USAID
FROM THE AMERICAN PEOPLE

Zambia Rural Electrification Master Plan: Phase 1: Rapid Resource Assessment

FINAL REPORT

December 30, 2005

This document was produced for review by the United States Agency for International Development. It was prepared by CORE International, Inc.

The following document was prepared by CORE International, Inc. (www.coreintl.com).

For more information, please contact Dr. Kevin Warr
(kwarr@usaid.gov), 202-712-4779.

TABLE OF CONTENTS

ACRONYMS

GIS	Geographic Information Systems
ISIC	International Standard Industrial Classification
JICA	Japan International Cooperation Agency
K	Kwacha
Km	kilometer
Kv	kilovolt
kW	Kilowatt
kWh	Kilowatt hour
kWp	Kilowatt peak
m/s	Meters per second
MEWD	Ministry of Energy and Water Development
MOE	Ministry of Education
MOH	Ministry of Health
MW	Megawatt
NORAD	Norwegian Agency for Development Cooperation
NREL	National Renewable Energy Laboratory
PV	Photovoltaic
RE	Renewable Energy
REA	Rural Electrification Authority
RRA	Rapid Resource Assessment
SIDA	Swedish International Development Agency
UNIDO	United Nations Industrial Development Organization
WASP	Wien Automatic System Planning Package
WWF	World Wildlife Foundation
ZESCO	Zambia Electric Supply Company

List of Figures

List of Tables

1. Rapid Resource Assessment for Rural Electrification

1.1 INTRODUCTION

Although Zambia is a country with abundant resources, less than 2 % of its rural population has access to electricity. Access to electricity is important not only for economic development but also to provide energy for irrigation so that Zambian farmers can feed themselves and the nation. Zambia is currently facing another drought, but significant water resources lie only 3 to 4 meters below the surface in many parts of the country. Despite the critical need for electricity to pump irrigation water, the traditional programs for expanding access to electricity through extending the power grid implemented by the national utility Zambia Electric Supply Company (ZESCO) have thus far failed to produce significant improvements. In response, the Government of Zambia created the Rural Electrification Authority (REA) to implement innovative approaches to rural electrification and oversee the Rural Electricity Fund (REF). Zambia requires an innovate approach to rural electrification projects and it requires an innovate approach for planning and developing those projects. Zambia's needs are critical and it does not have the time nor the resources required for traditional planning methods. If Zambia is to stave off rural flight and starvation, it must directly impact rural incomes and farm productivity and it must do it quickly.

Traditional rural electrification has often failed because it is generally based on grid extension with minor off-grid investments:

- Grid extension is too expensive for most rural consumers;
- Traditional master plan methods are too expensive and time consuming to produce;
- Traditional master plan methods are geared towards the grid connected utilities' traditional customer base – rural customers are very different and the approach to electrification must be very different for rural electrification to succeed, and,
- Traditional methods fail to involve local communities in the process.

There are two types of traditional rural master plans. The first type uses the grid connected utility model for system expansion planning, which is either a least-cost model, such as the Wien Automatic System Planning Package (WASP)[1] or an integrated resources planning model. The principal problems with this approach in the Zambian context are:

1. By their very nature these are system expansion models, which means they focus on the least-cost supply options-- the urban or peri-urban areas near to the existing grid. Many

[1] **WASP** is the most widely used model in developing countries for power system planning (over 100 countries). Within constraints defined by the user, WASP determines the optimal long-term expansion plan for a power generating system. Constraints may include limited fuel availability, emission restrictions, system reliability requirements and other factors. Optimal expansion is determined by minimizing discounted total costs.

of the best opportunities for rural electrification may be so far from the grid that extending the grid to them may be uneconomic.

2. ZESCO is the only organization that has access to these models in Zambia. Thus, the REA would have to rely on ZESCO to run the model or purchase it themselves. The first option contains conflicts of interest since ZESCO is a potential supplier of rural electrification services, and the second option is not feasible at this time since REA does not have sufficient funds to fully staff its operations.
3. These models optimize the cost of meeting a specific level of demand. The assumption is that one kWh of demand is of the same value of as another kWh of demand. This will not be the case in Zambia's rural areas since income generating activities are specifically targeted as the main customers.
4. There is a tendency to focus on status quo methods or projects for new power. Thus, analysts tend to focus on grid expansion or isolated small (but not micro-mini) hydro and diesel for new power generation. The models' databases have generic data on renewable energy but not specific data; thus, the tendency is to fall back on generic data or to collect expensive and time-consuming localized data.

The second type of rural master plan uses a variety of models that prioritize projects on the basis of their cost per kWh served. It is more oriented toward off-grid or distributed power, but it is still not the appropriate method for Zambia at this time. It is unsuitable for REA principally because it:

- Treats the value of kWh served as equivalent for all consumers or classes of consumer;
- Is data intensive and requires lengthy and costly data acquisition; and,
- Does not involve local communities in the process.

As part of a continuing effort to bring pivotal assistance to Zambia's electricity sector, USAID funded assistance to the REA for the preparation of a methodology for Rapid Resource Assessment (RRA) as an innovative substitute for the traditional rural electrification master plan. RRA is a technique that uses local knowledge and local participation as a key input to reduce both cost and risk. It is suited to Zambia's rural electrification planning since these rural projects will be small in scale, they require local participation, and costly data collection can be avoided. RRA provides the REA with a tool to reduce cost and begin enlisting local participation in the rural electrification process.

The purpose of the task described in this report is to develop an RRA methodology and to provide the REA with tools for identifying and prioritizing rural electrification projects. The goal is to jump start the process of rural electrification in the most effective manner. This report covers the first part of a two-step process. The first step focuses on methodology. The second step focuses on implementation.

The development of a comprehensive national rural electrification plan for Zambia will be based on a series of discrete steps that will build – from the bottom up – a set of supply and demand tools that can be used to guide development funds toward the projects with the greatest likelihood of success in the near term. This effort will complement activities at the policy level in Zambia to fund and empower the REA. Non-grid approaches to rural electrification are expected to be undertaken to a large extent by non-governmental entities, including, communities, cooperatives, energy service companies, and other organizations.

For non-grid approaches to rural electrification to succeed, it will be necessary to identify potential areas where there is sufficient density of demand – actual or potential – combined with the possibility of supplying at least some electricity from local primary energy sources. The actual examples of the RRA method combine these demand-side and supply-side elements. An RRA exercise consists of the following elements:

- Use of Geographical Information System (GIS) data to quickly identify overlaps in population density, economic activity and key resources (water, wind speed, distance to markets, etc);
- Examination of proximity and existence of key public sector institutions, such as schools and transport centers; and
- Use of GIS data to identify potential emergence of new or enlarged resource-based industries, such as irrigated agriculture, forest products, and food processing.

Using data available from GIS mapping services, it will be possible to construct a picture of the most likely and lowest cost prospects for a local electricity supply system based primarily on demand from economic activities rather than household consumption.

1.2 RAPID RESOURCE ASSESSMENT

Rapid Resource Assessment (RRA) is the application of rapid rural appraisal to resources, in this case, energy. It is part of a growing field of rapid appraisal techniques. "Rapid rural appraisal developed in the 1970s and 1980s was in response to the perceived problems of outsiders missing or not effectively communicating with local people in the context of development work."[2] In RRA, data collection and analysis are undertaken with the participation of local people drawing on their expertise and knowledge. Rapid rural appraisal is often described as a process of learning about rural conditions in an intensive, iterative, and expeditious manner. It can involve any systematic activity designed to draw inferences, conclusions, hypotheses or assessments, including the acquisition of new information during a limited period of time. An efficient RRA involves participation of small multidisciplinary teams that employ a range of methodological tools and techniques specifically selected to facilitate understanding of rural conditions in their natural context. RRA allows the user to obtain relevant and accurate information at low cost by rapid cycles of interaction among team members and locally impacted communities and creative utilization of various data collection tools and techniques, such as direct observation, short questionnaires, and brief and in-depth interviews. Rapid Resource Assessment is a very flexible process that allows for modification where appropriate.

Rapid Resource Assessment activities fall into three broad categories:

1. Preparatory work that includes selection of a multidisciplinary team, background information retrieval by maximal utilization of pre-existing data, team discussion for developing preliminary hypotheses, and selection of research tools and techniques;
2. Short single or multiple field visits to the study areas;
3. Discussion and analysis of the findings among the team members, and often the local community, aimed at reaching a consensus on what has been learned and what is still unclear. Report writing should take place immediately following fieldwork as any delay may result in loss of valuable information and insight.

The RRA process cannot be replicated exactly by a single model in different countries. Because economies and various other circumstances differ among countries, it is very difficult to

[2] World Bank Participation Source Book, Appendix I: Methods and Tools, February 1996.

establish a fixed pattern. However, there are some common principles for implementing such methodologies, collecting reliable information, and developing usable analyses and results. These fundamental principles are as follows:

Triangulation. Triangulation means looking at any problem from as many perspectives as possible, but at the least from the following three:

- Having at least three people with different points of view (women/men, social scientists/technical specialists, insiders/ outsiders, youth/elders, etc.);
- Ensuring that a wide range of people are interviewed and all information is verified by at least three different sources (owners/renters, farmers/nonfarmers, educated/uneducated, above poverty line/below poverty line, etc.); and
- Addressing the same issue using several different tools (historical interviews, spatial maps, seasonal calendars, etc).

Optimal Ignorance. There always exists a trade-off between collecting more data and the cost of collection. The concept of optimal ignorance encourages the investigator to limit data collection to what is needed.

Appropriate Imprecision. Often the measurement of the data is to a higher degree of precision than is necessary for the analysis. Appropriate imprecision explicitly determines the level specificity and precision that is required for any specific analysis.

Rapid and Progressive Learning. The exploratory and iterative nature of RRA allows for rapid and progressive learning during implementation.

*Learning from and along with Rural Peopl*e. Typically, this means that planning and analysis should take into consideration the perspective of the rural population.

Data gathering includes primary and secondary data collection. Primary data collection varies significantly depending on the subject of RRA. For energy resource assessment, primary sources include direct observations, actual meter readings, key informants, and interviews. Secondary sources of data collection include reviewing papers on the issue for the particular region under study; published government data and statistics; discussion with selected experts from various organizations; informal discussions with selected key experts; maps and aerial photographs; and knowledge of existing programs for rural development, both regional and national.

1.3 WHY RRA IS THE BEST APPROACH FOR THE REA

Rapid Resource Assessment is an ideal approach for planning and prioritizing rural electrification projects. Most rural electrification projects in Zambia will be small and may need to be subsidized. Experience has shown that large utilities are unable to plan, build, and/or operate small scale renewable energy projects on a cost effective or profitable basis.[3] Moreover, experience has shown that for energy projects to be successful, local stakeholders must participate in their planning, construction, and operation. Using RRA as a tool for planning allows the REA to jump start not only the master planning process because it is quicker and more cost effective than the traditional method, but also because it involves local stakeholders from the very beginning of the process. The participation of local stakeholders helps to reduce

[3] Electricity for Rural People, Gerald Foley, Panos, 1991.

costs and time by tapping their knowledge of local conditions and their data collection services and helps to reduce local opposition because communities do not feel left out of the process.

While RRA is not new and has a long history of application in areas from water to health and for individual small scale renewable energy projects, this is the first application the authors are aware of in rural electrification planning. In the past, most rural electrification was undertaken by vertically integrated state-owned utilities that used mainstream system planning tools – principally, looking at grid expansion. Even when rural electrification was given to another body, the staff and/or the tools available were from the national utility.

Zambia's REA is new and lacks sufficient resources to conduct the traditional assessments. Moreover, the traditional assessments were geared for judging ability to pay based on past experience by customer class. REA's approach to rural electrification explicitly targets economic activities rather than numbers of potential customers. This report demonstrates why RRA is an appropriate and cost-effective technique for rural electrification planning.

1.4 RAPID RESOURCE ASSESSMENT TOOLS

To improve the ability of the REA to assess the demand and supply factors that may contribute to the success of rural electrification projects, two analytical tools were used to assist in the selection of potential development sites. These tools – GIS and an Optimization Model for Resource Assessment – are described in the following sections.

1.4.1 USING GEOGRAPHIC INFORMATION SYSTEMS (GIS) FOR RAPID ENERGY RESOURCE ASSESSMENT

Geographic Information Systems (GIS) are quickly becoming an everyday tool in peoples' lives. They can be used for a variety of applications, ranging from domestic interactive maps and vehicle Global Positioning Systems (GPS) to system planning. In the energy field, GIS is often used for planning and designing city power lines and for planning installation of energy efficient technologies. One of the most widespread GIS tools is the ArcView application, which is used by various organizations to build their specific GIS systems. For this project, the team utilized a publicly available system that could be used by all energy sector stakeholders without making additional investments into software purchases – DIVA-GIS. DIVA was designed for environmental and biological spatial analysis, but is it also useful for energy resource analysis.

Geographic Information Systems are digital maps that are layered, with each layer containing a particular feature of the area under investigation. These layers of information can provide a comprehensive overview of a region, including the geographical location of the country and regional borders, rivers, lakes, roads, railroads, towns, and villages, as well as information about the region's industries, agriculture, environment, energy, and other statistical information.

The user can create a project and include the layers of the data relevant to the task. These layers can be observed individually or in any combination, including altogether, on the map. This process provides the possibility of seeing a complete picture of the technical, economic, or combined conditions in specific region. The system allows a user to manipulate the data in different ways, grouping them and building distribution patterns for analysis. Figure 1 illustrates a sample map created for Zambia rural electrification RRA. In Figure 1, the active information layers represent country and province borders, rivers, lakes, major towns, meteorological stations and power plants.

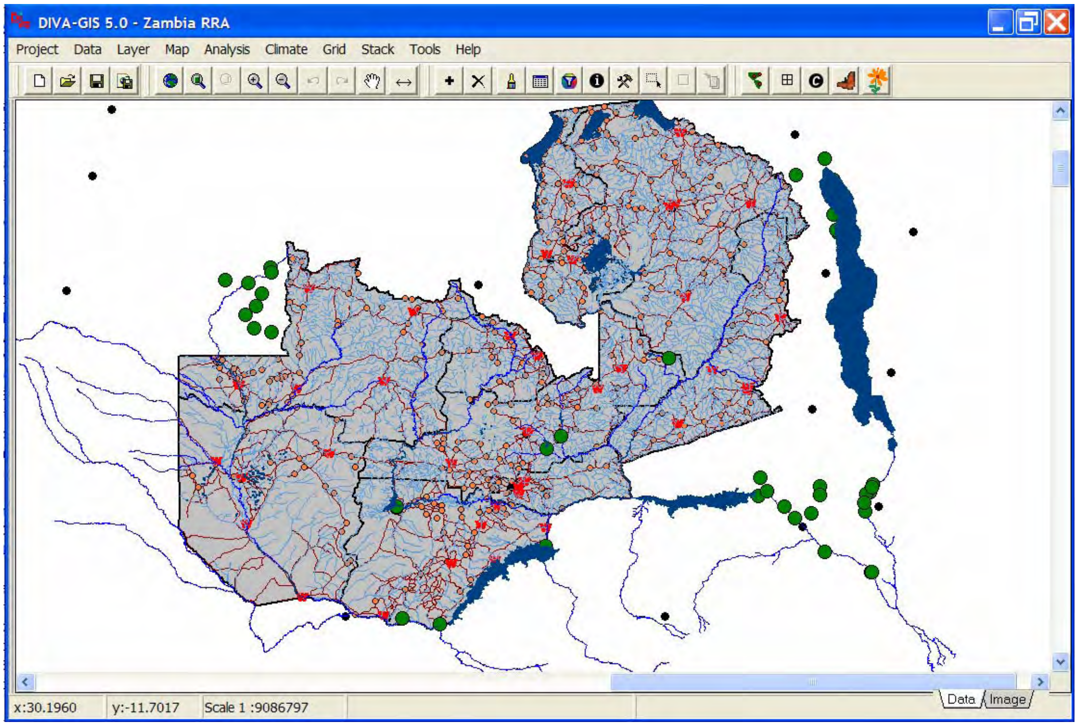


Figure 1: Sample GIS Map of Zambia

DIVA is particularly useful for analyzing the existing infrastructure and available energy resources. By adding successive layers of information, the user can quickly see (and determine) which areas have the strongest electricity demand potential. The GIS can answer questions such as:

How many potential residential customers are there?
What is their income?
What types of economic activity exist in the area?
Are their other potential users such as schools, clinics or government offices?
How far is this area from roads and other transportation?

Based on this data, demand can be approximated. In this manner, comparisons can be made quickly with other locations to develop a ranking of demand centers.

Similarly, areas can be viewed based on potential electricity supply, and GIS helps to quickly answer the following types of questions:

Are there renewable resources nearby in economic quantities to supply electricity?
What is the stream flow of the nearby river?
Is there sufficient solar radiation for solar systems?
Are there geothermal resources?

How far is the national grid?
Is there a sufficient mix of agricultural and under ground water to justify electrification for irrigation purposes?
Are there sufficient population and/or economic activity to support a power project?

Using the appropriate data, GIS can answer a host of supply and demand related questions. This information can be used for further modeling of technical options for electrification based on the location and availability of renewable resources, proximity to the existing grid, and other pertinent supply factors. Such distance information facilitates the supply cost estimate. More importantly, GIS allows a prescreening of potential sites based on already existing information to determine if there is any real potential for demand or supply. This can significantly reduce the time required to find a suitable set of rural electrification candidate sites.

For example, the analyst can quickly pair sites with great supply potential with markets. Based on rules of thumb on distance from the source or grid (cost of transmission), availability of transportation, size of population, economic activity, resource availability, and proximity of other demands, the analyst can quickly rule out some areas and rank others as good candidates for further investigation. The same tools used for screening can use more detailed data for detailed analysis.

One of the most important things that the use of GIS does is to shift rural electrification away from its former narrow focus. It allows the analyst, planner, or policy maker to view electrification as part of an integrated rural development system. Planned rural development can be added as a layer. For example, one layer could be a plan for roads or schools or clinics. As a stand-alone project the benefits of a school will certainly be less than when combined with the supply of electricity. In essence, the use of GIS forces the electricity planner to see the bigger picture because he or she must collaborate with other rural development agencies in the collection of potential demand and supply data that, in turn, leads to more integrated rural development.

The GIS database used in this report conveys information on the following key indicators of demand and supply potential:

- Population and Income
- Schools, clinics, and government offices
- Distance to transportation, such as road or rail
- Rainfall
- Rivers and stream flow
- Wind direction and speed
- Solar radiation
- Geothermal potential
- Distance to the national grid
- Crop patterns
- Forest cover
- Industrial and commercial activity

At present, the GIS database shows the locations of schools that lack electricity, a rough proxy for the population currently not served by electricity. Figure 2 shows the GIS results for locating schools without electric power supply in 2000.

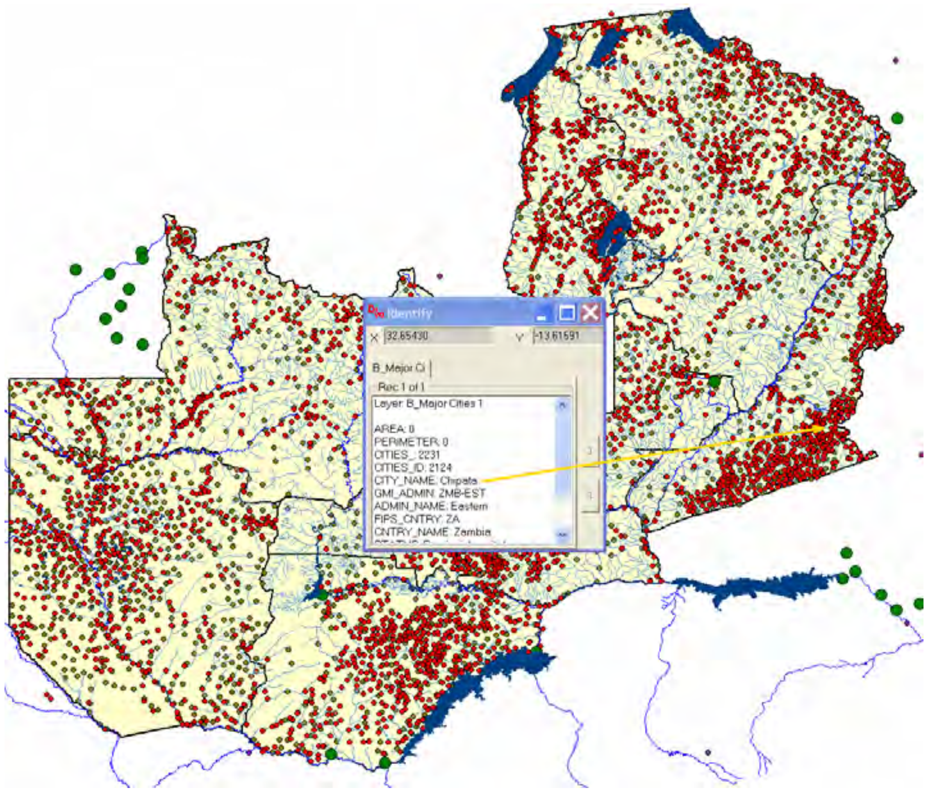


Figure 2: GIS Map of Zambian Schools without Electricity Supply, 2000 (red dots represent schools without electricity)

Overlays on the GIS map can be modified for a large variety of databases to track social and non-economic characteristics, as well as economic and physical characteristics. It is possible to help determine the parts of the country that offer the best promise for indigenous energy generation using these map overlays.

Specific overlays for the rural electrification RRA include the ones that help to identify the following criteria for choosing a location for a rural electrification project:

Demand Side Criteria

- Current or near-term potential for development of agro-industrial electricity use – economic and resource overlays;
- Current use of diesel generators in a region – comparison of electrification overlay with diesel generator map;
- Population density greater than provincial average – population overlay;
- Household income greater than provincial average – income overlay map (in the future);
- Proximity of schools and government health clinics – school and clinic overlays.

Supply Side Criteria:

- Availability of renewable resources;
- Proximity to roads and rivers – roads and rivers overlays;

- Likelihood of complementary hybrid systems – hydro/diesel, hydro/wind, wind/diesel – wind and river system overlays;
- Proximity to existing grid – comparison of potential demand center to grid map.

