-term power development plan. Given the importance of using indigenous Tanzanian resources, though, a future Power System Master Plan update could include a 100 MW geothermal plant as a candidate in 2025 or later (TANESCO, 2009). This recognizes the fact that since very little information is currently available, substantial time is required to prove the resource and develop it.

As mentioned before, the electric power development plan of each government is a plan that the government or electric utilities work out on the basis of the generation costs, the security of the energy supply, and the technical aspects of power sources. The fact that geothermal energy is included in the plans is indicative of the great expectations each country has for geothermal energy.

10.2 Electric Power Development Simulation for an Integrated Rift Valley System

10.2.1 Conditions of Simulation

In this section, the Study Team reports on simulations carried out to verify the above-mentioned electric power development plan of each country with simulation computer code. Since international power transmission lines have been planned in the African Rift region, the "EPCD System Planning Program Reflecting Interconnection & Transmission (ESPRIT)" is used for this purpose. ESPRIT is simulation code that can analyze the least-cost electric power development plan in multiple systems which are connected with a limited capacity of transmission lines.

First of all, the integrated Rift Valley system was modeled as the system shown in Fig.-10.2-1. Namely, as a system that consists of five individual systems (Djibouti, Ethiopia, Kenya, Uganda, and Tanzania) with connected transmission lines, as shown in Table-10.2-1. In this integrated system, the electric power development plan was simulated under the given power demand of each country during the period from 2011 to 2025.

Table-10.2-1 Assumptions of Transmission lines in the Rift Valley Integrated system

International Transmission Lines	Capacity (MW)	Commission
Djibouti - Ethiopia	200 MW	2011-
Ethiopia - Kenya	2,000 MW	2018-
Kenya - Uganda	50 MW	Existing
	300 MW	2018-
Kenya – Tanzania	50 MW	Existing
	300 MW	2018-

The annual growth rate of the peak power demand in each country is the same as that forecasted in the electric power development plan of each country. Namely, a 6.1% growth rate is used in Djibouti by 2025. In Ethiopia, the rate is assumed to be 14.0% by 2020 and 10.0% is assumed between 2020 and 2025[1]. The annual growth rate of Kenya is assumed to be 10.4%, 6.1% for Uganda, and 8.8% for Tanzania. In addition, this simulation assumes that the shape of the daily load curve in each country remains unchanged during the study period. The Study Team recognizes that this assumption is unrealistic, but used this assumption due to the lack of future data. Therefore, the growth rate of above-mentioned peak demand (MW) becomes the growth rate of energy demand (GWh) at the same time.

The daily load curve used in the simulation is modified from the real daily load curve to represent the annually averaged daily load curve. That is, the peak demand is adjusted to represent the annual peak demand and other demand is adjusted to keep the daily load factor the same as the annual load factor. Since the daily load curve data for Djibouti is not available, the daily load curve data of Ethiopia is used for Djibouti as well. The adjusted daily load curves of each country used in the simulation are shown in Assumption-10.2-1 to Assumption-10.2-5.

1 The annual growth rate of peak demand is assumed to be 10.0% after 2020 in this report although the Electric Power Development plan of Ethiopia forecasts 14.0% growth until 2030.

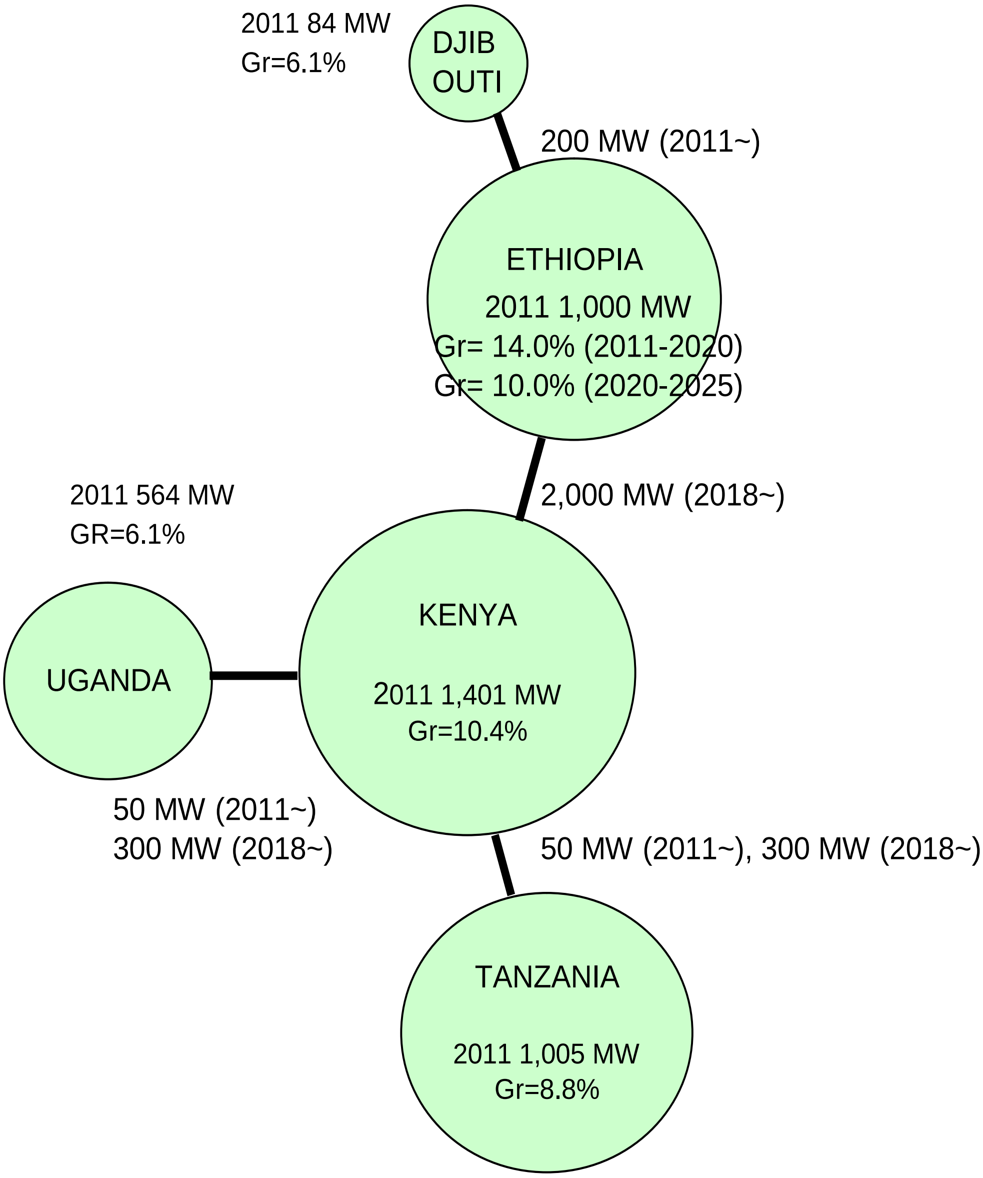

Fig.-10.2-1 Model of Power System in the African Rift Valley Region

Assumption-10.2-1 Assumptions of Simulation in Djibouti

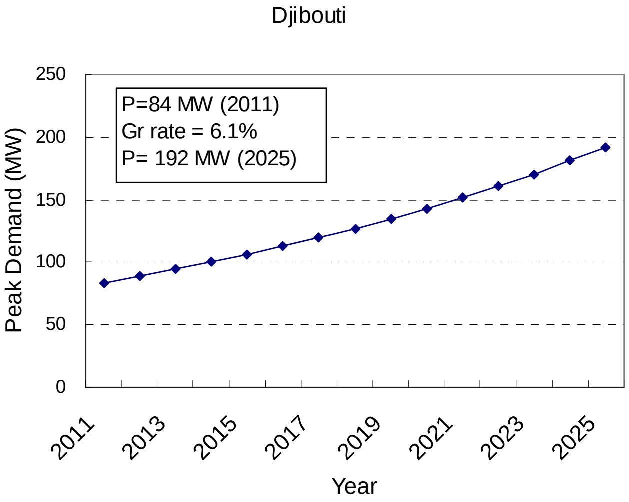

Fig.-1 Peak Demand Forecast

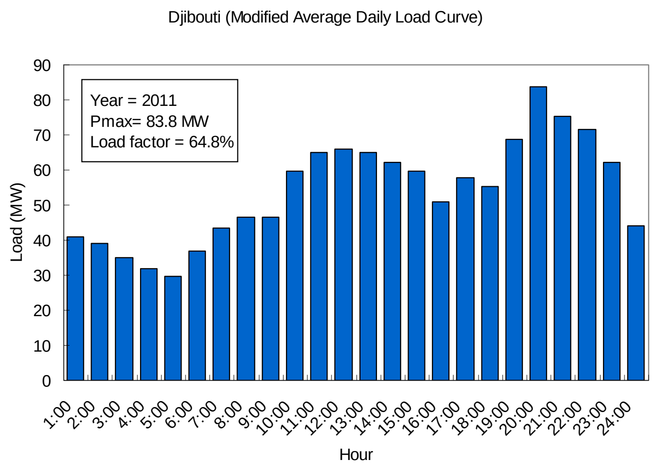

Fig.-2 Modified Daily Load Curve

Table-1 Approximation of Existing Power Plants in Djibouti

Power Plant	Source	Unit	Capacity (MW)	Generation Energy (GWh)	Commision Year	Remarks
1FD1	Diesel	12	7.0		EXIST	Boulaos
1FD2	Diesel	6	3.0		EXIST	Marabout

Table-2 Candidate Power Plants in Djibouti

Type	ID	Fuel	Capacity (MW)	Const. Cost ($/kW)	Plant Life (yrs)	Heat Rate (kcal/kWh)
Diesel	DSL	Diesel Oil	20	1,200	20	2,450
Geothermal	GEO	-	20	4,500	30	-

（Source） Brinckerhof (2009)

Assumption-10.2-2 Assumptions of Simulation in Ethiopia

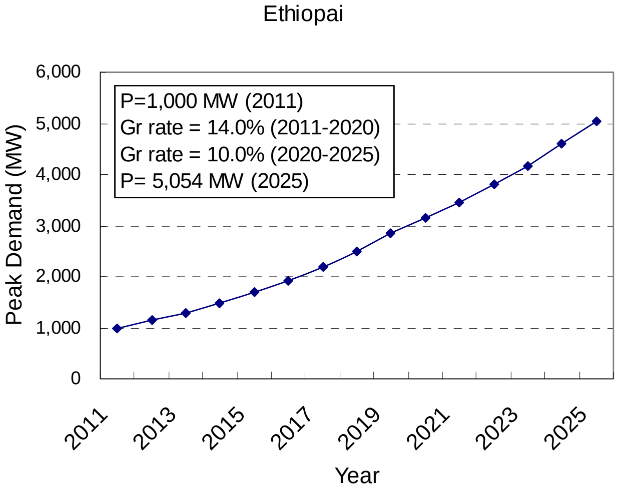

Fig.-1 Peak Demand Forecast

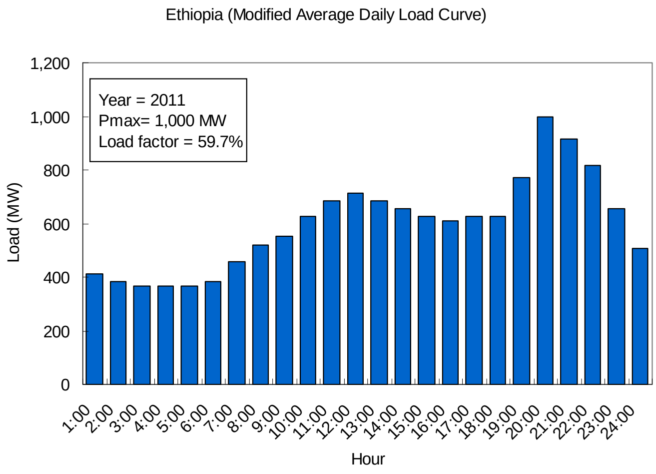

Fig.-2 Modified Daily Load Curve

Table-1 Approximation of Existing Power Plants and Large Hydropower Plants Planned in Ethiopia

Power Plant	Source	Capacity (MW)	Generation Energy (GWh)	Commision Year	Remarks
2FH1	Hydro	40	110	Exist	Koka
2FH2	Hydro	10	85	Exist	Tis Abbay
2FH3	Hydro	30	165	Exist	Awash II
2FH4	Hydro	130	640	Exist	Finchaa
2FH5	Hydro	30	165	Exist	Awash III
2FH6	Hydro	150	550	Exist	Melka Waken
2FH7	Hydro	70	280	Exist	Tis Abbay II
2FH8	Hydro	190	850	Exist	Gilgel Gibe I
Sub total		650	2,845		
2FH9	Hydro	300	1,270	2011	Tekeze
2FH10	Hydro	420	1,780	2011	Gilgel Gibe II
2FH11	Hydro	435	1,800	2011	Tana Beles
2FH12	Hydro	100	420	2014	Amerti Neshe
2FH13	Hydro	935	3,950	2015	GG-III (1/2)
2FH14	Hydro	935	3,950	2018	GG-III (2/2)
Sub total		3,125	13,170		
2FD1	Diesel	40		Exist	
Total		3,815			

Table-2 Candidate Power Plants in Ethiopia

Type	ID	Fuel	Capacity (MW)	Const. Cost ($/kW)	Plant Life (yrs)	Heat Rate (kcal/kWh)
Hydro	HYDR	-	250	1,500 / 2,000	50	-
Geothermal	GEO	-	35	3,800	30	-

（Source） EEPCO (2009)

Assumption-10.2-3 Assumptions of Simulation in Kenya

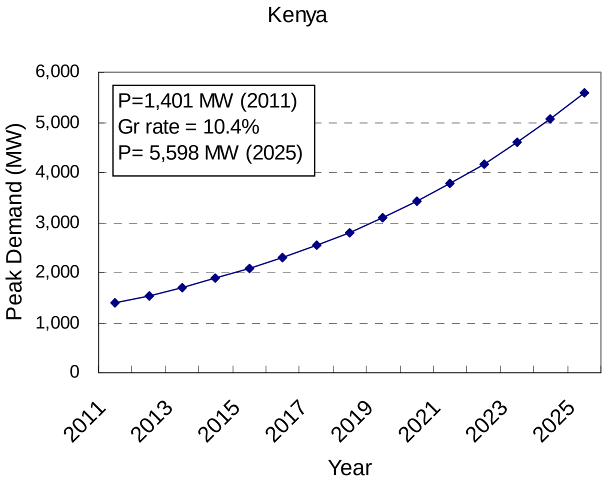

Fig.-1 Peak Demand Forecast

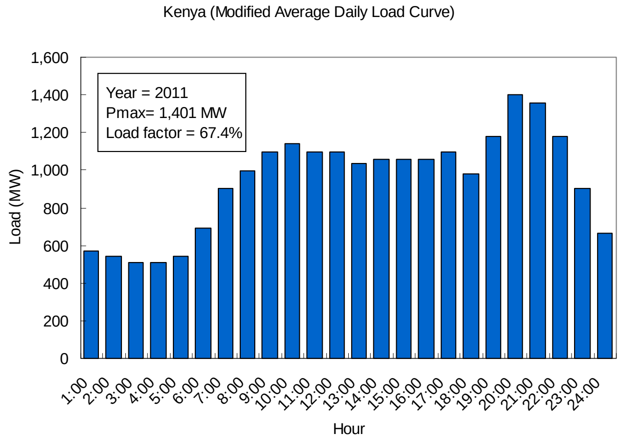

Fig.-2 Modified Daily Load Curve

Table-1 Approximation of Existing Power Plants in Kenya

Power Plant	Source	Capacity (MW)	Generation Energy (GWh)	Commision Year	Remarks
3FH1	Hydro	225	1005	EXIST	Gitau
3FH2	Hydro	144	643	EXIST	Kiambere
3FH3	Hydro	106	474	EXIST	Turkwel
3FH4	Hydro	94	421	EXIST	Kamburu
3FH5	Hydro	40	179	EXIST	Kindaruma
3FH6	Hydro	40	179	EXIST	Masinga
3FH7	Hydro	14	64	EXIST	Tana
3FH8	Hydro	14	33	EXIST	Others
3FH9	Hydro	60	268	EXIST	Sondu
Sub total		737	3,266		
3FG1	Geo	45		EXIST	Olkaria I
3FG2	Geo	70		EXIST	Olkaria II
3FG3	Geo	13		EXIST	Olkaria III
3FD1	Diesel	75	to be culculated by Simulator	EXIST	Kipevu Diesel
3FD2	Diesel	75		EXIST	Tsavo
3FD3	Diesel	75		EXIST	Others
3FGT	GT	60		EXIST	Kipe GT
Sub total		413			
Total		1,150			

Table-2 Candidate Power Plants in Kenya

Type	ID	Fuel	Capacity (MW)	Const. Cost ($/kW)	Plant Life (yrs)	Heat Rate (kcal/kWh)
Geothermal	GEO	-	70	3,000	30	-
Hydro	HYDR	-	50	2,800	50	-
Coal-fired	COAL	Coal	300	1,600	30	2,500

(Source) KPLC (2008)

Assumption-10.2-4 Assumptions of Simulation in Uganda

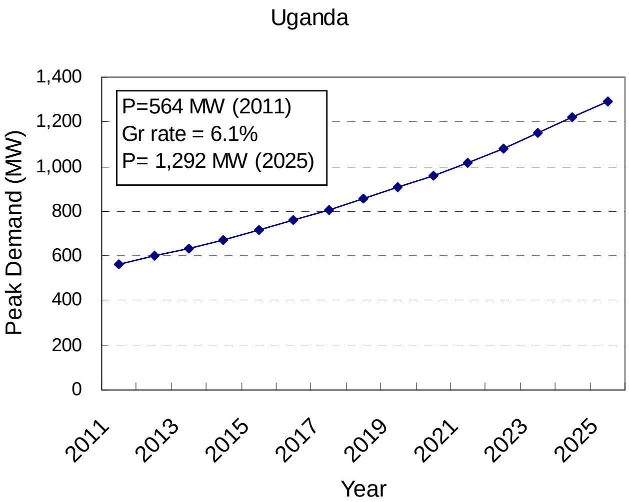

Fig.-1 Peak Demand Forecast

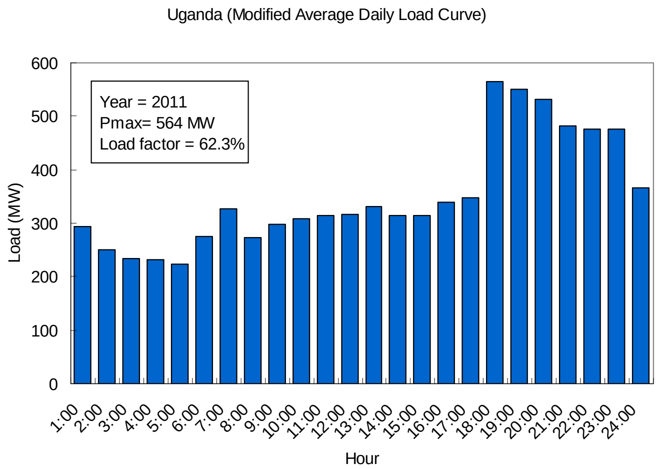

Fig.-2 Modified Daily Load Curve

Table-1 Approximation of Existing Power Plants and Large Hydropower Plants Planned in Uganda

Power Plant	Source	Capacity (MW)	Generation Energy (GWh)	Commision Year	Remarks
4FH1	Hydro	200	920	EXIST	Kiira
4FH2	Hydro	180	820	EXIST	Nalubale
4FH3	Hydro	15	80	EXIST	Others
Sub total		395	1,820		
4FD1	Diesel	50	to be culculated by Simulator	EXIST	Aggreko
4FD2	Diesel	50		EXIST	Namanve
4FD3	Diesel	50		EXIST	Aggreko
Sub total		150			
4FH4	Hydro	250	1,000	2013	Bujagali
4FH5	Hydro	250	1,000	2017	Karuma
4FH6	Hydro	250	1,000	2024	Ayago
4FH7	Hydro	250	1,000	2025	Karuma
Sub total		1,000	4,000		
Total		1,545			

Table-2 Candidate Power Plants in Uganda

Type	ID	Fuel	Capacity (MW)	Const. Cost ($/kW)	Plant Life (yrs)	Heat Rate (kcal/kWh)
Geothermal	GEO	-	35	3,500	30	-
Hydro	HYDR	-	50	2,800	50	-
Coal-fired	COAL	Coal	150	1,600	30	2,500
Oil-fired	Oil	Heavy Oil	150	1,200	30	2,250

(Source) MEMD (2009)

Assumption-10.2-5 Assumptions of Simulation in Tanzania

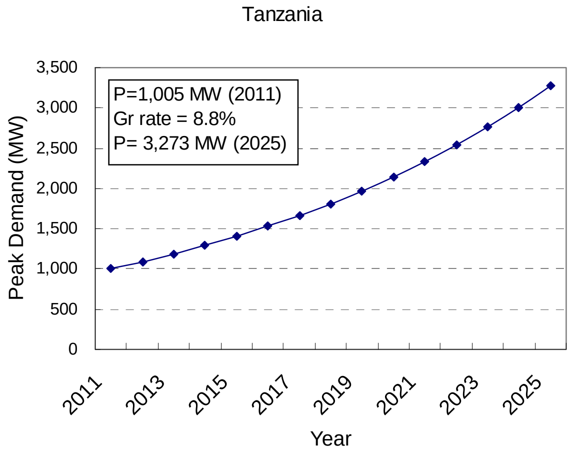

Fig.-1 Peak Demand Forecast

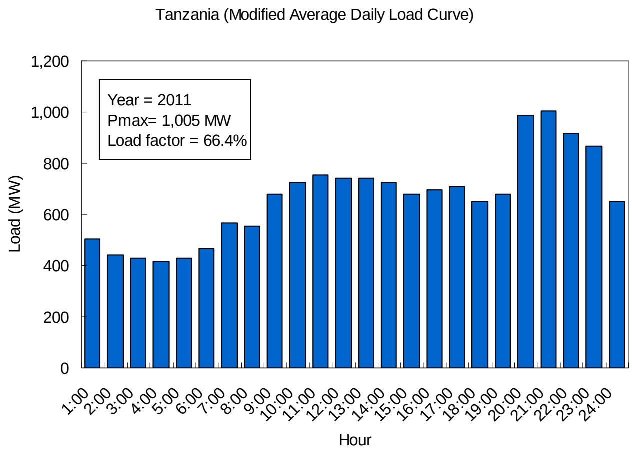

Fig.-2 Modified Daily Load Curve

Table-1 Approximation of Existing Power Plants and Large Hydropower Plants Planned in Tanzania

Power Plant	Source	Capacity (MW)	Generation Energy (GWh)	Commision Year	Remarks
5FH1	Hydro	200	1100	EXIST	Kidatu
5FH2	Hydro	80	450	EXIST	Mtera
5FH3	Hydro	30	40	EXIST	Others
5FH4	Hydro	70	170	EXIST	New Pangani
5FH5	Hydro	180	850	EXIST	Kihansi
Sub total		560	2,610		
5FT1	Gas	180	to be	EXIST	Songas
5FT2	Gas	150	culculated by	EXIST	Others
5FD1	Diesel	140	Simulator	EXIST	
Sub total		470			
5FH6	Hydro	300	1,100	2016	Ruhudji
5FH7	Hydro	300	1,100	2018	Rumakali
5FH8	Hydro	300	1,100	2020	Stieglers I
5FH9	Hydro	600	2,200	2023	Stieglers II
Sub total		1,500	5,500		
Total		2,530			

Table-2 Candidate Power Plants in Tanzania

Type	ID	Fuel	Capacity (MW)	Const. Cost ($/kW)	Plant Life (yrs)	Heat Rate (kcal/kWh)
Geothermal	GEO	-	35	3,500	30	-
Coal	COAL	Coal	300	1,600	30	2,500
Diesel	DSL	Diesel Oil	70	1,200	20	2,450
Natural Gas CC	N'Gas	Natural Gas	250	1,200	25	1,900

(Source) TANESCO (2009)

The existing power plants in each county and the large-scale power plants under construction are assumed as shown in the Approximation tables. Candidate power plants for development in the future are also considered in Assumptions. The large-scale hydropower plants in Uganda and Tanzania are assumed to be developed according to the Electric Power Development Plan. In Ethiopia, the construction costs of candidate hydropower plants are assumed to be USD 1,500/kW for the first five plants, and to be USD 2,000/kW for the remaining ones. In Tanzania, the number of candidate plants powered by natural gas is assumed to be four (4) at most, considering the limitation of gas resources.

The oil price is assumed to be USD 80/barrel and the coal price to be USD 90/ton (6,000 kcal/kg base), and these prices are assumed to be constant during the study period (2011 - 2025). The simulation is done to search for a development scenario that shows an acceptable level of Loss of Load Probability (LOLP), i.e. approximately less than one day in a year.

10.2.2 Simulation Result (Simulation-1)

The geothermal development plans for each country that is simulated under the above-mentioned assumptions are shown in Table-10.2-2, and the details of the power development plan simulated are shown in Table-10.2-3. According to the results, Djibouti needs geothermal energy development of 80 MW in total by 2025. Kenya needs geothermal energy development of 1,960 MW in total by 2025. The reason for the large amount geothermal development in Kenya is that geothermal energy is cost-competitive with fossil fuel-fired power plants in Kenya, since Kenya has no domestic fossil fuel resources and must import expensive fuels for power generation. Uganda needs two 35 MW geothermal plants in 2018 and 2020. On the other hand, the results suggest that Ethiopia and Tanzania do not necessarily need geothermal energy, since Ethiopia has huge inexpensive hydropower resources and Tanzania has hydropower, natural gas and coal resources.

Table-10.2-2 Simulated Geothermal Energy Development Plan by Country (Simulation-1）

Year	Djibouti	Ethiopia	Kenya	Uganda	Tanzania	Total
2011			280MW			280MW
2012			140MW			140MW
2013						
2014			280MW			280MW
2015			280MW			280MW
2016	20MW					20MW
2017						
2018	20MW			35MW		55MW
2019						
2020				35MW		35MW
2021	20MW		280MW			300MW

2022			280MW			280MW
2023	20MW		140MW			160MW
2024						
2025			280MW			280MW
Total	80MW		1,960MW	70MW		2,110MW

Fig.-10.2-2 shows the outline of the energy flow in the integrated system in 2025. It shows energy flowing from Ethiopia to Djibouti and Kenya, and another flow from Tanzania to Kenya. Some of it overflows from Kenya to Uganda.

Table-10.2-3 Power Development Plan of each Country (Simulation-1)

DJIBOUTI	NEW DEVELOPMENT (CONNECTED SYSTEM)							TOTAL	UNDER	PLANED	TOTAL	LOAD	RES	LOLP
YEAR	GAST	OIL	COAL	DSEL	GEOT	NGAS	HYDR	DEV'T	CONST	RETIRE	CAP			
				20MW	20MW			(MW)	(MW)	(MW)	(MW)	(MW)	(%)	(days)
2011				0	0			0	0	0	102	84	21.4	0.00
2012				0	0			0	0	0	102	89	14.4	0.00
2013				0	0			0	0	0	102	95	7.9	0.64
2014				0	0			0	0	0	102	100	1.7	0.00
2015				1	0			19	0	0	121	106	13.7	0.45
2016				0	1			38	0	0	140	113	24.0	0.00
2017				0	0			38	0	0	140	120	16.8	0.01
2018				0	1			57	0	0	159	127	25.1	0.02
2019				0	0			57	0	0	159	135	17.9	0.02
2020				0	0			57	0	0	159	143	11.1	0.02
2021				0	1			76	0	0	178	152	17.2	0.38
2022				0	0			76	0	0	178	161	10.5	0.01
2023				0	1			95	0	0	197	171	15.2	0.01
2024				0	0			95	0	0	197	181	8.6	0.80
2025				3	0			152	0	0	254	192	32.0	0.00
TOTAL				4	4									

ETHIOPIA	NEW DEVELOPMENT (CONNECTED SYSTEM)							TOTAL	UNDER	PLANED	TOTAL	LOAD	RES	LOLP
YEAR	GAST	OIL	COAL	DSEL	GEOT	NGAS	HYDR	DEV'T	CONST	RETIRE	CAP			
					50MW		250MW	(MW)	(MW)	(MW)	(MW)	(MW)	(%)	(days)
2011					0		0	0	0	0	1,835	1,000	83.5	0.00
2012					0		0	0	0	0	1,835	1,140	61.0	0.00
2013					0		0	0	0	0	1,835	1,300	41.2	0.00
2014					0		0	0	100	0	1,935	1,482	30.6	0.51
2015					0		0	0	1,030	0	2,865	1,689	69.6	0.00
2016					0		0	0	1,030	0	2,865	1,925	48.8	0.00
2017					0		0	0	1,030	0	2,865	2,195	30.5	0.00
2018					0		0	0	1,960	0	3,795	2,502	51.7	0.00
2019					0		2	498	1,960	0	4,293	2,853	50.5	0.47
2020					0		3	1,245	1,960	0	5,040	3,138	60.6	0.00
2021					0		0	1,245	1,960	0	5,040	3,452	46.0	0.00
2022					0		1	1,494	1,960	0	5,289	3,797	39.3	0.00
2023					0		2	1,992	1,960	0	5,787	4,176	38.6	0.00
2024					0		2	2,490	1,960	0	6,285	4,594	36.8	0.00
2025					0		2	2,988	1,960	0	6,783	5,054	34.2	0.00
TOTAL					0		12							

KENYA	NEW DEVELOPMENT (CONNECTED SYSTEM)							TOTAL	UNDER	PLANED	TOTAL	LOAD	RES	LOLP
YEAR	GAST	OIL	COAL	DSEL	GEOT	NGAS	HYDR	DEV'T	CONST	RETIRE	CAP			
			300MW		140MW		50MW	(MW)	(MW)	(MW)	(MW)	(MW)	(%)	(days)
2011			3		2		0	1,128	0	0	2,114	1,401	50.9	0.14
2012			0		1		0	1,260	0	0	2,246	1,547	45.2	0.20
2013			0		0		0	1,260	0	0	2,246	1,708	31.5	0.96
2014			0		2		0	1,524	0	0	2,510	1,885	33.1	0.40
2015			0		2		0	1,788	0	0	2,774	2,081	33.3	0.46
2016			1		0		1	2,126	0	0	3,112	2,298	35.4	0.31
2017			1		0		0	2,414	0	0	3,400	2,537	34.0	0.42
2018			0		0		0	2,414	0	0	3,400	2,800	21.4	0.37
2019			1		0		0	2,702	0	0	3,688	3,092	19.3	0.05
2020			1		0		0	2,990	0	0	3,976	3,413	16.5	0.58
2021			1		2		1	3,592	0	0	4,578	3,768	21.5	0.91
2022			1		2		1	4,194	0	0	5,180	4,160	24.5	0.42
2023			1		1		0	4,614	0	0	5,600	4,593	21.9	0.48
2024			2		0		0	5,190	0	0	6,176	5,070	21.8	0.58
2025			2		2		0	6,030	0	0	7,016	5,598	25.3	0.25
TOTAL			14		14		3							

UGANDA	NEW DEVELOPMENT (CONNECTED SYSTEM)							TOTAL	UNDER	PLANED	TOTAL	LOAD	RES	LOLP
YEAR	GAST	OIL	COAL	DSEL	GEOT	NGAS	HYDR	DEV'T	CONST	RETIRE	CAP			
		150MW	300MW		35MW		50MW	(MW)	(MW)	(MW)	(MW)	(MW)	(%)	(days)
2011		2	0		0		0	292	0	0	832	564	47.5	0.07
2012		0	0		0		0	292	0	0	832	598	39.0	0.11
2013		0	0		0		0	292	249	0	1,081	635	70.3	2.82
2014		0	0		0		0	292	249	0	1,081	674	60.5	2.28
2015		0	0		0		0	292	249	0	1,081	715	51.2	0.15
2016		0	0		0		0	292	249	0	1,081	758	42.6	0.45
2017		0	0		0		0	292	498	0	1,330	805	65.3	0.61
2018		0	0		1		0	325	498	0	1,363	854	59.7	1.80
2019		0	0		0		0	325	498	0	1,363	906	50.5	0.79
2020		0	0		1		0	358	498	0	1,396	961	45.3	0.96
2021		1	0		0		0	504	498	0	1,542	1,020	51.2	0.51
2022		0	0		0		0	504	498	0	1,542	1,082	42.5	0.46
2023		0	1		0		0	792	498	0	1,830	1,148	59.4	0.25
2024		0	0		0		0	792	747	0	2,079	1,218	70.7	0.16
2025		0	0		0		0	792	996	0	2,328	1,292	80.2	0.07
TOTAL		3	1		2		0							

TANZANIA	NEW DEVELOPMENT (CONNECTED SYSTEM)							TOTAL	UNDER	PLANED	TOTAL	LOAD	RES	LOLP
YEAR	GAST	OIL	COAL	DSEL	GEOT	NGAS	HYDR	DEV'T	CONST	RETIRE	CAP			
			250MW	70MW	50MW	250MW		(MW)	(MW)	(MW)	(MW)	(MW)	(%)	(days)
2011			0	1	0	1		311	0	0	1,326	1,005	31.9	0.71
2012			0	0	0	1		554	0	0	1,569	1,093	43.5	0.15
2013			0	0	0	0		554	0	0	1,569	1,190	31.9	0.62
2014			0	0	0	1		797	0	0	1,812	1,294	40.0	0.14
2015			0	0	0	0		797	0	0	1,812	1,408	28.7	0.69
2016			0	0	0	0		797	299	0	2,111	1,532	37.8	0.66
2017			0	0	0	1		1,040	299	0	2,354	1,667	41.2	0.29
2018			0	0	0	0		1,040	598	0	2,653	1,814	46.3	0.43
2019			1	0	0	0		1,280	598	0	2,893	1,973	46.6	0.55
2020			0	0	0	0		1,280	897	0	3,192	2,147	48.7	0.31
2021			0	0	0	0		1,280	897	0	3,192	2,336	36.6	0.93
2022			1	0	0	0		1,520	897	0	3,432	2,541	35.0	0.78
2023			1	0	0	0		1,760	1,196	0	4,270	2,765	54.4	0.54
2024			1	0	0	0		2,000	1,196	0	4,510	3,008	49.9	0.76
2025			1	0	0	0		2,240	1,196	0	4,750	3,273	45.1	0.75
TOTAL			5	1	0	4								
GRAND TOTAL	0	3	20	5	20	4	15							

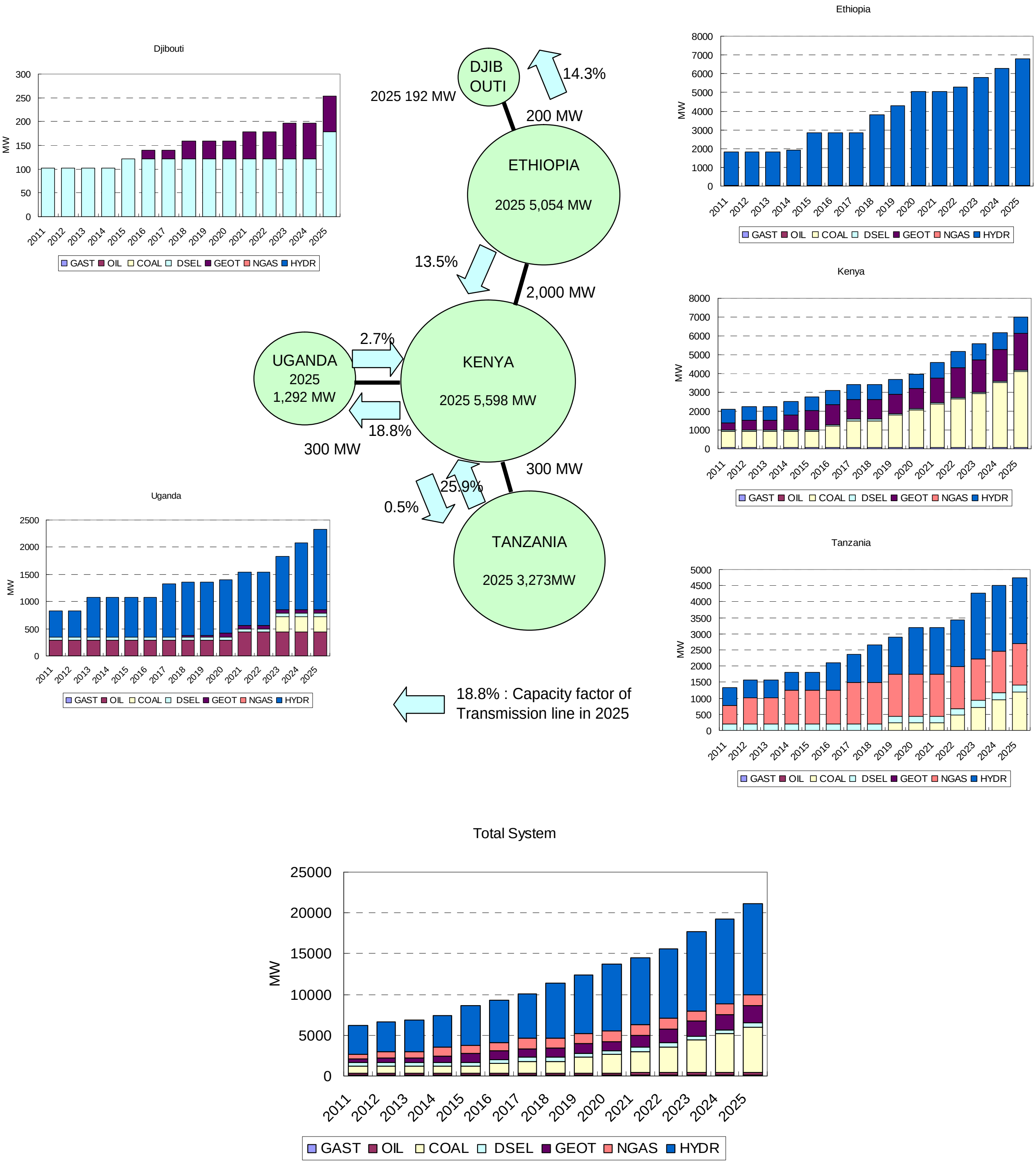

Fig.-10.2-2 Evolution of Power Mix in each Country and Energy Flows in 2025 (Simulation-1)

10.2.3 Simulation Results with Consideration of Water Shortages (Simulation-2)

The simulation in the previous section shows that geothermal energy in Ethiopia and Tanzania is not necessarily needed in their power development plans. This is due to the fact that both countries have a large amount of inexpensive hydropower potential. In spite of this hydropower potential, however, Ethiopia is considering developing geothermal energy to avoid the risk of depending too much on hydropower. Therefore, a second simulation that considers water shortages was carried out and is reported in this section. In this simulation, additional assumptions are used such that the energy production of all hydropower plants is reduced to 80% of the normal case in 2020 in Ethiopia and that it is reduced to 80% of the normal case in 2023 in Tanzania. These assumptions aim to simulate an abnormal drought happening in both countries. The results of this simulation (Simulation-2) are shown in Table-10.2-4 and Table-10.2-5.

This simulation shows that Ethiopia needs 700 MW of geothermal energy in 2020, and Tanzania needs 50 MW in 2022. Interestingly, it also shows that Uganda needs only one 35 MW geothermal plant in 2018, rather than two geothermal units of 35 MW in 2018 and 2020, as for the normal case. It is thought that the one geothermal unit needed in 2020 in Uganda is rendered unnecessary due to the many geothermal plants newly developed in Ethiopia under the Simulation-2 scenario. Geothermal energy development in Djibouti does not change, i.e. 80 MW in total by 2025. A total of 1,960 MW of geothermal is also needed in Kenya, but the development schedule changes slightly from the normal case. In total, 2,825 MW of geothermal energy is needed in the five countries by 2025. Fig.-10.2-3 shows the outline of the energy flow in the integrated system in 2025 in Simulation-2.

