# UNEP/GEF PROJECT BRIEF

1. IDENTIFIERS

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| PROJECT NUMBER | |
| PROJECT NAME | **Renewable Energy Based Electricity Generation for Isolated Mini-Grids** |
| DURATION | **6 Years** |
| IMPLEMENTING AGENCY | **UNEP** |
| EXECUTING AGENCY | **UNIDO with regional dissemination through UNEP** |
| NATIONAL COUNTERPART AGENCY | **Ministry of Energy and Water Development, Government of Zambia[1]**<br>**Development Bank of Zambia[2]** |
| REQUESTING COUNTRY | **Republic of Zambia** |
| ELIGIBILITY | **Zambia ratified UNFCCC on May 28, 1993** |
| GEF FOCAL AREA | **Climate Change** |
| GEF PROGRAMMING FRAMEWORK | **OP 6 - Promoting the adoption of renewable energy by removing barriers and reducing implementation costs**<br>**CC 3 – Power Sector Policy Frameworks Supportive of Renewable Energy** |


SUMMARY

The main objective of this project is to help reduce the global green house gas (GHG) emission by promoting renewable energy based mini-grids for rural electrification in Zambia. Although Zambia has abundant hydropower, which is estimated at 6000 MW (currently installed capacity is about 1700 MW), only 50% of the urban population has access to electricity, and only 2% of the rural population has been connected to the national power grid. In keeping with the New Partnership for African Development (NEPAD), Zambia plans to provide commercial energy services to 15% of the population by the year 2010. The large land span and sparse population in Zambia have made it difficult to extend the national power grid to far-flung rural areas. The baseline trend is that supply of power in many of remote rural areas is predominately serviced by diesel generators, facing high imported diesel fuel cost with consequent environmental impact. Thus, Zambia presents an ideal opportunity for GEF to intervene and promote the use of abundant renewable energy resources —


[1] Department of Energy (DOE) under the Ministry of Energy and Water Development, Government of Zambia is the national counterpart agency.

[2] Development Bank of Zambia (DBZ) is a national level financial and banking institution with mandate to fund developmental projects. DBZ has shown strong ownership to manage innovative funding mechanisms for promoting investments in renewable energy-based rural electrification in Zambia.

biomass, solar, and mini-hydro, that are indigenously available to facilitate the rural electrification and promote linked productive use activities.

The project, which primarily aims at removing the key barriers and reducing implementation costs of renewable energy to accomplish this goal, would adopt a holistic approach by including two main components - technical assistance and business model demonstrations. The technical assistance component would engage activities for barrier removal including strengthening of the enabling environment in terms of policy instruments, capacity building, institutional strengthening and information dissemination to support the wide spread replication and sustainability after the GEF intervention. Increased power supply and reliable energy services in the rural areas will promote income generation activities, which is a key element in the Zambian Government's efforts to eliminate/reduce poverty in the rural areas. The business model component would aim at setting up of three pilot mini-grids to commercially demonstrate the technical and financial viabilities of using renewable energy technologies for electricity generation as well as for providing reliable energy services under the respective applicable business models. Development Bank of Zambia (DBZ) - a national level financial and banking institution is the designated agency for the introduction of business models to support their wide spread replication and sustainable development in Zambia.

## 2. EXPECTED OUTCOME

- Enabling environment in terms of a legal, institutional and policy framework to support commercial deployment of renewable energy based mini-grids in rural areas of Zambia;
- Enhanced capacity at national and local levels for the commercial deployment of renewable energy based mini-grids in rural areas of Zambia;
- Public/private project financing mechanisms to attract private sector investments, including a "Risk and Replication Management Fund (RRMF)", to share the risks, and encourage replication of renewable energy based mini-grid projects;
- Demonstrated business models of the technical and commercial viabilities of mini-grids based on biomass gasification, solar photovoltaic (PV) and small hydro technologies with their applicable financing mechanisms; and
- Replication of renewable energy-based mini-grids for rural electrification in Zambia and the region for productive uses and income-generating activities.

## 3. COSTS AND FINANCING (US $)

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| **GEF:** | Full Project | : | 2.950 | million |
| | PDF-B | : | 0.325 | million |
| | **Subtotal GEF** | : | **3.275** | **million** |
| **Co-financing:** | Government of Zambia[3] | : | 1.256 | million |
| | Private Sector Investors[4] | : | 2.750 | million |
| | UNIDO[5] | : | 0.500 | million |
| | UNEP[6] | : | 0.050 | million |
| | **Subtotal Co-Financing** | : | **4.556** | **million** |
| | **Total Project Cost** | : | **7.831** | **million** |

[3] Government of Zambia's contribution in-cash/in-kind would fund in-country training activities, project coordination, infrastructure and overall logistic support at the national level.

[4] Private sector investors also include strong interest expressed by ZESCO, the national electricity utility to participate in the implementation of the business models. While this amount is the estimated investment cost, Letters of Intent on file (shared with the GEF Sec) indicate a variety of investors willing to compete in a selection process and a total finance exceeding this amount available for such investments.

[5] UNIDO's contribution (in cash/kind) is primarily for policy planning, capacity building, feasibility studies and training activities.

[6] UNEP In-kind is primarily for coordination, dissemination and replication activities in the region.

## 4. OPERATIONAL FOCAL POINT ENDORSEMENT

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|---|---|
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## LIST OF ACRONYMS/ABBREVIATIONS

| | |
|---|---|
| AEG | Advisory Expert Group |
| BOO | Build-Own-Operate |
| BOT | Build-Operate-Transfer |
| CD | Certified Deposit |
| CEC | Copperbelt Energy Corporation |
| CEEEZ | Centre for Energy, Environment and Engineering of Zambia |
| COMESA | Common Market for Eastern and Southern Africa |
| DBZ | Development Bank of Zambia |
| DOE | Department of Energy |
| EIA | Environmental Impact Assessment |
| ERB | Energy Regulation Board |
| ESCO | Energy Services Company |
| GEF | Global Environmental Facility |
| GHGs | Green House Gases |
| ICT | Information and Communication Technology |
| ICTP | Industrial, Commercial, and Trade Policy |
| IPP | Independent Power Producer |
| ISO | Independent System Operator |
| JICA | Japanese International Co-operation Agency |
| KGRTC | Kafue Gorge Regional Training Center |
| KNBC | Kariba North Bank Company |
| kWh | Kilo-Watt hour |
| LEDs | Light Emitting Diodes |
| LHPC | Lunsemfwa Hydro Power Company |
| LRMC | Long Run Marginal Cost |
| MCTI | Ministry of Commerce, Trade and Industry |
| MEWD | Ministry of Energy and Water Development |
| MFNP | Ministry of Finance and National Planning |
| MOE | Ministry of Education |
| MOH | Ministry of Health |
| MTENR | Ministry of Tourism, Environment and Natural Resources |
| NEP | National Energy Policy |
| NEPAD | New Partnership for African Development |
| NGO | Non-Governmental Organization |
| NISRI | National Institute for Science and Industrial Research |
| NRSE | New and Renewable Sources of Energy |
| PDF | Project Preparation and Development Facility |
| OPPPI | Office for Promoting Private Power Investment (used on Page |
| PPA | Power Purchase Agreement |
| PRSP | Poverty Reduction Strategy Paper |
| PV | Photovoltaic |
| RE | Renewable Energy |
| REF | Rural Electrification Fund |
| RET | Renewable Energy Technology |
| REMP | Rural Electrification Master Plan |
| RRMF | Risk and Replication Management Fund |
| SADC | Southern African Development Community |
| SAPP | Southern African Power Pool |
| SHEMP | Smallholder Enterprise and Marketing Program |

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| SHS | Solar Home Systems |
| SIDA | Swedish International Development Agency |
| SSI | Small Scale Industry |
| TDAU | Technology Development and Adaptation Unit |
| TEVETA | Technical Education, Vocational and Entrepreneurship Training Authority |
| TNDP | Transitional National Development Plan |
| USAID | United States Agency for International Development |
| UNEP | United Nations Environmental Program |
| UNICEF | United Nations Children's Fund |
| UNIDO | United Nations Industrial Development Organization |
| UNZA | University of Zambia |
| UNF | United Nations Foundation |
| VAT | Value Added Tax |
| WB | The World Bank |
| ZABS | Zambia Bureau of Standards |
| ZACCI | Zambia Chamber of Commerce and Industry |
| ZAM | Zambia Manufacturing Association |
| ZAMSIF | Zambia Social Investment Fund |
| ZCCM | Zambia Consolidated Copper Mines |
| ZESCO | National Utility Company, previous called Zambia Electricity Supply Company |
| ZNFU | Zambia National Farmers Union |
| ZPA | Zambia Privatization Agency |

Currency conversion used: 1 USD = 4,800 Kwacha

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# 1 BACKGROUNDS AND CONTEXT

## 1.1 Country Context

1. Zambia is a land locked country, bordering with Democratic Republic of Congo and Tanzania in the north, Malawi and Mozambique in the east, Zimbabwe, Botswana, and Namibia in the south, and Angola in the west. It has a land size 40% larger than France, but with only 10 million people. About 64% of the population resides in the rural areas while the remaining 36% reside in urban areas. The country is generally flat with tropical lowland in the north, cooler high plateau in the south, and arid grassland in the west.

2. Due to the large number of rivers and streams in the country, as exemplified by the Victoria Fall at the border with Zimbabwe, Zambia has abundant supply of hydropower. Zambia's hydropower potential is estimated to be 6,000 MW, excluding the mini-hydropower. Currently, hydropower provides more than 94% of the 1,170 MW total power consumption in Zambia (1,600-1,700 MW installed capacity). In fact, Zambia has excess hydropower (about 20% of the total power produced), which is exported to neighboring countries. Location wise, Zambia is strategically positioned in linking the Southern Africa Power Pool (SAPP) with East Africa. Existing power export is made through interconnections with Zimbabwe (on to South Africa) and Democratic Republic of Congo. The contemplated Zambia-Tanzania -Kenya interconnection will link SAPP with East Africa and beyond and thus open a new market for power export.

3. Despite the abundant hydropower resources, only 44% of the urban population has access to electricity. ZESCO's coverage in rural areas is even less. Currently, only 2% of the rural dwellers have electricity supply, mainly because the extension of power grid to many widespread rural areas is very expensive and is cross-subsidized by a uniform electricity tariff. Low capital cost diesel generation is often used but due to the high cost of importing and transporting diesel,[7] the generators run for short periods, and electrification is not reaching people quickly. Overall, only 17% of the country's population has access to electricity, which is seen as an impediment to economic development

4. The production and export of copper used to be the main economic base for Zambia. Since the collapse of world's copper market due to the use of optic fibers for telecommunication, Zambian economy has shown a downward trend. As electricity supply is critical to the economic development and majority of country's population (about 64%) live in the rural areas, rural electrification has been accorded high priority by the Zambian Government.

5. Zambia has abundant renewable resources in the rural areas, which can be harnessed on a sustainable basis. The utilization of these indigenous renewable energy resources (i.e. mini-hydro, solar, and biomass resources) would be a very effective and sustainable alternative for the rural electrification on a decentralized basis. If ZESCO levels the playing field for renewable energy technologies (RETs), they would save dramatically on diesel costs and could more easily meet the growing energy needs in the rural areas and also reduce GHG emissions. In an IPP market, the lower cost of RETs would make them a preferred choice; where local industries are active, productive uses will result in a willingness to pay the cost of energy production as a niche commercial market.

6. Zambia has already restructured its energy sector and privatization is being pursued in phases. The modern concepts such as Independent Power Producers (IPPs) and Energy Service Companies (ESCOs) are already being implemented. The large hydropower sector has been opened to private investment and

[7] Diesel cost varies between 3000-4800 Kwacha per liter (Zambian national currency). Currently exchange rate is about 4800 Kwacha: 1 US $.

several projects are under negotiation. Given the low power grid access and the abundant availability of renewable energy resources in the rural areas, the options to enhance national energy security in Zambia would invariably include integrated energy policy planning, strengthening of key institutions, diversifying the energy supply by including locally-available renewable resources, and actively involving local communities and private sector focusing mainly on the income generation activities.

### 1.1.1 National Energy Policies and Institutions

National Policies

7. The development of the national energy policies and strategy in Zambia includes three milestones: (a) the Government's promulgation of a National Energy Policy (1994); (b) an Energy Regulation Act (of 1995 as amended in 2003) under which the Energy Regulation Board (ERB) was established; and (c) a new Electricity Act (of 1995 as amended in 2003) which permitted private sector investment in the power sector. The National Energy Policy (NEP)- continues to be the key document to guide the energy sector development. Its major focus is to promote socio-economic development by an optimum supply and utilization of energy, especially in indigenous forms, while maintaining a safe and healthy environment. It encourages the use of renewable energy sources, and accords priority to rural electrification programme.

8. The Zambian Government created a Rural Electrification Fund in 1994 with the objective to raise funds for rural electrification. This fund was created by dedicating a percentage of the sales tax on electricity consumption, which changed to a direct 3% levy on all electricity consumption in 1995. The Zambian Government, in May 1999, came out with a "Framework and Package of Incentives for Private Sector Participation in Hydropower Generation and Transmission Development". An Office for Promoting Private Power Investment (OPPPI)[8] has been set up under the Ministry of Energy and Water Development (MEWD) to implement the framework.

9. To tackle poverty problems in the country, the Zambian Government has developed a Poverty Reduction Strategy Paper (PRSP), which outlines national policies and developmental priorities to alleviate poverty. One of the key focus areas in the PRSP is to pursue rural electrification to uplift the living standards in rural areas. The Ministry of Commerce, Trade, and Industry has also come out with a national-level Industrial, Commercial and Trade Policy (ICTP) in 1994. The main objective of ICTP is to encourage the diffusion of industries into rural areas by giving appropriate incentives to enterprises located in such areas. Unfortunately the referred incentives are not elaborated beyond the general statement.

10. Driven by the NEP, PRSP, and ICTP, the Government is currently contemplating to draft a National Rural Electrification Master Plan (NREMP). This plan will identify various options for rural electrification for implementation by the Rural Electrification Authority (REA)[9] to focus exclusively on

[8] According to OPPPI and World Bank reports, a study has recently been completed on the solicitation strategy and documents for a number of projects, among which, two projects are directly related to rural electrification: (i) electrification of Mkushi Farm Block through grid connection, and (ii) development of north-west small hydropower. These projects are envisaged to be developed by the private sector on a BOO (Build-Own-Operate) basis.

[9] In November 2002, the Government recognized the limitations of current institutional organization and financing mechanism, were acting as key barriers to increased access to electricity in the rural areas. A roadmap and timeframe was drawn for the passage of Rural Electrification Bill aiming at direct channeling of the Rural Electrification Levy into the Rural Electrification Fund Account and establishment of an autonomous Rural Electrification Agency. A Bill to set up the Rural Electrification Authority was passed in the Parliament in November 2003.

rural areas. One of the elements of NREMP is to integrate new and renewable sources of energy to provide reliable electricity services to the rural communities in far-flung areas. The goal is to increase the rural electricity access from the current 2% rural population to 15% by 2010.

11. The Ministry of Energy and Water Development (MEWD) has been administering the Rural Electrification Fund since 1995. Due to other more pressing financial needs in the country, the Ministry of Finance and National Planning (MFNP) has not been releasing the funds consistently for the original purpose. One of the key reasons for forming REA is to prevent this fund diversion and attracting additional financing from external sources, particularly from multi/bilateral cooperating partners for rural electrification.

