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USAID'S LIBERIA ENERGY SECTOR SUPPORT PROGRAM (LESSP)

CONCEPT STUDY:
EXPANSION OF EAGLE POWER GENERATION CAPACITY USING RENEWABLE ENERGY TECHNOLOGY AND IMPROVEMENTS TO THE ELECTRICITY DISTRIBUTION SYSTEM

CONTRACT NO.: 669-C-00-10-00059-00

November 19, 2013

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EXPANSION OF EAGLE POWER GENERATION CAPACITY USING RENEWABLE ENERGY TECHNOLOGY AND (2) IMPROVEMENTS TO THE ELECTRICITY DISTRIBUTION SYSTEM

Public Private Partnership (PPP) Agreement – Eagle Power and Winrock International / Liberia Energy Sector Support Project – Concept Study – (1) Expansion of Eagle Power Generation Capacity Using Renewable Energy Technology and (2) Improvements to the Electricity Distribution System

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Applicable Strategic Objectives:

- SO1: To extend grid electricity throughout Monrovia and environs
- SO2: To develop hydro capacity and other Renewable energy resources
- SO3: To expand grid electricity to other Urban areas and some rural areas

The author's views expressed in this publication do not necessarily reflect the views of the United States Agency for International Development or the United States Government.

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Acronyms and Abbreviations

AAAC	All Aluminum Alloy Conductor
ACSR	Aluminum Conductor Steel Reinforced
A-E	Architecture-Engineering
ATP	Ability to Pay
CA/CM	Contract Administrator & Construction Management
CBO	Community-Based Organizations
CEG	Clean Energy Group
COP	Chief of Party
COR	Contracting Officer's Representative
COTR	Contacting Officer's Technical Representative
DCOP	Deputy Chief of Party
EHELD	Excellence in Higher Education for Liberian Development
EP	Eagle Power
EPA	Environmental Protection Agency
ESG	Energy and Security Group
GOL	Government of Liberia
HFO	Heavy Fuel Oil
HQ	Head Quarters
HV	High Voltage
IBEX	Liberia Investing in Business Expansion Project
IFB	Instructions for Bidders
LCC	Life Cycle Cost
LCCA	Life Cycle Cost Analysis
LEC	Liberia Electricity Corporation
LESSP	Liberia Energy Sector Support Program
LOP	Life of Project
LV	Low Voltage
MLME	Ministry of Lands, Mines and Energy
MPW	Ministry of Public Works
MV	Medium Voltage
OJT	On the Job Training
O&M	Operation and Maintenance
PPP	Public-Private Partnership
PRS	Poverty Reduction Strategy
QA/QC	Quality Control & Quality Assurance
RE	Renewable Energy
RET	Renewable Energy Technologies
RFP	Request for Proposal
ROW	Right of Way
RREA	Rural and Renewable Energy Agency
SCADA	Supervisory Control and Data Acquisition
T&D	Transmission and Distribution
UL	University of Liberia
USAID	U.S. Agency for International Development
WI	Winrock International
WTP	Willingness to Pay

1 EXECUTIVE SUMMARY

This concept study was made possible through a Public-Private-Partnership (PPP) between the USAID funded Liberia Energy Sector Support Program (LESSP) and Eagle Power (EP). It was undertaken to provide Eagle Power and possible Liberian funding / investing entities with information that can be used to make decisions concerning the expansion / upgrading / improving of Eagle Power generation capacity using renewable energy (RE) technology and improvements to its existing electricity distribution system.
Solar photovoltaic and biomass power generation are the technological options examined in this report for increasing Eagle Power generation capacity weighted against diesel power generation.

The information presented in this report is structured mainly in four sections: (1) existing system and infrastructure, (2) renewable energy technological options, (3) proposed facilities, (4) cost estimates and financing, and (5) implementation plan and estimated schedules.

Scope: The main purpose of this study is to provide an engineering plan that can be used to develop a business plan to assist Eagle Power to apply for funding / investment to interconnect its six currently close to each other, but isolated mini service areas and to provide new generation facilities through Renewable Energy Technologies (RET).

Main Findings: There are two major findings under this study:

1. **Eagle Power and Eagle Power Improvements / Expansion**: Eagle Power is perhaps the largest private sector informal electricity provider in the Monrovia urban area today successfully serving over 350 to 750 customers depending on their delinquent accounts condition at any given time. Eagle Power operations include basic diesel generation (899 kVA) and T&D facilities (35 km) that work well but do not meet any accepted construction standard. With 41 employees, operations and the business are effective but also are suffering due to a lack of experience in running a professional public utility. Their ownership is dedicated to public service and improvements and expansion of the EP utility but also understands the risks involved with such goals to become a viable private sector electricity provider.

   Our studies indicate that EP can make changes to improve and expand and become a viable utility but that both will require:

   - Outside loans and/or investment with payback period requiring several years;
   - Absent a new Energy Law that allows and promotes independent and private sector electricity providers, the GOL/MLME must agree through concession to allow EP to generate, distribute and sell electricity;
   - LEC must also agree to allow EP to operate and provide private services in their service area through some type of mutually agreeable sharing, support and perhaps a franchise agreement; and
   - EP must evolve to become a professional electricity service provider with industry acceptable business and operational practices.

All of these four things can happen but they <u>all must</u> happen together for any expansion / improvement plan to be considered viable and then to be successful.

2. **The Provision of Electricity by the Private Sector in Monrovia and Liberia**: Every report written about the provision of electricity in Liberia today should be edited to read that only 10% of Monrovians have access to electricity **<u>from LEC</u>**. Only 2% of Liberians have access to electricity **<u>from LEC</u>**. During the course of this study it has become apparent that there is not Eagle Power providing electricity informally to hundreds of customers in urban Monrovia but these such informal private sector providers exist all over the city and the urban area. Our unscientific surveys indicate such private sector providers are operating all over the city and its surrounding areas generating and selling electricity to many more customers than LEC serves today by far. **It would seem that the private sector is alive and well in the energy sector in Liberia today and it is not talked about**. This is to our knowledge totally unstudied and not well understood.

   This raises several questions. How many Monrovians and Liberians receive electrical service from informal providers today? Is it 5,000, 10,000, 100,000, 500,000? Nobody knows. Could the private electricity sector work better and benefit Liberia if there was an Energy Law that promoted small mini grids and private sector involvement? At what rates is the private sector selling electricity? Does this provision of electricity through informal providers extend to the County capitals today? Does the lack of a modern Energy Law that allows, promotes and regulates private sector providers cause safety problems for consumers and citizens? Does this result in environmental problems in country as these unregulated private sector providers have no environmental permits and oversight? How much tax revenue is the government missing out on here? How much diesel fuel is being used to provide electricity in Monrovia and Liberia today? Who is selling this diesel? What are the diesel margins?

   Is the only approach to the future provision of electricity in Liberia LEC-centric? It would seem there is a large existing private electricity sector that may be benefitting Monrovia and Liberia today. If it was allowed to exist, was properly regulated and promoted, it might flourish and act to provide Monrovians and Liberians with reliable electricity faster than simply waiting for LEC to expand the national grid which seems to be the MLME and GOL strategy today.

Main Recommendation: There are three scenarios and recommendations that address the original Scope of Work and one that is added and discussed in this Study but is to a large extent outside the original Scope. Choosing one depends on how Eagle Power can address risks that are outlined in the Risk and Risk Mitigation Section of this report. Until these risks are addressed, one option cannot be recommended over another:

1. **No Change**: The current Energy Law does not permit or promote private sector participation in the generation, transmission, distribution and/or sales of electricity to the public. Under this law if Eagle Power cannot obtain a concession from the GOL and LEC to provide electricity for some reasonable period of time required for them to pay back debt that they need to generate to move forward, they should not change their operations and simply be consumed when LEC expands into their current service area probably within the next three to five years.

2. **Provide 24-h Electricity to Existing Customers through a 0.64 MW Solar PV System, Improve Service Area Distribution Facilities and Interconnect with LEC Electrical Distribution System in Say Five Years**: This recommendation includes replacing existing diesel generators with a 0.64 MW PV generation plant with a battery bank sized to provide 2-day autonomy and tying the six sub-service areas together. This size of the generation facility improvement is equal to current energy demand levels extrapolated to 24 hour, seven days per week requirements and assumes that EP will serve the same number of customers as it does today. It would also require EP not only to obtain a concession from the GOL and some type of a franchise from LEC to provide electricity for some reasonable period of time but for it to have positive cash flow it needs to increase the number of customers by interconnecting with LEC. Increasing the plant capacity would increase the number of customers but EP will not be able to pay back any loan at interest rates greater than 2%. The recovery time for the investment is estimated to be approximately seven years and no replacement of batteries will be necessary as interconnection with LEC is considered. The cost estimate for the proposed infrastructure work under this scenario is approximately $6.34 Million.

   We estimate under this scenario that EP would be producing solar electricity for $0.508 per kWh where extra costs included are 15 km electrical distribution system to interconnect the six existing isolated service areas, power company management and operation improvement, and a maintenance deferred program to replace the existing distribution system to equal LEC construction standards. Individual metering systems are also highly recommended. Assuming a $20.00 per residential connection, an average monthly bill with peak load not exceeding 100 W would be approximately $50.00 per month. Under this scenario, EP would need to ensure that all T&D facilities designed and constructed meet LEC standards and specifications. This cost is included in our infrastructure cost estimates.

3. **Provide New Generation Facilities to Serve Additional Customers in a Larger Contiguous Service Area and to Interconnect with LEC Electrical Distribution system in Five Years**: Assuming EP can obtain a concession from the GOL and a franchise from LEC to operate as a private sector utility, it is recommended under this scenario that EP should invest in power generation expansion so as to design, construct and operate a plant of higher capacity than 0.64 MW. The higher the number of connections, the less expensive the cost per kWh becomes, especially because the same investment is to be made for 15 km of transmission and distribution for no matter what number of customers, as well as the implementation of a maintenance program to replace existing distribution system and for improvement of the power company operations. The capacity of the plant should be decided upon the financed amount to start the project. For this scenario, it is required that LEC and EP interconnect their T&D systems so the project becomes economically feasible. The expensive replacement of batteries at the 12-year mark is no longer necessary. This particular cost also decreases the investment recovery time from 12 years to 7 years. EP will provide daytime electricity and will buy LEC electricity at night to provide to its customers.

4. **Out of Scope Alternative**: This alternative starts with alternative 3 above and includes Eagle Power ramping up the production of PV generation over some schedule to be decided upon to 17 MW to service the 21,000 + customers in its

service area and perhaps increasing this capacity well beyond 17 MW and selling solar electricity to LEC during the day as well as proving for its own customers. The production cost per kWh for solar electricity at say the 20 MW production level would probably be approximately $0.27. This scenario would include a phased approach to the ramp up from 5 MW to 20 over some yet to be studied time period, but it would offer a mutually beneficial situation to both LEC and EP. This alternative needs further study but it includes a possible private sector investment opportunity within the Monrovia grid that would seem beneficial for the City and LEC.

2 INTRODUCTION

2.1 Background

Eagle Power (EP) approached the USAID funded Liberia Investing in Business Expansion Project (IBEX) seeking assistance in obtaining bank funding to carry out desired system improvements that included using renewable energy (RE) as a source for new electrical generation facilities. IBEX advised EP that they need a technical and cost study that they can be used to develop an implementation plan before any funding could probably be requested at a bank or from an investor. IBEX suggested EP talk to the USAID funded Liberia Energy Sector Support Program (LESSP) for advice and EP met with LESSP and asked for assistance in developing such a proposal. LESSP discussed this with USAID and it was agreed that LESSP would provide a Concept Study for EP to meet their requirements if EP was willing to also contribute resources and funds for this study and participate in the study work in a partnership arrangement (Public Private Partnership – PPP). EP agreed and USAID concurred that LESSP can work with EP on this work so as do deliver to EP a Concept Paper that addresses the issues at hand.

2.2 The Organizations

2.2.1 Liberia Energy Sector Support Project (LESSP)

The U. S. Agency for International Development's (USAID) LESSP contract was awarded to Winrock International (WI) on October 4, 2010 under USAID Contract 669-C-00-10-00059-00. The Winrock International team, including subcontractors Energy and Security Group (ESG) and Tetra Tech ES Inc. are implementing LESSP.

LESSP was developed by USAID in response to the priority set by the Government of Liberia (GOL) of rehabilitating energy infrastructure, which is an integral component of the nation's macroeconomic development strategy as set forth in the Poverty Reduction Strategy (PRS). Specifically, LESSP contributes to the following goals stipulated in the PRS:

- Builds the capacity of the Rural and Renewable Energy Agency (RREA) and the restructured Ministry of Lands, Mines and Energy (MLME);
- Increases energy access in both Monrovia and three rural counties;
- Explores additional generation options from other renewable energy sources; and
- Improves legal, institutional, and regulatory framework within the energy sector.

The purpose of the LESSP program is to increase access to affordable RE services in geographically focused rural and urban areas in order to foster economic, political and social development in Liberia. The program is aiming its work in Bong, Nimba and Lofa counties. The ultimate impact of the program, the change that USAID Liberia expects to see in targeted areas, will include:

- Increased and sustainable access and affordability of electricity within urban and rural poor communities;

- Improved performance of local governments, civil society and the private sector in monitoring, regulating, and managing the use of renewable energy;
- An increase in the percentage of households and businesses utilizing clean energy and a corresponding increase in economic activity; and
- Policy changes that improve the investment climate for the energy sector.

LESSP's objectives embrace energy sector regulation and institutional reform, RE pilot power plant construction and commercialization, strengthening of community-based organizations (CBOs) and capacity of institutions of higher education, public-private partnership development, and capacity building for support of the Liberia Electricity Corporation's to hasten electricity connections for lower income customers. A common thread connects the various subcomponents: the focus on RE as a key tool for enabling economic growth, and building an environment conducive to private investment in the energy sector.