Table-10.2-4 Simulated Geothermal Energy Development Plan by Country (Simulation-2)

Year	Djibouti	Ethiopia	Kenya	Uganda	Tanzania	Total
2011			280MW			280MW
2012			140MW			140MW
2013						
2014			280MW			280MW
2015			280MW			280MW
2016	20MW					20MW
2017						
2018	20MW			35MW		55MW
2019						
2020	20MW	700MW	140MW			860MW
2021						
2022			280MW		100MW	380MW
2023	20MW		280MW			300MW

2024						
2025			280MW			280MW
Total	80MW	700MW	1,960MW	35MW	100MW	2,875MW

Table-10.2-5 Power Development Plan of each Country （Simulation-2）

DJIBOUTI	NEW DEVELOPMENT (CONNECTED SYSTEM)							TOTAL	UNDER	PLANED	TOTAL	LOAD	RES	LOLP
YEAR	GAST	OIL	COAL	DSEL	GEOT	NGAS	HYDR	DEV'T	CONST	RETIRE	CAP			
				20MW	20MW			(MW)	(MW)	(MW)	(MW)	(MW)	(%)	(days)
2011				0	0			0	0	0	102	84	21.4	0.00
2012				0	0			0	0	0	102	89	14.4	0.00
2013				0	0			0	0	0	102	95	7.9	0.64
2014				0	0			0	0	0	102	100	1.7	0.00
2015				1	0			19	0	0	121	106	13.7	0.45
2016				0	1			38	0	0	140	113	24.0	0.00
2017				0	0			38	0	0	140	120	16.8	0.01
2018				0	1			57	0	0	159	127	25.1	0.02
2019				0	0			57	0	0	159	135	17.9	0.02
2020				0	1			76	0	0	178	143	24.4	8.08
2021				0	0			76	0	0	178	152	17.2	0.39
2022				0	0			76	0	0	178	161	10.5	0.01
2023				0	1			95	0	0	197	171	15.2	0.01
2024				0	0			95	0	0	197	181	8.6	0.71
2025				3	0			152	0	0	254	192	32.0	0.00
TOTAL				4	4									

ETHIOPIA	NEW DEVELOPMENT (CONNECTED SYSTEM)							TOTAL	UNDER	PLANED	TOTAL	LOAD	RES	LOLP
YEAR	GAST	OIL	COAL	DSEL	GEOT	NGAS	HYDR	DEV'T	CONST	RETIRE	CAP			
					50MW		250MW	(MW)	(MW)	(MW)	(MW)	(MW)	(%)	(days)
2011					0		0	0	0	0	1,835	1,000	83.5	0.00
2012					0		0	0	0	0	1,835	1,140	61.0	0.00
2013					0		0	0	0	0	1,835	1,300	41.2	0.00
2014					0		0	0	100	0	1,935	1,482	30.6	0.51
2015					0		0	0	1,030	0	2,865	1,689	69.6	0.00
2016					0		0	0	1,030	0	2,865	1,925	48.8	0.00
2017					0		0	0	1,030	0	2,865	2,195	30.5	0.00
2018					0		0	0	1,960	0	3,795	2,502	51.7	0.00
2019					0		2	498	1,960	0	4,293	2,853	50.5	0.47
2020					14		4	2,152	1,960	0	5,947	3,138	89.5	1.45
2021					0		0	2,152	1,960	0	5,947	3,452	72.3	0.00
2022					0		0	2,152	1,960	0	5,947	3,797	56.6	0.00
2023					0		2	2,650	1,960	0	6,445	4,176	54.3	0.00
2024					0		2	3,148	1,960	0	6,943	4,594	51.1	0.00
2025					0		2	3,646	1,960	0	7,441	5,054	47.2	0.00
TOTAL					14		12							

KENYA	NEW DEVELOPMENT (CONNECTED SYSTEM)							TOTAL	UNDER	PLANED	TOTAL	LOAD	RES	LOLP
YEAR	GAST	OIL	COAL	DSEL	GEOT	NGAS	HYDR	DEV'T	CONST	RETIRE	CAP			
			300MW		140MW		50MW	(MW)	(MW)	(MW)	(MW)	(MW)	(%)	(days)
2011			3		2		0	1,128	0	0	2,114	1,401	50.9	0.14
2012			0		1		0	1,260	0	0	2,246	1,547	45.2	0.20
2013			0		0		0	1,260	0	0	2,246	1,708	31.5	0.96
2014			0		2		0	1,524	0	0	2,510	1,885	33.1	0.40
2015			0		2		0	1,788	0	0	2,774	2,081	33.3	0.46
2016			1		0		1	2,126	0	0	3,112	2,298	35.4	0.31
2017			1		0		0	2,414	0	0	3,400	2,537	34.0	0.42
2018			0		0		0	2,414	0	0	3,400	2,800	21.4	0.37
2019			1		0		0	2,702	0	0	3,688	3,092	19.3	0.05
2020			1		1		0	3,122	0	0	4,108	3,413	20.4	0.91
2021			2		0		1	3,748	0	0	4,734	3,768	25.6	0.46
2022			0		2		1	4,062	0	0	5,048	4,160	21.3	0.88
2023			1		2		0	4,614	0	0	5,600	4,593	21.9	0.84
2024			2		0		0	5,190	0	0	6,176	5,070	21.8	0.79
2025			2		2		0	6,030	0	0	7,016	5,598	25.3	0.14
TOTAL			14		14		3							

UGANDA	NEW DEVELOPMENT (CONNECTED SYSTEM)							TOTAL	UNDER	PLANED	TOTAL	LOAD	RES	LOLP
YEAR	GAST	OIL	COAL	DSEL	GEOT	NGAS	HYDR	DEV'T	CONST	RETIRE	CAP			
		150MW	300MW	70MW	35MW		50MW	(MW)	(MW)	(MW)	(MW)	(MW)	(%)	(days)
2011		2	0	0	0		0	292	0	0	832	564	47.5	0.07
2012		0	0	0	0		0	292	0	0	832	598	39.0	0.11
2013		0	0	0	0		0	292	249	0	1,081	635	70.3	2.82
2014		0	0	0	0		0	292	249	0	1,081	674	60.5	2.28
2015		0	0	0	0		0	292	249	0	1,081	715	51.2	0.15
2016		0	0	0	0		0	292	249	0	1,081	758	42.6	0.45
2017		0	0	0	0		0	292	498	0	1,330	805	65.3	0.61
2018		0	0	0	1		0	325	498	0	1,363	854	59.7	1.80
2019		0	0	0	0		0	325	498	0	1,363	906	50.5	0.79
2020		0	1	0	0		0	613	498	0	1,651	961	71.8	0.13
2021		0	0	0	0		0	613	498	0	1,651	1,020	61.9	0.38
2022		0	0	0	0		0	613	498	0	1,651	1,082	52.6	0.15
2023		1	0	0	0		0	759	498	0	1,797	1,148	56.6	0.59
2024		0	0	0	0		0	759	747	0	2,046	1,218	68.0	0.24
2025		0	0	0	0		0	759	996	0	2,295	1,292	77.6	0.04
TOTAL		3	1	0	1		0							

TANZANIA	NEW DEVELOPMENT (CONNECTED SYSTEM)							TOTAL	UNDER	PLANED	TOTAL	LOAD	RES	LOLP
YEAR	GAST	OIL	COAL	DSEL	GEOT	NGAS	HYDR	DEV'T	CONST	RETIRE	CAP			
			250MW	70MW	50MW	250MW		(MW)	(MW)	(MW)	(MW)	(MW)	(%)	(days)
2011			0	1	0	1		311	0	0	1,326	1,005	31.9	0.71
2012			0	0	0	1		554	0	0	1,569	1,093	43.5	0.15
2013			0	0	0	0		554	0	0	1,569	1,190	31.9	0.62
2014			0	0	0	1		797	0	0	1,812	1,294	40.0	0.14
2015			0	0	0	0		797	0	0	1,812	1,408	28.7	0.69
2016			0	0	0	0		797	299	0	2,111	1,532	37.8	0.66
2017			0	0	0	1		1,040	299	0	2,354	1,667	41.2	0.29
2018			0	0	0	0		1,040	598	0	2,653	1,814	46.3	0.43
2019			1	0	0	0		1,280	598	0	2,893	1,973	46.6	0.55
2020			0	0	0	0		1,280	897	0	3,192	2,147	48.7	0.21
2021			0	0	0	0		1,280	897	0	3,192	2,336	36.6	0.88
2022			4	0	2	0		2,334	897	0	4,246	2,541	67.1	0.87
2023			1	0	0	0		2,574	1196	0	5,084	2,765	83.9	0.87
2024			1	0	0	0		2,814	1196	0	5,324	3,008	77.0	1.25
2025			1	0	0	0		3,054	1196	0	5,564	3,273	70.0	1.60
TOTAL			8	1	2	4								
GRAND TOTAL	0	3	23	5	35	4	15							

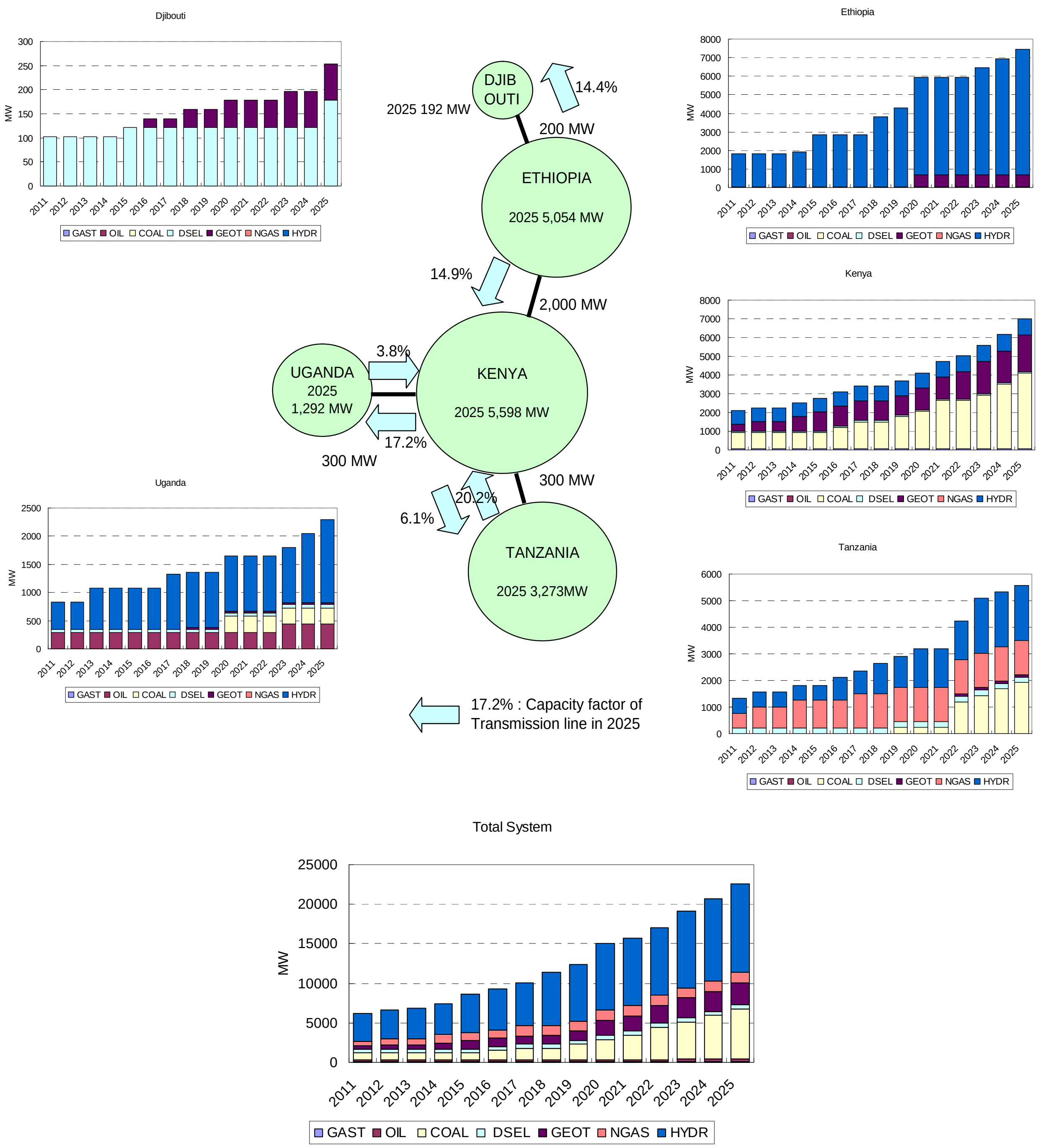

Fig.-10.2-3 Evolution of Power Mix in each Country and Energy Flows in 2025 (Simulation-2)

10.3 Expectations for Geothermal Energy in the African Rift-valley Region

Considering the electric power development plan of each country and the results of the simulations in the previous sections, the Study Team summarizes the expectation for geothermal energy in each country by 2025 in Table-10.3-1 below. This would total to about 2,600 MW ~ 3,000 MW.

Tabel-10.3-1 Expectations for geothermal Energy in the Africa Rift-valley Region

(Unit: MW)

Period	Djibouti	Ethiopia	Kenya	Uganda	Tanzania	Total
2011-2025	60-80	450-700	1,900-2,100	70-90	App.100	2,600-3,000

Chapter 11 Road Maps for Geothermal Development

11.1 Introduction

In this chapter, geothermal development road maps until 2025 are worked out for each country, based on their field development status and results confirming the presence of geothermal resources in them. The information compiled and integrated in Section 4 of Chapters 4 through 8 is reconsidered in light of the geothermal development targets for each country which were calculated in Chapter 10. Among the five targeted countries, Kenya is the most advanced in geothermal development and there is abundant resource data for it. Ethiopia is second to Kenya in development and has carried out studies up to the detailed surface exploration stage in several areas. On the other hand, in Djibouti, Tanzania, Uganda, only a few areas have been studied, and almost all of the geothermal fields are unexplored and a geothermal inventory is not available. There is a general shortage of geothermal data for the East Africa Rift region. Because of the lack of information in many fields, this road map is offered as a rough sketch of future possibilities, and the reader is advised that the presence of all the geothermal resources that are assumed in the road map has not necessarily been confirmed.

Apart from this final report, a document of “Geothermal Data in Each Field", is prepared as an Annex.

11.2 Road Map for Kenya

The expectation for geothermal power development in Kenya by 2025 is estimated at around 1,600-2,000MW. The main geothermal data for each Kenyan geothermal field is shown in Table-11.2-1. Deep geothermal wells to confirm the existence of geothermal fluid at great depth have been drilled in only two prospects, Olkaria and Eburru. In the Olkaria field, power plant generation was commissioned in the first half of the 1980's, and more than 100 geothermal wells have been drilled so far. The highest temperature for a geothermal reservoir there has been reported as 340^{o}C. In the Eburru field, a high-temperature geothermal reservoir (max. 279^{o}C) has also been confirmed. Besides these two prospects, surface surveys have been carried out in prospects at Suswa, Longonot, Menengai, Paka and Silali, and a large-scale geothermal resource potential has been estimated for these fields. The Kenyan government has already established its own geothermal development plan including targeted quantities, which are only slightly lower than the targeted generation output in this proposed road map. In order to achieve their development target, the Kenyan government established the Geothermal Development Company (GDC) and plans to have GDC carry out various surveys including well drilling for the confirmation of geothermal steam.

The proposed geothermal development road map until 2025 is shown in Fig.-11.2-1. Because there are many large-scale geothermal prospects in Kenya, the candidate prospects have been narrowed down and set up for development.

There is already a geothermal power generation capacity of 204MW operating in the Olkaria area, but KenGen is planning to enlarge that capacity with a new 140MW expansion in Olkaria IV and another 140MW expansion in Olkaria I by 2012 and 2013, respectively. The development funding for this expansion will be provided by JICA, WB, KfW, EIB and AFD.

Regarding the development of the Eburru field, KenGen is considering the introduction of a small binary power plant. On the other hand, the Kenyan government is encouraging Independent Power Providers (IPPs) to develop the resources at the Suswa prospect and the Longonot prospect. Since a development program for the above-mentioned four prospects has already been set by the Kenyan government, there is no need for special consideration in this report.

The development of the Menengai prospect is scheduled to come online in 6 phases by 2025 (140MW x 6 units). Because no deep wells have been drilled and the feasability of large-scale geothermal plant construction is unclear, the Study Team proposes that a conceptual design for plant facilities be elaborated after 6 deep wells have been drilled and resource evaluation has reached the FS stage. The completion of each phase will take around 4½ years, so FS activity should start in 2011 for the first unit, 2013 for the second unit, 2015 for the third unit, 2017 for the fourth unit, 2019 for the fifth unit, and finally in 2021 for the sixth unit. The required financing will be equivalent to around USD 485-490 million per phase (refer to Table-11.2-2).

The development of the Silali prospect will take place in 4 separate phases up to 2024 (140MW x 4 units). Since this prospect is still at the stage of geological-geochemical reconnaissance, a geophysical surface study should be done to select targets for the deep exploratory wells. After that, a conceptual design for plant facilities will be undertaken after 6 deep wells have been drilled and resource evaluation has reached the FS stage, as for the development in Menengai. The duration of each phase will be around four and a half years to five years, so FS activity should begin in 2011 for the first unit, 2014 for the second unit, 2017 for the third unit, and finally in 2020 for the fourth unit. The required financing will be equivalent to around USD 485-492 million per phase (refer to Table-11.2-2).

The development of the Paka prospect will take place in 3 phases in the period from 2012 from 2020 (140MW x 3units). Because no deep wells have been drilled and the feasability of large-scale geothermal plant construction is unclear, the Study Team proposes to elaborate a conceptual design for plant facilities after 6 deep wells have been drilled and resource evaluation has reached the FS stage, as for the development in Menengai prospect and Silali prospect. The duration of each phase will be around four and a half years, so FS activity should begin in in 2012 for the first unit, in 2014 for the second unit, and finally in 2016 for the last unit. The required financing will be equivalent to around USD 485-490 million per phase (refer to Table-11.2-2).

As described above, the geothermal development road map for Kenya consists of the enlargement of the Olkaria field, and several large-scale plant constructions in the Menengai prospect, Silali prospect and Paka prospect. The geothermal potential to meet the future increases proposed for each prospect has not yet been identified, except for Olkaria, but since there are many geothermal prospects in the Kenyan Rift Valley and two IPP projects in Suswa prospect and Longonot prospect, the expectation of tapping 1,600-2,000MW of geothermal energy in Kenya by 2025 is considered to be achievable.

Table-11.2-1 Main Geothermal Data for Each Field (Kenya)

	No.	Field Name	Drilling/Testing	Development Stage	Temperature			Estimated Resource Potential (Mwe)	Task for Geothermal Resource Development	Remarks
					Max. Surface Temp.(℃)	Possible Deep Fluid Temp. (℃) (Geothermometer)	Max. Measured Temp. (℃)			
Kenya	1	**Olkaria**	100 wells over	OP	-	-	340	400	Production drilling	
	2	**Eburru**	6 deep wells	FS	-	-	279	45	Appraisal Drilling	
	3	**Suswa**	-	Pre-FS	93	250	-	600	Exploratory drilling	Developed by IPP
	4	**Longonot**	-	Pre-FS	92-97	>250	-	>200	Exploratory drilling	Developed by IPP
	5	**Menengai**	-	Pre-FS	60-94	>250	-	>200	Exploratory drilling	
	6	**Arus/Bogoria**	-	Pre-FS	100	180-248	-	>20	Exploratory drilling	
	7	**Baringo**	-	Pre-FS	97	>170-210	-	200	Exploratory drilling	
	8	**Korosi/Chepchuk**	-	Pre-FS	80-96	>220-250	-	>700	Exploratory drilling	
	9	**Paka**	-	Pre-FS	97	>250-300	-	>750	Exploratory drilling	
	10	**Silali**	-	Re	97	250-300	-	>400	Well Targetting & Exploratory drilling	
	11	**Em urangogolak**	-	Re	96	250-350	-	300	Detailed surface exploration & Well targeting	
	12	**Namarunu**	-	Re	30-100	>200	-	>20	Detailed surface exploration & Well targeting	
	13	**Barrier volcano**	-	Re	99	220-296	-	>200	Detailed surface exploration & Well targeting	
	14	**L. Magadi**	-	Re	85	150	-	-	Detailed surface exploration & Well targeting	

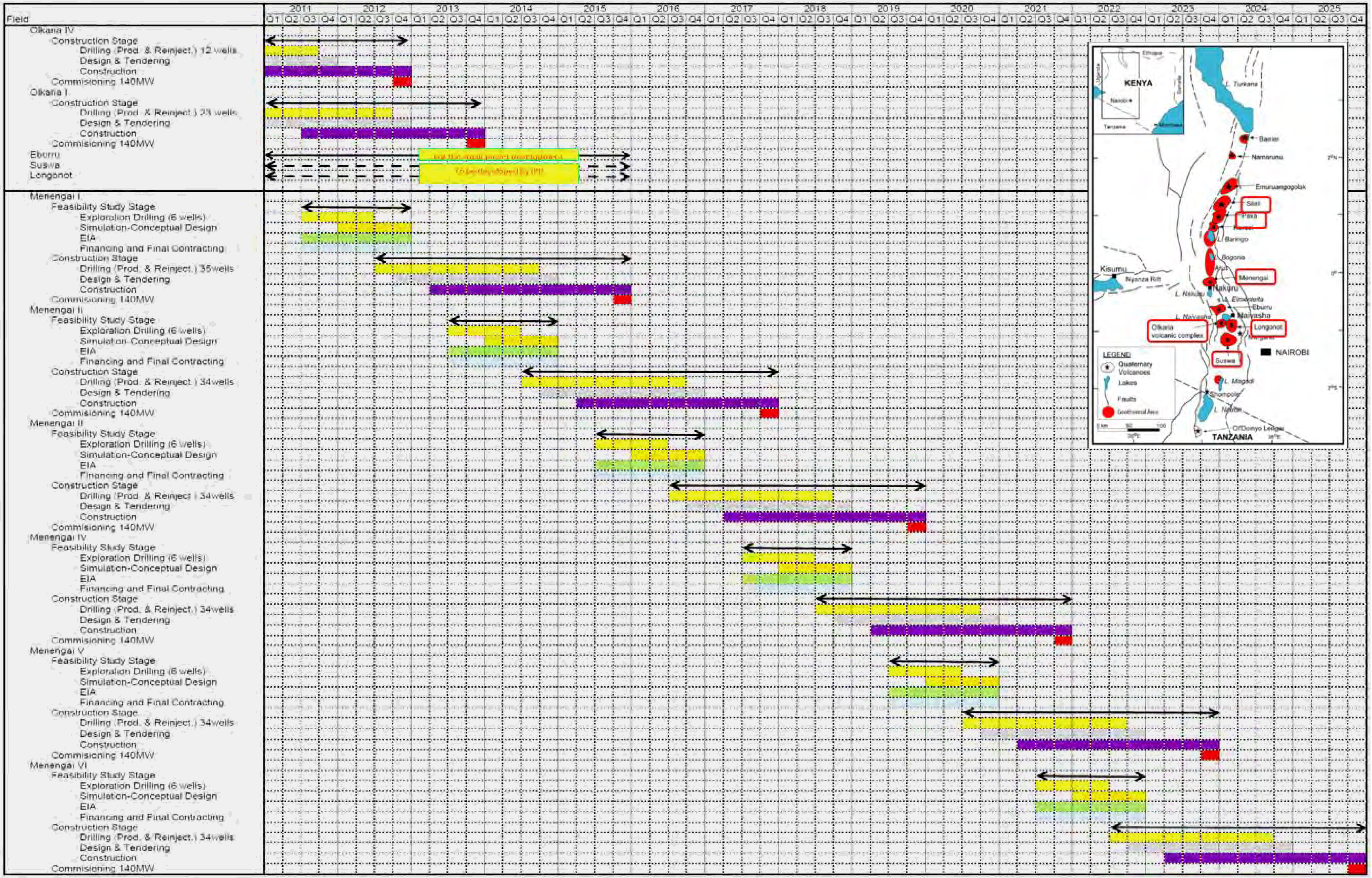

Fig.-11.2-1 Road Map for Kenya (1)

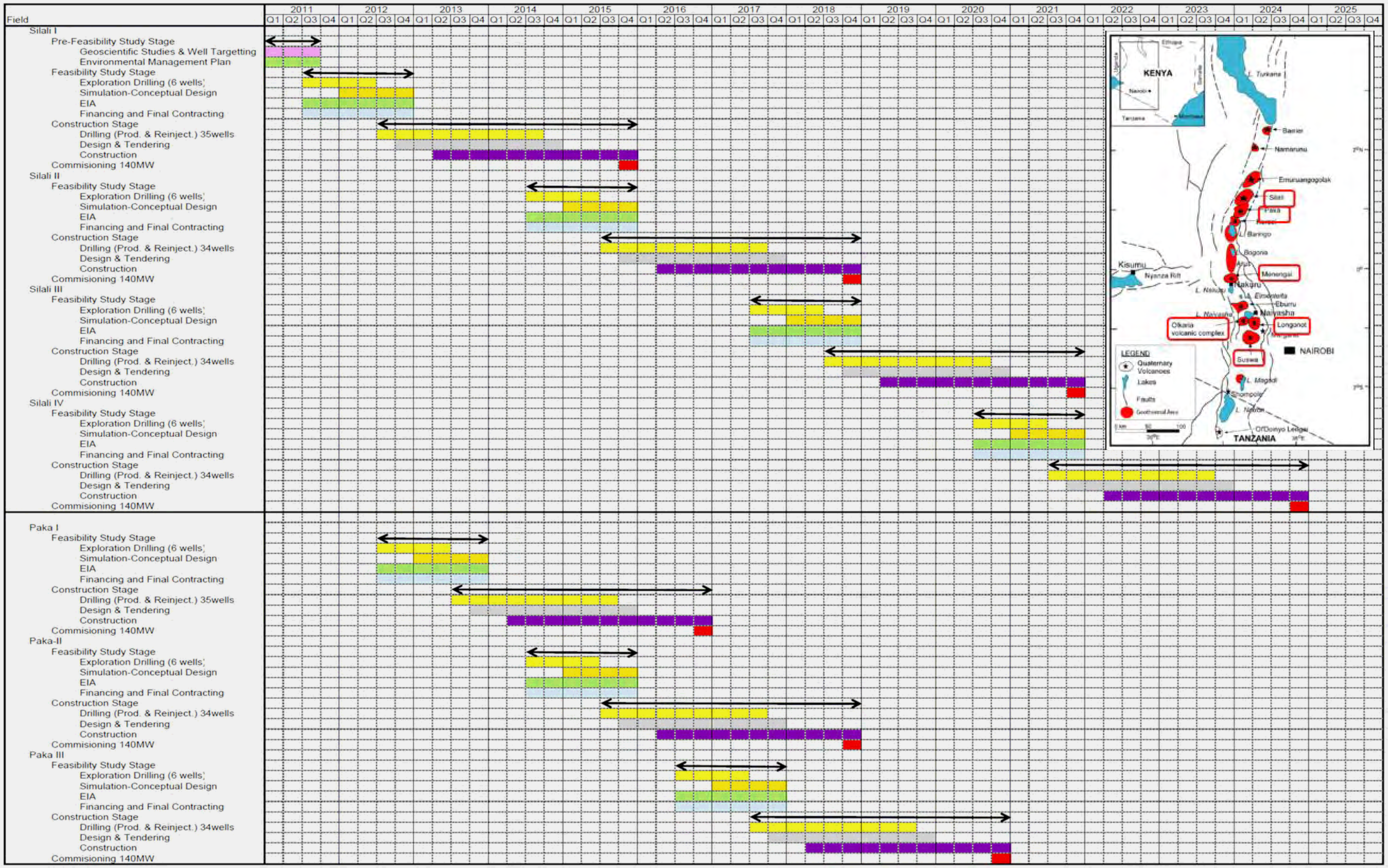

Fig.-11.2-1 Road Map for Kenya (2)

Table-11.2-2 Cost Estimates for Each Project (Kenya)

Description / Prospect	Unit Price	Menengai-I Q'ty	Menengai-I Cost	Menengai-II Q'ty	Menengai-II Cost	Menengai-III Q'ty	Menengai-III Cost	Menengai-IV Q'ty	Menengai-IV Cost	Menengai-V Q'ty	Menengai-V Cost	Menengai-VI Q'ty	Menengai-VI Cost
1 Nation-wide Survey & Master Plan	2,000,000												
2 Pre-Feasibility Study Stage	2,500,000												
3 Feasibility Study Stage			**32,300,000**		**32,300,000**		**32,300,000**		**32,300,000**		**32,300,000**		**32,300,000**
Site Development (Land, Roads, Pad, Water Supply)	5,000,000	1	5,000,000	1	5,000,000	1	5,000,000	1	5,000,000	1	5,000,000	1	5,000,000
Exploration Drilling (by contractor)	6,000,000												
Exploration Drilling (by own)	4,000,000	6	24,000,000	6	24,000,000	6	24,000,000	6	24,000,000	6	24,000,000	6	24,000,000
Well Testing	50,000	6	300,000	6	300,000	6	300,000	6	300,000	6	300,000	6	300,000
Feasibility study & Design Concept	3,000,000	1	3,000,000	1	3,000,000	1	3,000,000	1	3,000,000	1	3,000,000	1	3,000,000
4 Construction Stage			**457,639,000**		**453,305,500**		**453,305,500**		**453,305,500**		**453,305,500**		**453,305,500**
Production drilling (by contractor)	6,000,000												
Production drilling (by own)	4,000,000	26	104,000,000	25	100,000,000	25	100,000,000	25	100,000,000	25	100,000,000	25	100,000,000
Reinjection drilling (by contractor)	4,500,000												
Reinjection drilling (by own)	3,000,000	9	27,000,000	9	27,000,000	9	27,000,000	9	27,000,000	9	27,000,000	9	27,000,000
Well Testing	50,000	26	1,300,000	25	1,250,000	25	1,250,000	25	1,250,000	25	1,250,000	25	1,250,000
Steam field development (450K per MW)	450,000	140	63,000,000	140	63,000,000	140	63,000,000	140	63,000,000	140	63,000,000	140	63,000,000
Turbine, generator, condenser, etc. (1,100K per MW)	1,100,000	140	154,000,000	140	154,000,000	140	154,000,000	140	154,000,000	140	154,000,000	140	154,000,000
Civil Works (Power house, staff houses, roads)	560,000	140	78,400,000	140	78,400,000	140	78,400,000	140	78,400,000	140	78,400,000	140	78,400,000
Construction supervision and administration	(7%)		29,939,000		29,655,500		29,655,500		29,655,500		29,655,500		29,655,500
Total			**489,939,000**		**485,605,500**		**485,605,500**		**485,605,500**		**485,605,500**		**485,605,500**

(Unit: US$)

Description / Prospect	Unit Price	Silali-I Q'ty	Silali-I Cost	Silali-II Q'ty	Silali-II Cost	Silali-III Q'ty	Silali-III Cost	Silali-IV Q'ty	Silali-IV Cost	Paka-I Q'ty	Paka-I Cost	Paka-II Q'ty	Paka-II Cost	Total
1 Nation-wide Survey & Master Plan	2,000,000													
2 Pre-Feasibility Study Stage	2,500,000	1	**2,500,000**											**2,500,000**
3 Feasibility Study Stage			**32,300,000**		**32,300,000**		**32,300,000**		**32,300,000**		**32,300,000**		**32,300,000**	**387,600,000**
Site Development (Land, Roads, Pad, Water Supply)	5,000,000	1	5,000,000	1	5,000,000	1	5,000,000	1	5,000,000	1	5,000,000	1	5,000,000	60,000,000
Exploration Drilling (by contractor)	6,000,000													
Exploration Drilling (by own)	4,000,000	6	24,000,000	6	24,000,000	6	24,000,000	6	24,000,000	6	24,000,000	6	24,000,000	288,000,000
Well Testing	50,000	6	300,000	6	300,000	6	300,000	6	300,000	6	300,000	6	300,000	3,600,000
Feasibility study & Design Concept	3,000,000	1	3,000,000	1	3,000,000	1	3,000,000	1	3,000,000	1	3,000,000	1	3,000,000	36,000,000
4 Construction Stage			**457,639,000**		**453,305,500**		**453,305,500**		**453,305,500**		**457,639,000**		**453,305,500**	**5,452,666,500**
Production drilling (by contractor)	6,000,000													
Production drilling (by own)	4,000,000	26	104,000,000	25	100,000,000	25	100,000,000	25	100,000,000	26	104,000,000	25	100,000,000	1,212,000,000
Reinjection drilling (by contractor)	4,500,000													
Reinjection drilling (by own)	3,000,000	9	27,000,000	9	27,000,000	9	27,000,000	9	27,000,000	9	27,000,000	9	27,000,000	324,000,000
Well Testing	50,000	26	1,300,000	25	1,250,000	25	1,250,000	25	1,250,000	26	1,300,000	25	1,250,000	15,150,000
Steam field development (450K per MW)	450,000	140	63,000,000	140	63,000,000	140	63,000,000	140	63,000,000	140	63,000,000	140	63,000,000	756,000,000
Turbine, generator, condenser, etc. (1,100K per MW)	1,100,000	140	154,000,000	140	154,000,000	140	154,000,000	140	154,000,000	140	154,000,000	140	154,000,000	1,848,000,000
Civil Works (Power house, staff houses, roads)	560,000	140	78,400,000	140	78,400,000	140	78,400,000	140	78,400,000	140	78,400,000	140	78,400,000	940,800,000
Construction supervision and administration	(7%)		29,939,000		29,655,500		29,655,500		29,655,500		29,939,000		29,655,500	356,716,500
Total			**492,439,000**		**485,605,500**		**485,605,500**		**485,605,500**		**489,939,000**		**485,605,500**	**5,842,766,500**

11.3 Road Map for Ethiopia

The expectation for geothermal power development in Ethiopia until 2025 is that around 450-700MW can be developed. The main geothermal data for each Ethiopian geothermal field is shown in Table-11.3-1. Deep geothermal wells to confirm the existence of geothermal fluid at great depth have been drilled in only two fields, Aluto Langano and Tendaho. In the Aluto Langano field, a 7.3 MW pilot power plant began operating in 1998, eight (8) deep exploratory wells were drilled, and a high-temperature geothermal reservoir (max 350^{o}C) was also confirmed. In the Tendaho field, three (3) deep wells and three (3) shallow wells (around 500 meters deep on average) were drilled, and the existence of a geothermal reservoir with a highest temperature of 278^{o}C has been reported. In addition to the above two advanced fields, the Corbetti prospect and the Abaya prospect have been moderately explored up to the Pre-FS phase. There has been no geothermal well drilling at either prospect, but the existence of a high-temperature geothermal reservoir (with temperatures higher than 300^{o}C) is estimated from analysis of the geochemical temperature. This thermometry information underlines the necessity for deep drilling. Aside from these prospects, detailed surface surveys were undertaken in the Tulu Moye, Dofan, Fantale and Gedemsa prospects by the Geological Survey of Ethiopia (GSE), but these prospects need further advanced exploration. In addition, an increase in the geothermal resource potential is to be expected following a nationwide survey, because many geothermal manifestations are seen in the Ethiopian rift valley. The Ethiopian government has not yet devised a concrete power development plan targeting geothermal resources.

The proposed geothermal development road map until 2025 is shown in Fig.-11.3-1.

The most promising field for geothermal development in Ethiopia is the Aluto Langano field, which is now generating 7.3 MW of electricity. A Feasibility Study including the drilling of four (4) deep geothermal wells is now programmed. The geothermal wells, which can be converted to commercial wells, will begin to be drilled in 2011, and these will be followed by resource evaluation and a conceptual design for plant facilities. The World Bank and the Government of Japan offered to fund the planned FS, including the well drilling. However, the funding for the construction of the power plant that follows the FS stage is not yet fixed at all. The required financing amounts to around USD 130 million for a 35MW plant (Unit-I) and USD 166 million for both the FS drilling stage and a 40MW plant construction stage (Unit-II, refer to Table-11.2-2). If the development advances smoothly, startup of unit-I will take place in 2014, followed by startup of unit-II in 2016.

Next to Aluto Langano, the most promising field for development is Tendaho. GSE plans to carry out a geophysical surface survey beginning in 2010 with financial support from the Federal Institute for Geosciences and Natural Resources of Germany (BGR). However, the funding sources for appraisal well drilling and for power plant construction have not yet been fixed. The required financing amounts to around USD 203 million for all stages of a 50 MW plant construction (Unit-I) and USD 195 million for the whole cost of another 50 MW plant construction (Unit-II, refer to Table-11.3-2). If the project proceeds efficiently, operation of unit-I will start in 2015, and the startup of unit-II will take place in 2017, one year behind the Aluto Langano commissioning.

The next most promising prospects after these are Corbetti and Abaya. The development of the Corbetti prospect is separated into 2 phases to be completed by 2018 (35MW x 1unit and 40MW x 1 unit). Corbetti is already at the Pre-FS stage, and a geophysical surface study should be done to target deep exploratory wells. After that, a conceptual design for plant facilities will be undertaken after four (4) deep wells have been drilled and resource evaluation reaches the FS stage. Each phase will take around four (4) years, so FS activity should begin in late 2012 for the first unit and in 2015 for the second unit. The required financing is equivalent to around USD 156-166 million per phase (refer to Table-11.3-2). The development of the Abaya prospect is similarly separated into 2 phases to be completed by 2019 (50MW x 2 units). Abaya is already at the Pre-FS stage, and a geophysical surface study should be done to select targets for deep exploratory wells. Subsequently, a conceptual design for plant facilities will be undertaken after four (4) deep wells have been drilled and resource evaluation reaches the FS stage. Each phase will last around four (4) years to four and a half (4½) years, so FS activity should begin in 2013 for the first unit and in 2016 for the second unit. The required financing amounts to around USD 195-203 million per phase (refer to Table-11.3-2).

In order to achieve expectations for the development of 450-700MW of geothermal energy in Ethiopia by 2025, the remaining geothermal prospects (Tulu Moye, Dofan, Fantale, Gedemsa and others) should be explored and developed. However, there is little geothermal data for these remaining prospects and the accuracy of what date there is also low. Therefore, a nationwide survey of the entire national area is recommended (refer to Fig.-11.3-1(2)). A two-year regional study will be scheduled for 2014 and the promising prospects will be identified. The selected promising areas will be prioritized for exploration, drilling and finally construction in turn.

Large-scale geothermal fields such as are found in Kenya are unknown in Ethiopia. However, the East African Rift stretches across the central part of Ethiopia from the northeast to the southwest. Because of insufficient exploration information, though, it seems that the correct geothermal potential of the various fields has not been calculated. A nationwide survey, followed by local detailed surface surveys and geothermal well drilling, will help to confirm the quantity of exploitable geothermal resources.

