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GEOTHERMAL CONSULTANT STEPHEN HIRSCH RECOMMENDATIONS TO USTDA

FOR

CONSULTANCY AND REPAIR SERVICES FOR THE ALUTO LANGANO GEOTHERMAL PILOT POWER PLANT

AND

SUPPORT FOR A FEASIBILITY STUDY FOR A 2-5 MW PILOT GEOTHERMAL PLANT AT TENDAHO

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3.1 EXECUTIVE SUMMARY

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On July 6, 2006, following an international competitive bidding procedure, the Ethiopian Electric Power Corporation (EEPCO) signed a contract agreement with Geothermal Development Associates of Reno, Nevada, USA for consultancy and repair services on the Aluto Langano Geothermal Pilot Power Plant. No further involvement of US TDA is recommended at this time in the Aluto project.

The Consultant is recommending US TDA finance the preparation of a feasibility study (FS) that can be used by the Ethiopian Electric Power Corporation (EEPCO), in collaboration with a private geothermal consulting company or consultants, to plan, build and operate a 2-5 MW pilot geothermal plant to be installed at Tendaho.

The pilot plant will enable EEPCO and GSE engineers and scientists to study the performance and capacity of the Tendaho geothermal reservoir and pave the way for environmentally-clean power generation on a large scale that can be connected to the grid for use within the country and for export. In addition, the plant will ensure the availability of electric power for farms and four towns in the vicinity of the drilled area, three of which (Semera, Logiya, and Dubti) are already connected by an existing mini-grid and are being served by expensive, polluting diesel gensets.

The Tendaho pilot project will make use of geothermal wells that have already been drilled and partially tested. GSE studies indicate proven reserves from this site of 10 MW with a probable capacity of 30 MW. Estimates of possible total site capacity are as high as 1,000 MW[1].

The FS will provide a management plan, including coordination with the Geological Survey of Ethiopia (GSE), on resource-related issues, feasibility study team meetings, communications with the Ethiopia Government, American Embassy, US equipment suppliers, and strategic planning for expansion of power generation as rapidly as possible from the Tendaho geothermal resource.

The proposed US TDA grantee for the feasibility study will be the Ethiopia Electric Power Corporation (EEPCO). EEPCO does not have experience with the technical aspects of geothermal feasibility studies but will provide overall management and logistical support and the participation of staff members from its recently-established geothermal division. The FS will be carried out by US geothermal consultants with experience in the East Africa region.

The Geological Survey of Ethiopia (GSE) will provide resource-related information for the FS, provide equipment, assist with logistical arrangements at the Tendaho site and provide staff members who will

[1] Ethiopian Power System Expansion Master Plan, March 2002, ACRES International

receive on-the-job training from the US consultants. GSE will also provide cash and in-kind financial support for the FS.

The actual size of the pilot plant will be determined by the capacity of the existing boreholes, and the results of the FS. EEPCO has indicated it would like the pilot plant to be as large as possible and that it would provide the required financing from either its own resources or through additional loans from bi and/or multilateral agencies.

Institutional roles for the Tendaho FS can be summarized as follows:

Tendaho pilot plant owner	-	Ethiopia Electric Power Corporation
Feasibility study contractor	-	US geothermal consultants or company
Plant supplier	-	US geothermal company
Short-term plant operator	-	US geothermal consultant or company
Resource Advisor / Monitor	-	Geological Survey of Ethiopia (GSE)
Transmission Line Builder	-	EEPCO or Ethiopian firm (5 qualified firms exist)
Proposed TDA grantee	-	EEPCO

3.2 PROJECT DESCRIPTION

The project consists of carrying out a feasibility study to enable EEPCO to plan, finance and install a 2-5 MW pilot geothermal plant at Tendaho. The objective of the pilot plant will be to enable EEPCO and GSE to increase the level of knowledge that exists about the Tendaho geothermal resource that will allow EEPCO, in the near future, to finance and develop a 30 MW+ geothermal plant that will provide power to the Ethiopian grid (and possible export to Djibouti).

To achieve the above, the project will:

a. Take advantage of six already-drilled wells that identified a proven geothermal resource at relatively shallow depth to generate 2-5 MW of power and enable the resource to be monitored to assess its suitability for the near-term production of between 30 MW+ of electric power.

b. Give Ethiopian (EEPCO and GSE) personnel hands-on experience with the installation and operation of a small, easy to manage, single flash power plant.

c. Provide lower cost, cleaner geothermal power to local farms and towns (and the national grid) than is presently available from existing diesel generators.

d. Involve US geothermal consultants (and a US geothermal company) in an Ethiopian geothermal project in relation to:
   - Working in collaboration with EEPCO and GSE to plan and carry out the tests and analyses required for the pilot plant feasibility study.
   - Preparing the final feasibility study report.
   - Supplying, installing and commissioning the pilot plant.
   - Collaborating with EEPCO and GSE to establish a long-term monitoring program for the resource and maintenance / repair program for the pilot plant.
   - Training of Ethiopian personnel in all of the above operations and remaining on-site until Ethiopian personnel can operate and maintain the pilot plant and geothermal resource.
   - Planning for the supply, installation and commissioning of larger geothermal power generation plants at Tendaho in the future for connection to the national grid.

e. Provide a US contribution to and further the objectives of the ARGeo program.

3.2.1 Background

Ethiopia is endowed with the largest geothermal resource base in Africa. Resource quality is generally good, field productivity has the potential for being high and the cost of power generated should be relatively low. The high enthalpy resource areas are found well distributed along about 600 kms of the longitudinal spread of the rift system providing a wide choice for the strategic location of sites for development. Given its resource endowment, Ethiopia could generate more than 1,000 MW of geothermal-based electricity during the coming two to three decades which would complement energy supply from hydro-power plants and improve the generation mix for both internal consumption and export.

Presently, in the Interconnected System (ICS), there is 672 MW of installed generating capacity made up of 664 MW of hydro-power from 8 power stations and 8 MW of diesel capacity. The dependable capacity is approximately 660MW. An additional 14 MW of diesel capacity in located in areas served by the ICS that serves as standby for local supply. In addition to the above, there is the 7.3 MW net pilot geothermal plant at Aluto Langano that was connected to the ICS in 1999/2000 and is presently being repaired. Another 80 MW of diesel plants were recently installed in Addis Ababa, Awash and Dire Dawa to serve as reserve in the ICS system against power shortages during drought conditions. Three hydro-plants with a total capacity of about 6 MW and several isolated diesel plants totaling 23 MW capacity supply the non-grid connected, self-contained system (SCS).

An additional 300 MW hydro-power capacity is presently under construction on the Tekeze River in northern Ethiopia and is expected to raise the gross total generation capacity to about 1,100 MW by 2008.

3.2.2 Demand For Electricity In The Tendaho Area

All electric power generated in the Afar region is from diesel generators. Diesel fuel is imported, and transported from the port of Djibouti at high cost. Thus the electricity generation cost is very high (US 21 cents/kWh at Dubti and Det Bahri farms). Nearly US 12 cents/kWh of this amount is the cost of diesel fuel. Household and commercial consumption is now severely limited due to the high cost of power.[2]

All four towns near the Tendaho geothermal prospect (Semera, Logiya, Dubti and Det Bahri) use electricity primarily for household lighting and commercial purposes. Until recently Dubti farm supplied all the electricity consumed by the farm and the towns of Dubti and Logiya using diesel plants. Dubti and Logiya are now connected to an EEPCo diesel generator in Semera[3]. Dubti Farm generates its own electricity for use at its ginnery and workshop and for air conditioning, refrigeration and lighting. The average temperatures are hot throughout the year which requires the use of significant amounts of electricity for refrigeration and air conditioning. Irrigation and drainage pumps also use considerable diesel fuel that could be replaced by geothermal-based electricity.[4] Det Bahri and farm sections within the Dubti plantation also have smaller diesel generators.

EEPCo projections show that total peak load for the four towns and farms will grow from 2.33MW in 2004 to 4.22MW in 2010. Power sales will increase from 7.2gWh to 13.5gWh with commercial and residential consumption growing the fastest.

The proposed geothermal installation would provide power for the Dubti Farm and towns of Semera, Logiya, Dubti and Det Bahri. The combined historic and projected electricity supply situations in the four towns and commercial farms in the immediate vicinity of the drilled area are as follows:

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[2] Access to electricity by the population of the towns and per capita electricity consumption are 23.4% and 190 kWh/year in 2002/03 respectively.

[3] 1,069 mWh was generated during 2002/03.