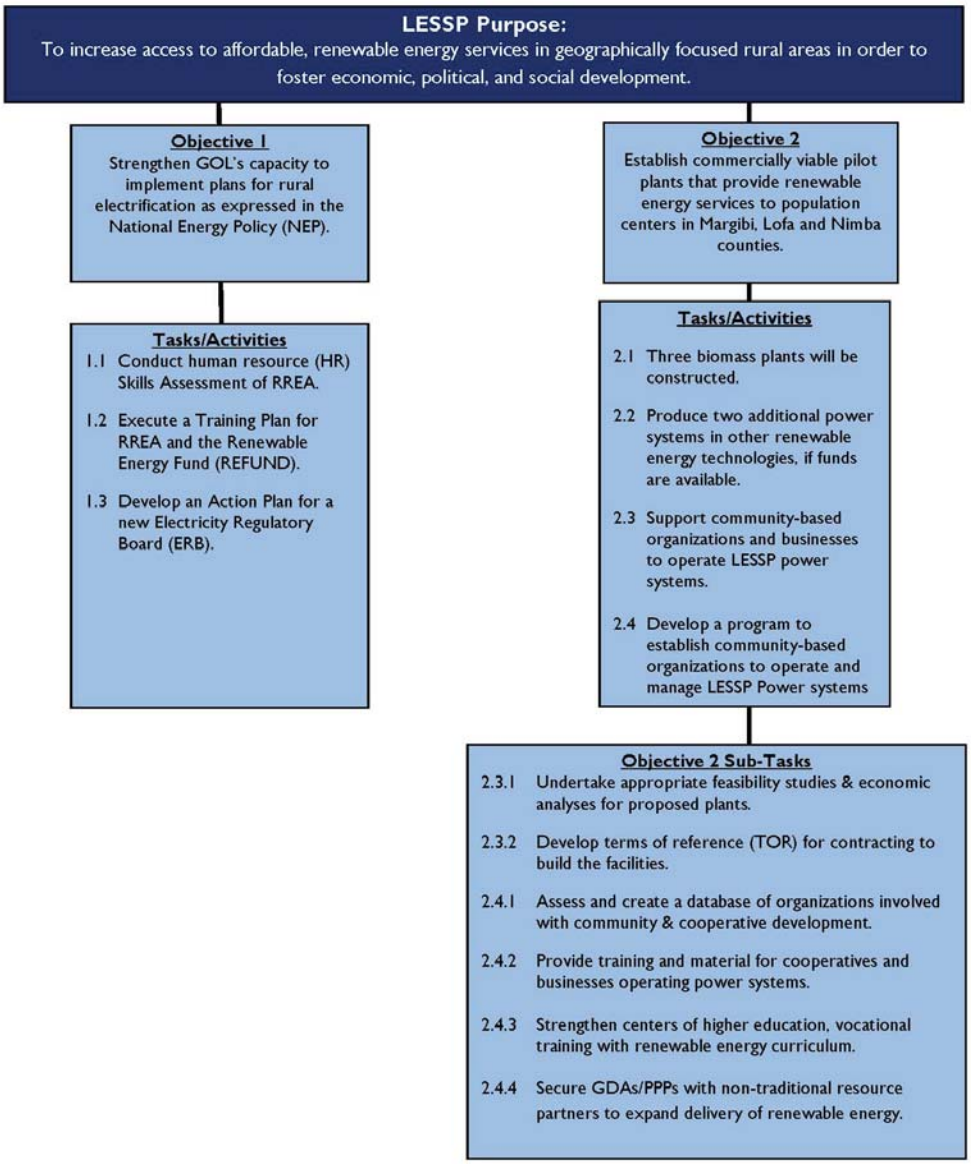


Figure 1. LESSP Activity Map

2.2.2 Eagle Power

Eagle Power (EP) is a privately-held Liberian owned and operated micro-utility, min-grid, providing night-time electric service in six discontinuous but closely located sub-service areas in Monrovia between Roberts International Airport and Paynesville with an installed generation capacity of 899 kW through diesel generators.

EP is under pressure with more nearby potential customers calling for service. EP wishes to respond to these requests for expansion of service and to carry out improvements in accord with the rules of the GOL and also to make these changes in accordance with sound business practices. EP seeks to be a first class electricity utility within the City and within Liberia.

Currently the EP service area extends in the west from incorporated Paynesville City in Montserrado County to the east past the Paynesville City limits to unincorporated Duazon in Margibi County. See the Service Area Map **Figure 2** that includes our best understanding of Paynesville City Limits and the Montserrado and Margibi Country Line.

Figure 2: Jurisdictional Map and Rough Limits of Eagle Power Service Area.

2.2.2.1 History

In keeping with the new 2009 Energy Policy of the Government of Liberia, which encourages private participation in the energy sector, Eagle Power was created as a community electricity service provider, a subsidiary of the 2G Companies, Ltd. 2G Companies, Ltd is also a privately held company. EP commenced operations in April of 2011 with an initial capital investment of $10,000, and only five customers. Over the last two years EP has connected 756 homes and businesses to its grid withe active connections today at the time of this study varying between 300 to 550 depending on delinquent account(s) status. Eagle

Power has deployed independent power generation facilities and distribution networks in six nearby communities along the Roberts International Airport Highway. EP's electricity is provided through low-tension conductors on locally made wooden poles. Subscriber amperage through circuit breakers at customer locations is the unit of measurement for pricing purposes in absence of a pay as you go used electricity-metering system.

The growing electricity demand from within the existing and adjacent served area is the main motivation for EP to look for funding for improving their operations, increasing/replacing generation capacity and to interconnect the now isolated but close by served communities.

2.2.2.2 Legal Documentation

On August 21, 2009, 2G Companies LTD obtained a Certificate of Business Registration before the Ministry of Commerce and Industry/Ministry of Foreign Affairs/ Ministry of Finance/ Ministry of National Social Security and Welfare Corporation. The Certificate is renewed in a yearly basis since then. The enterprise code 050996115 identifies the Company to the Government of Liberia for licensing and taxation purposes. The business activity is registered as "Electric Power Generation, Transmission and Distribution". **Annex A** shows a copy of the last renewal of the Business Registry.

In adherence to the Liberian Energy Law, the Liberia Electricity Corporation (LEC) is the only GOL entity with the responsibility for generation, transmission and distribution of electricity throughout Liberia. This fact makes EP an informal electricity provider. A license or concession regulated by the Ministry of Lands, Mines and Energy (MLME) would be required to allow EP to operate legally in accordance with the current Liberian laws and regulations.

2.3 Purpose of the Concept Study

The purpose of this concept study is to provide a **professional engineering plan, cost estimate and schedule** to expand Eagle Power service area to provide service to 1,200 or more customers for twenty four hour electricity; to increase power generation capacity by implementing Renewable Energy Technologies, and consolidate the six adjacent EP service clusters. It is our understanding that the engineering plan is to be used to **develop a Business Plan** that can be used to **obtain external funding** to finance the expansion and improvement.

2.4 Methodology

This concept study was divided mainly in three areas: (a) Existing Infrastructure, (b) New proposed generation and distribution infrastructure and (c) Findings and Recommendations. In depth understanding about EP existing operations was considered critical for the development of a realistic engineering plan that could enable them to obtain financing for

improvements so LESSP staff spent considerable time studying existing EP financial and customer records and examining exiting infrastructure operational records. Our work focused on the following:

Existing Infrastructure:

a. Analyze current Eagle Power management, finance and operations;
b. Characterization of current customers;
c. Analysis of potential customers;
d. Location and site maps, mapping of current customers;
e. Gather information about EP infrastructure, operation, maintenance, and capabilities for expansion; and
f. A review of how such a project would impact LEC's Monrovia power distribution system.

New Infrastructure:

g. Field trips to project area to identify route constraints and line routing;
h. Design of mini grid, and power generation for expansion of EP capacity;
i. Listing of minimum technical specifications for electric distribution and new power generation system;
j. Economic analysis of renewable energy technological options against diesel power generation;
k. A cost estimate that includes capital costs, additional design and environmental studies and construction costs; and
l. A schedule including design studies, procurement time, construction, testing and commissioning time.

Findings and Recommendations:

m. Conclusions and recommendations;
n. A review of risks, opportunities and implementation issues that may exist; and
o. Follow up work beyond the scope of work of this concept study.

3 EXISTING MANAGEMENT AND OPERATIONS

3.1 Eagle Power's Management, and Operations

Eagle Power Head Office is located in Duazon, Margibi along the Robertsfield Highway (6°13'16.27"N 10°35'58.40"W). Eagle Power management is distributed into the Accountant/Commercial and the Technical Departments. The main building consists of three offices

- CEO
- Accountant/Commercial Officer
- Senior Technician

Figure 3: Eagle Power Head Office.

Customer tariff collection takes place in six field offices; each one adjacent to existing EP power generation facilities for that cluster.

EP Head Quarters also hosts the workshop and technical crews that mobilize to the field whenever required. Distribution system and generator materials and parts and tools and stored here. Fuel is also stored here.

Administrative tools are basically three computers and two printers. The EP filing system was checked and is found to be in need of better organization.

The diagram on **Figure 4** shows the EP structure and the relationship and relative ranks of its staff positions. Currently, Eagle Power has forty-one employees. The Chief Executive Officer (CEO) is the administrator, decision maker, and leader in charge of general management of Eagle Power. The second ranked personnel are the Accountant and the Senior Technical Supervisor. Each one of them heads their respective Departments.

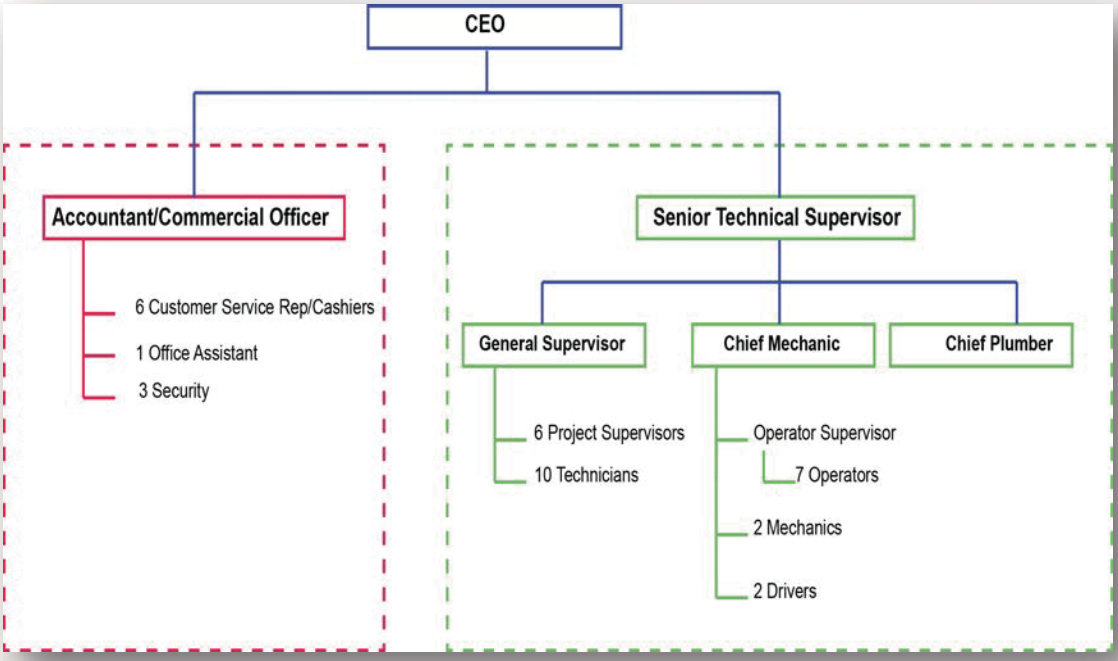


Figure 4: Eagle Power Organization Chart.

EP history is founded on sharing and good will. It was the main motivation of the founder to provide basic electricity service to people in need to light at night. As the system grew, communities requested additional service and **EP grew as it is today with its but effective limited technical, managerial, financial and administrative knowledge**.

EP is currently lacking operational policies that should provide direction to managers and staff in general to perform their duties. Policies needed generally include:

- Corporate governance (bylaws);
- HR and employee relations;
- Organizational structure;
- Finance, accounting; revenue management, auditing
- Procurement
- Planning, engineering and operations;
- Quality Assurance / Quality Control
- Health & Safety
- Security;
- Environmental Protection
- Member and community relations; and
- Rules of service, consumer rights and tariffs.

Not having procedures in place can create conflicts in both human resources and physical plant operations. Procedures provide details of how policies should be executed. EP staff is currently left to their own devices to determine how to manage daily activities. This leads to inefficiencies, disorganization, wasted effort, service issues, customer issues, accidents, lack of morale, and ultimately higher operational costs.

Personnel are the most important assets of any enterprise. Typically in electric companies, salaries and benefits are the second highest operating expense. However, **EP does not today have employee policies that include a basic salary plan, benefit plan, safety plan or training program**. **Annex B** summarizes the current EP salaries for its staff.

EP financial sustainability is at risk since no financial policies and procedures are in place to ensure adequate financial control, accountability and transparency. Expense reports were found inconsistent when comparing monthly fuel expenses, the highest cost in a power company, against monthly reports. **Annex B** includes EP expenses data highlighting inconsistencies through data analysis of actual records of fuel. EP is currently mixing accounting methods for which information is not readily available. Generally accepted cost accounting standards and methods are needed and recommended to make EP information readable to accounting professionals and EP managers and officers.

The operations of the Accountant/Commercial Department consist of managing consumer information, billing, collections, new connections and service disconnections. Even though such activities are conducted on a timely basis in EP operations, it was found that

- Consumer information is not well organized;
- Consumer identification numbers were non-existent for many;
- Consumer identification numbers were duplicated for some;
- Active and inactive accounts are not easy to categorize;
- Amperage subscriptions were not up to date;
- Reason for disconnections are unknown;
- Account delinquency data is not clear; and
- Customer database is non-existent.

Table 1: Sample of EP Customer Information.
As a customer database was not existent, LESSP developed it from multiple files and hard copies. However, there is still data conflict and this information remains to be audited and verified by others.

Customer	ID	Location	Amperage
Fatu K. S.	EPRC-1323	RC	2
Dayougar J.	EPRC-1324	RC	1
Ellen K.	EPRC-1339	RC	2
Eddie J.	EPRH-1184	RC	2
Isaac L. M.	EPRC-1233	RH	1
Yeannie G.	EPRC-1319	RH	1
Jartu C. J.	EPRH-0002	RH	1
Rebecca C.	EPRH-0007	RH	1

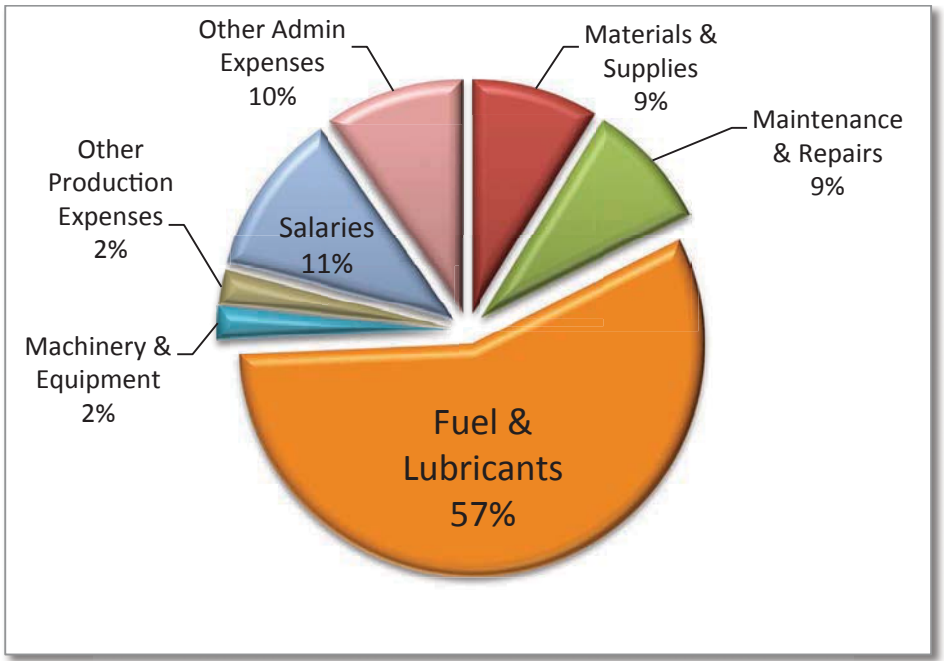


Figure 5: EP expenses.

3.2 Customer Agreement

EP stipulates the requirements customers must comply to be served through the EP distribution system. All consumers are required to complete the application form presented in **Annex A**. A non-refundable registration fee of 25.00 USD is required for the application. EP flat rate for electricity is based on amperage subscription.

