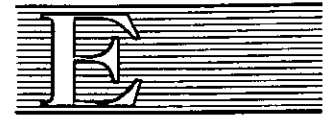




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**RURAL ELECTRIFICATION PROJECTS FRAMEWORK
DOCUMENTS**

(PROTOTYPES)

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Executive Summary

1. The ECA/Regional Cooperation and Integration Division in its desire to meet the energy requirements of the rural population of most developing countries in Africa proposes project prototype using renewable energy technologies (RETs), such as biomass-fired power systems, mini-hydropower stations, wind power, or PV solar energy systems.

2. The proposed prototype projects are based on the assessment of three East African Countries, Ethiopia, Kenya and Uganda. The development of rural electrification in most developing countries is similar and conclusions reached are in general applicable to most of the countries needing rural electrification.

3. In the past the three countries have attempted to reach rural areas through subsidizing rural electrification programs. In most cases, these projects based on grid extension or diesel generated electrification programs have failed to reach the targeted customers. The percentage of population receiving electricity in all these three countries does not exceed 5% of the total population. It is thus evident that alternative approaches to rural electrification schemes have to be found.

4. Decentralized electricity supplies using renewable energy technologies, particularly small hydropower stations, Photovoltaic solar energy systems, wind power and biomass based power systems can often provide remote communities and businesses with the most reliable and affordable sources of electricity.

5. Although all these renewable energy resources are available in abundance in the three East African countries assessed in this study, none of them have benefited from the technologies now available in the market to ensure their sustainable development to meet the energy needs of their rural population.

6. In Uganda, Kenya and now in Ethiopia there is a UNDP/GEF project build up for a sustainable commercial dissemination network for household PV systems. The World Bank is launching this project to also cover Tanzania and Eritrea. The project objectives are:

- a) Create one sustainable commercial corridor of PV supply between importers, dealers and rural consumers in a high potential district;
- b) Raise awareness among policy makers and development partners;
- c) Assist commercial companies to develop viable PV business;
- d) Encourage international PV companies to participate in the business development; and;
- e) Create awareness and put in place the required technical capacity to market, design, install and maintain PV systems for small needs in one rural district.

7. The Uganda Renewable Energy Association (UREA) was established in 1996 in conjunction with an innovative developed by the Government of Uganda to address the problem of rural electrification through the installation of solar photovoltaic (PV) system in rural areas of the country by the Uganda private sector. Similar companies do exist in Kenya and could be established in Ethiopia. These companies could also promote renewable energy electrification programs based on mini-hydro, wind and biomass based power if appropriate government institutional mechanism are in place.

8. As regards mini-hydro development in all three countries it is embarrassing to note that not a single mini-hydropower plant has been commissioned in the past 15 years, yet sufficient numbers of potential sites have been identified. It is the intent of this study to indicate that a mechanism could be established for a sustainable implementation of mini-hydro project in these countries.

9. Biomass based powered generation is a new technology, and if introduced as a demonstration plant in any of these three countries through bilateral assistance, private entrepreneur could be attracted to promote the marketing in sustainable manner.

10. Wind power based technologies are developing at an economically attractive rate, and at the moment the installation per kW costs are comparable to diesel generators, and with a negligible operating cost advantage, it could replace diesel generators in most of the places where diesel generators are installed, or planned to be installed, as rural electrification program by the governments.

11. In order to convince the private entrepreneurs to market these technologies bilateral donors have been approached to install demonstration plants in these countries, so that implementation of rural electrification programs using the renewable energy resources could be carried out in a sustainable manner.

12. It is the findings of this study that three governments are ready to alleviate any barriers for the development of electrification based on renewable energies. The governments do realize the importance of providing electricity in the rural communities. All three have identified rural electrification as one of the priority sectors in their financial year programs. All three governments have or are in the process of establishing rural electrification fund from which soft loans will be provided to the private sector on appropriate good terms.

13. The governments have approached donor communities such as the World Bank, Global Environmental Facilities, UNDP, etc. to finance the fund.

14. The implementation of rural electrification programs would be sustainable through strengthening local expertise to support the private sector to design, manufacture, supply and install RETs.

15. The promotion of regional programs at all levels of development, research, design, contract, manufacturing, marketing will ensure the confidence of the governments, financial institutions in meeting the needs of the rural poor.

I. Introduction

1. Electricity in almost all Sub-Saharan African countries is a privilege and that for cities only. The World Energy Council proposed a target of a minimum of 500 kWh per person per year for everyone in the world by 2020. With the current per capita consumption (Ethiopia: 25 kWh, Kenya 127 kWh and Uganda 44 kWh) this figure seems to be out of all bounds for these countries at the moment.

2. Even to achieve a modest target, which is well short of the proposed 500 kWh, African countries need to undertake strenuous efforts. The terrain in most countries and the settlement pattern are such that distributed generation seems to be the only viable option to increase the level of electrification in any significant manner. Many African countries are ideally placed in terms of resource base for such a strategy. Large parts of the countryside receive sufficient solar radiation throughout the year. The average wind velocity in many regions is known to be large enough for electric power generation. The mini/micro hydropower resource base in countries like Ethiopia and Uganda is probably one of the largest in Africa.

3. The provision of adequate and affordable rural energy in general and electricity in particular- especially renewable energy-based- have direct synergy with poverty reduction strategies that many African countries are now implementing. An affordable source of electrical as well as mechanical and thermal energy could encourage the establishment of agro-processing and cottage industries, which would create employment opportunities in rural areas and increase disposable income. In addition, it would enhance the development prospects of many countries by increasing their exchange earning through export of agricultural products.

4. Enabling individual rural households to have access to amenities like affordable electricity, which is currently restricted to urban areas, would improve the quality of education, health, and other services. Additionally, electricity would improve the attractiveness of rural areas and would provide an incentive for better-trained persons to serve in more remote areas and encourage the establishment of government offices and associated services.

5. The proposed activities within the realm of this project aim to establish a comprehensive picture with regard to the resource base and to map out a broad strategy for their long-term sustainable utilisation.

6. When talking about rural electrification, the basic problem that needs to be addressed is the question of affordability. Even though costs of renewable energy are continuously going down as volume increases, in many cases renewables are not directly competitive with conventional alternatives. Accordingly, the high up-front costs and impediments to capital mobilisation are leading to inadequacies and shortfalls in financing programs. Additionally, weak or non-existing incentives and inconsistent government policies are leading to a situation where characteristics and benefits of renewables are not always adequately addressed in energy policy frameworks.

7 The launching pad for renewables in the rural energy scene is, therefore, rather unfavourable. In most cases, there is a very limited capacity to support projects and markets due to lack of experience and investments. Additionally, one has to contend with insufficient human and institutional infrastructure.

8. The study, therefore, aims to identify ways of:

- Reducing technology costs by expanding markets
- Building a strong market environment and encouraging market-based mechanisms
- Mobilising financing
- Enhancing the local capacity to technology absorption and adaptation related to design, manufacturing, operation and maintenance of equipment of renewable energy technology.

9. In the following sections detailed descriptions of issues that need to be addressed are given. Further, pilot installations based on micro hydro, solar biomass and wind based technologies are proposed

II. Problem statement

10. The most important energy sector problems in the sub-region as elsewhere in Sub-Saharan Africa can be summarized as follows:

- Heavy reliance on biomass fuels, which has resulted in a serious gap between supply and demand. Increasingly the expanding gap between the supply and demand of energy, especially biomass has resulted in undermining forest resources. Because of this, unless measures to reverse this situation are undertaken, there will be a serious adverse effect on the environment and on agricultural production.
- Low level of per capita energy consumption that is insufficient for both developmental activities and maintaining a reasonably good standard of living.
- Under-utilization of renewable energy resources.
- Low level of fuel utilization efficiency in the households.
- Excessive use of foreign exchange earnings for imports of petroleum products to meet only a tiny portion of the overall energy demand.

11. In general, it can be noted that the amount of energy supply available at the moment *in most countries in Sub-Saharan Africa* is inadequate for survival and developmental requirements of the population. This situation, unless reversed, will result in an undesirable situation such as the disruption of the entire socio-economic fabric of the society.

III Overview of the current state of energy supply in the selected countries

III.1 Background

12. Although the problem of deforestation and land degradation has assumed alarming proportions in many of the countries under consideration, it is highly unlikely that a massive transition from biomass fuels to commercial energy sources will take place in the near future. Accordingly the efforts aimed at a sustainable utilization of biomass resources and renewable energy development must be mutually supporting. The constraints to development in each of these sectors are inter-related.

13. The backward institutions and lack of consistent policy frameworks do not allow the treatment of the energy problem in an integrated manner. Rather, most of the ongoing solutions (mostly using diesel engines) are ad hoc in nature and narrow-focused.

14. To achieve the rural electrification goals, major institutional and attitudinal changes will be needed.

III.2 Energy demand and supply patterns in the selected countries.

IV.2.1 Ethiopia

15. Ethiopia is bordered by Djibouti, Eritrea, Sudan, Kenya and Somalia. It has large water resources potential. Though located very close to the equator its temperatures is cooler due to its altitude. Dry seasons are from November to February and from May to June. Annual rainfall varies from few millimetres to 2500 millimetres.

16. The Ethiopian population is approximately 60 million and is increasing at about 3.6% annually. The annual per capita income is estimated at \$100. About 85% of the population live in rural areas.

17. The energy sector of Ethiopia can be divided into four major categories: biomass, petroleum, electricity and renewable sources. Ethiopia is endowed with a large array of renewable energy resources. The hydropower potential of Ethiopia is one of the highest in Africa. As might be expected there is abundant solar radiation throughout the year in many parts of the country.

III.2.1.1 Biomass

18. Woody biomass, agricultural residue, animal and human waste constitute the biomass resource. The total energy that can be derived annually from these resources is estimated at 1016516 Tera calories Tcal). Out of this the contribution of the woody biomass and animal waste is 79 % and 11 %, respectively.

19. Historically, 35 % of Ethiopia's land surface was covered by high forests. If the savannah woodlands are included 66 % of the country is believed to have been covered by forest at the turn of the 20th century. By the early 1950s the high forests

covered only 16 % of the territory The current forest cover is variously estimated between 3.6 and 2.7 %.

III.2.1.2 Petroleum

20. Ethiopia has no oil refining facilities therefore it imports refined fuel. Petroleum products are imported into the country by the government institution the Ethiopian petroleum Corporation, while marketing of this products is catered for by the three international agencies i.e. Agip, Shell and Mobil.