12. The proposed full project is in line with the national policies and priorities, and will contribute to the extensive use of renewable energy technologies to continue as a key element in Zambian Government's rural electrification programme beyond the GEF's intervention.

National Institutions

13. In Zambia, the Ministry of Energy and Water Development (MEWD) is responsible for the overall energy supply and utilization in the country. Under MEWD, the Department of Energy conducts the energy planning and formulates the national energy policies, including development and dissemination of new and renewable energy technologies. MEWD is the national counterpart department to coordinate with UNEP and UNIDO for the execution of the proposed full project.

14. ZESCO, the national electricity utility company, generates and distributes more than 90% of the electricity in the country and is currently the implementation agency for the national rural electrification programme. Kariba North Bank Company (KNBC), Copperbelt Energy Corporation (CEC), and Lunsemfwa Hydro Power Company (LHPC) produce and distribute the balance. In 2001, the Government outlined steps for the divestiture of Government's interest in ZESCO. The steps included: (i) Zambia Privatization Agency (ZPA) undertaking the necessary studies to enable the operations and management of ZESCO to be carried out by a private sector operator, (ii) identification and establishment of suitable modalities for peri-urban and rural electrification, and (iii) regulatory capacity building. However, given its past experience in dealing with privatization[10] of other enterprises, the Government is now focusing[11] on the commercialization of ZESCO's operations instead of privatization.

15. The Energy Regulation Board (ERB), which was set up in 1997 to oversee the regulatory functions for the energy sector, has also made several recommendations to restructure the power sector. These recommendations are still under the consideration of the government. Under ERB's recommendations, establishment of new power generation companies would be encouraged, and even ZESCO's generation assets would be separated into several independent generation companies. Existing transmission companies, such as CEC, and the new transmission companies would continue to own and invest in building transmission lines and networks to augment ZESCO's transmission assets. ZESCO's National Control Center and regional control centers would be taken to form an Independent System Operator (ISO) to manage the entire interconnected network. ZESCO's power distribution/supply system would also be separated into several regional companies, each covering a specified geographical area. These distribution companies will have concessions for their respective areas. Developers may build distribution

[10] This is mainly because purely commercial interests conflict with national development goals. The untimely closure of these units made the government to revise its economic liberalization policies by exempting certain state owned enterprises "strategic" to national interests from the privatization process. ZESCO is one of these "strategic" state owned enterprises.

[11] Government of Zambia and the World Bank have jointly agreed on a roadmap for commercialization of ZESCO, which is currently under implementation.

lines and networks within the areas. If the power sector restructuring is approved and proceeds as planned, it will encourage the private sector investment in the power sector including renewable energy technologies.

16. ZESCO charges a uniform electricity tariff for the entire nation. As ZESCO has already recovered the capital investment in many of the large hydropower projects, the tariffs set are very low in the 1-3 ¢/kWh range (details in Annex J). Users with very large electricity consumption usually negotiate lower rates with ZESCO, as their utilization is often high voltage power without the distribution costs. But these negotiated lower rates have to be reviewed and approved by ERB for their reasonableness. The privately owned power generation/distribution companies are not subject to uniform tariff. The ERB intervenes only if the customers of these companies submit complaints on the electricity rates charged.

17. For the GEF activities, the Ministry of Tourism, Environment and Natural Resources (MTENR) is the national focal point, which coordinates all GEF activities with other ministries including MEWD. Under MTENR, the Department of Environment has special interest in climate change issues and promotes related clean technologies by mobilizing international bilateral and multilateral funding resources and the Department of Forestry is responsible for managing the forest resources.

18. The inter-ministerial efforts on rural electrification are coordinated through the Rural Electrification Committee (REC). The REC comprises of MEWD, Ministry of Local Government and Housing, MFNP, ZESCO, National Energy Council, and the Engineering Institution of Zambia.

19. Even though the Zambian Government has revised its privatization policy for ZESCO, overall it encourages private investments. It has established two institutions to facilitate small private enterprises. As mentioned earlier, the first one is the Office for Promoting Private Power Investment[12] (OPPPI) under the MEWD to attract private investments in the power sector, and second one is Small Enterprises Development Board set up under the Ministry of Commerce, Trade and Industry (MOCI).

20. For building national capacity on new technologies, the Zambian Government has established the Technical Education Vocational and Entrepreneurship Training Authority (TEVETA). Also, several public research institutes, such as Technology Development and Adaptation Unit (TDAU) under the University of Zambia and National Institute for Science and Industrial Research (NISIR), have been actively involved in renewable energy technology research and training. But the research and training activities are mostly related to the mini-hydro and solar PV technologies.

21. There are quite a few companies in Zambia engaged in the design, manufacturing, assembling, installing, and servicing renewable energy based power generation facilities, but they are mostly related to mini-hydro and PV. Some of the renewable energy equipment manufacturing and supply companies in Zambia are Solar World, Suntech Appropriate Technology, Electrical Maintenance Lusaka, BP Zambia, Solaris Africa, Hazida Communications, Powerlink Solar Equipment, Siemens Zambia, Assimex Agency Import, Solar City, and Sun Solar Systems and Supplies. Some of key companies for installation and maintenance of renewable energy technologies systems are Behrens, Electrical Techniques, and Hold Trade Engineering Zambia. Few operational energy service companies include Nyimba Energy Service Company, Chipata Energy Service Company, and Concord Investments. Multi/bilateral agencies have supported promotion of renewable energy technologies to a great extent in the country.

[12] OPPPI has so far received a total of 21 inquiries from potential IPPs interested in the development of small hydropower schemes in the country.

### 1.1.2 Linkages to Other On-going Projects and Programs

22. At present, in Zambia as well as in the African region, a number of renewable energy-based projects and activities funded by GEF and other agencies are under implementation. The proposed RE Mini-grids project in Zambia has been designed to complement activities of other ongoing projects/programmes, and to build synergies with them. Lessons learned from other important climate change projects[13] will be taken into account while implementing the project activities to avoid duplication, and establish close linkages with the ongoing initiatives to make full use of their results, complement their activities and to develop synergies to maximize the impact.

23. A brief description of the important energy projects, which are ongoing in Zambia as well as in the region, and have relevance to the proposed project, is as follows:

24. GEF has funded two PDF-B projects for UNIDO namely: (a) Renewable energy (RE) based electricity generation for isolated mini-grids; and (b) Renewable energy promotion through Information and Communication Technology (ICT) introduction in off-grid rural communities in Zambia and Malawi. While the first PDF-B project on RE mini-grids has been successfully implemented, and has resulted into the proposed project brief, the second PDF-B project which is a regional project on linking RE with ICT, has just started.

25. The proposed RE mini-grids project will incorporate results from field studies to be undertaken under the second PDF-B project, link up with social and productive activities, and would strive to achieve synergies by exchanging information on the project activities on regular basis. In both projects, UNEP is the IA for GEF funding.

26. GEF has recently approved a PDF-B project in Zambia for World Bank on power sector reforms for increased access to energy services. The project aims at expanding access to electricity in large-scale in the rural and peri-urban areas through creation of an enabling policy and institutional environment in terms of power sector reforms with increased private sector participation in order to promote sustainable economic growth and reduce poverty.

27. The proposed RE mini-grids project will link up with World Bank PDF-B project activities which may result into a large (about US $ 100 million) project looking at much broader policy issues including setting up of a Rural Electrification Authority. A roadmap for ensuring close coordination between the UNEP/UNIDO and WB projects has been drawn in consultations with WB team, which is placed at Annex K. The UNIDO project size has been reduced by about 25%, and will focus on technologies that could be introduced into the World Bank programme.

28. GEF funded an UNEP implemented Enabling Activity Project - National Communications to the UNFCCC for Zambia in 1997. This project provided assistance to the Government of Zambia to comply with the provisions of the UNFCCC.

29. The proposed RE mini-grids project has benefited from the information already made available under the first national communication report, especially from the details given on GHGs emission sources and abatement options, and would strive to achieve synergies by exchanging information on the project activities on regular basis.

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[13] Experience gained and lessons learned from the GEF funded UNEP/UNIDO's renewable energy project for Isla de la Juventud in Cuba will also be taken into account while implementing RETs based business models in Zambia.

30. UNEP/UNF and E+Co are executing the African Rural Energy Enterprise Development (AREED) project in Africa. The Centre for Energy, Environment & Engineering Zambia Ltd (CEEEZ) is a non-governmental organisation collaborating with Government and various institutions, and investigates, analyzes and makes useful conclusions and policy recommendations on energy, environment and engineering concerns, and also carries out studies, research and development, consultancy and training in those areas. CEEEZ represents AREED in Zambia. GEF has approved funding for a global/ multi-country expansion PDF-B – Global Renewable Energy Enterprise Development (REED). The project provides "patient" seed capital and enterprise development/assistance services to small rural enterprises engaging in providing energy services based on renewable energy. Enterprises' services are for both household systems and productive uses (income generating activities). It removes key barriers preventing new or existing small and medium-size enterprises from expanding their services with renewable energy.

31. The proposed RE mini-grids project will incorporate results from the REED project, link up with social and productive activities through energy enterprise development, and would strive to achieve synergies by exchanging information on the project activities on regular basis. In particular, the E+Co has been asked to assist in training the DBZ and CEEEZ would provide training for small and medium enterprises (SMEs) like the fishing lanterns activity or the biomass gathering enterprises.

32. Partners for Africa is a regional networking project, which is looking at implementation of renewable energy technologies and renewable energy market opportunities in Africa.

33. The proposed RE mini-grids project will link up with regional network of institutions working on developing renewable energy markets and would strive to achieve synergies by exchanging information on the project activities on regular basis.

34. The Swedish International Development Authority (SIDA) has implemented a project called "Providing Solar Photovoltaics Electricity through Energy Service Companies (ESCO) in Rural Areas of Zambia" in 1999. The project provided upfront costs for the equipment and technical support to ESCOs for meeting the electricity needs of 400 households for lighting and radio/TV through solar PV systems in three districts (Nyimba, Chipata and Lundazi) of the Eastern Province.

35. The proposed RE mini-grids project has incorporated results from SIDA project, looked at the critical issues that need to be taken into account while planning for pilot mini-grids, and incorporated them into the project design. The project would strive to achieve synergies with SIDA initiatives by exchanging information on the project activities on regular basis.

36. UNEP is implementing a global programme — Global Network of Energy for Sustainable Development (GNESD), which aims at enhancing national capacities to develop policy and planning efforts that integrate solutions to energy, environment and development problems. Renewable energy technologies and systems are an integral part of this global network, which also covers institutions in Zambia and other countries in the region.

37. The proposed RE mini-grids project will link up with GNESD network of institutions working on developing capacities in renewable energy technologies, and would strive to achieve synergies by exchanging information on the project activities on regular basis.

### 1.1.3 Past Experiences of Renewable Energy Technologies in Zambia

38. Zambia already has experience in renewable energy technologies, and Ministries of Energy, Health and Education have closely been involved in the implementation of a number of renewable energy technologies based energy and social projects[14] funded by various multi/bilateral agencies.

39. The major PV solar experience in Zambia was a pilot project in 1999 called "Providing Solar Photovoltaics Electricity through Energy Service Companies (ESCO) in Rural Areas of Zambia" as mentioned earlier. It provides 400 households with electricity for lighting and radio/TV in each of the three districts (Nyimba, Chipata and Lundazi). An ESCO provides the day-to-day maintenance, service, fault repair, and troubleshooting based on a monthly fee charged to each customer for the Solar Home Systems (SHS) used, which include the PV panels, power converter, and storage battery. In the past, many solar PV projects failed due to lack of technical support. In this SIDA funded project, the Energy and Environment Resource Center (EERC) of University of Zambia (UNZA) provides the technical training for the ESCOs' operating and maintenance staff. As a result, most of the 400 SHS are still in operation. EERC itself also has a PV unit to provide electricity for its laboratory. DOE and SIDA have now an expansion plan to install 20,000 more SHS over the next ten years.

40. Other solar PV experiences in Zambia include a project undertaken by the Ministry of Health (MOH) with funding from the European Union, UNICEF and Japanese International Co-operation Agency (JICA) to provide medical refrigeration and lighting to about 200 rural health centers and a project by Ministry of Education (MOE) under the World Bank funding (through Zambia Social Investment Fund, ZAMSIF) to provide electricity for teachers' houses in 80 schools. Overall, the number of PV units installed in Zambia has increased from 6 in 1993 to over 750 in 2001.

41. Although the Government has evaluated the development potential of small hydropower for many years, Zambia has now only six mini-hydro or micro-hydro stations with capacities ranging from 750 kW to 20 MW. ZESCO owns four of them and LHPC owns the other two. Currently, ZESCO is planning to build a 3.5 MW mini-hydro plant at Chikata in the Northwestern Province to replace an existing diesel generation station.

## 1.2 Energy Scenario in Zambia

### 1.2.1 Primary Energy Supply in Zambia

42. The primary sources of energy consumption in Zambia are hydro, coal, petroleum, and wood. The relative share of use for these primary energies is given in Figure 1[15], which shows wood, (used mainly as fuel for home cooking), is the main source of energy, particularly in rural areas. Wood is used directly as fuel and also converted to charcoal, which is also extensively used in urban centers. The petroleum fuel consumed in the country is all imported. Despite the fact that Zambia has a large coal reserve exceeding 80 million tonnes, coal accounts for only 2% of the national total energy consumption, that is mostly in industry.

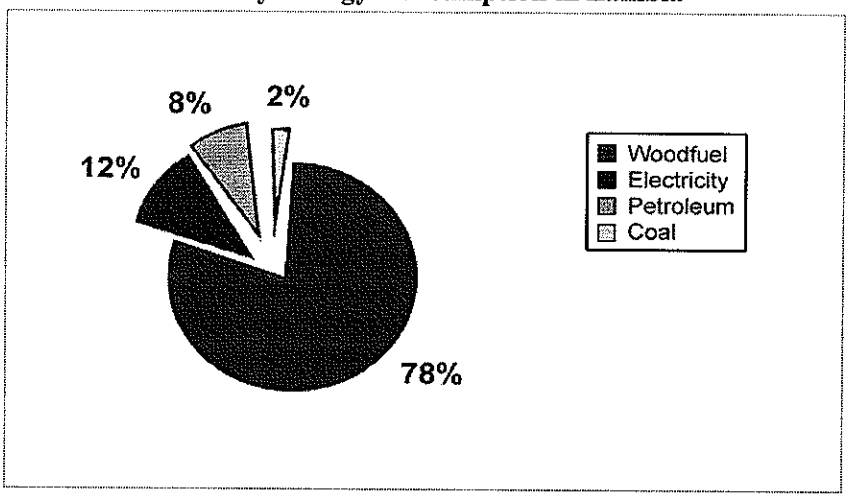
43. As mentioned earlier, Zambia is blessed with immense hydro potential, and the country power consumption about 1,170 MW is almost exclusively (>94%) supplied by hydropower. The remaining electricity supply is generated mostly by diesel engines, particularly at remote locations. The major

[14] Most of the renewable energy projects so far have focused on use of solar PV and mini hydro technologies for providing energy services or linking on education or health institutions.