[4] Total diesel fuel consumption in the four towns during 2001/02 was estimated to be approximately 1.7 million liters. About 1 million liters of this was consumed by power generation for cotton farms in the region in 2002.

Table 1 – Electricity Supply and Demand Information in the Tendaho Area

	Actual				Projected						
Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Installed Capacity, MW	2.23	2.23	2.21	2.25							
Peak Load, MW					2.33	2.54	2.8	3.1	3.43	3.79	4.22
Energy, gWh					8.0	9.0	9.8	10.8	11.9	13.4	15.1
Population of the 4 Towns, '000	17.8	18.5	19.3	20.0	21.0	21.9	22.8	23.6	24.7	25.2	25.8
Number of consumers	702	760	831	936							
Access to electricity, %	19.7	20.5	21.5	23.4							
Per capita consumption, kWh/yr				190							

3.2.3 Impact of Drought on Electric Power Supply in Ethiopia

More than 75 per cent of Ethiopia's rainfall occurs in intense downpours over a period of 3–4 months, while conditions are relatively dry for the rest of the year (Ministry of Water Resources 1998).

Periodic droughts have occurred in Ethiopia for hundreds of years. A century ago the country suffered a drought every 10-15 years. Today they are occurring every five years or less. Although the drought-caused famine of 1984-85 is well known, less serious but significant droughts were suffered in 1987, 1988, 1991-92, 1993-94, 1999 and in 2003.

Drought has had a direct impact on electricity generation. In 2003, Ethiopian Electric and Power Corporation (EEPCO) announced it was facing severe problems in its power generation system that were attributed to the decline in rainwater flowing to its reservoirs for hydropower generation. As a result, EEPCO initiated power cuts for two days every week with the possibility that the number of days without power would increase when required.

3.2.4 The Tendaho Geothermal Resource

The Tendaho geothermal field is located in Dubti district, Afar region in the NE part of Ethiopia, some 600 kms from the capital city, Addis Ababa. It is situated in the northwestern part of Tendaho graben[5], a 4,000 km^2 structural feature with high-standing fault scarps bounding a flat plain dotted by young volcanic edifices and structural highs. The graben hosts the world famous "Afar Triple Junction" where the Red Sea, Gulf of Aden and main Ethiopian rifts come together giving rise to a prime region of geothermal potential. Altitudes on the graben floor vary from about 400m in the northwest to about 240m at Lake Abe in the southeast. The Awash River enters the graben through a gap in the western graben bounding up-lands at Logiya and flows southeast into Lake Abe, on the border with Djibouti.

The economic livelihood of the region's population is based on pastoralism (mainly camels and goat herding). Secondarily, because of the existence of fertile alluvial soils and the Awash River, the most important sedentary economic activity for the past 4-5 decades has been growing cotton at plantations at Dubti, Det

[5] A graben is a down-dropped block of the earth's crust resulting from extension, or pulling, of the crust.

Bahri, Tangaye Koma and Asayita. Recently, irrigated farming for food crops has been growing in importance.

The area is crossed by an excellent tarmac highway that serves as the main transport route for Ethiopia's foreign trade to Djibouti. The town of Logiya is a product of the road traffic. Dubti (the regional seat of government) and Det Bahri started as satellite towns to the farms that bear their names. Semera, which started out as a road maintenance camp, is, since 2004, the capital of Afar region. The total population of the Dubti region in 1995/96 was 64,353 of which 15,355 live in the four towns.

All four towns have electricity that is used primarily for household lighting and commercial activities. Dubti and Logiya are now connected to the EEPCo diesel generator in Semera. Dubti farm generates its own electricity for use at its ginnery and workshop, and for air conditioning and lighting. Irrigation and drainage pumping use diesel fuel. Det Bahri and farm sections within the Dubti plantation have smaller diesel generators.

3.2.5 Past Exploration Activities in the Tendaho Area

The first inventories of hydrothermal features were carried out in the Tendaho area on two occasions: during 1969 by a ground-based survey and during 1971 when ground truth work was carried out in conjunction with an airborne thermal infrared survey for locating areas of surface thermal anomaly in remote areas. This work provided extensive information on the distribution and characteristics of hydrothermal manifestations in Ethiopia and formed the basis for the selection of the Tendaho graben as a priority target for exploration.

3.2.5.1 Surface Geo-scientific Investigations

The first geothermal exploration work, following the reconnaissance survey of 1969-71, was carried out under a technical cooperation program with the Italian Ministry of Foreign Affairs (IMAE). IMAE paid for the technical services of Aquater spa which provided a team of geologists, geochemists and geophysicists who worked with counterparts from the Geological Survey of Ethiopia (GSE). Exploration equipment was brought from Italy under the project.

Detailed geo-scientific studies (geology, geochemistry, geophysics) followed by the drilling of shallow temperature gradient holes, was carried out in two phases during the late 1970s into the early 1980s. The work aimed at gaining an understanding of the probable heating and circulation system and the siting of exploration wells aimed at discovering an economically exploitable geothermal reservoir. After a long interval following the completion of these surveys, exploration drilling was carried out from 1993-95 with further financial and technical assistance from the IMAE. GSE carried out further drilling during 1997-98 using its own resources.

3.2.5.2 Exploration Drilling

A Massarenti drilling rig with a hook-load capacity of 300,000 lb. was brought from Italy for the project, and destined for continued use by GSE. Beginning in October 1993, TD1 was drilled vertically on the northeastern margin of Dubti plantation in close proximity to the fault along which the weak hydrothermal manifestations emanate. The well bottomed in the Afar Stratoid Series substratum, at a temperature of 278°C at about 1,050m depth. TD2 was drilled in 1994 to a depth of 1,811m.

Of particular importance was that during the drilling of TD1 and TD2, hot water inflow was encountered in the 200-600m depth range but had been cased off in preference to continuing drilling to discover a deeper reservoir. Beginning in April 1995, TD4 was thus drilled to 466m depth to enter this zone and 245°C fluid was encountered. The well had a temperature profile that is identical to that in TD2 to 420m depth. This ended the drilling program supported by the Italian MAE.

The drilling of two additional shallow wells in the vicinity of TD4 had been recommended in the shallow resource evaluation and in techno-economic studies by Aquater to further explore and utilize the shallow

resource. Accordingly, TD-5 and TD-6 were drilled from December 1997 to February 1998 with similar results as TD4.

A summary of the drilling activity and well information is provided in Table 2.

Table 2 - Data on the Exploratory Wells Drilled at Tendaho

Well No.	TD1	TD2	TD3	TD4	TD5	TD6
Drilling period	20/10/93 - 27/02/94	13/03/94 - 10/05/94	07/09/94 - 19/10/94	27/04/95 - 09/05/95	20/12/97 - 14/012w/98	01/02/98 - 20/02/98
Drilled depth (m)	2196	1811	1989	466	516	505
Elevation (m.a.s.l)	365.9	365.7	366.8	365.2	366.3	366
Permeable zones	400-600* 1200-1300	220-500* 1200-1300	50-200*	220-466	220-516	220-505
Maximum Down-hole Temp. (°C)	278	245	198	245	253	245
Status of the well	Non-productive	Productive	Non-productive	Productive	Productive	Productive
Note: * Cased						

3.2.5.3 Follow-up Work

Short-term well testing and reservoir engineering studies were subsequently performed which included the following:

- Down-hole temperature and pressure surveys;
- Limited pressure transient tests;
- Limited short term production tests;
- Resource evaluation based on data collected from one shallow well, TD4.

3.2.5.4 Conclusions

The existence of a shallow geothermal reservoir at Tendaho was confirmed including:

- Location of the shallow reservoir
- Determination of characteristics of the shallow reservoir
  - temperature distribution with depth is close to boiling point to depth curve
  - reservoir temperature is 220-250 °C
  - permeability is relatively high (K_h= 3-10Dm)
  - the geo-fluid has low salinity and low non-condensable gas content
  - 2-3MW electric power can be generated from the existing wells

3.2.6 Institutional Mandates

The state owned power company, the **Ethiopian Electric Power Corporation (EEPCo),** is responsible for the generation, transmission, distribution and sale of electric power throughout Ethiopia. It operates under the oversight of the Ministry of Infrastructure. EEPCO is the owner and operator of the Aluto Langano Geothermal Pilot Plant and plans to build a 30 MW expansion at the Aluto site. EEPCO also hopes the Tendaho pilot plant will pave the way for the development and construction of a large-scale power generation station at Tendaho in the shortest time possible.