To make the most effective use of these overlays, it is necessary to have an initial hypothesis regarding the feasibility of providing electric service to specific towns, villages, or locales, which can then serve as a standard against which to compare competing projects. The initial hypothesis is based on the demand-side analysis, which indicates whether and to what extent there is, or can be, sufficient electricity demand in a given village or locale to justify investment in a small grid. This grid should be large enough to achieve certain minimal economies of scale in output and should provide for economically beneficial demand for electricity. Under this hypothesis, electricity can be provided using a combination of conventional and local resources at an acceptable price.

DIVA allows analysts to locate high potential areas, for example, by ranking areas by proximity transportation, population, agricultural activity, commercial activity, industrial activity, and government services such as schools. Similarly, high potential supply areas can be located and ranked. Together, these overlays allow high demand-supply areas to be quickly identified. The next step is to conduct a more thorough financial analysis of these areas, using an optimization model as described in the following section.

1.4.2 AN OPTIMIZATION MODEL FOR ENERGY RESOURCE ASSESSMENT

HOMER, a publicly available optimization model for distributed power, is used for determining the cost of supply. HOMER was developed by the U.S. Department of Energy's National Renewable Energy Laboratory (NREL). HOMER simplifies the task of evaluating designs of both off-grid and grid-connected power systems for a variety of applications. It offers a wide variety of power system configurations and their components. HOMER helps to evaluate these configurations for both technical and economic feasibility. The HOMER model simulates stand-alone hydro, wind, solar, and diesel-based power systems. A sample equipment selection screen is illustrated in Figure 3.

To use HOMER, the model has to be provided with inputs, which describe technology options, component costs, and resource availability. Based on these inputs, the model will simulate different system configurations, or combinations of components, and generate results that can be viewed as a list of feasible configurations sorted by net present cost. The model uses sensitivity analysis to determine the impact of changes in factors, such as resource availability and economic conditions, on the cost-effectiveness of different system configurations. Such sensitivity analysis can answer general questions about technology options and facilitate planning and policy decisions.

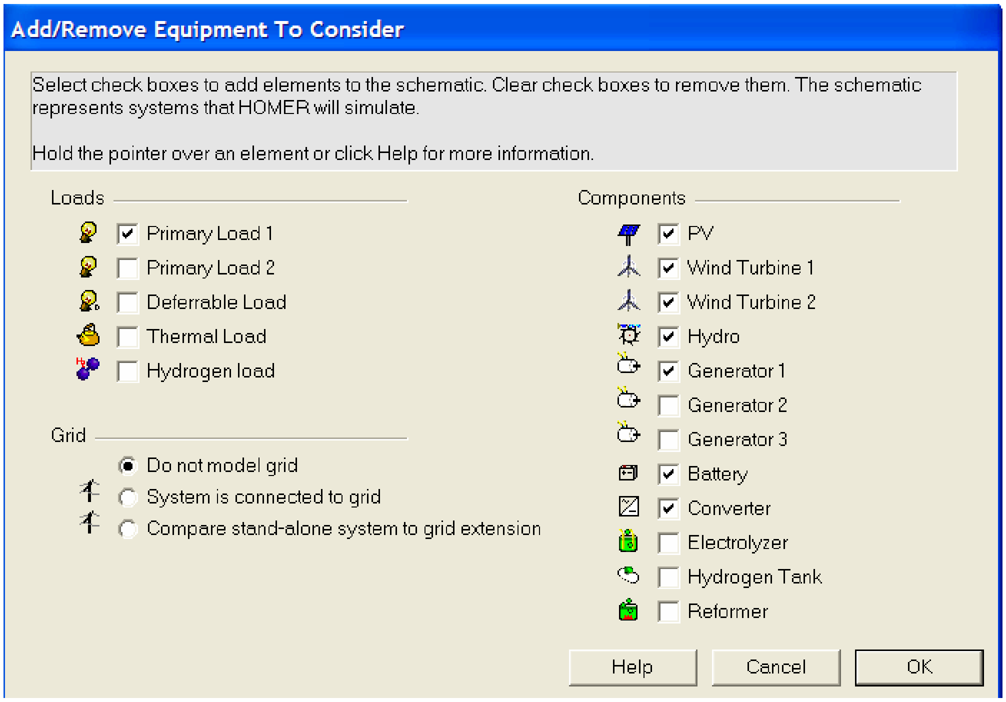


Figure 3: Sample HOMER Equipment Selection Screen

HOMER simulates the operation of a system by making energy balance calculations for each of the 8,760 hours in a year. For each hour, HOMER compares the electric and thermal demand in the hour to the energy that the system can supply in that hour, and it calculates the flows of energy to and from each component of the system. For systems that include batteries or fuel-powered generators, HOMER also decides for each hour how to operate the generators and whether to charge or discharge the batteries.

HOMER performs these energy balance calculations for each system configuration under consideration. It then determines whether a configuration is feasible, i.e., whether it can meet the electric demand under the specified conditions, and it estimates the cost of installing and operating the system over the lifetime of the project. The system cost calculations account for costs, such as capital, replacement, operation and maintenance, fuel, and interest.

To test the hypothesis, a given service area proposal must be compared to other proposals for other service areas. HOMER was used to compare the key performance and cost parameters for a variety of investment options. HOMER is intended to provide a rapid screening of potential technologies to match the demand and local energy supply characteristics of a chosen demand center at least cost. Key characteristics of an energy system that are included in the HOMER modeling approach include the following:

- Load curve – at whatever level of detail exists for the system;
- Resource supply curves for wind, water, and sun;
- Reliability requirements for system;

- Hybrid system preferences – multiple sources, including diesel backup or primary diesel generation;
- Fuel prices;
- Interest rates;
- Replacement and service costs for various technologies; and
- Electricity storage and management.

Based on the inputs to the HOMER model, a wide array of potential results can be derived, including:

- Cost of generation;
- Initial investment costs;
- Present value of total costs; and
- Renewable energy fraction for different system choices.

Of great interest and usefulness is the ability of HOMER to provide side-by-side comparisons of the key characteristics of the least-cost set of systems. HOMER is able to provide analytical assistance on many of the important economic and quantitative issues that must accompany an appropriate rapid assessment methodology. These economic criteria include:

- Ability of economic activity in target region to generate payments for electricity;
- Existence of market infrastructure to absorb additional economic activity including:
    - Roads, water transport, etc.
    - Value-added activities – schools, health clinics, communications;
- Repair and parts infrastructure to maintain system;
- Organization to collect fees and operate system; and
- Potential contributions to electricity output from local or renewable resources.

In addition, the HOMER output can also be used to compare alternative projects that are candidates for government or foreign funding.

1.5 RAPID RESOURCE ASSESSMENT METHODOLOGY

Rapid Resource Assessment is conducted in three parts: First, potential demand areas are assessed and ranked; second, potential areas of supply are assessed and ranked, and third, demand is matched with supply and an overall priority ranking of projects is determined based on the net economic benefits.

There are several basic postulates upon which the RRA methodology is based, which the REA should follow in developing its overall rural electrification strategy. Of these, the most important is that most rural households cannot fully support a rural electricity project. Either the quantity they consume or their ability to pay or both is below that required for an economic rate of return.

The average rural household monthly income was estimated to be US$ 118.25 or 283,796 kwatcha (K). However, this must be viewed with caution for at least three reasons: (1) people tend to less accurately report their income than expenditures, (2) 48% of this was imputed income from consumption of own agricultural produce and this may not reflect market prices for the self-consumed goods, and (3) people will tend to underreport or not report at all begging or borrowing.

Expenditures are a more reliable indicator. Table 1 presents monthly expenditure data for 2002-03. Mean rural household expenditures including self-produced food totaled US$ 161.12 (386,676 K) per month. Since the bulk of rural peoples are at or below the poverty level, the expenditures devoted to food are not discretionary. In other words, at the subsistence level they are highly unlikely to divert spending from food to nonfood items and some portion of additional income is likely to go to food. Approximately 18% of total expenditures or US$ 29.42 was spent on non-food items per month and mean monthly expenditures on household utilities including energy was US$ 1.47. Rural households consistently spend 5% of their monthly non-food expenditures on household utilities with the exception of large farmers.

Table 1: Monthly Expenditures by Household Type in U.S. Dollars, 2002-2003

Consumer	Total Expenditure	Nonfood Expenditure	Expenditure on Utilities	Percent Nonfood to Total Expenditures	Utilities as % of Nonfood Expenditure
All Zambia	$ 204.39	$ 48.14	$ 2.89	24%	6%
Rural	$ 161.12	$ 29.42	$ 1.47	18%	5%
Small Scale Farmer	$ 157.08	$ 27.09	$ 1.35	17%	5%
Medium Scale Farmer	$ 316.45	$ 88.93	$ 4.45	28%	5%
Large Scale Farmer	$ 778.96	$ 327.74	$ 45.88	42%	14%
Non-Ag Household	$ 119.53	$ 50.97	$ 2.55	43%	5%

Utilities include items such as water, energy, and phone service. To put this in perspective, if we assume that the average rural household spent its entire utility budget on electricity at US$ 0.89 (207 K) per kWh, this family could consume slightly more than 17 kWh per month or enough to power two 60-Watt light bulbs for a little less than 5 hours per day. However, it is unlikely that the typical rural family could spend all of its utility expenditures on lighting.

Data on energy expenditures provide useful information because they indicate how much of a rural household's money income is devoted to energy. Only 3% of rural households use electricity for lighting; paraffin and kerosene are the main sources of lighting and account for 63% of rural households' main lighting energy source. Surveys indicate that the bulk of this is actually paraffin. Note that the main source of cooking fuel – 88% for rural households – is from self-collected fire wood for which there is no monetary outlay. Clearly, for many families on the lower end of the income spectrum, the vast majority of energy services are self-supplied – that is, through the gathering of fuel wood, crop residues, and other biomass. Energy expenditures were dominated by wood, charcoal, paraffin, and candles. Wood and charcoal are used mainly for cooking and heating, while paraffin and candles are the main source of lighting.

It is important to note that the above discussion assumes that people can move from their current energy source to electricity without any conversion costs. Conversion costs include the cost of installation or hookup and also the cost of new appliances for electricity. For example, a home switching to electricity would need to purchase wiring and meters as well as light bulbs. Empirical evidence from the developing world clearly indicates that the transition to different forms of energy involves complex economic, cultural, technical, and social relationships. People do not just go from cooking with firewood to cooking with electricity. In addition, if they used a certain amount of lumens or btus for lighting, for example, they would not use the same amount when moving up from candles to kerosene or from kerosene to electricity.

These findings lead to several major conclusions that have profound implications for rural electrification.

- First, given these income levels, some electricity services will need to be subsidized. As shown above, if rural households were using all their utility expenditures for lighting, this would mean consumption of 17 kWh per month or enough to run two 60 W electric light bulbs for about 5 hours per day.

- Second, residential energy use will be very limited and there is a definite transitioning in energy use that takes place. The order of use will most likely be lighting, radio, fan, TV, and then an iron or some other small appliance. It will be a long time before electricity is used for cooking and heating. Until incomes increase significantly, only a small portion of energy expenditures will be directed to electricity. *Residential consumers will consume very small amounts of electricity for the foreseeable future.*

- Third, another problem exists because of such low income levels and imperfect markets. Even if consumers were willing to pay and able to afford the full cost electricity per kilowatt hour, they could not afford the connection costs. This is called the "first-cost problem." For example, it has been estimated that the cost of purchasing a small solar home system would be 61% of a typical Zambian household's annual income.[4] Even if consumers would benefit from paying their electricity bill monthly, they could not afford the first cost of electricity consumption. With rural Zambians spending 82% of their income on food, they would be unable without some form of subsidy to purchase a solar home system. This problem leads many countries to subsidize connection costs even if they do not subsidize consumption or provide other forms of concessional financing.

- Fourth, even when the first-cost problem is overcome, the low population density coupled with low income and low demand, will mean that either: (a) the consumption will need to be met by small modular units like solar; or (b) that a base load needs to be identified and developed, e.g., a school or clinic or a larger scale economic use such as milling or irrigation.

Together, these first four conclusions lead to a fifth and sixth conclusion that will have profound implications for the implementation of rural electrification in Zambia.

- Fifth, where incomes and consumption are unlikely to support electricity, rural electrification may need to focus on finding or creating a customer that can act as the base load as well as subsidize other users[5]. The cornerstone for most rural electrification activities must be productive use of electricity that will reduce costs and increase incomes. Productive use, which can be defined as either income generating activities such as milling or irrigation, or end use activities in clinics or schools, will subsidize other consumers. However, there is an important difference between these two types of productive uses. Income generating activities have economic impacts in the near term that increase consumption and ability to pay because the demand for

[4] Renewable Energy Strategies for Rural Africa, AFREPREN.
[5] This subsidization can be indirect in that the increase consumption allows economies of scale in supply and lower costs. For example, the project sponsor identifies the use of electricity for a grain mill and then uses mini hydro instead of solar. This will result in lower costs of production for all users. The subsidization can be direct when the base load use pays more than its marginal supply costs, thereby lowering the amount needed to be covered from other users.

electricity grows as income increases. This impacts rural electrification in two ways: (1) it acts as a base load with the consequent reductions in the cost of supply, and (2) in the near term it increases economic activity in the area and increases demand due to the positive spillover effects. The economic impact of electricity on those who consume education and health services will usually be in the distant future. This use can benefit rural electrification by acting as a base load and reducing costs.

- Sixth, in the case of income generating activities, subsidization will be required in almost all cases because of the first-cost problem. For example, farmers will undoubtedly benefit from using electricity to irrigate their lands. Recent studies show an increase in farm incomes between 600% and 800% from the introduction of small hand-pumps on rural farms in Zambia. However, since the pumps cost of US$ 90, farmers could not afford to purchase the pumps without some form of credit that takes into account the timing between planting, harvesting, and sale, and the precarious financial condition of subsistence farmers. Low cost credit schemes will also be needed for many productive uses.

The following 10 steps were developed for conducting the RRA in Zambia:

1. Identify major organizations and individual experts in Zambia involved in rural electrification or that could potentially be involved.
2. Develop a plan of interviews and meetings.
3. Gather and assess all pertinent supply-side data (including GIS information) on renewable energy sources, including hydro, wind, solar, biomass, and geothermal.

   Hydro
   - Existing measurements of river flow rates in throughout the country;
   - Rainfall data so that the rainfall approximation method can be used to estimate the flow rates of the rivers in identified demand centers, where river flow data is not available;
   - Existing studies that have been conducted on mini/micro hydro locations;
   - Identify data gaps and the measurements that need to be performed.

   Solar
   - Existing measurements (sunshine hours);
   - Existing studies that have been conducted on mini/micro hydro locations;
   - Identify data gaps and the measurements that need to be performed.

   Wind
   - Existing measurements (wind speeds);
   - Existing studies that have been conducted on wind power applications in Zambia;
   - Location of existing stations and their applicability for representative wind measurements;
   - Identify data gaps and the measurements that need to be performed.

   Biomass
   - Collect data on agriculture and forest wastes, and based on the conversion ratios estimate the amount of biomass available for electricity generation;
   - Existing studies that have been conducted on biomass projects in Zambia;
   - Identify data gaps.

Geothermal

- Collect data on different spring sites in Zambia;
- Assess the geothermal potential for electricity generation.

4. Collect information, including maps and GIS data, on the location of existing power transmission lines, as well as power plants and substations.

5. Collect the available demand data, including:
   - Census data;
   - List of industries, their locations and parameters, energy demand;
   - List of agricultural farms, their locations and parameters, energy demand;
   - Locations and population of towns and villages;
   - Location and energy needs of schools;
   - Location and energy needs of hospitals.

6. Enter all GIS information into DIVA-GIS, and create various maps to analyze the regional availability of electric power in Zambia.

7. Analyze all energy resource data and rank the demand centers located in the vicinity of the available energy resources.

8. Use the hydro, solar, and wind data in the HOMER optimization model to identify feasible technological solutions for off grid rural electrification.

9. Assess the demand centers based on their economical development potential, importance for Zambian economy, population income levels and ability to pay for electricity.

10. Match the results of the resource assessment and demand assessment, and identify priority areas for rural energy projects implementation. The economic factors and usage of energy for productive purposes should prevail when determining the development priorities. The individual potential projects should be considered in the context of the country-wide rural energy development policy, national power grid development plan, and financial feasibility based on the ability of the population to pay for the electricity produced, or availability of governmental subsidies or donor grants or loans. It is important to use an integrated approach to utilization of energy resources in the rural areas. For example, in many areas hydro power can be used to both produce electricity and as mechanical force to run grain mills. In the areas with a steady but slow wind speed, instead of using a wind turbine, this wind can be used to drive a water pump for irrigation purposes.

1.5.1 DATA COLLECTION AND REVIEW

The project team undertook an aggressive approach to gathering the data for the initial RRA. The team developed a comprehensive list of organizations and individual experts in Zambia involved in either various aspects of rural development or general research activities that may produce relevant information. The objective was to collect available data both on energy resource supply and demand, as well as the information about existing or planned rural development or rural electrification projects. The data gathering approach included e-mail and telephone communication; visits to the data source organizations; interviews with the Government officials and industry experts; analysis of previous reports related to rural development in Zambia; and an internet search for publicly available statistics, energy data, and GIS data. The site visits to observe living conditions of the rural population and existing energy production were also a part of the data collection mission. As a result, a large amount of the data was collected. The project mission also identified the gaps in the available data, and it identified potential sources and/or methods to collect this missing information.

Table 2 illustrates the sources and availability of specific data categories.

Table 2: Data Categories for the RRA and Potential Sources of Data

Data Category	**Source of Data**	**Status of Data**
Wind data	Meteorological Department of Zambia	Collected: Table/GIS
Geothermal resources	Geological Survey of Zambia	Need to collect
Mini/micro hydro assessments	ZESCO, Donor Agencies: SIDA, UNIDO, NORAD, UN, USAID, JICA	Partially collected
Rainfall data	Meteorological Department of Zambia	Collected: Table/GIS
Existing/planned rural electrification projects	Electricity Regulatory Board (ERB), ZESCO, Private ESCOs, Rural Electrification Authority (REA)	Partially collected
Existing industry	Ministry of Commerce	Collected
Solar resource data	SIDA, University of Zambia: (Dr. Geoffrey Munyeme)	Insufficient – Need to collect
Wind technologies	University of Zambia (TDAU) - Dr. M.J. Tamba Tamba	Partially collected
River stream flow data	Ministry of Energy and Water Development -- Hydro Unit	Collected: Table/GIS, may require additional details for specific site locations
Census data	Central Statistic Office (CSO)	Collected
Schools data	Ministry of Education	Collected
Hospitals data	Ministry of Health	Need to collect
Agriculture data	Ministry of Agriculture	Need to collect
Transportation data	Ministry of Tourism	Need to collect
GIS maps	Public websites	Largely collected
Environmental data	Environmental Inspection	Need to collect
Energy consumption/demand/availability	MEWD, Ministry of Commerce, Ministry of Education, Ministry of Health, Ministry of Agriculture, Ministry of Tourism	Partially collected

There are several challenges in data collection. The first challenge is that the RRA experts have to clearly identify the data format needed for this specific assessment. Another is the frequent unwillingness of various agencies to disclose data. The important role of the leading experts in this case is to explain the goal of the data collection to these organizations, request only relevant information, and to be very persistent and consistent in contacting the organizations and obtaining the requested information.

During preparation of this report, the team was able to collect a significant amount of country data, including:

- GIS maps of Zambia, including cities, villages, provinces, rivers, lakes, wetlands, roads, railroads, etc.;
- River stream flow data;
- Rainfall data;
- Wind speed data;
- Energy availability and demand in schools;
- List of industrial enterprises; and
- Various maps, including electrical grid maps and geographical maps.

A detailed list of the collected data is illustrated in Appendix 1.

The team also identified additional data that would need to be collected to complete the RRA before preparing the Rural Electrification Master Plan. This data included, but was not limited to, the following:

- Detailed solar irradiation data, including GIS maps;
- Geothermal resource data, including GIS maps;
- Measured wind speed data in the locations of actual potential sites for wind generators installation, different from the location of the meteorological stations;
- Agricultural production/farming information, and estimated energy demand;
- Actual diesel generation installations and their status;
- Plans of ZESCO electric grid extension development;
- GIS maps of existing power grid;
- Energy demand of the industrial plants, and GIS maps; and
- Energy demand of hospitals, and GIS maps.

The following section describes the data gathering process during the preparation of this report and the analysis of the collected data. The data and information were combined into three large categories: energy supply resource, energy demand, and existing and planned electrification projects in the country.

1.5.1.1 Hydro Resources Data and Assessment

The Hydro Unit of the Ministry of Energy and Water Development maintains an inventory of the stream flow measurements throughout the country. This department has a GIS group that uses ArcView GIS software and digitizer to digitize the maps and convert the data into the GIS formats. It is planned to make this information available for the other institutions that may need it in their work. The World Wildlife Fund (WWF) has installed a network in Lusaka that is intended to join the local networks of the Hydro Unit, ZESCO, DWA (MOE), WWF, the Zambia Meteorological Department and the Zambezi River Authority. A detailed map of Zambia and its rivers and lakes was provided by the Hydro Unit. Currently, there are approximately 130 functioning river flow metering stations throughout the country, and the Hydro Unit contracts local residents to perform daily flow measurements at those locations. Historical data is available in a table format for the past 30-40 years; however, the data are often incomplete.

The GIS locations of the 130 metering stations were made available by the Hydro Unit of the Ministry of Energy and Water Development, and for 70 metering stations stream flow measurement data in the table format were provided for the period of 30-40 years as well.

Additional data for hydro resource assessment was obtained from the Department of Meteorology. The Department has a database for precipitation and wind over the past 50 years. The precipitation (rainfall) data would be useful (1) in the near term to fill gaps if the river stream flow data were unavailable in certain regions, and (2) later during the detailed assessment of regional energy potential for the master plan. The rainfall data was obtained in the form of sampling files with average rainfall data throughout the country, per each meteorological station location (39 total), for the past 30 years. This data was converted into GIS format.

Another important source of information for the hydro resource assessment, provided by the Hydro Unit, was a Water Development Master Plan prepared by Japan International Cooperation Agency (JICA) in 1995. This is a detailed study that contains comprehensive analysis of Zambian water resources and offers the options and potential projects for development of these resources for various purposes including the household water supply with potable and technical water, irrigation, other agricultural needs, and large electric hydro projects. This study, however, did not include the analysis of possible small, mini, and micro hydro projects.