[15] Department of Energy 2000 Energy Bulletin Statistics, Ministry of Energy and Water Development, Govt. of Zambia Printer, Lusaka, Zambia

hydropower schemes are Kafue Gorge (900 MW), Kariba North (600 MW), and Victoria Falls (108 MW). The copper mines consume about 70% of the electricity. Zambia has six hydropower stations that have over the years been classified as small. ZESCO runs four of these hydropower stations and the rest are run by ZCCM. There are 10 small hydropower stations, which total to 62 MW. About 13 small hydropower sites have also been identified by various studies on rivers such as Zambesi, Lunga, Kabompo, Chambeshi and Manshya with power generation potential ranging from 10 kW to 20 MW.

**Figure 1**
**Primary Energy Consumption in Zambia**

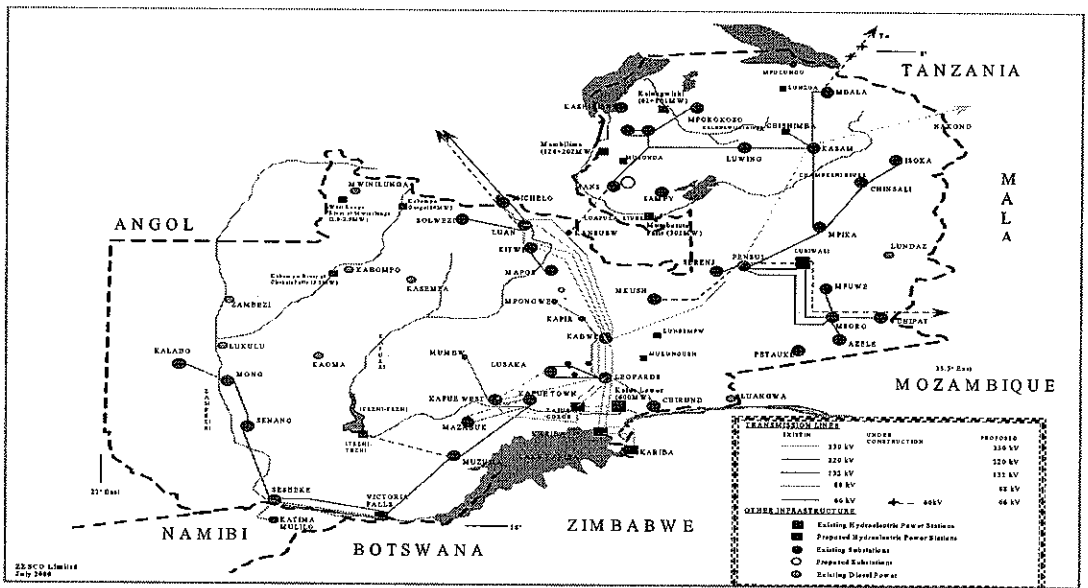



**Source: Annual Report of Department of Energy, Government of Zambia 2002.**

### 1.2.2 Power Supply and Rural Electrification in Zambia

44. The power generation stations and transmission systems in Zambia are shown in Figure 2.

**Figure 2**
**Power Generation and Transmission in Zambia**




**Source: Annual Report of ZESCO 2002.**

45. Currently, ZESCO provides electricity to far-flung rural areas mainly through the use of diesel power generation stations. There are ten such stations throughout the country with a total aggregate capacity of 9 MW. In each location, the power produced from the station is distributed to the consumers through a local mini-grid. In addition, many private enterprises and communities in Zambia also have captive diesel generators to meet their own power demands.

46. Some of the key isolated diesel-based electricity generation sites in Zambia are as under:

**Table 1**
**Isolated diesel-based electricity generation sites in Zambia**

| Site | Location – distance to the nearest grid line | Diesel genset capacity | Population, households |
|---|---|---|---|
| 1. Mwinilunga | 241 km west of Solwezi | 1.16 MW | 23,138 |
| 2. Kasempa | 184km south of Solwezi | 1.06 MW | 9,140 |
| 3. Kaoma | 181 km E of Mongu | 2.4 MW | 30,915 |
| 4. Kabompo | 355 km SW of Solwezi | 1.16 MW | 13,654 |
| 5. Zambezi | 515 km SW of Solwezi | 0.795 MW | 12,483 |
| 6. Kaputa | 152 km NE of Chiengi | 0.5 MW | 9,686 |
| 7. Lukulu | 370 km N of Mongu | 0.577 MW | 13,212 |
| 8. Mufumbwe | 246 km SW of Solwezi | 0.76 MW | 7,563 |
| 9. Luangwa | 331 km east of Lusaka | 0.27 MW | 3,817 |
| 10. Minga (Petauke district) | 30 km west of Petauke | 245 KVA | 47,957 |
| 11. Mulobezi (Sesheke district) | 100 km to the line 210 km from Livingstone | 335 KVA | 16,275 |
| 12. Kalungwishi Sugar Estates (Kasama district) | 6 km east of the line 40 km north of Kasama | 185 KVA | 36,067 |

**Source: Annual Reports of Department of Energy and Energy Regulation Board, 2002.**

### 1.2.3 Renewable Energy Sources in Zambia

**Mini-Hydro**

47. The power generation in Zambia so far focused on building large hydropower stations. Mini-hydropower from many suitable locations in Zambia is largely untapped. The mini-hydropower potential, estimated from the heads and flows at applicable locations in various river basins is about 15-30 MW. More details on mini hydro potential – province wise are given in Annex F.

**Solar**

48. Zambia is located just south of the equator and has ample sunshine to produce power by the use of photovoltaic (PV). The annual solar radiation in Zambian is amongst the highest in the world. The radiation is fairly uniform across the country, varying in the range of 6,600-7,700 MJ/$m^2$ (5.27- 6.09 kWh/$m^2$)[16]. More details on solar energy potential - province wise are given in Annex G.

**Biomass**

49. Land in Zambia is very fertile, and has large supply of biomass in terms of both agricultural wastes and forest residues. The biomass resources from agricultural residues are estimated to be 3.8 million tonnes / year based on the crop production [17]. The biomass resources from wood processing wastes are estimated to be 1.2 million tonnes / year. More than 60% of the Zambia land is forest (446,000 $km^2$), which contains 4,202 million $m^3$ growing stocks as shown in Table 2, with an annual composite growing rate of 17.4 $m^3$/hectare (of various forest types). This could be additional biomass resource if the forestland is properly managed for this purpose. Rural population pressures on biomass include fuel for cooking and slash and burn agriculture. Slash and burn practices have become unsustainable, and there are programmes by the International Centre for Research in Agro-forestry and SIDA to introduce alternatives. Suitably managed biomass resources can be gasified to produce fuel gas, which in turn, can be fed to gas engines to produce power. Potential power generation from the total biomass available (surplus) has been estimated at 500 MW in Zambia. More details on biomass potential - province wise are given in Annex E.

**Table 2**

**Estimated Growing Stocks and Annual Growing Rate by Forest Types**

| Category | Growing Stock ($10^6$ $m^3$) | Annual Growing Rate ($m^3$/ha) |
|---|---|---|
| Forest reserves | 779 | 12.2 |
| Open forest areas | 2,798 | 22.4 |
| National Parks | 544 | 1.6 |
| Trees outside forest | 81 | 3.3 |

**Source: Annual Report of the Department of Forestry, Government of Zambia 2002.**

**Wind and Geothermal**

[16] Jain, P.C., "Solar Radiation over Zambia", International Center for Theoretical Physics, Report No. IC/83/213 (1983)
[17] Agricultural Statistics Bulletin, 2001, Department of Planning and Cooperatives Development, Government of Zambia, Lusaka.

50. Zambia has limited wind energy resources as it does not have any significant geographic features that accelerate wind and the country is landlocked. Mean annual wind speeds are relatively low in Zambia, and inadequate for wind electric systems (JICA reports). The meteorology department has been carrying out wind speed measurements at 34 monitoring stations. The wind speeds vary between 0.1 and 3.5 m/s with an annual average of 2.5 m/s measured at 10m from the ground level. The University of Zambia has evaluated and determined that these low wind speeds are not sufficient for power generation and the wind resources are adequate only for water pumping. Due to the low wind resource, the wind energy industry has also been non-existent in Zambia.

51. Zambia has quite a few hot springs spread over the country. Most of them have low water temperatures (< 95 °C) and thus are not suitable for power generation. In late 1980s, a 200 kW geothermal power plant was built at Kapishya under a bilateral funding from Italy but this plant has never been operational due to lack of distribution infrastructure and thus was shut down. Government has handed over this project to ZESCO to revive it. Overall, the potential of geothermal resources in Zambia for power generation has not been tapped yet, and more field studies are required to estimate the potential of geothermal source of energy for Zambia.

## 2. BARRIERS TO RENEWABLE ENERGY DEPLOYMENT IN ZAMBIA

52. Although Zambia has some experience in the implementation of renewable energy projects funded by bilateral agencies, there are a number of generic barriers to renewable energy development and widespread adoption in the country. Extensive successful experience to deploy renewable energy technologies on commercial basis to meet rural energy needs is still missing. In general, the deployment of renewable energy systems has been slow in Zambia due to a variety of reasons, some of which act as key barriers not only for Zambia but also in the region.

53. The PDF-B phase identified a number of barriers that hinder the development of renewable energy sources for rural electrification and linked productive use activities. These barriers are inter-related and would require an inter-disciplinary and holistic approach to overcome through close and active participation of key stakeholders such as planners, experts, electric utility, investors and local communities. The proposed full project is designed to remove these barriers by technology demonstration in pilot projects, policy change, capacity building, institution changes, and information dissemination so that these technologies can be commercially viable in Zambia.

54. The barriers can be divided into policy/institutional, financial, technical, and information, and human resource areas as described individually below.

### 2.1 Policy and Institutional Barriers

55. Although the government has accorded priority to the use of renewable energy for rural electrification, there are several policy and institutional barriers that limit the spread of renewable energy technologies. In the absence of a level playing field in terms of policies and institutional mechanisms, renewable energy based mini-grids cannot compete effectively with conventional projects in the rural areas.

56. Some of the key institutional and policy barriers identified during the PDF-B phase are as follows:

- The renewable energy agenda and policies are scattered in many government ministries and agencies. Effective coordination among them is lacking, and an effective mechanism is urgently required for inter-agency coordination.

- The energy policies do not envisage specific direct incentives (such as import duty and VAT exemption, tax credit for the generation, higher power purchase price stipulated by the government, and government's low-interest loans for both the generation projects and equipment manufacturing) or indirect incentives (such as imposing carbon emission tax) to entice the required investments in renewable energy sector. In May 1999, the Department of Energy published "Framework and Package of Incentives for Private Sector Participation in Hydropower Generation and Transmission Development". But this was for large-scale private power projects only. The Government also has passed the "Investment Act" to provide tax advantages for investments in Zambia. But this is applicable to all types of investment and the tax advantages targeted at promotion of renewable energy systems are non-existent or very limited.
- The national policies have not addressed the capacity building issues concerning renewable energy technologies in terms of components adaptation and manufacturing, undertaking necessary research and development, provision of training and dissemination of information.
- Some of the institutions or offices established to facilitate private investments or encourage small power sector enterprises, such as OPPPI and Small Enterprises Development Board mentioned earlier are under staffed, low budgeted or never formalized to take a front line role.
- There is a lack of integrated development plans at the provincial and district-level to harness the potential of renewable energy-based electricity generation to support income generation activities and consequent poverty reduction.
- Absence of any institutional experience in dealing with power purchase agreements for production, distribution and sale of electricity from renewable energy technologies limits the private sector's ability to invest in renewable energy based mini-grids; and
- Complete absence of commercial and service networks and market linkages for providing maintenance and logistic support to renewable energy technologies and systems at the national/local level act as a key barrier for wide-spread replication

## 2.2 Financial Barriers

57. Given the high inflation rates, declining value of national currency and overall deficit budget scenario in Zambia, financial barriers have been identified as the key obstacles to the private sector investments in renewable energy based mini-grids for rural electrification.

58. Some of the significant financial barriers identified during the PDF phase are as follows:

- Due to the huge borrowing by the government to cope with the large national budget deficit, Zambia has very high interest rate of 40-50% if the investment loans are to be paid back on local currency. For loans to be paid back on foreign currency, the interest rate is lower in the 12-13% range. These high interest rates make private investments not very attractive in the renewable energy sector.
- Zambian currency, Kwacha has devaluated rapidly in the past few years. It has finally stabilized in last 6 months. But it will take some time to overcome the lack of confidence of investors in the currency, and overall economic environment is not very conducive for attracting new investments.
- The uniform low electricity tariff has led most people in Zambia to expect low cost electricity services. This makes it difficult to recognize and accept the actual costs of generation and distribution of renewable energy based mini-grids, which tend to be higher because of the small generation capacity and upfront higher costs of the technologies.
- Some of the renewable energy technologies, such as biomass gasification and PV, are still in the earlier stage of commercialization and thus have higher capital costs. As their performance and

the rate of return are not yet fully proven, particularly under the Zambian conditions, the investors shy away from investing in these technologies.

- There is no clear and dedicated financing mechanism within the national financial institutions to support renewable energy projects. There is also virtually no or very little capacity within these financial institutions to appraise new renewable energy projects for funding.
- Due to the long distance and usually bad road conditions to reach the far-flung rural areas, the installation, service and maintenance of renewable energy facilities will be more difficult and costly.
- As Zambia is a land locked country, trading and shipping goods in and out of the country are more difficult and costly.
- Due to wide spread poverty, people in the rural areas are not in a position to afford the high costs of renewable based electricity until their income levels rise, after the electricity becomes available to promote economic activities.

### 2.3 Technical Barriers

59. In Zambia, there are a number of technical barriers that need to be addressed on priority in order to enhance the credibility of renewable energy technologies in the local industry, and to build national capacity to manufacture, build, operate and maintain new renewable energy based mini-grids.

60. Some of the key technical barriers identified in Zambia during the PDF phase are as follows:

- Norms and standards in terms of renewable energy performance, manufacture, installation and maintenance are weak and/or non-existent.
- Local manufacturing capacity and/or assembly of renewable energy technology components are currently lacking, although the knowledge, skills and expertise to operate renewable energy systems are available in Zambia.
- There is a limited technical capacity to design, install, operate, manage and maintain renewable energy based mini-grids.

### 2.4 Information Barriers

61. Given the low connectivity and literacy levels, prevalent poverty and sparsely populated rural areas, information barriers have been identified as important barriers to renewable energy development in Zambia. Some of key information barriers identified during the PDF-B phase are as follows:

- There is no sufficient statistical data available on the renewable energy resources in terms of locations, sizes, and other characteristics to better define project opportunities for investors.
- A central information-clearing house on renewable technologies does not exist. Instead, the information is scattered among various institutions and ministries.
- There is lack of information on comprehensive evaluation of renewable systems already installed in the country. Many potential investors and equipment suppliers are not fully informed about the relevant government policies and programmes.
- Awareness level among public as well as decision-makers about the potential of renewable energy resources for providing electricity and energy services is low.
- The electricity supply is considered as a social welfare service in Zambia. With the low electricity tariffs charged by ZESCO as mentioned above, some people prefer to wait for the government to extend the national grid to them, rather than having a mini-grid operated by an investor, and paying the investor at the commercial electricity rate. Local consumers need to be sensitized on commercial viability of reliable energy services.