The **Geological Survey of Ethiopia (GSE)** is an autonomous federal agency under the Ministry of Mines. GSE undertakes studies and surveys about the earth's crust and mineral substances of economic value, applying earth science techniques to prospect for, explore, and estimate / delineate mineral deposits.

GSE has the responsibility, on behalf of the Government of Ethiopia, to:

- carry out geological mapping, prepares and publishes geological maps
- carry out exploration and studies on earth and water bodies related to minerals, oil and natural gas, geothermal, groundwater and engineering geology.
- investigate volcanic activity, earth-quakes, land slides, meteorites and other related natural phenomena.
- conduct ground and airborne geophysical surveys and remote sensing studies

GSE has had responsibility for geothermal exploration in Ethiopia for the past three decades through its Geothermal Division, which is under the Department of Hydrogeology, Engineering Geology and Geothermal. The staff of the geothermal team includes geologists, geochemists, geophysicists and reservoir engineers with geothermal specific training and hands-on experience at about 16 geothermal prospect areas including Aluto-Langano and Tendaho.

The GSE Geothermal Division has the following:

- a drilling department with 2 geothermal drilling rigs which carries out core, water well drilling, geothermal deep drilling and associated geotechnical work;
- a well-equipped central geological laboratory where surface and core samples as well as cold and geothermal fluids can be analyzed.

The **Ethiopian Environmental Protection Authority (EPA)** provides authorization for projects licensed under federal authority and monitors their implementation and operations. Regional environmental protection agencies have similar authority over projects that are licensed at the regional level.

The **National Mining Corporation (NMC)** received an exploration license for Tendaho from the Ministry of Mines in 2000 and renewed it in 2004. The renewed license will expire in October 2005. However, according to the NMC Deputy Managing Director, the NMC has not done any work at the site and has limited its activities to the review of reports and documents prepared previously by the Geological Survey of Ethiopia and foreign consultants.

3.2.7 Size of the Pilot Plant

The main purpose of the pilot plant is to use existing productive wells to indicate the capability of the Tendaho geothermal resource to support larger-scale geothermal power generation in the near to medium term. This will be done through monitoring the performance of the Tendaho geothermal resource while it is generating power through a small / modestly-sized pilot plant over a 9-12 month period. The results of the monitoring program will be used by EEPCO, with the support of GSE, to assess the capability of the resource to generate power on a much larger scale (30 MW+) as soon as possible.

Preliminary estimates of the capability of the existing wells at Tendaho indicate they can support a 2-3 MW plant. This analysis will be reviewed and updated during the FS. EEPCO would like the pilot plant to be as large as can be supported by the existing wells and to move as quickly as possible beyond the pilot plant to large-scale power generation. EEPCO understands that large-scale power generation will require the drilling of additional geothermal wells. However EEPCO indicated it is ready to finance such drilling should the resource prove that it is capable of a higher level of power generation.

At a July 15 meeting in Addis, it was decided that the size of the initial pilot plant would be determined by the results of the FS and would probably fall within the 2-5 MW range.

3.3 DEVELOPMENT IMPACT

Energy consumption in Ethiopia is made up of less than 1% electricity, about 5.4% hydrocarbon fuels with the balance being traditional biomass fuels.

Because of the underdeveloped state of electricity supply in Ethiopia, the major objective has become to achieve a high level of penetration by the electricity transmission and distribution system into all parts of the country in the shortest time possible.

3.3.1 Primary Developmental Impact

The development impact to the government and people of Ethiopia of the Tendaho project will be as follows:

- Decreased dependence on drought-prone hydro resources for power generation. Drought has resulted in significant losses to industry and commerce in Ethiopia during the past 5 years.
- Increased understanding of the potential for the use of a "new", clean power generation technology.
- An opportunity to lower the cost of the resulting electricity through the sale of carbon credits on the international market.
- Increased familiarity with a new geothermal resource in an area of the country that is considered a priority by government for development efforts.
- An opportunity to prove the viability of a proven geothermal resource that will allow increased political support for a much larger scale installation in the near future.
- An opportunity to train geo-scientists and plant engineers on a simple, small-scale geothermal plant and increased host country familiarity and confidence with geothermal power generation techniques.
- Increased familiarity of EEPCO and GSE personnel with members of the US geothermal industry.

3.3.2 Alternatives

Historically, hydro has been the only source considered suitable for large-scale power generation in Ethiopia.

As indicated above, there have been recent periods of large-scale load shedding as a result of the country's heavy dependence on hydro resources for power generation and the frequent recurrence of drought. The Government has, therefore, made it a priority to diversity its energy supplies and has given high priority to the development of alternative energy sources, especially geothermal.

In January 2003, EEPCO launched the Ethiopian Power System Expansion Master Plan for a time span of 25 years. The Master Plan is currently undergoing revision due to the need to further improve the generation mix and reduce reliance on hydro-power as it is prone to drought, the problem of dam siltation and environmental constraints. The revision aims to take into account the development of indigenous energy resources including geothermal energy. Other competing resources include coal deposits in the southwest of the country and a 2.4 TCF gas deposit in the southeast and wind energy.

The geothermal component of the 25 year Ethiopian Power System Expansion Master Plan includes a mix of hydro and thermal power, with a modest geothermal component including:

- the rehabilitation of the Aluto geothermal pilot plant to full operational condition at the earliest date possible;
- the implementation of the 2nd and 3rd phases of Aluto geothermal power generation projects to enable the postponement by one year of the hydro project that would follow the Tekeze hydro project;
- further geothermal exploration in several areas of Ethiopia to identify additional commercial resources.

3.4 Project Sponsor's Commitment

In the mid 1990's, EEPCO financed construction of the 8.5 MW plant at Aluto Langano at a cost of approximately $17 million.

EEPCO has renewed its commitment to geothermal by carrying out the following:

- Undertaking the financing and repair of the existing 8.5 MW Aluto Langano geothermal plant (estimated to cost between $3-4 million);
- Planning for a 30 MW expansion at Aluto Langano;
- Establishing a geothermal office within EEPCO and equipping it with a division head, plant engineer, computer, phone lines and internet;
- Offering to lead the FS effort for a pilot plant at Tendaho and assuring financing a 2-5 MW pilot plant.

In addition, EEPCO will provide the in-kind equivalent of $16,000 in local staff and logistical support. The Geological Survey of Ethiopia will provide cash and in-kind contributions totaling approximately $60,000.

3.5 Implementation Financing

As the exploration and drilling work has already been carried out with financing from the Government of Ethiopia and donor agencies, these are considered sunk costs and are not budgeted. The direct costs will be mainly the purchase, shipment, and installation of the plant and the construction of a 10 km transmission line.

Indirect costs that must be taken into account (in addition to the feasibility study) may include: administration, management, required infrastructure improvements (road, communication), negotiation of principle agreements and financing packages/credit enhancements with investors/lenders, legal services, country risk and other insurance, permitting, local taxes, royalties, and technical assistance/training. Indirect costs can be approximated as a percent of capital costs. Based on experience with other projects, and because the project is located in a relatively developed farm area with good infrastructure, reasonable access and adequate skilled labor, it is assumed indirect costs will be 10% of direct capital costs.

A breakdown of the estimated costs for the project is as follows:

Table 3 - Approximate Budgets for a 2-5 MW Geothermal Pilot Plant at Tendaho

Activity	Kms	Unit Cost ($/kW)	MW	Total ($M)
Exploration (completed)		$0	2 - 5	$0
Steam field:		$300	2 - 5	$.6 - $1.5
Power plant:		$1,500	2 - 5	$3.0 - $7.5
Subtotal				$3.6 - $9.0
10% indirect costs				$.36 - $.90
Transmission line	10	$11,000		$110,000
Total Cost of Geothermal Plant and Transmission Line				**$4.07 - $10.0**

EEPCO hopes to develop the Tendaho geothermal prospect as rapidly as possible in order to access the maximum amount of electric power and add it to the national grid when the grid reaches Semera in April 2007.

EEPCO has indicated it will finance the pilot plant and transmission line. EEPCO will provide the financing necessary for the pilot plant either entirely from its own resources or f necessary, with financing from bilateral

agencies such as the governments of Italy and Kuwait and from multilateral agencies such as the World Bank, African Development Bank, European Investment Bank and others.

3.5.1 Price of Electricity

As indicated above, the cost of electricity from the diesel gensets presently being used in the Tendaho area is US $0.21/kWh. This high cost has served to limit commercial, industrial and domestic consumption in the area and has discouraged agricultural expansion.