Table-11.3-1 Main Geothermal Data for Each Field (Ethiopia)

	No.	Field Name	Drilling Testing	Development Stage	Temperature			Estimated Resource Potential (Mwe)	Task for Geothermal Resource Development	Remarks
					Max. Surface Temp.(℃)	Possible Deep Fluid Temp. (℃) (Geothermometer)	Max. Measured Temp. (℃)			
Ethiopia	1	**Aluto Langano**	8 deep wells	OP	60-70	-	350	75	Appraisal Drilling	
	2	**Tendaho**	3 deep wells 3 shallow wells	FS	?	-	278	100???	Appraisal Drilling	Explored by BGR
	3	**Abaya**	Shallow TG wells	Pre-FS	96	>300	-	100	Well Targetting & Exploratory drilling	
	4	**Corbetti**	Shallow TG wells	Pre-FS	94	>300	-	75	Well Targetting & Exploratory drilling	
	5	**Tulu Moye**	Shallow TG wells	Detailed Surface	60-80	>150	-	40	Detailed surface exploration & Well targeting	
	6	**Dofan**	-	Detailed Surface	100	<280	-	50	Detailed surface exploration & Well targeting	
	7	**Fantale**	-	Detailed Surface	100		-	50	Detailed surface exploration & Well targeting	
	8	**Gedemsa**	Shallow TG wells	Detailed Surface	60-80	-	-	-	Detailed surface exploration & Well targeting	
	9	**Dallol**	-	Identified localities	-	-	-	-	Detailed surface exploration & Well targeting	
	10	**Kone**	-	Re	-	-	-	-	Detailed surface exploration & Well targeting	
	11	**Meteka**	-	Re	-	-	-	-	Detailed surface exploration & Well targeting	
	12	**Teo**	-	Re	-	-	-	-	Detailed surface exploration & Well targeting	
	13	**Danab**	-	Re	-	-	-	-	Detailed surface exploration & Well targeting	
	14	**Lake Abhe**	-	Identified localities	-	-	-	-	Detailed surface exploration & Well targeting	

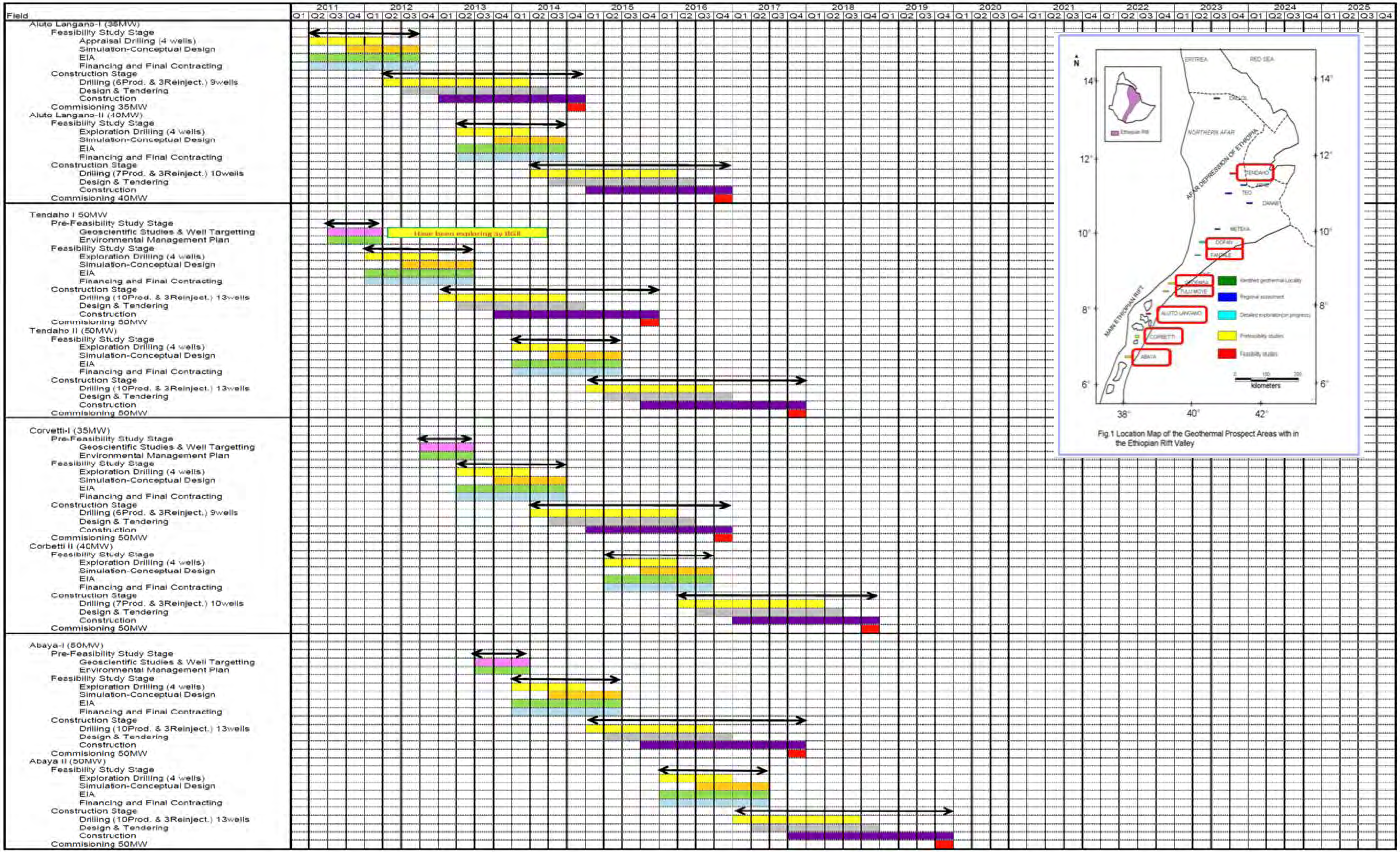

Fig.-11.3-1 Road Map for Ethiopia (1)

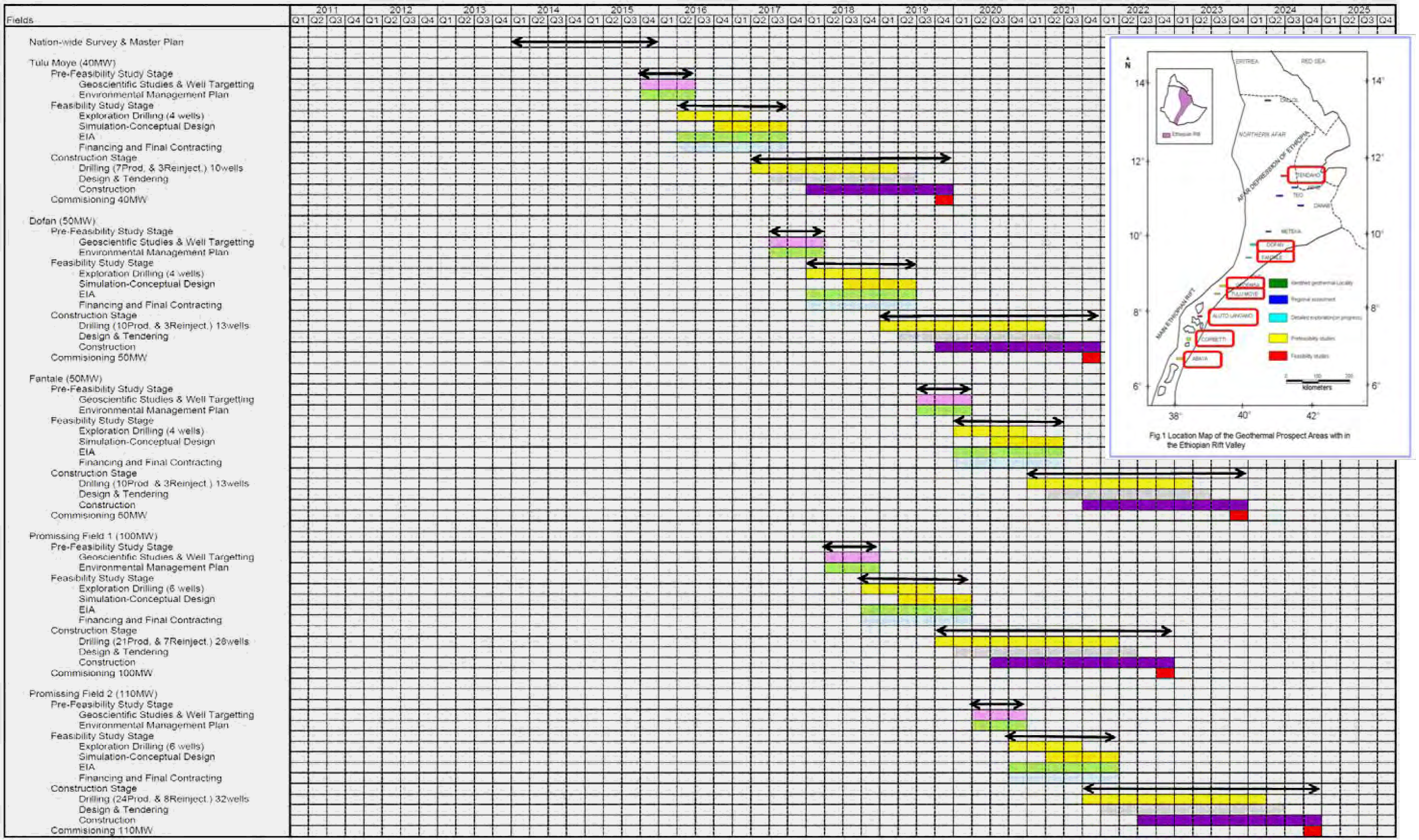

Fig.-11.3-1 Road Map for Ethiopia (2)

Table-11.3-2 Cost Estimates for Each Project (Ethiopia)

Prospect / Description	Unit Price	Aluto Langano-I Q'ty	Aluto Langano-I Cost	Aluto Langano-II Q'ty	Aluto Langano-II Cost	Tendaho-I Q'ty	Tendaho-I Cost	Tendaho-II Q'ty	Tendaho-II Cost	Corbetti-I Q'ty	Corbetti-I Cost	Corbetti-II Q'ty	Corbetti-II Cost	Abaya-I Q'ty	Abaya-I Cost	Abaya-II Q'ty	Abaya-II Cost
1 Nation-wide Survey & Master Plan	2,000,000																
2 Pre-Feasibility Study Stage	2,500,000					1	**2,500,000**			1	**2,500,000**			1	**2,500,000**		
3 Feasibility Study Stage					**19,200,000**		**24,200,000**		**19,200,000**		**24,200,000**		**19,200,000**		**24,200,000**		**19,200,000**
Site Development (Land, Roads, Pad, Water Supply	5,000,000					1	5,000,000			1	5,000,000			1	5,000,000		
Exploration Drilling (by contractor	6,000,000																
Exploration Drilling (by own)	4,000,000			4	16,000,000	4	16,000,000	4	16,000,000	4	16,000,000	4	16,000,000	4	16,000,000	4	16,000,000
Well Testing	50,000			4	200,000	4	200,000	4	200,000	4	200,000	4	200,000	4	200,000	4	200,000
Feasibility study & Design Concept	3,000,000			1	3,000,000	1	3,000,000	1	3,000,000	1	3,000,000	1	3,000,000	1	3,000,000	1	3,000,000
4 Construction Stage			**129,630,500**		**147,392,500**		**176,550,000**		**176,550,000**		**129,577,000**		**147,392,500**		**176,550,000**		**176,550,000**
Production drilling (by contractor	6,000,000																
Production drilling (by own)	4,000,000	6	24,000,000	7	28,000,000	10	40,000,000	10	40,000,000	6	24,000,000	7	28,000,000	##	40,000,000	10	40,000,000
Reinjection drilling (by contractor	4,500,000																
Reinjection drilling (by own)	3,000,000	3	9,000,000	3	9,000,000	3	9,000,000	3	9,000,000	3	9,000,000	3	9,000,000	3	9,000,000	3	9,000,000
Well Testing	50,000	6	300,000	7	350,000	10	500,000	10	500,000	5	250,000	7	350,000	##	500,000	10	500,000
Steam field development (450K per MW	450,000	35	15,750,000	40	18,000,000	50	22,500,000	50	22,500,000	35	15,750,000	40	18,000,000	##	22,500,000	50	22,500,000
Turbine, generator, condenser, etc. (1500K per MW	1,500,000	35	52,500,000	40	60,000,000					35	52,500,000	40	60,000,000				
Turbine, generator, condenser, etc. (1300K per MW	1,300,000					50	65,000,000	50	65,000,000					##	65,000,000	50	65,000,000
Civil Works (Power house, staff houses, roads)	560,000	35	19,600,000	40	22,400,000	50	28,000,000	50	28,000,000	35	19,600,000	40	22,400,000	##	28,000,000	50	28,000,000
Construction supervision and administration	(7%)		8,480,500		9,642,500		11,550,000		11,550,000		8,477,000		9,642,500		11,550,000		11,550,000
Total			**129,630,500**		**166,592,500**		**203,250,000**		**195,750,000**		**156,277,000**		**166,592,500**		**203,250,000**		**195,750,000**

(Unit: US$)

Prospect / Description	Unit Price	Tulu Moye Q'ty	Tulu Moye Cost	Dofan Q'ty	Dofan Cost	Fantale Q'ty	Fantale Cost	Promissing 1 Q'ty	Promissing 1 Cost	Promissing 2 Q'ty	Promissing 2 Cost	Q'ty	Cost	Total
1 Nation-wide Survey & Master Plan	2,000,000	1	**2,000,000**											**2,000,000**
2 Pre-Feasibility Study Stage	2,500,000	1	**2,500,000**	1	**2,500,000**	1	**2,500,000**	1	**2,500,000**	1	**2,500,000**			**20,000,000**
3 Feasibility Study Stage			**24,200,000**		**24,200,000**		**24,200,000**		**32,300,000**		**32,300,000**			**286,600,000**
Site Development (Land, Roads, Pad, Water Supply	5,000,000	1	5,000,000	1	5,000,000	1	5,000,000	1	5,000,000	1	5,000,000			40,000,000
Exploration Drilling (by contractor	6,000,000													
Exploration Drilling (by own)	4,000,000	4	16,000,000	4	16,000,000	4	16,000,000	6	24,000,000	6	24,000,000			208,000,000
Well Testing	50,000	4	200,000	4	200,000	4	200,000	6	300,000	6	300,000			2,600,000
Feasibility study & Design Concept	3,000,000	1	3,000,000	1	3,000,000	1	3,000,000	1	3,000,000	1	3,000,000			36,000,000
4 Construction Stage			**147,392,500**		**176,550,000**		**176,550,000**		**360,643,500**		**401,571,000**			**2,522,899,500**
Production drilling (by contractor	6,000,000													
Production drilling (by own)	4,000,000	7	28,000,000	10	40,000,000	10	40,000,000	21	84,000,000	24	96,000,000			552,000,000
Reinjection drilling (by contractor	4,500,000													
Reinjection drilling (by own)	3,000,000	3	9,000,000	3	9,000,000	3	9,000,000	7	21,000,000	8	24,000,000			144,000,000
Well Testing	50,000	7	350,000	10	500,000	10	500,000	21	1,050,000	24	1,200,000			6,850,000
Steam field development (450K per MW	450,000	40	18,000,000	50	22,500,000	50	22,500,000	100	45,000,000	110	49,500,000			315,000,000
Turbine, generator, condenser, etc. (1500K per MW	1,500,000	40	60,000,000											285,000,000
Turbine, generator, condenser, etc. (1300K per MW	1,300,000			50	65,000,000	50	65,000,000	100	130,000,000	110	143,000,000			663,000,000
Civil Works (Power house, staff houses, roads)	560,000	40	22,400,000	50	28,000,000	50	28,000,000	100	56,000,000	110	61,600,000			392,000,000
Construction supervision and administration	(7%)		9,642,500		11,550,000		11,550,000		23,593,500		26,271,000			165,049,500
Total			**176,092,500**		**203,250,000**		**203,250,000**		**395,443,500**		**436,371,000**			**2,831,499,500**

11.4 Road Map for Djibouti

The development of around 60-80MW of geothermal power is expected in Djibouti by 2025. The main geothermal data for each Djibouti geothermal field is shown in Table-11.4-1. Deep geothermal wells to confirm the existence of the geothermal fluid at great depth have been drilled in only two fields, Asal and Hanle. In the Asal field, the first two (2) deep wells were drilled in 1975, and the remaining four (4) deep exploratory wells were drilled between 1987 and 1988. A high-temperature geothermal reservoir (max 355°C) has also been confirmed. In the Hanle field, two (2) deep exploratory wells and three (3) shallow wells (around 450 meters deep on average) were drilled, but the subsurface temperature recorded a maximum of 124°C at a depth of 2,020 meters, and is not suitable for electricity generation. In addition to these two advanced fields, the Gaggade prospect and the Nord Ghoubhet prospect have been moderately explored up to the Pre-FS phase. There are no geothermal wells in either fields, but the existence of a relatively high-temperature geothermal reservoir (around 220°C in the Nord Ghoubhet prospect) is estimated by analysis of the geochemical temperatures. This thermometry information suggests the necessity of follow-up deep drilling. Besides the prospects already mentioned, geological-geochemical reconnaissance surveys have been carried out by CERD in the Arta, Obock, Lac Abhe, Chevery and Inakir prospects, but these prospects need further advanced exploration. In addition, it is expected that the geothermal resource potential will increase once a nationwide survey has been carried out, since many geothermal manifestations are seen in the Djibouti rift valley. The Djibouti government has not yet devised a concrete power development plan targeting geothermal resources.

The proposed geothermal development road map until 2025 is shown in Fig.-11.4-1.

The most explored field in Djibouti is Asal. However, the geothermal reservoir originates from seawater and creates a corrosion problem. Furthermore, there are other problems with various kinds of scale (chemical deposition), and the sulfide scale, in particular, has not yet found a technical solution. That is the reason why a power plant has not yet been constructed. To overcome this problem, it is desirable for development in the Asal field to start with the construction of a small pilot power plant at first and to expand the capacity step by step. In order to deal with corrosion and scale problems, it is necessary to find the most suitable generation conditions through the operation of a 5 MW pilot plant (the first phase) which will test various ways of controlling borehole pressure, such as application of crystallizer, installation of evaporation/deposition ponds, etc. After these technical problems have been overcome and the economic feasibility of the project has been confirmed, it is recommended to increase output slowly, with a 25MW power plant in the second phase and a 50MW large-scale power plant in the third phase. The cost is estimated to be around USD 46 million for the unit-1 small power plant (5MW) including four (4) geothermal wells, USD 130 million for the unit-2 medium-scale power plant (25MW), and USD 230 million for the unit-3 large size power plant (50MW) (refer to Table-11.4-2).

The Hydrocarbon Corporation, an Indian IPP company, has shown interest in geothermal development of the Lac Abhe prospect that is located on the border with Ethiopia and has acquired an exploitation license from the Djibouti government. In this report, the development program for the Lac Abhe prospect is left in the hands of this IPP, and the calculation of the necessary development financing is omitted.

Since there are a lot of technical and economic problems in the Asal field, it is recommended that the exploration of alternative fields such as the Hanle, Gaggade, Nord Ghoubhet, Arta, Obock, Chevery and Inakir prospects be undertaken in parallel with other geothermal development in order to realize the expectation for the development of 60-80MW of geothermal power in Djibouti by 2025. However, there is little geothermal data for these remaining prospects, and the accuracy of the available data is also low. Therefore, a nationwide survey of the whole national area is expected (refer to Fig.-11.4-1). A two-year regional study will be scheduled for 2013 and the promising prospects will be identified. The selected promising areas will be prioritized for exploration, drilling and finally construction in turn.

From their existing surveys and findings, CERD, the implementation agency for geothermal exploration in Djibouti, expects it to be possible to develop the Chevery prospect and the Inakir prospect. Djibouti is located at the intersection point where three (3) major extensional structures, the Red Sea, the East African Rifts and the Gulf of Aden join to form the Afar Depression and should have good geothermal potential. Due to the lack of exploration information, however, the correct geothermal potential has not been calculated for most fields. A nationwide survey, followed by local detailed surface surveys and geothermal well drilling, will help to confirm the quantity of exploitable geothermal resources.

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Table-11.4-1 Main Geothermal Data for Each Field (Djibouti)

	No.	Field Name	Drilling Testing	Development Stage	Temperature			Estimated Resource Potential (Mwe)	Task for Geothermal Resource Development	Remarks
					Max. Surface Temp.(℃)	Possible Deep Fluid Temp. (C) (Geothermometer)	Max. Measured Temp. (℃)			
[illegible]	1	**Assal**	6 deep wells	FS	100	-	355	50-150	Appraisal Drilling	
	2	**Hanle**	2 deep wells & 3 shallow wells	Pre-FS	>60	118-260	124 (at 2020m in depth)	?	Detailed surface exploration & Well targeting	
	3	**Gaggade**	-	Pre-FS	>60	-	-	?	Detailed surface exploration & Well targeting	
	4	**N. of Ghoubhet**	-	Pre-FS	?	220	-	?	Detailed surface exploration & Well targeting	
	5	**Arta**	-	Re	75-95	?	-	?	Detailed surface exploration & Well targeting	
	6	**Ohock**	-	Re	-	210	-	?	Detailed surface exploration & Well targeting	
	7	**Lac Abhe**	-	Re	>90	?	-	?	Detailed surface exploration & Well targeting	Explored by IPP
	8	**Chevery**	Shallow TG well(s)	Re	-	-	-	?	Detailed surface exploration & Well targeting	150°C at 150m in depth
	9	**Inakir**	-	Re	-	-	-	?	Detailed surface exploration & Well targeting	Recommended from CERD

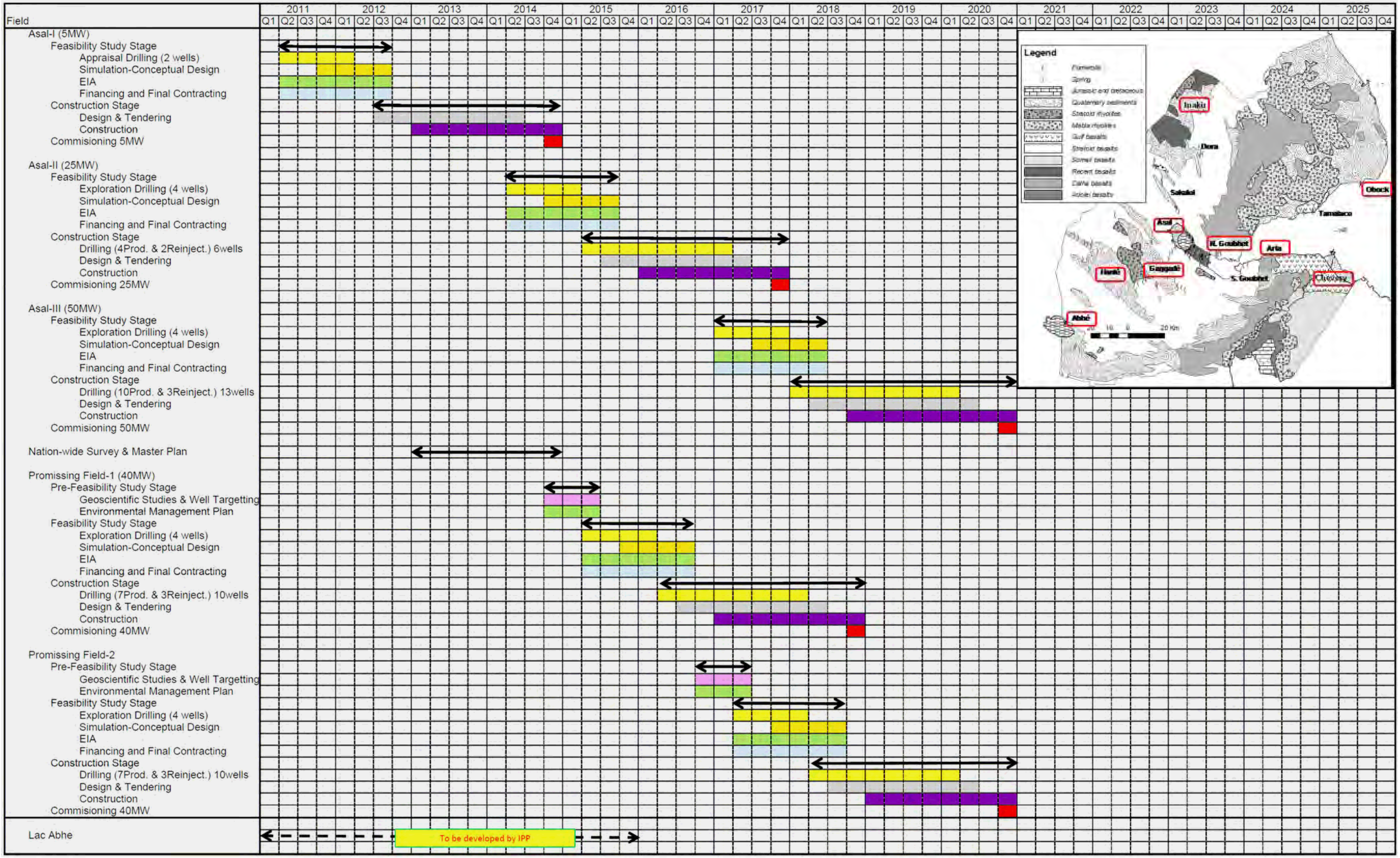


Fig.-11.4-1 Road Map for Djibouti

Table-11.4-2 Cost Estimates for Each Project (Djibouti)

(Unit: US$)

Description / Prospect	Unit Price	Asal-I Q'ty	Asal-I Cost	Asal-II Q'ty	Asal-II Cost	Asal-III Q'ty	Asal-III Cost	Promissing 1 Q'ty	Promissing 1 Cost	Promissing 2 Q'ty	Promissing 2 Cost	Total
1 Nation-wide Survey & Master Plan	2,000,000							1	**2,000,000**			**2,000,000**
2 Pre-Feasibility Study Stage	2,500,000							1	**2,500,000**	1	**2,500,000**	**5,000,000**
3 Feasibility Study Stage			**20,100,000**		**27,200,000**		**27,200,000**		**32,200,000**		**32,200,000**	**138,900,000**
Site Development (Land, Roads, Pad, Water Supply)	5,000,000	1	5,000,000					1	5,000,000	1	5,000,000	15,000,000
Exploration Drilling (by contractor)	6,000,000	2	12,000,000	4	24,000,000	4	24,000,000	4	24,000,000	4	24,000,000	108,000,000
Exploration Drilling (by own)	4,000,000											
Well Testing	50,000	2	100,000	4	200,000	4	200,000	4	200,000	4	200,000	900,000
Feasibility study & Design Concept	3,000,000	1	3,000,000	1	3,000,000	1	3,000,000	1	3,000,000	1	3,000,000	15,000,000
4 Construction Stage			**13,428,500**		**102,666,500**		**202,765,000**		**167,187,500**		**167,187,500**	**653,235,000**
Production drilling (by contractor)	6,000,000			4	24,000,000	10	60,000,000	7	42,000,000	7	42,000,000	168,000,000
Production drilling (by own)	4,000,000											
Reinjection drilling (by contractor)	4,500,000			2	9,000,000	3	13,500,000	3	13,500,000	3	13,500,000	49,500,000
Reinjection drilling (by own)	3,000,000											
Well Testing	50,000			4	200,000	10	500,000	7	350,000	7	350,000	1,400,000
Steam field development (450K per MW)	450,000	5	2,250,000	25	11,250,000	50	22,500,000	40	18,000,000	40	18,000,000	72,000,000
Turbine, generator, condenser, etc. (1500K per MW)	1,500,000	5	7,500,000	25	37,500,000			40	60,000,000	40	60,000,000	165,000,000
Turbine, generator, condenser, etc. (1300K per MW)	1,300,000					50	65,000,000					65,000,000
Civil Works (Power house, staff houses, roads)	560,000	5	2,800,000	25	14,000,000	50	28,000,000	40	22,400,000	40	22,400,000	89,600,000
Construction supervision and administration	(7%)		878,500		6,716,500		13,265,000		10,937,500		10,937,500	42,735,000
Total			**33,528,500**		**129,866,500**		**229,965,000**		**203,887,500**		**201,887,500**	**799,135,000**

11.5 Road Map for Tanzania

The development of around 100 MW of geothermal power is expected in Tanzania by 2025, as described in Chapter 10. The main geothermal data for each Tanzanian geothermal field is shown in Table-11.5-1. The most explored field in Tanzania is Mbeya, which has advanced to the Pre-FS stage through a collaboration with BGR. The Mbeya prospect is situated around Rungwe volcano in the southwest of Tanzania. Geological rock dating suggests that geothermal activity there started about 360,000 years ago, and many faults, fumaroles and hot springs are distributed widely. From the analysis of chemical thermometry of hot spring water, a geothermal reservoir with a temperature of 230^{o}C is thought to be present. Geophysical surface exploration by TEM has delineated the geological structural features of the shallow portion. No actual geothermal well drilling has been conducted in this prospect.

In the other prospects in Tanzania, geological/geochemical reconnaissance has been undertaken in prospects of Rukwa, Kisaki-Fujiji, Eyashi-Ngorongoro-Natron, and Dodoma-Singida-Kondoa, but these prospects need further advanced exploration. Among them, Natron is estimated from chemical analysis to host a high-temperature geothermal reservoir with a maximum temperature of over 270^{o}C. In addition, it is expected that the geothermal resource potential will increase once a nationwide survey has been carried out, since many geothermal manifestations are seen in Tanzania.

The proposed geothermal development road map until 2025 is shown in Fig.-11.5-1. Tanzania Electric Supply Corporation (TANESCO) has already given geothermal development priority to five (5) geothermal fields. The development road map presented in this report follows their priorities.

Development in the Mbeya prospect aims to set up a 30 MW power facility by 2015. A geophysical TEM survey has already been done, so it is suggested that an MT resistivity study should be done to target deep exploratory wells. After that, a conceptual design for plant facilities will be undertaken after four (4) deep wells have been drilled and resource evaluation reaches the FS stage. It will take around four and half (4-1/2) years to commission a plant, so FS activities should begin in the middle of 2012. The required financing for the 30 MW power plant construction is equivalent to around USD 157 million (refer to Table-11.5-2).

In order to achieve the expectations for the development of 100MW of geothermal energy in Tanzania by 2025, the remaining geothermal prospects (Rukwa, Kisaki-Rufiji, Eyashi-Ngorongoro-Natron, Dodoma-Singida –Kondoa and so on) should be explored and developed. However, there is little geothermal data for these remaining prospects, and the accuracy of the data is also low. Therefore, a nationwide survey of the whole national area is expected (refer to Fig.-11.5-1). A two-year regional study will be scheduled for 2012 and the promising prospects will be identified. The selected promising areas will be prioritized for exploration, drilling and finally construction in turn.

Although there are many geothermal manifestations in the Arusha area close to the Kenyan border and in the southwest portion of the country, there are hardly any reports about the geothermal resource potential. Due to insufficient exploration information, it seems that the correct geothermal potential has not been assessed for any of these prospects. A nationwide survey, followed by local detailed surface surveys and geothermal well drilling, will help to confirm the quantity of exploitable geothermal resources.

Table-11.5-1 Main Geothermal Data for Each Field (Tanzania and Uganda)

	No.	Field Name	Drilling Testing	Development Stage	Temperature: Max. Surface Temp.(°C)	Temperature: Possible Deep Fluid Temp. (°C) (Geothermometer)	Temperature: Max. Measured Temp. (°C)	Estimated Resource Potential (Mwe)	Task for Geothermal Resource Development	Remarks
Tanzania	1	**Mbeya (Songwe-Rungwe)**	-	Pre-FS	86	230	-	-	Detailed surface exploration & Well targeting	Explored by BGR
	2	**Rukwa**	-	Re	60	110	-	-	Detailed surface exploration & Well targeting	
	3	**Kisaki & Rufiji**	-	Re	75	-	-	-	Detailed surface exploration & Well targeting	
	4	**Eyasi - Ngorongoro – Natron**	-	Re	52	279	-	-	Detailed surface exploration & Well targeting	
	5	**Dodoma – Singida – Kondoa**	-	Re	47	210	-	-	Detailed surface exploration & Well targeting	
Uganda	1	**Buranga**	6 shallow TG wells	Pre-FS	98.3	120-150	-		Detailed surface exploration & Well targeting	Explored by BGR
	2	**Katwe-Kikorongo**	6 shallow TG wells	Pre-FS	70	140-200	-	-		Situated inside the Queen Elizabeth National Park
	3	**Kibiro**	6 shallow TG wells	Pre-FS	86.4	200-220	-	-	Detailed surface exploration & Well targeting	
	4	**Panymur**	Shallow TG well(s)	Re	-	-	-	-	Detailed surface exploration & Well targeting	Thermo-gradient: 80°C/km

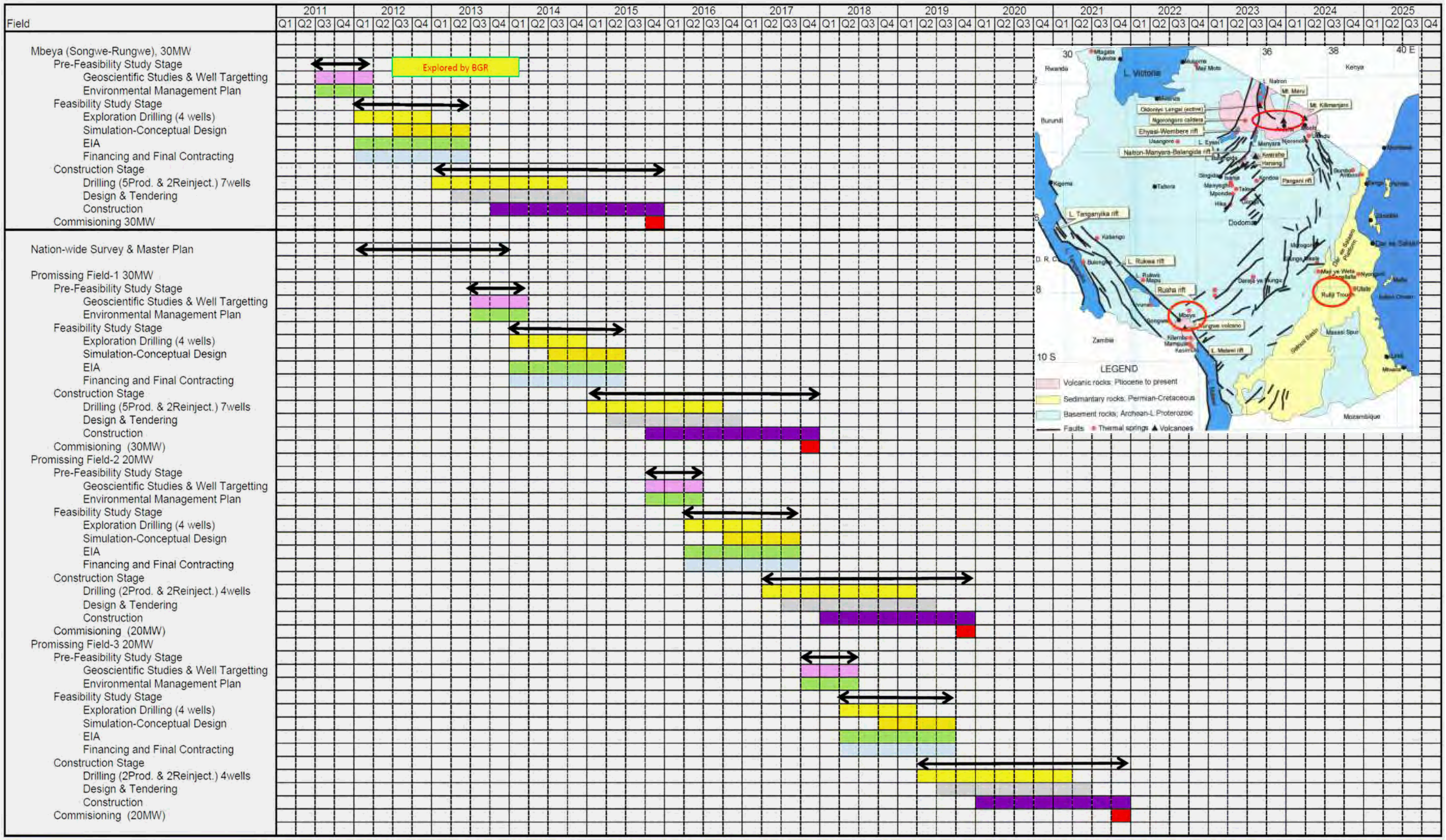


Fig.-11.5-1 Road Map for Tanzania

Table-11.5-2 Cost Estimates for Each Project (Tanzania)

(Unit: US$)

Description / Prospect	Unit Price	Mbeya Q'ty	Mbeya Cost	Promissing-1 Q'ty	Promissing-1 Cost	Promissing-2 Q'ty	Promissing-2 Cost	Promissing-3 Q'ty	Promissing-3 Cost	Total
1 Nation-wide Survey & Master Plan	2,000,000			1	**2,000,000**					**2,000,000**
2 Pre-Feasibility Study Stage	2,500,000	1	**2,500,000**	1	**2,500,000**	1	**2,500,000**	1	**2,500,000**	**10,000,000**
3 Feasibility Study Stage			**32,200,000**		**32,200,000**		**32,200,000**		**32,200,000**	**128,800,000**
Site Development (Land, Roads, Pad, Water Supply)	5,000,000	1	5,000,000	1	5,000,000	1	5,000,000	1	5,000,000	20,000,000
Exploration Drilling (by contractor	6,000,000	4	24,000,000	4	24,000,000	4	24,000,000	4	24,000,000	96,000,000
Exploration Drilling (by own	4,000,000									
Well Testing	50,000	4	200,000	4	200,000	4	200,000	4	200,000	800,000
Feasibility study & Design Concept	3,000,000	1	3,000,000	1	3,000,000	1	3,000,000	1	3,000,000	12,000,000
4 Construction Stage			**122,568,500**		**122,568,500**		**76,291,000**		**76,291,000**	**397,719,000**
Production drilling (by contractor	6,000,000	5	30,000,000	5	30,000,000	2	12,000,000	2	12,000,000	84,000,000
Production drilling (by own	4,000,000									
Reinjection drilling (by contractor	4,500,000	2	9,000,000	2	9,000,000	2	9,000,000	2	9,000,000	36,000,000
Reinjection drilling (by own	3,000,000									
Well Testing	50,000	5	250,000	5	250,000	2	100,000	2	100,000	700,000
Steam field development (450K per MW	450,000	30	13,500,000	30	13,500,000	20	9,000,000	20	9,000,000	45,000,000
Turbine, generator, condenser, etc. (1500K per MW)	1,500,000	30	45,000,000	30	45,000,000	20	30,000,000	20	30,000,000	150,000,000
Turbine, generator, condenser, etc. (1300K per MW)	1,300,000									
Civil Works (Power house, staff houses, roads)	560,000	30	16,800,000	30	16,800,000	20	11,200,000	20	11,200,000	56,000,000
Construction supervision and administration	(7%)		8,018,500		8,018,500		4,991,000		4,991,000	26,019,000
Total			**157,268,500**		**159,268,500**		**110,991,000**		**110,991,000**	**538,519,000**

11.6 Road Map for Uganda

Around 70-90MW of geothermal power development is expected in Uganda by 2025. The main geothermal data for each Ugandan geothermal field is shown in Table-11.5-1. Three (3) geothermal prospects, Katwe, Kibiro and Buranga, already reached the Pre-FS exploration stage. Among these three prospects, Katwe and Kibiro were explored with the support of ICEIDA of Iceland, and Buranga with the support of BGR of Germany. The Katwe prospect is reported as not suitable for power generation from the geochemical analysis (Arnarson and Gislason, 2009). On the other hand, good geothermometry data for the Kibiro prospect shows that the geothermal reservoir temperature is likely to be higher than 200°C. In the Kibiro prospect, a geophysical survey (MT survey) is necessary for well targeting. For the Buranga prospect, being carried out by BGR, an MT/TEM and microearthquake survey are needed to collect further detailed information. In the conclusion of the BGR report, the introduction of a grant finance scheme sponsored by KfW of Germany and access to the risk mitigation fund (RMF) of ARGeo are recommended to enable the drilling of two or three exploratory wells (BGR and KfW, 2,010 and Witte, 2010). In addition, on the basis of information derived from oil well drilling, the Ugandan Department of Geological Survey and Mines (DGSM) has shown interest in the Panyimur prospect as a new promising area. Since many geothermal manifestations are seen in Uganda, an increase in the anticipated geothermal resource potential is expected following a nationwide survey

The proposed geothermal development road map until 2025 is shown in Fig.-11.6-1.

Development of the Kibiro prospect aims towards the construction of a 30 MW power plant by 2015. Since the field is still in the Pre-FS stage, and the underground geological structures are unknown, an MT resistivity study should be carried out to for target deep exploratory wells. After that, a conceptual design for plant facilities will be undertaken after four (4) deep wells are drilled and resource evaluation reaches the FS stage. It will take around four and half (4½) years to commission a plant, so FS activities should begin in the middle of 2011. The required financing for the 30 MW power plant construction is equivalent to around USD 157 million (refer to Table-11.6-1).

For the Buranga development, the proposed road map schedules the start of the geophysical surface survey for one year after the commencement of the Kibiro development, and the 30 MW power plant should be commissioned in late 2016.