## 2.5 Human Resource Barriers

62. Although Zambia has skilled and trained manpower in the energy sector, a number of significant human resource barriers, which may have impact on dissemination and replication of investment projects for new renewable energy based mini-grids, were identified during the PDF-B.. The barriers identified are as follows:

- The local capabilities in Zambia for the design, manufacturing, assembling, installing, and servicing renewable energy based power generation facilities are limited mostly to mini-hydro and solar PV systems.
- There are very few training facilities in Zambia in the field of renewable energy for officials, utilities, developers and service providers. Training facilities offered so far do not reflect local priorities
- The research and training for renewable energy in Zambia are limited to the mini-hydro and PV technologies. Also, the training is limited to service providers. Training facilities need to be expanded to cover new technologies such as biomass gasification technology, and the training also needs to extend to government officials and planners, financing institutes, and utilities.

# 3. PROJECT RATIONALE AND OBJECTIVES

## 3.1 Rationale for Promoting Renewable Energy Based Mini-Grids in Zambia

63. The country context, the overall energy scenario, low penetration of power grid in the rural areas and present alternative to generate electricity through diesel gensets clearly present an ideal opportunity for GEF to intervene, which would use the abundant renewable energy resources available indigenously namely biomass, solar, and mini-hydro to provide a sustainable solution for the rural electrification in Zambia. The widespread use of renewable energy resulted would curtail the GHG emissions in Zambia to meet the major objective of GEF's Climate Change programme

64. Detailed feasibility and field studies carried out during the PDF-B phase identified, evaluated and designed appropriately adapted activities to reduce/remove the financial, institutional, technical, information and human resource barriers hampering the increased use of renewable energy based mini-grids, and promote investment projects in the renewable energy sector in Zambia. Although the full project activities will focus on addressing the barriers and promoting investment projects for renewable energy based mini-grids at three locations, replication activities will be designed for implementation of similar projects in the rest of the country as well as in the region. Special efforts will be made to achieve a win-win situation by supporting renewable energy technologies on commercial basis, thereby ensuring reduction in their implementation costs, enhancement in investments and improving sustainability for the renewable energy development in Zambia. At every stage of project implementation, local communities (especially women groups) will be involved closely to ensure the sustainability and local ownership of the project.

### Relevant GEF Operational Programme

65. The proposed project in Zambia is consistent with the GEF Climate Change Operational Programme OP 6 "Promoting the adoption of renewable energy by removing barriers and reducing implementation costs."

66. The project constitutes a part of the Zambian Government overall plans and strategies to increase the share of renewable energies in the country's energy mix with a view to improve sustainability and energy

security in the rural areas. It also supports the objective of NEPAD to provide sustainable and reliable energy services to rural communities in Zambia to enhance their quality of life.

67. Furthermore, the project takes into account the suggested principles for GEF assistance for mini-grids.

**Power sector policy frameworks supportive of renewable energy and energy efficiency**

68. Given the country context and innovative features of the project, it can be classified mainly under this strategic priority (CC3). The project will pave the way for renewable energy-based rural electrification in Zambia. Once appropriate policy, institutional and legal agreements including power purchase mechanisms are in place, broader replication will be supported. The project starts from a baseline of diesel based electricity generation in remote areas, and therefore has capacity to implement the proposed project.

69. The other key priorities of the GEF Business Plan are as follows:

***70. Increased financing availability:*** One of the key components of the project strategy would be to promote private sector investment in renewable energy mini-grids, enterprises and intermediaries, using leveraged private finance (with contingent loans to share early costs and risks, i.e. the "Risk and Replication Management Fund").

***71. Productive uses of renewable energy:*** The project focuses on rural electrification for productive use activities and social benefits, with applications of renewable energy in agriculture, education, health, telecommunications and local enterprise development (i.e. cold storage facilities for fish products).

## 3.2 Project Objectives

72. The main objective of this project is to address key barriers to the deployment of renewable energy based mini-grids for rural electrification in Zambia. The RETs alternative will displace diesel generation in the baseline thus achieving GHG emission reductions and also provide a platform for RETs to move into unelectrified rural areas.

73. In line with the national priorities, this project will help Zambia to improve its energy security, reduce environmental risks such as over-dependence on traditional fuels (i.e. wood and charcoal), and use a more sustainable approach to meet local electricity needs. The project, which primarily aims at removing the key barriers and reducing implementation costs of renewable energy to accomplish this goal, would adopt a holistic approach by including two main components – technical assistance and business models. The technical assistance component would engage activities for barrier removal including strengthening of the enabling environment in terms of policy instruments, capacity building, institutional strengthening and information dissemination to support the wide spread replication and sustainability after the GEF intervention. The increased power supply and reliable energy services in the rural areas will promote income generation activities, which is a key element in Zambian Government's efforts to eliminate/reduce poverty in the rural areas. The project would aim at setting up of three pilot mini-grids to commercially demonstrate the technical and financial viabilities of using renewable energy technologies for electricity generation as well as for providing reliable energy services under the respective applicable business models.

74. The project has the following immediate objectives:

- To demonstrate, through the pilot mini-grids, the technical and financial viability of using renewable energy resources for rural electrification to potential investors, financing institutions, the utility, equipment suppliers, energy service providers, and government planning and regulatory officers:
    - Biomass gasification technology demonstration will overcome perceived and real technical risks;
    - Solar PV mini-grid will demonstrate an alternate model to solar home systems; and
    - Mini-hydro demonstration has the least technical risk but highest likelihood of broad replication especially considering the follow-on WB project.
- To demonstrate, through the pilot mini-grids, the IPP and BOT business models for utilizing each of the three renewable energy sources in rural electrification;
- To set up a public/private project financing mechanism to entice investors. A revolving fund is proposed to share upfront risks for future renewable energy projects;
- To establish a legal, institutional, and policy framework to provide favorable environment for commercial deployment of renewable energy based mini-grids in rural areas of Zambia; and
- To build national and local capacity for commercial deployment of renewable energy based mini-grids in rural areas of Zambia.

### 3.3 Baseline

75. As many rural areas in Zambia have difficulty to access grid power, the lowest capital cost solution currently available for the electricity supply to promote their economic development and meeting the social objective is to use the conventional diesel generators. Under this baseline condition, these rural communities would continue to use of diesel generators despite the associated high generation cost (due to the high imported diesel fuel cost) and emissions of harmful pollutants. For ZESCO serviced areas, there is cross subsidization since the residents are currently too poor to afford the extremely high cost of generation from the diesel generators. Although the national electric utility has plans to feed isolated rural areas through fossil fuel based electricity generation, it has also started exploring[18] the potential and opportunities being offered by renewable energy technologies to meet the growing rural needs for electricity and energy services.

76. Some industrial activities like fishing and agro-based production in the rural areas have been adversely affected because the lack of reliable electricity supply or high fuel cost has made the storage, production and transport of their merchandises very expensive to reach the market. Without any external assistance, baseline energy scenario in the rural areas of Zambia would continue to be characterized by over-dependence on traditional fuel for cooking and mini-grids based on fossil fuels, under-utilization of industrial capacity, low employment opportunities and higher emissions of greenhouse gases.

### 3.4 Alternative Project

77. The alternative solution, as proposed in this full project, is to use and harness vast potential offered by abundant renewable energy resources available locally - mini-hydro, biomass, and solar energy to generate and supply the electricity required for the rural communities on a decentralized basis. The renewable energy based mini-grids presently constitute the most promising option to provide electricity to isolated rural locations not connected to the Zambia nation grid.

78. The three pilot mini-grids identified during the PDF-B phase activities and recommended for the proposed full project are designed to demonstrate the applicable business models for using the three types

[18] ZESCO, the national electricity utility joined with UNIDO during the PDF phase to carry out field studies to select potential sites for setting up of renewable energy based mini-grids in the country.

of renewable energy resources (mini-hydro, biomass, and solar energy) with proven potential for rural areas for future commercial deployment[19].

79. The proposed project in Zambia will have two main components: a) Technical Assistance (TA) and b) Business Models (BM).

80. Some of the key barriers identified during the PDF-B phase activities will be adequately addressed through TA targeted at the specific problems and issues facing the renewable energy sector in Zambia. TA will include, among others, activities to address barriers – institutional, technical and financial, developing standardized project development agreements, power purchase agreements, support to investment projects, and the identification of selection criteria for replication projects; developing project appraisal guidelines with particular emphasis on the business models, Government support agreements, policy dialogue with the Government (Ministry for Energy and Water Development, Ministry of Finance and National Planning, Ministry of Tourism, Environment and Natural Resources, in close co-operation with the Ministries for Industry, Agriculture and Health), and other national actors (Energy Regulation Board, ZESCO), capacity building, training and information dissemination initiatives, for addressing generic barriers related to wide-spread adoption of the proposed business models. Gender issues will be mainstreamed into the various project activities to ensure active involvement of women during the implementation phase.

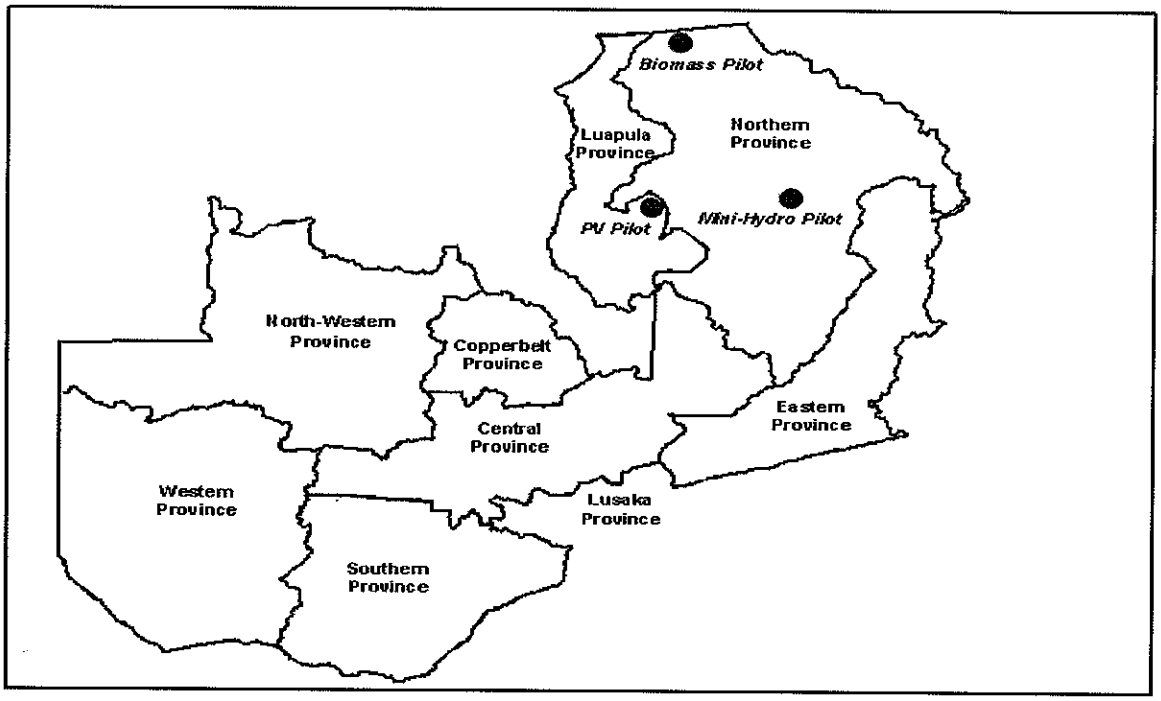
81. Based on the details available from the field visits, the overall benefits and the national priority, the following sites were selected for setting-up of business cum investment models in Zambia under the proposed project:

- A 1,000 kW mini-hydro business model at Shiwang'andu in Chinsali District;
- A 1,000 kW biomass gasification business model in Kaputa District; and
- A 36 kW PV business model at Chinsanka in Samfya District (also included in this model is the demonstrated use of solar lanterns in luring fish during the night fishing)

82. Active participation of the private sector along with the national electricity utility will be a pre-requisite for the successful implementation of the proposed business models. Figure 3 shows the locations of these pilot mini-grid projects.

[19] As regards the three business models (demonstration projects), the financial analysis revealed that when compared with base line diesel based electricity cost of production which comes to 25-30 cents / kWh, the mini-hydro project will produce electricity at 3-5.2 cents / kWh, the biomass gasifier system at 19 -20 cents / kWh, and the solar photovoltaic (PV) at $1.04 per kWh. The price of diesel as delivered to Kaputa and regulated by the government, is used for the baseline estimate although for smaller more remote installations like where the PV mini-grid is proposed, the true cost could be higher

**Figure 3**
**Business Models - Pilot Mini-Grid Sites in Zambia**




## 3.5 Replication Strategies and Relevance to GEF's Operational Programme

83. Successful implementation of replication strategies will be the key to wide spread dissemination of renewable energy technologies in Zambia. The ultimate success of this project will mainly depend on the demonstration of the technical and commercial viability of renewable energy based rural electrification (business models based on biomass gasifier, solar PV and mini hydro technologies) to meet the electricity and energy needs of the rural areas, and their wide-spread replication in the region. The project would specifically aim at setting up a sustainable financial mechanism for attracting private investments to business models, supporting feasibility studies for prospective investments, and would facilitate technological transfer to establish commercial renewable energy technologies based business models for electricity generation in Zambia. The project is expected to have a wide replication potential for renewable energy systems throughout the Africa region. Diesel mini-grids are a common feature in many African countries. The potential for managed biomass harvesting is also quite common. Remote fishing villages are seen on Lake Victoria, and many other areas with commonality of clustered dwellings as a source of cash income. Abundant hydro resources are also found in the region.

84. Since the PV mini-grid is a new model, information on the capital cost savings and performance will be documented for dissemination to others. The biomass gasification technology is very new to Africa and the monitoring of performance, costs and environmental impact will be necessary to manage operations. The biomass management system and advantages to the local population will be key features for dissemination. UNIDO organized a Round Table Meeting on Biomass Gasification Technology in conjunction with the Indian Institute of Sciences at Bangalore (India) in December 2003, which was attended by experts from 14 countries including Zambia. A similar regional meeting would be held in Zambia with a field trip to Kaputa once the plant becomes operational. A small working model will be used for touring technology transfer purposes. The mini-hydro demonstration will be documented and disseminated in the region. The World Bank project currently expected to focus mainly on larger small

hydro installations, may find that mini-hydro installations have less or minimal environmental impacts and offer more distributed generation benefits.

85. To sustain and replicate renewable energy based mini-grids for rural electrification in Zambia, the project will address issues such as policy change, capacity building of institutions, networking, and information dissemination as mentioned earlier. All the business models for the three pilot projects will include investments from private sector. This is designed to facilitate the future commercial deployment of renewable energy based technologies.

86. As 64% of the Zambian population is in the rural areas, the potential replication of the pilot mini-grids and their benefits in rural areas of Zambia are very high. With the replication, the volume demand for these generation facilities will increase to enable a reduction of the implementation costs[20]. This will fulfill the main objective of GEF Operational Program No. 6: promoting the adoption of renewable energy by removing barriers and reducing implementation costs.

87. Introduction of new renewable energy technologies on a commercial basis to the rural areas in Zambia will be an important first step towards the country and region-wide replication. This project would enhance the credibility of biomass gasifiers, solar PV and mini hydro based mini-grids, and the key role these technologies can play in facilitating rural electrification.

88. The experience with power production from the forestry biomass using gasifier technology at Kaputa will be replicated else where in the country where agro residues are available on a sustainable basis or small forestry plantations can be raised and managed for power generation. The gasifier technology for generation of electricity from forestry biomass or agricultural residues could also be adopted in the sugar industry, where surplus bagasse may be available for additional captive power generation or for supplying to the grid.