When applying for the service, the potential customer enumerates the wattage of the appliances and number of lights they wish to power and purchase. EP evaluates the customer ability to pay. When the application form is approved and signed by the two parts, this becomes the customer agreement with EP.

EP services are provided on a prepaid basis. It provides 11 hours of nighttime electricity with 95% guaranteed "uptime" from 7 pm to 6 am 365 years a year unless interrupted by incidents beyond EP control. **The service cost per ampere is 57.50 USD (two amps and above) but may be adjusted up or down depending on market factors such as fuel price.** A services tax of 7% is applied to the monthly EP bill in compliance with the 2007 Goods and Service tax code of the GOL.

Apart from servicing households and businesses electrification needs, EP provides security lights throughout the community at strategic locations. EP maintains these lights and replaces them in a regular basis.

EP provides feeder poles and low-tension distribution lines along the road and alleys within the service areas. If additional poles are needed to reach a customer, a fee of $20.00 per pole is charged. Service cables needed to reach a house or business from the nearest pole may be purchased from EP or at a local vendor. For quality purposes EP recommends #8 AWG or European cooper wire for customer connections. Should a line become disconnected due to delinquency or non-payment of bills, a reconnection fee of $30.00 must be paid before reconnection. A grace period of three days is given to all subscribers beyond

the due date. After three days, accounts are considered delinquent and subject to disconnection.

3.3 Electricity Pricing Review

EP set a flat rate per connection per amperage based on limited technical and financial knowledge. During first discussions with the LESSP team, EP opined that their electricity service is less expensive than the LEC's tariff. The fact is that strictly speaking EP service is more expensive: **$57.50/ (A-month) = $0.78/kWh or EP electricity Cost = $1.45 LEC tariff.**

However, because EP does not meter customers pay the same amount whether they use the electricity or not. **Figure 6** shows a typical load distribution for a Liberian household. From 7 to 10 pm, most lights and appliances are turned on; after 11 pm people go to sleep; and then again, in the early in the morning, lights and appliances are powered again. So, strictly speaking, they are paying for their electricity through their amperage subscription even when they are not using electricity. This makes their kWh cost appear higher than LEC's. If EP metered, we believe, but we are not sure, that the cost per kWh would be closer to $0.40. Again however, because EP's operational records are problematic, we cannot be entirely sure.

So for an example household, electricity consumption could deviate from the typical load distribution for many reasons. **Figure 6** accounts for 68% of the energy subscribed for and equivalent to 6.11 hours at full amperage. **Figure 7** compares LEC and EP costs of energy actually used. When subscribers use 100% of the energy they are billed for, they would be paying 45% more than a LEC customer. For the particular distribution shown in **Figure 6**, customer should be paying 150% more than a LEC customer. The less energy is used, the more expensive the cost per kilowatt-hour becomes. Implementation of electricity metering system for consumers is the first measure to lower costs of service and to attract more customers.

The tariff should be determined according to a revenue approach, which considers the total revenues required to meet all operating expenses and capital costs of the utility. The tariff should be calculated on a quarterly basis taking into account the price of equipment, service schedule, maintenance, 20% of technical and nontechnical losses, and distribution costs.

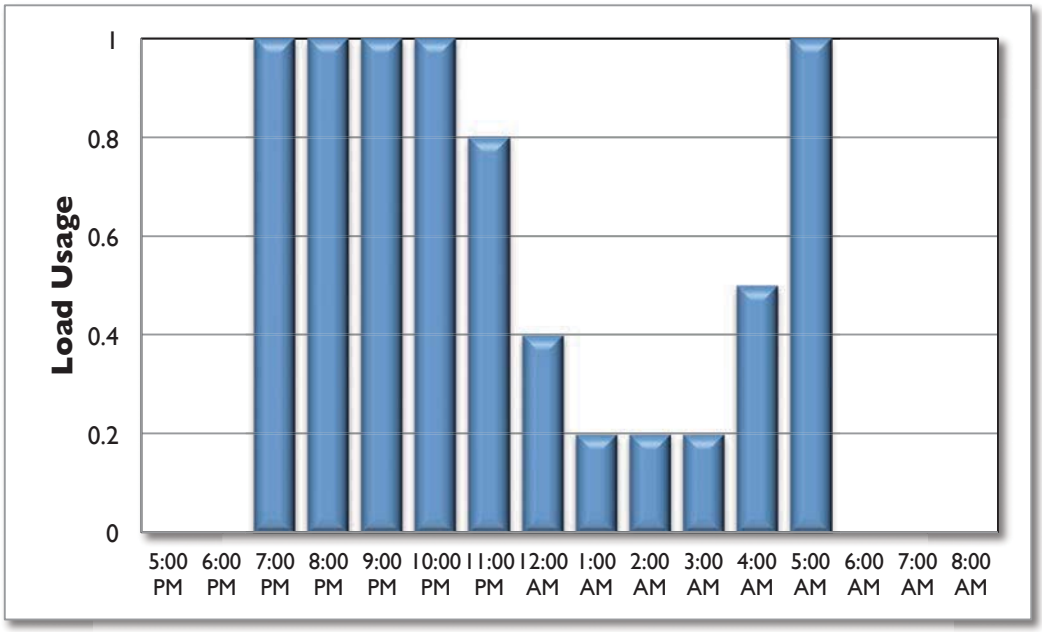


Figure 6: Typical load distribution for EP served households.

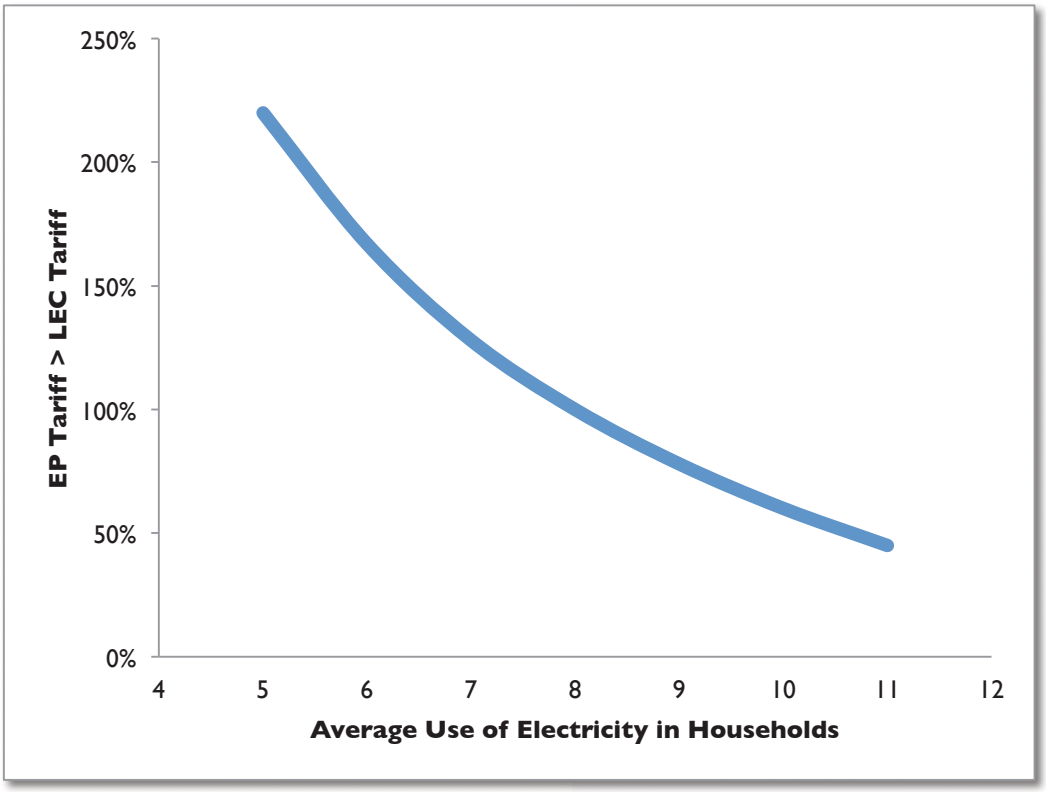


Figure 7: The lack of individual metering system makes electricity more expensive. The less hours electricity is used, the higher the cost per kWh.

3.4 Customer Service

EP customer service consists of attending applications for service, managing customer complaints and key accounts management. Customer service is available in the EP field offices, one located per served community:

- Thinker's Village (TVL);
- Guest House Road (GHR);
- Rockhill (RKH);
- Rehab Community (RHB);
- VOA (VOA); and
- Duazon (DZN).

Field offices facilitate the communication between customers and EP administration. Negotiation about due amounts and maintaining service is an example of a typical issue managed by customer service. Fee and money collection takes place in the field offices.

3.5 Customer Characterization

In the short life of Eagle Power, a total of 788 customers have been added and identified. **Figure 8** illustrates the connection breakdown showing their current status as per the date of this report. These figures are constantly changing due to the rather high percentage of relapsing delinquent accounts.

EP does not maintain an automated customer database to be able to categorize properly and also to perform a dynamic characterization of the customer base. Understanding of customer behavior for the total EP population, by community and by customer could improve general EP operations. **Table 2** presents the number of active and inactive connections per community. No more details were found for each community and data for 32 accounts is missing.

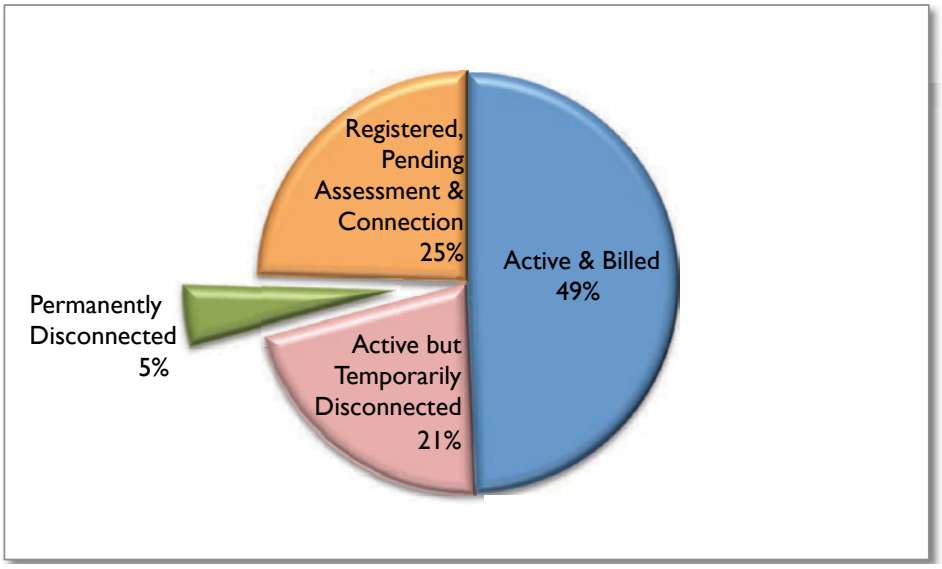


Figure 8: EP customer status.

Service subscriptions range from 1 to 20 amperes. A frequency plot of EP customer amperage subscription is presented in **Figure 9**. This represents a positive skewed distribution where 86% customers are subscribed to 1 to 3 amperes and 98% from 1 to 6. The total amperes that EP should be able to supply are 947 for the 389 currently active accounts.

Table 3 presents the energy for which EP charges its customers per community in a month. The calculation considered 11 hours of service provided every night (7 pm to 6 am) and 30 days per month. The table also includes maximum and minimum amperage occurrences within each community; and the calculated mean and standard deviation.

Table 4 shows equivalent data in terms of kilowatts, the most commonly unit used by electricity providers.

Eagle Power billing per month and per community is shown in **Table 5**. This table is equivalent to Table 3 but in terms of money. Customers are billed from 57 (1 A) to 1,140 (20 A) USD with an average of $145. EP should be billing $54,362 per month to the 389 customers. However, as EP does not have meters in place for which breakers are utilized instead, the actual amount of energy provided and used is not measured. People do not use a hundred percent of their subscriber amperage. They do not even use all their loads all the time when the service is available. If the billing were based on actual consumption of electricity, consumers bills would be less. The calculation of the cost per month was made under the assumption that users follow a consumption distribution as the one shown in **Figure 6**.

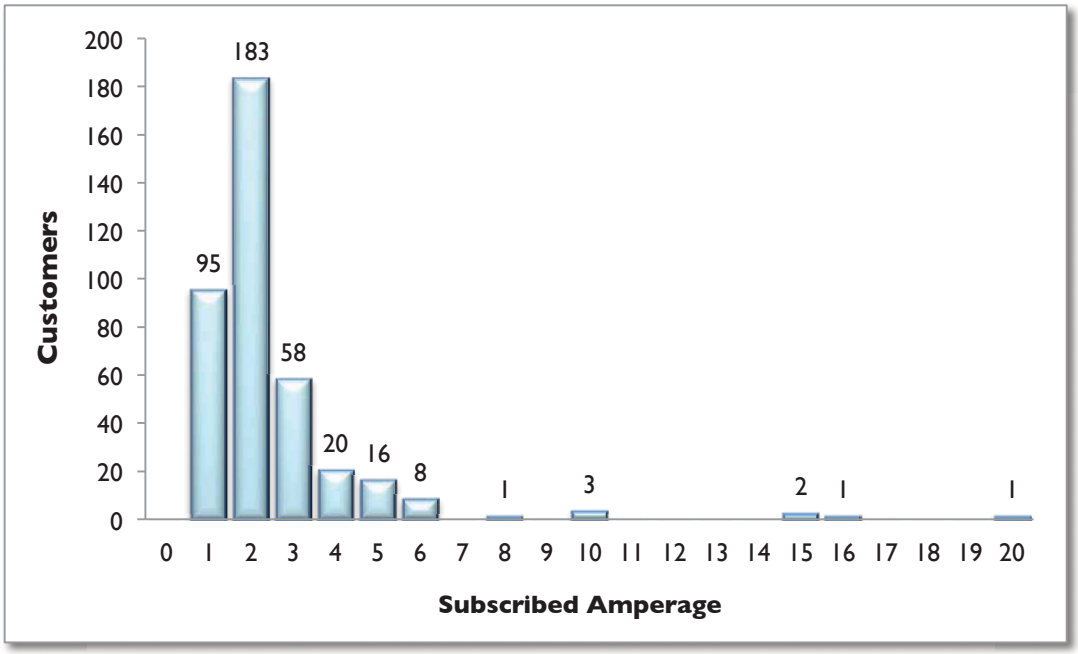


Figure 9: Amperage subscription of EP customers

Table 2: EP total connections per served communities.

	Zone	Active	Inactive	Total Connections
a	*b*	*c*	*d*	*e*
1	TVL	53%	47%	150
2	GHR	75%	25%	76
3	RKH	31%	69%	208
4	RHB	63%	37%	148
5	VOA	57%	43%	35
6	DZN	54%	46%	139
8	Average	51%	49%	
9	Total	389	367	756

Table 3: Monthly energy in Ampere-hours (Ah) for which each community is subscribed.