For small (< 5mW) geothermal plants, electricity costs range from US $0.05 to US $0.105/kWh. As the Tendaho resource has a relatively high temperature, and is a clean (low mineral content) resource, the cost of electricity generation is expected to be in the US $0.08 – 0.10 range. The cost difference between that of diesel-based electricity and geothermal power would be significant and create a significant number of income generating activities in the region.

3.5.2 Revenue Generated by the Pilot Plant

Assuming a 2 MW pilot plant and 98% plant availability (the availability of the Olkaria I plant in Kenya), over a 12 month period, the Tendaho pilot plant will generate approximately 17,122, 560 kWh of electricity. At EEPCO's average retail sale price of $0.046/kWhrs, the plant will generate $787,638 of revenue in one year (approximately 20% of the cost of the plant, steam field and transmission line).

If a 5 MW pilot plant is installed, it will generate approximately 42,806,400 kWhrs of electricity that will result in $1,969,094 of electricity sales revenue (also about 20% of the cost of the plant, steam field and transmission line).

3.5.3 Impact of Sale of Carbon Credits

The Kyoto Protocol is an amendment to the United Nations Framework Convention on Climate Change (UNFCCC). Countries that ratify the Kyoto Protocol commit to reduce their emissions of carbon dioxide and five other greenhouse gases, or engage in emissions trading if they maintain or increase emissions of these gases. A total of 141 countries have ratified the agreement. Ethiopia is a signatory to the UNFCCC and the Kyoto Protocol.

International environmental laws are increasingly requiring countries that emit carbon dioxide into the atmosphere to buy or lease carbon credits and, as a result, encourage the removal of carbon dioxide from the air. Carbon credits are units of measure that represent the natural ability of plants and soil to absorb carbon, in the form of carbon dioxide, from the air. One carbon credit is equal to one ton of carbon being absorbed by plants and soil.

Carbon sequestration credits or offsets are calculated by the amount of carbon emissions that would have been emitted if a diesel or other traditional polluting electric generator was used to produce the same amount of electricity. The present value of carbon credits is on the order of $10-12 per avoided ton of CO_2.

As EEPCO will accrue carbon credits through the use of the Tendaho geothermal pilot plant, it will benefit in the following ways:

- provide an additional source of revenue;
- improve the return on their investments for geothermal power plants;
- boost the economic feasibility of this and future geothermal projects; and
- accelerate project implementation.

The FS will include the sale of the carbon credits from the 2-5 MW pilot plant in the cost and economic evaluation calculations.

3.6 US EXPORT POTENTIAL

The strategy to assess the capacity of the Tendaho shallow geothermal resource using a small, simple, flash pilot plant has received the support of the GSE and EEPCO as well as a number of US geothermal companies. This technique has been used internationally at a number of locations (see section 3.17 below).

Roles for US geothermal companies in the Tendaho project include the following:

- Working in collaboration with EEPCO and GSE to plan and carry out the tests and analyses required for the pilot plant feasibility study.
- Preparing the components and final feasibility study report.
- Supplying, installing and commissioning the pilot plant.
- Collaborating with EEPCO and GSE to establish a long-term monitoring program for the resource and maintenance / repair program for the pilot plant.
- Training of Ethiopian personnel in all of the above operations and remaining on-site until Ethiopian personnel can operate and maintain the pilot plant and geothermal resource.
- Planning for the supply, installation and commissioning of larger geothermal power generation plants at Tendaho in the future for connection to the national grid.

It should also be mentioned that, in addition to the provision of the plant and related equipment at Tendaho, the involvement of one or more US companies in the Tendaho feasibility study will put US industry in a front-row position to provide goods and services for the planned 30 MW expansion at Aluto Langano. The 30 MW Aluto expansion is included in the March 2002 Ethiopian Power System Expansion Master Plan and will be a follow-on activity to the repair of the existing Aluto plant.

The value of the goods and services that could result from US TDA support for the Tendaho feasibility study can be estimated as follows:

2-5 MW pilot plant at Tendaho	-	$4-10 million
30 MW plant at Tendaho	-	$60-70 million
30 MW expansion plant at Aluto Langano	-	$60-70 million
Total value of goods and services for planned geothermal projects	**-**	**$124-150 million**

3.7 FOREIGN COMPETITION

The first exploration work, following the reconnaissance survey of 1969-71, was carried out under a technical cooperation program with the Italian Ministry of Foreign Affairs which financed the provision of technical services of Aquater SPA. Aquater provided a team of geologists, geochemists and geophysicists who worked with counterparts from GSE and provided exploration equipment from Italy.

More recently, companies from Italy and New Zealand have been involved in geothermal development in Ethiopia. These include Electro Consult (ELC), Milano, Italy (drilling and resource analysis at Tendaho) and GENZL, New Zealand (plant engineering and installation supervision at Aluto Langano).

The following companies participated in the January 26-29, 2005 pre-bid conference in Ethiopia for the repair of the Aluto plant:

1. US – Geothermal Development Associates
2. US – Veizades & Associates
3. Japan/US/Kenya – West Japan Engineering Consultants, Global Synergy Link, GeothermEx
4. New Zealand – Sinclair, Knight, Merz
5. Iceland – ENEX
6. Philippines - Philippine National Oil Company

For the development and supply of equipment for the Tendaho geothermal prospect, it is anticipated the main competition could come from Italy as Italian contractors have been involved in the exploration drilling

program. It is also possible that an Italian company, Turboden (http://www.turboden.it/about.asp), could provide the 2-5 MW pilot plant.

3.8 IMPACT ON THE ENVIRONMENT

Environmental issues that could arise in relation to the Tendaho pilot plant are as follows:

- Land requirements (vegetation loss, soil erosion, landslides, land ownership issues) – Some of these issues have already been addressed as part of the exploration work that has already taken place.
- Water intake issues from streams, waterways and reservoirs (for drilling and cooling) purposes – to be addressed as part of the FS.
- Drilling and production waste (brine & condensate) disposal into streams/ waterways (usually addressed through re-injection into the geothermal reservoir) – Drilling waste issues have already been addressed by GSE. Production waste will be addressed by the FS and will probably be re-injected into one of the non-productive wells that has already been drilled (TD 1 or 3).
- Air emissions (H_2S and other non condensable gases) - to be addressed as part of the FS.
- Noise pollution - to be addressed as part of the FS.

3.9 IMPACT ON US LABOR

The impact of the Tendaho pilot project US labor will be positive as it will increase the demand for US geothermal goods and services in relation to:

- Planning and design of the pilot plant;
- Supply, installation and initial operational supervision of the pilot plant and associated communication and resource/plant maintenance and monitoring systems;
- Data analysis and planning for expanded power generation at Tendaho.

US labor will be positively affected on a larger scale if the present pilot project leads to power generation on a much larger scale at Tendaho (30-100 MW - as is expected by EEPCO). In this case, larger scale drilling, scientific analysis and plant equipment and operations will be required which will increase the demand for US geothermal goods and services.

3.10 QUALIFICATIONS OF THE FEASIBILITY STUDY TEAM

The feasibility study team will consist of three experienced geothermal professionals who will work closely with personnel from EEPCO (for the geothermal plant) and from the Geological Survey of Ethiopia (in relation to the geothermal resource) respectively. Their expertise will include testing and analysis of geothermal resources, planning and sizing of geothermal plants and geothermal project financial analysis.

The resource expert should have experience with a wide range of similar geologic and geothermal environments, as well as direct involvement in exploration projects, resource/well field assessments, and modeling. Ideally, the person will also have Africa or developing country experience as well.

The plant expert should have experience with a range of geothermal plants but especially with small-scale flash and binary plants. Experience with small-scale flash steam plants is particularly important as they are the simplest and most common type of geothermal plant to install and operate.

The planner / financial analyst will be the team leader and should have a degree in engineering, economics or finance and at least 10 years experience with the financing of a wide range of geothermal plant installations in the US and other developing countries. Ideally, the person will have experience working with geothermal programs in East Africa, in general, and in Ethiopia, in particular.

3.11 JUSTIFICATION FOR US TDA GRANT FUNDING

Geothermal development has become a high priority for EEPCO as a result of (a) their need for additional generating capacity, (b) repeated droughts and the undependability of hydro supplies, and (c) interest generated by regional geothermal activities under ARGeo. The Tendaho project has been dormant for about 2 years with little activity. In the meantime, EEPCO interest and involvement in geothermal development has accelerated due to activities undertaken to repair and expand the Aluto plant, the establishment of a geothermal division within EEPCO, the appointment of a new EEPCO director for corporate planning and publicity given to geothermal energy as a result of the ARGeo program.