More information about the hydro resources and potential projects was derived from the report “Small Hydropower Preinvestment Study for North-Western Province” prepared by the Norwegian company NORAD under UNOPS program in 2000. This study analyzed 10 potential hydropower projects of various scale, from 0.1 MW to 1.2 MW. It is similar to other studies done in the country focusing on small and mini hydro projects with generating plants larger than 100 kW. However, one of the economical solutions for rural electrification in Zambia, where the villages can be as small as a dozen single family houses and settlement patterns are dispersed, would be off-grid micro hydro projects under 0.1 MW. The study did not address such small scale projects.

1.5.1.2 Analysis of the Stream Flow Data

Stream flow data was obtained from the Hydro Unit of the Ministry of Energy and Water Development, for the 69 locations of the operating metering stations, as illustrated in Appendix II, for the following river catchments:

- Chambeshi Catchment
- Kafue Catchment
- Tanganyika Catchment
- Luangwa Catchment
- Luapula Catchment
- Zambezi Catchment

Appendix III illustrates the initial format of stream flow data, including the metering station location and commissioning date, the catchment area, and the measured daily average flow rate. This data is gathered on a daily basis by local contractors. This data is reliable, but for some years and months it is missing. The data on each of the 69 locations was summarized by the average annual maximum, minimum, and mean flow, as shown in Appendix IV. To install micro hydro plants to provide sustainable energy supply, the rivers in those locations must have consistent flow throughout the year. Therefore, the summarized table and the initial data sets were analyzed to see if there were months with zero flow in the rivers. The analysis revealed that for most of the years for the majority of the locations, there were days, or even months, without the flow data; however, in many cases, this can be attributed to missing data. Such locations were included in the further analysis, while those with zero flow during the dry season, were considered unfeasible and excluded from the further analysis. The table representing the final list of the sites, for which the stream flow data is consistent and sufficient for analyzing the technical feasibility of hydro plants installation, is illustrated in the Appendix V. The data in this table was ranked by the mean flow during the year.

Most of the sites near the location of the river flow meters can be considered for micro or mini hydro plant installation, while several locations are suitable for mid-size hydro plants. As an example, the location at Kaleen Hill was analyzed (Zambezi River, metering station No.1080). It is located in the North-Western Province, Mwinilungu Region, near Kalene Hill Mission, as illustrated in Figure 4 below. There are four villages around this area and six schools that do not have electricity. Installation of an off-grid hydro power plant would provide electricity to these places.

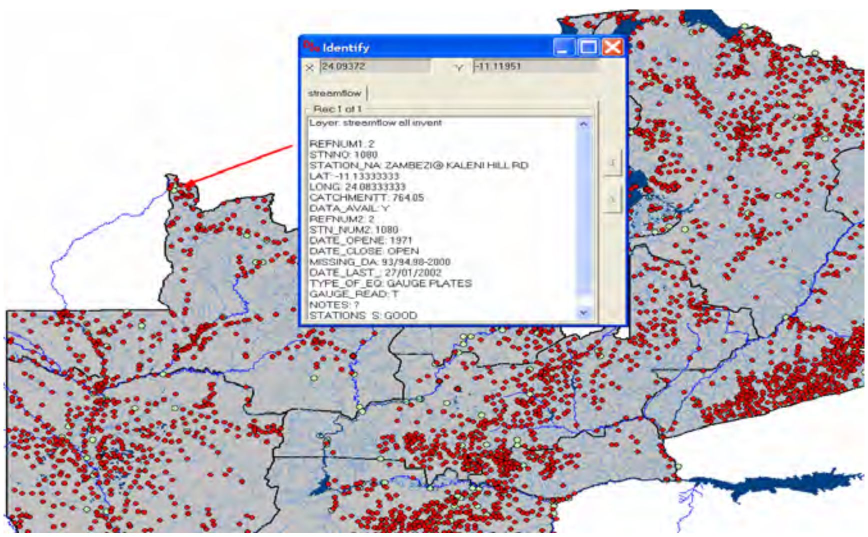


Figure 4: GIS Map Illustrating River Flow Measuring Stations and Location of Schools without Electricity Supply

HOMER estimated the potential for mini/micro hydro at this location. The flow data was averaged, and the average minimum flow was used as a baseline for calculating the parameters of a hydro plant.

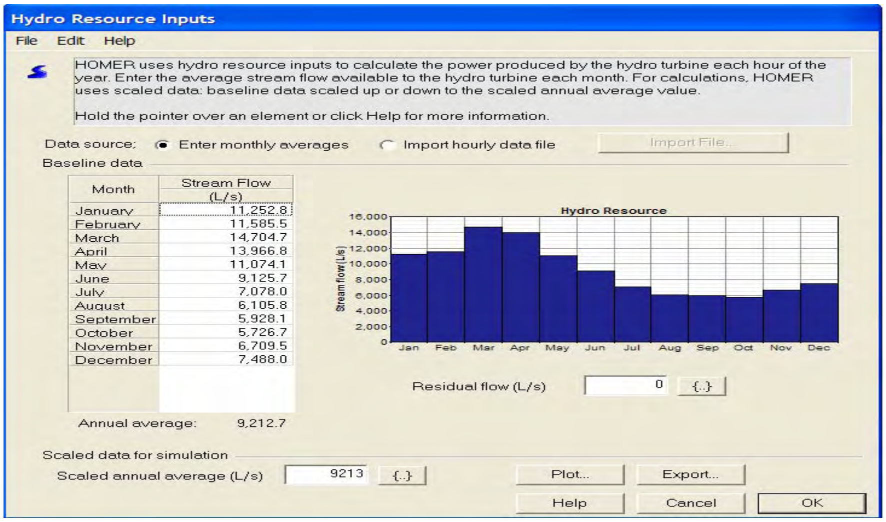


Figure 5: Example of the Initial River Stream Flow Data Input in HOMER

The available water flow allows for micro or mini hydro power plants of various sizes. The sizing of a micro hydro plant is always very site-specific, and it depends on two main factors: water head and water flow. The length and diameter of a pipe delivering water from intake to turbine is also considered as a limitation factor. To investigate in detail the potential projects near the river flow metering stations, additional information needs to be gathered or produced, such as water head, distance from the river to generation point, distance from the generation point to consumer, and actual user demand. Therefore, for the sample HOMER analysis, hypothetical numbers for water head and distances were assumed. Figure 6 illustrates the process of modeling a micro hydro plant based on the flow data in Figure 5.

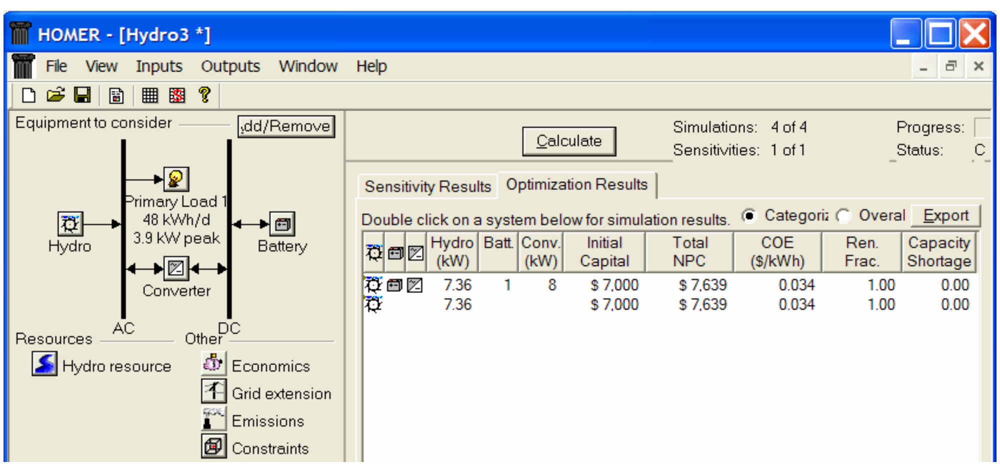


Figure 6: Example of HOMER Model for Micro Hydro Plant

At the present time, the information on the stream flow represents the best basis for prioritizing the available hydro resources. The next steps in the RRA are to build upon this list of prioritized locations and to collect additional data to facilitate modeling of potential micro hydro power plants. In addition, for the locations where the stream flow data is not available or cannot be obtained with reasonable efforts, rainfall data should be used as estimates. The rainfall data was collected from the Meteorological Department for 39 sites, where the meteorological stations are installed (Appendix VI).

1.5.1.3 Wind Resources Data and Assessment

The Meteorological Department of Zambia is in charge of collecting the measurements on wind speed across the country. Figure 7 shows the 39 meteorological stations in Zambia as illustrated on the map generated by DIVA-GIS.

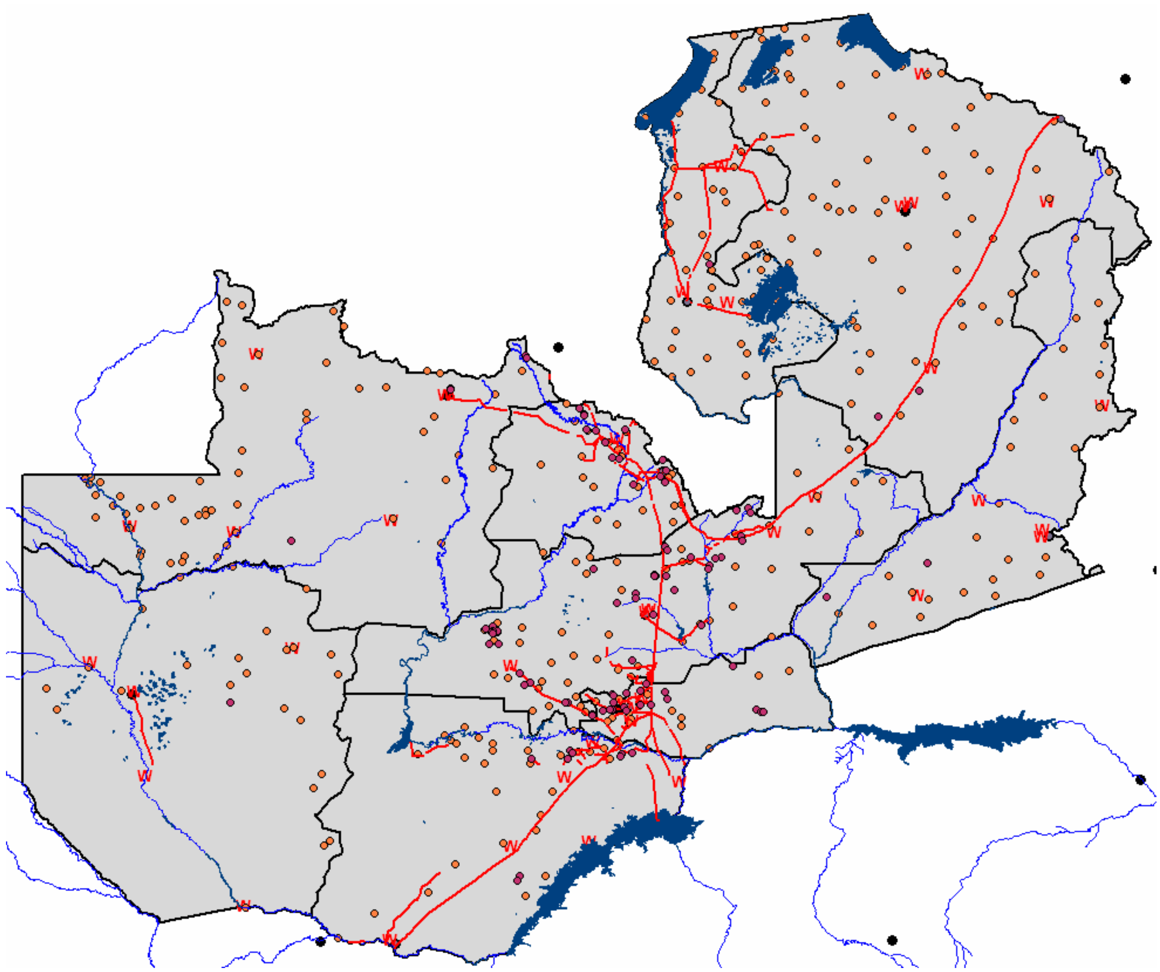


Figure 7: GIS Map of Zambia with the Locations of the Meteorological Stations and High-Voltage Transmission Lines (330-220 kV)

The Meteorological Department has a database of direct wind speed and rainfall level measurements for the past 50 years. For the purpose of the RRA, the file was generated from the database for all 39 stations for the representative period of up to 30 years depending on the availability of the measurements at certain locations. The geographic coordinates of the station locations were provided along with the measurement data, which allowed conversion of this information into GIS format. The data includes geographic coordinates of the meteorological stations, wind speed in meters per second, and number of years for which this measurement was collected. The collected complete set of the measurements is illustrated in Appendix VII.

According to international experience, the minimum wind speed that can make electricity generation economically feasible is 5 m/s. Thus, using the available measurements, there are only seven locations that can be used for wind generator installation (Table 3). A GIS map was prepared illustrating the locations of these sites showing that the higher wind speeds occur along the 330/220 kV transmission backbone in the Western, Lusaka, and Central provinces. Although the towns of Mongu and Kalabo in the Western provinces are supplied from the 66 kV power line coming from Victoria Falls Hydro Power Plant, and there is a potential for the development of the distribution electric grid to the surrounding districts, these surrounding districts can benefit from using the wind power for electricity generation.

Table 3: Locations with Wind Speed Greater than 5m/s

Station	Longitude	Latitude	Wind (m/s)	No. of Years
KABWE MET	28.48	-14.42	5.9	27
MONGU	23.17	-15.25	5.9	17
MKUSHI	29.80	-13.60	5.5	3
CHIPEPO	27.88	-16.80	5.2	2
LUSAKA HQ	28.32	-15.42	5	16
LUSITU	28.82	-16.18	5	6
KALABO	22.70	-14.95	4.9	11

As an example, a comparison of a wind turbine and diesel generator installation was performed using the HOMER model. Depending on the load, the price of diesel fuel, and other factors (e.g., type of equipment and its cost, and project life cycle), the most economical electrification option can be using a wind turbine in conjunction with a diesel generator. However, the overall solution for a small stand-alone home with daily load of 0.2 kW, using both generator and wind turbine is not very attractive economically, as the cost of energy is over US$ 0.8/kWh.

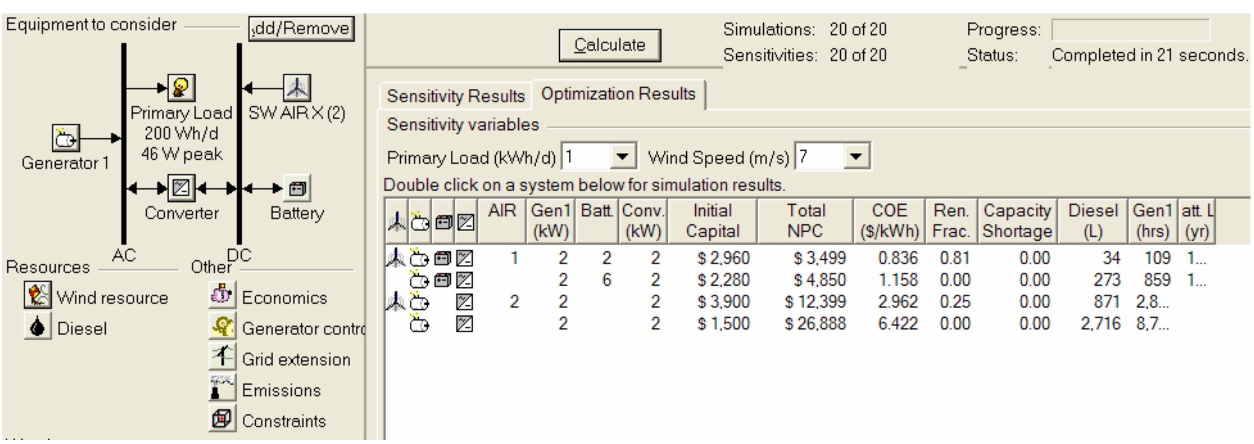


Figure 8 Comparative Analysis of Wind Turbine and Diesel Generator Off-Grid Systems

1.5.1.4 Demand Assessment

Census Data

Census data for the year 2000 was obtained from the Central Statistic Office (CSO) of Zambia. A hard copy of the Census Report and an electronic copy of the census database were obtained. The database (ZamSED) contains information on a very broad spectrum of social and economic indicators. It allows the user to select the required data by a sector of the economy or social indicators. For the purpose of RRA, various sets of data, down to the ward level, can be generated from ZamSED for analysis of the potential energy demand, including the following examples:

- Number of households with access to electricity and water;
- Proximity of the schools to the towns/villages;
- Agricultural production in various regions;
- Number of economically active population;
- Gross domestic production; and
- Number of households using electric home appliances, etc.

This type of information can be used to analyze economic and social activities throughout the country and to identify the regions that could economically benefit from implementation of the electrification projects, both off-grid and grid-connected.

School Data

The Zambian Ministry of Education, with assistance from USAID, The World Bank, and other donors, developed a database on all existing schools in the country. This database (EDASSIST) is a source of comprehensive information, including demographic data, school locations, number of pupils, and financial and infrastructure data, etc. Figure 9 illustrates a sample screen for data selection.

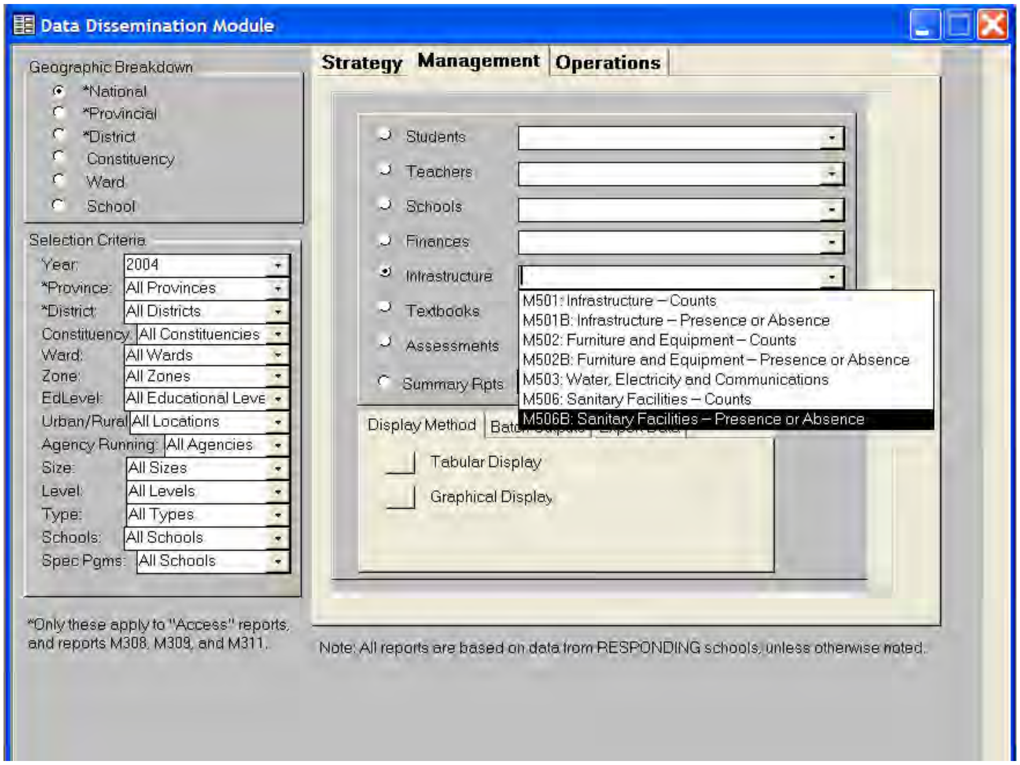


Figure 9: Data Selection Menu of the EDASSIST Database

For the purpose of the RRA, the database provides the important information about the availability of energy and water at certain schools. It also allows estimation of the energy requirements of the other schools that have electrical equipment, such as computers, faxes, and other office equipment.

Industry Data

The information about existing industries and their locations was made available by the Ministry of Commerce, which conducted an all-country Manufacturing Sector survey in 2003-04. The survey was done to provide statistical information for economic planning and monitoring of performance as well as constraints and potential for industrial growth. Based on the results of the survey, the Ministry designed a database, which is currently being finalized. The database contains information such as the industry location, its International Standard Industrial Classification (ISIC) code, ownership, types of products, various financial indicators of the enterprises, raw materials, applied technology and equipment, export/import data, and various constraints, including electricity, water, fuel, and other. Although the database itself does not provide direct information on the actual industrial energy demand (consumption), it indicates the level of availability of fuel and energy to a particular business. Also, this data can be used to estimate the level of current industrial production in the region and the potential production areas, thus providing estimates of energy demand that can be used for modeling purpose. The information about the Zambian Manufacturing Sector, obtained during the project mission, is illustrated in the Appendix VIII.

2. Using RRA in Zambia

2.1 APPLYING THE RRA METHODOLOGY

In the past, when grid extension was only option for electrification, proximity to the grid was the paramount consideration and new areas were incrementally added to the grid. Exceptions were areas where electrification was seen as politically expedient. Using the RRA, the main idea is to find areas that can support a small system and that either currently have or can easily develop a demand profile that makes such a system reasonably self-supporting.[6]

The first criterion for possible success is that an area may be able to use a system that is more than rudimentary. Such a system would include the following:

- Electricity is used for light industry, agro, or forest processing;
- There is extensive daytime demand for electricity;
- Electricity can add value to local agricultural, fishing, or forest product output;
- There are institutions such as schools and health centers that can use electricity during the day; and
- There is a reasonable expectation that demand will grow beyond the capabilities of the proposed system within five years.

Once an area has been selected that might potentially support a new electricity supply system, more detailed investigations are needed into the precise nature of that demand. These investigations will include the following types of information:

- Potential load curve;
- Potential for electrification of current processing or finishing activities;
- Potential for expansion of raw material output through better storage or water pumping; and
- Extent of resource base for new economic activity or expansion of existing activities.