Zone		Active Customers	Amperes				
			Max A/customer	Min A/customer	Avg A/customer	STD A/customer	Total Ah/month
a	*b*	*c*	*d*	*e*	*f*	*g*	*h*
1	TVL	79	10	1	2.913	1.624	75,929
2	GHR	57	16	1	3.544	3.111	66,660
3	RKH	65	4	1	1.667	0.730	35,750
4	RHB	93	5	1	1.730	0.836	53,104
5	VOA	20	4	2	2.750	0.754	18,150
6	DZN	75	20	1	2.632	2.529	65,132
7		389	20	1	2.539		314,724

Table 4: Monthly energy in kilowatt-hours (kWh) for which each community is subscribed.

Zone		Active Customers	kW			
			Max kWh/month	Min kWh/month	Avg kWh/month	Total kWh/month
a	*b*	*c*	*d*	*e*	*f*	*g*
1	TVL	79	726	73	211	16,704
2	GHR	57	1,162	73	257	14,665
3	RKH	65	290	73	121	7,865
4	RHB	93	363	73	126	11,683
5	VOA	20	290	145	200	3,993
6	DZN	75	1,452	73	191	14,329
7		389	1,452	73	184	69,239

There is a large deviation between billings and receivables according to the EP CEO. Billing statements are sent to the customers through the cashiers in the field offices. The statements include the due date for the prepaid service. If the service is not paid the customer is temporarily disconnected. **Figure 10** shows the EP customers' delinquency in terms of money collection and number of delinquent customers per account and age or delinquencies.

Table 5: Actual monthly energy billing in USD, and billing in the assumption that consumers utilize 66% of the energy for which they are subscribed.

Zone		Active	Billing					If meters were in place
			Max $/month	Min $/month	Avg $/month	STD $/month	Total $/month	EP $/month
a	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*
1	TVL	79	$ 570	$ 57	$ 166	$ 92.58	$ 13,115	$ 8,704
2	GHR	57	$ 912	$ 57	$ 202	$ 177.35	$ 11,514	$ 7,641
3	RKH	65	$ 228	$ 57	$ 95	$ 41.63	$ 6,175	$ 4,098
4	RHB	93	$ 285	$ 57	$ 99	$ 47.66	$ 9,173	$ 6,087
5	VOA	20	$ 228	$ 114	$ 157	$ 42.97	$ 3,135	$ 2,081
6	DZN	75	$ 1,140	$ 57	$ 150	$ 144.15	$ 11,250	$ 7,466
7		389	$ 1,140	$ 57	$ 145		$ 54,362	$ 36,076

The most likely reasons for the high percentage of the delinquent accounts in the first month are:

- The service is expensive: or low Ability to Pay (ATP)
- Liberians are not used to paying bills or low Willingness to Pay (WTP)
- A combination of the above

As seen in the plot on **Figure 10**, electricity service is highly appreciated or needed by the community so that for whatever reason payment was not made in the first month, almost half of the delinquent accounts recuperated their active status by prepaying the service in the second month thus allowing EP to recover more than 50% of the late fees. This improves in the third month and 80% of the money collected. EP is lacking any kind of delinquency reports other than billing statements. This plot was developed by gathering data "by hand" from hundreds of billing statements since the commercial department was unable to provide it.

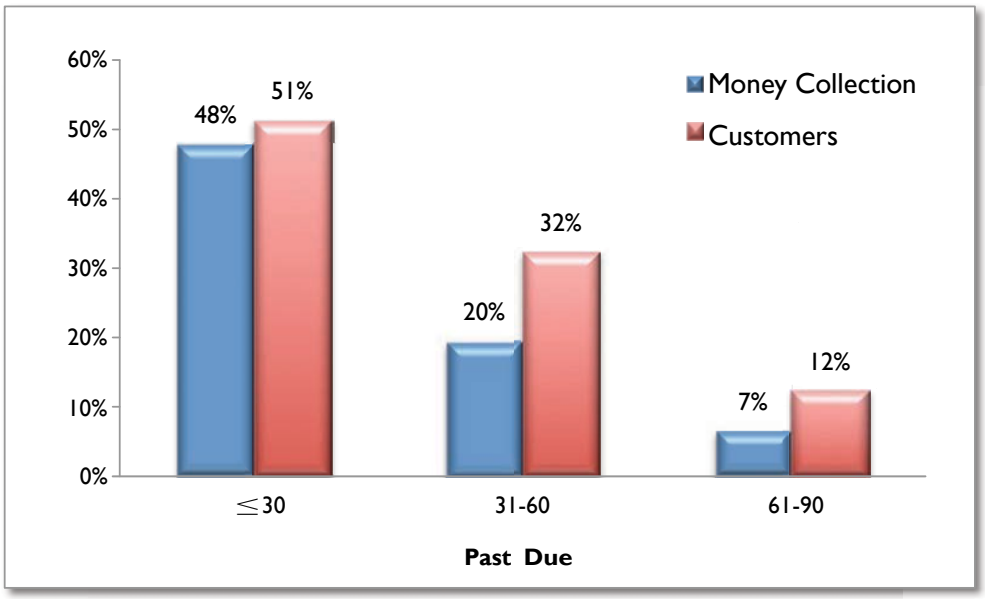


Figure 10: Delinquency per account by age.

Effective service should be based on an in-depth understanding of the customers, load profiles, ability to pay and willingness to pay. It is of great importance for EP to create and implement a strategy based on the real needs of its customers. As no meters are in place, actual loads profiles are not available. Willingness and ability to pay surveys are tools that should be utilized to be able to attract more customers and to recover the disconnected customers.

3.6 Engineering

3.6.1 Existing EP Power Generation and Distribution

The existing EP generation infrastructure consists of ten generators with a total installed capacity of 899 kVA. Generators capacities range from 5 to 200 kVA with an average of 89.9 kVA. Six generators were new when purchased with a total capacity of 409 kVA. The shadowed rows in Table 6 represent the total installed power capacity generated from these generators. The oldest generator of which there is record was purchased is a year 2000 model and it was bought in 2013.

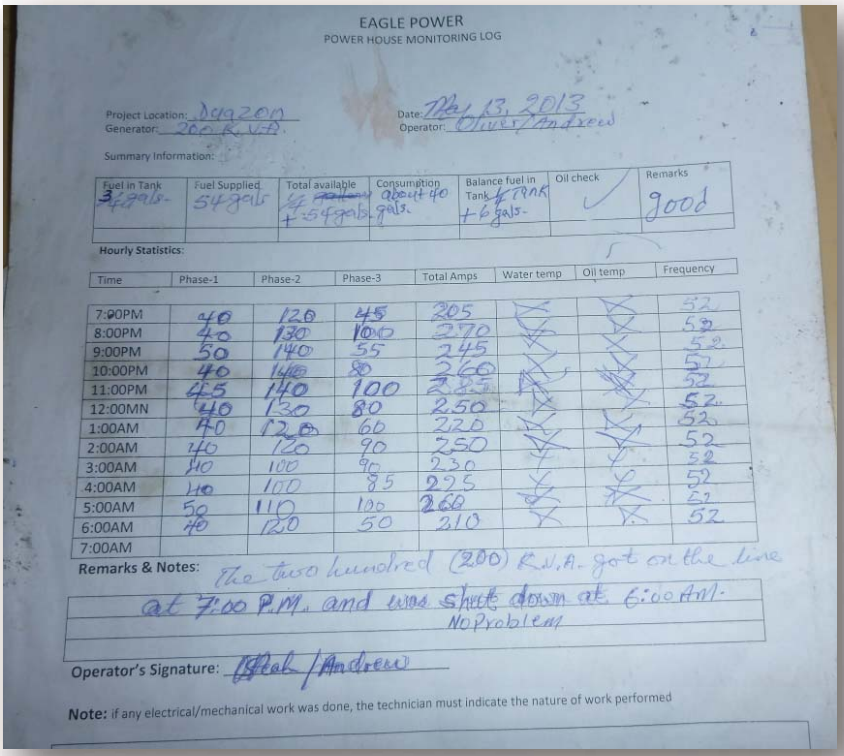
The average useful life of generators is about 6 years for 12 hour of daily operation and about 20 years when in stand-by mode. More than half of the EP capacity will have to be replaced in the near future. The standby generator located in the Duazon powerhouse with 100 kVA is the only generator that could be used in case of an emergency with the oldest generators located at Rockhill or Guest House. This will of course require relocation. There is no emergency or stand-by replacement service plan.

EP provides monthly preventive maintenance to all generators. It basically consists of replacing filters, and oil. **Annex B** includes a summary of the expenses for the generators scheduled maintenance.

Table 6: Eagle Power generators.

	Zone	Generator Use	Make	Model	Year	Capacity (kVA)	Voltage (V)	Current (A)
a	*b*	*c*	*d*	e	*f*	*g*	*h*	*i*
1	RKH	Main	Perkins	P83E1	2004	82.5	220/380	125
2	RKH	Standby	Lister Petter			77.5	120/208	215/172
3	TVL	Main	Stamford	UC1274f		150	380	225
4	GHR	Main	Magna Plus	MP-104-4	2000	130	400	188
5	RHB	Main	Perkins	FD3A1-4	2011	100	400	144
6	RHB	Standby	Perkins	HLDGGS6/30	2010	36	400	54
7	VOA	Main	Perkins	HLGF18	2011	18	400	32
8	VOA	Standby	Kama			5	400	19
9	DZN	Main	IVECCO	UCI274H1		200	400	289
10	DZN	Standby	Stamford	UCI274D		100	400	150
11	Installed Capacity (kVA)					899		
12	Operating Capacity (kVA)					681		

Even though EP records technical data at the powerhouses on a daily basis, such information was not readily available when requested for this analysis. **Figure 11** is a picture taken during a visit to the Duazon Powerhouse on July 24 (but it was dated as May 13 in error). When plotting the data and comparing it to the assumed load distribution for households presented in **Figure 6**, the load self-adjusting generator does not match a typical load as shown in **Figure 12**. There are technical issues with load and generated power throughout the system that require study.



EAGLE POWER

POWER HOUSE MONITORING LOG

Project Location: Duazon
Generator: 200 K.V.A.
Date: May 13, 2013
Operator: Oliver/Andrew

Summary Information:

Fuel in Tank	Fuel Supplied	Total available	Consumption	Balance fuel in Tank	Oil check	Remarks
3 gals.	54 gals	4 + 54 gals.	200+40 gals.	6 gals.	✓	good

Hourly Statistics:

Time	Phase-1	Phase-2	Phase-3	Total Amps	Water temp	Oil temp	Frequency
7:00PM	40	120	45	205			52
8:00PM	40	130	100	270			52
9:00PM	50	140	55	245			52
10:00PM	40	140	80	260			52
11:00PM	45	140	100	285			52
12:00MN	40	130	80	250			52
1:00AM	40	120	60	220			52
2:00AM	40	120	90	250			52
3:00AM	40	100	90	230			52
4:00AM	40	100	85	225			52
5:00AM	50	110	100	260			52
6:00AM	40	120	50	210			52
7:00AM							

Remarks & Notes: The two hundred (200) K.V.A. got on the line at 7:00 P.M. and was shut down at 6:00 AM. No Problem

Operator's Signature: Oliver/Andrew

Note: if any electrical/mechanical work was done, the technician must indicate the nature of work performed

Figure 11: Typical Technical data recorded in a daily basis at the powerhouses.

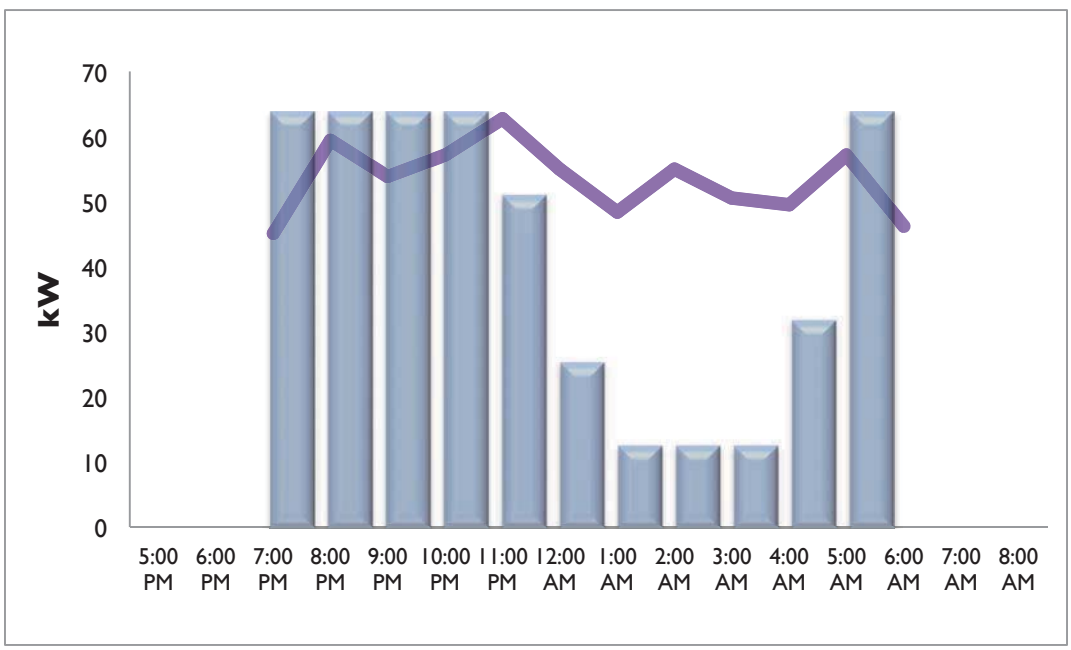


Figure 12: Actual self-adjusting power generation at Duazon compared to typical household load distribution. Installed capacity 200 kVA and average operation capacity 53.4 kVA.

Diesel of course is the highest EP expense as seen in **Figure 5**. The plumber is in charge of distributing fuel to the six powerhouses, and recording daily consumption. All that data must be captured in the computer to be able to monitor and improve operations, as well as for financial expenses comparisons. For this analysis, three months of daily fuel consumption per powerhouse was electronically captured from the handwritten forms by the technician. **Table 7** presents the total fuel consumption and cost per month. Actual fuel monthly expenses do not match to what was reported in the EP Monthly Expense Report included in Annex B. CSA method should be implemented for better tracking, analysis and understanding of expenses and receivables. **Figure 15** compares the monthly fuel expenses highlighting significant differences.

Figure 13: Diesel distribution at the workshop in the EP headquarters.

Figure 14: Diesel supply at the Duazon powerhouse.

Table 7. Fuel consumption per powerhouse and total cost.

Month	Volume (Gal/month)						Cost ($/month)	
	RKH	DZN	TVL	GHR	RHB	TOTAL		
Feb-13	972	1,467	1,242	647	1,344	5,672	$	23,708.96
Mar-13	1,074	1,722	1,584	1,092	1,464	6,936	$	28,992.48
Apr-13	1,071	1,660	1,764	1,192	1,260	6,947	$	29,038.46
AVERAGE							$	27,246.63

As no meters are in place to measure either the load nor the power generation, the monthly electricity production was estimated from amperage subscription, power generator infrastructure (self-adjusting or not) and available fuel consumption data. The cost of production is shown in **Table 8** was calculated for three particular months with financial data provided in the Monthly Expense Reports included in **Annex B**. **The estimated cost of electricity production was found to be in the range of $0.34 to 0.45 per kWh.**

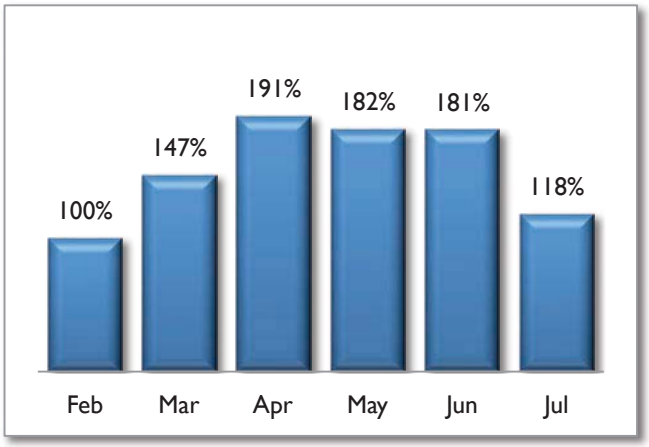


Figure 15: 2013 Comparative fuel expenses taking February's expense as the base amount.