21. Oil and gas explorations were carried out by international oil companies on a concessionaire basis since the 1940s and more recently in the late 1980s and early 1990s. Under a technical co-operation agreement signed in 1983/84 and with a loan extended to the Ethiopian government from the former USSR, seismic data collection and drilling of four exploratory wells in 10,000 square kilometres area in the Ogaden were conducted. This has resulted in the discovery of 76 billion cubic meters of natural gas at Calub. Apart from this no significant discoveries were made.

22. The Calub gas field development for petroleum products, electric energy, LPG and fertilizer production is under negotiation. When the negotiation is finished and implemented it is expected to produce about 180 MW of electric energy, 20% of the nations gasoline, fertilizer and LPG.

III.2.1.3 Electricity

23. The Ethiopian Electric Corporation is responsible for the Generation, transmission, distribution and sales of electricity. Most of the power is generated from hydro power plants located in the different regions of the country. Ethiopia has economically exploitable hydro power potential of 30,000 MW. The current installed capacity in terms of hydropower is 485.8 MW. The total installed capacity including diesel and geothermal plants is close to 529.4 MW. The generating capacity of these installations is 16.65GWh from diesel, 1.01 GWh from geothermal and 2224.8 from hydro plants. The Ethiopian Electric Power Corporation is currently undertaking the construction of two hydropower plants namely the Gilgel Gibe plant with a capacity of 184 MW and the Tekeze plant with a capacity of 300 MW. Since 1997 the power sector has been organized into the regulatory and operation functions to cater for a liberalized energy sector.

24. The regulator of the sector is the Ethiopian Electric Agency. The Ethiopian Electric Power corporation, though currently the main sole operator, is expected to be an operator among others. The legislation enacted in this regards allows the private sector to participate in power generation and distribution. The Electric law allows nationals to own and operate generating facilities up to 25 MW and foreigners capacities in excess of 25 MW with joint venture with government.

25. The gross hydro energy potential of Ethiopia's major river basins is estimated at 650 TWh/year. The Blue Nile and Omo basins alone account for 61.5 % of the total resource potential. In addition, the hydro energy potential from water bodies of valley courses is in the order of 130TWh/year. The average annual exploitable potential using small slope plants without the use of reservoirs is estimated to be about 20 TWh/year. The electric energy generated from small slope plants being smaller in capacity and dispersed geographically is of great significance for rural electrification.

III.2.1.4 Other Renewable Energy Sources

❖ Solar energy

26. Studies indicate that the yearly average daily radiation for Ethiopia as a whole is 5.26 kWh/m². This varies significantly during the year ranging from a minimum of 4.55 kWh/m² in July to a maximum of 5.55 kWh/m² in February and March. Regionally, the yearly average ranges from values as low as 4.25 kWh/m² in Gambela, Western Ethiopia to 6.25 kWh/m² in Adigrat area, Northern Ethiopia. The total exploitable solar energy for the whole country is estimated at 2673.54 X 10³ Tcal per year.

❖ Wind power

27. The available information regarding the wind energy resource base of Ethiopia identifies two distinct zones with homogenous periodicity that *are* separated by the rift valley. The first zone covers most of the highland plateaus. In this zone the wind speed exhibits two well-defined maxima occurring between March and May and between September and November. In the second zone, which covers most of Ogaden and Eastern lowlands, the wind on average attains maximum velocity between May and August. Average wind velocities for the first zone and second zone are estimated at 7.6 m/s and 6.9 respectively.

III.2.1.5 Mini/micro hydropower

28. Small, mini and micro hydro power plants have been in operation in Ethiopia starting since 1939. The first hydropower plant is the Aba Samuel hydropower plant with an installed capacity of 6 MW. The power plant served Addis Ababa in conjunction with other thermal plants until the power demand out stripped the capacity and a bigger power plant the Koka and Awash power plants had to be built. This plant was decommissioned in 1960. Other mini hydro plant were also built and operated by EEPCO and some or decommissioned when the grid extension reached the supply centers. To date a few plants are in service and these plants were constructed and operated by missionaries and EEPCO.

29. Currently EEPCO there are only three small and mini hydro plants that are operated by EEPCO; namely Sor small hydropower plant, Dembe mini hydropower plant and the Yadot mini hydropower plant with capacities of 5000 kW, 750 kW and 350 kW respectively. There are a number of hydro power plants that have been identified and awaiting implementation.

III.2.1.6 Geothermal energy

30. Several exploratory studies were conducted primarily by the Institute of Geological Survey to assess the geothermal resource base of Ethiopia. The following four areas have been identified on the basis of their energy potential and proximity to the Interconnected System or load centers. These sites are:

- The Tendaho Graben area near Dubti with a potential capacity of 120MW
- The Danakil Depression near Dallol area with an estimated capacity of 150MW
- The central Afar region with a potential capacity of 260MW and
- The Lakes District near Langano with a potential capacity of 170MW.

31. The total proven geothermal resource amounts to 700MW. Up to now, only a 7.3-MW plant at Aluto Langano has been developed.

III.2.2 Kenya

32. Kenya is bordered by Somalia, Ethiopia, Uganda, Tanzania and the Pacific Ocean. Kenya being near the equator, the temperatures are relatively constant year round and sunshine is abundant. The population is estimated at about 30 million with an annual growth rate of 2.69%.

33. The energy sector in Kenya can be divided into from dominant categories namely, biomass, petroleum, electricity and renewable resources.

III.2.2.1 Biomass

34. Biomass accounts for 70% of the total energy consumed in the country and includes firewood, charcoal, wood waste and farm residues. Among the biomass resources firewood and charcoal are the most used in the rural areas, while charcoal is used to a greater extent in the urban areas. Besides rural areas woody biomass is also *used* by cottage industries. The industries using woody biomass (firewood and charcoal) comprise brick factories, tobacco-curing industries, milk processing etc.

35 The total biomass consumption for 2000 was in the order of 35 million tones and this is assumed to increase over time resulting in large gap between the supply and demand. This clearly shows the intervention has to be taken. In the past measures to introduce efficient cook stove and improved and efficient tobacco curing methods to enhance reduce the consumption of woody biomass. However, there seems to be still sufficient room for improvement. The other measure used was to have more trees planted for the purpose.

III.2.2.2 Petroleum

36. Petroleum based products provide about 25% of Kenya's energy needs. Kenya operates a refinery in Mombassa which supplies most of the petroleum products consumed in the East African Region including Kenya, Uganda, Rwanda, Burundi, northwestern Tanzania and northeastern Democratic Republic of Congo. A petroleum pipeline linking Eldoret in western Kenya to Kampala in Uganda is expected to become operational in 2003.

III.2.2.3 Electricity

37. Electricity accounts for 0.7% of the total energy consumed in Kenya. KenGen is responsible for Generating power while KPLC for the distribution and sales of electricity. However the power shortage that took place in 2000 has forced the introduction and contracting for independent power producers (*IPPS*). The current installed capacity is 1172 MW with a firm capacity of 909 MW. Kenya has geothermal potential of about 835 MW and hydropower of 2000 MW. The generation mix of the supply system is 64.3% hydro, 11.7 % thermal 5.8 % geothermal, 7.7 % gas turbine and 10.5 % diesel. A 48 Mw Olkario is currently under construction and is expected to come on line in 2003.

38. Approximately 15% of the total population has access to electricity. About 3.8 % of the rural population is currently served with electricity. The Government of Kenya has launched Rural Electrification program, which is administered by KPLC. As only 3.8% out of the 75% rural population has access to electricity a lot remains to be done to reach the remaining rural population.

III.2.2.4 Other Renewable Energy Sources

❖ Solar energy

39. Kenya being located near the equator has a large solar energy potential. Though, the potential is enormous only 12% of Kenya's household use PV solar energy for lighting, water heating and cooking purposes. Compared to other countries in the region, solar *PV* development in Kenya is better and 150,000 systems have been installed in 2000. The major constraint for PV power development is its high capital cost and lack of personnel to cater for maintenance. Prices are estimated between US\$ 10 and US\$ 15 per installed Watt.

❖ Wind power

40. Kenya's wind speed and frequency of distribution clearly indicates that it has potential wind power for electricity production. Wind generators can be grouped in three different categories:

- Those directly connected to the main grid,
- Those connected to a remote medium size isolated grid,
- Those feeding isolated households through storage batteries.

There are very few from each category installed in Kenya.

41. The first category has got the advantage that the whole energy produced by the wind generator is absorbed by the grid whatever the time of production. As rated power of wind generators is very small compared to the capacity of the grid, these generators can be considered as contributing to cover intermediate loads, i.e. between base and peak loads. There are two such generators rated 150 and 200 KW installed at Ngong Hills that work satisfactory.

42. Due to unexplained reasons, the recorded availability factor of each generator was very low (around 70%) but in spite of that, the capacity factor of each of them was very good (around 40%). By improving the control system of these units, excellent capacity factors and very low energy unit prices can be reached.

43. The second category is more critical as the rated power of the wind generator has to be selected in accordance with the actual daily demand curves. This clearly means that as a wind generator may not feed alone the system, it has to share the load even at nighttime. Typically the wind generator has to be rated at around 20% of the peak load and as its daily production curve cannot be managed, its capacity cannot be accounted for as available and the energy it produces will only be considered as fuel savings. One single such generator, rated 200 kW is installed in Marsabit and is reported to work satisfactory. In spite of a very good availability factor (90%), the capacity factor is still quite low (20%) resulting probably; first from wind conditions not as good as Ngong Hills conditions and second from restrictions imposed to the ratio wind power to total load due to quite low reaction of the old diesel speed governors.

44. The third category sized from one to a few kW has to be complemented either by storage batteries or by a stand-by diesel generator to care for low wind speed periods.

III.2.2.5 Mini and Micro Hydropower

45. Mini hydro power plants are found in very few places in Kenya. Many of these mini hydro power plants are mainly used for milling and seldom for electricity provision. Only about six micro hydro power plants located in different parts of the country supply electricity.

III.2.2.6 Geothermal energy

46. Kenya has at present an installed capacity of 1064 MW of which 5% is from geothermal; there are now two projects with a total capacity of 116 MW under construction. As Kenya's remaining hydropower resource is limited the future expansion of Kenya's generation will focus on its available geothermal resource. A 48 Mw geothermal plant of Olkario III which is currently under construction is expected to come on line 2003.