To assess whether, and to what extent, this proposed methodology can identify areas that are appropriate for new rural electrification, the team chose two different regions of the country and evaluated supply and demand conditions in those areas. The team chose to assess the potential for regions that are not obvious candidates for new electricity supply initiatives from ZESCO or from Copperbelt Energy. As an initial negative screen, the team chose two regions that were not related to improved conditions in the copper industry; development of the new commercial farming areas; or new trading and economic ties with Tanzania.

[6] Reasonably self-supporting is, like many terms in the RRA lexicon, somewhat imprecise. It is not expected that any very poor region in rural Zambia can support the full cost of new electricity service, whether it is grid extension or a village system. However, an area that possesses the appropriate characteristics for a desirable demand profile will stand a better chance of supporting such a system than an area where the economy simply cannot provide adequate use for or infrastructure for more than a rudimentary system.

Two regions of the country appear to be potential candidates for new projects based on information from the RRA and the analytical models: the Western region and the Eastern region. The information on these areas, which provides the rational for selection for an investigative effort, is given in the next section.

2.2 EXAMPLES OF USING THE RRA METHODOLOGY

To show what can be done using the GIS and Homer approaches to project identification, the team chose one location from the Western Province and one from the Eastern Province.

2.2.2 THE WESTERN PROVINCE: WATER PUMPING AND FOREST PRODUCTS

The Western Province of Zambia is one of the poorest regions of the country. Landlocked, far from markets, and without mineral resources, this province remains largely without industry and with minimal electricity supply, despite the presence of the Zambezi River, which flows through much of the province in a southerly direction. Tables 4 the current household population statistics and Table 5 provides the locations of various industries in the province.

Table 4: Household Characteristics in Western Province

Province	Area Name	Households with access to electricity %	House-holds with radio %	House-holds with telephone %	House-holds with television %	Number of agricultural households	Population in agricultural households	Total house-holds
Western	Kalabo	1.57	20.08	0.20	1.55	22,527	103,222	23,970
Western	Kaoma	2.71	28.29	0.40	1.80	25,182	129,897	29,984
Western	Lukulu	0.87	19.86	0.35	0.52	12,383	57,272	13,488
Western	Mongu	8.06	31.75	1.94	9.74	23,326	112,736	32,054
Western	Senaga	2.71	21.03	0.44	1.66	18,483	92,899	20,956
Western	Sesheke	3.31	36.28	0.41	4.68	14,218	64,938	15,929
Total(average)		3.21	26.22	0.63	3.33	116,119	560,964	136,381
National averages		16.7	42.7	3.2	17.6	1,232,301	5,853,209	1,884,741

Source: ZAMBIA_CENSUS00, Zambia 2000 Census of Population and Housing, CSO, 2003

Although the statistics on education, electricity penetration, living standards, and so forth are not the direst in the country, the Western Province lacks significant economic infrastructure to take advantage of its two main natural assets – wood and water.

Table 5: Industrial Establishments in Western Province		
Company Name	**Type of Industry**	**Location**
Western Cashew Industries Ltd	Food	Limulunga Royal Village
M.J Bakery and Commodities	Food	Mongu
Mongu Joinery	Sawmills	Mongu
APG Milling Limited	Grain mill products	Mongu
Country Bakers	Food	Mongu
Sasha Timber Ltd.	Sawmills	Mongu

There are four food-related industries and two industries oriented toward the forestry resources. A look at the GIS, though, indicates that there is significant additional forest product potential in the province. However, without a means of processing the timber, it is unlikely that this potential can be realized. The province was chosen because of its potential for development and because further development can be based on existing industries.

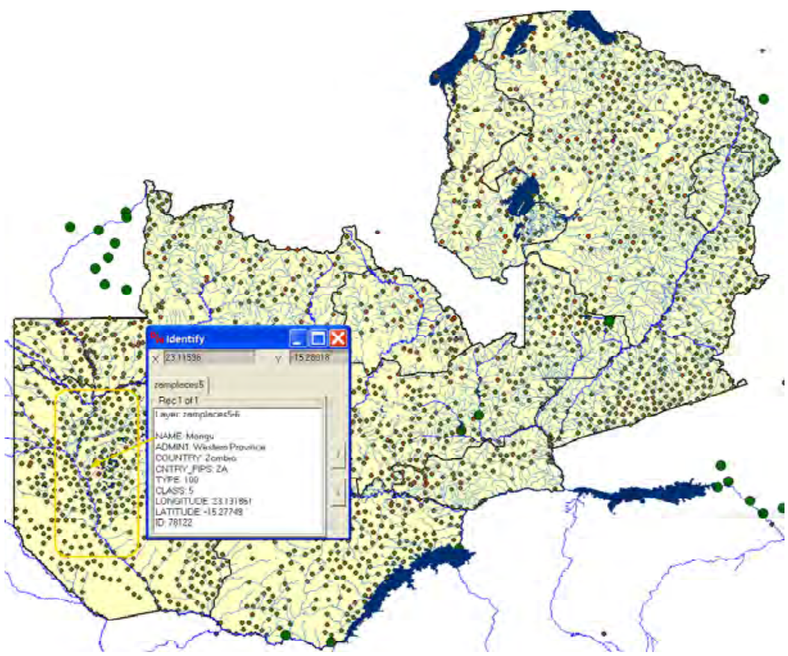


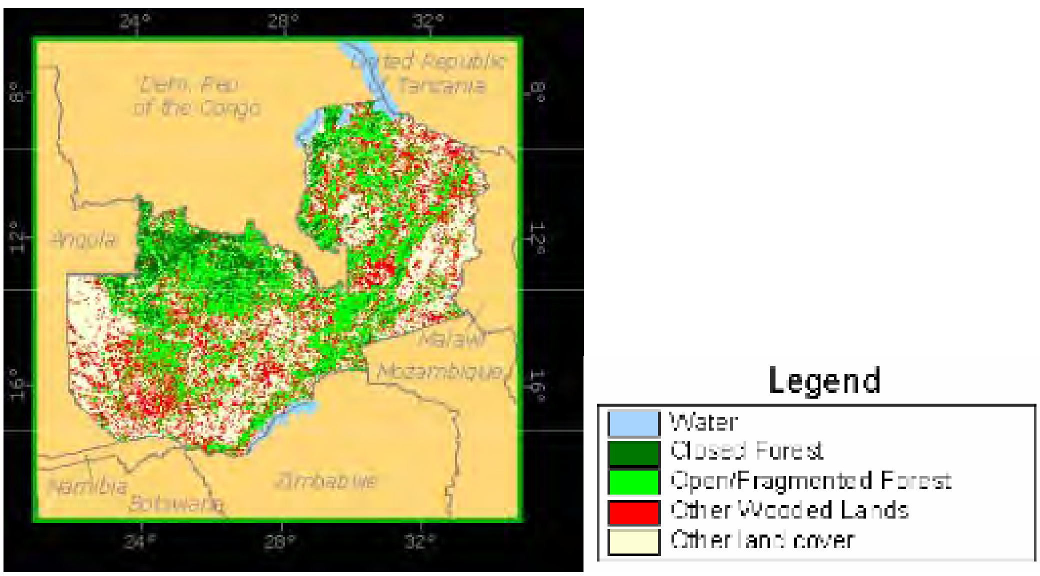
Figure 10: Areas in Western Province with Potential for Forest Products and Irrigation

The area surrounded by the yellow line in Figure 10 delineates the region in the Western Province that appears to possess significant potential for irrigated agriculture. The village centers and main towns and villages are displayed on the map. According to information from the Water Affairs Department of the MOWED, the area west of Zambezi River has a very good potential for irrigation agriculture development for two main reasons:

1. There is significant vegetation along the banks of the river, creating enough biomass to provide a functional natural fertilizer.
2. The underground water horizons can often be found as little as 2-5 meters below the surface in this area, so that pumping water from the aquifers can be a feasible task assuming sufficient power supply is provided to run the pumps.

The constraints for agricultural development in this area, and further to the west, are the relatively low population density (villages are of small size and often are scattered across vast areas of land), proximity of the desert, as well as an unstable border situation with Angola. However, appropriate land and financial policies accompanying a small rural electric project in this region could provide incentives for new residents, especially, if there were greater local processing ability.

Figure 11 shows the forest cover of the country, indicating the potential for additional value added in forest product processing in the Western Province.



Source: *thewoodexplorer.com*, Country Data for Zambia

Figure 11: Forestry Map of Zambia

The Zambezi River basin in the Western Province can be seen as the light green area. The forested area in question is to the west of the River itself. At the present time there is an existing small scale forest products industry in the region, with two sawmills. There is also some agro-processing with grain mills and bakeries in the local economy.

Electricity to this area is supplied via 66 kV power lines that go from the Victoria Falls hydro power plant through the town centers of Senaga, Mongu, and Kalabo. ZESCO plans to build a 66 kV line extension in the direction of Luculu, Zambezi, Chavuma, Kaoma, and Kabompo towns. However, the rural villages do not have electricity supply and would benefit from the small electrification projects. Moreover, this extension line is subject to ZESCO's funding constraints as well as its construction timetable. Electricity supply for smaller-scale sawmills and grain mills will be subject to considerable delay, given the slow pace of expansion of power supply outside of the cities and large towns.

2.2.1.1 Demand for Electricity

A small town of 250 households (~1,500 occupants), outside one of the candidate towns listed above, with a local forest, could probably support several small sawmills and perhaps other wood-based industries. The demand parameters for such a village might look like the ones in Table 6:

Table 6: Demand Parameters for Each Establishment in a Western Province Small Town

Parameters	kWh/mo	peak (kW)
Household demand	25.2	0.175
Commercial demand	72.0	0.5
Sawmill demand	3849.1	16.2
School	118.8	0.5
Clinic	237.6	1.0

The type of sawmill used would be a commercially available electric powered chain mill with a 2-3 kW draw. Such small electric mills are widely used throughout the world by wood craftsmen to provide the raw cuts for trees that they down themselves for construction or other purposes. It is assumed that each sawmill would have two of these and one electric molder capable of producing finished beams and logs suitable for construction.

Now assume that the town is fully electrified, as shown in Table 7 below:

Table 7: Demand for Electricity in a Developed Western Province Town

	Monthly Demand/unit			Total Monthly Demand	
	kWh	kW	# Units	kWh	KW
Households	25	0.175	250	6,300	44
Commercial	72	0.500	20	1,440	10
Sawmills	3,849	16.200	10	38,491	162
School	119	0.500	2	238	1
Clinic	238	1.000	1	238	1
Total for Town/Village				**46,706**	**218**

Such a town, with 10 small sawmills, could provide employment in the mills for as many as 60 men, plus employment in wood supply, including trucks and silviculture. Therefore, this prospect is not out of the realm of possibility for such a town. Total cost (delivered, with tariff) for the equipment for the 10 mills would fall into the $100,000 range, again not excessive, given the upside potential for new output and value added within the village (see below for discussion of potential economics of wood products).

2.2.1.2 Supply of Electricity

Given a peak demand of almost 220 kW, and the need to have reliable supply of power for at least 10 hours daily, it will be necessary to either connect such a town to the grid or to build a local power supply that meets the industrial demand of the town, while supplying houses, businesses, and civic institutions.

Two alternative supply modes are possible for this town. The first alternative is grid extension from one of the regional cities, via an 11 kV line, which would cost $10,000-15,000 per km. For a 25 km distance, this line would require ZESCO to recover at least $250,000-400,000 from electricity users in this town. The second alternative is to build a system to supply the town's current and projected (5 years) needs.

Using the HOMER model, the estimated demand for the above town was fed into the model and the cost of meeting the electricity load was calculated for two different combinations of diesel, wind, hydro, and storage, as chosen by the optimization routine. Other potential combinations of wind, hydro, and diesel might fit the demand pattern, but were calculated to be too expensive by the optimization program.

If ZESCO were able to build an extension and to supply that extension quickly, then grid extension probably provides the least-cost solution for such a town. Table 8, below, shows the probable costs for grid extension:

Table 8: Grid Extension Costs ($US)

Item	Total Cost	Cost/kWh
25 km line	400,000	0.107
Electricity supply	-	0.075
Total		**0.182**

This means that the full cost of electricity supply to meet the needs of a newly industrializing town would cost consumers on average about US $0.18 per kWh, or about three times the existing urban tariff.

The results of the HOMER model show significantly higher supply costs. Table 9 gives the results for the HOMER solutions:

Table 9: Town Electricity Supply Costs ($US)

System Configuration (kW)	Cost/kWh	Initial Investment
1 wind (15/50) + diesel (225) + battery	0.277	779,000
2 wind (15/50) + hydro (43) + diesel (225) + battery	0.294	854,000

Notes: Assumed fuel price of $0.80/liter for diesel, discount rate of 11.5%.
In system 1 wind supplies 54% of the electricity,
In system 2 wind supplies about 50% and hydro 4%.

Unless the hydro source is very good, the least-cost solution excludes it as a component. No all-diesel systems were found among the least-cost solutions.

A full cost-recovery supply of electricity for industrial, commercial, and residential consumption of electricity will probably cost at least $0.18-20 per kWh or more with a village supply system operating on a stand-alone basis.

Construction of village systems may make sense, provided funds are available, as a method of (1) providing electricity supply to areas too remote to expect a grid extension in the next few years; (2) as a way of capitalizing on donor programs to provide self-contained systems where there are beneficial uses for the electricity; and (3) where grid extension will come within 10-5 years but where the economic benefits of a self-contained system outweigh the costs of waiting for less expensive grid supply.

It should also be noted that the diesel component of a system can be moved to a new location once the grid is connected to a town or village. Given the substantial potential for either wind or hydro throughout the Western Region of the country, it is certainly possible to provide substantial inroads for renewable energy technology using hybrid generation for stand-alone systems.

2.2.1.3 Implications

The analysis and results shown above indicate that it will cost roughly $500,000-$1,000,000 to create economic opportunity for a village of 1,500. The joint provision of electricity and the economically beneficial means to use that electricity could generate hundreds of thousands of dollars annually in additional processed wood output. Currently, the country is a net exporter of wood and wood products but is suffering from rapid deforestation. With a locally based wood products industry, there might be incentives at the local level to harvest wood on a more sustainable basis. Moreover, organized sawmills could also start to produce charcoal with the waste cuttings, reducing the use of prime timber for household fuel.

A sawmill can be a good investment, even for a region far from the country's export customers. With a value for a cut 20 m hardwood tree of about 10% of its US value, and assuming the mill can process 20 logs of this type each year, the mill can cover all of its costs, including labor and whole log supply and earn a profit of about $17,000 (on sales of about $50,000). Under such circumstances, it does not appear to be worthwhile to wait for grid supply. Indeed, the sawmills could pay for the household and school electricity (a very small increment) and still find net profits of more than $14,000.

The real hurdle is finding enough money to jointly fund both the electricity system and the investment in the sawmills and the log supply systems. This will probably need to be done using donor funding.

2.2.3 EASTERN PROVINCE: WATER PUMPING AND AGRO-PROCESSING

2.2.3.1 Electricity Demand

The Eastern Province of Zambia is proximate to the borders and markets of Mozambique and Malawi. The area is far more densely populated than is the Western Province and contains far more industry as well. The map in Figure 12 shows the region of interest. Although this region is supplied with electricity through an existing HV line, and there is local hydro-based generation of electricity, the Figure 13 map shows that the schools in the region are largely unelectrified.

Therefore, obtaining the added value of electricity services for water pumping or local processing of output is not currently possible.

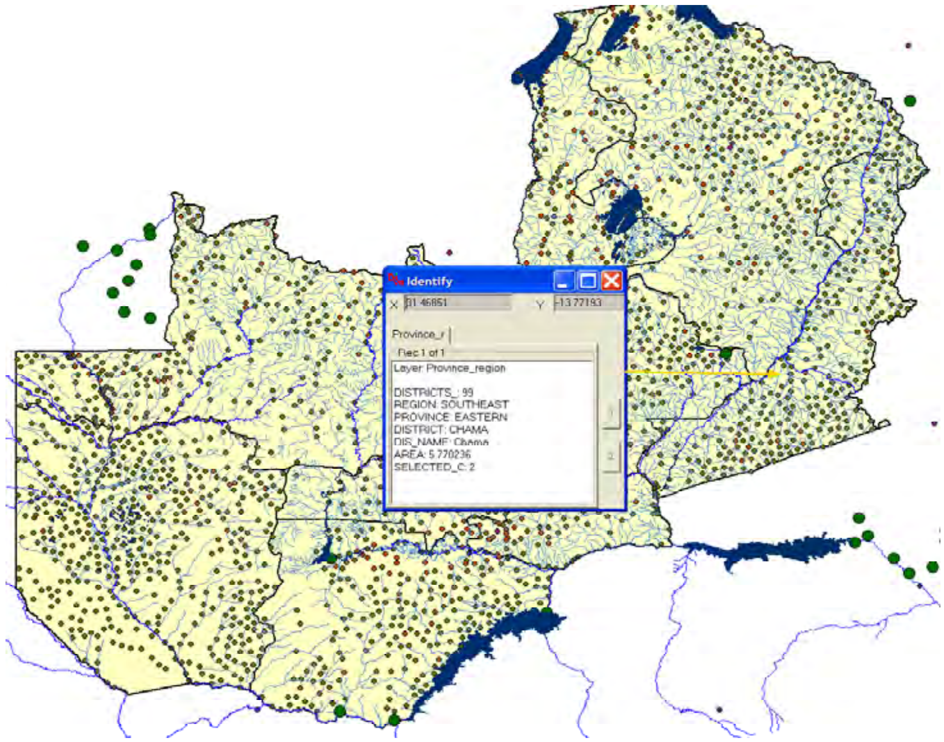


Figure 12: GIS Map of the Eastern Province with Major Town and Village Locations

Table 10: Household Characteristics in Eastern Province

Area Name	Households with access to electricity as %	Households with radio as %	Households with telephone as %	Households with television as %	Number of agricultural households Number	Population in agricultural households Number	Total households Number
Chadiza	1.76	37.56	0.28	2.37	15,147	76,655	15,928
Chama	0.38	27.62	0.13	0.35	13,800	67,388	14,397
Chipata	6.97	44.05	1.16	10.44	58,047	289,970	70,347
Katete	1.76	35.36	0.33	0.73	34,777	166,798	38,387
Lundazi	0.64	34.31	0.25	0.78	43,745	213,788	46,178
Mambwe	3.99	40.27	0.34	2.44	8,844	42,341	9,578
Nyimba	0.13	37.23	0.11	0.39	12,169	61,576	13,201
Petauke	1.94	36.87	0.31	1.18	44,591	216,529	46,587
Total (average)	**2.20**	**36.66**	**0.37**	**2.33**	**231,120**	**1,135,045**	**254,603**
National averages	**16.7**	**42.7**	**3.2**	**17.6**	**1,232,301**	**5,853,209**	**1,884,741**

Source: ZAMBIA_CENSUS00, Zambia 2000 Census of Population and Housing, CSO, 2003

Although the electrification rates in the province are below those of the Western Province, more households have radios, though fewer have telephones and televisions (Table 10). The Eastern Province is also important politically, as it contains roughly 20% of the nation's agricultural population.

According to the Ministry of Commerce Industrial Survey (2004), there are 16 major industrial enterprises in the Eastern Province. With two exceptions, these activities are located in the city of Chipata (Table 11).

Table 11: Key Industries in Eastern Province

Name of the company	Type of Industry	Location
Super Garage and Millers	Metal products	Chadiza
Sikunya Oil Products Ltd.	Cordage rope and twine	Chipata
Chikunto Building Contractors	Construction	Chipata
Rainbow Milling	Grain mill products	Chipata
Supernova Brewing Corporation Ltd.	Brewery	Chipata
Clark cotton (Z) Ltd.	Spinning	Chipata
Chipata Bakers	Food	Chipata
Jambo Bakery	Food	Chipata
Kwacha Milling Company Ltd.	Grain mill products	Chipata
PC Workshop	Computer service	Chipata
Shawa Engineering Ltd.	Metal products	Chipata
Highway Baker and Confectioners	Food	Chipata
Mako Ni Mako Coffin Workshop	Furniture	Chipata
Chikutano Auto services	Auto service	Chipata
Lundazi Village Industries Service	Metal products	Lundazi
Chinkhombe Oil Millers	Food (Oil)	Chipata

As Table 11 shows, this province has a more varied and diverse industrial base than does the Western Province. Yet, in looking at the vast number of schools in the province without electricity, as shown in Figure 13, there appears to be significant scope for a local electricity supply for villages that are more than 50 km from the grid.

2.2.3.2 Electricity Supply

The main source of electric supply in this area is Lusiwasi Hydro Power Plant (12 MW) from which the power is supplied via 132 kV line to Msoro town, and then transmitted via 66 kV power lines that spoke out to Azele, Chipata, and Mfuwe towns. Parts of the province to the west of Azele do not have grid-supplied electricity, nor does the area to the south of the main provincial city of Chipata (arrow in Figure 12 points to Chipata). ZESCO anticipates installing a 40 MW extension of the Lusiwasi hydro station. However, some of that output is destined for sale to Malawi via a 132 kV line now under study. In any event the new supply is all to the north of the densely populated farming communities along the Mozambique border region.