Table 8: Cost of electricity production.

Month	Total Production per month kWh	$/month	Production Cost $/kWh
Feb-13	108,168	$ 36,899.71	$ 0.34
Mar-13	108,168	$ 36,474.08	$ 0.34
Apr-13	108,168	$ 48,807.44	$ 0.45

Eagle Power has great potential to attract more customers with its existing infrastructure. **Figure 16** shows that 51% of the total installed capacity is used for generation. When replacing the old generators with new models, the difference between the consumption and the generated energy will become smaller. Implementation of meters at the individual load centers will decrease the cost of electricity for users since they will only pay for what is used.

If EP would double the number of customers with the existing infrastructure, the cost of amperage per month would nearly be decreased to half of the cost today.

EP has with 35 km of electrical distribution lines within the six communities. The distribution system consists of 1,617 non-standard, non-treated poles. Replacement is required as often as eight months to two years. Currently, the **EP distribution system does not follow any engineering standard and has no real legal Right of Way for the current land usage.**

Expansion of the distribution network around each powerhouse is possible without transformers. **Figure 18** is location map that include the six EP powerhouses. The 2.4 km diameter circles on the map represent the capability for network expansion without transformers.

Figure 19 shows that only a small percentage of households within each service area are connected to the EP electrical distribution system. EP should incentivize new subscribers within the existing service areas to be able to lower the overall cost per subscription. It already has the generation and distribution infrastructure in place to quadruple the connections it has today.

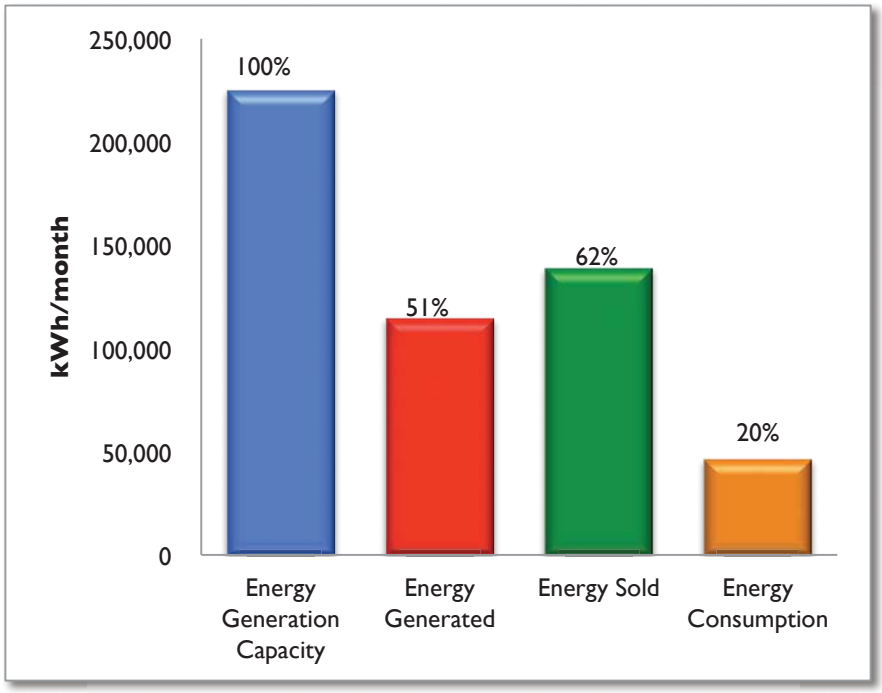


Figure 16: Comparison between EP generation capacity, actual generation, sold energy and energy consumed.

Figure 17: Eagle Power electrical distribution system.

Figure 18: Location map of EP powerhouses and capability for network expansion without transformers.

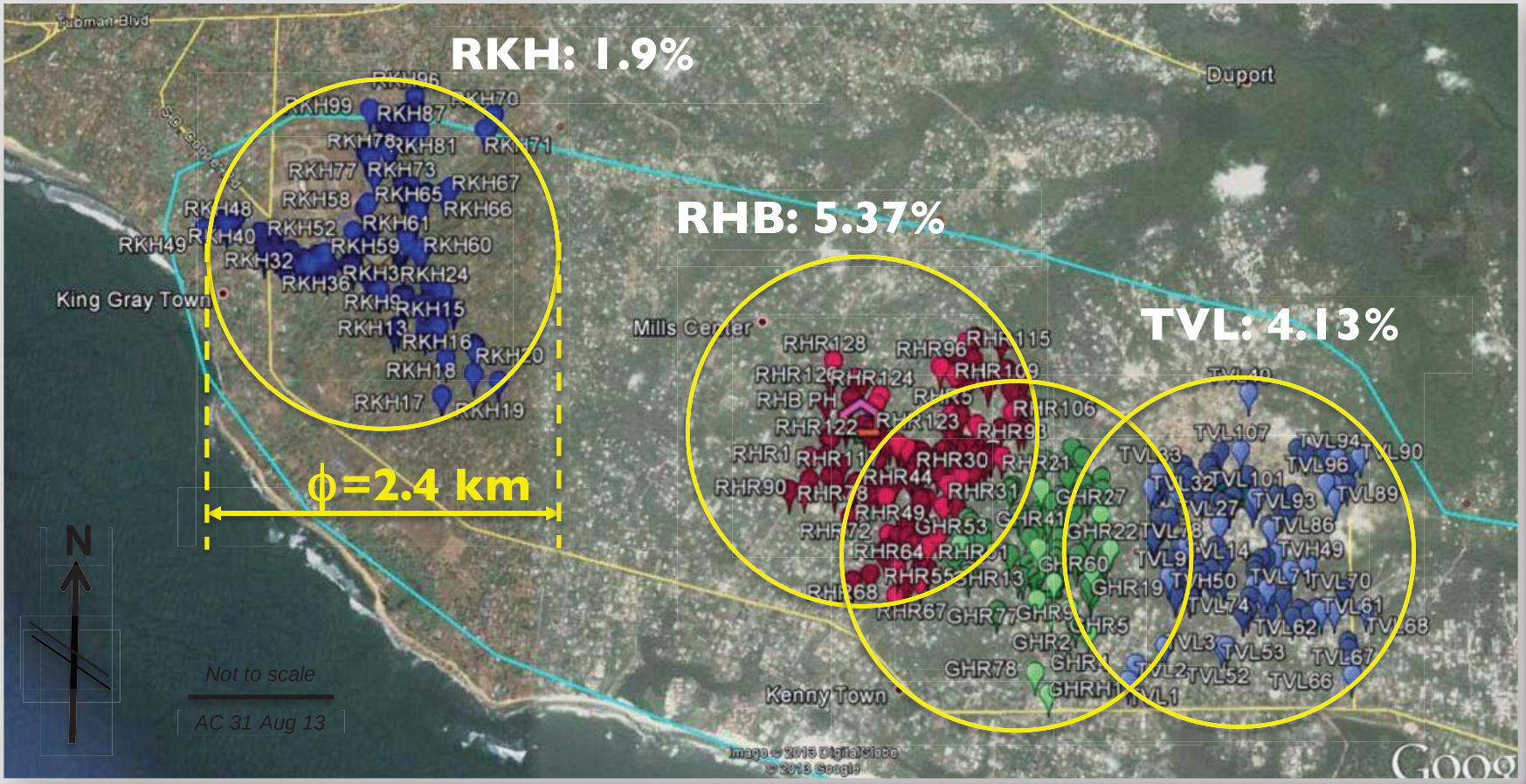


Figure 19: EP household connections, percentage of households connected per community and limits for network expansion without transformers.

3.7 Eagle Power Equity

A summary of EP assets are:

- Six power houses (10 generators);
- One Multipurpose building with three small offices and a workshop (3 small generators);
- Seven Vehicles: 1 GM Chevrolet Silverado 2500 HD Pickup Truck, 1 Toyota Tacoma Pickup, 1 Toyota Hillute Pickup, 1 DAF 1100 truck, 1 Jeep Cherokee, 2 Low Bed Trailers;
- Two Air compressors; and
- 35 km electrical distribution system with 1,617 standing poles and 155 streetlights.

4 PROPOSED FACILITIES

To guarantee high quality service at the lowest possible cost to the consumer, EP should not only improve management, financial and commercial operations but also establish engineering design and construction standards. **EP must adopt LEC engineering standards for the expansion of power generation and distribution systems and for a deferred program to replace the existing infrastructure.**

The EP expansion plan studied herein is to interconnect all communities within the network from a central power plant. The design should employ state-of-the-art technologies from the power station to the customer premise. EP long-term strategic objective is to occupy the last tier of the electricity production business that consists of generation, transmission and distribution.

4.1 Present and Future Energy Demand/Consumption

The potential for electrification in Liberia is unlimited for any power company. When EP is able to provide effective and LEC-cost-comparable electric service, it could attract all the residents within the currently served area through a proactive communication program. **Figure 20** shows a possible expanded area in which EP is interested to electrify.

The process of estimating the system demand is a function of identifying the geographic load centers, estimating the number of likely consumers and the electricity demand per consumer. **Table 9** shows the findings from an assessment to determine the number of load centers in the potential EP service. It was found that only 2.6% out of 21,155 load centers are presently EP customers.

Figure 20: Location map of the Eagle Power potential service area.

Table 9: Load centers windshield assessment within the EP potential service area shown in Figure 20.

Service Area	Existing EP Customer		Prospective EP Customer		Institutional								Total Housing
					Schools		Clinics		Police		Other		
	Res	Com	Res	Com	E	P	E	P	E	P	E	P	
DZN	106	5	5,483	277	1	49	0	20	0	2	0	93	6,036
VOA	8	0	800	10	0	0	0	0	0	0	0	4	822
TVL	108	2	2,275	172	0	32	0	10	0	0	1	65	2,665
GHR	77	2	723	105	0	15	1	9	0	0	2	20	954
RHB	111	3	1,858	75	1	19	0	13	0	0	0	63	2,143
RKH	139	3	7,474	499	15	106	5	70	0	3	0	221	8,535
Total	549	15	18,613	1,138	17	221	6	122	-	5	3	466	21,155

Table 10 shows a quick and conservative calculation to determine the power generation capacity to satisfy the peak demand for the current potential users as well as considering a 15% growth in population within 5 years from now. Two different peak loads were assumed for each type of consumer giving a conservative size and a bigger system. Considering a 70% total efficiency of the generation and distribution systems, 4 MW and 8.5 MW are the two estimated generation capacities to support the supposed peak loads.

Energy demand and forecast could also be estimated with daily load distribution for each type of consumers. **Figure 6**: Typical load distribution for EP served households. It was assumed to be the load distribution of EP consumers during EP power generation hours. Such distribution must be extended for a 24-hour service. **Figure 21** presents typical normalized load distributions for the three types of consumers found during the assessment summarized in **Table 9** and used to estimate the energy per day per consumer and total for the peak load assumptions made in **Table 10**. Total peak load, and total energy consumption and generation such as the presented in **Table 10** and **Table 11** are the foundation to calculate expenses and revenues of a power company.

Table 10: Power Demand and forecast for 5 years from now to satisfy load centers within the EP potential service area shown in Figure 20.

Peak Demand per	Number of Load Centers	Conservative Peak Load	Not so Conservative Peak Load	Units
Household	19,162	100	250	Wp
Businesses	1,153	300	400	Wp
Institutions	840	400	500	Wp
Total Peak Load	21,155	2,598	5,672	kWp
Peak Power Generation		3,378	7,373	kWp
Peak Power Generation in 5 years		3,884	8,479	kWp

Assumptions:

Generation and distribution system efficiency	70%
Percentage of new load centers in 5 years	15%

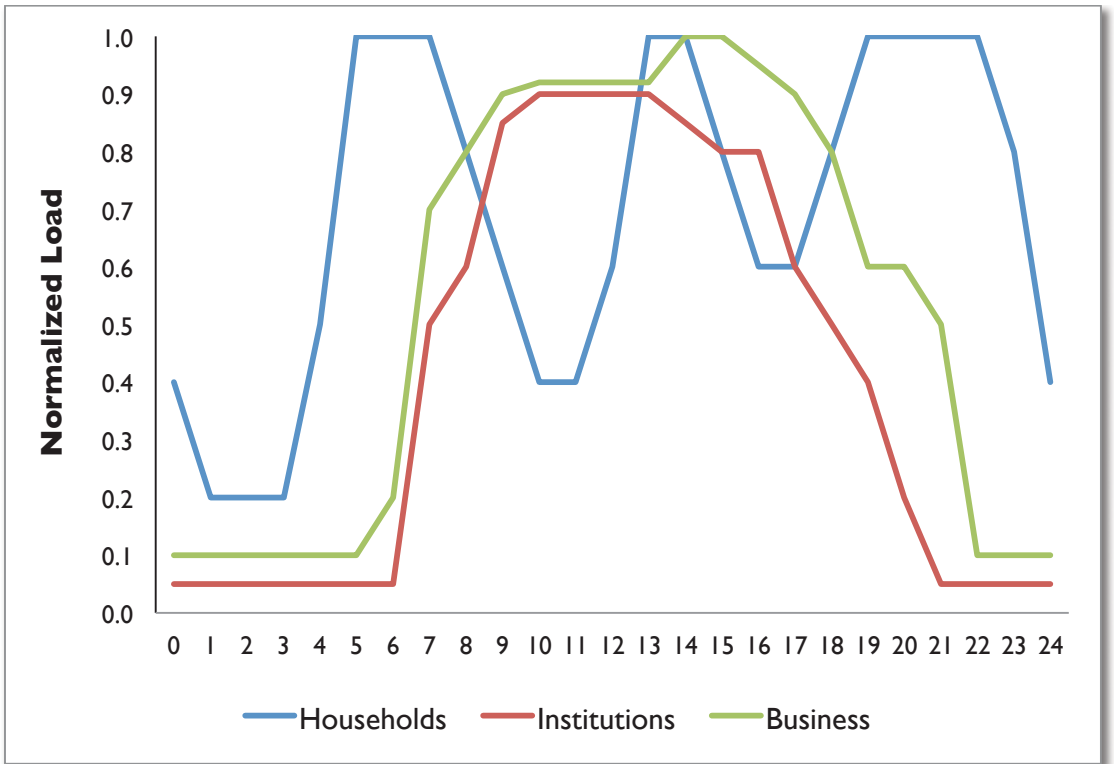


Figure 21: Assumed normalized load distributions for EP served households, institutions and businesses.