III.2.3 Uganda

47. Uganda is a landlocked country bordering Kenya, Tanzania, DR Congo, Rwanda and Sudan. It covers 241,000 square km of which 20% is covered by water including the White Nile River and a portion of Lake Victoria. Due to its position on the equator and being at an altitude of 1000 -1500 meters, temperatures are relatively constant year round and sunshine is abundant. Dry seasons are from December -February and from June -July. Annual rainfall averages 1400 mm in the southern part of the country and 500 mm in the northeast.

48. Uganda's population is approximately 19 million and is increasing at about 2.8% annually. Per capita income is estimated to be \$170. Approximately 90% of the population lives in rural areas. Due to the past economic and political problems rural-urban migration has been relatively low. Kampala, the capital, has a population of approximately 800,00 people.

49. The energy sector can be divided into 4 subcategories: biomass, petroleum, electricity and renewable resources.

III.2.3.1 Biomass

50. Biomass accounts for 96% of total energy consumed in the country and includes firewood, charcoal, agricultural residues and animal dung. Firewood is the predominant form of biomass used in rural areas while charcoal use is greatest in urban areas.

51. Wood fuel accounts for approximately 83% of the total biomass-based fuels used, with crop residues comprising 12% and animal dung 5%. It is estimated that Ugandans consume an average of one air-dry ton of woody biomass (fuel wood and charcoal) per capita per year (total approximately 17 million tons in 1992). Households consume approximately 75%. Significant quantities of fuel wood are also used for tobacco curing, tea drying, fish smoking, brick making, baking, and cooking in hotels. Biomass is also extensively used in many of Uganda's factories to provide process heat. Wood fuel is used in tobacco industry, tea processing, brick and tile industry, fish industry and bakeries.

52. While measures to alter this trend have been initiated, fuel wood use is expected to dominate the energy demand for the foreseeable future despite the deficit that has been noticed in the past few years. This will certainly increase the pressure on the base unless and otherwise profound changes are made in the country's energy consumption pattern or wood farms are introduced.

III.2.3.2 Petroleum

53. Petroleum-based products provide about 4% of Uganda's energy needs, including 70% of the commercial energy supply. All petroleum-based products are imported through seaports at Mombassa and Dar es Salaam. Due to foreign currency constraints in the 1970's, many industries switched from petroleum to other products (particularly wood fuel and electricity). As prices of petroleum products have continued to rise, this tendency to switch to other fuels has continued and petroleum imports have decreased.

54. Importation and marketing are handled by six companies, namely, Shell, Total, Caltex, Gapco, Agip and Upet, the market share of these companies are 34.2%, 23.5, 19.6%, 10.4, 6.0 and 6.3 respectively.

55. The transport sector consumes approximately 85% of petroleum imports with domestic and industrial uses accounting for 14% and 1% respectively. In rural areas, domestic use of kerosene is limited mainly to lighting.

56. Although some exploration work has been carried out in the Western Rift Valley area of Lake Albert, no commercially viable petroleum reserves have yet been identified.

III.2.3.3 Electricity

57. Electricity provides approximately 1 % of the total energy consumed in Uganda and 5% of commercial energy consumption. Most of this power is generated by the Owen Fall Dam (180 MW) at Jinja, which is managed by the Uganda Electricity Board (UEB). Diesel generators, also owned by UEB, generate an additional 3.8 MW in isolated areas. Two hydro plants in the western region supply local areas including (a) a 1 MW installation near Kabale, operated by UEB and (b) a 5.3 MW installation operated by the Kalembe Copper Mine. There are also a few other privately owned micro-hydro installations in operation. The third MW Owen Falls 200 MW plant is currently under construction. Uganda exports about 30 Mw of electricity to Kenya, this capacity will soon be increased soon. Currently a number of power plants are under development by independent power producers the Bugajali 294 MW The Kalagala 45 MW plants are a few of such developments. Three sugar factories carry out cogeneration using bagasse

58. Total known hydropower reserves have been estimated at 3000 MW. This includes 21 mini hydro sites, which have been identified as having the potential for development.

59. Approximately 4% of the population presently has access to electricity. Extension of the grid to rural areas has been carried out on a sporadic basis subject to the availability of funds. Additional impediments to a sustained rural electrification program include: (a) the dispersed nature of the population in Uganda, (b) UEB's difficulties in billing and collecting payments from consumers, (c) continuing capacity shortages (resulting in frequent brown- outs and black-outs) and (d) the high cost of

electricity connections and consumption. These conditions are expected to continue for the near and medium-term.

III.2.3.4 Other Renewable Energy Sources

60. Renewable resources (other than hydro) constitute a new field of interest in Uganda. The combined contribution of renewables is estimated at 1 % although this sub-sector has a much greater potential than this figure suggests, thus indicating that this resources is under utilized. Renewable resources include: .

❖ Solar power

61. It is estimated that there are about 1,500 installations of solar PV unit in Uganda. Most of these installations are financed by outside donor countries. The installations include about 300 community based systems serving clinics lightings and vaccine refrigeration implemented by the Ministry of Health of Uganda. Some installations serve communication needs for the telecom and railway. The major constraint for its wide use the high capital cost.

62. There are ten private companies selling and installing PV systems. To encourage wider use Uganda established a PV credit fund, which enables user pay off capital costs over a long period.

❖ Wind power

63. Uganda is thought to have high wind energy potential although data to support this assumption was not available. Windmills have reportedly been used successfully in the Karamoja region. A wind generator was recently installed in the Sese Islands by a local entrepreneur to provide power for a private residence

❖ Mini/micro hydropower

64. The Maziba mini hydro power plant near Kibale with a capacity of 500 kW which is to be upgraded to 1 MW operated by UEB and a 5.3 MW installation operated by the Kalembe Copper Mine and a few other privately owned micro-hydro installations are currently in operation in Uganda. However there are a few sites which have been identified for small hydro plant development. Very little is known by way of mini and micro hydro power plants.

❖ Geothermal energy

65. Uganda's geothermal energy resources, located in the Rift Valley region, are estimated at 450 MW. Three sites have been identified (Katwe field in the south, Buranga field near the Rwenzori Mountains and the Kibira field near Lake Albert). The Katwe field is considered the most promising due to the presence of subsurface steam at 230 deg. C and its location 35 km from a 132-KV transmission line at Kasese.

IV. Structure of Model Project Framework Document

IV.1 Background

66. Efforts to provide rural communities with modern energy such as electricity have been undertaken in the region for many years now. Despite this effort the rural community with access to electricity is insignificant (accounting only for less than one percent) and a lot remains to be done in this respect. The main drawback in this endeavor were lack of trained human resource, lack of finance, lack of institutional setup to closely monitor and implement rural electrification activities. Hence much has to be done to avert the situation.

67. Energy in the rural areas is mainly needed for lighting and smaller application for industrial purposes. The industrial demand however could develop as the economic activities of the rural community increases. The availability of electric power is believed to induce this aspect. The demand in these areas is enormous and as the natural energy resource (wood and woody biomass) is increasingly depleting the need for commercial energy will certainly increase.

68. Governments in all three countries have well recognized the need of providing electric power to their rural community. To facilitate this they have put in place regulations, which would enable formation of institutions to administer rural electrification projects. Some of these institutions are either specific technology oriented (solar, mini hydro or wind power) or of a general nature.

69. In Ethiopia rural electrification was catered by the Ethiopian Electric Power Corporation (EEPCCO) but as this venture in most cases is not financially viable financing was difficult. This therefore has necessitated the formation of an institution that will cater for this purpose. Recently rural energy access project was launched in order to organized rural electric fund. The fund is aimed to avail finance on loan basis for both the private and community based rural electrification. Similar institutions are also existent in the other countries.

70. Besides institutions sited above other forms such as suppliers and energy service companies could play a major role in the dissemination, training and development of rural energy. Hence effort in creating conducive atmosphere by of enacting appropriate legislations, financing options and in the coordination of the activities of the various actors in the area should be carried out and every means of encouragement be made in this direction.

IV.2 Objectives/Justification

71. The objective of this study is to indicate the means and ways of availing modern energy to the rural community of the four countries under consideration, through renewable sources. The availability of modern energy will significantly change the living and economic conditions of the rural population. It will therefore play as an instrument of poverty reduction. The renewable sources considered are wind, solar, mini/micro hydropower and biomass based generation. As a result of the implementation of these projects the following are expected to achieve;

- Create confidence in the public, private sector, the rural community, donor agencies, etc. for launching similar future developments,
- Technology transfer in operation and maintenance facilities of the plants will be enhanced both to the urban and rural community
- wider use of RETs in rural communities will be enhanced, thus reduce the pressure on the natural environment and use of kerosene and the like.

IV.3 Target Beneficiaries and Other Stake Holders

72. The major beneficiaries of rural electrification programs are the rural communities. The provision of electricity to rural areas will bring about economic and social benefits to the rural population. The social benefits are rural development through introduction of industries, better agricultural productivity, provision of better health care and educational enhancement. The lighting and power needs of the rural community will also be better served. Other beneficiaries of rural electrification would be the energy providers, equipment vendors, technical service providers, last but not least is the governments.

IV.4 Project Description

IV.4.1 Description of the Technology/Power System Adopted

IV.4.1.1 Mini/macro hydropower stations

73. The three countries are endowed with a large hydropower potential. Preliminary studies indicate that there are many sites suited for mini/micro hydropower development. Providing access to electricity to the rural population and linking these wherever possible with appropriate productive uses of electricity is of paramount importance for the structural transformation of the economy.

❖ Significance of micro hydro

74. At a theoretical level there are several options for the electrification of rural towns and localities. The options, however, are limited depending on the specific local conditions. The region's hydropower potential is enormous. In spite of this there is an apparent failure in recognizing the potential impact that micro hydropower schemes can have on the lives of rural of the rural population.

75. Advantages of micro hydropower include:

- It is a renewable, non-polluting, indigenous resource;
- It can be integrated with irrigation and water supply projects;
- It is a well-proven technology well beyond research and development stage

76. Additional positive attributes (not usually associated with large hydro) include:

- Because of their size, micro hydro schemes permit local involvement in the full range of activities including implementation, operation, maintenance and management leading to a much lower unit cost;
- In addition to electricity, micro hydro schemes permit the generation of mechanical energy for use in agro-processing machinery or cottage industry;
- Micro hydro schemes permit energy to be generated near where it is to be used, leading to reduced transmission costs;
- Most turbines for use in micro hydro schemes lend themselves to simple design and fabrication techniques, which in turn encourage their local manufacture;
- Dams are rarely used, and the civil works can be built with cement as the only imported material into the area;
- Micro hydro schemes seldom raise social and environmental concerns.