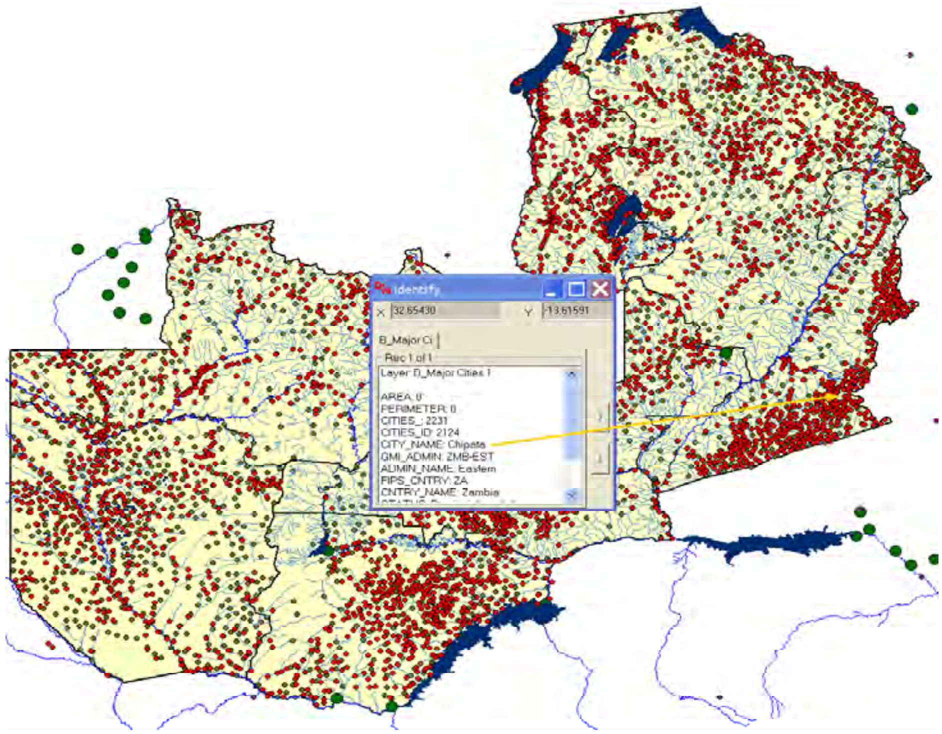


Figure 13: Schools without Electricity in Eastern Province

2.2.3.3 Adding Value in Local Agriculture

A project to fully irrigate local agriculture, adding two small (100 kg/day) grain mills using local electricity supplies, could add more than $250/year to the average household income in a 250 household town. Tables 12 and 13 show the calculations for electricity supply and pumping and processing energy that would be involved in putting together a complete supply for a small town of about 1,200-1,500 people.

Table 12: Individual Household/device Demand Characteristics

Parameters	kWh/mo	peak (kW)
Household Demand	25.2	0.175
Commercial Demand	72	0.5
Processing Demand	2376	10
Agro Pumping Demand	224.64	2.4
School	118.8	0.5
Clinic	237.6	1

The peak demand for such a town would probably fall into the range of 190-200 kW in a month where both the pumps and the mills were operated. Table 13 shows the calculated demand for that area.

Table 13: Monthly Demand Characteristics					
Demand For Electricity	Demand/unit			Total Demand	
	kWh	kW	# Units	kWh	kW
Household	25	0.18	250	6,300	44
Commercial	72	0.50	15	1,080	8
Processing	2,376	10.00	2	4,752	20
Agro PumpIng	225	2.40	50	11,232	120
School	119	0.50	1	119	1
Clinic	238	1.00	1	238	1
Total for Town/Village				**23,720**	**193**

2.2.3.4 Electricity Supply Economics

It appears, from the GIS database and other information on solar insolation, that the local energy supply situation in an off-grid village will be far more attractive than was the case in the Western Province. In particular, there is adequate scope for both small hydro as well as solar electricity and grain drying.

Investigations using the HOMER model indicate that a mixed system, using a diesel base load supply with solar, wind or hydro, plus a converter and battery storage, can be economical relative to grid supplied electricity, if the local inhabitants are required to pay the full costs in both cases (Table 14). To meet a peak demand of more than 200 kW, a system configured as follows will be able to generate electricity for about US$ 0.20/kWh. The total investment cost for the electricity generating system will range from about $200,000 for a mostly diesel system, to more than $750,000 for a hybrid system. The net generation costs for the hybrid systems are far lower (US$ 0.20 v. 0.27) for the mostly renewable system. However, the initial costs for such a system are two to three times greater.

Table 14: System Configuration for Eastern Province

Prime Mover	Size (kW)
Diesel	225
Wind	30-60
Hydro	8
Solar	0-15
Total	263-300

Note: system uses 48 kW battery to store intermittent energy.

A hybrid system that uses all of the available local resources will cost more than $790,000 initially but will be able to generate more than 60% of its output with renewable resources, insulating the farmers from future fluctuations in fuel prices.

The economic benefits of this electricity supply would allow an approximately 40% increase in grain output, worth about $450,000 after processing. The costs of making use of such electricity and the additional agricultural inputs required to obtain higher crop yields (e.g., seed, fertilizer, herbicides) would work out roughly as shown in Table 15.

Table 15: Agricultural Net Benefits of Improved Irrigation and Processing/Milling

	Item	Unit	# per year	Value
Sales	0.20	kg	2250000	$450,000
Less:				
Salaries	1,000.00	per person	96	$96,000
Electricity	4,981.28	cost of electricity/month	12	$59,775
Equipment	35,250.00	total initial cost	1	$11,633
Other Inputs	0.08	seed, etc.	2250000	$168,750
Misc.	15% contingency			$50,424
Total Additional Costs				$386,582
Net				**$63,418**

Sources for Agricultural yield improvement data are: An Appraisal of Irrigated Temperate and Tropical Millet Varieties in the Semiarid region of Senegal, Tanou Ba, C. F. Yamoah Saliou Diangar, African Crop Sciences Journal, Vol. 8, No. 3, 2000; Bosma, Andries, and Sikuleka, George, Informal Irrigation In Zambia GRID, Issue 14, July, 1999; Tushaar Shah, Barbara van Koppen, Douglas Merrey, Marna de Lange, and Madar Samad, Institutional Alternatives in African Smallholder Irrigation: Lessons from International Experience with Irrigation; and Management Transfer, International Water Management Institute, Research Report Number 60.

As already calculated, this increase in net income is worth more than $250/household, a significant boost in a region where household incomes are less than $500 annually and a disproportionate number of poor and extremely poor inhabitants live.

The system can absorb significant cost increases and still return net benefits to the town's inhabitants. In particular, if the price of electricity were to reach 30 cents/kWh (US), then the net benefit would fall to less than $35,000, still more than $135 more net income per household.

In a region that is potentially rich in small hydro sites, it is possible to extend the grid to the village or town. However, such a grid extension would probably not result in higher incomes for many years, since most households would not be able to take advantage of the new power supply by investing in pumps of other new technologies without some additional assistance.

As in the case of the Western Province, the new electricity supply is envisioned as a part of an overall package of financial assistance for economic as well as energy development of a small town or cluster of villages. This type of program is essential to making beneficial use of the new supply of electricity.

2.2.3.5 Implications

The results of the preceding analysis indicate that it will cost roughly $400,000-$750,000 to put an agricultural village of 1,500 on its way to a higher value-added, higher yield, and more viable long term trajectory. The joint provision of electricity and the economically beneficial means to use that electricity could generate more than $400,000 annually in additional agricultural production. In addition, with electricity to run cold storage, the region might be able to take advantage of the export of higher-value commodities to Europe, now done almost exclusively in the Lusaka region. Currently, the country is a net exporter of commodities. However, the agricultural sector has yet to take full advantage of the opportunities created by Zimbabwe's decline as an agricultural nation, both for staples and for more exotic crops. With a more advanced level of agricultural technology and processing, there should be greater incentives to abandon the vestiges of shifting agriculture in favor of a more sustainable combination of high-yield crops, irrigation and light processing.

Households will be the main beneficiaries of an improved local economy and electricity supply situation. Without an economically beneficial use for new electricity supplies, it is unlikely that small villages in the Eastern Region will receive power any time in the near future. However, with pumping and processing accounting for more than two-thirds of the local power generation, it should be possible to justify the financing of a 200-250 kW system. Unlike household-based rural electrification, a distributed system organized around economically beneficial uses of power should be (1) financeable; (2) sustainable; and (3) attractive candidates for grid extension when it becomes proximate and feasible.

Providing more water for agriculture can allow farmers to increase output significantly, and even add one more crop to their rotations. The addition of processing of local output should allow farmers to cut spoilage and losses, further improving incomes. As envisioned, the additional value crated by electrification of pumping and processing could allow free supply of electricity houses and schools, improving education and health services in the process. A sawmill can be a good investment, even for a region far from the country's export customers. The real hurdle is finding enough money to jointly fund both the electricity system and the investment in the sawmills and the log supply systems. This will probably need to be done using donor funding.

3. The Way Forward: Findings and Recommendations

This report provides an approach for using RRA for rural electrification planning. Moreover, the report team's interaction with REA and other Government bodies demonstrate how RRA can be used to incorporate the development of local economic activity, which is the goal of rural electrification in Zambia. Two tools were used in this RRA – HOMER and DIVA – that are well suited to the task. They require minimum data, are easy to use, and provide robust analyses. REA staff has become familiar with the models through this exercise. Finally, the report lays out the data requirements and methods for collecting this data.

Finding 1: ***Rapid Resource Assessment can be a valuable tool in helping the REA identify, evaluate, and rank potential sites and technologies for rural electrification.*** RRA is more cost effective and quicker than traditional rural electrification planning techniques. Moreover, the strengths of this approach reinforce the intent of Zambia's Global Village Energy Partnership – the integration of rural electrification with other development activities and the involvement of local stakeholders. The one weakness identified in this exercise was the lack of local site information available economically.

Recommendation 1: ***REA can begin using these tools to collect data, analyze sites, and rank them.*** Involving the local communities in the process at the time of data collection and analysis will help to insure their involvement in project implementation. This involvement can only reduce costs, strengthen the probability of success, and ensure more effective integration of rural electrification schemes into local and national economic development.

Finding 2: ***Sufficient data exists for REA to conduct preliminary analyses and rankings.*** Although the project team was unable to obtain all the available data, it was able to obtain sufficient data to demonstrate how these tools can be effectively used in moving rural electrification planning beyond the traditional methods.

Recommendation 2: ***REA can work closely with other Government bodies to collect additional data that will enhance the RRA results.*** This data includes:

- Detailed feasibility studies (from the supply side only) that have already been conducted;
- Planning data on schools which will be electrified;
- Information on commerce and industrial activity;
- ZESCO transmission network; and
- Resource data, such as wind speed, water flow, and solar radiation.

From local communities, the REA can work to collect site-specific data, such as distance from the resource to the community, household income, other household economic activity, and topography.

Finding 3: ***The REA is now equipped with tools that will allow it to move forward to quickly screen and rank potential sites.*** The results of these analyses are invaluable to potential project sponsors. Rural electrification costs and chances of success will be enhanced if REA makes the tools and the results of their analyses available to interested parties.

Recommendation 3: ***REA can make copies of the RRA screenings and analyses available to interested communities and potential project sponsors.***

Finding 4: ***RRA can be an effective tool for more than rural electrification.*** Rural economic development is still a challenge and integrated rural development is one method that is showing promise. Throughout its work, the project team found many examples where one agency was working on an area that complemented the work of another agency, yet neither knew of the overlap. This was also found for data collection and use. For example, the Ministry of Education has collected very detailed data on schools that could be of great use to electricity planners, and the Ministry of Commerce has collected data on industrial activity in rural areas. One donor was funding GIS data on ZESCO's transmission network, yet others were unaware its activities.

Recommendation 4: ***REA can act as a catalyst in GIS information dissemination and in rural development while furthering its own objectives.*** Proper use of RRA and the two accompanying models requires REA to continuously interact with other Government agencies, donors, and the local development community. In so doing, it can be the catalyst for developing a community of rural development specialists that share data, analytical methods, and tools. The DIVA database developed by REA can be an effective source of data and an effective tool for other Government planners.

BIBLIOGRAPHY

1. "Angola at a Glance," World Bank, 2001. http://www.worldbank.org/data/countrydata/pdf.
2. "Angola Data Profile," World Bank, 2000. http://devdata.worldbank.org.
3. "Angola Economy," Countrywatch, 2000. http://www.countrywatch.com.
4. "Angola Energy," Countrywatch, 2000. http://www.countrywatch.com.
5. "Angola," Energy Information Administration, 2000. http://www.eia.doe.gov/emeu/cabs/angola.html.
6. "Angola: Electrical Power," MBendi, 2001. http://www.mbendi.co.za/indy/powr/af/an/p0005.htm.
7. "Botswana at a Glance," World Bank, 2001. http://www.worldbank.org/data/countrydata/pdf.
8. "Botswana Data Profile," World Bank, 2000. http://devdata.worldbank.org.
9. "Botswana Economy," Countrywatch, 2000. http://www.countrywatch.com.
10. "Botswana Energy," Countrywatch, 2001. http://www.countrywatch.com.
11. "Botswana," Central Intelligence Agency, 2001. http://www.odci.gov/cia/publications/factbook/geos/bc.html.
12. "Botswana," Energy Information Administration, 1998. http://www.eia.doe.gov/emeu/world/country/cntry_BC.html.
13. "Climate Change Mitigation in Southern Africa: Botswana Country Study," 1999. UNEP Collaborating Centre on Energy and Environment, Risø National Laboratory, Denmark.
14. "Climate Change Mitigation in Southern Africa: Tanzania Country Study," 1999. UNEP Collaborating Centre on Energy and Environment, Risø National Laboratory, Denmark.
15. "Climate Change Mitigation in Southern Africa: Zambia Country Study," 1999. UNEP Collaborating Centre on Energy and Environment, Risø National Laboratory, Denmark.
16. "Congo (Kinshasa)," Energy Information Administration, 1998. http://www.eia.doe.gov/emeu/world/country/cntry_CG.html.
17. "Congo, Dem. Rep. at a Glance," World Bank, 2001. http://www.worldbank.org/data/countrydata/pdf.
18. "Congo, Democratic Republic Data Profile," World Bank, 2000. http://devdata.worldbank.org.
19. "Country Perspective on Rural Electrification." 1998. Presented at Village Power '98: Scaling Up Electricity Access for Sustainable Rural Development (October 6-8, 1998, Washington, DC). Zimbabwe Electricity Supply Authority (ZESA).
20. "Developments," Renewable Energy Information Network of Namibia, Polytechnic of Namibia, Windhoek, 2000. http://www.polytechnic.edu.na/reinnam/Developments.htm.
21. "Distributed Generation from Base load to Backyard", Chapter 20, International Electric Power Encyclopedia, PennWell, 1999.
22. "DR Congo Economy," Countrywatch, 2000. http://www.countrywatch.com.
23. "DR Congo Energy," Countrywatch, 2000. http://www.countrywatch.com.
24. "Electrical Power Transmission in Southern Africa," ESKOM, 2001. http://www.mbendi.com/eskomenterprises/powerpages/saf_transmission.h tm.
25. "Electricity [Namibia]," Investment Promotion Network (IPANET), World Bank, 1991. http://www.ipanet.net/documents/WorldBank/databases/namibia/na1iec01. html.

26. "Electricity," Chapter 5. In Energy in Africa. Energy Information Administration (EIA), 1999. http://www.eia.doe.gov/emeu/cabs/chapter5.html.
27. "Energy Issues in Africa: The ENDA Energy Programme," Environment Liaison Centre International, Nairobi, Kenya (ELCI), http://www.elci.org/energy/EIssues.htm. No date.
28. "Energy Resources on Gender," UN Commission on Sustainable Development, 2000. http://www.earthsummit2002.org/workshop/energyres.htm.
29. "Energy. Coordinated by Angola," 2000. http://www.sadcreview.com/sectoral%20reports%202001/energy.htm.
30. "Environment and Renewable," Chapter 7. In Energy in Africa. Energy Information Administration (EIA), 1999. http://www.eia.doe.gov/emeu/cabs/chapter7.html.
31. "Eskom Unveils Its New Plan to Restructure," Business Day (Johannesburg) 10/1/2001. http://allafrica.com/stories/200110010307.html.
32. "Factsheet No#2: Energy Resources," Musokotwane Environment Resource Centre for Southern Africa. http://www.sardc.net/imercsa/zambezi/zfsheet/zfsheet02.html. No date.
33. "Future Energy Requirements for Africa's Agriculture: Findings and Recommendations of an FAO Study," Environment Liaison Centre International, Nairobi, Kenya (ELCI), http://www.elci.org/energy/EnergyAfrica.htm. No date.
34. "Implementation strategy to reduce environmental impact of energy related activities in Zimbabwe," 1997. Working Paper No. 5. Risø National Laboratory, Denmark. UNEP Collaborating Centre on Energy and Environment. http://www.uccee.org/Workpapers/wpaper5.htm.
35. "Lesotho at a Glance," World Bank, 2001. http://www.worldbank.org/data/countrydata/pdf.
36. "Lesotho-Utilities Sector Reform Project," World Bank, 2000. Project No. PID9217. http://www-wds.worldbank.org/cgi-bin/cqcgi/@production.env?
37. "Malawi at a Glance," World Bank, 2001. http://www.worldbank.org/data/countrydata/pdf.
38. "Malawi Data Profile," World Bank, 1999. http://devdata.worldbank.org.
39. "Malawi Economy," Countrywatch, 2000. http://www.countrywatch.com.
40. "Malawi Energy," Countrywatch, 2001. http://www.countrywatch.com.
41. "Malawi," Central Intelligence Agency, 2000. http://www.odci.gov/cia/publications/factbook/geos/mi.html.
42. "Malawi," Energy Information Administration, 1998. http://www.eia.doe.gov/emeu/world/country/cntry_MI.html.
43. "Malawi-Power VI," World Bank, 1995. http://www-wds.worldbank.org/cgibin/ cqcgi/@production.env [2001]
44. "Mauritius at a Glance," World Bank, 2001. http://www.worldbank.org/data/countrydata/pdf.
45. "Mauritius Data Profile," World Bank, 1999. http://devdata.worldbank.org.
46. "Mauritius Economy," Countrywatch, 2000. http://www.countrywatch.com.
47. "Mauritius Energy," Countrywatch, 2000. http://www.countrywatch.com.
48. "Mauritius," Central Intelligence Agency, 2000. http://www.odci.gov/cia/publications/factbook/geos/mp.html.
49. "Mauritius," Energy Information Administration, 1998. http://www.eia.doe.gov/emeu/world/country/cntry_MP.html.
50. "Mozambique - Electricity Tariffs Study Document Type: ESMAP Paper," World Bank, 1995. http://wwwwds. worldbank.org/servlet/WDSServletpcont.
51. "Mozambique - The African Development Fund Approves a US $ 14 Million Loan to Finance the Rural Electrification Project (Electricity Iii Project) in Mozambique Electricity Tariffs Study Document Type: Sap Paper," African Development Bank (ADB), 2001. http://www.afdb.org/knowledge/pressreleases2001/adf_55_2001e.htm.

52. "Mozambique at a Glance," World Bank, 2001. http://www.worldbank.org/data/countrydata/pdf.
53. "Mozambique Data Profile," World Bank, 1999. http://devdata.worldbank.org.
54. "Mozambique Economy," Countrywatch, 2000. http://www.countrywatch.com.
55. "Mozambique Energy," Countrywatch, 2000. http://www.countrywatch.com.
56. "Mozambique," Energy Information Administration, 1998.
57. "Mozambique: Electrical Power," MBendi, 2001. http://www.mbendi.co.za/indy/powr/af/mz/p0005.htm.
58. "Mozambique: Private Participation in Isolated Electrified Grids," Findings, Africa Region, No. 62, March 2001. World Bank.
59. "Mozambique-Energy Reform and Access," Project No. MZPE69183. World Bank, 2001.
60. "Namibia at a Glance," World Bank, 2001. http://www.worldbank.org/data/countrydata/pdf.
61. "Namibia Data Profile," World Bank, 1999. http://devdata.worldbank.org.
62. "Namibia Economy," Countrywatch, 2000. http://www.countrywatch.com.
63. "Namibia Energy," Countrywatch, 2000. http://www.countrywatch.com.
64. "Namibia," Central Intelligence Agency, 1999. http://www.odci.gov/cia/publications/factbook/geos/wa.html.
65. "Namibia," Energy Information Administration (EIA), 1998. http://www.eia.doe.gov/emeu/world/country/cntry_WA.html.
66. "Project Experience," 1999. http://www.edg.co.za/project%20experience%20and%20references.htm#_project_experience.
67. "Renewable Energies in South Africa," Part I and II. Department of Minerals and Energy, South Africa. http://www.dme.gov.za/energy/restrategy_part3.htm. No date.
68. "Renewable Energy and Integrated Resource Planning," K. Porter, Proceedings of Solar ‘92, Cocoa Beach, Florida, June 15-18, 1992, pp. 370-73.
69. "Rural Electrification in South Africa", Project Brief, Renewables for Sustainable Village Power (RSVP), NREL, 1998.
70. "Seychelles at a Glance," World Bank, 2001. http://www.worldbank.org/data/countrydata/pdf.
71. "Seychelles Data Profile," World Bank, 1999. http://devdata.worldbank.org.
72. "Seychelles Economy," Countrywatch, 2000. http://www.countrywatch.com.
73. "Seychelles Energy," Countrywatch, 2000. http://www.countrywatch.com.
74. "Seychelles," Central Intelligence Agency, 2000. http://www.odci.gov/cia/publications/factbook/geos/se.html.
75. "Seychelles," Energy Information Administration (EIA), 1998. http://www.eia.doe.gov/emeu/world/country/cntry_SE.html.
76. "South Africa at a Glance," World Bank, 2001. http://www.worldbank.org/data/countrydata/pdf.
77. "South Africa Data Profile," World Bank, 1999. http://devdata.worldbank.org.
78. "South Africa Economy," Countrywatch, 2000. http://www.countrywatch.com.
79. "South Africa Energy," Countrywatch, 2001. http://www.countrywatch.com.
80. "South Africa," Central Intelligence Agency, 2001. http://www.odci.gov/cia/publications/factbook/geos/sf.html.
81. "South Africa," Energy Information Administration, 2000. http://www.eia.doe.gov/emeu/cabs/safrica.html.
82. "Southern Africa Development Community," Energy Information Administration, 2001. http://www.eia.doe.gov/emeu/cabs/sadc.html.
83. "Swaziland at a Glance," World Bank, 2001. http://www.worldbank.org/data/countrydata/pdf.