EEPCO now realizes it does not have the experience and training to plan a new geothermal plant but wants to move ahead to develop Tendaho as quickly as possible. ARGeo support has been requested for further drilling at Tendaho but the ARGeo program will not be operational until late 2006. EEPCO does not wish to wait that long to move ahead and has requested US TDA support for the Tendaho pilot plant FS.

In view of the lack of geothermal expertise, US TDA support is seen as critical to moving the project ahead in the near term. TDA support will make use of a proven, low-cost approach (a small pilot plant to test the resource), provide environmentally-clean power locally and provide a positive model of geothermal energy use for national decision-makers. It will also provide EEPCO with much-needed private sector geothermal expertise in the near-term.

3.12 TERMS OF REFERENCE

See attached Appendix 1.

3.13 FEASIBILITY STUDY BUDGET

Tendaho Feasibility Study Budget Summary

Categories	Days	P/M	$
Consultant labor	128	4.77	$140,800
Consultant per diem	93		$20,088
Plane fares			$17,500
In-country travel			$2,000
Communication			$2,000
Administrative support			$10,000
Final report production			$1,000
Misc. consulting costs			$5,000
Local resource tests			$79,400
Total US TDA Budget			**$277,788**
EEPCO In-Kind Contribution			$15,796
GSE Cash and In-Kind Contributions			$60,000
Total TDA and Local Contribution Budget			$353,584

For details, see Appendix 2 below.

3.14 RECOMMENDATIONS

3.14.1 Suitability of project to US TDA funding criteria

The project suits US TDA funding criteria in that it:

- Responds to a host country government development priority.
- Serves to leverage additional sources of financing from other government, multi and bilateral agencies.
- Makes use of indigenous resources.
- Is environmentally benign and encourages the use of an environmentally-friendly technology.
- Involves and paves the way for large scale US industry involvement.

3.14.2 Appropriateness of TORs for the Proposed Study

The TORs are appropriate for the proposed study since they involve close collaboration between representatives from the US geothermal industry and two important national agencies – EEPCO and the Geological Survey of Ethiopia. Each of the three entities will bring information and institutional support to the FS that will be important in order to make the resulting project a success.

3.14.3 Appropriateness of Budget for the Proposed Study

The FS will cost approximately $277,000. It is a reasonable budget as it will pave the way for larger scale power generation from the Tendaho resource.

3.14.4 Resource / Land Use Rights

As mentioned in section 3.2.6 above, the National Mining Corporation (NMC) received an exploration license for Tendaho from the Ministry of Mines in 2000 and renewed it in 2004. According to the NMC Deputy Managing Director, the NMC has not done any work at the site and has limited its activities to the review of reports and documents prepared previously by the Geological Survey of Ethiopia and foreign consultants. The renewed license will expire in October 2005.

EEPCO should contact the licensing office of the Ministry of Mines to evaluate the status of the NMC exploration license and ensure that EEPCO will have development (and follow-on exploration rights) at Tendaho before the FS work begins.

3.15 INDIVIDUALS CONTACTED

1. Ethiopia Electric Power Corporation

Mr. Mihret Debebe, General Manager, Ethiopian Electric Power Corporation, Tel: 251-1-56-0041, eepco@telecom.net.et

Mr. Tesfaye Delessa, Ethiopian Electric Power Corporation, Power Systems Operations Department Director. Tel. 251-1-50-93-77, pso.dept@telecom.net.et

Mr. Wadi Abdurahim, Corporate Planning Director, Ethiopian Electric Power Corporation, P.O. Box 1233, Tel. 251-1-56-25-40, wadiabdurahim@yahoo.com

Mr. Mulugeta Asaye, Ethiopian Electric Power Corporation, Geothermal Project Coordinator, P.O. Box 1233, Addis Ababa, Ethiopia. Tel. 251-1-50-93-77, asayemulu@yahoo.com

Mr. Merga Tassew, Ethiopian Electric Power Corporation, Geothermal Project Coordinator, P.O. Box 1233, Addis Ababa, Ethiopia. Tel. 251-1-50-93-77, mergatassew@yahoo.com

2. Ethiopian Electric Agency

Mr. Getahun Kifle, General Manager, P.O. Box 2554 Addis Ababa, Tel.: 251-1-507733/35/57, Fax: 251-1-507734. electric.agency@telecom.net.et

3. Geological Survey of Ethiopia

Mr. Ketema Tadesse, General Manager, Geological Survey of Ethiopia, P.O. Box 2302, Addis Ababa, Tel. 251-1-46-33-26, geology.institute@telecom.net.et

Dr. Meseret Teklemariam, Geology/Geothermal Department Head, Geological Survey of Ethiopia, P.O. Box 40069, Tel. 251-1-202858, meseret_zemedkun@yahoo.com

Mr. Yiheyis Amdebirhan, Chief Reservoir Engineer, Geological Survey of Ethiopia, P.O. Box 26397, Tel. 251-1-202486, geology.institute@telecom.net.et

Dr. Berhanu Gizaw, Expert Geochemist, Geological Survey of Ethiopia, P.O. Box 32399, Tel. 251-1-202861, berhanugizaw@yahoo.com

4. National Mining Corporation

Mr. Aberra Degefu, Deputy General Manager, P.O. Box 1174, Addis Ababa, Tel. 251-1-71-18-87, nmic@telecom.net.et

5. Ethiopian Rural energy Development and Promotion Center

Mr. Asress Woldegiorgis, Director General, P.O. Box 8063. Addis Ababa, Tel. 251-1-153689. eesrc@telecom.net.et

7. US Embassy

Ms. Aurelia E. Brazeal, US Ambassador, US Embassy, P.O. Box 1014, Addis Ababa, Tel: 251-1-550 666, Fax: 251-1-550 342

Mr. Dan Balzer, Regional Environmental Hub Officer, US Embassy, Addis Ababa, Tel: 251-1-55-06-66, ext. 283. balzerdk@state.gov

Mr. Moges Worku, Assistant to the Regional Environment Officer, US Embassy, Addis Ababa, Tel: 251-1-55-06-66, ext. 283, workum@state.gov

Mr. Robert Arbuckle, Press and Information Officer, US Embassy, Entoto Street, P.O. Box 1014, Addis Ababa. 251-1-17-40-07, arbucklerh@state.gov

Ms. Elizabeth Jaffee, Economic/Commercial Officer, US Embassy, P.O. Box 1014, Addis Ababa, Tel. 251-1-17-43-31, jaffeeee@state.gov

3.16 POTENTIAL US INDUSTRY PARTICIPANTS

Potential US companies that could participate in the FS should have expertise in either geothermal resource analysis, power plant planning, operation and maintenance or project financial analysis and planning. A few of the US companies with these types of expertise include:

Bibb and Associates – power plants
Tom Ettinger
35N Lake Avenue, Suite 800
Pasadena, CA 91101
(626) 396 - 3501
Fax: (626) 440-8848
tjettinger@bibbwest.com

GeothermEx – resource and power plants
Ann Robertson-Tait
5221 Central Avenue, Suite 201
Richmond, CA 94804
510-527-9876, Fax: 510- 527-8164
Email: mw@geothermex.com

Geothermal Development Associates – resource analysis and power plants
770 Smithridge Drive, Suite 550
Reno, NV 89502
G. Martin Booth III
(775) 825-5800 FAX (775) 825-4880
mbooth@gda.reno.nv.us WEBSITE www.greatbasin.net/~gda

Thermochem, Inc. – resource analysis
3414 Regional Parkway, Suite A
Santa Rosa, CA 95403
Paul Hirtz
(707) 575-1310 ext. 103
(707) 575-7932
paul@thermochem.com
www.thermochem.com

Science Applications International Corporation
John Pritchett
10280 Campus Point Drive
Mail Stop A-1082
San Diego, CA 92121
Phone: 858-826-1628
Fax: 858-826-1652
John.W.Pritchett@saic.com

Geo Hills Associates
Jim Combs
2395 Catamaran Dr.
Reno, NV 89509
775-827-1960; Fax: 775- 827-1960
jimjeany@ix.netcom.com

Veizades & Associates, Inc. – power plant design
Henry Veizades
One Hallidie Plaza, Suite 838
San Francisco, CA 94102

Phone: 415-394-8855; Fax: 415- 394-8866
hgveizades@veizades.com

Power Engineers – power plants
Marshall Ralph
3940 Glembrook Drive
PO Box 1066
Hailey, ID 83333
Phone: (208) 788-3456
Fax: (208) 788-2082
mralph@powereng.com

3.17 INTERNATIONAL PERSPECTIVE

There are approximately 50 small geothermal power units installed around the world, though not always in remote locations. Some small-scale plants have been used within larger geothermal developments because they fit with incremental energy development plans and were installed early in a site's development. Representative installations include:

- Indonesia – Dieng Monoblock – 2 MW
- Thailand – Fang – 300 kW
- Argentina – Copahue – 1 MW
- Tibet – Nagqu – 1.3 MW
- China – Tu Chang – 300kW
- Mexico – Los Azufres – 1.4 MW
- US – Amadee, CA – 2 MW
- US – Wabuska, NV – 2 MW
- US – Wineagle, Susanville, CA - 750 kW
- New Zealand – Tarawera – 2.6 MW

There is therefore a considerable body of experience to draw on to plan, install, operate, maintain and monitor a 2MW plant at Tendaho.