89. In Zambia, there are a number of industries (using boilers) that need process heat with capacities up to 20 tonnes of steam. Some of them are located in northern and central provinces where biomass is an abundant resource, and hence replication of gasifier systems can easily facilitate the supply of process heat.

90. It is realistic to envision vast replication potential of this project to other African countries as they have many similarities with the Zambian situation in the rural areas. National markets are small, technology and equipments are inefficient, and there is over dependence on imported fuel. Hence, local mini-grid power systems based on renewable energy technologies could easily be replicated in these countries. Zambia is fully integrated into SADC, COMESA and NEPAD under the African Union - regional organizations that would facilitate technology transfer and information sharing in the region.

91. At the policy level, it is expected that this project will help in creating a supportive and enabling environment for the entrepreneurial sector, especially for small businesses in order to fulfill the replication potential described above. Elements of such support may include developing business models for power generation through mini-grids based on renewable energy technologies for Zambia and other countries in the region, reduction in costs of renewable energy mini-grid projects by technology transfer and augmenting local manufacturing capacities, and helping to build the demand and capacity for the servicing and maintenance of renewable energy technologies.

[20] It is expected that successful implementation of demonstration mini-grid projects would lead to substantive reduction (savings could be in the range of 30 to 40%) in the implementations costs of subsequent business models on account of experience gained, enhanced local manufacturing capacity, availability of trained personnel and better financial management.

92. The strategy that will be implemented to ensure replicability would comprise of an advisory expert group within the project management structure of the project, with the following specific responsibilities:

- Provide single window technical advisory services, including technical feasibility study, fuel supply availability, and technical trouble shooting service, to potential developers.
- Promote renewable energy based mini-grids and associated development under each business model in Zambia and the region, at every stage of the implementation process.
- Develop mechanisms for effective country experience in biomass, solar and mini hydro technologies based mini-grids and ensure successful dissemination across the region.
- Plan capacity building activities for the potential investors, financiers, government officials, and general public to have an increased awareness and confidence level in new renewable technologies.
- Involve local communities and women groups closely during the implementation phase to ensure the sustainability and local ownership of the project.
- Implement workshops, seminars, and study tours to the successful demonstration projects for the key officials and stakeholders of other African countries, as well as project developers and potential investors.
- Provide information on financing sources and potential renewable energy mini-grid projects to potential investors within and outside Zambia.
- Provide competent advisory services to conduct financial feasibility studies, prepare agreements and contracts, and arrange project-financing package to potential investors.
- Seek bilateral and multilateral financing and international IPP investment for local biomass power and facilitate a strong relationship between the financial sector and the project development sector, and
- Facilitate enactment of policies, rules and procedures that would help in attracting investments on renewable energy technologies for power generation, and ensure their commercial viability through PPAs and ESCOs.

93. A Risk and Replication Management Fund (RRMF) being proposed under the project would present interest free loans to promote private investments in business models and be managed by the Development Bank of Zambia (DBZ). Detailed discussions held with the senior officials of the DBZ brought out need to frame procedures and rules for the management of RRM Funds, disbursal of interest free loans, repayment of the loans after a grace period by the investors and penal clauses for charging interest if loans are not returned on time as agreed with the investors. The DBZ will manage the funds on the same general terms as industry standards elsewhere with typical management fees subject to transaction costs. While UNIDO and UNEP will oversee administration of the fund during the project, capacity will be built such that a committee composed of the DOE, ERB, REA, and other partners would be able to select new beneficiaries and direct the ongoing fund management. While DBZ carries this function for Zambia generally, specific guidelines would be produced for renewable energy activities.

94. UNEP will facilitate networking of the proposed project with similar projects/initiatives being implemented in the region, and will create the necessary synergy among them. The project will use these projects as a channel to communicate and co-ordinate with other countries in the region into the replication process. By interacting with the above mentioned and future projects, the replication potential would increase enormously, and consequently, overlap and duplication of efforts will be avoided. Specific agreement will be reached with each of the ongoing projects to create appropriate channels of exchanging information and results.

95. The proposed RE mini-grids project for Zambia presents a unique opportunity to build a strong network and partnership among the government authorities, the private sector, the agricultural sector,

local communities, entrepreneurs, equipment manufacturers and technology/service providers in Zambia. The project components have been designed to ensure that the necessary and sufficient conditions exist to make the replication projects successful. Project activities are mainly designed to put in place institutional mechanisms for long-term sustainability of business models by addressing key barriers. It is expected that this project will lead to reduction in transaction costs and dissemination of information to different categories of potential renewable energy (i.e. biomass, solar and mini-hydro) investors. The project is expected to act as a catalyst to bring together various stakeholders on a common platform, and to expedite development of renewable energy technologies in Zambia.

### 3.6 Global Objective

96. The global objective of the project will be to reduce greenhouse gas emissions by supporting renewable energy based mini-grids for rural electrification. The proposed project in Zambia will demonstrate the technical and financial viability of renewable energy based mini-grids under investment business models, and will aim at removing the barriers to their development and wide replication. In particular, it will demonstrate the viability of new institutional and financial practices that would enable the private enterprises/companies to become power producers and energy service providers, and link reliable energy services with the productive use activities to enhance the employment opportunities in the rural areas of Zambia.

### 3.7 Project Design

97. The proposed project will aim at removing the barriers to the deployment of renewable energy technologies for rural electrification and promote investment projects in Zambia. As mentioned earlier, the project will implement technical assistance activities for capacity building, technology transfer, financial packaging and strengthening of institutional and policy mechanisms, and setting up initial investments as business models to demonstrate commercial viability of renewable energy based mini-grids to provide electricity and energy services in the rural areas of Zambia. The design would accommodate the expected World Bank OP6 project by reducing the effort and focusing more narrowly on relatively rapid demonstration of three technologies that could be adopted by the World Bank project.

98. On the basis of field data collected, resource availability, local demand for energy services and techno-economic feasibility studies including environment impact assessment studies carried out during the PDF-B phase, mini hydro, biomass gasification and solar PV technologies based mini-grids have emerged as most appropriate renewable energy technologies to meet the growing energy needs in the rural areas of Zambia, and there is also strong public and private interest to invest in and operate renewable energy based business models.

***Selection of Sites and Technologies***

99. The sites for setting-up of business models (renewable energy based mini-grids) were identified by the criteria developed during the national stakeholders workshop conducted as a start-up activity during the PDF-B phase implementation. Some of the key characteristics included in the criteria developed for site selection are as follows:

- Far-flung and inaccessible areas that cannot be reached economically through grid extension in the foreseeable future
- Areas with renewable energy resource potential for rural electricity generation
- Demand for rural electricity in areas that can pay at cost for the electricity service to be provided (agro-processing, rural industrial activities, public sector activities, existing demand centers serviced by expensive diesel-based electricity

- Areas with reasonable population densities or concentration
- Willingness of the local stakeholders to participate in the pilot project and pay for electricity services
- Availability of financing especially in areas where the community, private investors, public/private partners
- Local institutional capacity for implementation and operation
- Areas where the development of rural mini-grids would have less potential for adverse environmental impacts.

100. The field visits were undertaken to the selected sites for evaluating local basic conditions as well as local community development demands. Each pre-selected site was evaluated as per the following local condition parameters compiled in the form of a questionnaire:

(i) *Geographic*: location, distance to distribution and transmission lines, size of project area; wooded surface area; volume and flow rate of water resources, weather conditions (rainfall, wind factor, seasonal temperature variations), distribution of soil uses;
*(ii) Socio-cultural*: population; age structure; number of households; technical capacity of the population; existence of leaders; active institutions; local organizations;
*(iii) Economic and financial*: main economic activities (agriculture, livestock, forestry, artistry, and fishing); low-productivity economic activities; more dynamic economic activities; financing capacity; and
*(iv) Residential situation*: type of housing (family, complexes); main household activities (cooking, bread baking, brewing, water heating, lighting and pumping).

101. Abundant availability of biomass, solar and mini hydro resources, which can be harnessed on sustainable and commercial basis, influenced the final selection of technologies and sites in Zambia. Low availability of wind potential and lack of reliable information on geothermal potential ruled out their applicability as viable business model options. In all, initially 15 sites were selected all over the country, which were narrowed down to nine sites (three sites for each renewable energy technology – solar, biomass and mini-hydro). Out of the nine sites, three sites (one for each technology) were eventually selected and agreed with the national counterparts as these sites presented win win option at every level of implementation.

102. The following sites were selected for setting-up of business cum investment models in Zambia under the proposed project:

- Mini-hydro based business model at Shiwang'andu in Chinsali District;
- Biomass gasification business model in the Kaputa District; and
- Solar PV based Business model at Chinsanka in Samfya District.

103. Technology design for each business model was identified after going through very rigorous selection criteria, which among others included national priority, technical and commercial viability, environmental impacts and the GEF criteria.

104. A rapid environmental assessment study conducted for each site showed that there are no unacceptable environmental impacts, and with proper management plans in place, these projects can meet the environmental regulations in Zambia. Building on the field studies already undertaken during the PDF B phase, a comprehensive environmental management plan will be prepared for each of the demonstration mini-grid project, resources allocated, and regular monitoring will be undertaken to ensure its implementation. Further, to successfully implement the biomass gasification model in a sustainable

manner, it will be necessary to support and develop sustainable forestry activities in and around Kaputa project area. Thus the forestry management will form an integral part of the biomass model in order to support sustainable forest harvesting (only tops and lops, and fallen branches) to produce the quantity of biomass required to feed the gasifier systems for power generation.

105. Discussed below are the design and rationale for the each pilot project and the business model it intends to demonstrate.

**Mini-Hydro Based Business Model at Shiwang'andu Estate**

*Rationale*

106. Currently, at the Shiwang'andu Estate which was identified as most suitable site during the PDF-B phase activities for setting up of a business model using mini hydro based mini-grid, diesel generators are being used to generate power for:

- A metal/wood workshop (30 kW)
- A hammer mill for grinding animal feeds (12.5 kW)
- The tourist lodges at Shiwa House and Kapishya Springs (100 kW)

107. The estate has additional need of electricity to:

- Provide irrigation for coffee and sugar can plantation cultivated by the Estate and nearby farmers
- Process the coffee produced
- Expand the hammer mill to grind grains as well.

108. The local community also has needs for electricity for

- Supply power required by a hospital and a health centre nearby: The hospital is currently using a combination of diesel engine and PV to pump and treat its own water from the lake.
- Supply power to 100 residential homes: Some of these homes currently use dry cells to operate radio, TV, and other electrically operated goods.

109. The total electricity required in the immediate future by the Shiwang'andu Estate is 500 kW. But when needs of surrounding unelectrified rural areas and demand growth are taken into account, the estimated expanded requirement is significantly higher. The estate proprietor has a potential hydro resource within his property, and has expressed a strong interest to deploy it for the power supply.

*Proposed Intervention*

110. The hydropower resource in the Shiwang'andu Estate will be harvested from Manshya River when it flows from Shiwa Lake to join Chambeshi River. The pilot project will be based on the run-of-river design, i.e. no dam to be built. It comprises a power station with a diversion weir. A tailrace canal will lead the water back into the river. The effective diversion of flow will be for less than 400 meters. The project includes necessary distribution system to deliver the power to the users. As the capital cost difference between the 500 kW and 1,000 kW capacities is only 15%, this pilot mini-grid is designed for the 1,000 kW output.

111. The major difference of this pilot project from other hydropower projects in Zambia is that it is a run of the river project in the smaller capacity range with very limited or minor environmental impacts.

The electricity produced is used mostly to promote income-generating activities, which is one of the major objectives of the proposed full project.

*Applicable Business Model*

112. Mini-hydro is already commercially viable with a generation cost in the 3-5.2 ¢/kWh range. Its commercial deployment by private investors is fairly straightforward, and would be the first choice for the rural electrification, as long as the specific rural area has sufficient hydro resources with no adverse environmental or social impacts.

113. The Shiwang'andu Estate owner and ZESCO have expressed strong interests to jointly invest in this pilot project, which will demonstrate a joint-sector investment (public-private) business model. The success of this pilot project can facilitate the eventual transfer to total private sector ownership for future mini-hydro projects.

114. More details on Shiwang'andu mini-hydro business model are given at Annex F.

**Biomass Gasification Based Business Model at Kaputa**

*Rationale*

115. ZESCO currently has diesel generator station serving the Kaputa town, which is in a remote corner of Northern Province. The station currently has two Volvo Penta diesel generators of 267 kW and 181 kW, respectively. Due to the very high imported diesel fuel cost, the cost of electricity produced from this station is in the 25-30 ¢/ kWh range. Diesel transport is extremely difficult due to the terrain and bad road conditions. At present ZESCO is servicing on an average 200 – 250 kW load amounting to about 0.9 million units (kWh) annually. ZESCO is interested in finding alternative generation methods to reduce this high cost. Several businessmen in Kaputa have already urged ZESCO to increase the power supply so that they can start the fish processing plants. Due to the anticipated load increase, there is even more urgency for ZESCO to look for cost effective power generation method.

*Proposed Intervention*

116. In this pilot mini-grid, a biomass power generation unit will replace all the diesel based electricity generations at the ZESCO's Kaputa power station. Due to the anticipated power supply increase urged by the local businessmen, the biomass gasification plant is designed for 1,000 kW output.

117. The power generation will be made of two 500 kW gasifiers with gas engines. The gasifiers have the capability of multi-fuel option to provide flexibility in using agro residues or forest residues as the fuel. Use of gas engine totally eliminates the fossil fuel used, thus commercially attractive and environmentally acceptable. Thus, gas engines will use the producer gas totally, and would completely eliminate the diesel fuel consumption. The existing diesel engines will still be used but only for backup generation and providing startup power for the biomass gasifiers.

118. While a tendering procedure will be used, the project seeks an intermediate technology of relatively low cost to suit the local conditions with due importance to performance[21] and environmental conditions.

[21] Swiss/India cooperation has resulted in interesting applications in Switzerland/India, and similar cooperation will be sought to establish and support the African manufacturing of biomass gasification systems and their applications.

119. Aside from the gasifiers and gas engines, the generation plant will also include:

- A biomass receiving system
- A biomass preparation system for cutting, briquetting, and drying the gasifier feed to the required size consist and moisture content
- A feed loading system to the gasifiers
- A handling system to collect, transport, and use ash and char produced from the gasifiers (ash can be used as a soil supplement and char as a cooking fuel)
- A water treatment system to treat the circulated water for scrubbing and cooling of the gasifier product gas

120. The power produced will be delivered to the customers through the existing local grid, which will be further strengthened. The electric switchyard and the distribution system, however, will have to be expanded because the electricity to be delivered is 1,000 kW rather than 500 kW.

121. The biomass feed to the gasifiers at the rated capacity is about 1,200 kg/hr. With an average generation of 5.7 to 7.5 million units[22] (kWh) per annum (averaging 6700 hrs annual operations), the biomass consumption (at the maximum capacity) is expected to about 9,000 tonnes per year. The feed will be mainly lops and tops and fallen branches (from power pole fabrication) from the existing forests and milling waste or from new forest plantation (>90%) on fallow lands available in the vicinity, supplemented by agriculture residue (< 10%). Assuming the forest plantation can produce residues in the range of 6-7 tonnes/hectare woods annually and the woods will be harvested in a 5-year rotation cycle, the land required is less than 7, 000 hectares, which is only about 0.8 - 1.0 % of the total forest area in the Kaputa District. Kaputa is a farmland area, which produces primarily corn (maize), rice, millet, and groundnuts (peanuts) but also some beans, cassava, and sweet potato. In addition to wood, the agriculture waste to the gasifiers would mainly comprise of corncobs and groundnut shells collected in the vicinity of the power plant.