Table 11: Energy Demand and forecast for 5 years from now to satisfy load centers within the EP potential service area shown in Figure 20.

Energy Demand per	Number of Load Centers	Conservative Energy Demand	Not so Conservative Energy Demand	Units
Household	19,162	1,730	4,325	Wh/day
Business	1,153	4,059	5,412	Wh/day
Institution	840	4,100	5,125	Wh/day
Total Energy Demand	21,155	41,274	93,421	kWh/day
Energy to be Generated		53,657	121,447	kWh/day
Energy to be Generated in 5 years		61,705	139,664	kWh/day

Assumptions:

Generation and distribution system efficiency	70%
Percentage of new load centers in 5 years	15%

4.2 Proposed New Infrastructure

4.2.1 Electrical Distribution Grid

A 15 km overhead electrical line is required to interconnect the existing six independent EP electrical networks from Scheiffelin to Rockhill. As the LEC plan is to use 22 kV Medium Voltage (MV) lines to a larger extent than Low Voltage (LV) lines to spread out the grid for

customer connections, EP will distribute power at MV following LEC engineering plans and standards.

Figure 22 presents a preliminary design for a MV distribution line that will be able to serve the EP potential service area shown in Figure 20. **Table 12** lists the technical specification for the electrical distribution line including the 22/0.4-0.23 kV transformers that will be used to interconnect to the six communities.

Table 12: Technical specifications for the 15 km 22 kV distribution line.

Distribution Line Extension		
Length of extension	15	km
Power distribution voltage	22	kV
Low voltage for users	400	V
Number of poles	260	Units
Poles		
Height	11 and 13	m
Pole spam	50 to 60	m
Minimum top diameter	20	cm
Pole depth	1.8	m
Construction material	CCA Wood	
Conductor		
Area	120	mm^2
Area for neutral line	95	mm^2
Conductor type for 3-phase and neutral lines	AAAC	
Three Step down Transformers		
Voltage	22/0.40-0.23	kV
Frequency	50	Hz
Capacity	150	kVA
1 Step up Transformer		
Voltage	0.40/22 kV	kV
Frequency	50	Hz
Capacity	1,500	kVA

A material list has been developed for purposes of cost estimating. The final material quantities need to be revisited after the final design process has been completed. **Annex C** presents a detailed BOQ and cost estimate for the 15 km 22 kV electric distribution line required to tie the six load centers together. The estimate includes costs of materials, hardware and accessories, as well as for civil works and construction. Permits, taxes, fees, and material testing allowances are grouped as other costs. Contingency, subcontractor overhead and fee are also included. **Table 13** summarizes the cost estimate distributed by expense types.

Table 13: Distribution of costs for the 15 km 22 kV electric distribution line.

	% Costs	$/km	Total Cost $
Distribution equipment	39.1%	$29,301	$439,510
Site civil work and construction	14.9%	$11,179	$167,688
Subcontractor	40.5%	$30,331	$454,959
Freight/contingency	2.8%	$2,124	$31,860
Other costs	2.7%	$2,000	$30,000
Total	**100%**	**$74,934**	**$1,124,017**

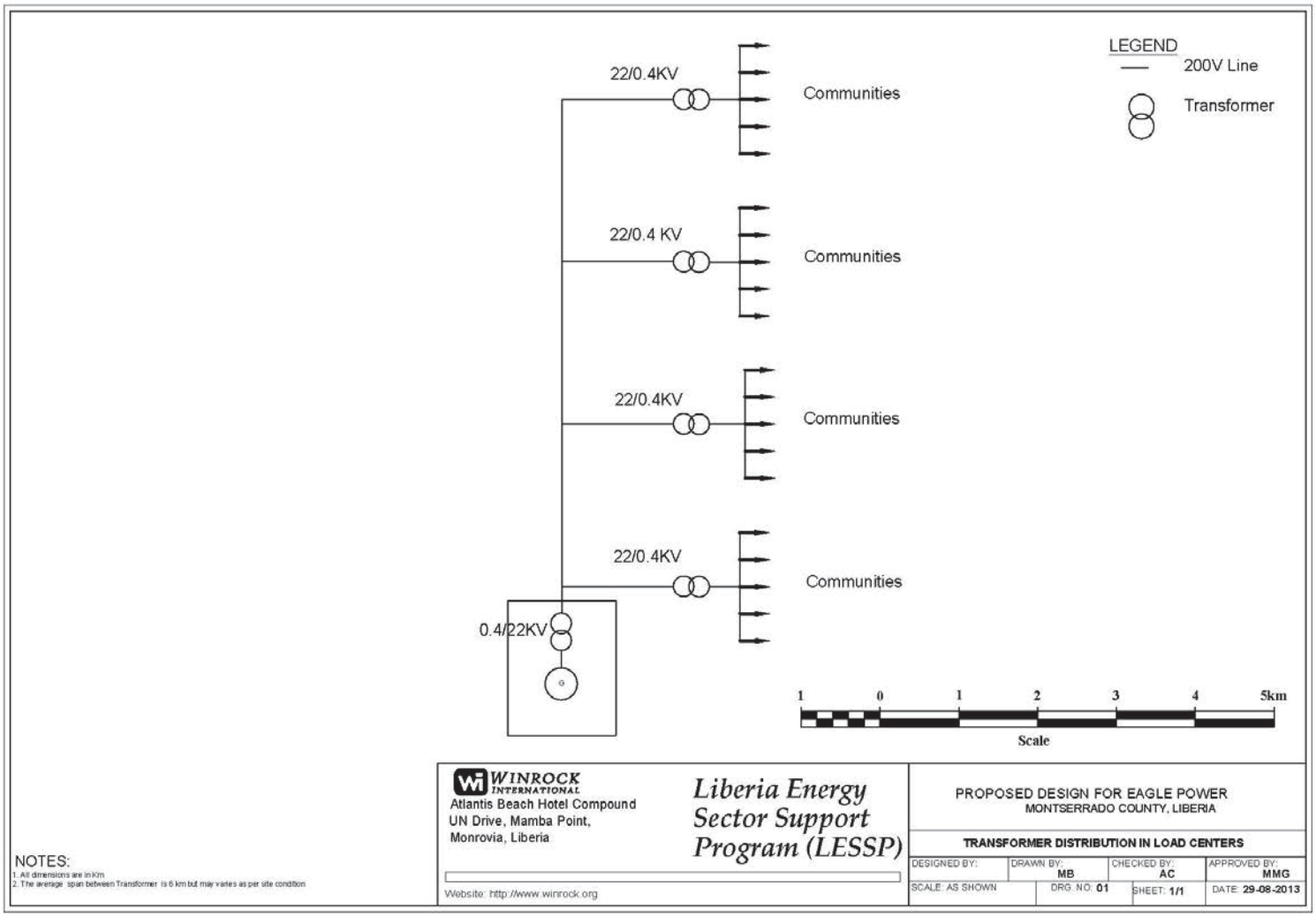


Figure 22: Proposed electrical grid for interconnecting the existing six independent EP electrical networks.

The major components of the EP MV electrical distribution system include:

- **Poles**: Pole structures are specially used for economic distribution at voltage levels of 380/415 V and 22/11 kV. Poles main function is to support the overhead power line, conductors and other accessories such as cross arms, lighting arrestors and insulators. Wood poles must be relatively straight and defects such as splits and shakes are unacceptable. CCA treated poles are to be used to provide structural protection from termites and fungal decay. CCA is a mixture of copper, chromium and arsenic. 11 and 13 m CCA wooden poles are selected to satisfy the ground clearance requirement.

- **Conductor:** Overhead lines are air-insulated cables suspended from insulated support with a power transfer capacity proportional to the square of the line of the voltage. The selection of the most appropriate conductor size at a particular voltage level must take into account both technical and economic criteria to maximize power transfer capability, minimize the initial capital cost, conform standard sizes already used on the network, and meet recognized international standards for radio interference and corona discharge.

  All Aluminum Alloy Conductor (AAAC) is the conductor selected for the implementation of the EP distribution system to maintain the level of standardization in Monrovia. AAAC offers excellent electrical and sag-tension characteristics, as well as great corrosion resistance.

- **Cross arm**: A support member attached to a pole horizontally for the purpose of supporting equipment or conductors. In many cases more than one cross arm is used on a pole.

- **Guy assembly**: Braces or cables fastened to the pole used to strengthen it and keep it in position. Guys are used wherever the wires tend to pull the pole out of its normal position. Guy assembly includes guy wire, anchor rod, steel plate and other guy accessories.

- **Transformer**: AC transformers allow widespread distribution of electric power. Transformers efficiently convert electricity to higher voltage for long distance transmission and back down to low voltages suitable for customer usage. The distribution transformer normally serves as the final transition to the customer and often provides a local grounding reference. Most distribution circuits have hundreds of distribution transformers. For the EP distribution system, four transformers are considered to step down the voltage level from 22 kV to 400/230 V.

- **Lightning Arrestor:** High voltage lighting surges can damage generators and transformers, and can be transmitted through the lines to the consumers. It is necessary to provide earthing for this high voltage caused due to the lightning strikes before it reaches to the generator, transformer or transmission line. Earthing is provided by a lighting arrestor connected between the phase wires and earth. The lighting arrestor should be placed at the first pole near to the power station and also it should be placed in each transformer location. Lightning arrestors are available in different voltage ratings, for different voltage levels. 24 kV lighting arrestors are included in this proposal for the protection of the 22 kV line and transformer.

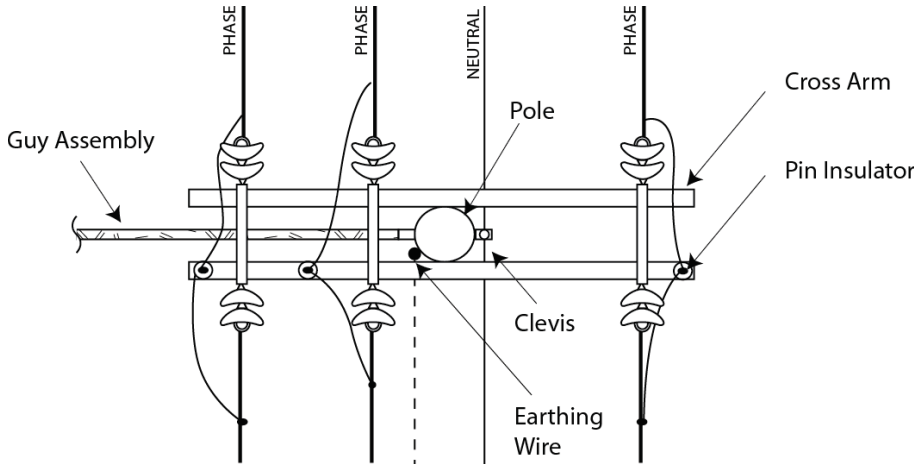


Figure 23: Interconnection of the EP distribution line to the transformer step up transformer at the power station.

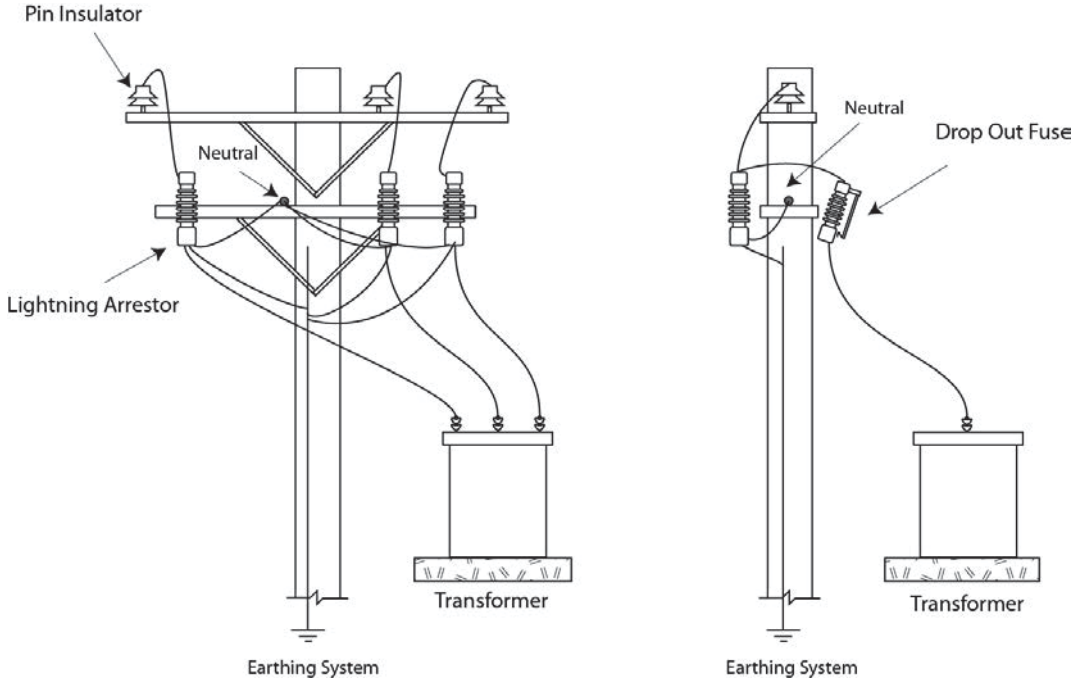


Figure 24: Pole serving the transformer at the interconnection to the communities.

Before the planning work on the overhead line, **the national authorities should first agree to the ROW** to ensure that no statutory regulations are being contravened with regard to planning permissions, and clearances between overhead ground and conductors. Distribution line is to be constructed along the RIA Highway and some other adjacent secondary roads.

4.2.2 Renewable Energy Technological Options for Power Generation

Solar and biomass energy are the locally available RE resources in Liberia that could be readily exploited by EP for power generation. Such resources imply that the technological options are either Photovoltaic (PV) or biomass technologies. For the selection of the Renewable Energy Technology (RET) for EP, it is necessary to understand the nature of the energy resources, load distribution and energy consumption. Adequate sizing shall allow consumers to run their loads in a daily manner without experiencing electricity shortages. Daily and annual load distribution information is required. The EP generation expansion should be designed to provide 24 h of service to the potential customers within the service area highlighted in **Figure 20**. A power company should seek complete satisfaction of its consumers. Satisfaction means having unlimited access to electricity at any time.

4.2.3 Solar Power Generation

A photovoltaic power station is a large-scale PV system designed for the supply of commercial power into the electricity grid. It provides power to end-users via transmission lines and a distribution system in the same way as other power stations do regardless of the type of fuel.

The major components of a grid-connected PV system include PV modules, mounting (or tracking) system, inverters, transformers, metering system and grid connection. In addition, the balance of systems (BOS) includes combiner boxes, protection devices, switches, lightning protection and signage as part of the wiring system.

- **PV Modules**: Solar PV modules are made up of PV cells, which are most commonly manufactured from silicon. Cells can be based on either wafers or "thin film" deposition of material over low cost substrates. In general, silicon-based crystalline wafers provide high efficiency solar cells but are relatively costly to manufacture, whereas thin film cells provide a cheaper alternative but are less efficient.

  Since different types of PV modules have different characteristics in terms of efficiency, cost, performance at elevated temperatures, degradation rate, etc.; no single type is preferable for all projects. In general, good quality PV modules are expected to have a useful life of 25 to 30 years, although their performance will steadily degrade over this period at about 1% per year. Selecting the correct module is of fundamental importance to a PV project, keeping in mind the numerous internationally accepted standards. All PV modules should be IEC or UL listed and systems installed in accordance with National Electrical Code (NEC) guidelines (NFPA, 2011).