APPENDIX I

Section 3.12 of Work Statement

Consultant Terms of Reference for Tendaho 2-5 MW Pilot Plant Feasibility Study (FS)

Planner / Financial Analyst – Resource Specialist – Power Plant Specialist

3.12.1. Purpose and Objective of the Study

The FS will assess the viability of using a simple flash steam geothermal plant mounted on the wellhead of one (or possibly two) of the existing wells at Tendaho to generate 2-5 MW of power for local use and connection to the national grid. The pilot plant will enable the Geological Survey of Ethiopia (GSE) and EEPCO to monitor the performance of the resource during a 9-12 month evaluation period to pave the way for large-scale power generation from the Tendaho resource.

In order of priority, the objectives of the 2-5 MW pilot plant installation are:

a. Evaluate the capacity of the shallow Tendaho geothermal resource for large scale (> 30 W) power generation
b. Train local scientists, engineers, and technicians in the use of a small-scale geothermal plant for the assessment and use of a geothermal resource and the operation of simple backpressure geothermal plant
c. Provide less expensive and polluting electric power for the immediate region
d. Explore how the sale of carbon credits can lower the cost of geothermal power generation in Ethiopia
e. Establish additional working relationships between EEPCO and the geothermal private sector
f. Help Ethiopia and the ARGeo program achieve regional geothermal-based power generation and environmental benefits.

3.12.2 Technical Analysis of the Project

See items 3.12.8.2, 3.12.8.3, 3.12.8.4, 3.12.8.14 b and c, 3.12.8.16 a, b, and c, 3.12.8.17, 3.12.8.18, 3.12.8.19 and 3.12.8.20 below

3.12.3 Financial Analysis of the Project

See items 3.12.8.5 a-d, 3.12.8.6 a-f, 3.12.8.7, 3.12.8.8, 3.12.8.10, 3.12.8.11, 3.12.8.12, and 3.12.8.13 below.

3.12.4 Environmental Analysis of the Project

See items 3.12.8.15 a-c below.

3.12.5 Review of Regulatory Issues

See items 3.12.8.11 below.

3.12.6 Summary of key Host Country Economic Benefits

See item 3.12.8.5e below.

3.12.7 Proposed Equipment and Services including US suppliers

See items 3.12.8.5a, 3.12.16a, 3.12.8.18 e and 3.12.8.19 below.

3.12.8 Project Implementation Plan

See items 3.12.8.1, 3.12.8.9 and 3.12.8.20 a-v below.

3.12.8.1 Feasibility Study Participants and Management

The FS will be managed by the Geothermal Division Director of EEPCO, Mr. Mulugeta Asaye. Mr. Mulugeta is an engineer, has received supplementary geothermal training at the United Nations University in Iceland and has been leading the geothermal rehabilitation work at Aluto Langano.

Three experienced private sector geothermal specialists (one geothermal planner, one resource and one plant specialist) will be contracted to lead the technical aspects of the FS.

Staff from the Ethiopian Electric Power Corporation (EEPCO) and the Geological Survey of Ethiopia (GSE) will participate in the FS as appropriate.

Terms of Reference for the Geothermal Planner/Financial Analyst

3.12.8.2 Country and Regional Profiles

Acquire and compile country and regional profile information pertinent to the planning and implementation of the project, including geography, climate/weather, cultural, government, economy, recent history, foreign relations, etc.

3.12.8.3 Electrical Market in Ethiopia and the Afar Region

Acquire and compile historical and projected energy and capacity information in Ethiopia and in the Afar region for use in assessing the market for electricity generated by the 2 MW pilot Tendaho geothermal power plant and future larger-scale (30MW+) capacity. Include plans EEPCO may have to (a) increase hydro and diesel generation capacity nationally, (b) connect the grid to Djibouti and (c) connect power generated from the Tendaho geothermal resource to the national grid when the grid is brought to Semera.

3.12.8.4 Institutional Framework

a. As EEPCO will own and operate the pilot plant, describe the EEPCO institutional structure and management plan for the project. Identify and describe role(s) to be assumed by EEPCO and the Ethiopia Geological Survey, local consumers, and other potential stakeholders.

b. Describe the local market for electric power and how local geothermal power generation (and the connection of Semera to the national grid) will affect the local economy. .

c. Provide record of past diesel energy expenditures in the area by EEPCO and local power producers and describe how the availability of less costly, more reliable electric power will impact agricultural production.

d. Evaluate how the connection of a 2-5 MW geothermal pilot plant (and eventually, a 30 MW+ plant) will influence the attitude of local and national leaders toward the use of geothermal energy.

3.12.8.5 Project Costs

a. **Capital Cost Estimate**
The capital cost estimate should provide a detailed breakdown of the costs that will be incurred to bring the project to successful commissioning. It should be subdivided into categories entitled: project administration, well field development, engineering, site development, powerhouse and cooling requirements, steam gathering system, substation and connection to the local and national grids, spare parts, tools, vehicles, and miscellaneous.

b. **Project Operating Expenses**
The projected operating expenses should include a detailed breakdown of the general, administrative, operating, and maintenance costs for the project. Escalation of the expenses over a 2-5 year period should be taken into consideration depending on the nature of the expense and the point in the life of the project at which they are incurred.

c. **Projected Revenue**
The projected revenue should model the electricity sales of the project over time. Projections should be based on the tariff applicable to the project, or a best estimate of what that tariff may be.

d. **Cash Balance Pro Forma**
The cash balance pro forma should present the net cash flow from the project, determined by netting revenue against expenses. Revenues should include income from energy and capacity sales. Expenses should include above mentioned administrative, operation, and maintenance expenses as well as debt service. The cash balance pro forma should also project after-tax income.

e. **Economic Development Benefits**

Economic, social, environmental and political benefits for the local area, country and East Africa region should be presented in detail if the project is implemented according to the FS recommendations. While specific attention should be paid to the immediate impact of the project, additional developmental benefits, including spin-off and demonstration effects, should also be included. The description and analysis of potential benefits should be as concrete and detailed as possible and provide the project's decision-makers and interested parties with a broad overview of the project's potential effects on the host country.

Assessments of the project's potential benefits should be provided in the following areas:

- Infrastructure / industry – by including a statement on the infrastructure impact giving a brief synopsis.
- Market-oriented reforms – by describing any regulations, laws, or institutional changes that are recommended and the effect they would have if implemented.
- Human capacity building – by describing the number and type of positions that would be needed to construct and operate the proposed pilot plant as well as the number of people who will receive training and a brief description of the training programs.
- Technology transfer and productivity enhancement – by providing a description of any advanced geothermal technologies that will be utilized as a result of the project including a quantitative description of any efficiency that will be gained.
- Other – by identifying any other developmental benefits of the project, including any spin-off or demonstration effects.