123. The Department of Forest under the Ministry of Tourism, Environment, and Natural Resources has agreed to participate in the pilot project, and shall be responsible for managing the feed supply. The biomass will be supplied to the Kaputa power station under a purchase agreement with ZESCO. Private investors will be invited to partake in this biomass supply in collaboration with the Department of Forest.

124. The major reasons to choose Kaputa as the pilot site for biomass based mini-grid include, among others, a pending request from the local business community for enhanced and reliable power supply, abundance of biomass in the vicinity and national priority for removing the suppressed generation towards meeting the local energy requirements. This pilot project will, for sure, promote income-generating activities such as fish and agro products processing, which is one of the key objectives of the proposed full project. The biomass gasification has never been tried in previous projects or programmes. The pilot mini-grid will introduce this new technology to Zambia.

*Applicable Business Model*

[22] The biomass demonstration project assumes up to 7500 hours of annual operation (averaging 6,700 hours) will be achieved early in the plant's life (from third year of its operations). This is to plan for sustainable supply of biomass. It is expected that there will be a gradual load increase. Kaputa has population about 90,000, and at present, there are only 170 domestic consumers and 50 commercial, with a peak load of about 260 kW. The75- 85% load factor may also take into account some load management (scheduling of off peak uses).

125. Preliminary discussions revealed a strong interest from ZESCO to invest, own and operate this pilot mini-grid. But several biomass gasifier suppliers and renewable energy project investors have also shown interest to invest, including a BOT (build, operate, and transfer) approach or a PPA (power purchase agreement) with ZESCO. Depending on the outcome of the negotiations between ZESCO and investors, this pilot project will demonstrate the business model of either joint partnership between the public and private sectors or total private sector ownership.

126. In this pilot mini-grid, the biomass gasification is expected to produce electricity below 12 ¢/kWh depending on the costs on collection, processing and transportation of biomass fuel. For the future privately owned commercial units, the implementation costs can be significantly reduced (in the range of 30-40 %) because:

- The commercial units will not have some of the cost provisions typical of pilot projects, such as vendor support, over-design due to technical uncertainty under the Zambian conditions.
- The private investors will pay the operating and maintenance labor costs based on the national commercial norms.
- The gasifier can be operated to convert 5-10% of the biomass feed to charcoal, which can be sold to compensate 25-50% of the biomass feed cost, and help reduce the unauthorized harvesting of forests, and harmful emissions from conventional charcoal-production kilns.

127. It is envisioned that this type of mini-grid will not just be ZESCO's undertaking to reduce financial losses in their diesel generation stations, but also has large commercial potential for replication in the country.

128. More details on Kaputa biomass based mini-grid business model are given at Annex E.

**Solar PV Based Business Model at Chinsaka**

*Rationale*

129. Situated in the Northern Province with no grid connection, the main economic activity in the rural areas of Samfya District is fishing from the nearby Bangaweulu Lake and surrounding swamp. Chinsanka is the biggest commercial centre in this district. It has 875 households and 70 shops, all clustered in an area of 2 km long and 1 km wide. Paraffin, candles, dry cells, firewood, and charcoal provide most of the current energy needs in Chinsanka. Lack of reliable energy services is a key barrier to the economic development.

130. The Samfya District has the need of electricity to further promote the fishing business and other economic activities. Due to the steady income from the fishing activities as identified during the PDF-B phase studies, the local people in the district have shown willingness to pay the higher cost for getting reliable energy services. The electricity provided could supply lighting to the shops to run longer businesses hours. It might also induce people to look for profitable business ventures, such as refrigeration of the fish catch to expand the sale and water pumping for irrigation of high value crops. Aside from the income generating activities, the electricity produced might further find use in social sectors, such as providing light to schools, powering refrigerators for storing vaccines in clinics, and running water purification to improve water supply quality.

131. The fishing in Samfya is usually done in the night with the use of kerosene lanterns to lure the fish. The kerosene purchased is very costly. There is also urgent need to find an alternative energy source to substitute for the kerosene used to catch fishes during the night.

*Proposed Intervention*

132. As Chinsanka is a small town, the power demand is not sufficiently high to justify conventional electrification methods. In view of availability of various renewable energy resources during the field studies, solar PV emerged as most attractive option to meet the local power needs.

133. The PV mini-grid is being proposed has 36 kW peak capacity to serve 550 homes and 50 shops, including provision for overcapacity to meet future demand increase and fluctuations. It is designed based on solar radiation of 5.2 peak sun hours over the annual 12-month period and has included technology package (mix of CFL/LED clusters) as well as the environmental management plan including recycling and disposal/management of the lead acid battery storage used. The electricity charges to these homes and shops will be collected through the use of prepayment cards, which will set a predetermined amount of electricity delivered periodically subject to the amount of payment deposited by the customers prior to the use. The battery storage is sized for 2-day system autonomy rather than the 3-days typically required for the off-grid Solar Home System to reduce the life cycle costs.

134. The pilot project will also include 10 large solar lanterns and 10 small solar lanterns to demonstrate their use in fishing as substitute for the kerosene lanterns. These solar lanterns will be charged by electricity generated from the PV panels during the daytime.

135. The major difference of this pilot project from the previous ones is that it is structured based on mini-grid rather than dispersed SHS. The previous PV projects showed the users tend to overuse the SHS by overdrawing the power. The central power generation in the mini-grid arrangement can be better monitored and controlled. It also allows commercial uses of the power generated, such as irrigation and food processing. Further more, the users' peak demands may not occur all at the same time. As a result, the central power generation will require less generation capacity and battery storage. Further, the project will utilize LED cluster lamps[23] to bring down the cost over period of time.

*Applicable Business Model*

136. Both ZESCO and a private investor experienced in designing, building, and servicing the solar PV based power distribution system have shown interest to co-finance and operate this mini-grid.

137. The PV mini-grid is an expensive power supply option with a generation cost in the US $ 1-1.5 per kWh range but on a monthly basis, the expenses are comparable to what people are already spending on traditional energy sources in many rural areas of Zambia. It will find its commercial value, as the power demand in a given rural area is very low to justify other electrification methods or lack of adequate availability of other renewable energy sources in the vicinity. Successful deployment of LEDs technologies for commercial applications such as solar lanterns to be used for fishing at night as envisaged under the project would also result in favorable economics, as any increase in income levels would further enhance the willingness of local population to pay more for the reliable energy services based on solar PV systems.

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[23] The project will aim at introducing Light Emitting Diodes (LEDs Clusters) at Samfya, as there could be substantive savings over a period of time, provided they meet local requirements of lumen/watt. The possible life cycle savings could come from the fact that recent advances made in the LED technology have made it possible that LED clusters can last upto 50,000 hrs when compared to 4000 hrs for Compact Fluorescent Lamps (CFLs). A detailed comparison and analysis of the costs across LEDs, CFLs and Kerosene lamps in the context of the local applications will be undertaken as a start-up activity of the full phase project before finalizing the technology design for the solar mini-grid.

138. ZESCO is interested in this business model because it could be an intermediate solution to their social-economic obligation to the rural electrification. When the power demand in a rural community has grown to the point of needing to switch to other power generation methods or even to be connected with the grid, the distribution system built in the PV mini-grid can continue to be used as part of the new system. The PV generation unit can then be moved to other sites. In essence, the solar mini-grid could be a pre-investment for ZESCO in their rural electrification program. However, it is also expected that the rural electrification niches where PV power generation is competitive and reliable, and where a strong linkage to productive use activities (e.g. solar lanterns for fishing) and social programmes (e.g. education and HIV Aids prevention through ICT) is carefully established, will grow over a period of time in Zambia as well as in the region.

139. The applicable business model to use this renewable energy source would be a joint partnership between the public and private sectors or total private investment (ESCO mode), but either case probably would require subsistence from the government or donors. As PV cost has steadily been reduced in the past, the subsistence would get reduced or even eliminated in the future, particularly if Zambia can transition into a totally market driven electricity pricing at that time. More details on Samfya solar PV business model are given at Annex G.

## 4. PROJECT ACTIVITIES AND EXPECTED RESULTS

140. The project activities (TA and Investment Component) that will address the key barriers to the deployment of renewable energy based mini-grids in Zambia can be broadly divided into five categories: a) designing and establishing institutional and policy framework; b) building national and local capacity to promote renewable energy based mini-grids; c) Setting up public/private financing mechanisms to attract private sector investment in renewable energy based mini-grids projects; d) Implementing pilot RE based mini-grids to demonstrate commercial viability of business models; and e) project coordination, management and information dissemination.

141. Each activity is composed of immediate objective, specific outputs and a number of sub-activities designed to address the key barriers that constrain development of renewable energy technologies in Zambia. Collectively, project activities will aim at the establishment of commercial business models for renewable energy based mini-grids at three rural locations, and their replication in the rest of the country.

142. Cross cutting themes such as gender issues and environment concerns will be mainstreamed into various project activities to ensure effective implementation of the project.

143. The project activities, immediate objectives and outputs are described as follows:

**Activity 1: Designing and Establishing Legal, Institutional, and Policy Framework**

144. The immediate objective of this activity will be to create a favourable enabling environment in terms of the legal, institutional, and policy framework for commercial deployment of renewable energy based rural mini-grids in Zambia. Except for a few donor funded renewable energy (mainly solar PV) projects, there is no past experience, policies or regulatory framework in place to support or encourage renewable energy based mini-grids in Zambia. Lack of any incentive or tax waiver to promote renewable energy technologies further hinders investment by the private enterprises. This activity will facilitate formulation of a policy and regulatory framework at the national level to mainstream renewable energy into the overall development strategy and integrated energy programmes in Zambia. It would also assist in providing a level playing field to renewable energy technologies to compete with conventional power generation (diesel based gensets) projects in the country.

145. Three project sub-activities are to be engaged to achieve this output.

***Output 1.1 An enabling framework in terms of policy, institutional and regulatory mechanisms for supporting renewable energy based mini-grids is established and made operational.***

146. Sub-activities:

- Examine and review all the existing policies, legislations, and regulations dealing with the renewable energy based power generation along with the gaps identified;
- Suggest new policy provisions and regulatory framework to provide a level playing field for the deployment of renewable energy technologies in Zambia as input to the Rural Electrification Authority (if formalized soon) and/or to the government body formulating the rural electrification legislation and policies;
- Assist DOE and ERB on devising a single window approach for clearance of new renewable energy based mini-grid projects;
- Assist DOE and ERB in updating the National Energy Policy and regulations with emphasis on the commercial use of renewable energy sources;
- Forge linkage among the key policies and programmes in the agriculture, industry, and community developments to ensure the use of renewable energy as a crucial elements in promoting income generating activities in rural areas;
- Draft and circulate to Investors and DBZ for review and comments on a model power purchase agreement for harnessing renewable energy for rural electrification; and
- Develop and suggest incentive schemes and tax waivers to the policy makers for attracting renewable energy investors and service providers.

***Output 1.2: National quality assurance standards on renewable energy technologies and mini-grids developed and disseminated.***

147. Sub-activities:

- Assist the ERB, ZABS and DOE to prepare national standards and norms on renewable technology performance and evaluation benchmarks to ensure the quality of both imported and domestically manufactured equipment and facilities;
- Assist DOE, ZABS and ERB in developing norms for RE mini-grids systems to ensure timely returns, quality standards and effective implementation; and
- Hold workshops and seminars to widely disseminate information on the standards, norms, and quality issues to the public and private sector, consumers, and other key stakeholders, such as service and maintenance providers.

***Output 1.3: Guidelines on environment impact assessment for renewable energy based mini-grids projects developed and disseminated.***

148. Sub-activities:

- Assist Department of Energy, Environmental Council and national institutions to formulate guidelines to evaluate new renewable energy projects on environmental concerns;
- Assist ERB to incorporate and internalize environmental and social costs in its rules and procedures while deciding on tariffs and PPAs; and
- Assist Department of Energy and Ministry of Tourism, Environment and Natural Resources to develop environment management plans for renewable energy based projects.

**Activity 2: Building National and Local Capacities to Promote Renewable Energy Based Mini-grids**

149. The immediate objective of this activity is to build national and local capability to facilitate commercial deployment of renewable energy based mini-grids for rural electrification in Zambia. This activity will address capacity barriers, and assist in building local manufacturing capacity to harness the potential of renewable energy technologies. Capacity building of the major stakeholders including the Government Ministries, national institutions, universities, enterprises, R&D institutions, financing institutions and banks will be undertaken to enable them to support renewable energy technologies and mini-grids on a commercial basis.

150. Capacity building and training programmes will be organized for the local and national government officials, public and private sector officials, manufacturing units, maintenance service providers, NGOs and communities to build a solid technical and planning base.

***Output 2.1: Main stakeholders are trained on evaluation and benchmarking of renewable energy mini-grid projects for Rural Electrification.***

151. Sub-activities:

- Train the key stakeholders, such as planners, professional, and experts, on evaluation, benchmarking, and validation of standards for renewable energy technologies through workshops and study trips;
- Provide training to the stakeholders on the techno-commercial status of renewable energy technologies in terms of specifications, inputs and outputs, capital and operating costs, minimum viable project sizes, and ranges of economic viability indicators; and
- Disseminate more widely techno-commercial status and evaluation of renewable energy technologies through workshops and seminars.

***Output 2.2: Key Stakeholders are trained on the management aspects of renewable energy based mini-grids.***

152. Sub-activities:

- Train the key stakeholders on general aspects of operational management of renewable energy based mini-grids, such as sustainable biomass supply through energy plantations, technical back-up for solar PV systems and mini hydro systems, and project financial and administrative operations; and
- Train the stakeholders for using national and international database on renewable energy resources, technologies, project experience, market applications, business opportunities, policies, regulations, financing sources, and participating players.

***Output 2.3: Technology experts and policy planners are trained to manage technical and financial services for projects appraisals, information dissemination, and implementation of replication strategy.***

153. Sub-activities:

- Organize training courses and seminars for the project team, experts, and planners to manage the technical and financial services, disseminate information on the project activities to a wider audience, and implement the replication strategy;
- Hold training workshops for relevant government organizations and private enterprises on the effective linkages between renewable energy technologies and productive use activities; and
- Include local communities and consumer groups under the various training programmes to ensure their close involvement in the project activities as well as in the replication strategy.

***Output 2.4: National capacities are strengthened to manufacture, assemble, and maintain renewable energy based mini-grids, and reduction in the implementation costs.***

154. Sub-activities:

- Strengthen national/local technical institutions and manufacturing units involved in the manufacturing and servicing of renewable energy equipments through technology selection, field visits, training workshops, and seminars;
- Train skilled personnel to enhance local capacity to assemble and build renewable energy based mini-grids;
- Assist training and research institutes, such as TDAU, NISIR, and KGRTC, in developing appropriate curricula on renewable energy technologies; and
- Initiate the formation of a "Center for Renewable Energy Technologies" at the School of Engineering, University of Zambia to dedicate and coordinate R & D efforts at the national level.

***Output 2.5: Capacity of financial institutions and banks is built to evaluate renewable energy based rural electrification projects.***

155. Sub-activities:

- Organize study trips, training workshops, and seminars for officials of the DBZ and other financial and public utility institutions to appraise, evaluate, and analyze renewable energy based projects; and
- Develop and provide guidelines to bankers, investors, and other relevant personnel regarding the required business, finance and technical skills, including the provision of business tools and financial mechanisms for evaluation of renewable energy projects.