77. Generally, if a country has large population, low urbanization rate and low rural electrification rate together with a rich hydropower resource then micro hydro is very likely to offer a solution for rural energy problem, and this obviously is the case in these Eastern African countries.

❖ **Obstacles to micro hydro development**

78. The single most significant obstacle is that micro hydro schemes have the reputation of being excessively expensive. Over the years engineering firms have accumulated considerable experience in designing and constructing large hydro-projects. As interest in harnessing small hydro resources grew, these same groups have been called upon to implement smaller schemes. Rather than considering the unique aspects of small hydropower and their implication on plant design and construction, these groups often have simply scaled down their more conventional designs and construction techniques. The increased cost largely results from economies of scale and the lack of cost savings otherwise possible through the use of non-conventional designs, materials and construction techniques.

❖ **Local capacity in mini/micro hydro technology**

79. In developed countries, the increased cost is offset by the environmental friendly nature of mini/micro hydro. (Mini/micro hydro is termed as "green" energy and even government subsidies are readily available in many countries). But in the antipodes, the result has been mini/micro hydropower equipment, which are not affordable. Major equipment manufacturers have also no incentive to research affordable solutions since the market in the developing countries does not promise to be lucrative. Similarly, few consultants have experience in designing cost-effective micro hydro schemes.

80. Micro hydro schemes can be designed and built by local staff and off-the-shelf components or locally made machinery can be used. Given a sustained and systematic

effort on part of the government agencies responsible for rural energy a localized approach to a local problem can be adopted. This effort would result in the mobilization and pulling together of all available technical as well as human resources together. In due course this is bound to lead to a situation where the cost of electricity from micro hydro is tremendously cheaper than what is now and, therefore, affordable to the rural population in the three countries of the region.

IV.4.1.2 Wind power systems

81. Wind power, as a fully renewable source of energy, is a fast growing source of power production in the world and its growth rate is exceeding all expectations. The worldwide installed capacity has risen from practically zero in 1990 to over 14 GW today. The technology has matured and the cost has fallen considerably. There is an enormous amount of energy in the wind and part of this energy can be converted in active mechanical energy that can be used for instance in water pumping or for electricity generation.

82. The power that can be extracted from the wind by a wind machine is expressed by the formula: $P = k.A. V^3$; where:

P: the extracted power in watts.

A: the surface of the rotor perpendicular to the wind direction (m^2)

V: the wind speed (m/s)

83. Wind power depends on its velocity that fluctuates and varies from one location to another. In order to minimize the effects of these variations, wind power plants are normally set up with many generators. Nevertheless, instantaneous power withdrawn from the wind cannot be managed and energy has to be collected "if and when".

84. To be economical, the energy collected per year from the wind divided by the rated power of the wind machine must reach a minimum value; this ratio indicates the technical performance of the installation that depends mainly on the wind behavior, namely the daily, monthly and yearly mean values and frequency distribution curve of the wind velocity at the level of the wind machine's axis. The ratio called capacity factor must be above 20% to be acceptable, above 30% to be good and above 40% to be very good.

IV.4.1.3 Biomass-based power generators

85. Energy consumption picture for all three countries under consideration as indicated earlier is characterized by heavy reliance on woody biomass that represents around 70% of the total consumption. Fuel wood consumed by the rural households is usually freely collected and the cost incurred may only be the labor hours spent in the collection. In the urban centers fuel wood is a commercialized commodity. The cost of fuel wood varies considerably from one region to the other, in Addis Ababa where the commodity is highly commercialized the cost is around 12,6 US\$/ m^3 , whereas in

places like Sawla-Bulki in the Southern Regional State of Ethiopia a cubic meter of fuel wood costs only about US\$ 2.36.

86. Fuel wood used directly for cooking or lighting if used for electricity generation, the cost of rural electrification could be affordable for the rural population. Fuel wood has an efficiency of less than 10%. If used to generate electricity, it can have an efficiency level of about 16%. Thus with the introduction of biomass powered generators that

87. Meeting the energy needs of the rural population through grid extension has been found very expensive and thus hampered the rural electrification programs of the countries. Alternatives to the traditional grid expansion have been considered in satisfying the energy need of rural sectors. Among the alternatives to grid expansion is the use of renewable resources is the biomass gasification

88. Electricity generation from biomass gasification is achieved by coupling three systems; a low BTU gas generation unit called a gas generator an engine utilizing the gas generated in the gasifier to be used as fuel and at the same producing heat as byproduct. These system are called a gas generator-based power plant.

89. Some of gas the generator power plants enable supply electricity and heating using agricultural waste or wood pellets. The cost of such power plant is about US\$ 1,000 per KW, and the plant can produce electricity and heat at a very attractive cost.

90. An example of such gas generator is the Martezo gas generator which transforms wood or agricultural wastes (biomass) into a clean gas which can be burned in an engine, replacing expensive liquid fuel for power generation at remote location. This therefore enables substantial cost saving. The Martezo gas generator has the following ranges of production.

a. Martezo type 100

Production 70 kWe + 140 kWt

Total production power and heat would amount to:

560,000 kWh of electricity; and

1,120,000 kWt of heat;

Assuming 8000 hours of operation per year

b. Martezo Type 200

Production: 135 kWe + 270 kWt

Total production of power and heat would amount to:

1,080,000 kWh (1.08 GWh) of electricity; and

2,160,000 kWt of heat;

Assuming 8000 hours of operation per year.

Total consumption of fuel wood would amount to: 1,404 ton of wood per year; assuming a consumption of 1.3 kg of fuel wood per kWh and total annual production of 1.08 GWh.

Total consumption of diesel fuel needed to produce 1.08 GWh of electricity would amount to 378,000 liters per year; assuming a specific consumption of 300 liters per kWh. To produce 1 kWe a gas generator requires 1.3kg of wood. In addition a Martezo is equipped with a cogeneration device producing almost 2kW of heat for each kWe.

91. Acceptance of biomass-powered generators is constrained because of their high investment costs. The biomass gasifiers will only receive wide acceptance of developing country governments and international development organizations establish proper policies and incentives for them. If such an institutional framework is established, there is no doubt that the entrepreneurship of private developers will bring about the wide use of these systems.

92. The prototype projects proposed for biomass gas generators in the three countries, Kenya, Uganda and Ethiopia are directed to the tea plantation factories, these are selected because at present the existing tea plantations in all three countries use diesel generators as well as forestry products for their energy need both for electricity and heat.

IV.4.2 Main Components of the Power System

93. The main components of the selected power systems are as described here below:

IV.4.2.1 Mini/Micro Hydropower System

94. This system is comprised of:

- Diversion Weir or small reservoir :- to facilitate the diversion of the river flows and to serve as a storage
- Power Channel:- For the transport of the water flows;
- Forebay:- Pondage to enhance hourly or daily storage of flows;
- Penstock :- Water conduit leading the flows to the turbine;
- Gates:- for closing the flows;
- Spiral casing, turbine, governor and draft tube;
- Generator and switchgear;
- Transmission and/or distribution lines;

95. The capacity of the equipment is totally dependent on the flow amount and the available exploitable head.

IV.4.2.2 Wind power system

96. The main components of wind power equipment are;

- Wind Vanes or blades;
- The mast
- The Shaft
- The generator
- Accumulator
- The Battery
- Distribution lines

IV.4.2.3 Solar PV system

97. The main components of solar power system are;

- The Photovoltaic module (s);
- The battery;
- The distribution lines

IV.4.2.4 Biomass-based power system

98 The main components of the Biomass power system are

- The gas generator;
- The heat exchangers;
- The engine
- The generator;
- The distribution lines

IV.4.3 Project Feasibility

IV.4.3.1 Techno-economic Feasibility Considerations

99. The technical feasibility of the selected RETs has already been proved to be feasible and being used all over the world. As regards to the individual economic viability it can generally be concluded to be economically viable when compared to grid expansion option. Hence making it acceptable for rural electrification purposes where the absence of large markets makes grid expansion not preferable.

100. The selected options are also environmentally friendly when seen from the environmental and social aspect of project development. They do not have green house effect as they have no gas emission

IV.4.3.1 Environmental and social impact considerations

101. Electrification through renewable technologies is environmentally friendly and has no negative environmental effect. It enables avoid carbon mono oxide emission as it enables replace petroleum products used for power generation. The availability

of electric power also reduces the use of wood for lighting purposes. It also improves the health condition of the community. Reduces the burden of women of fetching water and enables them participate in the economic activities of their community.

IV.4.4 Project Financing

IV.4.4.1 Mini/micro hydropower stations

❖ Ethiopia: Bonora mini hydropower Plant

102. The total cost of the small hydropower development is estimated at \$ 1,656,500. The whole Project financing is expected to come from community contribution and government loan or other grants. Reduction in the project cost could be achieved through having some of the electro-mechanical components manufacture locally

❖ Kenya: Mathioya Run off River Scheme

103. Financing could be covered by the Kanyenya-ini-tea factory, which processes about 16 million kgs of good quality tea every year. The plant expends about \$370,000 for electricity and 2,000,000 liters of fuel oil, which cost something in the order of \$1,000,000. Developing the mini hydropower plant could relieve the tea processing plant of some of it energy requirement.

❖ Uganda: The Olewa Hydropower Plant

104. The Capacity of the Olewa Hydropower Plant is estimated at 1500kW and the Capital cost at \$5.69 Million. At this stage no full feasibility has been done on the potential sites. Therefore the site to be developed shall be selected together with the relevant authorities.

IV.4.4.2 Wind power systems

❖ Ethiopia

105. To date there are no wind based power in Ethiopia. Wind Power plants are usually expensive when used for the purpose of power generation. It would be advisable that they are used for water pumping. However for the purpose of demonstrating its use it is recommended that that a 250kW unit is put up at Gode in the Somali Region of Ethiopia where sufficient wind is available. To realize this pilot plant finance has to be solicited from partner agencies such as UNDP, local NGOs, Financing institutions. The plant will demonstrate and would encourage the private sector and the community develop this supply system based on the experience of the demonstration/pilot plant.

❖ Kenya

106. In Kenya experience has shown that wind power is expensive that the other sources of energy and its use has been restricted to water pumping. There are also some local manufacturers for this purpose the recommendation of many studies is that it be used purely for water pumping.