3.12.8.6 Project Economics

An economic model of the project should be presented to measure its financial performance. The economic profitability (or need for a subsidy) of the project should be estimated including the following:

a. Electricity Cost

The cost of the electricity produced by the project should be compared with the cost of the present diesel-based system and anticipated grid connection.

b. Cost Benefit Analysis

A cost-benefit analysis of the project to EEPCO as well as an estimation of economic benefits of the project to Afar region and to the country should be prepared. The anticipated economic rate of return of the project to EEPCO should be evaluated based on assumptions including likely prices of electricity, regional and national demand, interest rates on loan capital, O&M, potential sale of carbon credits, insurance and other costs.

c. Monitoring Program

The cost of the resource monitoring program should be calculated and an understanding reached between EEPCO and GSE how it will be implemented and financed. Consideration should also be given to whether the incurred costs will be included in the cost of the resulting electricity.

d. Project Timing

Timing of the project should be analyzed, and the impact on project economics (i.e. internal rate of return) of potential delays.

e. Potential Subsidies

The type and amount of subsidy that may be available from the Ethiopian Rural Energy Development and Promotion Center (EREDPC) and the impact of the subsidy on the economic rate of return and profitability of the 2-5 MW pilot plant as well as future geothermal plants installed at Tendaho.

f. Risk Analysis

Risk analyses including the feasibility of the project in relation to issues of concern to investors and banks, resource characteristics, cost overruns, construction delays, country and off-taker risk and a sensitivity analysis of the impact of macroeconomic changes on cost and revenue. Also regulatory, or market structure factors that could negatively or positively affect the project's profitability.

3.12.8.7 Project Financing

Prepare a financial analysis and model of the project, considering alternative methods and sources of financing, including grants and concessionary financing, equity, and debt.

The financial model should be a tool for defining the terms and conditions of the financing structure and testing the volatility of the project's ability to service its debt. Appropriate assumptions related to capital costs, operations, maintenance, administrative/personnel costs, taxes, tariffs, etc. should be provided in the model, which will provide the project's projected pro forma financial statements and the IRR pre and post taxes. Any anticipated subsidies and sale of carbon credits should be included.

A sensitivity analyses in relation to changes in interest rates, marginal system costs, tariffs, operating and maintenance costs, exchange rate, among others, should be provided in order to determine impacts on the IRR and financial ratios, to the extent that it may relate to specific conditions in Ethiopia.

Comments regarding the economics of the project under the various assumptions (i.e., the magnitude of the loan and subsidy fractions to make future projects attractive to an equity investor, etc.) should be included.

3.12.8.8 Risk–Related Issues

Risks can be related to resource, economic, financial, environmental and political factors.
Identify project risk factors and develop a risk avoidance/reduction plan and budget for each factor by means of insurance and bonding, adequate to the requirements of the funding sources.

3.12.8.9 Implementation Schedule

Schedules should be provided for total project and power plant construction. project schedules, segmented into phases, should be: Phase I–Feasibility Study, Phase II–Principal Project Agreements, if required, Phase III - Project Implementation, Phase IV– Plant monitoring and resource evaluation.

3.12.8.10 Funding Sources

Potential funding sources should be identified, accompanied by letters of interest.

a. Grants

b. Loans

c. Subsidies

d. Sale of carbon credits.

3.12.8.11 Taxes, Duties and Fees

Acquire copies of pertinent documents which deal with import taxes, duties and fees; corporate and personal income taxes, property and other taxes.

Identify key elements to be agreed upon prior to or during PPA negotiations (tax holiday, import duty exoneration, etc).

3.12.8.12 Carbon Credits

Carry out the following:

a. Calculate value of the carbon credits that will result from the plant.

b. Identify potential institutional buyers for the carbon credits.

c. Integrate the cost benefits from the sale of the carbon credits into the project economics and financing calculations

Terms of Reference for the Geothermal Resource Specialist

3.12.8.13 Resource Information Collection and Modeling

Determine the character of the Tendaho geothermal resource based on available information, its potential to supply the energy required to support the planned power plant, and the cost to develop the resource. The analysis should focus on the shallow, moderate- to high-enthalpy reservoir. The steps to complete this task are:

a. Data Acquisition, Compilation and Analysis

Resource-related data from Tendaho to be acquired, compiled and analyzed will include topographical, geological, geophysical, geo-chemical, hydrological, well drilling and testing, and scaling information. Data will be put into a format which will provide the technical and scientific basis for geologic modeling of the reservoir. The model will be the basis for preparing a future resource confirmation and well field development program and related costs.

b. Resource Tests

Collaboration will take place with the Geological Survey of Ethiopia to carry out the following tests:

- A 15 day gravity survey to establish baseline data for subsidence monitoring

- Discharge tests over a 3 month period to assess well performance during extended discharge conditions at likely operating conditions and estimate reservoir transmission properties.

- 3 month output tests at one of the productive wells to ascertain the relationship between the wellhead pressure and a stable discharge rate and estimate productivity of the well and its potential for future exploitation.

c. Generation of a 3-D topographic base map

The map of the Tendaho area will be used as the platform for representing all geotechnical and environmental data for the project. For example, Land Desktop software can be used to create the project base map and incorporate a digital elevation model so that all data from existing wells and geological and geophysical exploration and resource assessment activities can be represented in three-dimensional spatial location.

3.12.8.14 Environmental and Social Considerations

Acquire copies of environmental laws and regulations which pertain to the project and to the permitting process. Prepare an environmental analysis of the project which should be presented in the form of a report to include:

a. Baseline Environment and Social Issues

Available information on regional geology, project area geology and minerals, geothermal manifestations and reservoir, exploration history, seismicity, subsidence, soils, vegetation, flora and fauna, surface water, groundwater, land use, air quality, cultural resources, noise, and visual resources.

Local farms, commercial establishments, industries and inhabitants who are likely to be affected by the project should be identified.

b. Environmental Impacts

The anticipated impacts on the above aspects of the existing environment, businesses and population groups due to the project should be defined.

c. Mitigation

Mitigations plans for the above elements should be provided to eliminate or minimize any environmental impacts.

3.12.8.15 Resource Monitoring and Assessment Plan

A schedule, implementation and staffing plans and budget for the monitoring and analysis of the resource will be prepared including:

a. Monitoring and evaluation objectives, procedures, equipment, personnel and costs.

b. Reservoir geochemistry

- Review of existing geochemical research pertaining to the Tendaho resource.
- Identification of surface hydrothermal features on the project base map.
- Utilize existing reservoir fluid chemistry to develop a scale control program, if one is needed, for both production wells and surface piping.

c. Reservoir geology and volume

- Surface geologic data including existing structural and geologic maps should be compiled. Existing surface and subsurface geologic, hydrothermal and geophysical data should be compiled into the comprehensive 3-D geologic model of the resource area.

3.12.8.16 Scaling Analysis and Mitigation

Prepare a program and budget for managing the geothermal fluids (liquid and gas components) and mitigation of any scaling that may result in wells, surface facilities and the reservoir upon injection. Consult with US chemical companies specializing in geothermal fluids scaling technology.

Terms of Reference for Power Plant Specialist

3.12.8.17 Power Plant Design

Based on the characterization and deliverability of the reservoir fluids and demand forecasts, the Power Plant Specialist will:

a. Utilize computer models to estimate power output from the various plant technologies (e.g. condensing vs non-condensing, dry vs wet cooling).

b. Compare the results of the modeling to select the optimal technology for the power plant taking into account both simplicity of operation and maximizing lessons that can be learned about the capacity of the reservoir.

c. Recommend an appropriate type and size of pilot plant taking into account the capacity of the existing wells, the resource quality, maintenance and monitoring requirements and the skill levels of the EEPCO and GSE personnel who will be responsible for maintenance and monitoring operations.

d. Prepare a schedule, cost estimate, staffing plan and monitoring program for the plant including operation of key components such as separator, turbine/generator, condenser, cooling system, re-injection lines and pumps, power control, monitoring and recording systems, environmental emissions sensors and transmission line.

e. Identify potential US suppliers of the goods and services required to install, and possibly operate and maintain the pilot plant.

f. Prepare components of the Final Report that summarize the above and compare different power generation technologies considered, provide recommendations for the power plant to be installed, the personnel required to operate it and the staffing, maintenance and monitoring programs that should be established to ensure its continued operation. Recommendations should also be provided for techniques to be used to assess the overall potential of the Tendaho geothermal resource and the steps that EEPCO may follow to increase the scale of power generation from the Tendaho resource in the shortest possible time.

3.12.8.18 Transmission Line Design and Planning

Provide preliminary design and costing of a 10 km transmission line (possibly 15kV) from the Tendaho field to Dubti and from Dubti to the EEPCO Semera substation. Prepare a list of local Ethiopian companies that could bid on, install and maintain the transmission line if EEPCO were to suggest this option.