In order to realize the expectations for geothermal power in Uganda, the rest of the geothermal prospects (Panyimur and others) should be explored and developed. However, there is little geothermal data for the remaining fields, and the accuracy of the data is also low. Therefore, a nationwide survey of the whole national area is expected (refer to Fig.-11.6-1). A two-year regional study will be scheduled for 2012 and the promising prospects will be identified. The selected promising areas will be prioritized for exploration, drilling and finally construction in turn.

Although many geothermal manifestations occur around Albert Lake and Edward Lake in the western portion of Uganda, there are hardly any reports about the geothermal resource potential there. Due to the lack of exploration information, it seems that the correct geothermal potential has not been determined for the various fields. A nationwide survey, followed by local detailed surface surveys and geothermal well drilling, will help to confirm the quantity of exploitable geothermal resources.

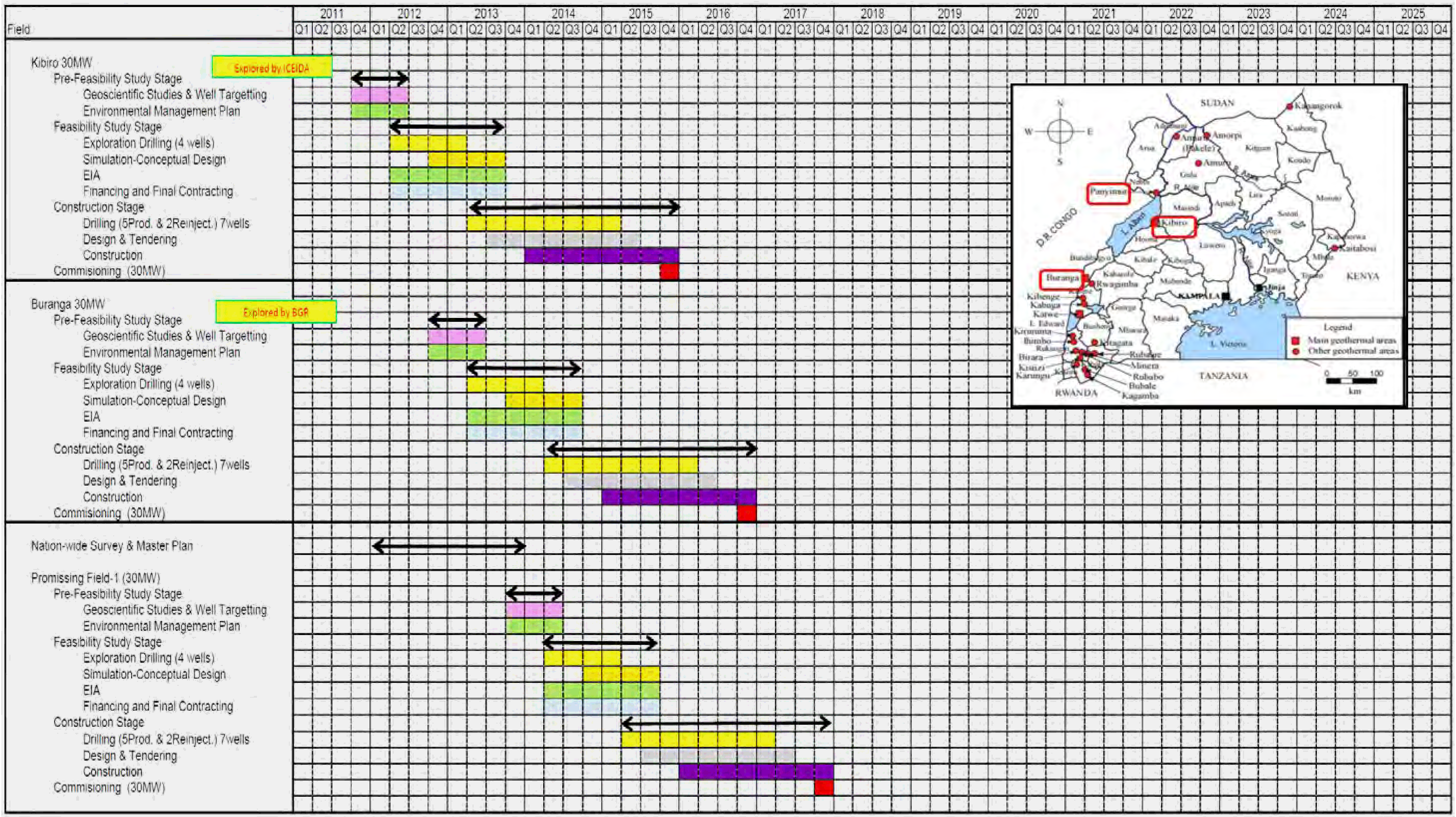


Fig.-11.6-1 Road Map for Uganda

Table-11.6-1 Cost Estimates for Each Project (Uganda)

(Unit: US$)

Description / Prospect	Unit Price	Kibiro Q'ty	Kibiro Cost	Buranga Q'ty	Buranga Cost	Promissing-1 Q'ty	Promissing-1 Cost	Total
1 Nation-wide Survey & Master Plan	2,000,000					1	**2,000,000**	**2,000,000**
2 Pre-Feasibility Study Stage	2,500,000	1	**2,500,000**	1	**2,500,000**	1	**2,500,000**	**7,500,000**
3 Feasibility Study Stage			**32,200,000**		**32,200,000**		**32,200,000**	**96,600,000**
Site Development (Land, Roads, Pad, Water Supply	5,000,000	1	5,000,000	1	5,000,000	1	5,000,000	15,000,000
Exploration Drilling (by contractor)	6,000,000	4	24,000,000	4	24,000,000	4	24,000,000	72,000,000
Exploration Drilling (by own)	4,000,000							
Well Testing	50,000	4	200,000	4	200,000	4	200,000	600,000
Feasibility study & Design Concep	3,000,000	1	3,000,000	1	3,000,000	1	3,000,000	9,000,000
4 Construction Stage			**122,568,500**		**122,568,500**		**122,568,500**	**367,705,500**
Production drilling (by contractor)	6,000,000	5	30,000,000	5	30,000,000	5	30,000,000	90,000,000
Production drilling (by own)	4,000,000							
Reinjection drilling (by contractor)	4,500,000	2	9,000,000	2	9,000,000	2	9,000,000	27,000,000
Reinjection drilling (by own)	3,000,000							
Well Testing	50,000	5	250,000	5	250,000	5	250,000	750,000
Steam field development (450K per MW	450,000	30	13,500,000	30	13,500,000	30	13,500,000	40,500,000
Turbine, generator, condenser, etc. (1500K per MW)	1,500,000	30	45,000,000	30	45,000,000	30	45,000,000	135,000,000
Turbine, generator, condenser, etc. (1300K per MW)	1,300,000							
Civil Works (Power house, staff houses, roads)	560,000	30	16,800,000	30	16,800,000	30	16,800,000	50,400,000
Construction supervision and administration	(7%)		8,018,500		8,018,500		8,018,500	24,055,500
Total			**157,268,500**		**157,268,500**		**159,268,500**	**473,805,500**

Chapter 12 The Importance of the Governmental Leading Role

12.1 Introduction

This chapter discusses how each government can proceed to achieve its geothermal energy exploitation goals following the Road Maps elaborated in chapter 11. The Study team believes that the most important issue is the governmental role. In many countries around the world where geothermal energy is being developed, the government is playing an important role in promoting it. The governments in the East African Rift region should play a similar leading role as well. It is true that the governments in this region face financial difficulties and, therefore, it is understandable that they have a temptation to entrust geothermal development to private Independent Power Providers (IPPs). However, it may be very difficult to expect the participation of IPPs from the early stage of geothermal development. So far, since these governments liberalized the power generation sector about two decades ago, the pace of private IPP participation in the geothermal market has been slower than the governments expected. Only in Kenya has a single IPP come into the market. It should be possible to entrust geothermal development to IPPs in later stages of development, when geothermal development has become very popular. However, in a situation where geothermal exploitation is just starting, as in most of the East African Rift countries, the Study Team believes that the governments should take much greater leading role in this development. This is the conclusion prompted by analysis of the barriers to geothermal energy development discussed below.

12.2 Barriers to Geothermal Energy Development

Although geothermal energy has the many attractive characteristics mentioned in Chapter 2, its development has not advanced well in many countries, even in countries such as the Philippines and Indonesia, which have abundant geothermal resources. Why is this the case? There are two major barriers that affect geothermal development. They are the problem of the "development risks of underground resources" and the "burdensome requirement for a large up-front investment". The problem of the "development risks of underground resources" is that geothermal power plants are site-specific and that there is no standard specification for a power plant. Modern surface technology has progressed considerably, but even today surface exploration technology cannot predict either the exact depth of reservoir or the exact steam output from drilled wells. Accurate values are not obtained until production wells are drilled. Therefore, the risks of geothermal power development are so large that only enterprises which have a strong appetite for risk can undertake such business. The problem of the "burdensome requirement for a large up-front investment" arises because geothermal development entails a large amount of exploration costs paid out over a long development lead time during which time the money invested does not produce profits. Therefore participation in geothermal development is limited only to enterprises that have a strong financial base and long-term investment strategy.

These issues are ones that even advanced countries face in their geothermal energy development process. And geothermal energy development in Africa faces a variety of additional problems, such as a weaker technological base, a lesser availability of development capital, a less favorable investment environment, and so on. These circumstances make the challenge of geothermal development even more difficult for Africa.

12.3 Comprehensive National Capability towards Geothermal Energy Development

The Study Team believes that the existence of geothermal resources is insufficient to ensure their successful development. There are additional, essential factors to consider before a society can enjoy the effective exploitation of geothermal energy.

The factors that the Study Team puts special stress on are shown in Fig.-12.3-1. They are; (a) Technology, (b) Development financing, and (c) Commitment of the government (the will of the government). The existence of geothermal resources is merely one of the preconditions of success. In order to develop geothermal resources, technology and development financing are necessary. And the most important factor is a strong will or commitment on the part of the government to exploit geothermal energy.

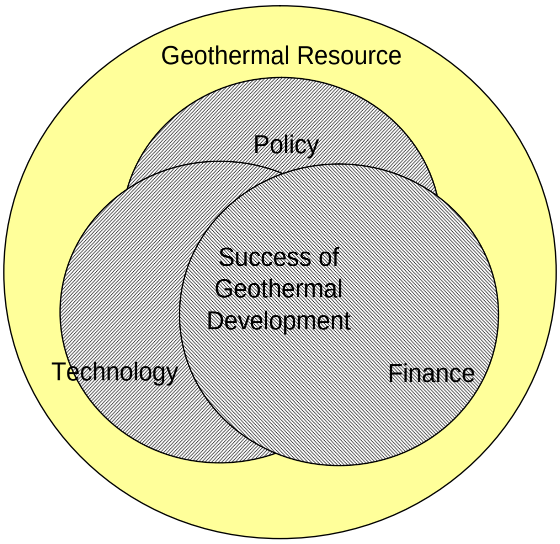


Fig.-12.3-1 Key Factors of Successful Geothermal Development

Let us consider the technology factor first. Geothermal development requires various kinds of technology: exploration technology, steam development technology, power generation technology, and operation and maintenance technology. Exploration technology consists of technologies such as those enabling geological surveys, geophysical surveys, geochemical surveys and so on. Steam development technology involves various technologies associated with well drilling, reservoir evaluation, the design and construction engineering of steam production facilities and so on. Power generation technology includes engineering technology for the design, manufacture and construction of power plants. And operation and maintenance technology for power plants is also critical. Although heavy electric machinery such as steam turbines and generators can be imported, exploration technology and development technology should be available within the country.

It is necessary for a country that desires geothermal development to have a certain level of these technologies readily available within the country. In this respect, one factor the Study Team is especially paying attention to is whether or not there is a core geothermal development organization that acts as an incubator for local expertise and technology. Such a core organization functions as the recipient of technology that is introduced from advanced countries during the initial stage. In a second stage, the introduced technology is digested, accumulated and localized within the core organization. Through a repetition of this process of assimilation, the core organization finally acquires enough technology to compete with advanced countries at least as in the development of its domestic resources. This is a common development pattern that can be seen in several countries that have succeeded in acquiring advanced technology. In addition, these acquired technologies spill over from the core geothermal organization into the local market to form an integrated geothermal-related industry within the country. Such a core organization exists in some countries where geothermal development is very active. The Commission Federal of Electricity (CFE), an electric power corporation in Mexico, and the Philippine National Oil Corporation (PNOC) of the Philippines are examples of such a core organization. Pertamina Geothermal Energy Corporation (PGE) of Indonesia and Geothermal Development Company (GDC) of Kenya are increasingly following this successful pattern, too. In this way, the key factor in the success of geothermal development is ultimately whether a country can establish a core organization within the country that will grow as development progresses.

The issue of the development financing is also a key factor. Geothermal power plants, although they do not incur fuel expenses every single day of operation, require a large initial investment. For instance, the development of a 50 MW class geothermal power plant usually requires some USD 150 million or more in capital investment. How to procure this large amount of capital is always a big problem for developers. Although everyone admits that private capital is an appropriate source of funds, it is not easy to mobilize private capital for geothermal development because geothermal development faces the twin barriers of development risk and the large up-front investment required. Therefore, in order to mobilize private capital for geothermal development, incentives such as low-interest rate loans should be offered by governments, even in advanced countries. From this point of view, it is not an appropriate policy for developing countries to entrust geothermal development to the hands of private investors from the beginning. It is advisable that the government execute initial surveys with several exploration wells drilled to reduce initial risks so that private companies have a better chance of success in the development. In developing countries, where sources of capital are scarce, such a policy of government invovlement in initial exploration is definitely necessary, and to realize this, strong support in the form of grant aid or low interest rate loans from donor agencies is also necessary.

Regarding the importance of the government’s commitment, or the importance of an appropriate energy policy that embodies the governmental commitment, the Study team’s view is as follows. Geothermal energy development suffers from the barriers of the "development risk of underground resources" and the "burdensome requirement for large up-front capital investment ", as already mentioned. These are high barriers for private companies wanting to participate in the geothermal business, as already described in Section 2.3. The Study Team believes that a powerful countermeasure mitigating this problem is for the government to provide appropriate incentives. The government should help private companies solve the problem by providing appropriate incentives, such as tax incentives, fiscal incentives, or financial incentives. However, implementing these incentives carries its own costs. Therefore, the question is whether it is worthwhile bearing the cost of these incentives or not. A study of Indonesia shows that the benefits to the government from geothermal development exceed the costs of the incentives in various incentive schemes (JICA 2009). The reason for this is that geothermal energy substitutes for the use of domestic fossil fuels, which are then available to export, improving the country’s balance of international payments. A part of this improved balance of international payments also improves the government’s balance of income and expenditure. The effect on governmental income exceeds the incentive costs, if oil and coal prices are as high as they are these days. Therefore, it is very reasonable for the government to support geothermal development by offering these incentives. Moreover, "existence of a strong governmental will” is pointed out as a key factor in the success of geothermal development in such countries as Japan, the Philippines, Indonesia, and the Central American countries where case studies have been conducted by the World Bank (World Bank（2004）).

Therefore, the Study team believes that "technology", "development funding", and a "strong commitment of the government" are absolutely crucial keys to the geothermal development of Africa.

12.4 Measures to mitigate large up-front investment costs

This section discusses the barriers to geothermal energy development in depth. First, let us consider the problem of "the burdensome requirement for a large up-front investment." When private companies carry out power generation as IPPs, they do not sell power at the cost of power generation. The companies sell power at a price which allows them to secure a return on their investment after taxes on the business are paid (Fig.12.4-1)[1]. In this case, the return on investment depends on how much the respective IPP companies require as their expected rate of return. In other words, the selling price of power is a function of the company’s expected rate of return, and the selling price of power rises as IPP companies require higher returns, and thus the function is represented by an upward-sloping curve (Fig.-12.4-2).

For geothermal power generation, the development lead time from the initial survey to the start of operation is very long, and the up-front investment required is extremely large in comparison to thermal power generation. For this reason, the selling price of geothermally generated power is represented by a steep upward-sloping curve relative to the expected rate of return (red bar graph in Fig.12.4-2). On the other hand, the selling price of thermally generated power, which requires only a

[1] The depreciation cost portion of the power generation cost is also added to the return on investment.

small amount of up-front investment and a short development lead time, is represented by a gently sloping curve (blue bar graph in Fig.-12.4-2. (The graph presents an example of natural gas combined power generation.).

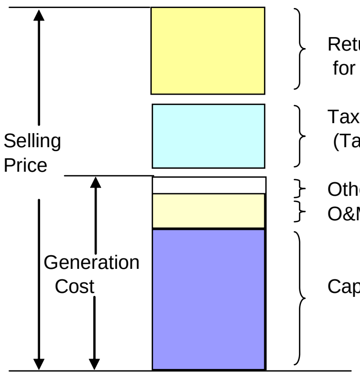
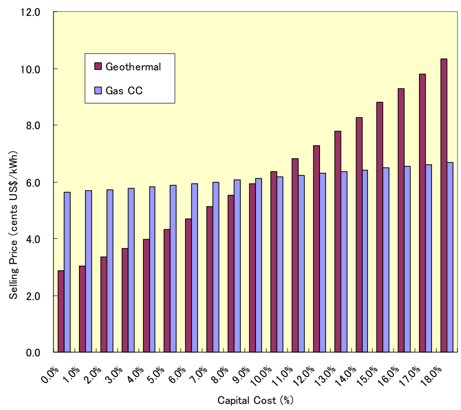


Fig.12.4-1 Makeup of the selling price of power



(Source: JICA (2007))

Fig.12.4-2 Relationship between the return on investment for the project and the selling price of power

Comparison of the two bar graphs shows that:

(i) The selling price of geothermal power and thermal power are approximately the same when the cost of capital is around of 10%– 12%.

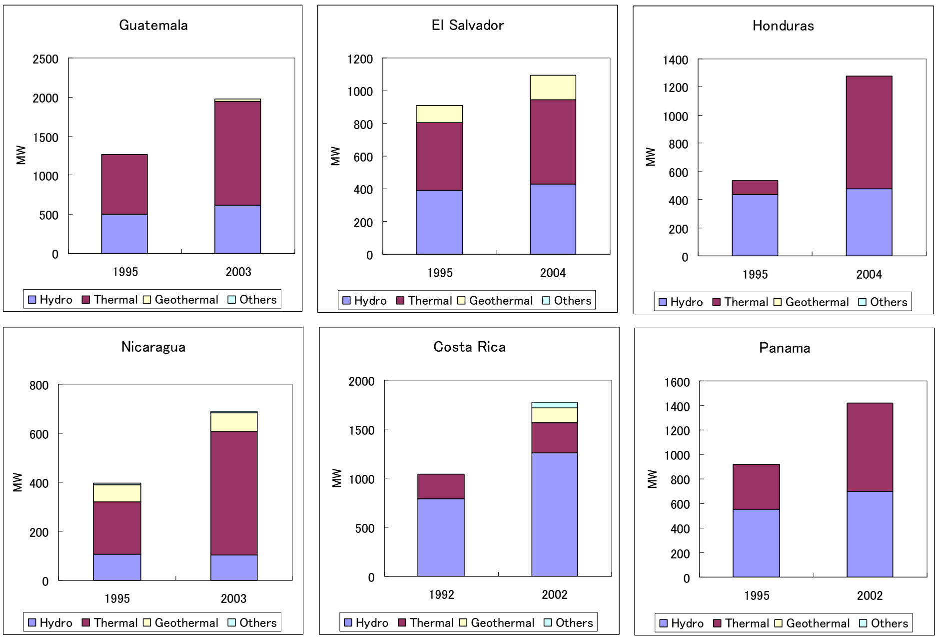
(ii) The selling price of geothermal power exceeds that of thermal power in an area where the cost of capital is higher than 12%.

(iii) The selling price of geothermal power falls below that of thermal power in an area where the cost of capital is lower than 10%.

In many countries, the cost of capital for a government-run power company is often about 10%-12%. On the other hand, the cost of capital is equivalent to the expected rate of return for private IPP companies, and it is often 15% or more. Therefore, Fig.12.4-2 can be interpreted as follows.

(i) For companies which consider their cost of capital to be about 12% (for example, a government-run power company), both geothermal power generation and thermal power generation have the same economic value.

(ii) Companies which require an expected rate of return of 15% or more (i.e. private IPP companies), consider geothermal power generation to be a high-cost power source, and thermal power generation to be a low-cost source. Therefore, if the other conditions are the same, private companies will move toward low-cost thermal power generation and will avoid geothermal power generation.



(Source: Study Team compiled from JEPIC data)

Fig.12.4-3 Change in sources of power generation in six Central American countries

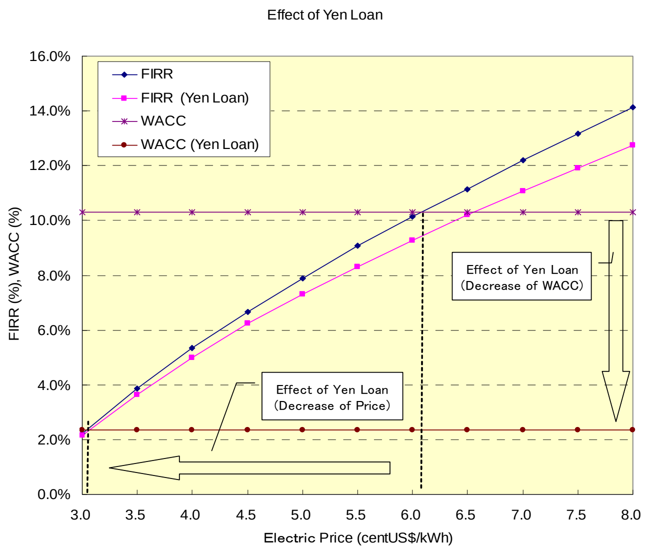
Because of consideration (ii), if the power generation business is entrusted to private IPPs and government takes no measures, a shift to thermal power generation will occur. Fig.12.4-3 shows the composition of power sources in the mid-90s and mid-2000s for Central American countries. Five countries - with the exception of Costa Rica - adopted a policy of entrusting the power generation business to private IPPs. As a result, the share of thermal power increased in these countries. On the other hand, Costa Rica alone maintained a government-run power company system. As a result, power sources have been diversified only in Costa Rica (Fig.12.4-3, bottom center).

Furthermore, the fact that geothermal power generation is cheaper than thermal power generation in an area where the cost of capital is lower than 10% means the following:

(iii) If low-cost funds can be provided for the construction of geothermal power plants, less expensive power sources than thermal power generation can be exploited.

As described above, power sources which require large up-front investment cannot be expected to be developed using high-cost money like that available to private companies. On the other hand, if low-cost capital can be provided to a geothermal project, it will transform geothermal plants into an inexpensive power source. Therefore, one of important roles of the government is to provide low-cost capital to private geothermal investors through governmental banking institution channels. For example, in Japan, the Japan Development Bank, a governmental banking institution for investment, provides low-interest, long-term loans to geothermal projects. This kind of financing scheme would be desirable also in East African counties to attract the private sector to enter the geothermal energy market.

In addition, when a state-run company like GDC in Kenya develops geothermal energy, ODA financing plays a very effective role. Fig.-12.4-4 shows the reduction in selling-price when a geothermal project uses Yen Loan finance. Since the interest rate of the Yen Loan is very low, it reduces the selling price of geothermal energy remarkably.



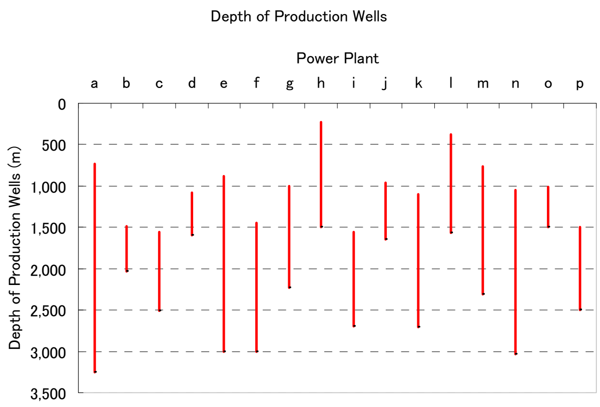
(Source: JICA（2007）)

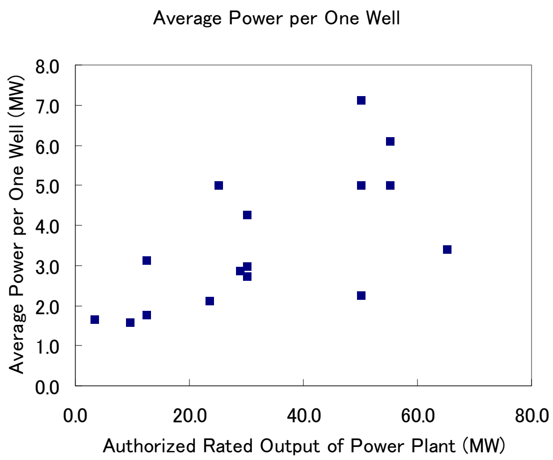
Fig.-12.4-4 Selling-price reduction effect by Yen Loan in geothermal plant

From the above considerations, the Study Team concludes that the governmental role in the short-term should be to utilize ODA financing for state-run geothermal developers and its role in long-term should be to establish a governmental banking mechanism to provide private geothermal IPPs with low interest rate financing.

12.5 Measures to mitigate resource development risks

The second barrier to developing geothermal energy is "resource development risks." Since geothermal energy is site-specific, its development involves various risks.



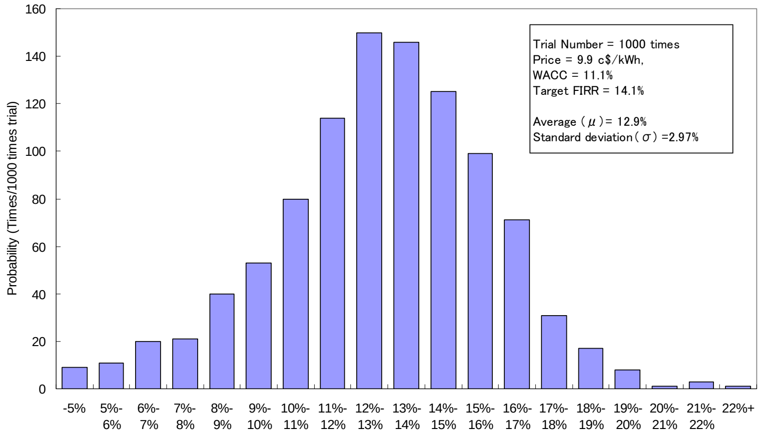


(Source: "Geothermal Development Master Plan Study in Indonesia" (JICA))

Fig.-12.5-1 Distribution of production well depth of geothermal power plants in Japan

Fig.-12.5-2 Distribution of productivity of geothermal power plants in Japan

For example, Fig.-12.5-1 shows the distribution of production well depths for geothermal power plants in Japan, and Fig.-12.5-2 shows the distribution of average production capacity per well. The depth of production wells and the average production capacity are critical values in the design of a geothermal power plant, and business profitability depends largely on these values. Fig.-12.5-1 and Fig.-12.5.2 both show that these numbers differ according to project site. The design of a geothermal power plant involves many unknown factors in addition to these values on which profitability largely depends, and the fate of a geothermal project depends on these factors, which become clear only after actual development is completed.



(Source: JICA（2009）)

Fig.-12.5-3 Profitability density curve of geothermal project

In corporate management theory, risk is defined by the width of fluctuating range of profitability for various potential situations. Fig.-12.5-3 shows that risk in geothermal projects is very large. There is a clear difference from the coal-fired power business, where the largest risk factor is a rise in coal prices in the future. However, in the coal-fired IPP business, even if coal prices rise during the operating period, the IPP usually does not bear the rise in cost, and is allowed to add on this price rise to the selling price of power in a practice called “Pass through.” Given this ability to “pass through” rising costs, there is almost no risk involved in the coal-fired power business, and the IPPs can always obtain almost the same profitability as that expected in the early planning stages. In contrast to this, uncertainty in a geothermal project is remarkably larger. This inhibits private companies from undertaking geothermal projects. Therefore, in order to promote geothermal energy development, government should provide some risk mitigation measures.

There is a variety of risk mitigation measures.

(a) Risk Premiums

One of the measures taken to address these risks is to a add risk premium onto the purchase price of geothermal energy. This risk premium helps the project to maintain some economical viability, even if project profitability not as good as planned. In short, this measure aims to offset risks with rewards. Although the specific level of risk premium needs further detailed consideration, this measure is deemed to be effective in practice. Feed in Tariffs (FIT) that set a high purchase price for geothermal energy fall into this category.

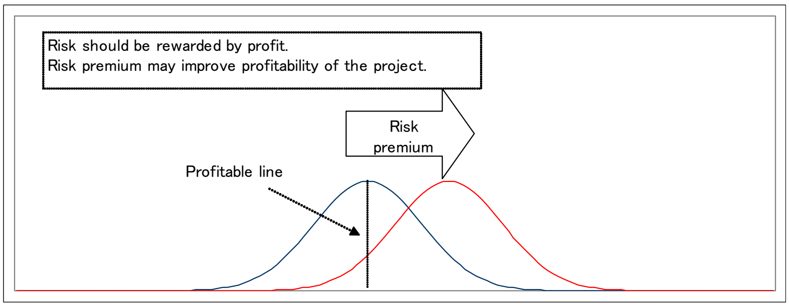


Fig.-12.5-4 Risk Premium

(b) Risk mitigation through initial survey by government

The level of risk which private investors can take is limited. Therefore, an entity that can bear greater risk, i.e., the government, is expected to take responsibility for the initial surveys to reduce the resource development risk. Many developers simply refuse to bear the green-field risks of geothermal development. Therefore, the involvement of a government body in the early stage to develop a green-field to brown-field status is effective in attracting more investors to geothermal IPP projects.

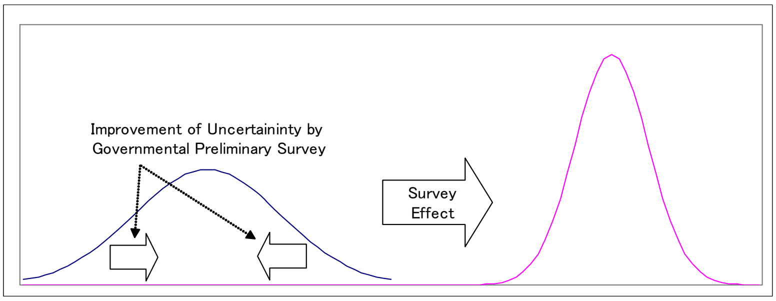


Fig.-12.5-5 Risk mitigation through initial survey by the government

Thus, several different measures can be considered to mitigate geothermal business risks. However, the Study team believes that the governmental initial survey is the most effective of all these risk mitigation measures. The risk premium measure is realized as an FIT pricing system. Among the countries of the East African Rift region, Kenya already has an FIT system, and Ethiopia and Uganda are working on their own systems now. However, the FIT prices for geothermal energy are not actually attractive enough to motivate many private IPPs to participate in geothermal market. The concessions for geothermal exploration in two fields in Kenya were given to two private companies[2]. However, actual exploration by these companies has progressed very little to date. In addition, it has also been reported that a big difference exists between what customers will be willing to pay for geothermal energy and what producers are willing to it sell for in the Asal project in Djibouti. Because of this

2 The license of Longonot field was given to AGIL and the license of Suswa field was given to WalAm, a Canadian company.

price gap, agreement concerning the project between a private company and the government has not yet been reached. These examples are revealing concerning the difficulty of having private companies participate in the geothermal market. Therefore, the Study Team believes that direct governmental involvement in geothermal development is necessary.

It is worth while noting that any risk mitigation measures require governmental will and policy, and incur costs. Since the governments in the African region have little money for this purpose, the assistance of donors can play very important role in effecting these risk mitigation measures.

12.6 Enhancing National Capability to Develop Geothermal Energy

The Study Team thinks that there are three stages of development in the geothermal development process in a country. Fig.-12.6-1 shows a model of the process of infiltration of renewable energy into a commercial market. This process can also be applied to the growth of geothermal energy. The upper part of Fig.-12.6-1 indicates the infiltration of geothermal energy into the energy market. This infiltration can be divided into three phases: Phase-I, Phase-II and Phase-III. The lower part of Fig.-12.6-1 shows the degree of the government support. Phase-I is a market introduction stage. In this stage, considerable governmental support is necessary so that geothermal energy can begin to appear in the energy market. However, once infiltration acquires a momentum, the infiltration grows rapidly (point B). This is because accumulated experience produces a learning effect and the learning effect works to reduce the cost of geothermal development. Thus the infiltration of geothermal energy into the market expands rapidly in Phase-II, the market infiltration period. Once this movement starts, the learning effect reduces costs, and the reduction in costs invites next movement. This virtuous cycle produces a new technological basis in a country, which then accelerates further investment. This growth maintains its autonomous development, even if the government gradually decreases its support. As a result, the infiltration arrives at the stage where development continues (point C) without governmental support (Phase-III; continued development period).

The infiltration of geothermal energy into the energy market faces difficulties even in advanced countries such as Japan. The reason is that there are barriers to development, as already described in Section 12.4 and 12.5. Therefore, geothermal development requires an appropriate energy policy on the part of the government. The Study

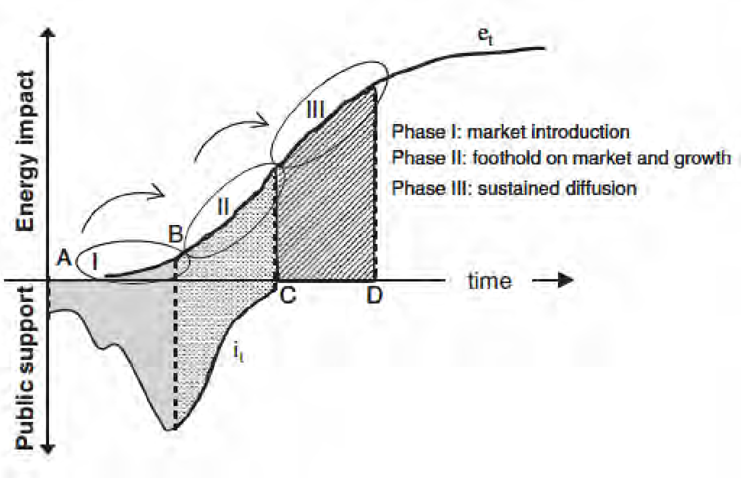


Fig.-12.6-1 Renewable Energy Growth Process and Governmental Support (Lund (2007))

Team believes that the infiltration would shift rapidly to Phase-III if high energy prices, with the oil price exceeding USD 100 per barrel as in 2008, become the future norm. However, the Study team would say that under today's conditions infiltration is in the latter half of Phase-II, even in Japan. In Indonesia, where private geothermal investment has become active recently, the Study Team would say infiltration is in the latter half of Phase-I. Among the East African Rift System countries, Kenya is leading in geothermal exploitation, but it is still thought that the geothermal energy infiltration into the energy market in Kenya is in the latter half of Phase-I, like Indonesia. As for the other countries, geothermal development remains almost at the starting point (point A). Therefore, considerable government support is necessary to get geothermal development started in each country. However, many African governments sufficient sources of capital. Therefore, Official Development Assistance (ODA) from development partners is expected to play an important role in the promotion of geothermal development in Africa.

12.7 The Desired Growth Process of Geothermal Development Structure

Given the view of the general development process described in the Section 12.6, it is premature to expect private IPP participation in the geothermal market in Africa from the early stage. It would be wise for governments to establish a structure lead by the government initiative. By accumulating experience and tangible results through this structure, the participation of private companies can be encouraged gradually (Fig.-12.7-1).

The reasons the Study team emphasizes the importance of governmental initiative are as follows.

(1) The basic infrastructure in Africa is not yet well developed. The legislation system that governs foreign investment is not well developed either. These insufficient physical and legal infrastructures create an unfavorable environment for foreign investment. Since geothermal has other big risks, such as resource development risks, it is rather difficult for private IPPs to invest in geothermal projects that need a large amount of initial investment from the beginning.

(2) The resource risks of geothermal projects are very large, as described in Section 12.4. Therefore the participation of private IPPs in the geothermal market is not well-advanced even in industrialized countries unless there are some risk mitigation measures in place for the development of "green fields" (regions where exploration wells have not been drilled yet). In Japan as well, initial surveying in green fields is a responsibility of the government.

(3) In order to promote geothermal exploitation, it is necessary to foster geothermal technology within the local market. For this purpose, it is necessary to foster a "local champion" within the country ,as described in Section 12.2. It is also necessary to promote technology spillover from the local champion to the broader local industry to enhance the technology level from the bottom up. For this, a strategy that fosters a local champion rather than one that depends on overseas IPPs is necessary. In realizing this strategy, the governmental role is indispensable.

Kenya has already noticed these points, and has been elaborating a geothermal development system in which the government takes a leading role. For example, steam development in the initial stage was carried out by KenGen, but the budget was provided by the government and the responsibility was also in the hands of the government. After the project became bankable, KenGen took responsibility for developing steam and a power station as a business entity. The failed exploration wells remained on the government account. The Kenyan government recently established a state-run company, Geothermal Development Company (GDC), and entrusted steam development to this special purpose company which will sell steam to many developers, including KenGen. This government-led system in Kenya has functioned very well up to now, and Kenya is a front runner in geothermal development in Africa. Other African governments should emulate this successful "Kenyan Model" of geothermal energy development for Africa.

The system that the Study Team thinks appropriate for African countries (other than Kenya) is as follows:

(i) The first stage: the initial surveys are done by the Geological Survey of each country backed by a sufficient budget from the government. The surveys should include drilling several exploration wells. (If capital support and technical assistance is needed, donor agencies are expected to respond to the need.)

(ii) The second stage: the full-scale development stage is carried out by a state-run power company. This is necessary because such a development project is too complicated for a research-oriented body such as geological survey to handle. The power company should establish a geothermal department and acquire enough skilled workers including through the transfer of engineers from the geological survey, if necessary. The power company can rely on ODA financing and technical assistance from donor agencies. In this stage, surveys up to appraisal drilling should be done as a responsibility of the government. That is, the government should bear the survey costs and risks.

(iii) The third stage: as a variation of the above-mentioned formala, a state-run special purpose company to develop steam fields could be established. The construction of power plants could be done either by a state power company or by private IPPs.

(iv) The fourth stage: when enough experience is accumulated through IPP participation in the third stage, it is an option to narrow the activities of the state-run steam development company and to expand the activities of private IPPs to include resource evaluation surveys.

(v) The fifth stage: it is an option to privatize the state-run steam development company through an Initial Public Offering (IPO). With this measure, the development system is transformed into a full-fledged private initiative structure.

It is predicted that the country can accumulate geothermal technology and experience in geothermal development through these processes. This accumulation leads to more effective development through the learning effect. The participation of private IPPs can be realized gradually through this process in which people involved in the domestic industry also acquire experience and expertise related to geothermal. In this way, a technological base will be gradually formed in the country.

Kenya is currently in the third stage of this development process. The other four countries should follow the Kenyan Model and should draw up a development strategy while carrying out resource surveys.