**Activity 3: Planning and Setting up Innovative Project Financing Mechanisms and Structures**

156. The immediate objective of this activity is develop financing plan and procedures, including a "Risk and Replication Management Fund (RRMF)" to attract private sector investments for future commercial renewable energy projects in Zambia. A specific objective of this activity will be to attract foreign investments as well as lower the implementation costs of renewable energy projects. This activity would facilitate setting up of an innovative financial mechanism at the national level to support development of renewable energy technologies throughout the country. A detailed analysis of fund flow, internal rate of return, interest rate and investment needed for business models in order to succeed in the local conditions revealed that the investment financing by the private companies would require an upfront targeted financial support to make the business models viable and attractive for the private investment.

***Output 3.1: An innovative funding mechanism is developed and made operational for supporting renewable energy based business models and their replication.***

157. Sub-activities:

- Develop financial rules/procedures working closely with the DBZ for setting up and managing the RRMF
- Assist the DBZ and other agencies to address critical issues in project financing, such as terms of the interest free loan, grace period, and penalty clauses if the loan is not returned on time by the investors; and
- Frame procedures for recovery and recycling of RRM fund, which essentially will be an interest free loan to cover a small percentage of the private investment component. The interest free loan will be taken as the upfront GEF risk sharing contribution to the private investors. Once the

demonstration period is over and the agreed grace period expires, the private investor will have to pay back the interest free loan as a part of their contribution to the RRMF.

***Output 3.2: Methodology and procedures are developed for the use of replenished fund for future projects and feasibility studies.***

158. Sub-activities:

- Develop methodology and procedures to enable the replenished fund to act as a revolving fund for the replication and development of renewable energy investment projects throughout the country. In addition, on completion of the project, RRM fund will also meet the costs on the pre-feasibility studies on a cost-sharing basis with private investors; and
- Establish criteria for allocating funds for future projects on activities such as undertaking feasibility studies, size and capping of study funding for each project, developer/financier share of the feasibility study, repayment schedule of the loan component, interest of financing partners for replication and terms and conditions for setting up of a national level revolving fund to promote renewable energy technologies in Zambia.

**Activity 4: Implementing Pilot Renewable Energy Based Mini-Grids to Demonstrate Business Models.**

159. The main objective of this activity is to successfully install and demonstrate the commercial viabilities of three pilot mini-grids based on mini-hydro, biomass gasification, and solar PV technologies for rural electrification in Zambia with their applicable business models. The site selection as well as technology design for each of the three business units has been done in view the resource availability, logistics involved, national priorities and willingness of the local consumers to pay for the cost of energy services to be provided by renewable energy technologies.

160. The main objective of this activity is to oversee the tendering, installation and demonstration of the commercial viabilities of three pilot mini-grids based on mini-hydro, biomass gasification, and solar PV technologies for rural electrification in Zambia. The site selection as well as technology design for each of the three business units has been done in view the resource availability, logistics involved, national priorities and willingness of the local consumers to pay for the cost of energy services to be provided by renewable energy technologies.

***Output 4.1:Three pilot mini-grids based on renewable energy technologies are implemented.***

161. Sub-activities:

- Conduct technical and financial design for the pilot projects, and prepare technical specifications for the key equipment or performance targets for the systems to be procured;
- Finalize financial packaging in consultation with ZESCO, private investors and financial institutions in a consortium approach;
- Pursue and finalize power purchase agreements, legal setup, fund flow arrangements, and operational structures.
- Procure equipment and services through an open bidding process and complete contractual arrangements including legal agreements wherever applicable;
- Oversee the installation of the pilot mini-grids in a systems approach to complete the implementation in a timely manner; and

162. UNIDO will facilitate the tendering and bidding process, and may facilitate purchase of the equipment to obtain tax waiver. The national government would be expected to consider this as an incentive for replication. Local suppliers will be short-listed and local institutions will be promoted through the global bidding processes as part of local content and capacity building. The local companies would then be involved in the replication strategy. They are therefore taken on board to gain experience, and technical tie up with the international companies supplying the technology transfer.

***Output 4.2: Training is imparted to operational and management staff of the pilot mini-grid projects, and close linkages between energy services provided by pilot projects and productive use activities are established.***

163. Sub-activities:

- Train the pilot project staff to successfully operate and maintain the mini-grids with technical support from the technology vendors;
    - A Build Operate and Transfer arrangement could be used for the biomass gasification plant, the biomass preparation activities.
    - The IPP operating the PV mini-grid would train local operators.
    - The mini-hydro if operated by ZESCO would not require training except for local subcontracted maintenance.
- Train the operators and managers in environmental management – monitoring, performance targets and mitigation measures
- Identify business and employment opportunities linking with reliable energy services, and train the key stakeholders to initiate productive use activities (i.e. setting up of agro-based SSI units).

**Activity 5: Establishing Project Coordination and Management Structures and Dissemination of Information and Lessons.**

164. The main objective of this activity is to ensure that the project is properly executed. This activity will help in developing a dedicated management and technical team with inter-disciplinary expertise to ensure the ultimate success of the activities. Formats for project activity, sub-activity, task-based monitoring, evaluation and lessons learned will be prepared, discussed and finalized in consultation with key stakeholders. These will be tested for specific tasks and activities, and applied in the implementation of the project activities.

***Output 5.1: Project management team and core experts are identified and recruited, and management structures are made operational.***

165. Sub-activities:

- Prepare work plan and TORs for all national and international experts to assist the effective implementation of project activities;
- Identify team members and recruit the team and experts through an open selection process;
- Frame TORs for national steering committee and advisory expert group, and reach agreement with the national counterparts on their membership;
- Undertake regular monitoring of the progress being made under the project, and take corrective steps wherever required; and
- Explore public-private partnerships and joint venture mechanisms for the implementation of pilot projects, and the establishment of innovative financial mechanism.

***Output 5.2: An effective replication strategy and a comprehensive information dissemination programme are developed and implemented.***

166. Sub-activities:

- Create and compile project database, technology newsletter, technology hand-book, model pre-feasibility study, detailed pilot project reports, model energy purchase agreements, project development agreements, fuel supply agreements, and package of bid documents;
- Prepare and disseminate model appraisal guidelines for different renewable energy projects;
- Prepare an effective replication strategy and implement reaching out to a wider audience in the region for maximizing the impact; and
- Create and update regularly a website to act as a clearing-house for providing detailed information renewable energy resources and technologies

***Output 5.3: Lessons learned and information disseminated, and regional networking is undertaken.***

167. Sub-activities:

- Create a regional network of agencies and institutions to share experiences and lessons learned from renewable energy projects;
- Disseminate results and exchange information by using regional initiatives such as NEPAD, SADC, COMESA, Partnerships for Africa, and AREED programme on renewable energy etc.
- As a part of replication strategy, lessons learned and experience gained under the project will be documented and disseminated by UNEP to a wider audience through brochures, workshops, press, electronic media and Internet.
- Create a network of investors[24], utilities, NGOs and financial institutions in the South Africa region to provide a common front to exchange information and mobilize resources for renewable energy mini-grid projects.

***Output 5.4: Monitoring and close supervision of project operations undertaken and corrective steps taken, wherever needed.***

168. Sub-activities:

- Closely monitor and evaluate pilot project activities and take corrective steps wherever required on regular basis; and
- Document and disseminate the best practices and lessons learned.

169. The project will be monitored and evaluated according to GEF, UNEP and UNIDO standard rules and procedures. For each of the activities, a monitoring plan will be put in effect with the detailed set of indicators shown in the Logical Framework in Annex B. In addition, record keeping will also be strengthened to enable adequate attention to information about electricity generation and sales, as well as renewable energy generation. Information about the quantity of energy provided by renewable sources vs. fossil fuel will be an important measure of the project success. A Monitoring and Evaluation Plan has been provided at Annex I.

## 5. RISKS AND SUSTAINABILITY

### 5.1 Sustainability

[24] Sharing of information by the demonstration project owners/investors was one of the key points discussed during the meeting held with potential investors in February 2004 at Lusaka, and the response of project owners/investors was quite positive on the subject as they showed willingness to share such information with the PMU and other projects on regular basis.

170. The national economic policies in Zambia accord priority to private investments, and has introduced a number of policies and measures to engage foreign enterprises in the local production of goods and services. The energy sector is included among the priority economic areas authorized for foreign partnerships, and some private initiatives are already at an advance stage of consideration by the Government. Presence of a vibrant and active Energy Regulatory Board and a well-established legal system further add to the conducive environment prevalent in the country for attracting private investments into the energy sector.

171. Active involvement of key partners under the various activities will be ensured to provide techno-commercial and management mechanisms suitable for long-term sustainability of renewable energy based mini-grids. Another measure to ensure sustainability will be the capacity building element mainstreamed into each activity and outputs.

172. The project will use grant funding to remove the barriers to expanded RET markets but the private sector providers of RET will only receive soft finance mechanisms to deploy the RETs. After the demonstrations, replication is much more likely in this case. The returned funding will be reused for replication as described earlier.

173. It is expected that the renewable energy based mini-grids can be sustained for rural electrification in Zambia based on the following reasons:

- The government has the general policies to encourage the use of renewable energy for rural electrification and is committed to this project.
- Zambia has very abundant renewable energy resources, which are available indigenously all over the country, and in comparison, the imported diesel is very expensive.
- The renewable energy based mini-grids are probably most practical and cost effective solution for the electrification in many far-flung rural areas where even if grid is extended at a very high cost, maintenance of transmission and distribution lines for these areas will be very expensive and difficult.
- Zambia already has some experience with renewable energy projects, particularly in the areas of harnessing the potential of mini-hydro and solar PV home systems.
- Except for wind and geothermal, other three renewable energy sources, namely the mini-hydro, biomass, and solar can be harnessed in expanded commercial niche markets.

174. Aside from these fundamental reasons, the project is designed also to further ensure the sustainability by establishing policy/regulatory framework, mainstreaming capacity building element into each activity and outputs, and pursuing creative financing. The project activities will further contribute to the sustainability by strengthening linkages with other ongoing renewable energy projects and programs in Zambia and other countries through participation in crucial meetings and exchanging information on regular basis.

175. When seen in the overall economic context in the country, the key end results of the proposed project to ensure the sustainability are as follows:

- Monitoring, analysis and dissemination of information on power generated and exported from the renewable energy projects – biomass, solar and mini hydro power,
- Skill up-gradation of the key stakeholders including financial institutions, R&D institutions, entrepreneurs and project developers, experts, consultants and engineers, central and local governments and institutions, equipment and technology providers to ensure their close long term involvement.

- Establishment of a management mechanism for certification, pre-investment studies, consultancy services, training, R & D, leasing & financing, insurance, and information dissemination to ensure long term availability of institutional service support.

## 5.2 Risk Assessment

176. This project has potentially several risks as summarized in Table 2. These risks and the mitigation measures to take are discussed as following:

- **The pilot projects have low performance**: The project has chosen near commercial renewable energy technologies to minimize the low performance caused by the technologies. The project will also have rigorous monitoring of the pilot project operation to minimize the low performance caused from mismanagement of the pilot projects. Thus, this risk is considered low.

- **Regulators are reluctant to support establishment of renewable energy policy/regulatory framework:** Since the preparatory phase of this project has been done in close consultation with the regulatory body and the government already has a national policy to use indigenous energy sources for electricity generation, this risk is low.

- **Reliable biomass supply cannot be secured:** This risk is moderate as lack of any previous substantive experience in this area, and weak institutional and commercial infrastructure available locally to supply biomass fuels could pose a risk. To mitigate this risk, the project has engaged the Forestry Department to manage the supply of biomass for the pilot project at Kaputa and the capacity building programme has included the survey and compiling of biomass resource data and information dissemination of biomass gasification technology to potential biomass suppliers.

- **The project has slow progress:** The long distance and bad road conditions to reach the rural areas, where the pilot projects are located, can cause slow progress on the pilot facility construction and make facility maintenance and services difficult. As this risk is important to overcome, it can be treated as moderate. To mitigate this risk, the project will anticipate this problem and more carefully plan and schedule the facility construction and services accordingly.

- **The pilot projects impose environmental impact:** The environmental impact assessment carried out during the PDF-B phase at all three sites revealed that implementation of these pilot projects are not expected to cause any environmental concerns. For instance, the mini-hydro pilot project is based on run-of-river design, and hence will have very little or no impact on the surrounding environment. Also, it has been proposed in the project design to place a rigorous environmental monitoring after the pilot project becomes operational. The biomass pilot project has minimal environmental impact as less than 1.0 % of total forest area in the vicinity will be used to provide biomass needed for the gasification plant, and further no globally significant endemic species (flora and fauna) were identified, which would be adversely affected by the biomass pilot project. However, to further mitigate this risk, the pilot project is designed to supply the biomass by lops and tops of normal operations, new forest plantations on fallow land and use of agriculture residues available in the area. The solar PV pilot project could have environmental impact if the spent batteries are not properly treated and disposed. To mitigate this risk, the pilot project has included an environment management plan for inspection, recycling and disposal of the lead battery storage used. Thus, this risk is considered low.

- **The replication of renewable energy based mini-grids is difficult:** Even though the sustainability of renewable energy use is shown to be high in Section 5.1, there are barriers to the

replication, which relate to overall economic situation and policies prevalent in the country. These barriers include the current high interest rate, ZESCO's uniform low electricity tariff in the country, high unemployment rate, low-income levels in the rural areas and low awareness about the potential value of renewable energy technologies. All these barriers are related to the poor economic state in Zambia. It is the objective of this project to influence policies along with other projects and promote the economic activities in Zambia in the long run, including enhancing job opportunities in the rural areas and consequent increase in their income levels. This risk is considered as moderate, and it will be overcome by implementing a well-defined replication plan.