❖ **Uganda**

107. Application of wind energy has been limited to water pumping and there are very few wind power generation. An appropriate site has not been identified at this stage and it is expected that this will be done in due process. The financing approach would again be similar to that of the Ethiopian case.

IV.4.4.3 Solar PV systems

❖ **Ethiopian**

108. The solar power experience in Ethiopia is quite limited. The experience of Uganda is far better than that of Ethiopia. Based on this experience a site will be selected with cooperation of EEPCO and implemented in the future. Meanwhile financing for the implementation shall be solicited from donors.

❖ **Kenya**

109. About 200,000 such plants have been put into operation in the last few years. The major constraint for the development of these renewable sources of energy is its forbidding capital cost. As Solar PV systems could be used for individual household, a group of households, and a community; i.e., schools, health center and water pumping, the capital cost would vary depending on the community and household sizes. This cost range from US\$ 12,400 up to US\$ 15,000 for a single pump, US\$ 6,000 for a household, and about US\$ 15,000 for community use.

110. No demonstration plant is proposed for Kenya, as the use of this resource is already well known in the country, it is believed that the development will pick up at a faster rate if the price of solar generating facilities prices go down. The price could only go down if and only if the demand for the facilities increases and the number of units to be produced increases. As this source of energy is environmentally friendly its use should be highly encouraged. Much is expected from financing institutions in financing such projects in significant numbers in order to bring the cost well below the current level.

❖ **Uganda**

111. It is estimated that there are about 1,500 installations of solar PV unit in Uganda. Most of these installations are financed by outside donor countries. The installations include about 300 community based systems serving clinics lightings and vaccine refrigeration implemented by the Ministry of Health of Uganda. Some installations

serve communication needs for the telecom and railway. The major constraint for its wide use is the high capital cost.

IV.4.4.4 Biomass-based power systems

❖ Ethiopia

112. The biomass plants envisaged to be constructed would be utilizing eucalyptus tree. The plant will be erected at two sites namely Wushwush and Gumero with capacities of 2Mw and 812 kW respectively. The capital costs for the Wushwush and Gumero plants are \$ 2 million and \$ 812,000 respectively. The operating and maintenance cost for the plant i.e. including preparation of the wood fuel is estimated at 5 % of the capital cost and is equivalent to \$100,000 and \$ 41,000. All the investment cost will be covered by the tea plantation.

❖ Kenya

113. As regards biomass plant in Kenya no site has been identified and plant and capacity selection has to be undertaken in the very near future. The selection and implementation shall be based on the experience of the Ethiopian case.

❖ Uganda

114. At Mbale in the Mbale Millers Association coffee husks and rice, maize and ground nuts residues in the order of 55710 tons is burnt off right at the field. This could be used to generate power so that it could serve the local population. To this end a biomass plant of 250kW is envisaged to be erected as a demonstration plant. The financing for the implementation of the plant would have to be solicited from partner organizations. This plant is expected to serve as pilot plant to demonstrate the use of agricultural residue as a source of energy production. From this experience will enable the local community and the private sector continue develop energy facilities wherever appropriate. The capital cost of the plant is estimated at \$ 250,000 with a corresponding operating and maintenance cost of \$ 10,000.

IV.4.4.5 Project Implementation

❖ Mini/Micro Hydropower Implementation

115. The soliciting of financing and project formulation is expected to take about one year. Once the finance is secured design site preparation is expected to take about six months and construction will take one year and half procurement and will be done during the early period of construction. The realization of the project therefore will take about three years. The duration of the implementation could be shorter if donors respond quickly.

b) As regards solar, wind and biomass it is expected to take a total of two years up to commissioning.

IV.4.4.6 Project Sustainability

❖ **Ownership**

116. The operation of the proto type plants depends on is developing the plants, the plants that will be developed by the tea plantation will certainly be owned, operated and managed by the tea plantations while the others will have to be owned, operated and managed by the different government agencies responsible for rural electrification.

117. In the long run, once experience is gained from the pilot plants different owners and operators such as the private energy providers, the community, rural electrification responsible agencies are expected to be involved.

❖ **Operation and Management**

118. For rural electrification to continue servicing the community on a sustainable basis it should be efficient and affordable in terms of costs. This could only be achieved if and only if the operating and maintenance costs could significantly. The most effective means is believed to be community handling of these services. Hence it is highly recommended the maximum effort be made in this direction.

❖ **Policy, Institutional, Legal and Regulatory Frameworks**

119. Energy is a key to bringing about sustainable economic development and enable eradicate poverty. Provision of energy triggers other economic sector development, which would enhance better living, social and economic development. Energy provision based on renewable energy and indigenous sources will reduce the high dependence on import fuel based energy, which in most cases results in major economic disruption, which would result as a result of price escalation. The price increase in fossil fuel of the seventy's is a living example. Since energy is a major contributor to sustainable economic development. appropriate policies should be put in place to enable bring about this change.

120. Policies that have been in place are either unclear or not properly spelt out and did not bring the changes expected. Similarly some of the legislations enacted were also equally not clear. Hence all this need to be revisited and made clear so that it would enable rural electricity provision and development would pick up and bring about reasonable change to alleviate the poverty that the region is in at the moment.

121. Like wise the regulatory framework should be made compatible with the changes envisaged to be brought about.

V Rural Electrification Project Prototypes

122. Using renewable energy technologies (RETs) in meeting the rural electrification needs of the East African countries, project prototypes proposed are based on biomass powered generators, mini hydro, wind and solar.

V.1 Project proposals for “Biomass-based power generating systems”

V.1.1 Ethiopia

123. The biomass powered generator project prototype outlined for Ethiopia are more detailed than in Uganda and Kenya because of the readily available data, but the application and conclusions are equally applicable to all. Hence the implementation shall be based on the Ethiopian experience.

124. In January 1997 Shell International carried out a study in Ethiopia on the possible use of biomass-powered generators in the rural sectors of Ethiopia. The study identified six project sites: and these are:

- Gidole in the Southern Ethiopia Nations and Nationalities Region. It has a plantation area of 7000 hectares mostly covered by eucalyptus.
- Bulkii in the Southern Ethiopia Nations and Nationalities Region. It has a plantation area of 1000 hectares of eucalyptus species, and 27000 hectares of forestland was demarcated as free of habitation.
- Wushwush in the Southern Ethiopia Nations and Nationalities Region. At that time 969 hectares of forest land has been brought under eucalyptus plantation, out of which about 40 hectares has already been harvested to supply the boiler for the drying of the tea in the process.
- Gumero in the Oromia Region, Metu Zone near the town of Gore 738 hectares has been planted with eucalyptus globulus. As in Wushwush part of the plantation has been harvested for tea drying.
- Fundune – Soddo in the Southern Ethiopia Nations and Nationalities Region. The plantation covers 1500 hectares, the main species being eucalyptus globulus.
- Debre Berhan in the Semen Shewa Zone. 1978 hectares of eucalyptus globulus plantation was initially established with the objective of satisfying the fuel wood demand of the nearby town of Debre Berhan.

125. The sites recommended for the implementation of biomass-based power generating plant are Wushwush and Gumero. At present in these two locations there are privately operated tea plantations and after being aware of this new technology, they are considering to purchase the equipment.

126. In order to utilize the biomass resources available at Wushwush and Gumero tea plantation sites, it is proposed to install two 135kWe and 270kWt gas generators at each of these sites. The generating plants will meet the electricity demand of the plantation as well as the steam required for tea drying, which amounts to 18,000 tonnes /year

V.1.1.1 Wushwush

❖ Site description

127. The Wushwush Tea Plantation site is located between 7°15' latitude and 35°14'E longitude. It is found in the Southern Ethiopia Nations and Nationalities Region of the Keffa-Sheka zone. The Mean annual rainfall is more than 1800 mm in good rain years and is often not below 1800 mm even in bad rain years. The mean annual temperature is between 22 highest sometimes goes up to 28° C. The geological formation is of Tertiary Volcanic origin of the Magical group and the dominant soil is an orthic acre sol type. The project site is found in an elevation range of 1900-2000 m above sea level. The site is an undulating ground cropping up as separate rolling hills here and there. Some part has been used for tea plantation purpose and the other portion for eucalyptus plantation.

128. The plantation is formed of eucalyptus globulus, which was started in 1984 for the purpose of curing the tea in the process of tea production. So far, about 969 hectares of forestland has been brought under eucalyptus plantation. Out of which about 140 hectares has already been harvested to supply the boiler for the drying of the tea in the process. At present the 969 hectares of the Wushwush Tea Plantation is being harvested at 40 hectares a year. One hectare of eucalyptus at Wushwush is estimated to yield 400m³ of wood.

129. The eucalyptus plantation was objective oriented; i.e., for raising steam required for curing tea; and hence annual coppice has been determined and the harvesting will continue at the specified rate. At the present level of 18,000 tones of dry tea production annually, harvesting 40 hectares of fuel wood has just been enough to fulfill the requirement of the boiler, which is often run almost 18 hours a day.

❖ Demand for fuelwood

130 The Wushwush Tea Plantation Project is situated in the middle of the Bonga forest project and hence is part of the intact high forest of Bonga. At a distance of three kilometers from the project is found the small town of Wushwush. The Wushwush Tea Plantation Project uses wood for the boiler in order to raise steam for drying the tea. Other uses of wood in the area include household energy needs of the project staff. This requirement however, is limited and may be easily fulfilled from the surrounding natural forest. Similarly, the nearby town of Wushwush may also have some demand for wood and wood products, which may easily be satisfied from the excessive yields of surrounding natural forest.

❖ Demand for electrical energy

131. Wushwush town is inhabited with an estimated population of less than 1000 people. The town is not having any significant business activity. The demand for electrical energy of this town is insignificant and can very easily be satisfied with some 20 kW installed capacity diesel generator set. Hence, unless the demand of the

nearby town of Bonga located some 17 km from the tea plantation is considered, the demand for electrical energy within Wushwush plantation is essentially the existing Wushwush tea plantation demand.

132. At Wushwush tea plantation, there are three generators. Two generators have a capacity of 240 kW each and the third one has a capacity of 336 kW. The average monthly fuel consumption is about 26,160 liters. At 20% diesel generator sets efficiency level, this represents an annual electrical energy demand of 785 MWh.