84. "Swaziland: Household Energy Strategy Study," Report No. 198/97. Energy Sector Management Assistance Programme (ESMAP), 1997.
85. "Tanzania at a Glance," World Bank, 2001. http://www.worldbank.org/data/countrydata/pdf.
86. "Tanzania-Privatization and Private Sector Development," Project No. PID8083. World Bank, 1999.
87. "Technology Cooperation Agreement Pilot Project (TCAPP)," National Renewable Energy Laboratory (NREL), 2000. http://www.nrel.gov/tcapp/april_2000_tcapp_newsletter.html#UPCOMING TCAPP.
88. "Updates of Privatizations in South Africa and Africa," Investment Promotion Network, World Bank. http://www.ipanet.net/documents/WorldBank/databases/busmap/DF_collat ion.htm. No date.
89. "Utilities Sector Reform Project," Environmental Review. Main Report. Kingdom of Lesotho. Lesotho Electricity Corporation. World Bank, 2000. http://www-wds.worldbank.org/cgi-bin/cqcgi/@production.env?
90. "White Paper on the Energy Policy of the Republic of South Africa," Environment Liaison Centre International, Nairobi, Kenya (ELCI), 1998. http://www.elci.org/energy/WhitePaper.htm.
91. "Zambia at a Glance," World Bank, 2001. http://www.worldbank.org/data/countrydata/pdf.
92. "ZESA Seeks Greenlight for 30 Percent Tariff Hike," Financial Gazette (Harare) 10/12/2001. http://allafrica.com/stories/200110120479.htm.
93. "Zimbabwe at a Glance," World Bank, 2001. http://www.worldbank.org/data/countrydata/pdf.
94. "Zimbabwe-Power Sector Reform Program-APL Phase 1-Power Sector Reform Project." Project No. PID9354. World Bank, 2000
95. Abdullah, Dr. Haji Ahmad, Hassan, Dr. Ibrahim and Mohammad Awang Damit, 1998. Masterplan on Natural Gas Utilisation and Development in the ASEAN Region: ASEAN Energy Journal, Vol.1, No. 2, 1998, pp. 179-
96. Ahluwalia, Sanjeev S. 2000. Power Sector Reforms: A Review of the Process and an Evaluation of the Outcome. New Delhi: Prepared for National Council of Applied Economic Research.
97. Ahmad, Datuk Dr. Tajuddin Ali, 1997. Development of ASEAN Power Grid: ASEAN Energy Journal. Vol.1, No.3, 1998, pp. 57-68.
98. Alam, Manzoor, Jayant Sathaye, and Douglas Barnes. 1998. “Urban Household Energy Use in India: Efficiency and Policy Implications,” Energy Policy, 26(No. 11, 1998) pp. 885-891.
99. Albouy, Y., Performance Monitoring for the Energy Sector, The World Bank, December 1999
100. Aqua-Media International Ltd., 1997. "The status of dams and hydropower development in 1997." Reproduced in The International Journal of Hydropower and Dams.
101. ASEAN Centre for Energy, 1999. ASEAN Plan of Action for Energy Cooperation 1999-2004. ASEAN Senior Officials Meeting on Energy (SOME) of the 17th ASEAN Ministers of Energy Meeting, 1-2 July 1999, Bangkok.
102. Asian Development Bank. 1999. Bank Policy Initiatives for the Energy Sector Asian Development Bank, February 1994 [cited July 1999].
103. Awerbuch 1996: Awerbuch, S., ed., "Valuing the Benefits of Renewables", Energy Policy, Special Issue, 24 (2), 1996.
104. Bacon, R.W. 1995. Privatization and Reform in the Global Electricity Supply Industry. Annual Review of Energy and Environment 20:119-143.

105. Balce, G.R., 1998. Pole-Vaulting Programme of the Energy Sector; Department of Energy, Metro Manila, Philippines, Unpublished.
106. Barnes, Douglas F. 1988. Electric Power for Rural Growth: How Electricity Affects Rural Life in Developing Countries. Rural Studies Series. Boulder, Colorado: Westview Press.
107. Barnes, Douglas F., and Jonathan Halpern, eds. 2000. The Role of Energy Subsidies. Edited by E. S. M. A. Program, Energy Services for the World's Poor. Washington D.C.: World Bank.
108. Barnes, Douglas F., Energy and Poverty: Strategies for Assisting the Rural Urban Poor, The World Bank, 2000.
109. Barnes, Douglas F., Willem M. Floor. Rural Energy in Developing Countries: A Challenge for Economic Development, The World Bank, 1996.
110. Barnes, Douglas, Kerry Krutilla and William Hyde. 1999. Urban Energy Transitions: Energy, Poverty and the Environment In the Developing World. World Bank Draft Manuscript.
111. Barua, Dipal C. "Grameen Shakti's Activity" Proceedings of World Renewable Energy Congress V, 20-25 September 1998 Florence, Italy, pp 2811-2816
112. Barua, Dipal C. Micro-Lending and Rural Economic Development: Lessons from Grameen Bank, Proceeding of "The Earth Technologies Forum" pp 65-74, International Climate Change Conference, 26-28 October'98.
113. Barua, Dipal C., "Energy's Role in rural Income Generation: The Grameen Strategy", Presented in the "Village Power Workshop, 1998" in Washington.
114. Besant-Jones, John, 1995. Attracting Finance for Hydroelectric Power. The World Bank Group, FPD Energy Note No. 3,
115. Bose, Sarmila, 1993. Money, Energy and Welfare. Delhi: Oxford University Press. New Delhi.
116. Bouille, Daniel, and Hilda Dubrovsky. 2000. Reform of the Electric Power Sector in Developing Countries: Case Study of Argentina. Buenos Aires: Institute of Energy Economics, Fundacion Bariloche.
117. Cabrera, R.E., 1992. Rural Electrification in the Philippines: In Rural Electrification Guidebook for Asia and the Pacific; Asian Institute of Technology, Bangkok, 1992, pp. 439-454.
118. Casten et al. 1997: S. Casten, M. Laser, J. Romero, B. Hirokawa, J. Braciak, R. Ross, R. G. Herst, and L. Lynd: "Costs and features of advanced biomass ethanol/electricity generation technology". Poster paper presented at Making a Business from Biomass in Energy, Environment, Chemicals, Fibers, and Materials, Third Biomass Conference of the Americas, Montreal, Canada, 24-29 August 1997.
119. Cavallo 1995: A. Cavallo, "High capacity factor wind energy systems", Journal of Solar Engineering, 117, 1995, 137-143.
120. Celelski, E., Enabling Equitable Access to Rural Electrification: Current Thinking and major Activities in Energy, Poverty and Gender, The World Bank, January 2000.
121. Chella Rajan, Sudhir. 1998. The Role of Independent Democratic Regulation in the Power Sector: Some Principles. Paper read at 12th Annual Conference of the Electrical Power Supply Industry Workshop, November 2-5, at Pattaya.
122. Cohen 1997: J. Cohen, Summary of Large HAWTs in Windfarms Technology Characterization. (Princeton Economic Research, Inc., Rockville, Md.) Prepared for the NREL under Subcontract No. AAT-6- 15292-01, June 1997
123. Covarrubias, Alvaro J., and Kilian Reiche, eds. 2000. A Case Study on Exclusive Concessions for Rural Off-Grid Service in Argentina. Edited by E. S. M. A. Program, Energy Services for the World's Poor. Washington D.C.: World Bank.
124. De Laquil et al. 1993: P. De Laquil, D. Kearney, M. Geyer, and R. Diver, "Solar-thermal electric technology", in Renewable Energy: Sources for Fuels and Electricity,

Johansson, T.B., H. Kelly, A.K.N. Reddy, and R.H. Williams (eds.), (Washington, DC: Island Press, 1993)
125. Department of Energy, 1998. Philippine Energy Plan 1999-2008; Energy Planning and Monitoring Bureau, DOE, Metro Manila, Philippines.
126. Department of Energy, 1999. Energy Resources for the Alleviation of Poverty (ERAP) Programme Framework; EUMB, DOE, Metro Manila, Philippines, Unpublished draft.
127. Department of Energy, 1999. Guide to Minihydro power Development in the Philippines; Minihydro Division, EUMB, DOE, Metro Manila, Philippines.
128. Dewan A. H. Alamgir, "Application of Photovoltaics System as an Alternative Sources of Electricity for Rural Areas in Bangladesh": Prospects and Challenges, Proceedings of IEB Conference March '99, pp 94-100.
129. Dewan A. H. Alamgir, "Utilisation of Wind Energy of Coastal Areas of Bangladesh by Using Hybrid Energy System for the Coastal Regions of Bangladesh", Proceedings of NSURAESD'98, pp 107-126.
130. DGEED, Indonesia. Statistic and Information on Electricity and Energy, 1999
131. Domdom, A. C., Abiad, V. G., Paimio H.S., Rural Electrification Benefit Assessment Study (Draft), The World Bank, September 1999.
132. Domdom, Aleta, Virginia Abiad, and Harry Pasimio, 2000. "Rural Electrification Benefit Assessment Study: The Case of the Philippines," ESMAP Draft Report, World Bank, Washington, DC.
133. Duff, Winston, and O'Gallagher, "Cooling of Commercial Buildings with ICPC Solar Collectors", Solar Engineering, Vol. 2 ASME, 1995.
134. Elauria, J., 1998. Status, Plans and Opportunities of New and Renewable Energy in the Philippines: In Proceedings of the Conference and Roundtable Discussion/Workshop on New and Renewable Energy Resources: Pole Vaulting Towards Sustainable Energy Development; Department of Energy, 1998, Attachment B, Unpublished.
135. Electricity Regulatory Journal (April, June, October, December 2000; March, April, May, June 2001). National Electricity Regulator (NER, South Africa).
136. Ellegard, Anders, and Mattias Nordstrom, 2001. "Rural Energy Service Companies-Experiences from Zambia." Stockholm Environment Institute (SEI). http://www.sei.se/energy/pvesco/PV%20ESCOs%20phase%20I%20final %20report.pdf.
137. Electrical Safety Code – Code of Practice, Zambia Bureau of Standards, DZS 418: Part1.
138. Energy survey for SPV power plants by SESI (Eastern Region Chapter)
139. Energy for Rural Development in Zambia, Proceedings of a National Policy Seminar, Sida/SAREC and AFREPREN/FWD, October 2000.
140. ESMAP, 1990. "Indonesia: Urban Household Energy Strategy Study — Main Report," ESMAP Report No. 107A/90, World Bank.
141. ESMAP, Energy Services for the Poor: Energy and Development Report 2000, The World Bank, 2000.
142. ESMAP. 1991. "Bolivia Prefeasibility Evaluation Rural Electrification and Demand Assessment," Energy Management Assistance Program, World Bank, Washington, DC.
143. ESMAP. 1994. Ecuador Energy Pricing, Poverty and Social Mitigation, Energy Management Assistance Program, World Bank, Washington, DC.
144. ESMAP. 1999. India: Household Energy Strategies for Urban India: The Case of Hyderabad. Joint UNDP/ESMAP Report 214/99, World Bank, Washington, DC.
145. ESMAP. 1999. Lao PDR: Institutional Development for Off-Grid Electrification, Joint UNDP/ESMAP Report 214/99, World Bank, Washington, DC.

146. ETSU, United Kingdom Department of Trade and Industry, RE Reviews, April 1994, February 1995), Renewable Energy Bulletin, December 1995.
147. Export Strategy for Renewables An Interview with Muhammed Yunus, the founder of the Grameen Bank in Bangladesh
148. Facts of Zambia, CIA World Factbook 2002, World Development Indicators Database, EIU Country Profiles, Estimated figures, CIA 2002
149. Financing Large-Scale Increases in Pv Production Capacity Through Innovative Risk-Management Structures and Contracts by Eric Ingersoll, Robert Dimatteo, and Romana A. Vysatova http://www.repp.org/article
150. Fitzgerald, K., D. Barnes, and G. McGranahan. 1990. “Interfuel Substitution and changes in the Way Households Use Energy: The Case of Cooking and Lighting Behavior in Urban Java.” Industry and Energy Department Working Paper, Energy Series Paper No. 29, World Bank, Washington, D.C.
151. Foley, G. 1992. Alternative Institutional Approaches to Rural Electrification Guidebook for Asia and the Pacific; Asian Institute of Technology, Bangkok, 1992, pp. 71-90.
152. Food and Agriculture Organization, 1997. FAOSTAT Statistics Database. On the internet at:. Rome, Italy: FAO.
153. Forest et al. 1997: H. Forest and G. Braun, "Renewable energies: are we on track?" Paper presented at the 1997 Environment Northern Seas Conference, Stavanger, Norway, 28 August 1997.
154. Geche, John, and Julia Irvine, 1996. "Photovoltaic Lighting in Rural Botswana: A Pilot Project," Stockholm Environment Institute (SEI), Renewable Energy for Development, Vol. 9, No. 2, Sep. 1996. http://www.sei.se/red/red9609e.html.
155. Gipe, Paul, Wind Power Renewable Energy for the 1990s and Beyond, Chelsea Green Publishing Company, 1993.
156. Goldemberg, J., Johansson, T.B., edited, Energy as an Instrument for Socio-Economic Development, UNDP, 1995.
157. Government Procurement to Expand Pv Markets by Joel Stronberg And Virinder Singh
158. Grubb et al. 1993: M.J. Grubb and N.I. Meyer: "Wind energy: resources, systems, and regional strategies" in Renewable Energy: Sources for Fuels and Electricity, Johansson, T.B., H. Kelly, A.K.N. Reddy, and R.H. Williams (eds.) (Washington, DC: Island Press, 1993).
159. G.S. Hamutwe, Solar Power in Namibia, February, 1999
160. Heruela, C.S., 1993, Rural Energy Systems in the Philippines: In Rural Energy Systems in the Asia-Pacific; Asian and Pacific Development Centre, Kuala Lumpur, 1993, pp.451-506.
161. Hills, O'Keefe and Snape, The Future of Energy Use, Earthscan, 1995
162. http://www.eia.doe.gov/emeu/world/country/cntry_MZ.html.
163. Hybrid Systems for Village Power Development in the U.S. Larry Flowers, National Renewable Energy Laboratory
164. Iwayemi, Akin. "Energy Sector Development in Africa," http://www.elci.org/energy/Energization.htm. No date.
165. Issues and Options for Rural Electrification in Zambia, CORE International, Inc., Report to USAID, 2002.
166. Jennifer L. Edwards*, Chris Marnay, Emily Bartholomew, Boubékeur Ouaglal, Afzal S. Siddiqui, and Kristina S. H. LaCommare, “Assessment of µGrid Distributed Energy Resource Potential Using DER-CAM and GIS”, Ernest Orlando Lawrence Berkeley National Laboratory, January 2002
167. J. L. Stone, H. S. Ullal, and E.V.R. Sastry, “The Indo- U.S. Cooperative Photovoltaic Project,” 26th IEEE Photovoltaics Specialists Conference, Sept.30-Oct.3, 1997, Anaheim, CA, pp. 1273-1275.

168. J.L. Stone and H. S. Ulal, “PV Opportunities in India,” 13 NREL Photovoltaics Program Review, Lakewood, CO, 1995, pp. 275-280, AIP Conference Proceedings 353.
169. J.L. Stone and H.S. Ullal, “The Ramakrishna Mission PV Project — a Cooperation between India and the United States,” NREL/SNL Photovoltaics Program Review, Proceedings of the 14 Conference—A Joint Meeting, the Lakewood, CO, 1966, pp. 521-527, AIP Conference Proceedings 394.
170. Jadresic, Alejandro, 2000. “Subsidies for Rural Electrification in Chile,” Draft Background paper for Energy and Poverty 2000, World Bank, Washington, DC.
171. Johanssen, Kelly Reddy, and Williams, Renewable Energy, Sources for Fuels and Electricity, Earthscan and Island Press, 1993.
172. Johansson et al. 1993: T.B. Johansson, H. Kelly, A.K.N. Reddy, and R.H. Williams, 1993: "Renewable fuels and electricity for a growing world economy: defining and achieving the potential" in: Renewable Energy - Sources for Fuel and Electricity, T.B. Johansson, H. Kelly, A.K.N. Reddy, and R.H. Williams (eds.), (Washington, DC: Island Press, 1993).
173. Karekezi, Stephen. "Renewable energy technologies as an option for a low-carbon energy future for developing countries: case examples from Eastern and Southern Africa," http://www.uccee.org/CopenhagenConf/karekezi.htm. No date.
174. Kelly et al. 1993: H. Kelly and C. Weinberg, 1993: "Utility strategies for using renewables", in Renewable Energy - Sources for Fuel and Electricity, Johansson, T.B., H. Kelly, A.K.N. Reddy, and R.H. Williams (eds.), (Washington, DC: Island Press, 1993).
175. Kozloff, Keith. 1998. Electricity Sector Reform In Developing Countries: Implications for Renewable Energy. Washington D.C.: Renewable Energy Power Project.
176. Laing, Cathy A. and Glynne Rosselli, 1998. "Energization: A Collaborative Application of Conventional Energy Resources For Energy Upliftment In Rural Communities,"
177. Laws Of The Republic Of Zambia, Volume 16, 1995 Edition (Revised)
178. Leeper, J. D., and Barich, J. T., "Technology for Distributed Generation in a Global Market Place", American Power Conference, Chicago, April 14- 16, 1998.
179. Liebenthal A S, Mathur S, Wade H. 1994. Solar Energy: Lessons from the Pacific Islands Experience. World Bank Technical Paper No. 224, Energy Series, Washington, D C: The World Bank.
180. Lovejoy D R. 1991. Experience with Village PV Systems in Pakistan. pp 1126–1129. 10th European Solar Energy Conference, Lisbon, Portugal, 8–12 April 1991.
181. Maduna, Dr. P.M., and S. Shabangu, 1998. "White Paper on the Energy Policy of the Republic of South Africa." Environment Liaison Centre International, Nairobi, Kenya (ELCI). http://www.elci.org/energy/WhitePaper.htm.
182. Marnay et al. 1997: C. Marnay, R.C. Richey, S.A. Mahler, and R.J. Markel (Energy Analysis Program, Lawrence Berkeley National Laboratory), 1997: "Estimating the environmental and economic effects of widespread residential PV adoption using GIS and NEMS", Paper presented at the 1997 ASES meeting, Washington, DC, May 1997.
183. Martens, J.W., T. de Lange, J. Cloin, S. Szewczuk, R. Morris, and J. Zak. "Accelerating the Market Penetration of Renewable Energy Technologies in South Africa." http://www.uccee.org/RETSouthAfrica. No date.
184. Martens, J.W., T. de Lange, J. Cloin, S. Szewczuk, R. Morris, and J. Zak. "Accelerating the Market Penetration of Renewable Energy Technologies in South Africa-Action Plan Summary." http://www.uccee.org/RETSouthAfrica. No date.
185. Mason M. 1990. Rural Electrification: A review of World Bank and USAID financed projects, draft background paper. April 1990.
186. Mintzer, Irving, Miller, Alan, Serchuk, Adam, The Environmental Imperative, Renewable Energy Policy Project Solstice, at http://solstice.crest.org/renewables/repp

187. Mkhwanazi, Xolani H. "Address to the National Power Forum 2000 by Xolani H. Mkhwanazi, Chief Executive of the National Electricity Regulator (NER), At Midland on 8 February 2000. http://www.ner.org.za/speeches/08022000NPF.htm.
188. Mock et al. (1998): J.E. Mock, J.W. Tester, and P.M. Wright, "Geothermal Energy From the Earth: Its Potential Impacts as an Environmentally Sustainable Resource," Annual Reviews of Energy and the Environment 22: 305-356 AR-039-10 (1998).
189. Modeling Renewable Energy Resources in Integrated Resource Planning, D. Logan, C. Neil, and A. Taylor, RCG Hagler, Bailly, Inc., 1994.
190. Models and Methods for Rural Electric Service, Daniel B. Waddle, NRECA International, Ltd., August, 1997
191. National Power Corporation, 1998. Power Development Programme (1998-2010); Corporate Planning Group; NPC, Diliman Quezon City, Philippines, Unpublished.
192. Nieuwenhout, F. P. van der Rijt, E. Wiggelinkhuizen, “Rural Lighting Services: A Comparison of Lamps for Domestic Lighting in Developing Countries,” Netherlands Energy Research Foundation, Netherlands.
193. Non-Grid Electricity Regulation: Towards Sustainable Rural Development, EU Synergy Workshop CSIR – Pretoria, NREL, February 2001.
194. O'Leary, Donal T., Jean-Pierre Charpentier, and Dianne Minogue. "Promoting Regional Trade-The Southern African Power Pool," Private Sector, Note No. 145, June 1998.
195. Operation Evaluation Department (OED), Rural Electrification: A Hard Look at Costs and Benefits, Precis No. 90, The World Bank, May 1995.
196. Philipson, L., and Willis, H. L., Understanding Electric Utilities and Deregulation, Marcel Dekker, 1988.
197. Policies to Support a Distributed Energy System by Thomas J. Starrs and Howard J. Wenger
198. Policy on Private Participation in the Power Sector, the Gazette of India, Extraordinary part I - section 1, published by authority, No. 237, New Delhi, Tuesday, October 22, 1991/Asvina 30, 1913, Ministry of Power and Non-conventional Energy Sources, [Department of Power], New Delhi, the 22nd October, 1991
199. Porter, James, 1994. "Manyana Pilot Project Evaluation," Renewable Energy for African Development, Baltimore, MD. http://fermi.udw.ac.za/renew/manyana/manyana.html.
200. Ramani, K. V, et. al. Rural Energy Systems in Asia-Pacific: APDC, Kuala Lumpur, Malaysia, 1993.
201. Ramani, K.V. 1993. Rural Energy Systems in the Asia-Pacific: Regional Overview and Country Profiles; Asian and Pacific Development Centre, Pesiaran Duta, Kuala Lumpur, Malaysia, p.17.
202. Reddy, A.K.N., Williams, R. H, Johansson, T.B., Energy After Rio: Prospects and Challenges, 1997.
203. Renewable Energy Technologies: A Review of the Status and Costs of Selected Technologies. Kulsum Ahmed. World Bank Technical Paper 240.
204. Revisiting Solar Power's Past by Charles Smith in Tech Review, July 1995.
205. Rinehart et al. 1997: B.N. Rinehart, J.E. Francfort, G.L. Sommers, G.F. Cada, and M.J. Sale, DOE Hydropower Program Biennial Report, U.S. Department of Energy, Idaho Operations Office, 1996-1997, (1997).
206. Rukato, Hesphina. 2001. "Gender and Energy in the South: A Perspective from Southern Africa," http://www.earthsummit2002.org/workshop/Gender%20and%20Energy%20S%20HR.txt.
207. Rural Electric Cooperatives IRP Survey, C. Garrick, National Renewable Energy Laboratory, 1995.