**Table 3**

**Potential Risks and Mitigation Measures**

| **Risks** | **Mitigation measures** |
|---|---|
| Low performance | *Risk level: Low*<br>Proven renewable energy technologies for rural electrification proposed;<br>Continuous, rigorous technical performance monitoring & reporting;<br>Qualified technical advisors are involved at multiple stages;<br>Maintenance contracts will ensure quick rectification of problems. |
| Role of Regulators to Uphold Renewable Energy Policy Guidelines | *Risk level: Low*<br><br>Capacity building activities to focus on building suitable regulatory environment for renewables;<br>Association of ERB officials in the project activities to ensure optimal communication. |
| Biomass Supply Risks | *Risk level: Moderate*<br><br>Long-term supply contracts to be established between the local forestry department and the business model operators to ensure supply of biomass feedstock;<br>Adequate local employment benefits and biomass efficiency improvements;<br>Pre-feasibility study shows that biomass supplies are sufficient to justify investments;<br>A targeted capacity building activity to create the proper business-institutional structure that will sustain the biomass production. |
| Slow progress | *Risk level: Moderate*<br><br>Commitment of the key stakeholders has been obtained;<br>Flexible ownership and purchase agreements would ensure that demonstrations are deployed on time;<br>Local implementing agency involved from inception of project preparation activities;<br>Close monitoring of the project proposed. |
| Environmental impact | *Risk Level: Low*<br><br>Closely monitoring of the environmental risk factors;<br>Selection of the appropriate renewable technology keeping in view the resource availability;<br>Adoption of a sustainable environment management plan for each pilot site. |
| Replicability | *Risk Level: Moderate*<br><br>Close monitoring of the project proposed;<br>A comprehensive information dissemination thrust proposed both at the national and international level to ensure replicability of business models. |

## 6. STAKEHOLDER PARTICIPATION

## 6.1 Key Stakeholders

177. In this project, a number of key stakeholders and institutions participated during the PDF-B phase activities, and their close involvement was also found to be critical during the implementation of the main phase. Some of the key stakeholders are as follows:

- *Department of Energy, MEWD:* It is the national counterpart agency to coordinate with UNEP and UNIDO for the execution of the project activities.
- *Ministry of Tourism, Environment and Natural Resources:* It is the national operational GEF focal point, endorsing the project.
- *Rural Electrification Authority:* It is the national authority, which is being set up to oversee the implementation of national rural electrification programme. This authority would also promote use of renewable energy resources under the rural electrification programme.
- *ZESCO:* The national electric utility company is the key government implementer for the rural electrification program in Zambia. It has shown willingness to invest in all the three pilot mini-grids singly or jointly with other investors, and has the expertise to assist in the planning, design, and operation of the power distribution system in the mini-grids.
- *Energy Regulation Board:* This regulatory board is interested in seeing the use of renewable energy as a sustainable solution to rural electrification. It will be involved in setting the electricity tariff and incentive programs to favor the use of renewable energy based power generation. It will also be instrumental in specifying the standards/norms to control the quality of renewable energy based equipment and system components.
- *Ministry of Finance and National Planning:* It is responsible for the planning and control of the national budget and expenditure. It has the interest in seeing the use of renewable energy to promote economic activities in the rural areas and to cut back national expenditure on imported diesel fuel.
- *Development Bank of Zambia:* It will administer the RRMF for the pilot projects, and manage the revolving fund to be set up later on to foster more renewable energy based projects in Zambia.
- *Department of Forest, Ministry of Tourism, Environment and Natural Resources:* It will be responsible for the supply of biomass for the biomass gasification pilot project. It will be further involved in the planning of feed supply for future biomass projects.
- *Office for Promoting Private Power Investments (OPPPI):* It will be involved in establishing the policy/regulatory framework to sustain the renewable energy based mini-grids and provides assistance to the investors for pursuing this type of project.
- *Financing Institutions and Banks (such as Micro Banker Trusts):* These institutions will be involved in financing renewable energy based projects and will participate in the training to evaluate these projects.
- *Local Administrations in Provinces, Districts, and Townships:* These organizations will be the local facilitators for the renewable energy based projects to benefit their communities. They will provide input in formulating the policy/regulatory framework.
- *ESCO and Other Interested Business Associations (such as Zambia Chamber of Commerce and Industry and National Farmers Union of Zambia), and Investors:* Currently there are a number of ESCOs in Zambia which are either captive power generation companies or have received upfront assistance from some donor agency. They will have keen interest in renewable energy based projects, as these projects will present investment and service opportunities for them. They are also the key players in sustaining and replicating these projects.
- *Research and Training Institutes and Organizations (such as Ministry of Science, Technology and Vocational Training, University of Zambia, School of Engineering, Ministry of Education,*

*CEEEZ, NISIR):* These institutes and organizations are the key players in the capacity building of renewable energy based power generation technologies and projects

- *Rural Households and Business Owners:* They will be the major beneficiaries of the renewable energy based mini-grids. Their active participation and favorable reaction is crucial to the success of this project.

178. Most of these stakeholders participated actively at the stakeholders meetings held during the PDF-B phase activities, where they provided their inputs and comments.

### 6.2 Public Involvement

179. The project team, in close collaboration with local administrations, will ensure active local community and public participation at every stage of the implementation phase, and to enhance local ownership of the project activities. As a start-up activity, the project team will organize "awareness meetings" with the local people to secure their support to the pilot mini-grids, and to explain to them the benefits that would accrue to them from the proposed project. Using the mechanism of national steering committee and stakeholders group, which were created during the PDF-B phase and comprises of key stakeholders, the project team will reach out to the general public, civil society, women groups and industrial associations to sensitise them about linkages between renewable energy technologies and productive use activities, and opportunities for income generation activities under the project. It is expected that the successful implementation of business models would greatly improve the financial status of participating enterprises, and consequent enhanced employment opportunities in Zambia.

## 7. IMPLEMENTATION PLAN

### 7.1. Project Implementation Arrangements

180. For the GEF, UNEP is the Implementing Agency, which will oversee the successful achievement of the project objectives, while UNIDO as the executing agency under expanded opportunities will execute the project activities. The national counterpart agency will be the Department of Energy under the Ministry of Energy and Water Development, Government of Zambia, and Development Bank of Zambia – a national level financial and banking company to fund developmental projects in Zambia.

181. UNIDO will set up a Project Management Unit (PMU) expanding the existing national field office to coordinate and execute the project activities. The project staff and experts will report to PMU on their inputs, which will be headed by a project coordinator. The project coordinator, who will be appointed by UNIDO, will coordinate and ensure timely implementation of the project activities.

182. A Project Steering Committee (PSC) will be set up to oversee the project implementation. The project steering committee would comprise of the key Government agencies (including Ministries of Energy and Water Development, Environment, Finance and Industry), ERB, local administration, financial community, public utility, civil society and the private sector. The PSC would advise on inter-ministerial coordination and cooperation, besides serving as a platform for sharing information on the project's progress. At the end of the project, this committee will include the DBZ and serve as the decision making body for the revolving fund.

183. An Advisory Expert Group (AEG) comprising of experts and other key stakeholders including local administration, NGOs and local industrial organizations will be set up, which will be responsible for the replication and coordination of the project activities. The AEG will facilitate public participation in the implementation phase, and would ensure local ownership of the project through information dissemination on regular basis. The AEG will also ensure that all key decisions on location of various

facilities under the proposed project are taken after taking into account inputs provided by the public representatives, NGOs and local industrial associations. The AEG will assist PSC at every stage including mainstreaming gender issues into the project activities by involving women groups in decision-making processes at every stage.

184. Implementation of the project activities would require close monitoring and rigorous evaluation to meet the key objectives. The Project Management Unit will coordinate the project activities and monitor indicators in Zambia for the sustainability and replicability of the project outputs beyond its life. A close supervision and monitoring of indicators for outputs and outcomes will be undertaken by the UNIDO and the project management unit (PMU) to establish global and local benefits accrued from the project.

185. UNEP will review UNIDO project monitoring reports, and as necessary join the Steering Committee meetings. Further details on the monitoring, evaluation and reporting along with the proposed management structure are given at Annex H.

186. UNEP and UNIDO will jointly execute dissemination in the region.

### 7.2 Project Schedule

187. The project is expected to start in the fourth quarter of 2004 and complete by the 2010 with a total duration of 6 years.

188. The pilot mini-grids will take three years to design, procure, construct, and start up. They will then be operated for 3 years. The sustainability activities, including establishing policy/regulatory framework, building national and local capability, and setting up innovative project financing mechanism, will commence when the pilot projects become operational and conclude at the same time when the pilot projects finish with the soft financing.

189. Activity-wise Time Frame is given in Annex J.

## 8. INCREMENTAL COSTS AND PROJECT FINANCING

### 8.1 Incremental Costs

190. This project is designed to remove barriers to the renewable energy technologies based rural electrification in Zambia. In doing so, it would aim at achieving the stated objectives of GEF Operational Program 6 as well as meeting secondary objectives of reducing the risks to the environment. The up-front cost of the proposed alternative is higher than the respective baseline project, i.e. the baseline is diesel generator. A RRM fund to provide for high upfront costs and attract private investments has been proposed for supporting the business models using the GEF funds. This involves the support of a new and innovative funding mechanism to provide interest free loan to ensure the long-term replicability, and to share risks with investors.

191. It is unlikely that the project activities would take place in the absence of GEF, UNEP and UNIDO support. But the life cycle cost analysis shows that pilot projects are more economic than diesel generation over the typical facility life (PV mini-grid will take more time to repay back the loan unless consumers pay higher costs for the services). Other than the GHG reduction, the use of the indigenous renewable energy source will curtail the use of diesel power generation and the harmful emissions from it. The biomass gasification technology was perceived as too risky by ZESCO and MEWD prior to this project. The demonstration of this win-win technology is highly justified. The PV model is different from

most PV demonstrations – adopting a mini-grid approach in a clustered community with high willingness to pay for the service. Willingness on the part of consumers to pay for the reliable energy services and possibility of using new LED technologies would make solar mini-grid a viable option where other renewable sources can not be harnessed commercially. The mini-hydro demonstration as public-private partnership model would not go ahead without this project, although the amount of soft finance and technical assistance will be much lower than solar mini-grid.

192. The CO2 emissions abatement potential calculated on fifteen years of operation at average of 75% capacity factor for mini-hydro and biomass gasification pilot projects and 21% capacity factor for the PV pilot project, comes to about 220,000 tonnes of $CO_2$ reduction over the expected life period of the mini-grids (20 years for mini-hydro and solar mini-grids and 15 years for biomass mini-grid) as compared to the diesel baseline.

193. More details of the incremental cost are given in Annex A.

## 8.2 Project Financing

194. The project financing is given in Table 4.

**Table 4**

**Project Financing (in million US $)**

| | **Total Cost (million USD)** | **Zambian Government contribution** | **GEF contribution** | **UNEP / UNIDO **** | **Private investment** |
|---|---|---|---|---|---|
| Activity 1. Designing an institutional, policy and regulatory framework to provide enabling environment to the development of RE based mini-grids | 0.206 | 0.056* | 0.025 | 0.125 | 0.000 |
| Activity 2. Building local and national capacity to utilize the commercial potential of renewable energy technologies | 1.276 | 0.675 | 0.326 | 0.275 | 0.000 |
| Activity 3. Setting up appropriate financial mechanisms and structures to encourage private sector investment in RE based mini-grids projects | 2.300 | 0.250 | 2.000 *** | 0.050 | 0.000 |
| Activity 4. Implementation of business models to demonstrate commercial feasibility of RE based mini-grids for electricity generation and productive use | 3.096 | 0.250 **** | 0.046 | 0.050 | 2.750 ***** |
| Activity 5. Establishment of project management structures for coordination, monitoring | 0.628 | 0.025 | 0.553 | 0.050 ****** | 0.000 |

| | Total Cost (million USD) | Zambian Government contribution | GEF contribution | UNEP / UNIDO ** | Private investment |
|---|---|---|---|---|---|
| and dissemination of results from the project | | | | | |
| **TOTAL** | **7.506** | **1.256** | **2.950** | **0.550** | **2.750** |

* Government of Zambia's contribution as diverted effort to put a policy framework in place for promoting renewable energy technologies.

** UNIDO in-kind/cash contribution (US $ 500,000) for activities such as capacity building, study trips and training workshops.

*** GEF funding to set up a RRMF, and to meet costs on capacity building of financial institutions on financial appraisals, contractual obligations and modalities for a revolving fund.

**** Government of Zambia's contribution to meet costs on land, building and related infrastructure including providing logistics support to the project team and experts.

***** Consultations held with private investors and companies during the PDF-B phase yielded documented results (letters of intent to bid on file).

****** UNEP matching in-kind contribution (US $ 50,000) for information dissemination and replication efforts in the Africa.

195. As shown in Table 4, the GEF fund requested is US $ 2.95 millions. The GEF fund will be split into two – US $ 2 million to set up Risk and Replication Management Fund (RRMF) which will provide the interest-free loan to assist part financing of the pilot projects, and the remaining US$ 0.95 million (along with funding from other sources) for establishing policy framework, capacity building, technical assistance, and project management. The interest-free loan will be paid back into a national level revolving fund (RRMF will converted into a national level revolving fund before the end of the project) to finance additional renewable energy based mini-grid projects in the future as part of the replication strategy and plan.

196. UNIDO/UNEP and the Zambia government will contribute US$0.55 million and US$1.256 million to the project, respectively. The UNIDO/UNEP funds will be used primarily for the capacity building, innovative financing mechanism, technical assistance and replication. The Zambia government fund will include US $ 0.256 million in-kind contribution related to the water rights, land and other logistic support and US $ 1.0 million in cash spread over 6 years for national level activities including workshops, study trips and support to pilot projects.

197. The investors will invest US$ 2.75 million to the pilot projects. However, modalities of investor's contribution will be worked out as start up activity under the full phase project because it would depend upon the Government policy on allowing sole ownership versus joint sector approach by the investors as well as scope and kind of association of ZESCO in the pilot projects.

## 9. MONITORING, EVALUATION & DISSEMINATION

198. The project will follow all standard UNEP, GEF, and UNIDO procedures for monitoring and reporting. UNEP and UNIDO will conduct a mid-term assessment and an end of project assessment. UNIDO and the project management unit (PMU) will closely monitor the indicators for outputs and

outcomes to establish global and local benefits accrued from the project. UNEP will review UNIDO's project monitoring reports, and as necessary, join the Project Steering Committee meetings in order to represent to the GEF M&E the status and impact of the project.

199. The Project Steering Committee will be responsible for the general monitoring and supervision of the project implementation. It will provide to UNEP and UNIDO independent assessments of the project progress based on annual reports provided by the PMU, which in turn are prepared based on reports received from experts, contractors and consultants. Based on the assessment of the progress, the Project Steering Committee will make recommendations for adjustments to the work plans.

200. The Project Steering Committee will evaluate the annual progress against the work plans and reports developed by PMU at the start of the project and updated at regulate intervals. These will be based on the log frame matrix (see Annex B). At the inception of each activity, a work plan will be established, whereby the sub activities will further monitored on time-bound milestones or indicators. Progress against these milestones will be reported from the PMU to the PSC, UNEP and UNIDO.

201. Each business model will also be annually reviewed against work plans established by the PMU in a similar manner to that described above. These will be developed initially in collaboration with the lead investors to whom business models will be awarded, based on guidelines provided by the PSC. The PMU will review each annual report and work plan and pass it on to the UNIDO, UNEP and PSC with comments as necessary.

202. The lessons to be learned from the project will be disseminated through a wide range of media to a number of targets to ensure that maximum benefit can be gained from the project. This dissemination will be through both mechanisms designed to achieve this and elements that are integral to the project. Business Models by their very nature are designed to disseminate the lessons learned as far as possible. Where relevant, they will be used as focal points for various projects activities such as the exchange program, and will be proposed as locations for training and awareness workshops and meetings. The progress and results of these activities will be regularly available through hard copy and electronic newsletters. A publication addressing the best practices used and lessons to be learned will also be produced. More generally, newsletters will be provided regular updated on activities at the national and regional level.

203. As well as dissemination outside the project, there will also be mechanism within the project to ensure that lessons learned can be shared across the country. This is especially important in terms of making sure that valuable experience gained can be applied in the rest of the country. The project will be subject to a joint review by UNEP, UNIDO and the Government of Zambia once a year. The national project coordinator shall prepare and submit to each review meeting a progress report highlighting the milestones achieved.

204. Sustainability prospects of business models implemented under the project will be evaluated by UNEP/UNIDO at the project conclusion, by examining the funding situation for continued operation, such as co-financing and revenue generation, commitment of investors and cooperating organizations and demonstration of growing demand for renewable energy technologies based power generation among key stakeholders in Zambia. A close coordination with ongoing national renewable energy projects and programmes as well as with projects of the World Bank and other donors will be ensured in order to complement field activities, support potential synergies and avoid any duplication or overlap.

205. More details on monitoring and evaluation plan are given at Annex I.