❖ Potential power generation capacity

133. At Wushwush about 18,000 tons of dry tea is produced annually. The rough estimate of fuel consumption rate established by the tea plantation is about 1.0 kg of wood for 1.5 kg of dry tea. Hence, the annual fuel wood consumption amounts to about 12000 m³. This quantity of wood in a co-generation system could, in addition to generating the required quantity steam at 16% overall plant efficiency, produce 3.0 GWh of electrical energy, which is far in excess of the electricity demand of the Wushwush plantation. The available amount of wood at 55% load factor can support a 600 kW capacity power plant. On the other hand, if all the 700 hectares of eucalyptus plantation is to be used on a seven years cycle on a sustainable basis, 40,000 m³ can be made available annually for power generation purpose. This resource at 16% overall plant efficiency can generate 9956 MWh annually and is enough to run a 2 MW installed capacity plant at 55% load factor.

134. Even if the 600 kW generator is taken into account it would avail energy equivalent to 3,000,000 kWh. This as expressed above requires 12,000m³ of wood the price of this at US\$ 2.36 would be US\$ 28,320 above and on top the benefit that would be gained from steam that can be used for drying the tea to be produced. In effect there will be a saving of the wood cost which is US\$ 28,320. Furthermore if a capacity of 2 MW is installed further revenue could be gained through sales of electric power to EEPCO by connecting to the grid at Bonga which is under construction currently. To have this delivered the operation and maintenance is only US\$ 100,000. Hence the development of either option is found to be attractive.

135. The costs associated with the two scenarios can be summarized as follows:

Own consumption

Capital Cost USD \$ = 600,000
 Fuel cost USD \$ = 28,320
 Operating and Maintenance cost USD \$ = 30,000

Sales to the grid

Capital cost USD \$ = 2,000,000
 Fuel cost USD \$ = 94,000
 Operating and Maintenance cost USD \$ = 100,000
 Revenue from sales @ USD \$0.35/kWh USD \$ = 397,000

V.1.1.2 Gumero**❖ Site Description**

136. The Gumero Tea Plantation site is located between 8'00 N latitude and 35'45E longitude. It is found in the Oromia Region Metu Zone and near by the town of Gore. The site was initially identified to be more suitable for tea plantation as it receives rain for most of the months in the year. The site receives a mean annual rainfall of 2260 mm and a mean annual temperature is 20-25°C. The site is found in an elevation range of 1800-1900 m above sea level. It is a rolling land, well drained and sloping towards small gorges. The geological formation of the site is of Tertiary volcanic trap series classified into cenozoic age formations. The dominant soils are a dystric nitosol type.

137. The Eucalyptus plantation was started in 1977 at a very minimum scale. Its objectives were to supply wood to the boiler that dries the tea. An intensified plantation program was started in 1980. At present an area of 738 hectares has been planted with eucalyptus globulus, out of which 144 hectares of the plantation has been harvested for tea drying. The plantation established since 1984 is still intact. It was observed that the part of the harvested plantation has started coppicing well. The area put under eucalyptus plantation is designated for the purpose of forest development and hence is not facing any encroachment or interference.

138. Some height and diameter measurements of very few trees were made during the field visit. It was observed that in the oldest plantation heights of some trees reached about 32 meters and diameters about 16cm. at eight years. The oldest plantation is 12 years and the youngest 6 years old. The estimated volume per hectare may reach 300m³ with an estimated 200 trees/hectare and an average yield of 1.5 m³/tree. The estimation is based on the information obtained from the forester in charge of the plantation and visual observation made during the field visit.

139. The forest is not under the usual management scheme except protection from external interference. For instance, no thinning or removal of inferior stands (improvement felling) is done. Neither removal of the undergrowth competing with the main stand is carried out. As a result, the number of trees remaining up to final rotation age was very small. Trees towards the forest receiving lowest sunlight in the middle of the plantation are over topped and stunted. Rotation age is fixed and the plantation is being harvested at 8-10 years cycle. The annual harvesting coupe is between 30-35 hectares all being used for tea drying.

❖ Demand for fuelwood

140. The Gumero Tea plantation project is situated at about 9-10 km from Gore town. There are remnant natural forests in its surroundings. The demand of woody biomass for household consumption purposes has not been assessed. However, it is observed that the demand can easily be fulfilled from the surrounding natural forest.

❖ Demand for electrical energy

141. Electric energy demand of Gumero tea plantation in terms of capacity is about 812 kW. The energy demand is not however clearly established until a year ago Gumero tea plantation used to produce its own electric energy using four diesel generators. Two of the generators have 238 kW capacities each. One generator has a capacity of 336 kW and the fourth generator, which is mainly used as a stand by unit, has a capacity of 137 kW.

142. When the plant works at full capacity, the usual utilisation schedule is to run, the 336 kW generators and one of the 238 kW generators for 16 hours and the other 238 kW generators for the remaining 8 hours. Hence, the maximum daily electric energy consumption of the Gumero tea plantation at peak load may reach about 8500 kWh. This happens only for a few days of the year and does not give the full picture of electric energy consumption. A more reasonable estimate can be made using the previous monthly fuel consumption, which were roughly about 30,000 teters. This consumption at a diesel generator set efficiency of 29% corresponds to 2.5 GWh per day or 912.5 GWh per year.

❖ Potential power generation capacity

143. According to the forester in charge of the tea plantation project, that out of the 738 hectares of forest planted, about 144 hectares has been cut down for use in the tea drying process. Currently, there is about 590 hectares of plantation ready for a systematic use. The estimate by the forester in charge is 200 trees per hectare with a yield between 1.5-2mJ of wood per tree. By the team's observation the lower value i.e. 1.5 m³ per tree is perhaps a better estimate. This estimate corresponds to 300m³ of wood per hectare.

144. The power requirement of the project is roughly about the same as that of Wushwush; i.e., about 800 MWh per year. The plantation produces about 18,000 tons of dry tea. The fuel wood consumption for drying this amount of tea is about 12,000 tons. With co-generation possibility this quantity of wood is enough to produce more than 3 times the energy required by Gumero tea plantation. This is in addition to satisfying the steam requirement of the plant.

145. The same argument of Wushwush holds true as the capacity to be developed either for factory use and higher capacity is developed and sold to EEPSCO. The surplus 2 MW capacity of the installation can be hooked to EEPSCO's grid that serves the isolated grid from Sor plant.

146. The costs associated with the two scenarios can be summarised as follows:

Own consumption

Capital Cost USD \$ = 600,000

Fuel cost USD \$ = 28,320

Operating and Maintenance cost USD \$ = 30,000

Sales to the grid

Capital cost USD \$ = 2,000,000

Fuel cost USD \$ = 94,000

Operating and Maintenance cost USD \$ = 100,000

Revenue from sales @ USD \$0.35/kWh USD \$ = 397,000

V.1.2 Project Proposals for Biomass-based Power Generation: Kenya & Uganda

V.1.2.1 Uganda

147. In line with the Government's Poverty Eradication Plan, there is need to establish a sustainable framework within which the potential of the indigenous alternative sources of energy will be assessed and developed to provide energy in forms and quality appropriate for different market requirements.

148. Biomass resources both woody and non-woody forms are key components for power generation consideration. Any one of the tea plantation sites in Uganda can be taken as a prototype project similar to Ethiopia. However, the installation of the proposed Martezo gas generator using agro-residues will substantially reduce the operating costs of the tea, coffee and rice factories in the region and the initial investment for the gas generators can be recovered in the period of two years. A specific site is not identified at this stage this could be done at a later stage with agreement with the concerned implementing agency.

149 The introduction of biomass-powered generators in the tea plantation could encourage local entrepreneurs to install appropriate size of 10kw capacity to meet the electricity and energy needs of the rural communities, as the know how in terms of installation, maintenance, operation could be obtained from the adjacent tea factories.

V.1.2.2 Kenya

150. The tea plantation industry is one of the most important fuel wood consumers in Kenya. There are over forty-five small-scale tea factories spreading eighteen districts. These factories spend over US\$ 15 million on furnace oil for tea processing. Due to the high costs of furnace oil many are resorting to the use of fuel wood. The average cost of processing 1kg of tea using fossil oil is 9 to 10 Ksh., whilst using biomass would cost only 3 Ksh.

151. Over 70% of the 45 small-scale tea factories use fossil oil for steam generation in processing tea. One of these plants can be taken as a prototype project. With the introduction of biomass gas power generation a substantial saving can be envisaged. The investment cost for the biomass gas power equipment would be covered from the saving of fossil fuel in one year. The cost of fuel in Kenya is three times of that in Ethiopia.

V.2 Project Proposals for “Small hydropower stations”

V.2.1 Mini/micro hydro project for Ethiopia: Bonora Mini-hydropower station

V.2.1.1 General considerations

152. The public power utilities in the three countries, Ethiopia, Kenya and Uganda were the only bodies that catered for the rural electrification programs. They were responsible for the study, design, realization and operation of each of the rural electrification projects. In Ethiopia, now, private groups are presently identifying and implementing run-of-the river mini-hydro sites ranging from 5 kW to 100 kW. There are also some local manufacturing enterprises manufacturing some components of mini and micro hydropower plants.

153. The proposed small hydropower project, being pilot projects, can contribute achieve the following broad objectives:

- i. Demonstrate that reliable electric energy can be supplied to the rural population using the local hydropower resource;
- ii. Assist the sustainable development of the target site;
- iii. Promote the transfer of technology;
- iv. Contribute to human capacity development; and
- v. Contribute to the modernization of local productive activities

154. The Bonora hydropower project site is 400 km south of Addis Ababa, 1.5 km away from the Bensa Ware village and 1 km from the highway from Wendo to Daye in the Sidama Zone, Southern Nations Nationalities and Peoples Region

V.2.1.2 Site selection criteria

155. The site was first identified by the Chinese Small Hydropower Investigation Team in 1989. Feasibility studies were carried out by the Chinese Northwest Investigation and Design Institute in 1997. These studies were recently updated through grant obtained from the Austrian Development Cooperation.