208. SESI (India) journal, vol. 8.Number -1,1998.Socio-economic evaluation of solar lanterns by Joysree Roy.
209. Shanker, A. and G.G. Krause, 1992. Decentralized Small-Scale Power Systems: In Rural Electrification Guidebook for Asia and the Pacific; Asian Institute of Technology, Bangkok, 1992, pp.243-300.
210. Smith, Kirk, 1987. Biofuels, Air Pollution and Health: A Global Review. New York: Plenum Press.
211. Solar Energy: Lessons from the Pacific Island Experience. Andres Liebenthal, Subodh Mathur, and Herbert Wade. World Bank Technical Paper 244.
212. Solar: Financing Household Solar Energy in the Developing World Michael F. Northrop, Peter W. Riggs, Frances A. Raymond A Report based on a Workshop at the Pocantico Conference Center of the Rockefeller Brothers Fund, October 11-13, 1995.
213. Specifications For The Use Of Renewable Energies In Rural Decentralized Electrification, Internacional Electrotechnical Commission, IEC/PAS 62111, 1999
214. State of Environment in Zambia 2000, Environmental Council of Zambia, Lusaka-Zambia, ECZ 2001.
215. Submission and Evaluation of Proposals for Private Power Generation Projects in Developing Countries. Peter A. Cordukes, editor. World Bank Discussion Paper No. 250.
216. Sustainable Development, Asian and Pacific Perspectives, Asian Development Bank, 1999.
217. Tania P. Urmee, "Promotions of Renewable Energy Sources in Bangladesh: Lessons from Grameen Shakti", Proceedings of world Sustainable Energy Day, Austria, March 1999, pp 93-98.
218. TERI. 1993 A Socio-economic Impact Assessment Study of Urjagram Projects - Interim Report. GR3402. New Delhi: TERI. 164 pp.
219. TERI. 1994b. Performance Evaluation of SPV Power Plants in UP, Final Report (Phase II). GR4461. New Delhi: TERI. 56 pp.
220. Tester et al. (1989): J.W. Tester, D.W. Brown, and R.M. Potter, "Hot Dry Rock Geothermal Energy: A New Energy Agenda for the 21st Century," Los Alamos National Laboratory Report, LA-11514-MS, July 1989.
221. The Case for Solar Energy Investments. Dennis Anderson and Khulsum Ahmed World Bank Technical Paper No. 279.
222. The Changing Structure of the Electric Power Industry, 1970-1991, March 1993, Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels, U.S. Department of Energy, Washington, DC 20585
223. The Cost-Effectiveness of GEF Projects. Dennis Anderson and Robert H. Williams. Global Environment Facility Working Paper 6.
224. The Environmental Protection and Pollution Control Act, 1990, The Laws of Zambia, Cap 204
225. The Financing of Hydropower, Irrigation and Water Supply Infrastructure in Developing Countries, a background paper for the UN Commission on Sustainable Development, January 1998, by John Briscoe, Senior Water Advisor, World Bank
226. The Public Benefits Agenda in Power Sector Reform, submitted to Energy for Sustainable Development, January 31, 2001, by Navroz K. Dubash, Senior Associate, World Resources Institute, 10 G St. NE, Suite 800, Washington DC 20009
227. The Rio Declaration on Environment and Development, Agenda 21 Sustainable Development Principles, UNCED, June 1992.
228. The Stockholm Environment Institute, Energy Interventions and Poverty Alleviation: Strengthening the Linkages, 1999.
229. The Stockholm Environment Institute, Energy Interventions and Poverty Alleviation: Strengthening the Linkages, 1999.

230. Trembath, Barry, 1997. Constraints to Hydropower Development in a Privatizing Sector. Paper presented at the World Bank's Energy Week, Washington DC, March 13-14, 1997.
231. Tuntivate, Voravate and Douglas F. Barnes, "Thailand's Approach to Rural Electrification: How Was It Successful," The World Bank, Washington DC. Draft, 1997.
232. Tuntivate, Voravate, Douglas F. Barnes, and Susan Bogach, Assessing Markets for Renewable Energy in Rural Areas of Northwestern China, ESMAP Technical Paper No. 3, World Bank, Washington, DC.
233. Ulfsby, Oyvind, 1997. Project Financing of Hydropower Projects in Developing Countries: Some Issues Worth Discussion. Paper presented at the World Bank's Energy Week, Washington DC, March 13-14, 1997.
234. UNDP, World Energy Assessment, New York, UNDP, 2000
235. Urja Bharati - Special issue on solar energy 15(1).
236. Van der Plas R J. 1997. Solar Lanterns: Results of marketing tests in the rural areas of Kenya and Niger. Journal of Energy in South Africa April 1997.
237. Van der Plas, Robert, and A.B. de Graaff. 1988. “A Comparison of Lamps for Domestic Lighting in Developing Countries.” Energy Series Paper 6. Washington, D.C.: World Bank, Industry and Energy Department.
238. Wamukonya, Njeri (ed.), 2001. "Proceedings of the African High-level Regional Meeting on Energy and Sustainable Development for the Ninth Session of the Commission on Sustainable Development," United Nations Environment Programme (UNEP).
239. Wan, Yihn-huei, Parsons, Brian, NREL Factors Relevant to Utility Integration of Intermittent Renewable Technologies, United States Government, NREL/TP463-4953, August 1993.
240. WEC 1994: World Energy Council, New Renewable Energy Resources) A Guide to the Future, (London, UK: Kogan Page, 1994).
241. Willis, H. L., and Scott, W. G., Distributed Power Generation, Marcel Dekker, 2000.
242. World Bank, Rural Energy and Development: Improving Energy Supplies for Two Billion People, Development in Practice Series, The World Bank, 1996.
243. World Bank. Evaluation Of Photovoltaic Household Electrification Programs: Indonesia, Consultants Report, Asia Alternative Energy Unit. Washington, D C: The World Bank.
244. World Competitiveness Report 1997, World Economic Forum
245. Wright et al. (1997): P.M. Wright, T. Sparks, D. Schochet, et al., Geothermal Energy, briefing document for the PCAST Renewable Energy Task Force (Washington, DC: 30 June 1997).
246. Yeager, Kurt, 1997. New Technologies for Power. Paper presented at the World Bank's Energy Week, Washington DC, March 13-14, 1997.
247. Yturregui, L.P., Coping with a Lack of Electricity in Marginal Urban Areas, ENEGIA News,

SELECTED WEB SITES

World Bank http://www.worldbank.org
International Monetary Fund http://www.imf.org
Food and Agriculture Organization http://www.fao.org/
United Nations http://www.un.org
Asian Development Bank http://www.adb.org
National Rural Energy http://www.nreca.org
Cooperative Association

Public Utilities Reports, Inc. http://www.pur.com
Oak Ridge National Laboratory http://www.ornl.gov
National Renewable Energy http://www.nrel.org
Laboratory
National Technical Information http://www.ntis.gov
Service (NTIS)
American Solar Energy Society http://www.ases.org
International Centre for http://www.icimod.org.np
Integrated Mountain Development
China http://www.pnl.gov/china/
Thailand http://www.dedp.go.th/,
http://berc.dedp.go.th/NRSE/
http://www.nepo.go.th/
http://www.egat.or.th/
http://www.pea.or.th/
Bangladesh http://www.bangladeshgov.org
http://bd-pdb.org
http://www.grameen.net
India http://www.nic.in
http://rec.nic.in
http://www.teriin.org

Other websites on Energy:
http://www.repp.org
http://www.ourplanet.com
http:// www.eia.doe.gov
http://www.eurosolar.org/
http://www.futureenergies.com/
http:// www.cei.org
http:// www.udel.edu
http://www.rsvp.nrel.gov
http://www.web.net/newenergy/links.html
http://solstice.crest.org/renewables/re-kiosk/index.shtml
http://www.energy.ca.gov/energy/education/eduhome.html
http://www.itc.nl/ha2/energy/links/biomass.html
http://www.itc.nl/ha2/energy/links/wind.html
http://www.itc.nl/ha2/energy/links/solar.html
http://www.itc.nl/ha2/energy/links/hydro.html
http://www.itc.nl/ha2/energy/links/other.html
http://www.solartoday.org/
http://solarcentury.co.uk
http://www.adal.com
http://www.worldbank.org/html/fpd/energy/energynotes
http://www.repp.org/article
http://apps.fao.org
http://www.web.net/newenergy/links.html
http://solstice.crest.org/renewables/re-kiosk/index.shtml
http://www.energy.ca.gov/energy/education/eduhome.html
http://www.itc.nl/ha2/energy/links/biomass.html
http://www.itc.nl/ha2/energy/links/wind.html
http://www.itc.nl/ha2/energy/links/solar.html

http://www.itc.nl/ha2/energy/links/hydro.html
http://www.itc.nl/ha2/energy/links/other.html
http://www.solartoday.org/
http://solarcentury.co.uk
http://www.adal.com
http://www.worldbank.org/html/fpd/energy/energynotes
http://www.repp.org/article
http://apps.fao.org
http://www.wired.com/news/technology/0,1282,66694,00.html#121
http://www.teriin.org/renew/tech/hydro/about.htm
http://alt-e.blogspot.com/2005/02/alternative-energy-zambia-solar-power.html
http://www.dis.anl.gov/CEEESA/about_programs_power_systems.html
http://microhydropower.net/download/books.php
http://www.fews.net/centers/?f=zm
http://www.awea.org/faq/tutorial/wwt_basics.html
http://data.geocomm.com/catalog/ZA/
http://www.zamsif.org.zm/

Appendix I – Data and Information Collected During the Project Mission

1. Small Hydropower Pre-Investment Study – North-Western Province, Zambia. Final Report, April 2000. Norplan A.S./UNOPS
2. 2000 Census of Population and Housing: Housing and household Characteristics. Analytical Report.
3. The Study on the National Water Resources Master Plan in the Republic of Zambia. Final Report, October 1995. Yachiyi Engineering Co., Ltd.
4. Current and proposed ZESCO tariff structure.
5. Map of high-voltage transmission grid.
6. Map of hydrological metering stations.
7. Solar Irradiation over Zambia, November 1983. International Centre for theoretical Physics, Trieste, Italy (contains data on solar radiation in several locations)
8. Ministry of Commerce – 2004 Manufacturing Sector Survey Form
9. Ministry of Commerce – List of Industries with their ISIC Codes, addresses and telephones (sorted by the type of Industry and location) – electronic file.
10. Stream level measurement data over past 50 years from Hydro Unit, MOE.
11. GIS map of stream flow measurement locations from Hydro Unit, MOE.
12. GIS stream flow data from Hydro Unit, MOE.
13. MIS: 2004 Annual School Census Data from Ministry of Education
14. GIS files: Zambia school locations.
15. 2000-2004 Census data on living conditions (electronic DB), including GIS maps, from the Central Statistics office.
16. GIS map of Zambian roads.
17. GIS rainfall data
18. GIS wind data
19. ZAMSIF project listing.
20. Energy Statistics Bulletin 2000- 2003.
21. Report on LPG utilization on Zambia, University of Zambia.

Appendix II – River Stream-Flow Measuring Stations Locations

Chambeshi Catchment
Chambeshi at Mbesuma Pontoon 6145
Chambeshi at Old Pontoon 6289
Kalunguwiwa at Chunga Ranch 6170
Kanchibiya at Mpika
Lukulu at Kasama-Luwingu Road Bridge 6350
Lukulu at Kasama-Luwingu Road Bridge 6350
Lukupa River at Pump House 6337
Lwitikila at Lwitikila Falls 6480
Lwitikila at Mpika Road Bridge 6486
Milima at Milima 6340
Mungwi at Mungwi 6224
Nakonde at Nakonde Dam Site 6130

Kafue Catchment
Baluba at Baluba 4170
Kafue at Chilenga 4350
Kafue at Kafironda
Kafue at Kipushi 4005
Kafue at Lubungu 4450
Kafue at Machiya Ferry 4280
Kafue at Mpatamato 4200
Kafue at Mswebi 4435
Kafue at Namwala Pontoon 4760
Kafue at Ndubeni 4260
Kafue at Raglan
Kafue at Smith's Bridge 4130
Kafue Hook Bridge 4669
Kaleya at Kaleya Dam Site 4941
Kaleya at Road Bridge 4949
Kaleya at Water Valley 4943
Kufue at Wusakile 4150
Luswishi at Lwendo 4340
Luswishi River at Lwendo 4302
Magoye at Chimbumbu's Farm 4915
Muchindamu at Muchindamu 4015
Mwambashi at Mwambashi
Mwembeshi River at Great North Road 4918

Tanganyika
Lucheche Below Lake Chila 7021

Luangwa Catchment
Chiwefwe at Mkushi Boma 5755
Katete at Katete Boma 5564
Luangwa at GER Bridge 5940
Luangwa at Mfuwe 5650
Lusiwasi at Masase 5670
Lutembwe Weir 5555
Makungwa at Great East Road Brigde 5562
Msipazi at Chadiza Road Bridge 5557
Mulungushi at GNR Bridge 5815

Luapula Catchment
Luapula at Chembe Ferry 6670
Lufubu at Chipili 6765
Lufubu at Green Water Falls 6020
Lufubu Near Chibote 6760
Luongo at Mwendakashiba 6750
Mutotoshi at Kapuma Falls 6855
Mwambeshi Near Nsama 6935
Ngona at Ntumbachushi Falls 6790

Zambezi Catchment
Chongwe at Chongwe-Ngwerere Confluence 5024
Chongwe River at Great East Road 5025
Kabompo at Kabompo Boma 1650
Kabompo at Watopa Pontoon 1950
Luakela at Sachibondu 1425
Luanginga at Kalabo 2250
Luinga at Ikelenge 1040
Makondu at Chivatu Village 1145
Makondu at Dipalata Missionary 1138
Manyinga at Manyinga 1630
Ngwerere at Estate Weir 5016
Zambezi at Chavuma 1105
Zambezi at Kaleni Hill 1080
Zambezi at Lukulu 2030
Zambezi at Nana's Farm 3045
Zambezi at Senanga 2400
Zambezi at Zambezi Pump House 1150

Appendix III – Sample River Stream Flow Initial Data Format

Annual Report of Daily Data: Daily Flow
Station Number : 6289 Year: 1988/1989
Station Name : CHAMBESHI PONTOON (6289)
Time-Series Type : Flow (cumecs)
Latitude : 10:57: 0 N Longitude : 31: 4: 0 E
Elevation : 0.0 meters Area : 34745.0 sq km

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	37.286	33.457	44.128	50.364	111.615	300.185	513.45	584.569	312.437	158.276	99.705	70.209
2	36.911	33.871	43.647	53.626	116.214	296.301	538.282	600.579	310.559	155.72	98.83	69.493
3	36.787	33.812	43.169	60.908	120.697	292.442	559.689	615.6	297.539	152.49	97.959	68.781
4	36.353	33.047	43.237	81.81	128.667	294.672	580.981	619.927	289.824	149.297	96.985	68.073
5	35.922	32.58	44.129	74.17	134.955	298.961	602.111	621.789	283.229	146.962	95.374	67.281
6	35.861	32.464	44.892	79.089	139.288	308.676	619.007	619.927	275.545	144.784	93.778	66.06
7	35.861	32.06	46.44	102.846	142.49	314.541	628.959	616.831	267.788	142.624	92.827	65.282
8	35.799	31.889	48.015	111.368	145.468	323.742	631.774	608.524	260.533	140.482	91.987	64.595
9	35.373	33.341	48.595	111.72	153.071	353.854	628.648	592.082	255.633	138.359	91.152	63.912
10	34.888	34.468	48.087	117.176	164.055	361.73	617.457	582.753	251.159	136.125	90.32	63.233
11	34.467	35.678	47.008	117.652	170.98	364.017	605.76	570.268	246.548	133.262	89.596	62.642
12	34.407	35.861	45.943	114.544	186.009	366.771	597.83	551.809	240.359	130.946	89.39	62.557
13	34.467	35.861	45.45	112.069	211.135	365.393	589.964	540.834	231.412	128.272	88.671	62.473
14	34.888	35.861	45.872	107.671	227.199	361.732	578.87	528.026	225.258	126.884	87.852	61.887
15	35.434	35.861	46.296	102.696	235.857	356.279	569.368	506.763	219.89	125.13	87.038	61.22
16	36.168	35.861	46.084	99.925	238.905	349.528	562.007	493.578	215.445	123.763	86.128	60.558
17	35.861	35.861	46.936	99.488	240.733	343.956	554.704	477.939	210.38	121.297	84.623	59.818
18	35.373	35.799	47.437	104.401	259.086	338.438	545.436	457.332	206.046	119.952	83.033	58.676
19	34.888	35.433	47.15	115.038	280.283	333.185	534.826	444.39	201.109	118.134	81.558	57.948
20	34.467	35.433	47.726	113.144	283.222	335.803	527.157	427.891	196.885	116.33	80.584	57.306
21	34.467	35.799	49.255	103.493	284.431	333.619	518.713	414.941	192.075	115.255	79.23	56.668
22	34.767	36.046	50.511	99.925	300.422	331.443	510.904	401.976	188.117	114.187	78.272	56.113
23	34.467	37.478	51.559	100.043	310.563	329.059	499.585	391.629	184.517	112.418	76.941	55.877
24	34.407	39.845	51.861	106.645	297.949	331.879	494.384	380.732	181.881	110.665	76.091	54.857
25	34.407	41.821	52.849	107.663	292.038	336.46	490.31	371.165	179.269	109.62	75.435	54.157
26	34.407	42.491	53.385	108.014	291.431	341.993	476.066	361.513	175.768	108.697	75.248	53.539
27	34.467	42.762	52.849	114.076	292.241	366.84	460.196	349.982	172.156	107.663	74.503	52.849
28	34.707	44.13	51.71	113.368	297.525	390.702	477.541	341.967	168.587	106.067	73.209	51.785
29	33.99	45.03	50.734	106.872		409.823	536.419	332.977	165.06	104.822	72.383	51.183
30	33.457	44.336	50.883	104.822		443.982	562.619	322.613	161.576	102.469	71.654	51.108
31	33.105		50.065	103.932		483.641		318.774		100.695	70.93	
Mean	35.1	36.608	47.932	99.953	216.305	347.085	553.767	485.474	225.553	125.86	84.88	60.338
Flow (MCM)	94.013	94.888	128.382	267.715	523.284	929.633	1435.365	1300.292	584.633	337.102	227.343	156.396
Maximum	37.286	45.03	53.385	117.652	310.563	483.641	631.774	621.789	312.437	158.276	99.705	70.209
Minimum	33.105	31.889	43.169	50.364	111.615	292.442	460.196	318.774	161.576	100.695	70.93	51.108
Runoff (mm)	2.706	2.731	3.695	7.705	15.061	26.756	41.311	37.424	16.826	9.702	6.543	4.501

Flow (cumecs)
Annual Statistics
Maximum : 631.774 cumecs Minimum : 31.889 Mean : 193.238

Appendix IV – Analysis of River Flow Data

Catchment	Station Location and Number	Max	Min	Mean	Zero Flow
Zambezi	Chongwe at chongwe-ngwerere confluence 5024	34.74	0.00	1.98	Y
Zambezi	chongwe river at great east road 5025	117.62	0.00	4.83	Y
Zambezi	Luinga at ikelenge 1040	23.80	0.00	1.07	Y
Zambezi	Zambezi at senanga 2400	3062.38	186.93	1013.11	N
Zambezi	Zambezi at nana's farm 3045	3344.59	44.24	788.91	N
Zambezi	Zambezi at lukulu 2030	2726.50	134.05	762.20	N
Zambezi	Zambezi at chavuma 1105	1030.47	392.88	535.21	N
Zambezi	Zambezi at Zambezi pump house 1150	2214.55	26.61	351.28	N
Zambezi	Kabompo at watopa pontoon 1950	2250.45	31.96	268.43	N
Zambezi	Kabompo at Kabompo boma 1650	518.28	108.15	238.44	N
Zambezi	Luanginga at kalabo 2250	320.80	6.28	59.44	N
Zambezi	Makondu at chivatu village 1145	92.73	0.91	17.80	N
Zambezi	Zambezi at kaleni hill 1080	48.60	4.17	11.71	N
Zambezi	Makondu at dipalata missionary 1138	52.99	1.07	8.60	N
Zambezi	Luakela at sachibondu 1425	59.16	0.59	8.04	N
Zambezi	Manyinga at manyinga 1630	34.93	0.18	7.40	N
Zambezi	Ngwerere at estate weir 5016	3.95	0.07	0.39	N
Tanganyika	Lucheche below lake chila 7021	1.29	0.04	0.47	N
Luapula	Lufubu at chipili 6765	65.59	0.02	8.15	Y
Luapula	Luongo at mwendakashiba 6750	1.14	0.06	0.34	Y
Luapula	Luapula at chembe ferry 6670	3921.54	4.60	515.39	N
Luapula	Lufubu near chibote 6760	43.44	4.45	13.75	N
Luapula	Mwambeshi near nsama 6935	93.28	0.01	5.27	N
Luapula	mutotoshi at kapuma falls 6855	41.19	0.18	4.84	N
Luapula	Ngona at ntumbachushi falls 6790	11.42	0.90	2.06	N
Luapula	Lufubu at green water falls 6020	6.94	0.60	1.34	N
Luangwa	Katete at katete boma 5564	0.46	0.19	0.22	Y
Luangwa	Luangwa at mfuwe 5650	0.00	0.00	0.00	Y
Luangwa	Makungwa at great east road brigde 5562	9.17	0.00	0.39	Y
Luangwa	Msipazi at chadiza road bridge 5557	2.83	0.00	0.36	Y
Luangwa	Mulungushi at GNR Bridge 5815	85.49	0.00	5.15	Y
Luangwa	Luangwa at GER Bridge 5940	10377.28	0.00	628.00	N
Luangwa	Lusiwasi at masase 5670	68.34	0.03	8.26	N
Luangwa	Chiwefwe at mkushi boma 5755	9.09	0.59	1.72	N
Luangwa	Lutembwe weir 5555	0.13	0.08	0.09	N
Kafue	Baluba at baluba 4170	19.26	0.53	2.90	Y
Kafue	kafue at kipushi 4005	9.10	0.17	1.67	Y
Kafue	Kaleya at kaleya dam site 4941	122.88	0.00	0.59	Y
Kafue	Kaleya at road bridge 4949	0.97	0.22	0.30	Y
Kafue	Kaleya at water valley 4943	2.44	0.00	0.34	Y
Kafue	Magoye at chimbumbu's farm 4915	91.56	0.00	2.72	Y
Kafue	muchindamu at muchindamu 4015	35.55	0.03	1.13	Y
Kafue	Mwembeshi river at great north road 4918	0.00	0.00	0.00	Y
Kafue	Luswishi at Lwendo 4340	230.52	0.99	18.12	unreliable
Kafue	Luswishi at Lwendo 4302	230.52	0.99	18.12	unreliable
Kafue	kafue at namwala pontoon 4760	1494.09	6.45	322.46	N
Kafue	Kafue hook bridge 4669	3039.81	12.55	294.27	N
Kafue	Kafue at chilenga 4350	646.23	52.42	174.23	N
Kafue	Kafue at lubungu 4450	685.55	8.68	159.36	N
Kafue	Kafue at mswebi 4435	1298.42	6.77	156.91	N