- **Mounting and Tracking System**: PV modules are mounted on a structure. This helps to keep them oriented in the correct direction and provides them with structural support and protection. Mounting structures may be either fixed or tracking. Since fixed tilt mounting systems are simpler, cheaper and have lower maintenance requirements than tracking systems, they are the preferred option for countries with a nascent solar market. Although tracking systems are more expensive and more complex, they can be cost-effective in locations with a high proportion of direct irradiation, especially in temperate climates where sun angles vary more.

  No tracking system was considered for the capacity determination of the solar system since the diffuse solar radiation predominates during the year in Monrovia.

Six degrees is the best slope for a fixed PV array in Monrovia since it maximizes solar radiation capture; however, to avoid soiling and to take advantage of rain for periodic cleaning of the system an angle of 10 degrees is better.

- **Inverters**: PV modules are connected in series to produce strings of modules of a higher voltage. These strings may then be connected together in parallel to produce a higher current dc input to the inverters. Inverters are solid-state electronic devices that convert electricity generated by the PV modules into ac electricity, suitable for supply to the grid. In addition, inverters can also perform a range of functions to maximize the output of a PV plant.

  Grid interactive inverters have the necessary power electronics controls, communications interfaces, and control system architecture to interface with utility energy management systems, provide adaptive anti-islanding, and manage real and reactive power output. Further, these inverters are readily controlled via utility SCADA systems. SCADA can provide the type of diagnostic and prognostic information that utilities require, and can incorporate a variety of solutions to weather induced intermittency.

- **Transformers**: The output from the inverters generally requires a further step-up in voltage to reach the AC grid voltage level. The purpose of transformers in a solar power plant is to provide suitable voltage levels for transmission across the site and for export to the grid. In general, the inverters supply power at low voltage (LV). But for a commercial solar power plant, grid connection is typically made at upwards of 11 kV, high voltage (HV). It is therefore necessary to step up the voltage using a transformer between the inverter and the grid connection point. The selection of an appropriate transformer should consider several basic issues. These include the required size of the transformer, its position within the electrical system, and the physical location of installation. The size of the transformer depends on the projected maximum power exported from the solar array.

- **Grid Connection**: The grid connection interface is where the electricity is exported into the grid network. The substation will also have the required grid interface switchgear such as circuit breakers and disconnects for protection and isolation of the PV power plant as well as generation and supply metering equipment. The substation and metering point are often external to the PV power plant boundary and are typically located on the network operator's property.

PV systems produce power in proportion to the intensity of sunlight striking the solar array surface. The intensity of light varies throughout the day, as well as day-to-day, so the output of a solar power system varies substantially over a daily cycle. EP and the system designers should understand this variable, and others listed further on in this section, so as to have realistic expectations of overall system output and economic benefits under variable weather conditions.

Table 14 presents the key environmental factors affecting PV system performance that are total solar energy available and module operating temperature. For this analysis, a fixed PV array is assumed using solar global horizontal insolation. PV modules are assumed to conservatively operate in ambient temperatures equals to the average daily maximum high temperature for each month.

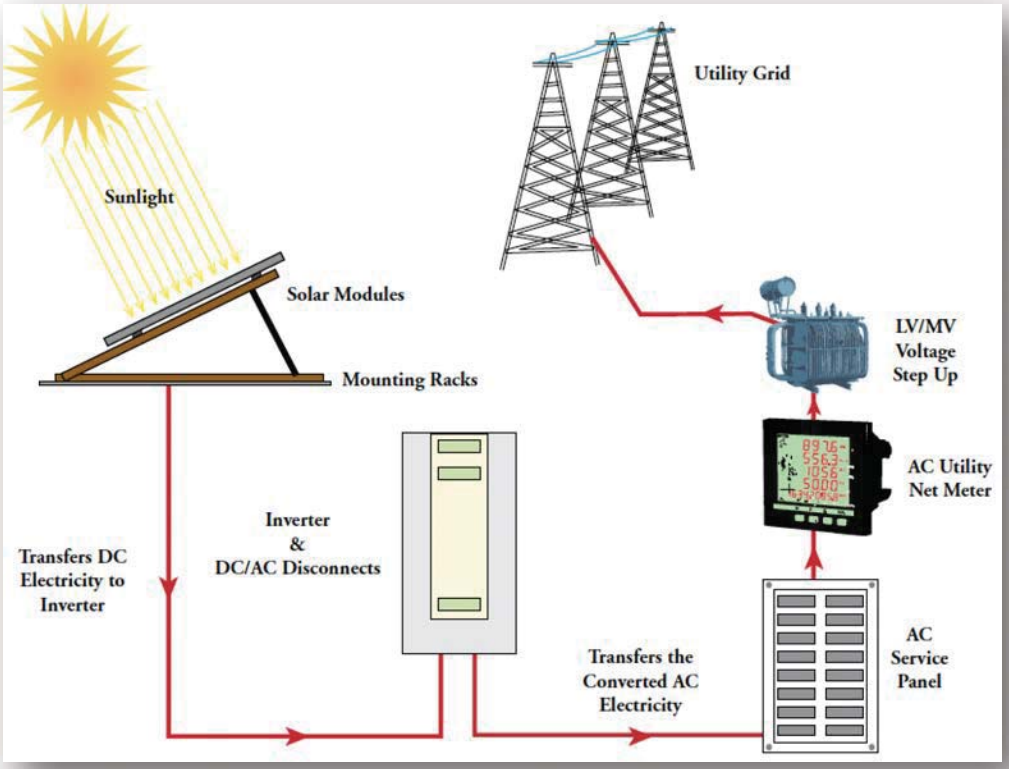


Figure 25: Overview of a Solar PV Power Plant.

Table 14: Monrovia insolation and average daily maximum temperature.

Month	GHI kWh/m²/day	Avg Day Max Temp °C
January	5.13	34
February	5.48	34.5
March	5.48	35
April	5.24	33
May	4.77	33
June	4.07	30
July	3.89	29
August	3.79	28
September	4.55	29.5
October	4.6	31
November	4.82	33
December	4.65	33.5
Average	**4.71**	**32.0**

A total average PV AC system efficiency of 71% is assumed for the first year of operation. Efficiency varies by month and is dependent on ambient temperature and PV technology. The efficiencies considered in the analysis to determine the system capacity are the following:

- PV modules efficiency is affected by module temperature. Power production decreases 0.5% per °C above 25°C for x-Si. The average monthly daily maximum temperature was used for this calculation;
- Inverter efficiency used is 90% average;
- Total wire, fuses, mismatch losses: 5%; and
- PV modules degrade slightly each year. For this analysis, the PV array was considered to degrade at an average rate of 0.8% each year. After 25 years, total array degradation is expected to be 20% below nameplate rating.

Energy production for the Monrovia solar electric system can be estimated given the solar resource for Monrovia and its ambient temperature. For the Monrovia system, it was estimated that given an average meteorological year, it should generate about 1,218 MWh/year during the first year of operation.

Table 15: PV array specification

PV System		
Size of PV Array	1,000	kWp
Total Area for PVPS	~1.5	Hectare
Annual PV Energy Generation	1,218	MWh/year (year 1)
Array Slope	10	degree
Array Azimuth	0	degree (due south)
Tracking Method	None	

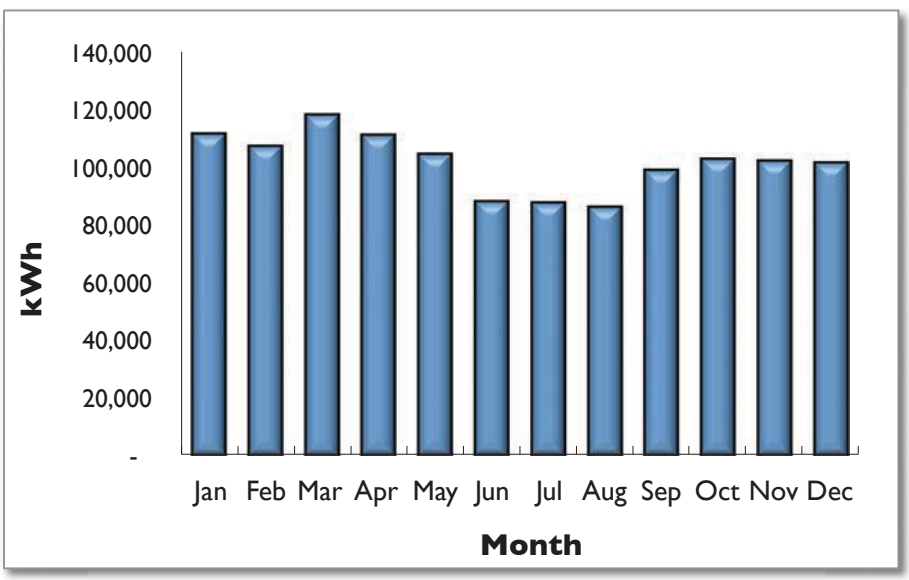


Figure 26: Expected monthly energy production for a 1 MW PV power system.

4.2.4 Biomass Power Generation

Biomass energy, also called bioenergy, derives from plants and plant-derived materials. Typical biomass that can be used as energy sources are wood, crops, residues from agriculture or forestry, oil-rich algae, organic component of municipal solid and liquid wastes and landfills fumes. Biomass feedstock is converted into usable energy for heat and power

production and for transportation, by physical, chemical or biological processes as shown in **Figure 27**.

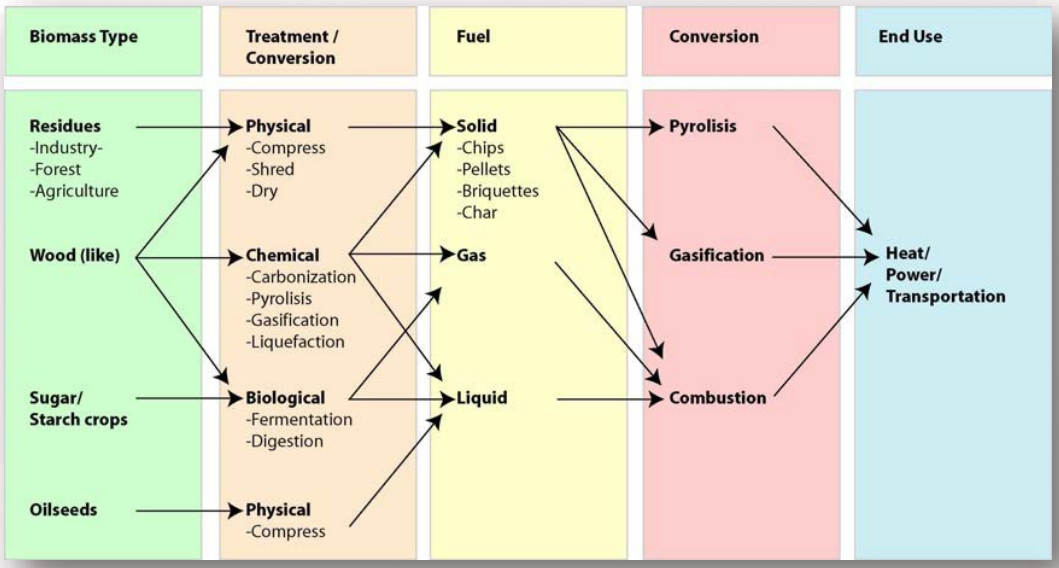


Figure 27: Pathways of biomass conversion into bioenergy.

Conversion of biomass to bioenergy can be undertaken in many ways. The most appropriate conversion basically depends upon the available biomass resources and the scale of operation. In large-scale operations, when there are many options available for biomass conversion, it is important to carry out a detailed techno- economic analysis to select the most economical method of conversion of biomass to bioenergy.

There are several proven technologies for biomass power generation. The most common available technologies are:

- Direct biomass combustion where electricity is generated through heat and steam;
- Biogas anaerobic digestion for power generation using scrubbed methane gas;
- Gasification of biomass where power is generated via producer gas;
- Biomass liquefaction via pyrolysis where power is generated by combustion of pyrolysis oil; and
- Organic plant based oil run generators where power is generated using straight vegetable oil (SVO).

Liberia is a country with significant resources of biomass that could be used for power generation in a sustainable manner. Gasification and SVO engines are two technologies that have been implemented in Liberia by LESSP with success. These two technologies are studied as RE options for EP new power generation infrastructure.

4.2.5 Gasification of Biomass

Gasification is the use of heat to transform solid biomass or other carbonaceous solid into a combustible gas mixture normally called producer gas and is itself a fuel. Through gasification, nearly any dry organic matter can be converted into a clean burning, carbon neutral fuel that can replace fossil fuel. Organic material is converted into carbon monoxide, hydrogen and carbon dioxide by reacting (no combustion involved) with a controlled amount of oxygen and/or steam at high temperatures. Combustion of the producer gas is potentially more efficient than direct combustion of the original fuel.

Although biomass gasifiers are reliable and safe equipment with easy operation and maintenance similar to ordinary diesel generators, the main challenge about this technology for this particular project is that the amount of biomass required is excessive as seen in Table 16. Economic analysis would have to include fuel and maintenance cost for the transportation of biomass material, and the expected continuous cost increment of the biomass as well as its conditioning into very small briquettes. Another technical constraint for the implementation of this project is the need of water for gas cleaning and cooling of the system. A water treatment is needed for the water to be recycled. Water utility is not available in Liberia.

Table 16: Biomass material consumption per unit of energy generated.

Biomass Material	Consumption Rate (ton/MWh)	Biomass Consumption per day (ton/year)
Energy generated per day (MWh/year)		**1,214**
Rice husk	1.7	2,064
Crop stalk	1.65	2,003
Straw	1.7	2,064
Saw dust	1.4	1,700
Wood chip	1.4	1,700
Coconut fabric dust	1.8	2,185
Palm bunch	1.8	2,185

Note: For effect of comparison, the biomass consumption calculation was made to produce the same amount of energy (1,214 MWh/year) as the 1 MW solar system described in the previous section.

Figure 28: 2x250 kWe Gasification Plant in Sri Lanka; Source: Ankur Technologies India

4.2.6 Straight Vegetable Oil Generators

Some countries are increasingly using Straight Vegetable Oil (SVO)-driven reciprocating engine generators for electricity generation or biodiesel production. The engines are similar to the common diesel engine. Technology is available to operate diesel generators up to 1 MW with SVO. Most of these SVO generators are operated with rape, canola, soya, sunflower, palm, jatropha oil etc. This is an inexpensive alternative to generate electricity in areas where vegetable oil is widely available at a price cheaper than the price of diesel fuel.

Crude Palm Oil (CPO) is a product available in Liberia for which SVO generators are a potential technology to be implemented by EP for power generation. However, real quantification of CPO available for power production remains to be evaluated.

Similarly to the diesel generators, SVOs are able to run for 12 hours per day. In the assumption that 1 MW flat production is required, then two generators (diesel or CPO engine) need to be installed to operate 12 hours each as seen in **Table 17.** Two different generator capacities could be selected when less power is needed in one of the shifts.

Table 17: CPO engine for power generation operating 24 hours.