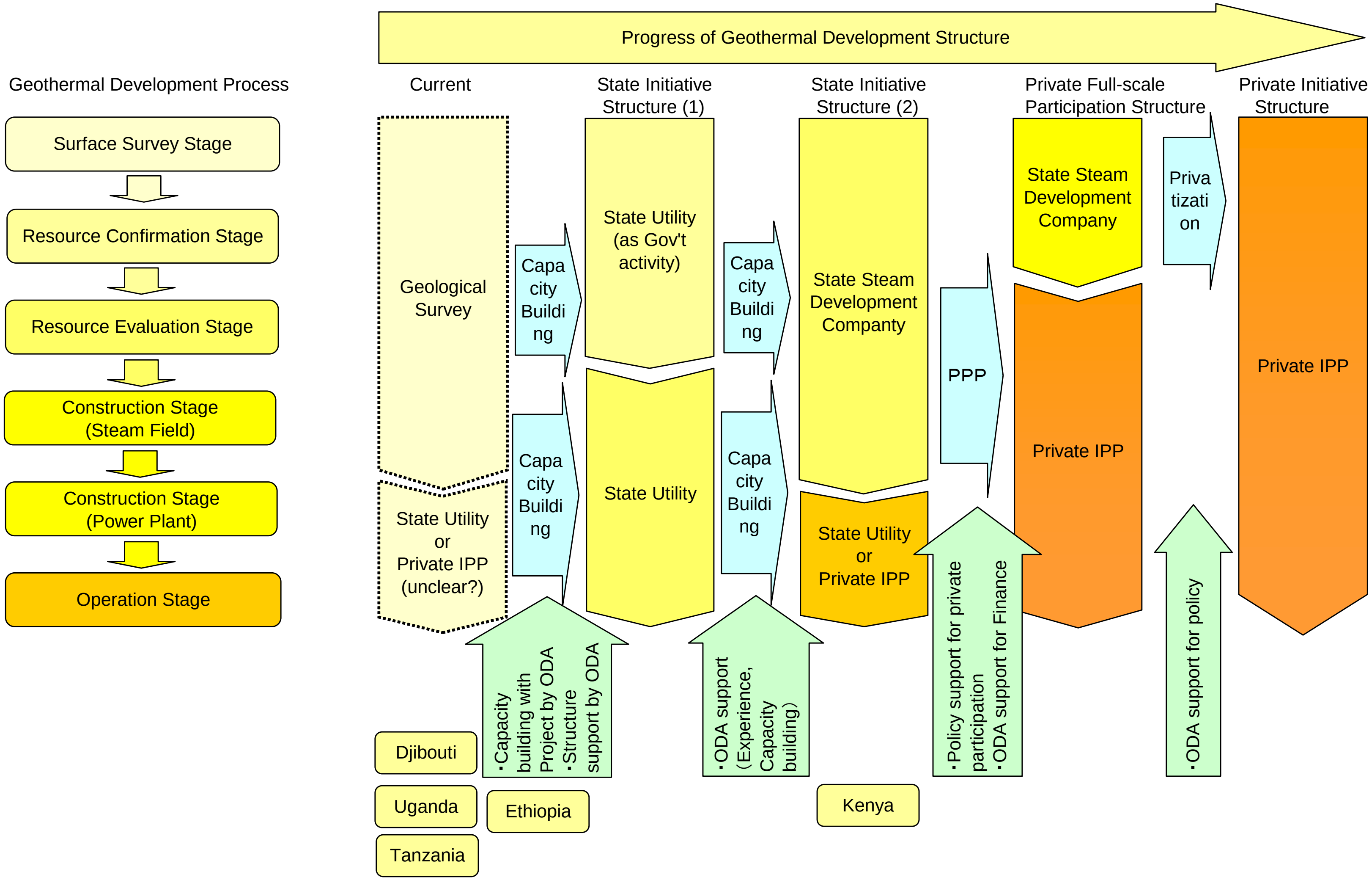


Fig.-12.7-1 The Desired Growth Process of Geothermal Development Structure

Chapter 13 Necessity of Technical Capacity Enhancement

13.1 Introduction

This chapter discusses the necessity of technical capacity enhancement that is important to following the Road Map policy framework. The current state of the technical capacities of the five countries is described in Section 5 of Chapters 4 to 8. These technical capacities in all five countries can be linked to their level of geothermal development, which has been affected by several factors specific to each country, as discussed below. A simple rule dictates that capacity must be developed in tandem with field development. For example, there is no need to train people in a field where they will not be employed.

The interest in geothermal development in all five countries, like in many countries in the world, was triggered by the high price of oil in the early seventies. The United Nations Development Program (UNDP) is very well known to have conducted many geothermal exploration programs in many developing countries and popularized geothermal utilization as an alternative source of energy. The results of this wave of UNDP initiative, combined with the availability of competing traditional sources of power, inappropriate organization structures for carrying out geothermal development and lack of continuous funding can go al long way to explaining the current state of geothermal development and the technical capacity in each of these countries.

13.2 Previous Technical Capacity Surveys

There have been two surveys regarding the technical capacity of the countries in the region, one conducted by ICEIDA in 2005 and the other by the African Union Commission (AUC) in March 2010.

13.2.1 ICEIDA Survey

In October-November 2005, under the auspices of ARGeo, ICEIDA financed a survey covering the six ARGeo countries (Arnason and Gislason, 2005; Arnason et al., 2005). Table-13.2-1 shows the results of the survey indicating that only 164 skilled people were involved in geothermal in the five countries which we are considering in this survey (excluding Eritrea). Of this number, 70 were professional engineers and scientists, the rest being technicians. Tanzania had only one person, which meant that no geothermal activity was being undertaken at that time at all. Kenya had the most people engaged in geothermal, followed by Ethiopia. Except in Kenya, all the geothermal staff were working for the Geological Survey Departments. Most of the personnel in Kenya were working for KenGen, and a few for the Ministry of Energy.

Table-13.2-1 Professionals working by 2005

	Djibouti	Ethiopia	Kenya	Tanzania	Uganda	Total
Professionals	7	21	31	1	9	**69**
Technicians	?	42	48		5	**95**
Total	**7**	**63**	**79**	**1**	**14**	**164**

(Source) Study Team compiled from ICEIDA data

Table-13.2-2 indicates that at that time most of the professionals (76) had been trained in various geothermal schools around the world. Table-13.2-3 shows the training demand outlook assessed in 2005. This table indicates that with more interest in geothermal development, more staff was going to be engaged and about 200 needed to be trained over the next 5 years (2006-2010) in the short courses which had been started in Naivasha and the regular 6-month course at UNUGTP in Iceland.

Table-13.2-2 Location of geothermal training of staff completed by 2005

	Djibouti	Ethiopia	Kenya	Tanzania	Uganda	Total
Iceland	1	13	21		5	**40**
Italy (pisa)		6	1			**7**
Japan		5	1			**6**
New Zealand	1	6	13	1	1	**22**
Other			1			**1**
Total	**2**	**30**	**37**	**1**	**6**	**76**

(Source) Study Team compiled from ICEIDA data

Table-13.2-3 Required training by 2010

	Djibouti	Ethiopia	Kenya	Tanzania	Uganda	Total
Four Weeks	6	46	29	25	20	**126**
Six Months	3	31	30	4	6	**74**
Total	**9**	**77**	**59**	**29**	**26**	**200**

(Source) Study Team compiled from ICEIDA data

The ICEIDA equipment survey concentrated on what was required mainly for surface exploration work. The main objectives of the study were to:

- take an inventory of existing equipment in the ARGeo countries and its condition;
- recommend the basic equipment and instruments which should be available in each ARGeo country;
- identify basic equipment that is lacking;
- Investigate the compatibility of equipment and instruments in the ARGeo countries, with regard to data collection, data transfer, data sharing etc;

- evaluate the technical skills available in each country for operating the existing equipment as well as processing and interpreting data;
- recommend which instruments could be pooled and made available to all ARGeo countries and recommend as to where such an equipment pool could be located, and
- make recommendations on the regulatory framework for the equipment pool, its supervision, responsibility for maintenance, rental rates, etc.

These objectives were set out on the view that the equipment available in the region could be more effectively utilized by sharing. It would also be more cost-effective to send samples for analysis in the laboratories in the region than sending them to some developed countries far away. It was also realized that many countries did not know what equipment neighbouring countries had because of a lack of communication, i.e. the Rift Valley countries were not sharing information well enough. It was noted, however, that for the testing of wells after drilling, the geochemical laboratories would need to be upgraded to handle the geochemical analysis of steam and brine and that reservoir engineering laboratories would accordingly need to be established. The survey therefore did not cover drilling and well-testing equipment requirements. Table-13.2-4 shows the various equipment available in each of the five countries. Some MT and portable seismic equipment in Kenya that had been procured for a Joint Geophysical Imaging (JGI) project funded by GEF was going to be part of the pooled equipment for the region. Table -13.2-5 indicates what geochemical analyses could be carried out at that point in time..

Table-13.2-4 Equipment available in 2005

Equipment Description	Kenya	Ethiopia	Djibouti	Tanzania	Uganda	Recomm.
Geology						
Topographic and geological maps	Y	Y	Y	Y	Y	R
Aerial Photographs	Y	Y	Y	Y	Y	R
Handheld GPS	Y	Y	Y	Y	Y	R
Thermometers	Y	Y	Y	Y	Y	R
Microscopes (bin, and pol.)	Y	Y	Y	Y	N	R
Thin section laboratory	Y	Y	N	Y	N	R
Petrochemical laboratory	N	Y	N	Y	N	R
X-ray laboratory	Y	Y	N	Y	N	R
Isotope laboratory, dating	N	N	N	N	N	R
Equipment Description	**Kenya**	**Ethiopia**	**Djibouti**	**Tanzania**	**Uganda**	
Geochemistry						
Topographic and geological	Y	Y	Y	Y	Y	R

maps						
Aerial Photographs	Y	Y	Y	Y	Y	R
Handheld GPS	Y	Y	Y	Y	Y	R
Thermometers	Y	Y	Y	Y	Y	R
Chemical sampling equipment	Y	Y	N	N	Y	R
Field laboratory	Y	Y	N	N	Y	R
Chemical laboratory	Y	Y	Y	Y	Y	
Stable isotope laboratory	N	N	N	Y	N	R
Equipment Description	**Kenya**	**Ethiopia**	**Djibouti**	**Tanzania**	**Uganda**	
Geophysics						
Topographical and geological maps	Y	Y	Y	Y	Y	R
Hand-held GPS	Y	Y	Y	Y	Y	R
Thermometers	Y	Y	Y	Y	N	R
Differential GPS	Y	N	N	Y	Y	R
Gravimeter	Y	Y	Y	Y	Y	R
Magnetometers	Y	N	N	Y	Y	R
Temperature logging reel	N	Y	N	N	N	R
Shallow resistivity equipment	Y	Y	Y	Y	Y	R
Deep resistivity equipment	Y	N	N	N	N	R
Portable seismic stations	Y	N	N	N	N	R
Meteorological station	Y	N	N	N	N	R
	KEY: Y= Available N= Not Available R= Required					

(Source) Study Team compiled from ICEIDA data

Table-13.2-5 Chemical analysis being done in the various laboratories in 2005

	Kenya	Ethiopia	Djibouti	Tanzania	Uganda	Chemical methods
	KenGen	**GSE**	**CERD**	**GST**	**DGSM**	
Laboratory	Geothermal	Water	Water	Petrochemical	Geothermal	
Water Samples						
Field Laboratory	Yes	Yes	No	No	Yes	TM – Titration, Manual
Steam/Water	Yes	Yes	No	No	No	CM -

separator						Conductivity meter
pH	pH	pH	pH	Ph	Ph	pH – pH Meter
Conductivity	CM	CM	CM	CM	CM	CO - Colourometry
Dissolved gases						AA - Atomic Absorption
CO2	TM	TM	TM	N/A	TM	IC - ICP
H2S	TM	TM	N/A	N/A	TM	TU - Titration
Main Components						ISE- Selective electrode
SiO2	CO	CO	N/A	N/A	CO	NaOH- Gas sample in NaOH solution
Na	AA	AA/IC	Fe	AA	IC	GC-Gas Chromatograph
K	AA	AA	FE	AA	IC	
Ca	AA	AA/IC	TM	AA	IC	
Mg	AA	AA/IC	TM	AA	IC	
SO4	CO	TU/IC	CO	CO	IC	
Cl	TM	TM,ISE, IC	TM	TM	IC	
F	ISE	ISE/IC	N/A	ISE	IC	
Fe	AA	AA	AA	AA	N/A	
Al	AA	AA	N/A	CO	N/A	
B	CO	CO	N/A	AA	CO	
Steam						
Sampling	KOH	NaOH	N/A	N/A	N/A	
CO2	TM	TM	N/A	N/A	N/A	
H2S	TM	TM	N/A	N/A	N/A	
H2	GC	GC	N/A	N/A	N/A	
CH4	GC	GC	N/A	N/A	N/A	
N2	GC	GC	N/A	N/A	N/A	
O2	GC	GC	N/A	N/A	N/A	
Ar	GC	N/A	N/A	N/A	N/A	

(Source) Study Team compiled from ICEIDA data

The ICEIDA survey recommended the following:

1. Each country should have:
    a. Topographic maps
    b. Geological maps
    c. Aerial photographs
    d. Hand-held GPS
    e. Radios
    f. Thermometer (suitable for soil penetration)
    g. Conductivity/pH/TDS multimeter
    h. Thin-section facilities
    i. Microscopes (polarized and normal binocular)
    j. X-ray diffraction (XRD) – After deep drilling starts
    k. Petrography laboratory
    l. Differential GPS
    m. Gravimeter
    n. Magnetometers
    o. Shallow well temperature measurement reel

2. Pooled equipment should include the following:
    a. Shallow resistivity equipment (TEM)
    b. Deep resistivity equipment (MT)
    c. Portable seismic stations
    d. Meteorological stations X-ray laboratory
    e. Total chemical laboratory
    f. Isotope dating laboratory
    g. Geothermal laboratory for water and gas
    h. Stable isotope laboratory

3. Each country should agree that their laboratories become ARGeo-affiliated laboratories, providing services to other ARGeo countries when needed.
4. A central ARGeo laboratory with advanced technology equipment (ICP, stable isotopes, HPLC etc.) should be established to serve all member countries.
5. There should be a complete geothermal laboratory in each member country.
6. Each country laboratory should be upgraded geothermal development in that country advances.
7. Each laboratory should receive initial support to update existing facilities and training in appropriate analytical methods.
8. During the early exploration stage in member countries, ARGeo should designate and provide easy access to external laboratory services to complement shortcomings in the local laboratory.

9. When wells are drilled, the country laboratory should be upgraded through ARGeo assistance or otherwise in order to perform complete analyses of major elements in water and steam. Well downhole and discharge reservoir engineering equipment (temperature and pressure gauges, spinner tools, winches and silencers) should be procured as well.
10. Analysis of minor elements could be provided by external ARGeo affiliated laboratories.
11. Within the ARGeo-affiliated laboratories there must be a capacity to determine environmentally hazardous elements common to geothermal resources (As, Hg, Zn, etc.).
12. The ARGeo central office should maintain an up-to-date database on equipment in each country and its availability, together with a list of planned projects.
13. The central office assigns equipment to projects and advises on laboratory services.
14. Each ARGeo supported project should be used, as much as possible, for training.
15. Most of the equipment would require trained operators and require professionals for data processing and interpretation.
16. When equipment is assigned to a project, technicians and professionals should also be assigned.
17. When a project was going on in an ARGeo country, the ARGeo training centre and the central office could assign trainees from other ARGeo countries to participate.
18. The ARGeo training centre should arrange seminars and/or short courses attached to ongoing projects to share knowledge and expertise.

Unfortunately, the ARGeo project was not approved until about the end of 2009. Therefore no equipment has been purchased yet under this project. However it is important to note that UNUGTP started training in short courses in Naivasha in 2005 in collaboration with KenGen and, more recently, GDC. Other collaborating organizations like BGR have been involved also in training and sponsoring conferences in the region, and KenGen staff have been engaged in MT surveys using JGI equipment in Zambia, Rwanda and Djibouti as part of the equipment sharing strategy discussed above.

13.2.2 The African Union Commission (AUC) Survey

In June 2009, in a meeting of Ministers held in Addis Ababa, Ethiopia, AUC was given a mandate to spearhead geothermal development in the African countries endowed with this resource. Under this mandate, AUC undertook to determine the gaps existing in the region that would need to be overcome to accelerate the development of geothermal. To achieve this task they sent a questionnaire to all the countries with known geothermal resource potential in the East Africa region, including the Comoros. The questionnaire requested the following information:

a) A brief summary of the status of geothermal exploration and development activities
b) A list of available manpower and equipment in the country
c) A statement of the strategic framework for geothermal development for the next 2-5 years, indicating geothermal prospects in order of priority for exploration and development activity

d) A list of the current main donors/stakeholders for/in geothermal exploration and development activities and the names of the projects
e) A list of required inputs from donors/stakeholders/investment bank to further explore and develop geothermal resources in the country, including
   a. Training needs for capacity building.
   b. Equipment requirements
   c. Technical assistance requirements
   d. Risk mitigation funding during drilling
   e. Financing for feasibility studies and power development
f) Any other relevant information

The results of this questionnaire as they relate to technical capacity are given in Tables-13.2-6 and 13.2-7 for the five countries (Teklemariam 2010), although it will be seen that, unfortunately, Djibouti did not provide any of the requested information. Based on this questionnaire results, over 150 engineers, scientists and technician were seen to be engaged in geothermal work in the five countries. Kenya had the largest number of people. In the next five years (Table-13.2-8), it was projected that 458 additional staff would be required, based on the expected increase in geothermal development in these countries (excluding those to be engaged by IPPs over the same period of time). Kenya again had the largest staff requirement, particularly because of the needs of the newly formed GDC company that intended to acquire up to 12 drilling rigs.

Table-13.2-6 Professional skilled staff by March 2010

	Kenya	Ethiopia	Djibouti	Tanzania	Uganda	Total
Geologists	8	3	No Info	10	3	24
Geochemists	7	4	No Info	1	4	16
Geophysicists	6	4	No Info	5	2	17
Reservoir Engineers	5	4	No Info	0	1	10
Drilling Engineers	7	0	No Info	0	0	7
Power Station Engineers	12	2	No Info	0	0	14
Drillers	5	25	No Info	0	0	30
Technicians	30	2	No Info	No Info	No Info	32
Total	80	44		16	10	150

(Source) Study Team compiled from AUC data

Table-13.2-7 Available equipment by 2010

Equipment Description	Kenya	Ethiopia	Djibouti	Tanzania	Uganda
Geological					
Simple GPS	Y	Y	Y	Y	Y
Digital Thermometer	Y	Y	Y	Y	Y
Fluid Inclusion Heating-freezing stage	Y	N	N	N	N
Binocular Microscope	Y	Y	Y	Y	Y
Petrographic Microscope	Y	Y	Y	Y	Y
X-Ray Diffractometer	Y	Y	N	N	N
X-Ray Fluorescence	Y	Y	N	Y	N
ICP-MS	Y	N	N	N	N
Mass spectrometer for dating	N	N	N	N	N
Geochemical	**Kenya**	**Ethiopia**	**Djibouti**	**Tanzania**	**Uganda**
Simple GPS	Y	Y	Y	Y	Y
Digital Thermometer	Y	Y	Y	Y	Y
pH meter	Y	Y	Y	Y	Y
Conductivity Meter	Y	Y	Y	Y	Y
Water Sampling Kit	Y	Y	N	N	N
Gas Sampling Kit	Y	Y	N	N	N
AAS equipment	Y	Y	Y	Y	N
Ion Chromatograph (IC)	Y	Y	Y	N	Y
Gas Chromatograph	Y	Y	N	N	N
Mass Spectrometer for stable Isotope	N	N	N	N	N
Tritium Scintillation counter & C14 analyser	N	N	N	N	N
Geophysical	**Kenya**	**Ethiopia**	**Djibouti**	**Tanzania**	**Uganda**
Differential GPS	Y	N	N	N	N
Simple GPS	Y	Y	Y	Y	Y
TEM equipment	Y	Y	N	Y	Y
MT equipment	Y	Y	N	N	N
Gravimeter	Y	Y	Y	N	Y
Magnetometer	Y	Y	N	Y	Y
Portable seismometer	Y	N	N	N	N
Reservoir Engineering	**Kenya**	**Ethiopia**	**Djibouti**	**Tanzania**	**Uganda**
Kuster gauge Tools set	Y	Y	N	N	N
Logging Winch	Y	N	N	N	N

Logging Truck (K10)	Y	N	N	N	N
Drilling	**Kenya**	**Ethiopia**	**Djibouti**	**Tanzania**	**Uganda**
Complete Rig	Y	Y	N	N	N
	Y= Available		N= Not Available		

(Source) Study Team compiled from AUC data

Table-13.2-8 Estimated professional skilled manpower required in the next 5 years

	Kenya	Ethiopia	Djibouti	Tanzania	Uganda	Total
Geologists	28	2	No Info	20	3	**53**
Geochemists	20	4	No Info	5	2	**31**
Geophysicists	15	4	No Info	5	4	**28**
Reservoir Engineers	15	2	No Info	2	3	**22**
Drilling Engineer	35	4	No Info	0	4	**43**
Power Station Engineers	40	4	No Info	2	0	**46**
Drillers	150	10	No Info	2	0	**162**
Technicians	65	8	No Info	No Info	No Info	**73**
Total	**368**	**38**		**36?**	**16?**	**458**

(Source) Study Team compiled from AUC data

The summarizing these findings, this study noted that, other than a large financial requirement, the following was required for technical capacity building in the target countries:

1. Uganda and Tanzania would concentrate on detailed surveys and drilling in the most suitable prospects in order to prove the availability of steam, while the other three countries already had targets to develop geothermal power stations as follows: Djibouti 50MW, Ethiopia 125MW and Kenya 880MW.
2. Based on these exploration and development targets, all the countries require:
    a. additional staff who will then be trained in scientific exploration, drilling and power station operations;
    b. staff training through four-week courses annually held at Naivasha, six-month courses at UNU in Iceland and ICS-UNIDO in Italy, and MSc and PhD courses at various universities;
    c. awareness training in funding options and attendance at ARGeo conferences and other international conferences and workshops;
    d. On-the job training during technical assistance for the various projects; and
    e. capacity for financial modeling, and Power Purchase Agreement (PPA) and Steam Supply Agreement (SSA) negotiations.

3. Field and laboratory equipment for all countries, including drilling rigs for Kenya and Ethiopia. Other countries would initially hire drilling rigs until their development is established enough that owning their own rigs and drilling themselves would reduce development costs.
4. Technical assistance was required in the following areas:
   a. detailed surface exploration and drilling;
   b. institutional restructuring of the policy and legal framework in order to encourage public and private participation in all countries except Kenya, where such a legal and policy framework already exists.
5. Lessons learnt from Kenya and which could be applied in other countries in the region were highlighted as follows:
   a. Aggressive training and retention of staff commensurate with geothermal development;
   b. Governments taking exploration drilling risks as IPPs were not willing to do this;
   c. Setting up of dedicated institutions favourable to geothermal exploration and development;
   d. Including geothermal energy in the country's Power Development Master Plan as a source of base-load power in priority over other renewable resources.
   e. Allocating annual budgets for capacity building as well as undertaking exploration and development within the country's own financial means.

Following on this study, AUC prepared a proposal for capacity building for the next three years requiring USD 4.8 million, and also recommended that two pilot plants (5MW each) be installed in Tendaho and Silali in Ethiopia and Kenya, respectively. It was the wish of AUC that the donor communities should support and contribute generously towards this goal.

13.3 Technical Capacity Survey by JICA

The JICA Study team visited the five countries to collect relevant information in face-to-face interviews, spending about two days in each country.

About 363 geothermal professionals are employed in various institutions and by IPPs within the five countries (Table-13.3-1). Except in Kenya and Ethiopia, where there are geothermal power plants, most of the staff works for Geological Survey institutions. Table-13.3-2, Table-13.3-3, and Table-13.3-4 show the number of trained people in various training facilities. Three hundred and thirty-eight (338) have been trained in geothermal-related disciplines in Iceland, Italy, Japan, New Zealand and, more recently, in Kenya. The course in Kenya is 4 weeks long, and the others are 6-10 months. Given that each of these countries seriously desires to develop geothermal resources to meet the increased demand for indigenous, low-cost, environmentally friendly power, about 903 more people (Table-13.3-2) will be required in the next 10 years and will consequently require training.

Table-13.3-1 Currently available manpower

	Djibouti	Ethiopia	Kenya	Tanzania	Uganada	Total
Category						
Geologists	3	2	6	8	9	28
Geochemists	2	4	5	2	8	21
Geophysicists	2	4	5	7	5	23
Reservoir Engineers	1	3	10	1	1	16
Drilling Engineers	0	2	24	0	0	26
Power Engineers	0	4	14	0	0	18
Environmental Scientists	10	0	11	3	1	25
Financial Planner/Modellers	0	1	2	0	0	3
GIS Scientists	3	2	5	1	0	11
Drillers	0	24	5	0	0	29
Technicians	1	26	119	13	4	163
Total	**22**	**72**	**206**	**35**	**28**	**363**

(Source) Study Team

Table-13.3-2 Personnel receiving geothermal training at various institutions up to 2009

Training by 2009	Kenya	Ethiopia	Djibouti	Tanzania	Uganda	Total
Iceland	86	65	8	4	14	177
Italy (Pisa)	1	6				7
Italy (ICS)	7	2	1	3	0	13
Japan	1	5				6
NZ	13	6	1	1	1	22
4 week-course at Naivasha	62	16	7	15	12	112
Other	1					1
Total	171	100	17	23	27	338

(Source) Study Team

Table-13.3-3 Personnel receiving six-month training in UNUGTP by 2009

	Kenya	Ethiopia	Djibouti	Tanzania	Uganda	Total
Geology	7	3	2	2	5	19
Geophysics	10	5		2	2	19

Reservoir Engineering	6	5	2		1	14
Geochemistry	7	4	1	1	4	17
Environmental science	7	1			1	9
Drilling	5	2				7
Power station	3	6				9
Total	**45**	**26**	**5**	**5**	**13**	**94**

(Source) Study Team

Table-13.3-4 Personnel trained at UNU in Iceland and Kenya and retained in geothermal industry

	4 Weeks	6 Months	MSc	PhD	Total	Lost	Total Active
Kenya	62	45	7	2	116	4	**112**
Ethiopia	16	26	2	0	44	11	**33**
Djibouti	7	5	1	0	13	1	**12**
Uganda	15	13	1	0	29	1	**28**
Tanzania	12	5	0	0	17	1	**16**
Total	**112**	**94**	**11**	**2**	**219**	**18**	**201**

(Source) Study Team

Table-13.3-5 Additional manpower required in the next 10 years

	Kenya	Ethiopia	Djibouti	Tanzania	Uganda	Total
Category						
Geologists	22	10	5	6	8	51
Geochemists	9	7	3	6	5	30
Geophysicists	12	7	2	2	5	28
Reservoir Engineer	14	7	5	6	6	38
Drilling Engineers	52	19	3	5	5	84
Power Engineer	20	5	3	6	6	40
Environmental Scientists	4	5	2	6	6	23
Financial Planner/Modellers	9	3	2	3	3	20
GIS Scientists	3	7	0	3	3	16
Drillers	91	100	2	4	4	201
Technicians	165	115	30	36	26	372
Total	401*	285	57	83	77	903

*Kenya's MoE staff not included

(Source) Study Team

The countries have some basic scientific equipment and geochemical laboratories. The lists of equipment by country have been described in the previous Chapters, but they are summarized in Table-13.3-6. Some of this equipment is old and needs replacement, and in some cases additional equipment is needed. Kenya has the best equipment and the most-equipped scientific laboratories, but due to its planned expansion, it needs more. Ethiopia has two drilling rigs, and Kenya has one, though they all need refurbishment. Kenya has ordered 4 rigs already and 10 more are required. Ethiopia and Kenya both have well-testing equipment, but the Ethiopian equipment needs replacement. Kenya is the only country with an electronic downhole logging truck. The other countries will need to procure their reservoir testing and geochemical equipment as the wells are drilled. Just as for human capacity, these countries will need to replace the old and procure more modern equipment to meet the challenges ahead, requiring substantial financing in both respects.

Table-13.3-6 Currently available equipment

Equipment Description	Kenya	Ethiopia	Djibouti	Tanzania	Uganda
Geological					
Simple GPS	2	3	4	5	0
Digital Thermometer	3	0	1	0	0
Fluid Inclusion Heating-freezing stage	1	0	0	0	1
Binocular Microscope	4	2	2	1	2
Petrographic Microscope	4	3	2	2	2
X-Ray Diffractometer	1	1	0	1	1
X-Ray Fluorescence	0	1	0	0	0
ICP-MS	1	0	0	1	1
Thin sectioning equipment	2	1	0	2	2
Geochemical					
Simple GPS	3	1	1	1	1
Digital Thermometer	3	1	1	0	1
pH meter	4	1	2	1	2
Conductivity Meter	4	1	1	1	2
Water Sampling Kit	1	1	1	0	1
Gas Sampling Kit	170	70	0	0	0
AAS equipment	1	1	1	2	1
Ion Chromatograph (IC)	0	1	1	0	1
Gas Chromatograph	2	1	0	0	0
Mass Spectrometer for stable Isotope	0	0	0	0	0

Tritium Scintillation counter & C14 analyser	0	0	0	0	0
UV-SP	0	1	0	0	0
Geophysical					
Differential GPS	2	0	1	1	0
Simple GPS	8	0	1	1	1
TEM equipment	3	0	1	0	0
MT equipment	15	2	1	0	1
Gravimeter	2	1	0	1	2
Magnetometer	2	1	0	0	0
Portable seismometer	4	0	0	0	0
Reservoir Engineering			0		
Kuster gauge Tools set	12	0	0	0	0
Kuster TPS with SRO	2	0	0	0	0
Logging Winch	3	0	0	0	0
Logging Truck (K10)	3	0	0	0	0
Discharge Silencer	11	0	0	0	0
Drilling					
Complete Rig	1	2	0	0	0
Water supply system(pumps, pipelines, tanks)	2	1	0	0	0
Site preparation equipment (dozer, grader, tipper trucks)	1	0	0	0	0
Small water Rig	0	1	0	0	0
General					
4x4 field vehicles	50	40	1	2	0
GIS System	1	0	1	0	0
Total station	1	0	0	0	0
Complete weather station	2	0	0	0	0

(Source) Study Team

13.4 Current Situation and Future Development of Kenya

Kenya has limited hydro potential and has not discovered any oil or gas, either. Currently, prospecting for coal is ongoing. Geothermal exploration in Kenya started in the 70s, with UNDP and Government of Kenya funding. The earliest project incorporated some counterpart staff from the Mines Department of the Ministry of Natural Resources and from Kenya Power and Lighting

Company. This project culminated successfully with the commissioning of Olkaria I power station under the management and ownership of the Kenya Power Company (KPC), now KenGen. The staff who were originally involved in the UNDP were brought to KPC, and the company was given the mandate to explore and develop geothermal resources on behalf of the government. A geothermal law was also introduced in 1982, which allowed the private sector to develop geothermal resources. In 1986, geothermal was formerly incorporated in the National Power Development Plan (Acres 1987) and has remained an element ever since. KenGen has aggressively tried to achieve the goals of the geothermal component of the Plan. In retrospect, this arrangement has worked very well for Kenya.

Buoyed by the good performance of Olkaria I, Kenya has aggressively trained staff and has managed to retain many of them, some of whom have PhD degrees in geothermal technology. It has also built its equipment pool including drilling rig commensurate with these activities. In 2005, in collaboration with UNU-GTP, KenGen staff started the 4 week Short Training Course in Naivasha which has been held annually ever since. A total of 112 students from the five countries out of 153 students from about 14 African countries including Yemen have benefitted (Fredleifsson 2010). This course was set up on the view that KenGen staff, many of whom have been trained in UNU-GTP, could contribute to the region by sharing the knowledge and experience they had acquired over the years. The staff have also been involved in technical assistance in Zambia, Rwanda, Djibouti, Uganda and the Comoros. When liberalization of the power sector was introduced, Kenya quickly licenced one IPP in geothermal and several others have been licenced since then because the legal framework was already in place. The government and KenGen have realized that geothermal is going to contribute immensely in the future of power in Kenya.

These activities have made Kenya the only African country so far that has proved beyond any reasonable doubt that geothermal can be explored and developed on a large scale within the East African Rift system. It also offer some successful models that can be emulated by other countries in the region.

On the basis of the experience it has gained so far, Kenya is ready to develop geothermal on a much bigger scale and in an accelerated manner. The 2009-2029 Update of the Least-Cost Power Development Plan (Ministry of Energy 2009) requires the development of about 2,746 MW of geothermal out of the planned total of 7,470MW, or about 37% of that total. In order to achieve this very ambitious target, the government decided to establish a special-purpose company, GDC, to focus more on removing some of the barriers to geothermal development, especially the exploration drilling risk and the large amount of upfront capital required for production drilling.

GDC's 10-yr Business Plan (GDC 2010) is even more ambitious than is stated in the Least-Cost Power Development Plan mentioned above. It plans to explore and drill 2,336MW worth of steam by acquiring 12 rigs and drilling about 566 wells. The capital required is estimated to be in excess of

US$ 2.5 billion. Seventeen percent (17%) of the funding will come from the government, 59% from the sale of steam and the remaining 23% from various development donor partners. GDC will need to recruit about 232 people and train them in geothermal technology. AFDB has pledged to provide about €6 million to GDC for capacity building. It is estimated that the equipment required, including the twelve rigs, will cost US$ 373 million. The government will provide funds to procure 2 rigs already on order, AFD has pledged to provide funding for 2 more rigs, the French government 1 rig and China Exim Bank 3 rigs, for a total of 8 rigs, which leaves a balance of 4 more to be acquired. Even with these 8 rigs, it will be quite a challenge to raise funds to buy drilling materials and defray other operational costs.

KenGen, for its part, plans to develop 500MW of geothermal power in the next 10 years. It has recently recruited more staff to replace those who have left for GDC and to meet the needs of this increased development. It therefore requires 156 skilled staff to be recruited and trained in geothermal. It has recently ordered 2 new large-capacity rigs capable of drilling very deep directional wells. This will give it a total of 3 rigs, after the refurbishment of the old one. These rigs will initially be used to drill wells for Olkaria I and IV jointly with GDC and later to drill in Eburru field. Later, KenGen will continue drilling for make-up wells in Olkaria and Eburru fields. The rigs could also be available for hire by those IPPs licenced to develop Suswa and Longonot. It is estimated that KenGen will also need about US$ 74 million for new and replacement equipment, including the drilling rigs already on order.

There is a huge interest in geothermal development in Kenya at this time due to the fact that Kenya has proved the reliability of geothermal power stations and confirmed the potential the country has. With GDC taking the risk of drilling wells and selling steam, more IPPs will come into the market over and above those currently licenced to develop Olkaria West, Suswa and Longonot. Orpower 4 plans to increase its current capacity by 50MW. Suswa is planned to be developed initially to 75MW and Longonot is currently being investigated by the licensee. These IPPs will need to train their own staff in geothermal operations. If each IPP keeps their operational staff to a minimum, as Orpower 4 has, about 50 more trained geothermal staff will be needed. Drilling in these fields will be done by a contractor and well measurements by a consultant. This means that the geothermal industry in Kenya will need more trained staff to offer various specialized geothermal services.

With increased geothermal activity in the country on the part of GDC, KenGen and the IPPs, as well as the Ministry of Energy, will also need more staff. It is estimated that about 401 new staff members to deal with geothermal will be recruited and trained. The government staff will concentrate on policy and supervisory roles and therefore will not need equipment.

Table-13.4-1 shows available and required professional skilled manpower in Kenya. Table-13.4-2 shows a list of equipment available and required by Kenya.

13.5 Current Situation and Future Development of Ethiopia

Ethiopia has a huge potential for hydropower, which tends to overshadow geothermal development. The only reason Ethiopia is now keen on geothermal development is because of the severe drought which tends to occur frequently in many East African countries. Ethiopia also started geothermal exploration work early, in 1969, and this led eventually to installation of a 7.3 MW binary pilot plant in Aluto-Langano geothermal field in 1998 (Kebede 2010). The exploration work and drilling was done by staff from Geological Survey of Ethiopia (GSE) using its own rig and assisted by foreign consultants. The field was then handed over to EEPCO, which installed the pilot plant. Unfortunately, the plant developed technical problems and was shut down 1 year after commissioning. GSE continued aggressively with its exploration activities elsewhere and drilled 3 deep and 3 shallow wells in Tendaho in the northern part of the Rift system and also acquired a second deep drilling rig. Over the years, GSE has continually trained its staff, but has lost a good number as well due to a slump in geothermal activity in the country. This staff have managed to conduct detailed geoscientific surveys in six fields, however, in two of which temperature gradient wells were also drilled. Reconnaissance surveys have been done in more than 5 other prospects.

As mentioned elsewhere in this report, Ethiopia requires the installation of an additional 10,000MW in the next 10 years, of which 450MW will be from geothermal, 764MW from wind, and the rest from hydro (EEPCO 2009). Geothermal generation targets six fields shown in the Table-13.5-1. The specific commissioning dates for these developments is not specified because feasibility studies are yet to be carried.

On the basis of this plan, the Study Team and Ethiopian counterparts have made an estimation of the available and required professional skilled manpower in Ethiopia (Table-13.5-2) and an estimation of equipment available and required in Ethiopia (Table-13.5-3). These tables show that 285 skilled staff members are needed, and USD 131 million of equipment will be necessary in the future.

In order to achieve the development plan shown in Table 13.5-1, GSE has recently put together a geothermal project to be funded by the Japanese Government (USD 10 million), World Bank (USD 10 million) and Ethiopian Government (USD 10 million) to carry out further feasibility studies at Aluto-Langano, where 4 appraisal wells will be drilled. The surface exploration work for this project has already been completed during a JETRO study, and appraisal drilling using one of the two rigs owned by GSE will be done. GSE staff will drill the wells after the rig has been refurbished with support from the grant aid from the Japanese Government.

In order to achieve the 450MW of geothermal required by the Power Master Plan, GSE (Kebede 2010) would also like to undertake detailed studies in Corbetti, Abaya, Tulu-Moya and Dofan. Tendaho studies are being carried out by BGR, and it is hoped that drilling will commence as soon as the MT surveys are completed. These planned activities will therefore require nearly 285 staff to be employed and trained and retiring personnel will need to be replaced. More equipment will be required, as shown in Table-13.5-3, to allow several teams to work simultaneously. Drilling is expected to be undertaken by GSE with six rigs, as they have had experience operating rigs in the past. Four new rigs will thus be required. Huge financial resources will obviously need to be found to train staff, procure new equipment and acquire the necessary materials before the prospects are ready for power station development. Equipment alone is expected to cost about USD 131 million.

13.6 Current Situation and Future Development of Djibotui

Djibouti has no traditional source of energy such as hydro, coal, gas or even biomass. It depends entirely on imported diesel to generate power. It is therefore understandable that it has been, and still is, very determined to explore for geothermal resources. The first concerted geothermal exploration efforts took place in 1970-83 and were funded by the French and Djibouti governments (Business Council for Sustainable Energy, 2003). During this project, foreign experts and equipment were utilized in surface exploration, drilling and testing of the wells. However, some staff from CERD were also involved in the project. Two deep wells were drilled in Hanle and six in Assal. The wells at Assal discovered a very high-temperature resource. Although the Assal field is hot, problems related to high salinity and sulphide scaling discouraged further development.

After the collapse of Assal project, no further funds were available either from the donors or the Djibouti government, and even though CERD was mandated to be responsible for geothermal activities, very little exploration work has been done since. Given that state of affairs, there was no further building of technical capacity. Furthermore, CERD is a research organization and depends on government funding to do what it is mandated to do.

When the interest in geothermal development revived in the late 90s, Djibouti's strategy was then to license IPPs to develop the resource and sell power to EdD. In this model, the responsibility for building capacity was left purely to the IPPs. But even in such a situation, local staff would have been required to supervise the IPPs and negotiate suitable Project Agreements (PAs) and Power Purchase Agreements (PPAs). It was not until 1999-2000 that Geothermal Development Associates (GDA) completed a feasibility study for 30MW in Assal, after signing a Memoradum of Understanding with the Djibouti government. EdD, which was going to buy power from GDA, formed a geothermal department and obtained one geologist from CERD who was originally involved in the Assal exploration activity. Unfortunately, no further development took place at Assal because a price for electricity could not be agreed upon. There was no need to expand the capacity in EdD, either. With the formation in 2003 of ARGeo, of which Djibouti is a member, several conferences and workshops have been organized in which officials of Djibouti were involved. Tables-13.2-2, 13.2-3 and 13.2-4 in the previous section show the numbers of variously trained staff up to 2009 and of those currently working in the geothermal sector. Only twelve (12) of the 17 Djiboutians who have trained at various institutions are still active in the field.