156. The site is selected for implementation due to the following main reasons:

- (i) availability of sufficient water and head;
- (ii) high-energy demand of the area; and
- (iii) economic potential of the area. Details of the project site are as follows:

Project location: Bensa Ware, Sidama

Type: With daily regulation

Average annual energy: 6,189 MWh

Installed capacity: 1040 kW

Rated head: 64 m

V.2.1.3 Description of the mini/micro hydropower facility

157. The following equipment and facilities are required for the project.

- 2 Turbines (Francis horizontal), each with 520 kW capacity
- 2 Generators each with 650 kVA capacity
- A Canal
- Forebay
- Penstock
- Power house
- Intake
- Transformer and switch gear
- Transmission and distribution system

V.2.1.4 Project cost

158. In the 2002 feasibility study update, the project cost is estimated as follows.

<i>Item</i>	<i>Cost in US \$</i>
Civil works	694,200
Electromechanical equipment	883,350
Transmission and distribution system	118,910
Total	1,696,460

V.2.1.5 Financial and economic viability

159. It was initially indicated that the total cost of the project development was estimated at US\$ at \$ 1,656,500, and that financing would come from community contribution and government loan and/or other grants. Reduction in the project cost could be achieved through having some of the electro-mechanical components manufacture locally. However, the total cost of the project according to the 2002 estimate is US \$ 1,696,460. The operating and maintenance cost of the scheme is estimated at \$33,130. The load forecast for the supply area is shown in Annex VIII, and the detailed cost estimate is tabulated in Annex IX

160. Based on the load forecast and the cost estimate cited above an economic and financial analysis was made in the review study undertaken and the result is:

- Total investment in US\$ per kW of installed capacity 1,600\$/kW
- Total investment in US\$ per kWh of annual production 0.30\$/kWh
- Net Present Value (NPV) 790,000\$
- Financial Internal rate of return (FIRR) 14.07%
- Economic net present value 1,148,000\$
- Financial Internal rate of return 16.10
- The average tariff is calculated as 0.0568 US\$/kWh

The interest rate assumed is 6%

V.2.1.6 Method of management, operation and maintenance of the Facility

161. The Ethiopian Electric Power Corporation will manage the facility. Additionally, EEPSCO will allocate budget for the maintenance of the facility.

162. The project is intended to have a model character and the experiences gained should help as example for application elsewhere in Ethiopia and beyond.

V.2.1.7 Local involvement in the implementation of the project

163. With the objective of promoting the local manufacturing of electromechanical components, efforts should be made to use the turbines manufactured by Selam Vocational Centre, Mesfin Engineering or the Basic Metal and Engineering Industries Agency.

V.2.1.8 Benefits of the project

164. Over 21,036 people living in Bensa, Bona, Warencha and Daye districts will benefit from this project.

- Expected economic and social benefits such as improve the quality of educational, health, and other services, available electricity will facilitate the creation of social services such as schools, health care, etc
- An energy source that can be viably implemented in a rural setting would contribute to the attractiveness of the rural areas and would provide an incentive for better-trained persons to serve in more remote areas;
- Electric power would encourage the establishment of government offices and associated services:
- Can initiate the development of local mini hydro technology
- Reduce the dependency on imported fuel
- Can spur cottage industry and agro-processing.
- Can initiate the development of local mini hydro technology
- Reduce the dependency on imported fuel
- Can spur cottage industry and agro-processing

V.2.2 Mini/micro hydro project for Kenya: Mathioya run-of-the river hydro scheme

V.2.2.1 General considerations

165. The ITDG/ Ministry of Energy site at Jiameceu falls on the river Tunga is expected to provide 18 kW to alleviate environmental problems associate with biomass and diesel fuel use. The implementation of this hydropower project will replace the use of firewood by utilizing ballast load heat from the scheme to cure tobacco, it will replace the diesel engine currently in use for maize grinding, it will replace the kerosene for lighting and supply energy for recharging batteries.

166. About 21 similar sites of mini hydro had been identified and their implementation will contribute significantly in raising the income and improving the livelihood of the communities.

V.2.2.2 Site selection

167. One possible immediate prototype mini hydro project in Kenya is the development of run-of-the-river hydro project on Mathioya River. The Kanyenya-in factory is situated near Kanyenya-ini-centre on the upper reaches of river Mathioya. The factory has rich hinterland and processes quality tea farm some 7000 farmers processing farm 16 million kgs of green tea per annum and production of some 4 million kg of processed tea per annum.

168. Presently the factory uses on average US\$ 370,000 for electricity and utilizes some 2,000,000 liters of fuel oil for tea curing and processes steam. The tea factory is considering developing the mini hydropower, which is capable of meeting part of the factory's load.

V.2.2.3 Financing strategy

169. It was indicated earlier that financing of the proposed project could be covered by the Kanyenya-ini-tea factory, which processes about 16 million kgs of good quality tea every year. The plant expends about \$370,000 for electricity and 2,000,000 litres of fuel oil, which cost something in the order of \$1,000,000. Developing the mini hydropower plant could relieve the tea processing plant of some of it energy requirement.

V.2.3 Project Proposal for Mini Hydro in Uganda: *Olewa¹ hydro project (?)*

V.2.3.1 General considerations

170. In Uganda, recent study has identified 19 possible sites at which power can be generated. The total potential generation capacity is 27MW. This is located on nine principal rivers. These are Nyagak, Narwodo, Ala, Enyau, Agoi, Kochi, Esia, Amua and Leya. The Sites identified in the study are shown in Annex V.

171. The run-of-the river potential (i.e. generation without regulating dam) is 5,4 MW at 90% reliability. The rivers in the area show marked seasonal variation in flow, with the severe months of low flow being January, February and March. For the balance of the nine months in the year, there is a high flow, which on average is greater 30% to 40% of the average annual flow, as compared to the flow, which is about 10% to 15% of the average. In the absence of funds to construct regulation dams, there is a good case to have an installed capacity of 3 to 4 times of that based purely on the run of the river scheme

V.2.3.2 Site selection

172. Olewa has been proposed for initial development, and could be taken as a prototype project; as it is a run of the river scheme it has no environmental impact, the study, design and implementation can be carried out with the involvement of local capabilities.

VI.2.3.3 Description of the mini/micro hydropower scheme

173. The scheme consists of a weir across the river with limited storage for daily regulation. Open channel low pressure pipes about 400m long to carry water to their forebay.

- A 1200 mm. diameter steel penstock, 1200 meter long to carry water to the power house
- In the powerhouse are two turbines and two generators each with a rating of 750 KVA to give an installed capacity of 1500 KVA.
- The power is transmitted to Arua 26 Km away through transformers and a 33 KVA overhead line.
- In Arua the voltage is stepped down to feed the distribution system.

V.2.3.4 Project cost

174. The total cost is estimated at US \$ 5.69 Million and is to be carried out in 18 months.

¹ This site is not included in the list of hydropower sites reported either in the Chapter on Company Infrastructure of the Uganda Electricity Board: see website: www.ueb.co.ug/infrastructure.html nor in the Presentation on "Uganda Strategy for Accelerated Grid-based Renewable Power Generation for Clean Environment" made by the Ugandan Minister of Energy and Mineral Development at a Workshop in Washington DC: see website: www.worldenergy.org/wec-geis/global/downloads/p4b_p_p.pdf

VI.2.4 Project Proposals for Wind Power Systems

V.2.4.1 Wind power generating system for Kenya

175. The proposed prototype wind turbine project in Kenya is for the installation of 850kW located near Naivasha on the periphery of the Great Rift Valley. The site being close to the national grid it can feed to the grid. It is intended to be presented to possible donors for funding with the intent of to demonstrate to the future investors that the technology can easily be applied for generating electricity to the rural communities.

V.2.5 Project Proposal for Hybrid Wind/Diesel System for Ethiopia

V.2.5.2.1 General considerations

176. There is no wind energy development in Ethiopia, which one could speak of. There is a tendency to dismiss the significance of wind energy in the Ethiopian energy scene. Awareness can be brought to the attention of EEPSCO in order for it to substitute wind power for the diesel engines now in operation, private entrepreneurs could be encouraged to promote the technology to the rural areas by supplier (manufacturers) or donors.

177. Grid extension programs are very expensive, in the order of USD 5000 per customer. Some of these towns under the present EEPSCO's electrification program are a long distance away from fuel depots and the availability of diesel will limit their operation to a few hours a day. The objective of this project is to reduce the consumption of carbon fuel through the installation of a wind power generator which would operate either in parallel with the diesel plant or alone provided the power demand is within its capacity limit.

❖ Site selection

178. Consider the diesel installations at Kebri Dehar and Gode for which wind speed data is available. A medium-sized diesel generator set suitable for these sites would cost EEPSCO US \$ 1300/kW of installed capacity. While a 250 kW wind turbine generator set (30m tubular tower, including installation costs) costs US \$ 312,500 (US \$ 1250/kW).

179. When one considers the fact that the unit cost of a wind turbine is going down all the time at a fast rate with technological improvements in turbine design, wind generator can favourably compete with diesel engines. Additionally, the wind turbine has practically no running costs.

180. For the purpose of demonstrating the viability of wind generators in alleviating the rural energy problem, it is recommended the installation of two 250-kW units in Gode and Kebri Dehar together with the envisaged diesel units.

❖ Project cost

181. The viability of wind turbines in such remote locations with wind energy potential can easily be demonstrated. The running costs of the units in Gode and Kebri Dehar are Birr 1/kWh and Birr 0.98/kWh, respectively. During a one-year period in 1998-99, the total running costs for these units were Birr 264,491 and Birr 283,121, respectively. The diesel needs to be transported over a very long distance sometimes through areas with insufficient security. In Ogaden and Afar areas of Ethiopia wind energy is likely to be an important option for rural electrification, and the pilot projects, if implemented, will demonstrate this.

182. The installation of wind turbine generators in Kenya, Ethiopia and Uganda as a demonstration plant funded by donors will motivate private investors in picking up the market. already donors have been approached, and are awaiting their favourable response.

V.2.6 Project Proposals for Solar PV systems

V.2.6.1 Availability of solar energy

183. Due to their localization across the equator, Ethiopia, Kenya and Uganda have abundant solar energy. An area of only 2km² of the Kenyan territory, for example, is sufficient to receive during daytime sun radiation energy equal to the present national demand in electricity.

184. This is of course a purely theoretical figure as conversion factor from solar energy to useful energy is far away from 100%. Nevertheless this figure gives an idea of the abundance of solar energy. Like wind, solar energy is neither permanent nor constant, but unlike wind energy, the average quantity and the time of the day of solar production are well known. Apart from photosynthesis processed by green plants thanks to solar energy useful energy taken from solar radiation is based either on thermal or photovoltaic effects.