Catchment	Station Location and Number	Max	Min	Mean	Zero Flow
Kafue	Kafue at machiya ferry 4280	892.96	12.26	147.97	N
Kafue	Kafue at ndubeni 4260	692.07	12.90	129.59	N
Kafue	Kafue at mpatamato 4200	530.01	3.85	90.26	N
Kafue	Kufue at wusakile 4150	482.00	4.10	78.80	N
Kafue	Kafue at smith's bridge 4130	605.50	4.56	71.55	N
Kafue	kafue at kafironda	434.38	3.81	59.43	N
Kafue	kafue at raglan	300.42	0.49	35.22	N
Kafue	Mwambashi at mwambashi	49.90	0.55	7.18	N
Chambeshi	Kanchibiya at Mpika	0.00	0.00	0.00	Y
Chambeshi	Lwitikila at mpika road bridge 6486	26.08	0.59	6.11	Y
Chambeshi	Mungwi at mungwi 6224	5.11	0.17	1.27	Y
Chambeshi	Nakonde at nakonde dam site 6130	5.95	0.01	0.77	Y
Chambeshi	Chambeshi at old pontoon 6289	1192.59	8.22	170.25	N
Chambeshi	Chambeshi at mbesuma pontoon 6145	257.01	7.33	70.80	N
Chambeshi	Lukulu at kasama-luwingu road bridge 6350	173.79	24.54	51.04	N
Chambeshi	Lukupa river at pump house 6337	26.25	1.98	8.17	N
Chambeshi	Kalunguwiwa at chunga ranch 6170	29.55	0.00	6.71	N
Chambeshi	Lwitikila at lwitikila falls 6480	10.81	0.24	1.87	N
Chambeshi	Milima at milima 6340	1.39	0.36	0.69	N

Appendix V – River Stream Flow Data, Sorted by Mean, m^3/s (locations with dry periods are excluded from analysis)

Catchment	Station Location And Number	Max	Min	Mean
Zambezi	Zambezi at Senanga 2400	3062.38	186.93	1013.11
Zambezi	Zambezi at Nana's Farm 3045	3344.59	44.24	788.91
Zambezi	Zambezi at Lukulu 2030	2726.50	134.05	762.20
Zambezi	Zambezi at Chavuma 1105	1030.47	392.88	535.21
Luapula	Luapula at Chembe Ferry 6670	3921.54	4.60	515.39
Zambezi	Zambezi at Zambezi Pump House 1150	2214.55	26.61	351.28
Kafue	Kafue at Namwala Pontoon 4760	1494.09	6.45	322.46
Kafue	Kafue Hook Bridge 4669	3039.81	12.55	294.27
Zambezi	Kabompo at Watopa Pontoon 1950	2250.45	31.96	268.43
Zambezi	Kabompo at Kabompo Boma 1650	518.28	108.15	238.44
Kafue	Kafue at Chilenga 4350	646.23	52.42	174.23
Chambeshi	Chambeshi at Old Pontoon 6289	1192.59	8.22	170.25
Kafue	Kafue at Lubungu 4450	685.55	8.68	159.36
Kafue	Kafue at Mswebi 4435	1298.42	6.77	156.91
Kafue	Kafue at Machiya Ferry 4280	892.96	12.26	147.97
Kafue	Kafue at Ndubeni 4260	692.07	12.90	129.59
Kafue	Kafue at Mpatamato 4200	530.01	3.85	90.26
Kafue	Kufue at Wusakile 4150	482.00	4.10	78.80
Kafue	Kafue at Smith's Bridge 4130	605.50	4.56	71.55
Chambeshi	Chambeshi at Mbesuma Pontoon 6145	257.01	7.33	70.80
Zambezi	Luanginga at Kalabo 2250	320.80	6.28	59.44
Kafue	Kafue at Kafironda	434.38	3.81	59.43
Chambeshi	Lukulu at Kasama-Luwingu Road Bridge 6350	173.79	24.54	51.04
Kafue	Kafue at Raglan	300.42	0.49	35.22
Zambezi	Makondu at Chivatu Village 1145	92.73	0.91	17.80
Luapula	Lufubu Near Chibote 6760	43.44	4.45	13.75
Zambezi	Zambezi at Kaleni Hill 1080	48.60	4.17	11.71
Zambezi	Makondu at Dipalata Missionary 1138	52.99	1.07	8.60
Luangwa	Lusiwasi at Masase 5670	68.34	0.03	8.26
Chambeshi	Lukupa River at Pump House 6337	26.25	1.98	8.17
Zambezi	Luakela at Sachibondu 1425	59.16	0.59	8.04
Zambezi	Manyinga at Manyinga 1630	34.93	0.18	7.40
Kafue	Mwambashi at Mwambashi	49.90	0.55	7.18
Chambeshi	Kalunguwiwa at Chunga Ranch 6170	29.55	0.003	6.71
Luapula	Mwambeshi Near Nsama 6935	93.28	0.01	5.27
Luapula	Mutotoshi at Kapuma Falls 6855	41.19	0.18	4.84
Luapula	Ngona at Ntumbachushi Falls 6790	11.42	0.90	2.06
Chambeshi	Lwitikila at Lwitikila Falls 6480	10.81	0.24	1.87
Luangwa	Chiwefwe at Mkushi Boma 5755	9.09	0.59	1.72
Luapula	Lufubu at Green Water Falls 6020	6.94	0.60	1.34
Chambeshi	Milima at Milima 6340	1.39	0.36	0.69
Tanganyika	Lucheche Below Lake Chila 7021	1.29	0.04	0.47
Zambezi	Ngwerere at Estate Weir 5016	3.95	0.07	0.39
Luangwa	Lutembwe Weir 5555	0.13	0.08	0.09

Appendix VI – Rainfall Data Collected from Meteorological Department

Station	Longitude	Latitude	Rainfall (mm)	No. of Years
CHIPATA	32.58	-13.57	980.4	30
CHIPEPO	27.88	-16.80	776.5	11
CHOMA	27.07	-16.85	770.7	30
ISOKA	32.63	-10.17	1086.2	24
Kabompo	24.20	-13.60	1040.6	30
Kabwe Met	28.48	-14.42	901.4	30
Kabwe Agro	28.50	-14.40	878.2	27
Kafironda	28.17	-12.63	1274.8	30
Kafue	27.92	-15.77	746.3	29
Kalabo	22.70	-14.95	807.8	17
Kaoma	24.80	-14.80	904.5	30
Kasama	31.13	-10.22	1309.5	30
Kasempa	25.83	-13.47	1155.4	26
Kawambwa	29.25	-9.80	1361.9	27
Livingstone	25.82	-17.82	637.1	30
Lundazi	33.20	-12.28	874.2	29
Lusaka Hq	28.32	-15.42	821.5	30
Lusaka Airport	28.43	-15.32	934	30
Lusitu	28.82	-16.18	534.7	9
Magoye	27.63	-16.13	715.1	25
Mansa	28.85	-11.10	1179.2	30
Mbala	31.33	-8.85	1202.4	30
Mfuwe	31.93	-13.27	810.8	25
Misamfu	31.22	-10.18	1330.7	30
Mkushi	29.80	-13.60	1178.4	5
Mongu	23.17	-15.25	914.4	30
Mpika	31.43	-11.90	993.6	30
Msekera	32.57	-13.65	1010.3	21
Mtmakulu	28.32	-15.55	878.2	30
Mumbwa	27.07	-14.98	820.6	26
Mwinilunga	24.43	-11.75	1390.4	30
Ndola	28.66	-13.00	1185	29
Petauke	31.28	-14.25	967.8	30
Samfya	29.32	-11.21	1478.7	10
Senanga	23.27	-16.12	727	22
Serenje	30.22	-13.23	1058.7	30
Sesheke	24.30	-17.47	627.7	30
Solwezi	26.38	-12.18	1341.9	30
Zambezi	23.12	-13.53	1022.3	30

Appendix VII – Wind Speed Data Collected from Meteorological Department

Station	Longitude	Latitude	Wind (m/s)	No. of Years
Chipata	32.58	-13.57	4	28
Chipepo	27.88	-16.80	5.2	2
Choma	27.07	-16.85	3.1	30
Isoka	32.63	-10.17	1.9	24
Kabompo	24.20	-13.60	1.5	29
Kabwe Met	28.48	-14.42	5.9	27
Kabwe Agr	28.50	-14.40	3.3	23
Kafironda	28.17	-12.63	1.8	30
Kafue	27.92	-15.77	3.8	28
Kalabo	22.70	-14.95	4.9	11
Kaoma	24.80	-14.80	1.8	29
Kasama	31.13	-10.22		
Kasempa	25.83	-13.47		
Kawambwa	29.25	-9.80	2.4	18
Livingstone	25.82	-17.82	3.6	17
Lundazi	33.20	-12.28	2.3	23
Lusaka Hq	28.32	-15.42	5	16
Lusaka Airport	28.43	-15.32		
Lusitu	28.82	-16.18	5	6
Magoye	27.63	-16.13	3.5	24
Mansa	28.85	-11.10	3.2	24
Mbala	31.33	-8.85	3.8	30
Mfuwe	31.93	-13.27	2.6	24
Misamfu	31.22	-10.18	3.6	30
Mkushi	29.80	-13.60	5.5	3
Mongu	23.17	-15.25	5.9	17
Mpika	31.43	-11.90	3.4	27
Msekera	32.57	-13.65	2.8	20
Mtmakulu	28.32	-15.55	3.5	28
Mumbwa	27.07	-14.98	2.7	21
Mwinilunga	24.43	-11.75	2.4	29
Ndola	28.66	-13.00		
Petauke	31.28	-14.25	3.2	29
Samfya	29.32	-11.21	3.4	7
Senanga	23.27	-16.12	3.3	22
Serenje	30.22	-13.23	3.2	22
Sesheke	24.30	-17.47	3.1	29
Solwezi	26.38	-12.18	2.9	29
Zambezi	23.12	-13.53	3.1	29

Appendix VIII – List of the Industries in Zambia, According to the Manufacturing Sector Survey Conducted by the Ministry of Commerce

MINISTRY OF COMMERCE, TRADE AND INDUSTRY
-- INDUSTRIAL DATABASE --

REPUBLIC OF ZAMBIA

LUAPULA PROVINCE

Company Name	Address	Phone Number
Kawambwa Tea Company Limited	Box 230020 Ndola Box 730194	651058/650561/960171/960105
Peco Limited	Box 710358- Former LCU harchery	
Danty's Bakery	Box 710027	821827/821797
Colwyn Ltd	Box 70431	611763

NORTH - WESTERN PROVINCE

Company Name	Address	Phone Number
North-Western Bee Products Ltd	Box 140096 Kabompo	8375085
Kupela Milling Ltd	Box 120109	8251064
Solwezi Youth Supercrafts Enterprises	Box 110232	
Chops Carpentry/Furniture	Box 110194	
Efyo Chaba Carpentry Ltd	Box 110077	
Fine Carpentry and Joinery Workshop		
LAS Crafts Centre		
Kamwanga Carpentry	Box 110159	
Kamagala Carpentry workshop	Box 110205	
North West Funeral		
Reliance Enterprises	Box 110278	
Zowari Bakers	Box 150052	371122
Zango Bakery	Box 150085	371015

Town: *Zambezi*
ISIC Code: *3117-Manufacture of bakery products*

Company Name	Address	Phone Number
Zowari Bakers	Box 150052	371122
Zango Bakery	Box 150085	371015

Town: *Solwezi*
ISIC Code: *3320-Manufacture furniture*

Company Name	Address	Phone Number
Solwezi Youth Supercrafts Enterprises	Box 110232	
Chops Carpentry/Furniture	Box 110194	
Efyo Chaba Carpentry Ltd	Box 110077	
Fine Carpentry and Joinery Workshop		
LAS Crafts Centre		
Kamwanga Carpentry	Box 110159	
Kamagala Carpentry workshop	Box 110205	
North West Funeral		
Reliance Enterprises	Box 110278	

Town: ***Kasempa***
ISIC Code: ***3116-Grain mill products***

Company Name	Address	Phone Number
Kupela Milling Ltd	Box 120109	8251064

Town: ***Kabompo***
ISIC Code: ***3121-Manufacture. of food products***

Company Name	Address	Phone Number
North-Western Bee Products Ltd	Box 140096 Kabompo	8375085

WESTERN PROVINCE

Company Name	Address	Phone Number
Western Cashew Industries Ltd (3121)	Box 910442- Limulunga Royal Village	
M.J Bakery and Commodities(3117)	Box K1- Mongu - Lusaka Rd	7221139
Mongu Joinery (3311)	Box K1- Mongu - Lusaka Rd	7221139
APG Milling Limited (3116)	Box 910115 off airport road	221361
Country Bakers (3117)	K213	221220
Sasha Timber Ltd (3311)	Box 910427	67414169

Town: ***Mongu***
ISIC Code: ***3121-Manufacture. of food products***

Company Name	Address	Phone Number
Western Cashew Industries Ltd	Box 910442- Limulunga Royal Village	

Town: ***Mongu***
ISIC Code: ***3117-Manufacture of bakery products***

Company Name	Address	Phone Number
M.J Bakery and Commodities	Box K1- Mongu - Lusaka Rd	7221139
Country Bakers	K213	

Town: ***Mongu***
ISIC Code: ***3116-Grain mill products***

Company Name	Address	Phone Number
APG Milling Limited	Box 910115 off airport road	221361

Town: ***Mongu***
ISIC Code: ***3311-Sawmills***

Company Name	Address	Phone Number
Mongu Joinery	Box K1- Mongu - Lusaka Rd	7221139
Sasha Timber Ltd	Box 910427	67414169

EASTERN PROVINCE

Company Name	Address	Phone Number
Super Garage and Millers	Box 520075 (Chadiza)	251125
Sikunya Oil Products Ltd.	Box 510168 (Chipata)	221070/252298
Chikunto Building Contractors	Box 510423	222069
Rainbow Milling	Plot No. 1591 Airport road Box 510110 (Chipata)	221097/221262
Supernova Brewing Corporation Ltd.	702 Chachacha Road Reedbuck House (Chipata)	221400
Clark cotton (Z) Ltd.	Nassa Street 1439 Box 510274(Chipata)	221215/221790
Chipata Bakers	Box 510122 (Chipata)	221324
Jambo Bakery	Chipata	221040
Kwacha Milling Company Ltd.	Box 31186	221363
PC Workshop	Box 510379	

Shawa Engineering Ltd.		22388
Higway Baker and Confectioners	Box 510191(Chipata)	221369/221226
Mako Ni Mako Coffin Workshop	C/O 530142	80284
Chikutano Auto services	Box 530091	
Lundazi Village Industries Service	Box 35500 (Lundazi)	480184
Chinkhombe Oil Millers	Box 560009	371089

Town: ***Chipata***
ISIC Code: ***3117-Manufacture of bakery products***

Company Name	Address	Phone Number
Chipata Bakers	Box 510122	221324
Jambo Bakery		221040
Higway Baker and Confectioners	Box 510191	221369/221226

Town: ***Chipata***
ISIC Code: ***3116-Grain mill products***

Company Name	Address	Phone Number
Rainbow Milling	Plot No. 1591 Airport road Box 510110	221097/221262
Kwacha Milling Company Ltd.	Box 31186	221363

Town: ***Chipata***
ISIC Code: ***3133-Malt liquors and malt***

Company Name	Address	Phone Number
Supernova Brewing Corporation Ltd.	702 Chachacha Road Reedbuck House	221400

NORTHERN PROVINCE

Company Name	Address	Phone Number
Chinsali Maize Mill	Box 480176- Main Boma Road Opposite Chinsali Girls High School	565012
Kasama Bakery Limited	Box 410405- Plot 3264 Mpulungu Road	222338
Mutondo Breweries Limited	Box 410334- 1716 miles Kasama - Mpika Road	221411
Kasama Timber and General Contractors	Box 410071- Plot 1702 Mbala Road	222975
Kalungwishi Estate Limited	Box 410023- 40 Km along Kasama - Mbala Road	221194
Kats Meat Processing	Box 410858- Mpulungu Road	097751577/097896257
Lyashilishala Farms Limited	Box 410278- Mpulungu Road	097815134/097815134
African Plantations Company Limited	Box 410208- Kateshi Plot 4133 Mbala Road	221591/222485
Bakers Delight and Confectioners Ltd	Box 410601- 939 b Mubanga Chipoya Road	974586083
Kasama Sawmill	Box 410017- Along Kasama - Mbala Road	221222/221333
Best Harvest Millers	Box 410217- Plot 2788- Mpika Road	222038
Namukolo Bakery	Box 460095	235029
Sansin Milling Limited	Box 420007- Plot 439 Insanya Road	450633
Ntumbi Trading	Box 420001- President Road	450369
Kalolo Bakery	Box 450115- Plot 109 Boma Road	370083
Pamulambe Mpika Milling	Mpika Self Help Complex Town Centre	370326
Iseni Bakery	Box 430039- Along Great North Road- Plot 85 Kalunde.	567031/13
Amico Bakery - Nakonde Branch	Along Kanyala Road	567072
Peniel I. General Dealers	Box 430130	

Pwniel I. General Dealers	Box 430130	
A.M. Tailors Limited	Box 430122	

Town: ***Kasama***
ISIC Code: ***3116-Grain mill products***

Company Name	Address	Phone Number
Best Harvest Millers	Box 410217- Plot 2788- Mpika Road	222038

Town: ***Kasama***
ISIC Code: ***3117-Manufacture of bakery products***

Company Name	Address	Phone Number
Kasama Bakery Limited	Box 410405- Plot 3264 Mpulungu Road	222338
Bakers Delight and Confectioners Ltd	Box 410601- 939 b Mubanga Chipoya Road	974586083

Town: ***Kasama***
ISIC Code: ***3311-Sawmills***

Company Name	Address	Phone Number
Kasama Timber and General Contractors	Box 410071- Plot 1702 Mbala Road	222975
Kasama Sawmill	Box 410017- Along Kasama - Mbala Road	221222/221333

Town: ***Mbala***
ISIC Code: ***3117-Manufacture of bakery products***

Company Name	Address	Phone Number
Ntumbi Trading	Box 420001- President Road	450369

Town: ***Mbala***
ISIC Code: ***3116-Grain mill products***

Company Name	Address	Phone Number
Sansin Milling Limited	Box 420007- Plot 439 Insanya Road	450633

Town: ***Mpika***
ISIC Code: ***3117-Manufacture of bakery products***

Company Name	Address	Phone Number
Kalolo Bakery	Box 450115- Plot 109 Boma Road	370083

Town: ***Mpika***
ISIC Code: ***3116-Grain mill products***

Company Name	Address	Phone Number
Pamulambe Mpika Milling	Mpika Self Help Complex Town Centre	370326

Town: ***Nakonde***
ISIC Code: ***3117-Manufacture of bakery products***

Company Name	Address	Phone Number
Iseni Bakery	Box 430039- Along Great North Road- Plot 85 Kalunde.	567031/13
Amico Bakery - Nakonde Branch	Along Kanyala Road	567072

Town: ***Chinsali***
ISIC Code: ***3116-Grain mill products***

Company Name	Address	Phone Number

Chinsali Maize Mill	Box 480176- Main Boma Road Opposite Chinsali Girls High School	565012

Town: ***Kawambwa***
ISIC Code: ***3121-Manufacture. of food products***

Company Name	Address	Phone Number
Kawambwa Tea Company Limited	Box 230020 Ndola Box 730194	651058/650561/960171/960105

SOUTHERN PROVINCE

Company Name	Address	Phone Number
Choma Milling Company Ltd	Plot 669-off Masuku Rd Box 630549	032-20484-20544
L. Tembo Workshop	Box 630597	20184
Supersonic	Box 60497	320533/323354
Mosi -o-tunya Dairies	Box 60179	321857
Food Mary	Box 60456	3323402
Murdochi Model	Box 60054	3241110
Continental Ginnery Ltd	Box 60010- Chifubu Rd	3320175
I. Ngulube	Box 447	324424
Fallsway Timbers Ltd	Kamatanda- Kazungula Rd	3324425
Doors of the World (z)	African Decks - 9 unit 5 Imvubu Rd	114522466
Finata Farms	Box 60023	03321524/5
Matrich Enterprises Ltd	Box 60385	3320954
Continetal Textiles Ltd	Box 60010	3323286
Lemro	Box 60588	320338
Rite Investments	Box 60688	320298
Zambesi Tailoring and Clothing	Box 60161	320161
Menybo Enterprise	Box 670246	30382
I.MJ Limbada Bakery	Box 670143	3230339
Machangulu Enterprise	Box 670499	3230788
Makubu Steel Works Ltd	Box03230292/512	03230292/512
Bhagoos Bakery Ltd	Plot 140- Great North Rd	3230292
Monze Dairy Farmers	Box 660281	50469
JandJ Coffins	BOx 660350	3250917
Desmond Hakabanze	Box 660208	50119
St Paulas Traing Centre	Monze Dioces	3230107
Mwapona Bakery	Box 660354	3250184

Town: ***Kapiri Mposhi***
ISIC Code: ***3117-Manufacture of bakery products***

Company Name	Address	Phone Number
Kapiri Bakery Ltd.	Plot No. 57 Box 810002	272140/271178/271051

Town: ***Kapiri Mposhi***
ISIC Code: ***3116-Grain mill products***

Company Name	Address	Phone Number
Chimsoro Milling Company Ltd.	Plot 2258 Great North Road Box 810129	271215