It is clear that Djibouti is very keen to develop its geothermal resources, because these early efforts culminated with the drilling of 6 deep wells in Assal. The last well was financed by the Djibouti government itself. Unfortunately, the high salinity and the sulfur scaling problems characteristic of the resource did not have a technical solution at that time, and further work was abandoned. It is therefore clear why many staff have not been recruited and trained in the geothermal sector. Without an active geothermal project being undertaken in the country, a clear and well defined structure could not be developed. When geothermal interest revived, the government had chosen to allow IPPs to undertake the development and sell power to the state-owned EdD. With this model, the government did not need to restructure its organization to accommodate geothermal development. EdD, however, did establish a geothermal department, but did not staff it completely because no geothermal projects have been developed by the IPPs, as originally planned by the government.

CERD has been trying to train its staff to play an increased role in surface exploration. Several of its staff have been trained in Iceland and Kenya, and one reservoir engineer is currently undertaking a PhD degree at University of California at Berkeley. CERD has a geochemical laboratory which needs to be fully equipped to undertake geochemical analysis. Other relevant equipment required is outlined in the tables provided.

The Study Team and Djiboutian counterparts have made an estimation of the available and required professional skilled manpower in Djibotui (Table-13.6-1) and an estimation of equipment available and required in CERD (Table-13.6-2). These tables show that 57 skilled staff members are needed and USD 7.5 million of equipment will be necessary in the future. It is planned not to contract out drilling until much later, when the direction of further development is clearly defined.

13.7 Current Situation and Future Development of Tanzania

According to the Power System Master Plan 2009 Update for Tanzania, about 7,500 MW of additional power is required by 2033 (SNC-Lavalin International 2009). The report suggests that the Ministry of Energy and Minerals and TANESCO should develop plans for further exploration to identify and quantify indigenous energy resources, which should include geothermal, wind and new deposits of coal and gas. Power from geothermal resources could not be included in this master plan because the resource potential and the costs of development remain unknown. Like Ethiopia and Uganda, which also have large hydro potential, Tanzania is keen to develop its geothermal resources alongside other renewable energy sources, in order to overcome the problems of severe drought, which is frequent in most of these East African countries. In this regard therefore, a well-defined roadmap is required.

As discussed in Section 4 of Chapter 7, Tanzania has about 50 geothermal sites located near hot springs with temperatures of 32 - 86^{o}C (Hochstein et al., 2000). DECON et al. (2005) carried out some preliminary studies in Lake Natron in the north and Songwe-Mbeya in the western part of the country and recommended that the Mbeya area warranted a further detailed followup survey. During this time, FEC had already been licenced to develop the Luhoi field located in the Rufiji basin. Based on this recommendation, BGR carried out further geological, geochemical and geophysical work in the Mbeya area between 2006-2009 during their Geotherm I programme (BGR 2009). This study involved staff from GST, MEM and TANESCO as part of a technological transfer program (Mbogoni and Simon, 2010). This work identified the Songwe area, which is is associated with Ngozi volcanic complex, as having predicted reservoir temperatures greater than 200^{O}C. BGR plan to carry out further detailed surveys during Geotherm Phase II project in the Songwe area, with a view to identifying 2 or 3 suitable deep exploration drilling sites. As in the Ugandan exploration strategy, BGR hopes that a KfW drilling grant and Risk Mitigation funds can be used for this purpose (BGR and KfW 2010; Witte 2010).

The Study Team and Tanzanian counterparts have made an estimation of the available and required professional skilled manpower in Tanzania (Table-13.7-1) and an estimation of equipment available and required in Tanzania (Table-13.7-2). These tables show that 83 skilled staff members are needed and USD 7.6 million of equipment will be necessary in the future.

13.8 Current Situation and Future Development of Uganda

Uganda has large hydro potential, which impacts negatively on geothermal development. In addition, Uganda has recently discovered oil resources. The initial surveys were done in the early 70s, but the geothermal prospects were reported to have low temperatures. The institution mandated to undertake the work was the Department of Geological Survey and Mines (DGSM) of the Ministry of Energy and Minerals. This institution was originally established to spearhead and support mineral exploration and is still very strong in that respect, but there are no dedicated geothermal sections, nor is there a budget to conduct exploration work. It is only recently that some of the prospects have received detailed geoscientific investigation, with, for example, Katwe, Kibiro and Buranga being explored by BGR and ICEIDA.

Katwe and Kibiro were comprehensively covered by ISOR under a project financed by the Icelandic International Development Agency (ICEIDA), which has an office in Uganda. The results in Katwe were not encouraging (Arnason and Gislason, 2009), but Kibiro requires some more MT measurements augmented with structural geological and hydrological studies, with a view to targeting a deep exploration well. Initial surface exploration work at Buranga by BGR has led to recommendations for some more detailed surveys in their Geotherm Phase II programme, which will include MT, TEM, gravity and microseismic surveys. It is hoped that the results at the end of this survey will be encouraging enough that it can be followed by the exploration drilling of 2-3 wells under a KfW drilling grant and Drilling Risk Mitigation mechanism (BGR and KfW 2010; Witte 2010). DGSM has also recently become interested in a new geothermal site called Panyimur, which is said to have been discovered by oil well exploration drilling. Review of exploration drilling is initially required in this area, and could be followed by detailed surface exploration work, if the results are positive.

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The National Development Plan 2010/11-2014/15 anticipates that geothermal will be developed within this period in Katwe, Buranga and Kibiro to augment hydropower. The Power Sector Investment Plan drafted in December 2009 proposed that a plan and process for geothermal pre-feasibility and feasibility studies should be initiated immediately to confirm the viability of geothermal power plants so that the plants can be included in future Power Master Plans.

The Study Team and Ugandan counterparts have made an estimation of the available and required professional skilled manpower in Uganda (Table-13.8-1) and an estimation of equipment available and required in Uganda (Table-13.8-2). These tables show that 77 skilled staff members are needed and USD 7.6 million of equipment will be necessary in the future.

13.9 Role of Universities in Capacity Building

Our discussions with people actively involved in geothermal activity in all the five countries suggested that the local universities are not in a position to effectively undertake a capacity building role beyond basic graduate studies. Most of the universities are crowded with students who are either doing normal undergraduate courses or some evening classes. Geothermal being a specialized area, no lecturers have been trained or have the necessary experience to effectively train students in a geothermal technology course in a manner and to a level which would be useful to the industry. The lecturers are also not actively involved in solving industry problems and therefore have very little experience to offer.

The UNUGTP course attempted to train some lecturers in order to introduce appropriate courses in the local universities, but with very little success, and the plan was discontinued. The lecturers themselves are not trained in geothermal, nor are they equipped. Furthermore, working staff usually wish to undertake courses that will help them perform the duties for which they are employed as quickly as possible, rather than going through rigorously theoretical courses. One of the reasons the UNUGTP has proved very popular with many trainees is because it tends to emphasize practical training more than theoretical knowledge. Students who are involved in ongoing projects in Iceland or solving practical problems with data collected from their home countries learn more. It was found that students who took the Auckland course, which was more theoretical, preferred to also take the UNUGTP course, which gave more practical training.

It is the Study Team's view that the training required is specialized and requires the different setting of specialized geothermal schools rather than the currently available local universities. The number to be trained is large and yet, given that UNUGTP accepts on average only 2 persons per country each year, in the next 10 years only 100 people from the area will be able to participate in the six-month course in Iceland. It is in light of these facts that the Study Team supports further consideration of the idea of having a local geothermal school in Kenya, which has been proposed since the foundation of ARGeo, leading to the start of the Short Courses in Naivasha, Kenya. The school would be linked with other schools and/or Universities offering geothermal courses around the world. GDC has proposed to establish the school. However, further details are not yet available.

Table-13.4-1 Available and required professional skilled manpower in Kenya

Organisation	MOE		KenGen		GDC		Orpower4		ODCL		Total	
Category	Avail.	Req.	Avail.	Req.	Avail.	Req.	Avail.	Req.	Avail.	Req.	Avail.	Req.
Geologists	2	2	3	6	3	13	0	1		0	**6**	**22**
Geochemists	1	1	2	3	3	5				0	**5**	**9**
Geophysicists	1	1	4	2	1	9				0	**5**	**12**
Reservoir Engineers		1	9	8	1	5				0	**10**	**14**
Drilling Engineers		1	21	11	3	40				0	**24**	**52**
Power Station Engineers		1	8	14	1	5	3		2	0	**14**	**20**
Environmental Scientists	1	1	6	3	4	0	1			0	**11**	**4**
Financial Planner/Modellers		1	2	6	0	2				0	**2**	**9**
GIS Scientists			3	1	2	2				0	**5**	**3**
Drillers			5	10	0	81				0	**5**	**91**
Technicians			84	92	0	70	16	3	19	0	**119**	**165**
Total	**5**	**9**	**147**	**156**	**18**	**232**	**20**	**4**	**21**	**0**	**211**	**401**

(Source) Study Team

Table-13.4-2 Available and required equipment in Kenya

		KenGen			GDC		
Equipment Description	**Unit Cost US$**	**Available**	**Required**	**Total Cost US$**	**Available**	**Required**	**Total Cost US$**
Geological							
Simple GPS	2,000	0	4	8,000	2	10	20,000
Digital Thermometer	1,800	0	6	10,800	3	10	18,000
Fluid Inclusion Heating-freezing stage	35,000	1	2	70,000	0	1	35,000
Binocular Microscope	20,000	2	3	60,000	2	2	40,000
Petrographic Microscope	35,000	2	2	70,000	2	2	70,000
X-Ray Diffractometer	65,000	1	0	-	0	1	65,000
X-Ray Fluorescence	65,000	0	1	65,000	0	1	65,000
ICP-MS	68,000	1	0	-	0	1	68,000
Thin sectioning equipment	54,000	2	1	54,000	0	1	54,000
Geochemical							
Simple GPS	2,000	1	5	10,000	2	0	-
Digital Thermometer	1,800	1	5	9,000	2	2	3,600
pH meter	2,500	2	5	12,500	2	2	5,000
Conductivity Meter	4,500	2	5	22,500	2	0	-
Water Sampling Kit	2,000	1	1	2,000	0	5	10,000
Gas Sampling Kit	670	70	100	67,000	100	0	-
AAS equipment		1	0		0	1	

	65,000			-			65,000
Ion Chromatograph (IC)	65,000	0	0	-	0	1	65,000
Gas Chromatograph	5,000	2	0	-	0	1	65,000
Mass Spectrometer for stable Isotope	255,000	0	0	-	0	1	255,000
Tritium Scintillation counter & C14 analyser		0	1	-	0	1	-
Geophysical							
Differential GPS	210,000	0	3	630,000	2	0	-
Simple GPS	2,000	2	3	6,000	6	0	-
TEM equipment	80,000	1	5	400,000	2	1	80,000
MT equipment	38,000	5	5	690,000	10	0	-
Gravimeter	160,000	2	0	-	0	1	160,000
Magnetometer	16,000	2	0	-	0	1	16,000
Portable seismometer	20,000	4	31	620,000	0	10	200,000
Reservoir Engineering							
Kuster gauge Tools set	13,000	2	8	104,000	10	0	130,000 -
Kuster TPS with SRO	425,000	1	4	1,700,000	1	1	425,000
Logging Winch	115,000	2	8	920,000	1	1	115,000
Logging Truck	1,400,000	1	3		2	5	

(K10)				4,200,000			7,000,000
Discharge Silencer	23,400	7	18	421,200	4	0	-
Drilling							
Complete Rig	30,000,000	1	2	60,000,000	0	12	360,000,000
Water supply system(pumps, pipelines, tanks)	1,200,000	2	1	1,200,000	0	1	1,200,000
Site preparation equipment (dozer, grader, tipper trucks)	,800,000	1	1	1,800,000	0	1	1,800,000
Small rig		0		-	0		-
General				-			-
4x4 field vehicles	45,000	40	10	450,000	10	30	1,350,000
GIS System	85,000	1		-	0	1	85,000
Total station	15,000	1		-	0	1	15,000
Complete weather station	38,000	1		-	1	1	38,000
Total				73,602,000			373,387,600

(Source) Study Team

Table-13.5-1 Planned geothermal generation in Ethiopia in the next 10 years

No.	Project	Current Status	Capacity (MW)	Energy (GWh)	Estimated Commissioning Date
1	Aluto-Langano	Appraisal	75	525.6	2012
2	Tendaho	Prefeasibility	100	700.8	2018
3	Corbetti	Prefeasibility	75	525.6	2018
4	Abaya	Prefeasibility	100	700.8	2010
5	Tulu-Moya	Prefeasibility	40	280.32	2018
6	Dofan	Prefeasibility	60	420.48	2018
	Total		450	3153.6	2018

(Source) Study Team

Table-13.5-2 Available and Required professional skilled manpower for Ethiopia

	MME		**GSE**		**EEPCO**		**Total**	
Category	Avail.	Req.	Avail.	Req.	Avail.	Req.	**Avail.**	**Req.**
Geologists	0	2	2	8			**2**	**10**
Geochemists		1	4	6			**4**	**7**
Geophysicists		1	4	6			**4**	**7**
Reservoir Engineers		1	3	4		2	**3**	**7**
Drilling Engineers		1	2	18			**2**	**19**
Power Engineers		1	0	0	4	4	**4**	**5**
Environmental Scientists		1	0	3	0	1	**0**	**5**
Financial Planner/Modellers		1	0	1	1	1	**1**	**3**
GIS Scientists			2	6	0	1	**2**	**7**
Drillers			24	100			**24**	**100**
Technicians		9	12	90	14	16	**26**	**115**
Total	**0**	**18**	**53**	**242**	**19**	**25**	**72**	**285**

(Source) Study Team

Table-13.5-3 Available and required equipment in Ethiopia

Equipment Description	**Available**	**Required**	**Unit cost in US$**	**Total costs US$**
Geological				
Simple GPS	3	3	2,000	6,000
Digital Thermometer	0	0	1,800	-
Fluid Inclusion Heating-freezing stage	0	1	35,000	35,000
Binocular Microscope	2	2	20,000	40,000
Petrographic Microscope	3	3	35,000	105,000
X-Ray Diffractometer	1	1	65,000	65,000
X-Ray Fluorescence	1	1	65,000	65,000
ICP-MS equipment	0	1	68,000	68,000
Thin sectioning equipment	1	1	54,000	54,000
Geochemical				
Simple GPS	1	0	2,000	-
Digital Thermometer	1	0	1,800	-
pH meter	1	0	2,500	-
Conductivity Meter	1	0	4,500	-
Water Sampling Kit	1	0	2,000	-
Gas Sampling Kit	70	20	670	13,400
AAS equipment	1	0	65,000	-

Ion Chromatograph (IC)	1	0	65,000	-
Gas Chromatograph	1	1	65,000	65,000
Mass Spectrometer for stable Isotope	0	1	255,000	255,000
Tritium Scintillation counter & C14 analyser	0	1		
UV-SP	0	1		
Geophysical				
Differential GPS	0	1	210,000	210,000
Simple GPS	0	4	2,000	8,000
TEM equipment	0	4	80,000	320,000
MT equipment	0	2	138,000	276,000
Gravimeter	1	2	160,000	320,000
Magnetometer	1	2	16,000	32,000
Portable seismometer	0	10	20,000	200,000
Reservoir Engineering				
Kuster gauge Tools set	0	5	13,000	65,000
Kuster TPS with SRO	0	1	425,000	425,000
Logging Winch	0	1	115,000	115,000
Logging Truck (K10)	0	1	1,400,000	1,400,000
Discharge Silencer	0	10	23,400	234,000
Drilling				
Complete Rig	2	4	30,000,000	120,000,000

Water supply system (pumps, pipelines, tanks)	1	4	1,200,000	4,800,000
Site preparation equipment (dozer, grader, tipper trucks)	0	1	1,800,000	1,800,000
Small water Rig	1	0		
General				
4x4 field vehicles	40	10	45,000	450,000
GIS System		1	85,000	85,000
Total station		2	15,000	30,000
Completer weather station	0	6	38,000	228,000
Total				131,331,400

(Source) Study Team

Table-13.6-1 Available and required professional skilled manpower in Djibouti

	MENR		CERD		EdD		**Total**	
Category	Avail.	Req.	Avail.	Req.	Avail.	Req.	**Avail.**	**Req.**
Geologists		2	2	3	1		**3**	**5**
Geochemists		1	2	1		1	**2**	**3**
Geophysicists		1	2	1			**2**	**2**
Reservoir Engineers		1	1	2		2	**1**	**5**
Drilling Engineers		1	0	2			**0**	**3**
Power Engineers		1				2	**0**	**3**
Environmental Scientists		1	10	1			**10**	**2**
Financial Planner/Modellers		1	0	1			**0**	**2**
GIS Scientists			3	0			**3**	**0**
Drillers			0	2			**0**	**2**
Technicians			1	10		20	**1**	**30**
Total	**0**	**9**	**21**	**23**	**1**	**25**	**22**	**57**

(Source) Study Team

Table-13.6-2 Equipment available and required by CERD

Equipment Description	Available	Required	Unit cost in US$	Total Cost in US$
Geological				
Simple GPS	4	0	2,000	-
Digital Thermometer	1	0	1,800	-
Fluid Inclusion Heating-freezing stage	0	1	35,000	35,000
Binocular Microscope	2	2	20,000	40,000
Petrographic Microscope	2	3	35,000	105,000
X-Ray Diffractometer	0	1	65,000	65,000
X-Ray Fluorescence	0	1	65,000	65,000
ICP-MS equipment	0	1	68,000	68,000
Thin sectioning equipment	0	1	54,000	54,000
Geochemical				
Simple GPS	1	0	2,000	-
Digital Thermometer	1	0	1,800	-
pH meter	2	0	2,500	-
Conductivity Meter	1	0	4,500	-
Water Sampling Kit	1	0	2,000	-
Gas Sampling Kit	0	20	670	13,400
AAS equipment	1	0	65,000	-

Ion Chromatrogaph (IC)	1	1	65,000	65,000
Gas Chromatograph	0	1	65,000	65,000
Mass Spectrometer for stable Isotope	0	1	255,000	255,000
Tritium Scintillation counter & C14 analyser	0	1		-
Geophysical				
Differential GPS	0	1	210,000	210,000
Simple GPS	1	0	2,000	-
TEM equipment	1	1	80,000	80,000
MT equipment	1	2	138,000	276,000
Gravimeter	1	1	160,000	160,000
Magnetometer	0	1	16,000	16,000
Portable seismometer	0	10	20,000	200,000
Reservoir Engineering				
Kuster gauge Tools set	0	5	13,000	65,000
Kuster TPS with SRO	0	2	425,000	850,000
Logging Winch	0	1	115,000	115,000
Logging Truck (K10)	0	1	1,400,000	1,400,000
Discharge Silencer	0	2	23,400	46,800
Drilling				
Complete Rig	0	Hire	30,000,000	

Water supply system (pumps, pipelines, tanks)	0	1	1,200,000	1,200,000
Site preparation equipment (dozer, grader, tipper trucks)	0	1	1,800,000	1,800,000
Small water rig	0			
General				-
4x4 field vehicles	1	5	45,000	225,000
GIS System	1	0	85,000	-
Total Station for land survey	0	1	15,000	15,000
Complete weather station	0	1	38,000	38,000
Total				**7,527,200**

(Source) Study Team

Table-13.7-1 Available and required professional skilled manpower in Tanzania

	MEM		GST		TANESCO		TOTAL	
Category	Avail.	Req.	Avail.	Req.	Avail.	Req.	Avail.	Req.
Geologists	2	1	4	5	2		8	6
Geochemists	1		1	5		1	2	6
Geophysicists	1		6	2			7	2
Reservoir Engineers		1	1	3		2	1	6
Drilling Engineers		1	0	4			0	5
Power Engineers		1				5	0	6
Environmental Scientists		1	3	4		1	3	6
Financial Planner/Modellers		1		1		1	0	3
GIS Scientists			1	2		1	1	3
Drillers				4			0	4
Technicians			13	16		20	13	36
Total	**4**	**6**	**29**	**46**	**2**	**31**	**35**	**83**

(Source) Study Team

Table-13.7-2 Available and required equipment in Tanzania

Equipment Description	Available	Required	Unit cost in US$	Total Cost in US$
Geological				
Simple GPS	5	5	2,000	10,000
Digital Thermometer	0	2	1,800	3,600
Fluid Inclusion Heating-freezing stage	0	1	35,000	35,000
Binocular Microscope	1	2	20,000	40,000
Petrographic Microscope	2	2	35,000	70,000
X-Ray Diffractometer	1	1	65,000	65,000
X-Ray Fluorescence	0	1	65,000	65,000
ICP-MS equipment	1	1	68,000	68,000
Thin sectioning equipment	2	2	54,000	108,000
Geochemical				
Simple GPS	1	2	2,000	4,000
Digital Thermometer	0	3	1,800	5,400
pH meter	1	3	2,500	7,500
Conductivity Meter	1	3	4,500	13,500
Water Sampling Kit	0	3	2,000	6,000
Gas Sampling Kit	0	3	670	2,010
AAS equipment	2	1	65,000	65,000

Ion Chromatrograph (IC)	0	1	65,000	65,000
Gas Chromatograph	0	1	65,000	65,000
Mass Spectrometer for stable Isotope	0	1	255,000	255,000
Tritium Scintillation counter & C14 analyser	0	1		
Geophysical				
Differential GPS	0	1	210,000	210,000
Simple GPS	1	3	2,000	6,000
TEM equipment	1	1	80,000	80,000
MT equipment	0	2	138,000	276,000
Gravimeter	0	1	160,000	160,000
Magnetometer	1	2	16,000	32,000
Portable seismometer	0	10	20,000	200,000
Reservoir Engineering				
Kuster gauge Tools set	0	3	13,000	39,000
Kuster TPS with SRO	0	2	425,000	850,000
Logging Winch	0	1	115,000	115,000
Logging Truck (K10)	0	1	1,400,000	1,400,000
Discharge Silencer	0	2	23,400	46,800
Drilling				
Complete Rig	0	Hire	30,000,000	

Water supply system (pumps, pipelines, tanks)	0	1	1,200,000	1,200,000
Site preparation equipment (dozer, grader, tipper trucks)	0	1	1,800,000	1,800,000
Small water rig	0	Hire		
General				
4x4 field vehicles	2	3	45,000	135,000
GIS System	0	1	85,000	85,000
Total station	0	1	15,000	15,000
Complete weather station	0	1	38,000	38,000
Total				**7,640,810**

(Source) Study Team

Table-13.8-1 Available and required professional skilled manpower in Uganda

	MEMD		DGSM		P ST		TOTAL	
Category	Avail.	Req.	Avail.	Req.	Avail.	Req.	Avail.	Req.
Geologists		2	9	6	0	0	9	8
Geochemists		1	8	3	0	1	8	5
Geophysicists		1	5	4			5	5
Reservoir Engineers		1	1	3	0	2	1	6
Drilling Engineers		1	0	4			0	5
Power Engineers		1	0	0	0	5	0	6
Environmental Scientists		1	1	4	0	1	1	6
Financial Planner/Modellers		1	0	1	0	1	0	3
GIS Scientist			0	2	0	1	0	3
Drillers			0	4			0	4
Technicians			4	6		20	4	26
Total	**0**	**9**	**28**	**37**	**0**	**31**	**28**	**77**

(Source) Study Team

Table-13.8-2 Available and required equipment in Uganda

Equipment Description	Available	Required	Unit cost in US$	Total Cost in US$
Geological				
Simple GPS	0	10	2,000	20,000
Digital Thermometer	0	5	1,800	9,000
Fluid Inclusion Heating-freezing stage	1	1	35,000	35,000
Binocular Microscope	2	2	20,000	40,000
Petrographic Microscope	2	2	35,000	70,000
X-Ray Diffractometer	1	1	65,000	65,000
X-Ray Fluorescence	0	1	65,000	65,000
ICP-MS equipment	1	1	68,000	68,000
Thin sectioning equipment	2	1	54,000	54,000
Geochemical				
Simple GPS	1	4	2,000	8,000
Digital Thermometer	1	4	1,800	7,200
pH meter	2	4	2,500	10,000
Conductivity Meter	2	4	4,500	18,000
Water Sampling Kit	1	1	2,000	2,000
Gas Sampling Kit	0	20	670	13,400
AAS equipment	1	1	65,000	65,000

Ion Chromatograph (IC)	1	0	65,000	-
Gas Chromatograph	0	1	65,000	65,000
Mass Spectrometer for stable Isotope	0	1	255,000	255,000
Tritium Scintillation counter & C14 analyser	0	1		
Geophysical				
Differential GPS	0	1	210,000	210,000
Simple GPS	0	2	2,000	4,000
TEM equipment	1	1	80,000	80,000
MT equipment	0	2	138,000	276,000
Gravimeter	1	0	160,000	-
Magnetometer	2	0	16,000	-
Portable seismometer	0	10	20,000	200,000
Reservoir Engineering				
Kuster gauge Tools set	0	10	13,000	130,000
Kuster TPS with SRO	0	2	425,000	850,000
Logging Winch	0	1	115,000	115,000
Logging Truck (K10)	0	1	1,400,000	1,400,000
Discharge Silencer	0	2	23,400	46,800
Drilling				
Complete Rig	1	Hire	30,000,000	

Water supply system (pumps, pipelines, tanks)	2	1	1,200,000	1,200,000
Site preparation equipment (dozer, grader, tipper trucks)	1	1	1,800,000	1,800,000
Small water rig	0	Hire		
General				
4x4 field vehicles	0	7	45,000	315,000
GIS System	0	1	85,000	85,000
Total station	0	1	15,000	15,000
Complete weather station	0	1	38,000	38,000
Total				**7,634,400**

(Source) Study Team

Chapter 14 Expected Government Action

14.1 Introduction

This chapter reviews the situation of each country that was described in the previous chapters, and proposes the action expected from the government in following the Road Map.

14.2 Kenya

14.2.1 Government Awareness of Geothermal Energy

Since Kenya has not discovered fossil fuel resources in its territory, geothermal energy is the least-cost energy in Kenya. In addition, since hydropower carries some risk of water shortages during droughts, Kenya recognizes geothermal energy as the main source of its future power supply. This recognition is clearly embodied in the Least-Cost Power Development Plan. The Least-Cost Power Development Plan 2009-2029 includes rapid development of geothermal energy to deliver about 1,578 MW by 2025 and about 2,746 MW by 2029 (Table-14.2-1)

14.2.2 Development Structure

The Kenyan geothermal development structure is strongly driven by the government. Up to 2008, while Kenya Electricity Generating Company (KenGen) was still the only geothermal development entity, the initial exploration surveys, including 6 exploration wells, were the responsibility of the government, and KenGen was the executing agent for the government.. In 2008, the Government of Kenya established a special-purpose company for geothermal development, Geothermal Development Corporation (GDC), with 100% of its shares held by the government. This means that the government bears the development risks of promoting steam development proactively in the country. GDC has the mission of developing geothermal steam and selling it either to private IPPs or to the state-run electric power company (KenGen). On the other hand, the government of Kenya (GoK) has granted two private companies the geothermal development concessions in two promising geothermal fields (Longonot field: AGIL Co. and Suswa field: WalAM). However, actual development by the two companies is not well advanced due to delays in negotiations, concluding PPAs and so on. Therefore the GoK has put a high priority on steam development by GDC in realizing the construction of the geothermal power plants anticipated in its development plan.

Table -14.2-1 Power Development Plan by 2029 （unit: MW）

Source	Geo	Hydro	MSD	GT	Coal	Wind	Others	Import	Total
New capacity	2,746 (36.8%)	224 (3.0%)	541 (7.2%)	450 (6.0%)	1,800 (24.1%)	155 (2.1%)	25 (0.3%)	1,530 (20.5%)	7,470 (100%)

(Source) KPLC (2008)

14.2.3 Geothermal Development Plan

Although Kenya has the above-mentioned power development plan, GDC has its own more challenging plan to develop 2,300MW of geothermal over 10 years and 4,000-5,000MW over 20 years. The details of this development plan are shown in Table-14.2-2. To realize this plan, GDC is estimating that 12 drilling rigs will be necessary and is requesting foreign assistance to obtain the necessary rigs. GDC also forecasts a need for funding of USD 2,567 million for the coming 10 years, as shown in Table-14.2-3. In addition, KenGen is also planning to develop geothermal power plants in Olkaria-IV, Olkaria-I and Eburru.

Table-14.2-2 GDC Well Drilling Plan during 2010～2019 (Units: MW, wells)

Field	MW	Wells	2010	2011	2012	2013	2014	2015	2016	2017	2018
Olkaria-IV	140	18	6	10	2						
Olkaria-I	140	23		5	8	10					
Menengai-I	140	41		8	15	15	3				
Menengai-II	140	40					12	15	13		
Menengai-III	140	40							2	15	15
Menengai-IV	140	40									
Menengai-V	140	40									
Menengai-VI	140	40									
Silali-I	140	40			14	15	12				
Silali-II	140	40					3	15	15	7	
Silali-III	140	40								8	15
Paka-I	140	41			8	15	15	3			
Paka-II	140	40						12	15	13	
Paka-III	140	40								2	15

(Source) GDC (2010)

Table-14.2-3 Rig Requirements

Rig Name	2009	2010	2011	2012	Remarks
HIRED-1,2,3	3				
GDC-1,2,3,4,5		5			GoK & China EXIM
GDC-6,7,8			3		AFD & French Gov.
GDC-9,10,11,12				4	GDC self finance
Total (cum.)	3	8	11	15	

（Source） GDC (2010)

Table-14.2-4 Resources required (10 year plan)

Rigs required	12 rigs
Number of wells	566 wells
Required skilled staff	912
Steam capacity	2,336 MW
Necessary financing	205 billion KSH (2,567 million USD)

（Source）GDC (2010)

14.2.4 Barriers to Geothermal Development

The biggest barrier standing in the way of Kenyan geothermal development is the difficulty of securing the necessary funding to carry out the ambitious plan. Since a large part of the necessary funding will be have to be found from the cash flow of GDC's business, it is necessary for GDC to jumpstart its activity. For this purpose, GDC needs substantial financial assistance from donor agencies. The second barrier to development is the shortage of technical manpower at GDC. It urgently needs to acquire the necessary manpower, especially skilled drilling engineers and technicians.

Table-14.2-5 10 year budget required (million US$)

Description	GOK	GDC (net revenue)	Development Partners	Total
Rigs & Equipment	130	177	205	512
Drilling Work	264	1,184	394	1,842
Scientific Services	25	58		83
Staff & Admin. Costs	28	102		130
Total	448 (17%)	1,520 (59%)	599 (23%)	2,567 (100%)

（Source）GDC (2010)

14.2.5 Donor Assistance

With the growing recognition of the importance of geothermal energy in Kenya, donor agencies are extending significant assistance to Kenya. Donor-funded programs of support to the Kenyan government are shown in Table-14.2-6.

Table-14.2-6 Programs supporting Geothermal projects (Kenya)

Dev.Partner	*Description*
UNU	UNU-GTP Training
UNEP	Joint geophysical imaging for geothermal exploration (completed)

IAEA	Isotope hydrology for exploration and management of geothermal resources in the Rift Valley System
AFD	- € 6 million for training and capacity building - Purchase of 2 rigs (€ 50 million) - Olkaria I & IV GPP (€ 150 million)
French Gov.	1 drilling rig
BGR	Geothermal II - Thermal mapping for northern Kenya (application prepared)
KfW	Olkaria I & IV GPP - € 150 million for plant construction - € 11 million for production drilling - € 11 million drilling service Olkaria IV
EIB	Olkaria I & IV GPP - € 200 million
World Bank	Olkaria I & IV GPP - $ 200 million
JICA	Olkaria I & IV GPP - $ 200 million
China EXIM	- $ 97 million for 130 sets of well materials - $ 90 million for purchase of 3 rigs - $ 95 million for drilling 26 wells in Olkaria I & IV

(Source) Peter (2010)

14.2.6 Proposed Actions to Follow the Road Map

In terms of policy framework, Kenya has already developed a wonderful development structure. This structure aims to exploit geothermal energy through a strong governmental initiative. The Kenyan structure is an admirable one for developing geothermal resources effectively, as described in Chapter 12, and can become a model for the other Africa 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 for the geothermal developmental of Kenya is procuring the necessary capital to support ambitious geothermal development. Strong support from the donor agencies is necessary in addition to Kenya government funds. The second challenge is to train the necessary geothermal engineers, scientists and technicians to support the positive geothermal development plan. To this end, GDC is availing itself of training opportunities in the UNU-GTP and is considering establishing its own training facility. It is necessary to speed up this training strategy.

14.3 Ethiopia

14.3.1 Government Awareness of Geothermal Energy

While it has abundant hydropower resources, Ethiopia fully recognizes the importance of energy source diversity in addressing the risk of the drought. Geothermal energy development is highly regarded as one of the most promising candidates for alternatives to hydropower. This recognition is widely shared among policy decision-makers including the Prime Minister himself. The government wants to see “something tangible” come from geothermal development. This means that the development of the 35MW power plant at Alto Langano has the highest priority.

14.3.2 Development Structure

Geothermal resource surveys are currently done by the Geological Survey of Ethiopia (GSE). GSE has a strong intention to spearhead geothermal energy development and, to this end, GSE has its own five-year geothermal development program. Ethiopian Electric Power Corporation (EEPCO) operates the pilot plant in Aluto Langano and has expressed its intention to participate in the proposed expansion plan for Aluto Langano. The Government of Ethiopia is considering developing geothermal energy mainly through EEPCO, but at the same time is working out a Feed-in Tariff bill that will facilitate indigenous energy development by the private sector.

14.3.3 Geothermal Development Plan

Ethiopia is forecasting power demand to grow at a high annual rate of 14%-17% in the future. This vigorous demand growth can be attributed to increasing access to electric power both in urban and rural areas. To respond to this power demand, EEPCO is planning to proactively develop hydropower plants. It is also eyeing the opportunity of selling power across its borders to Djibouti, Kenya and Sudan. However, EEPCO also recognizes the danger of relying too much on hydropower that loses generation ability when serious droughts take place. In order to address this concern the company intends to add geothermal power into its power source mix. According to EEPCO, Aluto Langano will be expanded to 35 MW in 2012, and five (5) other geothermal plants with total capacity of 375 MW are expected by 2018 (EEPCO (2009)). In response to these plans, GSE has elaborated the following 5-year program for 2009/10-2014/15:

(i) Steam development for power generation in Alto Langano field

(ii) Steam development for power generation in Tendaho field

(iii) Surface surveys including MT surveys in six (6) promising fields other than the two fields mentioned above.

14.3.4 Barriers to Geothermal Development

The first barrier to geothermal development in Ethiopia is the shortage of funds to execute the above geothermal development plan. The second barrier is the shortage of the technical capacity at GSE and EEPCO (shortage of MT equipment, directional drilling technology, resource evaluation technology and so on at GSE, and shortage of power plant operation and maintenance technology at EEPCO). In addition, of the lack of clarity concerning which organization is responsible for steam development is a defect in the development structure. Currently, GSE is in charge of resource surveys, but it is inappropriate for such a research institute to execute a large-scale resource development programme. EEPCO is better positioned to carry out such a development, but it has not fully developed its geothermal department, nor does it have sufficient development technology. Regarding the maintenance of the Aluto Langano pilot project, the Study Team observed a lack of clarity as to whether responsibility for steam-field activities fell to GSE or to EEPCO.

14.3.5 Donor Assistance

Against this background, donor agencies are strengthening their assistance to Ethiopian geothermal development. First of all, Japan offered non-project type grant aid of USD 10 million in March 2010 for the resource evaluation survey project in Aluto Langano. This grant is accompanied by a World Bank credit amounting to USD 10 million and an Ethiopian government contribution in kind equivalent to USD 10 million. Ethiopia will start resource evaluation (four exploration well drillings) with these funds in Alto Langano. In addition, BGR of Germany will support surface surveys in the Tendaho by carrying out detailed MT measurements as part of a technology transfer program at a cost of about EUR 300,000 in 2010 and 2011. If the results of this survey are positive, exploration drilling in Tendaho covered by KfW's Risk Mitigation Fund is expected afterwards. As mentioned elsewhere in this report, the African Union Commission (AUC) proposed the installation of a 5MW well-head generator in Tendaho using steam from the existing 3 shallow and 3 deep wells. AUC is looking for possible donor agencies to support this plan, although no donors have declared support to date.

Table-14.3-1 Support programs for Geothermal projects (Ethiopia)

Dev.Partner	*Description*
World Bank	Aluto Langano Reservoir Evaluation ($10m)
Japan	Aluto Langano Reservoir Evaluation ($10m)
BGR	Tendaho Surface survey (including MT survey and technology transfer)
UNU	UNU-GTP Training
Proposed by AUC	Tendaho 5 MW Well-head generators (proposal)

(Source) Study Team

14.3.6 Proposed Actions to Follow the Road Map

In order for the government of Ethiopia to promote geothermal development, the following actions would seem to be necessary. First of all, GoE should create a clear development structure. It is understood that for the Aluto Langano resource evaluation study being financed by the WB and the Japanese and Ethiopian governments, a new project office will be established in EEPCO. This new office is being established out of the realization that, for that project to succeed, a new well-focused structure is required. The Study Team proposes that Ethiopia use this opportunity to develop a dedicated geothermal department within EEPCO and to move the relevant current staff at GSE to this new department. Alternatively, a dedicated geothermal company could be formed which will undertake geothermal exploration and power station operations. Geothermal development projects definitely need an organization and management system that can handle a large amount of money efficiently, which is beyond the capabilities 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. Power plant construction is expected, following favorable drilling results. Resource surveys in other promising fields such as Abaya and Corbetti are also required. In addition, it is necessary to carry out a nationwide resource survey to select other promising fields for further development. It is hoped in this way to identify possible resource capacity in various other promising fields so that the Power Development Master Plan can include concrete geothermal projects. Moreover, the Study Team proposes that a geothermal development Road Map like the one proposed in this report be drawn up by GoE itself .

As far as technology is concerned, the training of technical professionals is indispensable. It will be necessary to recruit 250 engineers or more in the coming 10 years, according to the Study team's estimation. It will be necessary to make full use of training courses in UNU-GTP or other facilities. Moreover, it is necessary to expand the range of equipment available and to replace old and obsolete equipment. In particular, the procurement of four (4) drilling rigs will be needed in order to achieve the proposed capacity expansion, as resource surveying progresses.

14.4 Djibouti

14.4.1 Government Awareness of Geothermal Energy

Since Djibouti has no fossil fuel resources and is totally dependent on imported fuel, geothermal energy, which is the only indigenous energy resource the country has, is receiving very great attention from the government. The cost of imported fuel for power generation has increased over the years until it is estimated to have reached more than USD 200 million in 2007. Given that securing inexpensive power and water has the highest priority in Djibouti's policy, geothermal energy development is an urgent issue right now. There are several development projects on hold right now - water desalination in particular - because of the lack of sufficient low-priced power. Even though a transmission line between Ethiopia and Djibouti is almost complete, and importation costs have yet to be agreed, Djibouti strongly believes that it should develop its own geothermal resources in order to guarantee the security of its energy supply.

14.4.2 Development Structure

With six (6) exploration wells drilled already, the Asal field is the most advanced geothermal field in Djibouti. To promote Asal development, the Djibouti government had issued an exploration concession to an Icelandic private company, Reykjavik Energy Invest(REI). which is a subsidiary of Reykjavik Energy. However, because an agreement on the further development between GoD and REI was not reached, GoD began to look for another developer. GoD also began to solicit for funds from international fund sources such as the Arab Fund. The idea is for the Djibouti government to carry out the exploration drilling by itself in preparation for the possibility that no new private developer appears. As for later development of Asal, it has not yet been decided who will construct the power plant. There are many options available, including (a) development by GoD, (b) development by PPP, and (c) development by the private sector. In Lac Abhe field, an exploration concession for100 MW was given to an Indian company, Hydrocarbon Co. In other promising fields, CERD (the National Research Institute) is expected to execute the initial surface surveys. The development structure as development proceeds remains undecided.

14.4.3 Geothermal Development Plan

According to the Ministry of Energy and National Resources, the priority projects are as follows:

(i) Construction of a geothermal power plant in Asal

(ii) Development of the Lac Abhe area by Hydrocarbon

(iii) Exploration and construction of small-scale power plants in other promising fields and, in particular, in locations such as Chebelly, where power for cutting building stones will create gainful employment in that part of Djibouti.