V.2.6.2 Ethiopia's experience

185. Ethiopia has a vast sunshine potential however; experience with PV systems is still limited. The market for PV systems has been in the order of 30-60 kWp per year over the last 10 years, and, in the recent years, the installation of PV systems has increased to about 500kWp. Virtually all PV projects have been donor/Government led and there are little commercial PV activities.

V.2.6.3 Kenya's Experience

186. Fifteen years ago the first solar electric systems showed up in Kenya; these were very expensive mainly due to the high cost of the photoelectric cells at that time. There are three types of PV system currently in service in Kenya. These are the solar home system serving a single homestead, the PV powered vaccine refrigerator serving clinics and roof mounted community or school PV system.

187. The majority of the installations are of the first type generally made of one single array rated from 30 to 100 Wp; the second type includes several arrays of standard rate in the same range as here above.

V.2.6.4 Uganda's experience ²

❖ Private Sector Companies

188. There are 10 private sector commercial companies selling and installing PV systems in Uganda in addition to two local battery manufacturers/assemblers. Most of these small enterprises have sales averaging 0.5-3 KWp/year. Some are also involved with the sale of other electro-mechanical equipment (i.e. for agriculture) and see PV as a related technology for which the market will expand in the near future. Others are traders who are marketing a range of commercial products. and would like to sell PV systems as off-the-shelf items

² A Project Brief on "*Uganda Photovoltaic Pilot Project for Rural Electrification*" provides valuable insight information on how the Ugandan Government is intended to promote its rural electrification programme with the "*Energy for Rural Transformation (ERT) Programme*"; see: www.energyandminerals.go.ug/ert.htm

similar to kerosene lanterns and transistor radios. Uganda's two battery producers, Uganda Battery Ltd. and Battery Power Systems Uganda Ltd. have expressed interest in expanding their involvement with the use of batteries for PV systems and requested Project assistance in obtaining information and support related to the manufacture and sale of deep-discharge batteries for use in Uganda and in the region.

189. Approximately 25 private Ugandan companies, training institutions, and consultants recently organized themselves into the Uganda Renewable Energy Association (UREA). While UREA is yet in its formative phase, its members are committed to strengthening and expanding the use of renewable energy technologies in Uganda through commercial channels and are an increasingly active group.

❖ **The PV Credit Fund**

190. When a consumer is connected to the grid, the individual pays a connection fee and for the consumption on a monthly (or bi-monthly) basis. As a result, the payments are affordable for people with modest but regular incomes. However, with a PV system, a consumer is obliged to pay most of the cost of 20 years worth of electricity (the life of a solar panel) up-front. The establishment of financial mechanisms to spread this up-front cost over a reasonable period of time (and enable a significant portion of the population to afford the required payments) is a critical step in promoting large-scale PV-based rural electrification.

191. The demonstration of sustainable credit mechanisms to help both end-users and local PV vendor/installers spread the cost of household and community-based PV systems over time is an essential aspect of the Project UNDP/Kampala has made a grant of \$ 1 million to the Government of Uganda to facilitate the development of such credit mechanisms in collaboration with existing local financial institutions. Using the PV Credit Fund (PCF), loans will be made available to credit-worthy PV vendor/installers, community-based organizations, individual end-users and public sector institutions to facilitate the purchase of household and PV systems and their repayment over time.

192. Between 3-5 local financial institutions will be identified to participate in the administration of the PV Credit Fund. These institutions will be selected from among existing commercial financial institutions and/or NGOs with experience in providing credit to small-scale enterprises and/or community-based organizations.

❖ **Market size**

193. An estimate can be made of the annual market for PV systems in Uganda based on Uganda Electricity Board (UEB) projections. The 1992 National Electrification Planning Study prepared by Electricité de France International (EdFI) projected UEB making 25,000 new connections between the year 2000 and 2005 in areas already served by the grid and an additional 38,000 connections in areas scheduled for electrification during the same period. If we assume that PV systems will be used only to provide power for domestic consumers in new areas, we can project an average of 3,800 new PV -system customers/year. If we assume each household system uses a 50 Wp solar panel, the annual market in Uganda will be on the order of 190 KWp (approximately 20-40 times the present market).

194. This projection is conservative, as it does not take into account demand from:

- i. Domestic and commercial customers in already-electrified areas who are not yet connected to the grid and who are situated more than 60m from an existing grid point,
- ii. People living in rural areas not yet scheduled to receive grid power, which will now have the option of PV -based electricity, and
- iii. People living in urban areas who are connected to the grid but who require a more dependable electricity supply than is presently available from UEB.



❖ **Project Strategy and Implementation Arrangements**

195. The Government of Uganda (GOU), through the National Execution Unit (NEU) of the Ministry of Planning and Economic Development will be the executing agency for the project and the Ministry of Natural Resources will be the implementing agency. As Cooperating Agency, UNOPS will provide services such as identification and recruitment of international personnel as well as procurement of some of the equipment.

196. The project will overcome constraints to market development including:

- i. The high initial cost and lack of long term financing;
- ii. Lack of information at the household level and community levels, as well as among decision makers and government ministries;
- iii. Undeveloped private sector-based supply and service networks; and
- iv. A policy environment, which is not conducive to PV market development.

197. The Government and UNDP/GEF expect the Project to lead to the expanded provision of sustainable, commercially based, PV rural electrification services by the Ugandan private sector. All project initiatives have been planned from this perspective.

198. Promoting a Sustainable PV Market Structure in Uganda would include the following:

- i. *Raising public awareness:* - Consumer education will be organized by the Project Management Unit (PMU) and carried out by either the PMU, subcontractors and/or NGOs. The objective will be to enable large segments of the population to become aware of the services and limitations of PV systems, their maintenance requirements, costs and where/how they may be purchased;
- ii. *Selection of pilot sites and market assessment for various PV equipment options.* Target sites will be selected according to agreed-upon criteria. Various size PV systems will be market tested in these areas in close collaboration with the Ugandan private sector vendor/installers. Micro-lights as well as solar home and community-based systems will be considered; and
- iii. *System installation and final inspection:* -Once groups of at least 60 consumers in an area have made down payments on either household or community-based PV systems, and a local vendor/installer has signed a loan agreement with a participating financial institution, the project staff (in conjunction with the Uganda National Bureau of standards) will monitor system installation to ensure conformity to contract

specifications and installation codes of practice. This will also include final system inspection and certification.



❖ Financing strategy: Large-Scale Investment Potential

199. As part of the GEF evaluation process, the World Bank reviewed the Project Brief and indicated a preliminary willingness to provide loan on a long term basis to Uganda for PV - based rural electrification.

200. An initiative known as the "The Solar Development Corporation" is underway within the World Bank. The SDC will be wholesale loan window, which will provide capital resource to local lending organizations, such as banks, credit unions and co-operatives in developing countries, which will apply the funds to long-term loans and leases for solar energy end- users. Preliminary discussions with World Bank representatives have resulted in all Indication that Uganda could be a pilot country in Africa for the SDC following the completion of the Project.

201. Interest has been expressed by the German organization GTZ, the European Union, the Grants Management Unit of the USAID and the European Development Fund in providing additional grant-based funding for Project. If/when this funding/credit becomes available, additional, innovative financing schemes may be established in collaboration with other financial institutions.

VI. Regional Approach to Rural Electrification Development³

202. A UNEP/GEF project to build sustainable commercial dissemination networks for household PV systems in Eastern Africa will be launched shortly. This project covers Kenya, Tanzania, Uganda, Ethiopia and Eritrea. Its objectives are to:

- i. Create one sustainable "commercial corridor" of PV supply between importers, dealers and rural consumers in a high potential district;
- ii. Raise awareness among policy makers and development partners;
- iii. Assist commercial companies to develop viable PV businesses;
- iv. Encourage international PV companies to participate in the business development; and
- v. Create awareness and put in place the required technical capacity to market, design, install, and maintain PV systems for small needs in one rural district.

203. The proposed project will provide technical assistance for development of local capabilities for formulating strategies and plans for renewable energy development, as well as for identifying and developing specific renewable energy projects. It would also support implementation of actual investments.

204. Investments in institutional/household solar PV Systems will firmly be anchored within the energy sector selectively build and exploit cross sectoral synergies via coordinated investments in rural education, health, and water supply facilities

205. The activities would support cash purchases of community sized solar PV systems as well as smaller household-size solar PV systems. The purpose of this intervention is to open up the institutional (health clinics, schools, NGO posts, and private businesses) market for solar PV systems to local competitive procurement, and to establish the financial, technical and business development inter-mediation mechanisms for local suppliers. Financial inter-mediation would be via a Rural Electrification Fund for channeling GEF and bilateral grants.

206. Institutional Renewable Energy Applications activities would be directed at meeting efficiently all the modern energy needs of rural institutional consumers, such as health clinics and schools, and initiate the process by providing light, cooling for vaccines and electricity for other appliances via solar PV systems or other renewable technologies. This would be a 'cash market' by private suppliers, with the bulk of financing coming from donor-supported investment programs in the education and health sectors, as well as Government's budget for these sectors, and the remainder from GEF grants support under the project.

207. Household solar PV systems activities would aim to provide solar home systems for lighting and TV or lanterns to rural households and small commercial users, by private solar PV dealers on commercial terms with some subsidies. Qualifying solar PV dealers would receive competitive subsidy support, and may be also to refinance consumer credit, provided commercial banks are interested in such on-lending scheme. However, these activities are pending the Government decision on the UNEP/GEF project.

³ Regional Approach to Rural Electrification Development: *Where are the other components of the regional programme for rural electrification the author is talking about?*

VII. Conclusion and Recommendation

208. Electricity supply to rural sub-Saharan Africa, governments and utilities have tried their utmost best, is still below the level of other African countries outside the region.

209. In order to change this situation a different approach than the traditional approach that was being used up to now should be changed.

210. To bring about meaningful change in terms of better economic development better health care access to energy has to be increased and supplied to the rural community and has to be made sustainable, affordable and reliable. Hence governments and concerned bodies have to work to this end with clear commitment.

211. The use of proven renewable energy technologies can be an advantage both from the development and its environmental impact aspects. Solar, mini/micro hydropower, wind power and biomass based energy supplies are the best options for the purpose.

212. The governments' role in the implementation of rural electrification should be as minimum as possible and should encourage the involvement of the private sector. The governments' role should concentrate on creating enable conditions for private community partnership, rationalization of import duties, and creation of conducive situation for private sector in marketing, supplying and maintaining the renewable energy technologies. The other important aspect is the provision of access to public, private and NGO finance.

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