3.12.8.19 Ste Development Plan

Prepare a plan for the completion of the well field (production and injection wells), if required, in sufficient detail for budgeting and scheduling. Include:

a. Communications between site office, management quarters and the Dubti Farm.

b. Plant security, fencing, and site access control.

c. Access to and description of closest medical facility

d. H_2S detection, alarm system, safety equipment.

e. Measurement procedures instrumentation for pressure and temperature (down hole and wellhead).

f. Measurement procedures and instrumentation for steam and fluid flow rates.

g. Gas and fluid sampling and preservation procedures and equipment

h. Fluid reinjection, storage and/or disposal

i. Required modifications to wellheads for steam collection

j. Site cleanup

k. Specifications for reservoir testing and modeling.

l. Equipment specifications for down-hole monitoring of well pressure.

m. Monitoring equipment specifications and procedures for flowing production wells.

n. Monitoring equipment specifications and procedures for injection wells.

o. Method of initiating flow, if required.

p. Reservoir testing procedure including duration of flow, step rate test and shut-in.

q. Scale control during reservoir testing, if necessary.

r. Data reduction, interpretation and modeling of reservoir test results.

s. Final reservoir report and estimate of sustainable reservoir production capacity.

t. Plant construction schedule including verifiable milestones.

u. Plans amenable to EEPCO, the Dubti Farm (and joint venture industry partner, if appropriate) for ordering, transporting and installing the plant.

v. Plans for construction of a transmission line to the Dubti Farm and to the anticipated grid connection point at Semera.

3.12.8.20 Final Report

The final FS report should present the findings of the Feasibility Study. All 3 experts will contribute to the report although completion and submission of the final report will be the responsibility of the Geothermal Planner / Financial Analyst.

The Geothermal Planner / Financial Analyst will ensure that the final report is submitted in accordance with Clause H of Annex II of the standard US TDA Grant Agreement, and that it is a substantive and comprehensive report of the work performed. The final report should include evidence of the completion of all of the tasks set forth in the terms of reference and will include an executive summary. Each task of the terms of reference will form a separate chapter of the final report. The final report must also include a comprehensive list of suppliers, including potential sources of U.S. equipment and services that are relevant to the implementation of each component of the project as outlined in the FS. In addition, other documents or materials that provide material input or clarity to the final report should be included as appendices including contacts made by the FS team, and documents that would be of interest to potential financiers.

The final report will be submitted in English. Ten (10) hard and one (1) electronic version of the final report will be submitted to USTDA in accordance with Clause H of Annex II of the standard US TDA Grant Agreement.

APPENDIX II

Detailed Budget for Tendaho Feasibility Study

Tendaho Feasibility Study Budget

Geothermal Planner/Financial Analyst	Person days	Daily rate	IC days	USG perdiem	Consult. Fees	Perdiem total
Country and Regional Profile	2	$1,100			$2,200	
Perdiem			2	$216		$432
Electrical Market in Ethiopia and Region	4	$1,100			$4,400	
Perdiem			4	$216		$864
Institutional Framework	5	$1,100			$5,500	
Perdiem			7	$216		$1,512
Project Costs						
Capital Cost Estimate	5	$1,100			$5,500	
Perdiem			3	$216		$648
Project Operating Expenses	4	$1,100			$4,400	
Perdiem			3	$216		$648
Projected Revenue	4	$1,100			$4,400	
Perdiem			3	$216		$648
Cash Balance Proforma	3	$1,100			$3,300	
Perdiem			1	$216		$216
Economic Development Benefits	4	$1,100			$4,400	
			1	$216		$216
Project Economics						
Electricity Cost	1	$1,100			$1,100	
Perdiem			1	$216		$216
Cost-Benefit Analysis	4	$1,100			$4,400	
Perdiem			2	$216		$432
Monitoring Program	4	$1,100			$4,400	
Perdiem			3	$216		$648

Project Timing	2	$1,100			$2,200	
Perdiem			1	$216		$216
Potential Subsidies	2	$1,100			$2,200	
Perdiem			1	$216		$216
Risk Analysis	3	$1,100			$3,300	
Perdiem			2	$216		$432
Project Financing	3	$1,100			$3,300	
Perdiem			3	$216		$648
Risk-related Issues	2	$1,100			$2,200	
Perdiem			2	$216		$432
Implementation Schedule	2	$1,100			$2,200	
Perdiem			2	$216		$432
Funding Sources	2	$1,100			$2,200	
Perdiem			2	$216		$432
Taxes, Duties, Fees	2	$1,100			$2,200	
Perdiem			2	$216		$432
Sale of Carbon Credits	2	$1,100			$2,200	
Perdiem			2	$216		$432
Final Report Preparation	12	$1,100			$13,200	
Perdiem			5	$216		$1,080
Geothermal Resource Specialist						
Resource Info Collection, Modeling						
Data Acquisition, Compilation, Analysis	8	$1,100			$8,800	
Perdiem			6	$216		$1,296
Resource Tests	12	$1,100			$13,200	
Perdiem			10	$216		$2,160
Generation of 3-D Topographic Map	5	$1,100			$5,500	
Perdiem			3	$216		$648
Environmental and Social Considerations						
Baseline Environment and Social Issues	7	$1,100			$7,700	
Perdiem			5	$216		$1,080

Environmental Impacts / Mitigation	5	$1,100			$5,500	
Perdiem			4	$216		$864
Resource Monitoring, Assessment Plan	5	$1,100			$5,500	
Perdiem			4	$216		$864
Scaling Analysis and Mitigation	2	$1,100			$2,200	
Perdiem			1	$216		$216
Power Plant Specialist						
Power Plant Design	5	$1,100			$5,500	
Perdiem			3	$216		$648
Transmission Line Design and Planning	3	$1,100			$3,300	
Perdiem			2	$216		$432
Site Development Plan	4	$1,100			$4,400	
Perdiem			3	$216		$648
Subtotal 1 - Consulting Fees, Perdiem	**128**		**93**		**$140,800**	**$20,088**
Other Consultant Costs						
	Trips	**Cost/trip**				
Consultant plane fares to Ethiopia	7	$2,500			$17,500	
Incountry travel					$2,000	
Communication					$2,000	
Administrative support					$10,000	
Final report reproduction					$1,000	
Miscellaneous					$5,000	
Subtotal 2 - Other Consultant Costs					**$37,500**	
Local Resource Testing Costs						
15 Day Gravity Survey						
Equipment, lubricants, parts, fuel					$2,400	
3 Month Discharge Tests						
Equipment, lubricants, parts, fuel					$15,000	

3 Month Output Tests Equipment, lubricants, parts, fuel	$15,000
5 Month Geochemical Monitoring Tests Equipment, lubricants, parts, fuel	$15,000
Interference Testing (2 wells) Equipment, lubricants, parts, fuel	$32,000
Subtotal 3 - Local Resource Testing Costs	**$79,400**
Total TDA Budget	**$277,788**
EEPCO In-Kind Contribution Vehicle, perdiem, local salaries	**$15,796**
GSE Cash and In-Kind Contribution Vehicle, perdiem, local salaries	**$60,000**
Total TDA and Local Contribution Budget	**$353,584**

Tendaho Pilot Plant FS Proposal Evaluation Criteria

I. Specific experience of the consultants related to the assignment (10 points)	
a) Relevant experience with similar geothermal consultancy work	5
b) Relevant experience with similar geothermal consultancy work in developing countries, esp. Africa	5
II. Qualifications and competence of the key staff for the assignment (50 points)	
a) A geotheral planner / financial analyst (Team Lead) with sufficient knowledge and experience to advise EEPCO, GSE and the team members in relation to the overall scope and objectives of the FS as well as detail the financial and institutional aspects of the project. Africa experience a plus.	20
b) A geothermal resource expert with experience in a wide range of geologic and geothermal environments, as well as direct involvement in exploration projects, resource/well field assessments, and modeling. Africa experience a plus.	15
c) A geothermal plant expert with experience in a range of geothermal plants especially small-scale flash and binary. Africa experience a plus.	15
III. Adequacy of the proposed work plan and methodology in responding to the terms of reference (30 points)	
a) Understanding of the current electricity sector environment in Ethiopia and projected role of geothermal	5
b) Understanding of institutional roles of Ethiopia Electric Power Corporation, Geological Survey of Ethiopia, Ethiopia Electricity Agency and private sector in relation to geothermal development	5
c) Proposed workplan for the FS including development of strategy for use of the pilot plant to assess power generation potential of the resource and steps to be taken to develop resource as quickly as possible on large scale.	20
IV. Local Participation (10 points)	
a) Strategy for planning participation of local plant, resource and power planning specialists in the FS	5
b) Strategy for use of the plant for training of local plant and resource specialists	5
Total	**100**