(iv) Detailed surface exploration of other geothermal prospects.

14.4.4 Barriers to Geothermal Development

The barriers to geothermal development in Djibouti are;

(i) The shortage of capital necessary to execute the above geothermal development plan

(ii) The shortage of adequate and experienced professionals in the Ministry of Energy and Natural Resources, CERD and EdD (Electricité de Djibouti)

(iii) The lack of an autonomous and clearly defined organization with staff and an annual budget that is responsible for geothermal development.

(iv) Technical problems, such as high salinity brine and scaling in Asal field.

This last is a problem peculiar to Asal. The Asal field is located near the ocean, and there seem to be myriad cracks developing underground that enable seawater to penetrate into the field. Penetrating seawater is heated by geothermal heat and is increasing the density of various factors such as salinity and sulfides. As a result, the salinity of the geothermal brine has gone up to three times or more that of seawater. Salinity in brine causes corrosion of the equipment and requires the use of more expensive stainless steel or other alloys. Therefore, it is easy to foresee that this will negatively affect the economics of any power plant. In addition, the problem of sulfide scaling is even more formidable. A technical countermeasure to the sulfide scaling problem has yet to be found, either in Japan or in the

United States. There is a power plant in Japan where similar sulfide scaling is observed, but various measures examined have not succeeded yet in resolving the problem. Therefore, the only available choice currently is not to use this reservoir. Icelandic engineers have suggested, however, that the area where exploration drilling is planned might have relatively low salinity due to the independence of the reservoir there. If this is the case, then a technical solution might be available based on their experience in Iceland. Therefore, the most important thing is to drill exploration wells, as proposed by REI, to explore this possibility.

14.4.5 Donor Assistance

In Asal, REI executed a pre-feasibility study in 2007 and 2008 and IFC and other private financiers have committed to providing some portion of the equity for this project. However, REI had not drilled exploration wells before the time limit for concession was up in 2009, and an agreement to extend the concession was not reached because the conditions of development could not be agreed. Therefore, the Djibouti government is currently looking for new financing sources to drill exploration wells. The GoD expects the GoJ to extend technical assistance in the form of advisory and supervision services to monitor the exploration activities. In Lac Abhe, Hydrocarbon has been given a concession, but the actual work has not yet started. For other fields, there has been no offer of support from donor agencies so far.

Table-14.4-1 Support programs for Geothermal projects (Djibouti)

Dev.Partner	*Description*
Reykjavik Energy Investment (REI)	Asal Pre-F/S in 2007-2008. (Extension is not agreed yet.)
UNU	UNU-GTP Training

(Source) Study Team

14.4.6 Proposed Actions to Follow the Road Map

One of the barriers to geothermal development in Djibouti is the weak structure at the Ministry of Energy and Natural Resources, the ministry in charge of geothermal development policy. Currently, geothermal issues are dealt with by one (1) Secretary-General alone. 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 with geothermal that has the right qualified staff. This staff should elaborate a national geothermal policy, and the Study Team recommends that a geothermal law be enacted with clear licensing mechanism which would allow both private and public participation in geothermal generation. A more appropriate structure should be developed that supports geothermal development. 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 within EdD, with staff transferred from 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 is obviously dependent on whether the government can garner international donor support. On the other hand, there is still the option bringing in another IPP, because, fortunately, there is another 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 and how to proceed. Currently, there seems to be a discrepancy between what price the government is willing to pay for the power and what the IPPs are ready to accept. If the government wants to adopt development by IPPs, it should basically accept, after careful negotiation, the prices requested by the IPPs. In this case, the government certainly needs advisory support to conduct Power Purchase Agreement (PPA) negotiations and technical support during which local staff will work with consultants to learn the skills of negotiating project agreements and PPAs and supervising IPP performance. If the government does not accept the prices offered by the IPPs, it should take the option of creating a national geothermal developer, whether that might be EdD or a new company, and provide funds to develop the technological capacity of that national developer so that the developer can utilize low-cost funding to make geothermal energy as inexpensive as possible. Further, the government should consider adopting a strategy that aims at creating a vigorous, local geothermal industry within its own country by fostering this national geothermal developer as a local leading force for development.

On the resource development front, it is necessary for the government to promote resource surveys in fields other than Asal. It is recommended to first carry out a nationwide resource survey to choose the most promising fields. It is realistic to give CERD this responsibility, but if the government creates a new geothermal development entity, it is also appropriate to let the new entity carry out this nationwide survey. It is recommended to concentrate ODA funding into such a survey under government responsibility.

On the technical front, the training of more Djibouti professionals is important. The Study Team estimates that Djibouti will need 57 engineers within the next 10 years. These engineers should be trained in UNU-GTP or other training facilities as soon as possible. Also needed is the expansion and renewal of the equipment inventory. It will be necessary to be undertake these measures in parallel with the resource surveys.

14.5 Tanzania

14.5.1 Government Awareness of Geothermal Energy

While it has a variety of energy resources such as hydropower, natural gas and coal, Tanzania fully recognizes the importance of energy source diversity in addressing the risk of drought. In this regard, geothermal energy development is one of the most promising candidates. This recognition is highlighted in the statement in the Power System Master Plan 2009 update (July 2009) that “PSMP could include a 100 MW geothermal plant as a candidate in 2025 or later.” However, no geothermal power plant is planned in the "base case generation plan 2008-2033", since resource surveys have yet to clarify the possible power capacity.

14.5.2 Development Structure

The Renewable Energy Department of the Ministry of Energy and Minerals is in charge of renewable energy policy, and the Geological Survey of Tanzania (GST) within MEM, which is headquartered in Dodoma, is in charge of the exploration work. The GST has been carrying out surface surveys since the 1970's. However, no exploration wells have been drilled so far. Therefore, it remains to be decided who in Tanzania should lead the way in geothermal development.

14.5.3 Geothermal Development Plan

There are more than 50 geothermal prospects in Tanzania where surface manifestations (hot springs) have been observed. Among these prospects, the GST is paying special attention to such fields as (i) Rungwe (Mbeya), (ii) Rukwa, (iii) Luhoi (Rufiji basin), (iv) lake Natron, and (v) the Pangani Falls fault region. The GST has estimated the geothermal resource potential in the country to be more than 650MW. GST has the following development plan for geothermal:

(i) Continue surveys, including exploration drilling, in Mbeya field, where the BGR is providing support now.

(ii) Conduct nationwide surface exploration in other promising fields.

14.5.4 Barriers to Geothermal Development

According to the Ministry of Energy and Minerals and TANESCO (Tanzania Electricity Supply Company), the barriers to development in Tanzania can be summarized as follows:

(i) Lack of awareness among the policy decision-makers

Many policy decision-makers do not have enough knowledge of geothermal energy. Therefore, appropriate policy is not formulated. Moreover, the role of the various parties concerned (such as GoT, TANESCO, universities, private companies, etc.) is uncertain.

(ii) Insufficient technical capacity

There are around ten (10) experts in geothermal energy at GST and less than three (3) staff members at TANESCO who are well-trained in geothermal. There are few people whose specialty is geothermal energy.

(iii) Shortage of financing

The lack of funding determines the lack of activity and equipment at GST

(iv) Development structure

There is no legal basis for geothermal energy development (No geothermal law)

14.5.5 Donor Assistance

UNDP supported geothermal development until 1976. Its assistance was primarily for surface reconnaissance surveys. AfDB supported a Rural Electrification Study with a view to utilizing geothermal energy for rural electrification. BGR (Germany) supported a surface survey in Mbeya in 2006-2008 (Geotherm Program Phase-I). The Mbeya surface survey, including geochemical and geophysical (MT, TEM) surveys and analysis was supported with a EUR 340,000 budget (which included the personnel costs for the German experts). The report (BGR 2009) recommended that further detailed geophysical and geochemical surveys be conducted during Geotherm Program Phase-II in order to site exploration wells. The budget for this additional work is around EUR 300,000 and does not include exploration drilling. Tanzania is hoping that exploration wells will be drilled in order to move geothermal progamme forward. Tanzania has benefited to some extent from both the geothermal training course of UNU-GTP and the short course in Kenya.

Table-14.5-1 Support programs for Geothermal projects (Tanzania)

Dev.Partner	*Description*
UNDP	Surface surveys up to 1976
AfDB	Rural Electrification Study (geothermal as possible power source for rural electrification)
BGR	Supported surface survey in Mbeya (2006-2008). Geochemical, geophysical (MT、TEM etc.) survey and analysis. Geotherm Program Phase-II is scheduled in 2010. It does not include exploration drilling.
UNU	UNU-GTP Training

(Source) Study Team

14.5.6 Proposed Actions to Follow the Road Map

In proceeding with geothermal development, the first thing 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 more promising areas for further detailed surveys. Detailed exploration surveys with exploration well-drilling will also be needed in the selected areas. It will then be possible, on the basis of this survey information, to formulalte a road map for development.

On the policy front, in parallel with the nationwide resource assessment, a policy framework and development strategy should be developed An institutional structure which would be more effective in delivering the developments outlined by the roadmap should also be created. Given that no geothermal power station has been commissioned 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, as indicated in Table-13.7-1 in the previous chapter. The required staff will include drilling and reservoir engineers and related support staff. In the early stage of development, drilling rigs are not necessarily required, and a drilling contractor could be hired for this purpose, but government drilling engineers are necessary for directing and monitoring purposes. With positive results, more staff will be engaged to undertake drilling in order to reduce the future costs of development.

14.6 Uganda

14.6.1 Government Awareness of Geothermal Energy

While it also has abundant hydropower resources, Uganda fully recognizes the importance of energy source diversity in addressing the risk of drought. In this regard, geothermal energy is a promising energy source. This recognition is clearly highlighted in the intention expressed in the National Development Policy 2010/11-2014/15 (Government of Uganda 2010) to “study, design and build geothermal plants to generate 100 MW” over this period.

14.6.2 Geothermal Development Structure

The Geological Survey and Mines Department (GSMD) of the Ministry of Energy and Mineral Development (MEMD), often simply referred to as the Geological Survey of Uganda (GSU), is in charge of initial government surveys. The geothermal development structure is still open; which is to say that all kinds of development structures remain possible, such as development by a public developer, development by private IPPs or development by Public-Private-Partnership. The public utility, Uganda Electricity Generation Company Ltd (UEGCL), has shown interest in development of a geothermal power plant and has carefully studied the Kenyan situation, with particular attention to the governmental commitment and the establishment of GDC. At the same time, in order to promote geothermal development by the private sector, the government of Uganda is working out a Feed-in Tariff (FIT) system, which is currently in its final draft stage.

14.6.3. Geothermal Development Plan

According to its Project Profile paper presented to the Energy Sector Working Group, the intentions of the Geological Survey and Mines Department (GSMD) are as follows;

(i) to carry out a Pre-Feasibility Study in four promising fields (Katwe, Buranga, Kibiro, and Panyimurat, at an estimated cost of $2.6m)

(ii) to provide support in the formulation of policy and a regulatory framework, and in training ($400k)

(iii) to carry out a Feasibility Study (exploration drilling and testing) in one field (at an estimated cost of $17.2m).

14.6.4 Barriers to Geothermal Development

As in other countries, the following barriers are found:

(i) Institutional weakness, such as lack of clarity in development strategy

(ii) The shortage of the funding, equipment and manpower that hinders GSMD in executing geothermal development activities.

(iii) The shortage of fundamental technology at GSMD and UEGCL

14.6.5 Donor Assistance

(i) ICEIDA

ICEIDA assisted Pre-Feasibility Studies in Kibiro and Kikorongo (Katwe) fields during the period 2001-2009. United Nations University (UNU-GTP) has been providing training for geothermal professionals.

(ii) BGR/KfW (German Geological Institute/ German Development Bank)

BGR has supported some Pre-Feasibility Studies in Buranga. In addition, it has also supported some institutional development as well. In Geotherm-II some additional field studies are planned at Buranga, with the hope of supplying exploration drilling with KfW Risk Mitigation Fund (RMF) support. The proposed budget for RMF is about EUR 50 million and the Africa Infrastructure Fund of EU will co-finance it.

(iii) The prospects of four (4) promising fields according to donors' studies:

Kibiro: It is worth advancing further with additional detailed surveys and exploration drilling.

Katwe(Kikorongo): The capacity of the reservoir does not seem to be large.

Buranga: It is worth developing for small-scale power generation (10MW).

Panyimur: Surveys have not been carried out yet. The results of petroleum exploration drilling should be evaluated first, before any further work can be justified.

Table-14.6-1 Support programs for Geothermal projects (Uganda)

Dev.Partner	*Description*
ICEIDA	Kibiro and Kikorongo (Katwe): PreFS (2002-2009)
BGR	Buranga: Pre-FS Geotherm Program Phase II is scheduled Reservoir Evaluation stage (USD 10 million for drilling two wells)
KfW	Risk Mitigation Fund (under consideration)
UNU	UNU-GTP Training

(Source) Study Team

14.5.6 Proposed Actions to Follow the Road Map

Uganda needs to follow a similar strategy and take action much like Tanzania. Given that it is the wish of the government to develop the geothermal resources in Uganda, the first thing that 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 the drilling of 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. Based on the information collected in these surveys, a road map for government development can be formulated.

A comprehensive policy framework to realize this road map is required. In Uganda, privatization of the electric power sector is most advanced, 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 private participation in geothermal development in Uganda is unlikely under the current conditions, since there is not a single 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 Development) and take a leading role in the initial resource surveys. Once resource surveying is advanced and the results are promising, it is possible to strengthen Uganda Electric Generation Company Limited (UEGCL) sufficiently that it can undertake geothermal development under government initiative. This would be followed by private sector participation.

Additional manpower and training is required in order to achieve the roadmap. It would be appropriate for initial drilling to be done by a contractor, but the contractor needs to be supervised by qualified drilling engineers. New scientific equipment is also required to upgrade the geochemical laboratory, which has no equipment at all. When wells are drilled, the relevant reservoir engineering equipment for testing and evaluation will be needed. About USD 7.6 million is required for this purpose, as shown in Table-13.3-13 in the previous chapter.

Chapter 15 Recommendations to JICA

(This chapter shows a view of the Study Team and does not show either that of JICA or that with JICA's consent.)

15.1 Introduction

With a steady increase in electric power demand foreseen in the East African Rift region, geothermal energy is drawing great attention. The question the governments in the region face is how each country can best exploit this indigenous renewable energy. In this regard, the Study Team drew up a geothermal development Road Map country by country (see Chapter 11), and proposed the government action necessary to fulfill these Road Maps (see Chapter 12 to Chapter 14). In this chapter the Study Team proposes candidate projects that JICA could support.

15.2 Basic Philosophy

Nowadays, Japanese Official Development Assistance is said to be transforming from “ODA noted for its quantity” to “ODA noted for its quality”, with the ODA budget of Japan decreasing for the past several years. For the 2010 fiscal year, the budget is around 657 billion yen, which is 2% less than the previous year. As the world-biggest donor, Japan had been a leader in international development aid for in the decade of the 1990's. However, the ODA budget has decreased since around 2000, due to the adverse financial situation of the government. As a result, Japanese ODA fell to second place in 2007, following the U.S., and it is anticipated that Japan will be outstripped in the future by Germany, Britain and France, which have all increased their ODA budgets to fight terrorism and poverty. In these circumstances, identifying aid projects that satisfy the needs of recipient countries effectively and efficiently is essential.

On the other hand, there is an important advantage to the recent configuration of the Japanese ODA scheme: the flexibility of the scheme has increased. JICA and the former JBIC (OECF section) amalgamated in 2008 to form a new JICA. As result of this reorganization, the new JICA became an organization that could use three different assistance schemes, namely technical assistance, grant assistance and soft loan (yen loan) assistance. This made JICA into an integrated donor agency that could deal with projects from their formation to implementation in a consistent manner, as well as doing so over a shorter period of time. Moreover, it can carry out a new type of assistance scheme that combines soft loans and technical assistance. Thus, the Japanese ODA scheme has become a system that has more flexibility to meet the requirements of recipient countries than ever before. These advantages of the new Japanese ODA scheme should be fully exploited.

In addition, cooperation among donor agencies has become very important recently. A lot of organizations and donor agencies are participating already in assisting geothermal development in the

East African Rift region. As early as the 1980's, the World Bank was financing the geothermal power plants Olkaria-I and II in Kenya. The Bank is now supporting the Olkaria-IV (Olkaria Domes) geothermal project. Moreover, the African Rift System Geothermal Facility (ARGeo) was established with the support of the Global Environment Facility (GEF), KfW, and other donor agencies. Furthermore, the Icelandic government has also declared its support for geothermal development in Djibouti. In a similar manner, various other donor agencies have already started their support to geothermal development in this region. Therefore, it is necessary to adjust the assistance of each donor agency to avoid duplications. Cooperation among donor agencies is essential in assisting geothermal energy development in Africa.

As mentioned in Chapter 3, Japan was early to recognize the importance of African development, and is devoting its energies to the assistance of Africa. As a result, Africa is now a region that receives more Japanese assistance than any other region of the world. The Study Team hopes that Japan will harness the power of its ODA to help each government in the region to exploit geothermal energy.

The Study Team believes that the following three points are very important to keep in mind when JICA considers supporting geothermal exploitation in Africa. The first point is that "it is necessary for a technical training project to be followed by a large development project that employs the trainees." Up to now, the United Nations University geothermal training program (UNU-GTP) has played an important role in providing training to geothermal engineers and scientists, not only in the Africa region, but throughout the world. However, several cases have been reported of trainees who had taken a 6-month geothermal training course, only to be moved to other busier departments such as metallic minerals or oil and gas exploration when they returned to their home countries, because there were no on-going geothermal projects in their countries, thus wasting their training. These cases show the importance of the availability of actual development projects in which trainees can apply and hone their skills following appropriate training. In actual development projects, the trainees can confirm the newly-acquired knowledge and technology in their own working lives and develop them in their own individual ways. It is the belief of the Study Team that if there are no such actual projects to work on after training, the transferred technology cannot put down roots in the trainees' countries. Fortunately, JICA has become a powerful organization which is able to use three different assistance schemes (technical co-operation, grant aid and soft loan aid). It is necessary for JICA to leverage this advantage, and to formulate new comprehensive projects that combine training and development projects or to support new large projects that offer employment opportunities to already trained engineers.

The second important point to keep in mind is that "Kenya should be promoted as a showcase for successful geothermal development in Africa". Kenya has devised an admirable development structure under government initiative and is a front runner in Africa in exploiting geothermal energy. In order to promote geothermal development, it is very important to share with as many people as possible, including decision-makers, the unique advantages of geothermal energy, the nature of the barriers to its development, ideas concerning what kind of role the government should play, and so on. Since this kind of awareness constitutes a strong driver of geothermal development, it will be extremely effective to present Kenya to a wide audience as a paradigm for successful geothermal development in Africa. In a manner similar to the way many Asian countries like Korea, Taiwan, Singapore, ASEAN nations, and more recently China, have succeeded one after another in economic development following the successful example of Japan, Africa can follow the lead of Kenya. Also, one can expect to see more success stories, as Ethiopia, Djibouti, Tanzania and Uganda follow in the footsteps of Kenya to develop their geothermal resources. Strong support for Kenya today is the key to realizing this broader story of success in the future.

The third important point in supporting geothermal exploitation in Africa is "to create a new assistance scheme that resolutely mitigates geothermal development risks.” The biggest barrier to geothermal development is exploration risk, and it is impossible to overcome this risk without drilling exploration wells. However, the cost of drilling one exploration well is several million dollars, and there is always the very real possibility of failing to obtain usable steam. It is this fear that has caused many promising geothermal areas to remain unexplored in many countries. In order to expedite geothermal development in these areas, initial exploration drilling by the government is necessary, but since many governments in Africa do not have a sufficient financial base, ODA support is necessary to accomplish the necessary drilling. Conventional ODA schemes, however, very rarely approve this kind of request. For example, JICA’s Development Studies are its most suitable scheme for this survey, but there are difficulties in accommodating the needs of an expensive survey that includes exploration drilling, partly because the drilling costs exceed the budget limitations of the scheme, and partly because JICA hardly bears the risk of drilling failure. However, without the drilling of exploration wells, there cannot be any progress in geothermal development. In this regard, ARGeo and the German Development Bank (KfW) have recently each worked out their own risk mitigation assistance schemes. In response to this trend, JICA should consider initiating its own risk mitigation support assistance. Specifically, JICA should expand the budget limitations on its Development Study schemes to accomodate initial surveys, including exploration well drilling within the scheme.

15.3 Proposed JICA Support to Kenya

15.3.1 Basic Policy

The biggest issue in Kenya at present is to secure financing for the activities of GDC. It is necessary for JICA to extend strong financial support to Kenya so that Kenya can become a showcase for success in Africa. This financial support should take the form of soft loans that can provide a large amount of money. In addition to ordinary Project-type Loans, it is worth considering Sector Loans as well, so that JICA can support GDC’s activity flexibly. Moreover, grant aid for large-scale Development Studies that include exploration drilling should also be considered, if necessary. Support in enhancing technology capacity-building is also important. For this purpose, we recommend that geothermal training facilities be supported, because they will not only train Kenyans, but personnel from other countries as well. Ensuring that GDC and KenGen have the necessary equipment is also critical in driving geothermal development in Kenya.

15.3.2 Possible Projects

The following projects are listed up here as possible JICA projects.

Project No.	K-1	Country	Kenya
Project Name	Menengai Exploration Activity		
Project Outline	To provide large-scale financial support to the exploration activities of the Geothermal Development Company (GDC) in Menengai field through a Yen Loan in the form of a “sector loan” or “project loan”.		
Beneficiary	Geothermal Development Company (GDC)		
Scheme	Yen Loan	Category	Resource survey
Project Scale	Approx. 5 years USD 150～200 million		
Remarks			

Project No.	K-2	Country	Kenya
Project Name	Silali-I Pre Feasibility Study		
Project Outline	To carry out a pre feasibility study including MT survey in Silali – I field through the Development Study scheme.		
Beneficiary	Geothermal Development Company (GDC)		
Scheme	Development Study	Category	Resource survey
Project Scale	Approx. 2 years Approx. USD 2 million		
Remarks			

Project No.	K-3	Country	Kenya
Project Name	Provision of Two Drilling Rigs for GDC		
Project Outline	To provide two (2) drilling rigs for GDC through Yen loan financing. Technical assistance is included.		
Beneficiary	Geothermal Development Company (GDC)		
Scheme	Yen Loan	Category	Resource survey
Project Scale	Approx. 3 years Approx. USD 80 million		
Remarks			

Project No.	K-4	Country	Kenya
Project Name	Nationwide Resource Re-evaluation and Regulatory Framework Study		
Project Outline	(1) Nationwide Resource Re-evaluation Study - Re-evaluation of existing data - Additional MT survey - Drawing Road Map, etc. (2) Regulatory Framework Study - Model of field concessioning - Criteria for selection of private investors - Review of regulatory framework, etc.		
Beneficiary	Ministry of Energy, Geothermal Development Company (GDC)		
Scheme	Development Study	Category	Policy
Project Scale	Approx. 2 years USD 2-3 million		
Remarks			

Project No.	K-5	Country	Kenya
Project Name	Geothermal Training Center		
Project Outline	To support the Geothermal Training Center that is being considered by United Nations University, Kenya government and GDC. Support is needed for the establishment of the facility as well as for its operation. Since this is still at the planning stage, support for a feasibility study is necessary.		
Beneficiary	Geothermal Development Company (GDC), Ministry of Energy		
Scheme	Development Study	Category	Technical
Project Scale	2 years some USD 1 million (for F/S), 2 years some USD 10 million (establishment)		
Remarks	Cooperation with UNU, GDC and the Icelandic government is needed.		

Project No.	K-6	Country	Kenya
Project Name	Equipment provision to GDC, KenGen		
Project Outline	To provide necessary equipment to GDC and KenGen.		
Beneficiary	Geothermal Development Company (GDC), KenGen		
Scheme	Grant aid	Category	Technical / Financial
Project Scale	1 year, Approx. USD 10 to 25 million		
Remarks			

15.4 Proposed JICA Support to Ethiopia

15.4.1 Basic Policy

The biggest present concern in Ethiopia is promoting geothermal development in Aluto Langano, where resource exploration has started. Following exploration, the construction of a geothermal power plant, hopefully of 35 MW, is expected. Financial support for the construction stage is needed. This financial support should be in the form of a Yen Loan. However, since new loans are not available to Ethiopia due to its over-indebted situation, it is hoped that a ground-breaking solution can be found that enables new loans to be provided to Ethiopia, for example, through co-financing with other donors. The second most promising field in Ethiopia is Tendaho, but JICA can focus on support to other promising fields, since BGR of Germany is already supporting Tendaho development. In the next most promising fields, such as Abaya or Corbetti, it is appropriate to carry out exploration surveys including drilling. A large-scale Development Study is needed for this purpose. In addition, it would be wise to carry out a nationwide survey to identify other promising fields. Support for technology capacity enhancement is also important. For this purpose, equipment for the Geological Survey of Ethiopia (GSE) is also necessary to drive geothermal activities in Ethiopia. Furthermore, it is necessary to support policy framework development and institutional arrangements for effective geothermal development.

15.4.2 Possible Projects

The following projects are listed up here as possible JICA projects.

Project No.	E-1	Country	Ethiopia
Project Name	Aluto Langano Geothermal Power Plant Construction		
Project Outline	To provide financial support through a Yen Loan to construct Aluto Langano (35MW) geothermal power plant including production wells.		
Beneficiary	Ethiopia Electric Power Corporation (EEPCO)		
Scheme	Yen Loan	Category	Resource survey
Project Scale	Approx. 5 years Approx. USD 150 million		
Remarks			

Project No.	E-2	Country	Ethiopia
Project Name	Resource Exploration Survey (Abaya or Corbeeti)		
Project Outline	To carry out exploration surveys including drilling two (2) to four (4) exploration wells in Abaya or Corbetti through the Development Study scheme.		
Beneficiary	Geological Survey of Ethiopia (GSE)		
Scheme	Development Study	Category	Resource survey
Project Scale	Approx. 3 years Approx. USD 10-20 million		

Remarks	

Project No.	E-3	Country	Ethiopia
Project Name	Nationwide Resource Re-evaluation Study		
Project Outline	To carry out Nationwide Resource Re-evaluation Study including; - Re-evaluation of existing data, - Additional MT survey - Drawing up a Road Map, etc.		
Beneficiary	Geological Survey of Ethiopia (GSE)		
Scheme	Development Study	Category	Resource survey
Project Scale	Approx. 2 years Approx. USD 2 million		
Remarks			

Project No.	E-4	Country	Ethiopia
Project Name	Equipment Provision to GSE, EEPCO		
Project Outline	To provide necessary equipment to GSE and EEPCO.		
Beneficiary	Geological Survey of Ethiopia (GSE), Ethiopia Electric Power Corporation (EEPCO)		
Scheme	Grant aid	Category	Technical / Financial
Project Scale	1 years, Approx. USD 5 million		
Remarks			

Project No.	E-4	Country	Ethiopia
Project Name	Regulatory Framework Study		
Project Outline	To develop a regulatory framework for geothermal policy, the following are to be studied: - Drawing up a Road Map, - Institutional arrangements - Review of regulatory framework, etc.		
Beneficiary	Ministry of Energy and Minerals (MEM)		
Scheme	Development Study	Category	Policy
Project Scale	Approx. 1-2 years Approx. USD 1 million		
Remarks			

15.5 Proposed JICA Support to Djibouti

15.5.1 Basic Policy

Currently, the most important issue in Djibouti is the development of the Asal field. Reykjavik Energy Investment (REI), the international development and business arm of Reykjavik Energy of Iceland, has executed a pre-feasibility study in this field. Moreover, International Finance Corporation (IFC) is also expressing support for the project. However, a development agreement between the Djibouti government and REI has not been reached as yet. Therefore, in parallel with its negotiations with REI, the government of Djibouti is considering undertaking the development by itself. To this end, the GoD is soliciting for funds for exploration drilling, for which the GOD is expecting technical assistance from Japan. The Asal field suffers from the technical problems of high salinity and sulfide scaling, and it is not known whether available technology can solve these problems or not. In any case, 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 the drilling of more exploratory wells. Therefore, the Study Team proposes that a resource survey including exploration well drilling be carried out to examine the possibility of development. For this survey, it will be necessary to form an international expert team, including Icelandic experts who have experience with these problems. However, if the GoD is successful in obtaining the funding it is already seeking from other donors for this purpose, it would be wise to use those funds instead.

The development of other fields is also important. In this regard, a nationwide reconnaissance survey is recommendable. Support for enhanced technology capacity is also important. For this purpose, equipment for CERD will also be necessary to drive geothermal activities in Djibouti.

15.5.2 Possible Projects

The following projects are listed up here as possible JICA projects.

Project No.	D-1	Country	Djibouti
Project Name	Feasibility Study for Asal Field		
Project Outline	To carry out a feasibility study for Asal project. This study includes two (2) to four (4) exploration wells to confirm the characteristics of the steam and brine. Based on the results, a development strategy (including possible abandonment of the project) is to be elaborated.		
Beneficiary	Ministry of Energy and Natural Resources (MENR)		
Scheme	Large-scale Development Study	Category	Resource survey
Project Scale	Approx. 3 years Approx. USD 20 million or 2 million (if GOD obtains drilling funds)		
Remarks	International experts are necessary		

Project No.	D-2	Country	Djibouti
Project Name	Nationwide Resource Re-evaluation Study		
Project Outline	To carry out a Nationwide Resource Re-evaluation Study including; - Re-evaluation of existing data, - Additional MT survey - Drawing up a Road Map, etc.		
Beneficiary	Centre de Recherche Scientifique de Djibouti (CERD)		
Scheme	Development Study	Category	Resource survey
Project Scale	Approx. 2 years Approx. USD 2 million		
Remarks			

Project No.	D-3	Country	Djibouti
Project Name	Resource Exploration Survey (in promising field chosen by Nationwide survey)		
Project Outline	To carry out an exploration survey including drilling two (2) to four (4) exploration wells in a promising field chosen through a nationwide survey.		
Beneficiary	Centre de Recherche Scientifique de Djibouti (CERD)		
Scheme	Development Study	Category	Resource survey
Project Scale	Approx. 3 years Approx. USD 10-20 million		
Remarks			

Project No.	D-4	Country	Djibouti
Project Name	Equipment Provision to CERD, EdD		
Project Outline	To provide necessary equipment to CERD and EdD		
Beneficiary	Centre de Recherche Scientifique de Djibouti (CERD), Electricité de Djibouti (EdD)		
Scheme	Grant aid	Category	Technical / Financial
Project Scale	1 years, Approx. USD 7.5 million		
Remarks			

Project No.	D-5	Country	Djibouti
Project Name	Regulatory Framework Study		
Project Outline	To develop a regulatory framework for geothermal policy, the following are to be studied: - Drawing up a Road Map,		

	- Institutional arrangements - Review of regulatory framework, etc.		
Beneficiary	Ministry of Energy and Natural Resources (MENR)		
Scheme	Development Study	Category	Policy
Project Scale	Approx. 1-2 years Approx. USD 1 million		
Remarks			

15.6 Proposed JICA Support to Tanzania

15.6.1 Basic Policy

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. In the selected fields it will subsequently be necessary to carry out exploration drilling. JICA is expected to support these surveys from both the technical and financial sides. In order to support exploration drilling, it is necessary to approve a large-scale Development Study. Moreover, support for enhancing technology capacity is also important. To this end, funding necessary equipment for the Geological Survey of Tanzania is also expected to drive geothermal activities in Tanzania.

15.6.2 Possible Projects

The following projects are listed up here as possible JICA projects.

Project No.	T-1	Country	Tanzania
Project Name	Nationwide Resource Re-evaluation Study		
Project Outline	To carry out a Nationwide Resource Re-evaluation Study including; - Re-evaluation of existing data, - Additional MT survey - Drawing up a Road Map, etc.		
Beneficiary	Geological Survey of Tanzania (GST)		
Scheme	Development Study	Category	Resource survey
Project Scale	Approx. 2 years Approx. USD 2 million		
Remarks			

Project No.	T-2	Country	Tanzania
Project Name	Resource Exploration Survey (of promising field chosen by Nationwide survey)		
Project Outline	To carry out an exploration survey including drilling two (2) to four (4) exploration wells in a promising field chosen through a nationwide survey.		
Beneficiary	Geological Survey of Tanzania (GST)		
Scheme	Development Study	Category	Resource survey

Project Scale	Approx. 3 years Approx. USD 10-20 million
Remarks	

Project No.	T-3	Country	Tanzania
Project Name	Provision of Equipment to GST and TANESCO		
Project Outline	To provide necessary equipment to GST and TANESCO		
Beneficiary	Geological Survey of Tanzania (GST), Tanzania Electric Supply Corporation (TANESCO)		
Scheme	Grant aid	Category	Technical / Financial
Project Scale	1 years, Approx. USD 7.5 million		
Remarks			

Project No.	T-4	Country	Tanzania
Project Name	Regulatory Framework Study		
Project Outline	To develop a regulatory framework for geothermal policy, the following are to be studied: - Drawing up a Road Map, - Institutional arrangements - Review of regulatory framework, etc.		
Beneficiary	Ministry of Energy and Minerals (MEM)		
Scheme	Development Study	Category	Policy
Project Scale	Approx. 1-2 years Approx. USD 1 million		
Remarks			

15.7 Proposed JICA Support to Uganda

15.7.1 Basic Policy

Uganda is similar to Tanzania, and therefore the strategy should be to promote resource surveys in various promising fields. Specifically, it is recommended that the results of previous studies in Kibiro field which recommended further MT surveys be followed up with exploration drilling. In order to find other promising fields, it is necessary to carry out a nationwide reconnaissance survey followed by exploration drilling in the most promising fields.. JICA is expected to support these surveys from both the technical and financial sides. In order to support exploration drilling, it is necessary to approve a large-scale Development Study. Moreover, support to enhance technology capacity is also important. To this end, funding machinery and equipment for the Geological Survey and Mines Department of Uganda (GSMD) is also expected to drive geothermal activities in Uganda.

15.7.2 Possible Projects

The following projects are listed up here as possible JICA projects.

Project No.	U-1	Country	Uganda
Project Name	Resource Exploration Survey in Kibiro		
Project Outline	To carry out an exploration survey including drilling two (2) to four (4) exploration wells in Kibiro field.		
Beneficiary	Geological Survey and Mines Department of Uganda (GSMD)		
Scheme	Development Study	Category	Resource survey
Project Scale	Approx. 3 years Approx. USD 10-20 million		
Remarks			

Project No.	U-2	Country	Uganda
Project Name	Nationwide Resource Re-evaluation Study		
Project Outline	To carry out a Nationwide Resource Re-evaluation Study including; - Re-evaluation of existing data, - Additional MT survey - Drawing up a Road Map, etc.		
Beneficiary	Geological Survey and Mines Department of Uganda (GSMD)		
Scheme	Development Study	Category	Resource survey
Project Scale	Approx. 2 years Approx. USD 2 million		
Remarks			

Project No.	U-3	Country	Uganda
Project Name	Provision of Equipment to GSMD		
Project Outline	To provide necessary equipment to the Geological Survey of Uganda (GSU)		
Beneficiary	Geological Survey and Mines Department of Uganda (GSMD)		
Scheme	Grant aid	Category	Technical / Financial
Project Scale	1 year, Approx. USD 7.5 million		
Remarks			

Project No.	U-4	Country	Uganda
Project Name	Regulatory Framework Study		

Project Outline	To develop a regulatory framework for geothermal policy, the following are to be studied: - Drawing up a Road Map, - Institutional arrangements - Review of regulatory framework, etc.		
Beneficiary	Ministry of Energy and Mines Department (MEMD)		
Scheme	Development Study	Category	Policy
Project Scale	Approx. 1-2 years Approx. USD 1 million		
Remarks			

15.8 Proposed JICA Support to Regional Initiatives

15.7.1 Basic Policy

In order to promote geothermal development in the East African Rift region, in addition to support for individual government programs, support to the whole region is necessary, and support for training programs is one of the main forms that regional projects can take.

15.7.2 Possible Projects

The following projects are listed up here as possible JICA projects.

Project No.	R-1	Country	Region
Project Name	Training Support in UNU-GTP (6 months training)		
Project Outline	To provide financing together with UNU-GTP to admit engineers from each country to UNU-GTP for 6 months. Training in UNU-GTP of Iceland is playing a big role in developing skilled engineers not only in Africa, but around the world. The UNU-GTP is planning to expand its training capacity from the current level of 20 trainees to 30 trainees. However, financial support from Icelandic government is limited. Therefore, JICA is expected to support this expansion. (Cost USD 40,000 per trainee; 5 trainees from Africa every year for 5 years)		
Beneficiary	United Nations University (and/or each country)		
Scheme	Technical assistance, Contribution to UN etc.	Category	Technical capacity
Project Scale	Approx. 5 years Approx. USD 1 million		
Remarks	Coordination with UNU and the Icelandic government is needed.		

Project No.	R-2	Country	Region
Project Name	Training Support in UNU-GTP and GDC (short course training)		

Project Outline	To provide financing to UNU-GTP and GDC to accept engineers from each country into the UNU-GTP / GDC short course training in Naivasha, Kenya. Training in UNU-GTP/GDC plays a complementary role to the 6-month course of UNU-GTP. The UNU-GTP and GDC are planning to hold a short course in Naivasha, Kenya. However, financial support from the Icelandic government and Kenyan government is limited. Therefore, JICA is expected to support this course. (Cost USD 4,000 per trainee; 50 trainees from Africa each year for 5 years)		
Beneficiary	United Nations University (and/or each country)		
Scheme	Technical assistance, Contribution to UN etc.	Category	Technical capacity
Project Scale	Approx. 5 years Approx. USD 1 million		
Remarks	Coordination with UNU, the Icelandic government and the Kenyan government is needed.		

Project No.	R-3	Country	Region
Project Name	Dispatch professionals and decision-makers to International Conferences		
Project Outline	Participating in international geothermal conferences such as ARGeo , the International Geothermal Association Conference, the World Geothermal Conference, etc. is a good opportunity for African engineers to enhance their knowledge and technology. Therefore, JICA is expected to provide support to each government to dispatch engineers to these international conferences. (Cost USD 5,000 per trainee; 20 trainees from Africa each year for 5 years)		
Beneficiary	Each country involved		
Scheme	Technical assistance	Category	Technical capacity
Project Scale	Approx. 5 years Approx. USD 0.5 million		
Remarks			

Project No.	R-4	Country	Region
Project Name	Advanced Technology Training in Japan		
Project Outline	Training in advanced technologies such as reservoir simulation is to be carried out at Japanese universities or companies. JICA is expected to provide support to each government to dispatch engineers and scientists or professionals to this advanced technology training in Japan leading to an MSc or PhD degree. (Cost for trainees USD 50,000 per trainee; 5 trainees from Africa each year for 5 years) (Cost for trainers USD 0.5-1.0 million)		
Beneficiary	Each country involved		

Scheme	Technical assistance	Category	Technical capacity
Project Scale	Approx. 5 years Approx. USD 2 million		
Remarks	This scheme needs to program appropriate compensation for the universities or companies carrying out the training, otherwise it is very difficult to find excellent trainers. The universities or companies that could provide training courses of advanced geothermal technology are: Kyushu University, Tohoku University, Akita University, Hirosaki University, Advanced Industrial Science and Technology (AIST), Kyushu Electric Power Co., West Japan Engineering Consultants Inc., and so on. In in-depth feasibility study for this training is needed.		

Chapter 16

This report describes the current state of geothermal development activities in the East African Rift region, discusses road maps for future development, and presents recommendations for JICA support of these activities. In the interviews conducted for this study, the Study Team could sense a very strong expectation for the future of geothermal in the people concerned with the geothermal development of each country. However, it remains true that actual geothermal development has not been advancing as quickly as expected because of the inherent uncertainty and risk involved in the development of underground resources. The keys to solving this problem, as laid out in this report, are appropriate technology, adequate financing, and strong will on the part of government. With these three conditions satisfied, geothermal development will start to move forward. As development starts to move forward, the countries involved will acquire more knowledge and will accumulate experience. The learning effect seen in this process will enable each country to make development more efficient and less expensive in the next iteration of development. Through this virtuous circle, geothermal technology will gradually be accumulated in each country and will eventually lead to the creation of a strong local technical base for further development.

Geothermal power plants run on steam with a lower temperature and pressure than the steam employed in state-of-the-art coal-fired or natural gas-fired power plants. Therefore, there is a possibility that the small pipes and small containers of geothermal power plants could be produced with local technology in the future, although it is rather challenging technology. Moreover, if drilling is done by local contractors, the major portion of an investment in drilling will circulate in the domestic economy. A study shows that, for plants of the same capacity, construction of a geothermal power plant provides 4.3 times more stimulus to the local economy than a coal-fired power plant and produces 2.5 times more domestic employment, because there is greater procurement of goods and services from the domestic market in geothermal plant construction than for coal-fired plants[1].

It would be wonderful if energy development could also contribute to local economic development and create local employment at the same time. Geothermal energy is energy that has this potential. The Study Team will be very much satisfied if this report makes a small contribution to advancing the geothermal energy development of the East African Rift region.

[1] JICA "A Study on Fiscal and Non-fiscal Incentives for Geothermal and other Renewable Energy Development in the Republic of Indonesia" (July, 2009)

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APPENDIX-1 Country Index (Natural Environment)

Country	Kenya	Djibouti	Ethiopia	Tanzania	Uganda
Area:	total: 580,367 sq km	total: 23,200 sq km	total: 1,104,300 sq km	total: 947,300 sq km	total: 241,038 sq km
Climate:	varies from tropical along coast to arid in interior	desert; torrid, dry	tropical monsoon with wide topographic-induced variation	varies from tropical along coast to temperate in highlands	tropical; generally rainy with two dry seasons (December to February, June to August); semiarid in northeast
Natural resources:	limestone, soda ash, salt, gemstones, fluorspar, zinc, diatomite, gypsum, wildlife, hydropower	geothermal areas, gold, clay, granite, limestone, marble, salt, diatomite, gypsum, pumice, petroleum	small reserves of gold, platinum, copper, potash, natural gas, hydropower	hydropower, tin, phosphates, iron ore, coal, diamonds, gemstones, gold, natural gas, nickel	copper, cobalt, hydropower, limestone, salt, arable land, gold
Land use:	arable land: 8.01% permanent crops: 0.97% other: 91.02% (2005)	arable land: 0.04% permanent crops: 0% other: 99.96% (2005)	arable land: 10.01% permanent crops: 0.65% other: 89.34% (2005)	arable land: 4.23% permanent crops: 1.16% other: 94.61% (2005)	arable land: 21.57% permanent crops: 8.92% other: 69.51% (2005)
Irrigated land:	1,030 sq km (2003)	10 sq km (2003)	2,900 sq km (2003)	1,840 sq km (2003)	90 sq km (2003)
Total renewable water resources:	30.2 cu km (1990)	0.3 cu km (1997)	110 cu km (1987)	91 cu km (2001)	66 cu km (1970)
Freshwater withdrawal (domestic/industrial/agricultural):	total: 1.58 cu km/yr (30%/6%/64%)	total: 0.02 cu km/yr (84%/0%/16%)	total: 5.56 cu km/yr (6%/0%/94%)	total: 5.18 cu km/yr (10%/0%/89%)	total: 0.3 cu km/yr (43%/17%/40%)
	per capita: 46 cu m/yr (2000)	per capita: 25 cu m/yr (2000)	per capita: 72 cu m/yr (2002)	per capita: 135 cu m/yr (2000)	per capita: 10 cu m/yr (2002)
Natural hazards:	recurring drought; flooding during rainy seasons	earthquakes; droughts; occasional cyclonic disturbances from the Indian Ocean bring heavy rains and flash floods	geologically active Great Rift Valley susceptible to earthquakes, volcanic eruptions; frequent droughts	flooding on the central plateau during the rainy season; drought	NA
Environment - current issues:	water pollution from urban and industrial wastes; degradation of water quality from increased use of pesticides and fertilizers; water hyacinth infestation in Lake Victoria; deforestation; soil erosion; desertification; poaching	inadequate supplies of potable water; limited arable land; desertification; endangered species	deforestation; overgrazing; soil erosion; desertification; water shortages in some areas from water-intensive farming and poor management	soil degradation; deforestation; desertification; destruction of coral reefs threatens marine habitats; recent droughts affected marginal agriculture; wildlife threatened by illegal hunting and trade, especially for ivory	draining of wetlands for agricultural use; deforestation; overgrazing; soil erosion; water hyacinth infestation in Lake Victoria; widespread poaching
Environment - international agreements:	party to: Biodiversity, Climate Change, Climate Change-Kyoto Protocol, Desertification, Endangered Species, Hazardous Wastes, Law of the Sea, Marine Dumping, Marine Life Conservation, Ozone Layer Protection, Ship Pollution, Wetlands, Whaling	party to: Biodiversity, Climate Change, Climate Change-Kyoto Protocol, Desertification, Endangered Species, Hazardous Wastes, Law of the Sea, Ozone Layer Protection, Ship Pollution, Wetlands	party to: Biodiversity, Climate Change, Climate Change-Kyoto Protocol, Desertification, Endangered Species, Hazardous Wastes, Ozone Layer Protection	party to: Biodiversity, Climate Change, Climate Change-Kyoto Protocol, Desertification, Endangered Species, Hazardous Wastes, Law of the Sea, Ozone Layer Protection, Wetlands	party to: Biodiversity, Climate Change, Climate Change-Kyoto Protocol, Desertification, Endangered Species, Hazardous Wastes, Law of the Sea, Marine Life Conservation, Ozone Layer Protection, Wetlands
	signed, but not ratified: none of the selected agreements	signed, but not ratified: none of the selected agreements	signed, but not ratified: Environmental Modification, Law of the Sea	signed, but not ratified: none of the selected agreements	signed, but not ratified: Environmental Modification

APPENDIX-1 Country Index (Social Environment)

Country	Kenya	Djibouti	Ethiopia	Tanzania	Uganda
Population:	39,002,772	724,622 (July 2009 est.)	85,237,338	41,048,532	32,369,558
Age structure:	0-14 years: 42.3% (male 8,300,393/female 8,181,898)	0-14 years: 36.3% (male 131,878/female 131,449)	0-14 years: 46.1% (male 19,596,784/female 19,688,887)	0-14 years: 43% (male 8,853,529/female 8,805,810)	0-14 years: 50% (male 8,152,830/female 8,034,366)
	15-64 years: 55.1% (male 10,784,119/female 10,702,999)	15-64 years: 60.4% (male 194,503/female 243,495)	15-64 years: 51.2% (male 21,376,495/female 22,304,812)	15-64 years: 54.1% (male 10,956,133/female 11,255,868)	15-64 years: 47.9% (male 7,789,209/female 7,703,143)
	65 years and over: 2.6% (male 470,218/female 563,145) (2009 est.)	65 years and over: 3.2% (male 10,462/female 12,835) (2009 est.)	65 years and over: 2.7% (male 975,923/female 1,294,437) (2009 est.)	65 years and over: 2.9% (male 513,959/female 663,233) (2009 est.)	65 years and over: 2.1% (male 286,693/female 403,317) (2009 est.)
Population growth rate:	2.691% (2009 est.)	2.164% (2009 est.)	3.208% (2009 est.)	2.04% (2009 est.)	2.692% (2009 est.)
Birth rate:	36.64 births/1,000 population (2009 est.)	26.34 births/1,000 population (2009 est.)	43.66 births/1,000 population (2009 est.)	34.29 births/1,000 population (2009 est.)	47.84 births/1,000 population (2009 est.)
Death rate:	9.72 deaths/1,000 population (July 2009 est.)	8.53 deaths/1,000 population (July 2009 est.)	11.55 deaths/1,000 population (July 2009 est.)	12.59 deaths/1,000 population (July 2009 est.)	12.09 deaths/1,000 population (July 2009 est.)
Urbanization:	urban population: 22% of total population (2008)	urban population: 87% of total population (2008)	urban population: 17% of total population (2008)	urban population: 25% of total population (2008)	urban population: 13% of total population (2008)
Sex ratio:	total population: 1 male(s)/female (2009 est.)	total population: 1.04 male(s)/female (2009 est.)	total population: 0.97 male(s)/female (2009 est.)	total population: 0.98 male(s)/female (2009 est.)	total population: 1 male(s)/female (2009 est.)
Infant mortality rate:	total: 54.7 deaths/1,000 live births	total: 58.33 deaths/1,000 live births	total: 80.8 deaths/1,000 live births	total: 69.28 deaths/1,000 live births	total: 64.82 deaths/1,000 live births
Life expectancy at birth:	total population: 57.86 years	total population: 60.32 years	total population: 55.41 years	total population: 52.01 years	total population: 52.72 years
Total fertility rate:	4.56 children born/woman (2009 est.)	2.92 children born/woman (2009 est.)	6.12 children born/woman (2009 est.)	4.46 children born/woman (2009 est.)	6.77 children born/woman (2009 est.)
Ethnic groups:	Kikuyu 22%, Luhya 14%, Luo 13%, Kalenjin 12%, Kamba 11%, Kisii 6%, Meru 6%, other African 15%, non-African (Asian, European, and Arab) 1%	Somali 60%, Afar 35%, other 5% (includes French, Arab, Ethiopian, and Italian)	Oromo 32.1%, Amara 30.1%, Tigraway 6.2%, Somalie 5.9%, Guragie 4.3%, Sidama 3.5%, Welaita 2.4%, other 15.4% (1994 census)	mainland - African 99% (of which 95% are Bantu consisting of more than 130 tribes), other 1% (consisting of Asian, European, and Arab); Zanzibar - Arab, African, mixed Arab and African	Baganda 16.9%, Banyakole 9.5%, Basoga 8.4%, Bakiga 6.9%, Iteso 6.4%, Langi 6.1%, Acholi 4.7%, Bagisu 4.6%, Lugbara 4.2%, Bunyoro 2.7%, other 29.6% (2002 census)
Religions:	Protestant 45%, Roman Catholic 33%, Muslim 10%, indigenous beliefs 10%, other 2%	Muslim 94%, Christian 6%	Christian 60.8% (Orthodox 50.6%, Protestant 10.2%), Muslim 32.8%, traditional 4.6%, other 1.8% (1994 census)	mainland - Christian 30%, Muslim 35%, indigenous beliefs 35%; Zanzibar - more than 99% Muslim	Roman Catholic 41.9%, Protestant 42% (Anglican 35.9%, Pentecostal 4.6%, Seventh Day Adventist 1.5%), Muslim 12.1%, other 3.1%, none 0.9% (2002 census)
Literacy:	total population: 85.1%	total population: 67.9%	total population: 42.7%	total population: 69.4%	total population: 66.8%
School life expectancy (primary to tertiary education):	total: 10 years	total: 4 years	total: 8 years		total: 10 years
Education expenditures:	6.9% of GDP (2006)	8.4% of GDP (2006)	6% of GDP (2006)	2.2% of GDP (1999)	5.2% of GDP (2004)

APPENDIX-1 Country Index (Economy)

Country	Kenya	Djibouti	Ethiopia	Tanzania	Uganda
GDP (purchasing power parity): (2009USD)	$63.52 billion (2009 est.)	$2.039 billion (2009 est.)	$75.91 billion (2009 est.)	$57.5 billion (2009 est.)	$42.18 billion (2009 est.)
GDP (official exchange rate):	$30.21 billion (2009 est.)	$1.089 billion (2009 est.)	$33.92 billion (2009 est.)	$22.16 billion (2009 est.)	$15.66 billion (2009 est.)
GDP - real growth rate:	1.8% (2009 est.)	6.5% (2009 est.)	6.8% (2009 est.)	4.5% (2009 est.)	4% (2009 est.)
Labor force:	17.47 million (2009 est.)	351,700 (2007)	37.9 million (2007)	21.23 million (2009 est.)	15.01 million (2009 est.)
Unemployment rate:	40% (2008 est.)	59% (2007 est.)	NA%	NA% est.)	NA% est.)
Population below poverty line:	50% (2000 est.)	42% (2007 est.)	38.7% (FY05/06 est.)	36% (2002 est.)	35% (2001 est.)
Distribution of family income - Gini index:	42.5 (2008 est.)		30 (2000)	34.6 (2000)	45.7 (2002)
Investment (gross fixed):	21.5% of GDP (2009 est.)		23.1% of GDP (2009 est.)	18.1% of GDP (2009 est.)	19.7% of GDP (2009 est.)
Budget:	revenues: $6.858 billion expenditures: $8.759 billion (2009 est.)	revenues: $135 million expenditures: $182 million (1999 est.)	revenues: $4.678 billion expenditures: $5.36 billion (2009 est.)	revenues: $3.78 billion expenditures: $4.693 billion (2009 est.)	revenues: $2.007 billion expenditures: $2.508 billion; including capital expenditures of $NA (2009 est.)
Inflation rate (consumer prices):	20.5% (2009 est.)	5% (2007 est.)	11% (2009 est.)	11.6% (2009 est.)	12.6% (2009 est.)
Central bank discount rate:	NA% (31 December 2008)	NA 11.56% (31 December 2008)	NA% (31 December 2008)	15.99% (31 December 2008)	19.42% (31 December 2008)
Commercial bank prime lending rate:	14.02% (31 December 2008)		8% (31 December 2008)	14.98% (31 December 2008)	20.45% (31 December 2008)
Exports:	$4.479 billion (2009 est.)	$340 million (2006)	$1.608 billion (2009 est.)	$2.744 billion (2009 est.)	$3.151 billion (2009 est.)
Exports - partners:	UK 10.2%, Netherlands 9.4%, Uganda 9.1%, Tanzania 8.9%, US 6.4%, Pakistan 5.7% (2008)	Somalia 79.9%, UAE 4.1%, Yemen 4.1% (2008)	Germany 11.8%, Saudi Arabia 8.7%, Netherlands 8.6%, US 8.1%, Switzerland 7.7%, Italy 6.1%, China 6%, Sudan 5.5%, Japan 4.4% (2008)	India 9.1%, Japan 6.5%, China 6.3%, UAE 5.7%, Netherlands 5.5%, Germany 5.1% (2008)	Sudan 14.3%, Kenya 9.5%, Switzerland 9%, Rwanda 7.9%, UAE 7.4%, Democratic Republic of the Congo 7.3%, UK 6.9%, Netherlands 4.7%, Germany 4.4% (2008)
Imports:	$9.031 billion (2009 est.)	$1.555 billion (2006)	$7.315 billion (2009 est.)	$5.545 billion (2009 est.)	$4.106 billion (2009 est.)
Imports - partners:	UAE 11.9%, India 11.8%, China 10.3%, Saudi Arabia 8.3%, South Africa 5.9%, Japan 5.3%, US 4% (2008)	Saudi Arabia 21.4%, India 16.8%, China 11.1%, US 6.3%, Malaysia 6.3% (2008)	China 16.3%, Saudi Arabia 12%, India 8.7%, Italy 6%, Japan 4.9%, US 4.5% (2008)	China 13.7%, India 13.4%, South Africa 7.4%, Kenya 6.6%, UAE 5.6% (2008)	UAE 11.4%, Kenya 11.3%, India 10.4%, China 8.1%, South Africa 6.7%, Japan 5.9% (2008)
Reserves of foreign exchange and gold:	$2.601 billion (31 December 2009 est.)		$1.212 billion (31 December 2009 est.)	$2.897 billion (31 December 2009 est.)	$2.296 billion (31 December 2009 est.)
Debt - external:	$7.729 billion (31 December 2009 est.)	$428 million (2006)	$4.229 billion (31 December 2009 est.)	$7.07 billion (31 December 2009 est.)	$2.05 billion (31 December 2009 est.)

APPENDIX-1 Country Index (Energy & Infrastructure)

Country	Kenya	Djibouti	Ethiopia	Tanzania	Uganda
Electricity - production:	5.223 billion kWh (2008 est.)		3.46 billion kWh (2007 est.)	3.786 billion kWh (2007 est.)	2.256 billion kWh (2007 est.)
Electricity - consumption:	4.863 billion kWh (2008 est.)	260.4 million kWh (2007 est.)	3.13 billion kWh (2007 est.)	3.182 billion kWh (2007 est.)	2.068 billion kWh (2007 est.)
Electricity - exports:	58.3 million kWh (2007 est.)	0 kWh (2008 est.)	0 kWh (2008 est.)	0 kWh (2008 est.)	30 million kWh (2007)
Electricity - imports:	22.5 million kWh (2007 est.)	0 kWh (2008 est.)	0 kWh (2008 est.)	200 million kWh (2007 est.)	0 kWh (2008 est.)
Oil - production:	0 bbl/day (2008 est.)	0 bbl/day (2008 est.)	0 bbl/day (2008 est.)	0 bbl/day (2008 est.)	NA bbl/day bbl/day NA
Oil - consumption:	75,000 bbl/day (2008 est.)	13,000 bbl/day (2008 est.)	37,000 bbl/day (2008 est.)	32,000 bbl/day (2008 est.)	13,000 bbl/day (2008 est.)
Oil - exports:	7,270 bbl/day (2007 est.)	19 bbl/day (2007 est.)	0 bbl/day (2007 est.)	0 bbl/day (2007 est.)	0 bbl/day (2007 est.)
Oil - imports:	80,530 bbl/day (2007 est.)	8,476 bbl/day (2007 est.)	33,590 bbl/day (2007 est.)	28,070 bbl/day (2007 est.)	13,090 bbl/day (2007 est.)
Oil - proved reserves:	0 bbl (1 January 2009 est.)	0 bbl (1 January 2009 est.)	430,000 bbl (1 January 2009 est.)	0 bbl (1 January 2009 est.)	0 bbl (1 January 2009 est.)
Natural gas - production:	0 cu m (2008 est.)	0 cu m (2008 est.)	0 cu m (2008 est.)	560.7 million cu m (2008 est.)	0 cu m (2008 est.)
Natural gas - consumption:	0 cu m (2008 est.)	0 cu m (2008 est.)	0 cu m (2008 est.)	560.7 million cu m (2008 est.)	0 cu m (2008 est.)
Natural gas - exports:	0 cu m (2008 est.)	0 cu m (2008 est.)	0 cu m (2008 est.)	0 cu m (2008 est.)	0 cu m (2008 est.)
Natural gas - imports:	0 cu m (2008 est.)	0 cu m (2008 est.)	0 cu m (2008 est.)	0 cu m (2008 est.)	0 cu m (2008 est.)
Natural gas - proved reserves:	0 cu m (1 January 2009 est.)	0 cu m (1 January 2009 est.)	24.92 billion cu m (1 January 2009 est.)	6.513 billion cu m (1 January 2009 est.)	0 cu m (1 January 2009 est.)
Telephones - main lines in use:	252,300 (2008)	10,800 (2008)	908,900 (2008)	179,849 (2009)	168,500 (2008)
Telephones - mobile cellular:	16.234 million (2008)	44,100 (2005)	3.168 million (2008)	14.723 million (2009)	8.555 million (2008)
Television broadcast stations:	8 (2008)	1 (2001)	1 (plus 24 repeaters) (2001)	3 (1999)	8 (plus 1 repeater) (2001)
Internet hosts:	32,913 (2009)	199 (2009)	136 (2009)	24,724 (2009)	6,757 (2009)
Internet users:	3.36 million (2008)	13,000 (2008)	360,000 (2008)	520,000 (2008)	2.5 million (2008)
Airports:	181 (2009)	13 (2009)	63 (2009)	125 (2009)	35 (2009)
Airports - with paved runways:	total: 16	total: 3	total: 17	total: 9	total: 5
Airports - with unpaved runways:	total: 165	total: 10	Airports - with unpaved runways:	total: 116	over 3,047 m: 1
Railways:	total: 2,778 km	total: 100 km (Djibouti segment of the 781 km Addis Ababa-Djibouti railway)	total: 681 km (Ethiopian segment of the 781 km Addis Ababa-Djibouti railroad)	total: 3,689 km	total: 1,244 km
Roadways:	total: 63,574 km (interurban roads)	total: 3,065 km	total: 36,469 km	total: 78,891 km	total: 70,746 km

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

Appendix-2 Geothermal Resources by Country (1)

Country	No.	Field Name	Surface Geoscientific Survey					Drilling/Testing		Development Stage	Temperature	
			Geology/Geochemistry		Geophysics							
			Geological Survey	Geochemical Survey	Gravity	Schlumberger	MT/CSMT	Well Drilling	Production Test		Max. Surface Temp.(°C)	Possible Deep Fluid Temp. (°C) (Geothermometer)
Kenya	1	**Olkaria**	Done	Done	Done	Done	Done	100 wells over	Done	OP	-	-
	2	**Eburru**	Done	Done	Done	Done	Done	6 deep wells	Done	FS	-	-
	3	**Suswa**	Done	Done	Done	Done	Done	-	-	Pre-FS	93	250
	4	**Longonot**	Done	Done	Done		Done	-	-	Pre-FS	92-97	>250
	5	**Menengai**	Done	Done	Done	Done	Done	-	-	Pre-FS	60-94	>250
	6	**Arus/Bogoria**	Done	Done	Done		Done	-	-	Pre-FS	100	180-248
	7	**Baringo**	Done	Done	Done		Done	-	-	Pre-FS	97	>170-210
	8	**Korosi/Chepchuk**	Done	Done	Done		Done	-	-	Pre-FS	80-96	>220-250
	9	**Paka**	Done	Done	Done		Done	-	-	Pre-FS	97	>250-300
	10	**Silali**	Done	Done	Done		-	-	-	Re	97	250-300
	11	**Em urangogolak**	Done	Done	Done		-	-	-	Re	96	250-350
	12	**Namarunu**	Done	Done			-	-	-	Re	30-100	>200
	13	**Barrier volcano**	Done	Done	Done		-	-	-	Re	99	220-296
	14	**L. Magadi**	Doen	Done	Done		Done	-	-	Re	85	150
Ethiopia	1	**Aluto Langano**	Done in 1970, 77 & 84	Done in 1970 and 83	Done in 1970, 81 & 82	Done in 1981 & 82	Done in 1981, 82 & 2009	8 deep wells	Not reliable	OP	60-70	-
	2	**Tendaho**	Done in 1970, 79 & 94	Done in 1970, 80, 95 upto 2007	Done in 1979, 80, 87 & 96	Done	Will be done in 2010	3 deep wells 3 shallow wells	Done	FS	?	-
	3	**Abaya**	Done in 1970 & 2000	Done in 1970 & 2000	Done in 1970 & 2000	Done in 2000	-	Shallow TG wells	-	Detailed Surface Exploration	96	>300
	4	**Corbetti**	Done in 1970, 83 and 84	Done in 1970	Done ub 1983 & 84	Done ub 1983 & 84	-	Shallow TG wells	-	Detailed Surface Exploration	94	>300
	5	**Tulu Moye**	Done in 1970, 86, 87, 88 & 2000	Done in 1970, 86, 87 & 2001	Done in 1986, 87, 88, 2000	Done in 1986, 87, 88 & 2000	-	Shallow TG wells	-	Detailed Surface Exploration	60-80	>150
	6	**Dofan**	Done in 1970, 86,87, 2003-07	Done in 1970, 86,87, 2003-07	Done in 1970, 86,87, 2003-07	Non???	-	-	-	Semi-detailed surface explor.	100	<280
	7	**Fantale**	Done in 1970, 86, 87, 2003-07	Done in 1970, 86, 87, 2002-07	Done in 1970, 86, 87, 2003-07	Non???	-	-	-	Semi-detailed surface explor.	100	
	8	**Gedemsa**	Done in 1970, 86, 87, 88 & 2000	Done in 1970, 86, 87, 88 & 2000	Done in 1970, 86, 87, 88 & 2000	Done in 1986, 87, 88 & 2000	-	Shallow TG wells	-	Detailed Surface Exploration	60-80	-
	9	**Dallol**	Done in 1970, 86 & 87	Done in 1970, 86 & 87	Done in 1970, 86 & 87	-	-	-	-	Identified localities	-	-
	10	**Kone**	Done in 1970, 86 & 87	Done in 1970, 86 & 87	Done in 1970, 86 & 87	-	-	-	-	Re	-	-
	11	**Meteka**	Done in 1970, 86 & 87	Done in 1970, 86 & 87	Done in 1970, 86 & 87	-	-	-	-	Re	-	-
	12	**Teo**	Done in 1970, 86 & 87	Done in 1970, 86 & 87	Done in 1970, 86 & 87	-	-	-	-	Re	-	-
	13	**Danab**	Done in 1970, 86 & 87	Done in 1970, 86 & 87	Done in 1970, 86 & 87	-	-	-	-	Re	-	-
	14	**Lake Abhe**	Done in 1970, 86 & 87	Done in 1970, 86 & 87	Done in 1970, 86 & 87	-	-	-	-	Identified localities	-	-
Djibouti	1	**Assal**	Done	Done	Done	Done	Done	6 deep wells	Done	FS	100	-
	2	**Hanle**	Done	Done	Done	Done	-	2 deep wells & 3 shallow wells	-	Pre-FS	>60	118-260
	3	**Gaggade**	Done	Done	Done	Done	-	-	-	Pre-FS	>60	-
	4	**N. of Ghoubbet**	Done	Done	Done	Done	-	-	-	Pre-FS	?	220
	5	**Arta**	Done	Done	Done	-	-	-	-	Re	75-95	?
	6	**Obock**	Done	Done	Done	-	-	-	-	Re	-	210
	7	**Lac Abbe**	Done	Done	-	-	-	-	-	Re	>90	?
	8	**Chevery**	-	-	-	-	-	Shallow TG well(s)	-	Re	-	-
	9	**Inakir**	-	-	-	-	-	-	-	Re	-	-
Tanzania	1	**Mbeya (Songwe-Rungwe)**	Done	Done	-	-	Done	-	-	Pre-FS	86	230
	2	**Rukwa**	Done	Done	-	-	-	-	-	Re	60	110
	3	**Kisaki & Rufiji**	Done	Done	-	-	-	-	-	Re	75	-
	4	**Eyasi - Ngorongoro – Natron**	Done	Done	-	-	-	-	-	Re	52	279
	5	**Dodoma – Singida – Kondoa**	Done	Done	-	-	-	-	-	Re	47	210
Uganda	1	**Buranga**	Done	Done	-	-	-	6 shallow TG wells	-	Pre-FS	98.3	120-150
	2	**Katwe-Kikorongo**	Done	Done	Done	-	TEM	6 shallow TG wells	-	Pre-FS	70	140-200
	3	**Kibiro**	Done	Done	Done	-	TEM	6 shallow TG wells	-	Pre-FS	86.4	200-220
	4	**Panymur**	?	?	?	?	?	Shallow TG well(s)	-	Re	-	-

TG: Thermo-Gradient Well

Re: Reconnaissance
Pre-FS: Preliminary Feasibility Study
FS: Feasibility Study
OP: Operation

Appendix-2 Geothermal Resources by Country (2)

Country	No.	Field Name	Max. Measured Temp. (℃)	Geothermal Structure			Hot Spring Water Chemistry
				Possible Heat Source	Hydrothermal Alteration	Permeable Structure	
Kenya	1	**Olkaria**	340	Several up-flow zone above magma reservor	Hot springs and fumalores alon the faults	Ol Butot fault and NW-SE trending fault	pH: 8.5-9.5, Nacl type ,Cl Max: 200-700
	2	**Eburru**	279	Narrow volcanic body	Along Eburru caldera and N-S trending faults	NE-SW, NW-SE trending faults	Cl Max: 700
	3	**Suswa**	-	Magma body uner Suswa caldera	Solfatara within the annular trench	Faults	Low pH
	4	**Longonot**	-	Single Magma chamber under caldera and crater	Numerous manifestations within the summit crater and outside on	NE & NW trending faults	
	5	**Menengai**	-	Hot body that underlies Menengai caldera			pH: 7-9,
	6	**Arus/Bogoria**	-	Thin crust/shaloow dykes and intrusives		Faults	pH: 6.5-9.2, HCO3 type, Cl Max: 3,295
	7	**Baringo**	-	Main: Under Korosi volcano (to the north)		NNE and N-S trending structures	pH: 7.0-9.3, HCO3 type,
	8	**Korosi/Chepchuk**	-	Uner Korosi and Ol kokwe volcanoes		Shallow magmatic intrusions and dykes	Cl Max: 500
	9	**Paka**	-	Trachyte/trachyte-basaltic body	Reddish 6 whitish kaolinite and alunite clays	Faults/fractures	pH: 6.7-8.5, HCO3 type,
	10	**Silali**	-	Silali caldera volcano		NNE and NNW trending structures	NaHCO3 type, pH: 8.25-9.15
	11	**Em urangogolak**	-	Shallow hot magma body under caldera		NNE, E and S trending faults	Ph: 8.25, Cl max: 350
	12	**Namarunu**	-	Namarunu volcano		NNE trending faults	pH: 8.8
	13	**Barrier volcano**	-	Large hot body under Kakorinya volcano		Faults/fractures	pH: 8.3, Cl. Max: 3,420
	14	**L. Magadi**	-	Heat generated along fault plane and Dyke Intrustion	-	-	NaHCO3 type, pH: 8.8-9.9
Ethiopia	1	**Aluto Langano**	350	Up-flow zone along Wangi fault zone	Fumaroles and Hot Springs related to the fault and ring structure	Wanji Fault Zone	pH: 9, HCO3-Cl ,Cl Max: 350
	2	**Tendaho**	278	Magma remenants injected along crustal separation zones	Surface manifestations in alignment of Dubti fault	Dubti Fault	NaCl type, medium to high temperature.
	3	**Abaya**	-	Rhyolitic intrusion within the greater Abaya area.	Assiciated with Duguna central volcano and Chericho volcano	Wonji Fault Belt (NNE-SSW) and trasverse structure (NW-SE and E-W)	pH: neutral, Nacl-HCO3 type,
	4	**Corbetti**	-	Remnant magma intruded at shallow depth	Associated with Corbetti caldera	Corbetti caldera and traverse structure (NNE-SSW)	NaCl-HCO3 type
	5	**Tulu Moye**	-	A shallow magmatic chamber beneath young eruptive centers (0.07 My)	Numerous gaseous manifestations with significant H2 content	Numerous NNE-SSW trending faults, rift forming faults and the NNS-SSE oriented transverse faults	Na-HCO3 type
	6	**Dofan**	-	A shallow magma chamber whichi gave rise to voluminous eruption of volcanic products, which consists of rhyolite, obsidian, trachyte, pumice and ignimbrite	Fumaroles and hot springs within a rhyolitic volcano	A NNE-SSW trending graben along the faults	pH: 8.2-8.18, Na-HCO3 type
	7	**Fantale**	-				pH: 8.2-8.18, Na-HCO3 type
	8	**Gedemsa**	-	-	-	-	-
	9	**Dallol**	-	-	-	-	-
	10	**Kone**	-	-	-	-	-
	11	**Meteka**	-	-	-	-	-
	12	**Teo**	-	-	-	-	-
	13	**Danab**	-	-	-	-	-
	14	**Lake Abhe**	-	-	-	-	-
Djibouti	1	**Assal**	355	Volcanics related to the Assal Rift	Fumaroles and hot springs along NW-SE trending faults	Dominant NW-SE trending faults in Assal Rift	Weakly acidic NaCl type
	2	**Hanle**	124 (at 2020m in	-	Several Fumaroles and Springs	-	Alkaline-chloride type
	3	**Gaggade**	-	-	Several Fumaroles and Springs	-	Alkaline-chloride type
	4	**N. of Ghoubhet**	-	Volcanics related to the Gulf of Tadjourah Ridge	Several Fumaroles and Springs	Assal Rift NW-SE, Makarasou N-S and old trends	-
	5	**Arta**	-	Volcanics related to the Gulf of Tadjourah Ridge	along the Gulf of Tadjourah Ridge	Tadjourah Ridge	Alkaline-Chlorine in relation with sea water
	6	**Obock**	-	Volcanics related to the Gulf of Tadjourah Ridge	Hot springs and fumaroles	Tadjourah Ridge	Alkaline-chloride type
	7	**Lac Abhe**	-	-	Hot springs, fumaroles and travertine	?	Alkaline-chloride-sulfated type Lake Abhe is hypersaline
	8	**Chevery**	-	-	-	-	-
	9	**Inakir**	-	-	-	-	-
Tanzania	1	**Mbeya (Songwe-Rungwe)**	-	volcanics from the Rungwe massif	magnetic iron oxides	NW-SE horizontal extension and NE-SW horizontal compression	pH:6.6-8.0, Cl max: 2,040ppm
	2	**Rukwa**	-	-	-	-	pH:8.0, Cl:2,040ppm
	3	**Kisaki & Rufiji**	-	-	-	-	pH:7.5-8.5, Cl max: 160ppm
	4	**Eyasi - Ngorongoro – Natron**	-	-	-	-	pH:7.6-10, Cl max: 4,810ppm
	5	**Dodoma – Singida – Kondoa**	-	-	-	-	pH:7.2-8.9, Cl max: 770ppm
Uganda	1	**Buranga**	-	magmatic intrusion	-	-	pH: 7.5-8.5, Cl max:4,240 mg/kg
	2	**Katwe-Kikorongo**	-	magmatic intrusion	-	-	pH: 7.0-9.6, Cl max 86,600mg/kg
	3	**Kibiro**	-	intrusive rock?	-	-	pH: 7-8, Cl max: 2,580mg/kg
	4	**Panymur**	-	-	-	-	-

Appendix-2 Geothermal Resources by Country (3)

Country	No.	Field Name	Fluid Flow: Deep Reservoir Fluid Discharge at the Surface	Fluid Flow: Production Flow Rate	Geothermal System	Estimated Resource Potential (Mwe)	Task for Geothermal Resource Development	Remarks	Reference
Kenya	1	**Olkaria**	-	-	NaCl typed Steam dominated hot temperature	400	Production drilling		(2)
	2	**Eburru**	3wells discharged. 1 well (EW-1) produced.	82 t/h from EW-1	Medium to high temp.	45	Appraisal Drilling		(1)
	3	**Suswa**	-	-	Medium to high temp.	600	Exploratory drilling	Developed by IPP	(1)
	4	**Longonot**	-	-	Medium to high temp.	>200	Exploratory drilling	Developed by IPP	(1)
	5	**Menengai**	-	-	Medium to high temp.	>200	Exploratory drilling		(1)
	6	**Arus/Bogoria**	-	-	Medium temp.	>20	Exploratory drilling		(1)
	7	**Baringo**	-	-	Medium to high temp.	200	Exploratory drilling		(1)
	8	**Korosi/Chepchuk**	-	-	High temp.	>700	Exploratory drilling		(1)
	9	**Paka**	-	-	High temp.	>750	Exploratory drilling		(1)
	10	**Silali**	-	-	Medium to high temp.	>400	Well Targetting & Exploratory drilling		(1)
	11	**Em urangogolak**	-	-	Medium temp.	300	Detailed surface exploration & Well targeting		(1)
	12	**Namarunu**	-	-	Medium to hit	>20	Detailed surface exploration & Well targeting		(1)
	13	**Barrier volcano**	-	-	High temp.	>200	Detailed surface exploration & Well targeting		(1)
	14	**L. Magadi**	-	-	Medium temp.	-	Detailed surface exploration & Well targeting		(1)
Ethiopia	1	**Aluto Langano**	4 wells : productive	32.8 to 42.8 t/h at 1MPaG (LA-3 and LA-6)	Hydrothermal Convection system with high temp.	75	Appraisal Drilling		(3)
	2	**Tendaho**	3 deep wells and 1 shallow well: productive	Total Mass Flow: 33 to 70 kg/s (TD-5 shallow well)	Water dominated reservoir with medium to high temperature	100???	Appraisal Drilling	Explored by BGR	(3)
	3	**Abaya**	-	-	The sodium bicarbonate type with neutral pH (similar to the Aluto-Langano	100	Well Targetting & Exploratory drilling		(3)
	4	**Corbetti**	-	-	The sodium bicarbonate type with neutral pH (similar to the Aluto-Langano	75	Well Targetting & Exploratory drilling		(3)
	5	**Tulu Moye**	-	-	Mainly Structure controlled	40	Detailed surface exploration & Well targeting		(3)
	6	**Dofan**	-	-	Mainly Structure controlled	50	Detailed surface exploration & Well targeting		(3)
	7	**Fantale**	-	-	Mainly Structure controlled	50	Detailed surface exploration & Well targeting		(3)
	8	**Gedemsa**	-	-	-	-	Detailed surface exploration & Well targeting		(3)
	9	**Dallol**	-	-	-	-	Detailed surface exploration & Well targeting		(3)
	10	**Kone**	-	-	-	-	Detailed surface exploration & Well targeting		(3)
	11	**Meteka**	-	-	-	-	Detailed surface exploration & Well targeting		(3)
	12	**Teo**	-	-	-	-	Detailed surface exploration & Well targeting		(3)
	13	**Danab**	-	-	-	-	Detailed surface exploration & Well targeting		(3)
	14	**Lake Abhe**	-	-	-	-	Detailed surface exploration & Well targeting		(3)
Djibouti	1	**Assal**	-	350 t/h in total mass flow at 12 bar (AS-3)	High temp. reserv. With high salinity brine	50-150	Appraisal Drilling		(4)
	2	**Hanle**	-	-	-	?	Detailed surface exploration & Well targeting		(D-1)
	3	**Gaggade**	-	-	-	?	Detailed surface exploration & Well targeting		(D-1)
	4	**N. of Ghoubhet**	-	-	-	?	Detailed surface exploration & Well targeting		(D-1)
	5	**Arta**	-	-	-	?	Detailed surface exploration & Well targeting		(D-1)
	6	**Obock**	-	-	-	?	Detailed surface exploration & Well targeting		(D-1)
	7	**Lac Abhe**	-	-	-	?	Detailed surface exploration & Well targeting	Explored by IPP	(D-1)
	8	**Chevery**	-	-	-	?	Detailed surface exploration & Well targeting	150°C at 150m in depth	(D-1)
	9	**Inakir**	-	-	-	?	Detailed surface exploration & Well targeting	Recommended from CERD	(D-1)
Tanzania	1	**Mbeya (Songwe-Rungwe)**	-	-	Medium temp.	-	Detailed surface exploration & Well targeting	Explored by BGR	(T-1) (T-3)
	2	**Rukwa**	-	-	Low temp.	-	Detailed surface exploration & Well targeting		(T-1) (T-2) (T-3)
	3	**Kisaki & Rufiji**	-	-	-	-	Detailed surface exploration & Well targeting		(T-1) (T-2) (T-3)
	4	**Eyasi - Ngorongoro – Natron**	-	-	High temp.	-	Detailed surface exploration & Well targeting		(T-1) (T-2) (T-3)
	5	**Dodoma – Singida – Kondoa**	-	-	Medium temp.	-	Detailed surface exploration & Well targeting		(T-1) (T-2) (T-3)
Uganda	1	**Buranga**	-	-	Low temp.	?	Detailed surface exploration & Well targeting	Explored by BGR	(5)
	2	**Katwe-Kikorongo**	-	-	Medium temp.	?		Situated inside the Queen Elizabeth National Park	(5)
	3	**Kibiro**	-	-	Medium temp.	?	Detailed surface exploration & Well targeting		(5)
	4	**Panymur**	-	-	-	?	Detailed surface exploration & Well targeting	Thermo-gradient: 80°C/km	(5)

(1) KenGen "New Opportunities for Conventional Geothermal Fields in the East African Countries"
(2) Pilot Study for Project Formation for Geothermal Energy Projects in East Rift Valley of the East African Countries (JBIC, 2008)
(3) Data provided from Geological Survey of Ethiopia on May 2010.
(4) Assal Geothermal Power Development Project (West JEC, 1996)
(D-1) Julludin Mohamed: State of knowledge of the geothermal provinces of the repurblic of Djibouti, ARGeo-C1 conference 2006

(T-1) SWECO 2005
(T-2) Hochstein et al., 2000
(T-3) MoEM 2009
(5) Bahati 2010