Generator running the first 12 hours				
Capacity to install			1000	kW
Power production after generation and distribution efficiency			800	kW
Operation per day	12	h	9,600	kWh/day
Days of operation per year	365	days	3,504,000	kWh/yr
Generator running the second 12 hours				
Capacity to install			1000	kW
Power production after generation and distribution efficiency			800	kW
Operation per day	12	h	9,600	kWh/day
Days of operation per year	365	day	3,504,000	kWh/yr
Total				
Total Capacity to install			2000	kW
Power production after generation and distribution efficiency			800	kW
Operation per day	24	h	19,200	kWh/day
Days of operation per year	365	day	7,008,000	kWh/yr

4.2.7 Hybrid Technological Options for Power Generation

EP as a power company must ensure clients receive power 24 hours per day. Hybrid systems are desired through RET combinations with a diesel power generation backup system. Besides the environmental benefits of RET, they have proven that Life Cycle Cost LCC) is significant lower than for diesel. However, diesel generators ensure system reliability. To minimize the LCC, diesel power generation should only be planned as backup for maintenance time, or when the RE resources are not sufficient for instance when a solar system is not able to provide all the demand due to consecutive rainy days.

5 ECONOMIC ANALYSIS

In order to understand the economics of a large-scale RE power system, it is important to conduct financial analyses of such a system as compared to conventional alternatives on a life cycle cost basis.

The most critical factors in determining the value of energy generated by renewable energy systems are (1) the initial cost of the hardware and installation, and (2) the amount of energy produced annually. In determining economic feasibility, renewable energy must compete with the unit worth of energy available from competing technologies. If the system produces electrical energy for the grid, the price for which the electrical energy can be sold is also critical. For renewable energy to have widespread use, the return from the energy generated must exceed all costs in a reasonable time. Economics is intertwined with incentives and penalties, so actual life cycle costs vary, especially when externalities such as environmental impacts are excluded.

5.1 Life Cycle Cost Analysis

A Life Cycle Cost Analysis (LCCA) was performed to compare the three power generation alternatives that fulfill the same performance requirements, but differ with respect to initial costs and operating costs. The analysis was used to estimate overall costs to generate the same amount of energy, cost per kWh, and net savings. **Annex C** describes the LCCA methodology and **Table 18** lists the economic parameters used in this study.

Table 18: Economic parameters used in the LCCA.

Parameter		
Inflation Rate	7%	per year
Discount Rate	3%	per year
Real Discount Rate	4%	per year
Project Life	25	years
Fuel Escalation Rate (Grid)	6%	per year

Table 19, **Table** 20, and **Table** 21 list the present values of investment, O&M costs and replacements for photovoltaic, biomass gasification, and SVO technologies for power generation respectively. Values on each row correspond to the specific installed capacity on the first column (Table 19 for solar) or second column (Table 20 and Table 21 for biomass technologies). Each table has its own particulars:

- The PV system requires a battery bank to supply energy at night. The battery bank should be able to supply energy on two or three consecutive cloudy days for which the battery bank capacity is increased by two or three days of autonomy. The final decision on selection of the battery bank size depends on the funds available. Inverters and batteries will need to be replaced at the 12.5 year. The cost of battery disposal should be included in the economic analysis;
- The biomass gasifiers work only 12 hours a day. However a power company should offer service 24 hours, for this reason the installed capacity should be doubled.

Gasifiers should be replaced every five years. **Table 20** also includes the amount of biomass needed per day and per year. Biomass availability and conditioning is a disadvantage. Constant transportation represents high cost of fuel and maintenance of vehicles; and

- The SVO engines work only 12 hours a day. A 24-hour service requires doubling the generation units. Same as with diesel generators, their lifetime is about 12 years. The amount of CPO was also estimated.

The three technologies considered are different from each other in operation, fuel, replacement, and maintenance. To make a fair comparison, the annual energy value in kWh/year was used as the correlating parameter among the technologies. The energy values in red (around 3,600 MWh/year) indicate that the corresponding plant capacity will be further compared using a LCCA to determine the investment recovery time and the cost per kWh.

Figure 29 and **Figure** 30 show the LCCA for the three RET plus diesel power generation. They are both representing the same investment costs and future costs of operation and replacements. In **Figure 30**, the replacement costs were brought up front to identify the real payback time. As seen over the useful time of the systems (25 years), diesel is the most expensive technology. This is due to the high cost of diesel fuel. Biomass gasification is by a not so significant difference less expensive than solar; however, biomass collection, transportation and conditioning represent a great disadvantage and possible risk that argues in favor of a solar PV system. Power generation with CPO is less expensive than diesel but regular uninterrupted availability of CPO in such amounts must be verified.

On **Figure 29** the investment recovery for the biomass technologies is found to be fast in the first years. CPO engine technology behaves exactly as the diesel generators but the fuel is less expensive. Generation through gasification is similar to diesel and the CPO engine alternative but since generators must be replaced several times within 25 years, the cumulative cost increases linearly but every five years that cost is ramped up due to replacement. For the solar PV system, the investment should be recovered at the 6th year, however since the batteries replacement is scheduled on the 12.5 year, savings from non-diesel consumption should be used to replace the battery bank.

The LCCA shows that the cost of electricity generated by

- **Photovoltaic system <u>with 2 days battery autonomy</u> is $0.32 per kWh;**
- **Biomass gasifying system is $0.33 per kWh;**
- **CPO engine is $0.39 per kWh; and**
- **Diesel generation is $0.69 per kWh**

The projected cost of electricity from this study results in cheaper cost for a solar system since the battery bank will increase the amount of energy available for users. The rainy season in Monrovia takes place from May through August, for this matter a two day autonomy battery bank will increase the availability of electricity by a factor of 1.6.

Table 19: Investment, and operation and replacement costs for a PV Power System with battery bank storage (1,2&3 days of autonomy)

Solar MW	$/W @ 2-day autonomy	Energy kWh/year	PV System Investment + Civil Works			O&M $/year	Replacement $
			1	2	3		
a	*b*	*c*	*d*	*e*	*f*	*g*	*h*
1	$6.17	1,217,873	$4,827,243	$6,174,486	$7,521,729	$8,000	$2,994,486
2	$5.80	2,435,746	$10,251,729	$11,598,972	$12,946,215	$16,000	$5,988,972
3	$5.57	**3,653,619**	$15,376,215	$16,723,458	$18,070,701	$24,000	$8,983,458
4	$5.54	4,871,492	$20,800,701	$22,147,944	$23,495,187	$32,000	$11,977,944

Table 20: Investment, operation and replacement costs for a biomass gasifer for power generation.

Power MW flat	Capacity to install MW	Energy/year kWh/year	Wood Chips per day ton/day	Wood Chips per year ton/year	Investment: Equipment + Civil Works $	O&M per year $/year	Replacement x 3 times $
0.5	1	**3,504,000**	21.32	15,566.67	$3,317,066.67	$365,760	$8,400,000
1	2	7,008,000	42.65	31,133.33	$6,634,133.33	$731,520	$16,800,000
2	4	14,016,000	85.30	62,266.67	$13,268,266.67	$1,463,040	$33,600,000
3	6	21,024,000	127.95	93,400.00	$19,902,400.00	$2,194,560	$50,400,000

Table 21: Investment, operation and replacement costs for a CPO Engine for power generation.

Power MW flat	Capacity to install MW	Energy/year kWh/year	CPO per day m^3/day	CPO per year m^3/year	Investment: Equipment + Civil Works $	O&M per year $/year	Replacement at year 12 $
0.5	1	**3,504,000**	1.64	597.87	$2,863,139	$900,052	$583,333
1	2	7,008,000	3.28	1,195.74	$5,726,278	$1,800,104	$1,166,667
2	4	14,016,000	6.55	2,391.48	$11,452,556	$3,600,208	$2,333,333
3	6	21,024,000	9.83	3,587.22	$17,178,833	$5,400,311	$3,500,000

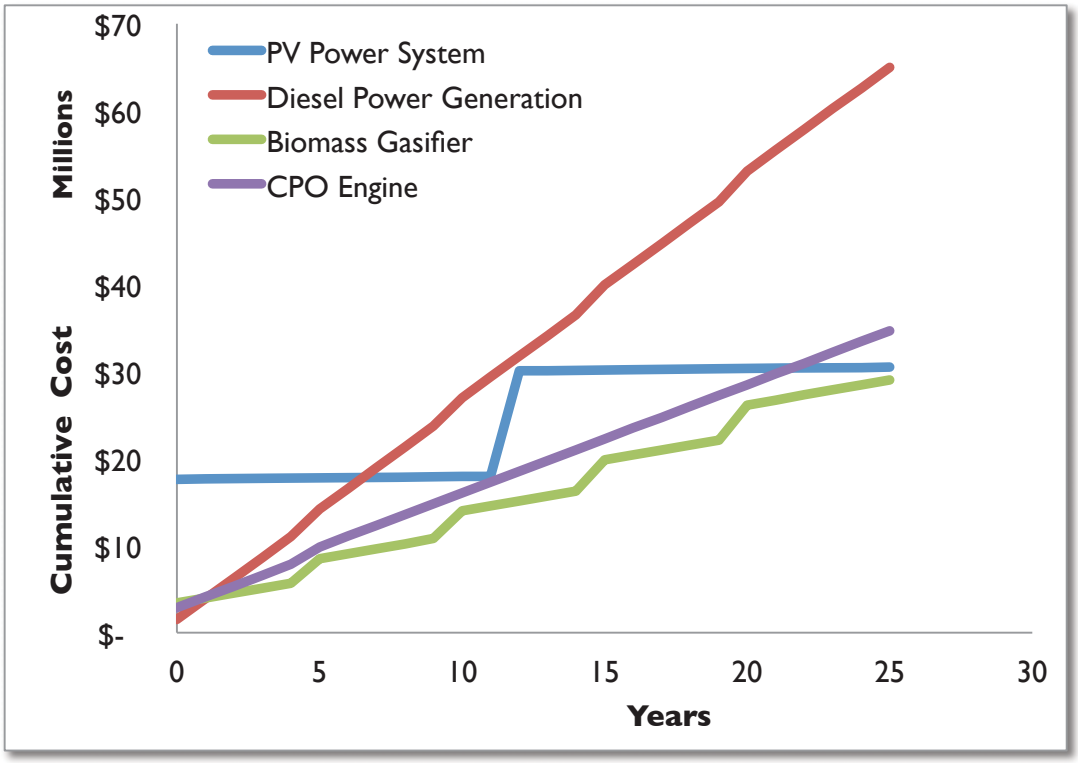


Figure 29: Life Cycle Cost Analysis Cumulative cost over the system lifetime.

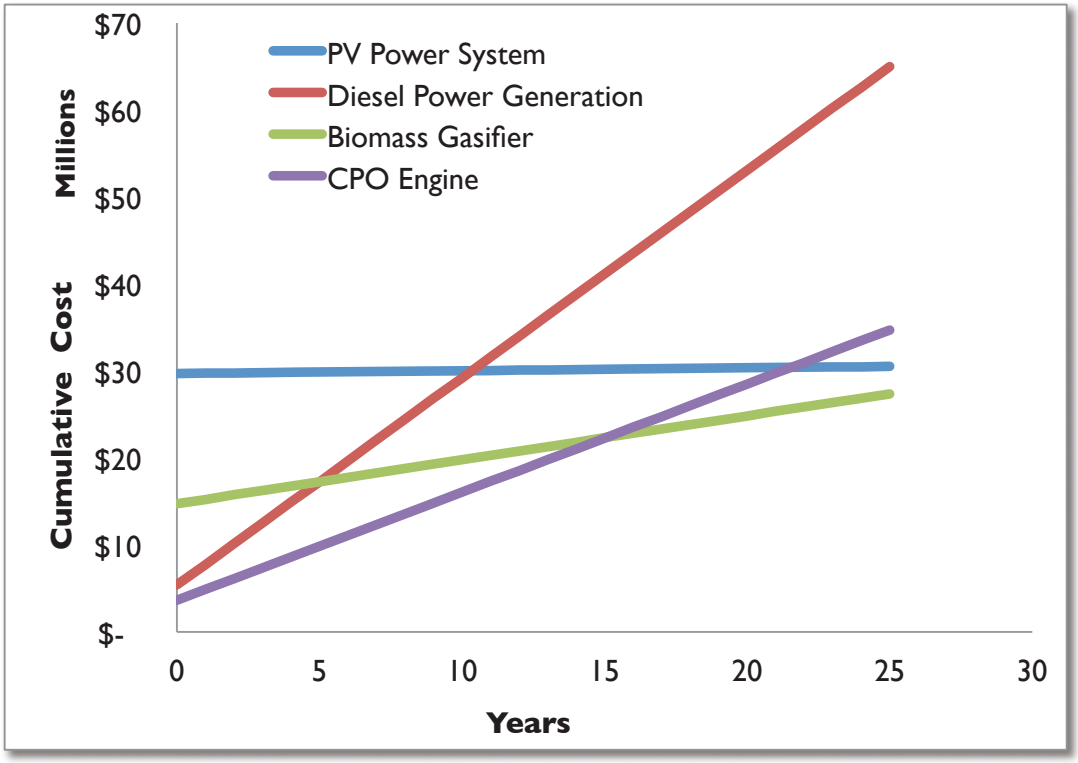


Figure 30: Payback time for investment recovery. Equipment replacement costs were added up to the investment.

5.2 Proposed New Facilities

The selection of the most appropriate technology for EP new power generation infrastructure could follow three approaches:

1. Maximum total savings during the system useful life

   Biomass Gasification > Solar > CPO Engine

2. Minimum payback time for investment recovery

   CPO Engine < Biomass Gasification < Solar

3. Since total savings from the RET options are not so different from each other; operation complexity should be considered.

   Solar < CPO Engine < Biomass Gasification

The investment recovery is an important aspect to consider under the uncertain scenario for Eagle Power. The least risk corresponds to the shortest payback period to recover the investment. However, <u>if the scenario is so unclear for EP, the recommendation is to not increase power generation capacity but to implement a strategy to increase the number of connections</u>. That strategy should include metering systems for each individual customer. EP already has a distribution system in place and the generation capacity is much higher than what is actually being consumed as seen in **Figure 16**.

Since total savings from the RET options are not so different from each other; operation complexity should be considered for the selection of the technology. Technically speaking, biomass technologies for power generation are viable options for small generation. For large systems, the excessive amount of biomass that must be transported continuously will increase complexity in logistics and operations. The challenge is greater when using solid biomass gasification. Moreover, availability of the resources must be evaluated.

LESSP recommendation for EP power generation expansion is to implement a photovoltaic power system with storage and use the existing diesel generation system as a backup.

5.2.1 Solar PV Power Generation

Most PV power plants installed around the world do not include a storage system. Solar electricity is commonly injected into the grid as a contribution to existing power generation. In this particular case where no electrical grid and no appropriate power generation infrastructure exists, the battery bank system is required. Reliability is added by increasing the size of the battery bank. However this also increases the capital cost by far. Doubling the battery bank size allows the system to supply electricity during two consecutive cloudy days. The recommendation for this project is to double the battery bank to have 2 day autonomy and to use the existing EP diesel generation infrastructure as a backup system which should only be used at some extent during rainy season.

Figure 31 shows the estimated cost breakdown for a 1 MW solar PV power system with two days of autonomy. The battery bank is the highest cost in the system. This component has to be replaced at the 12th year, for which a disposal plan for the exhausted batteries should be arranged.

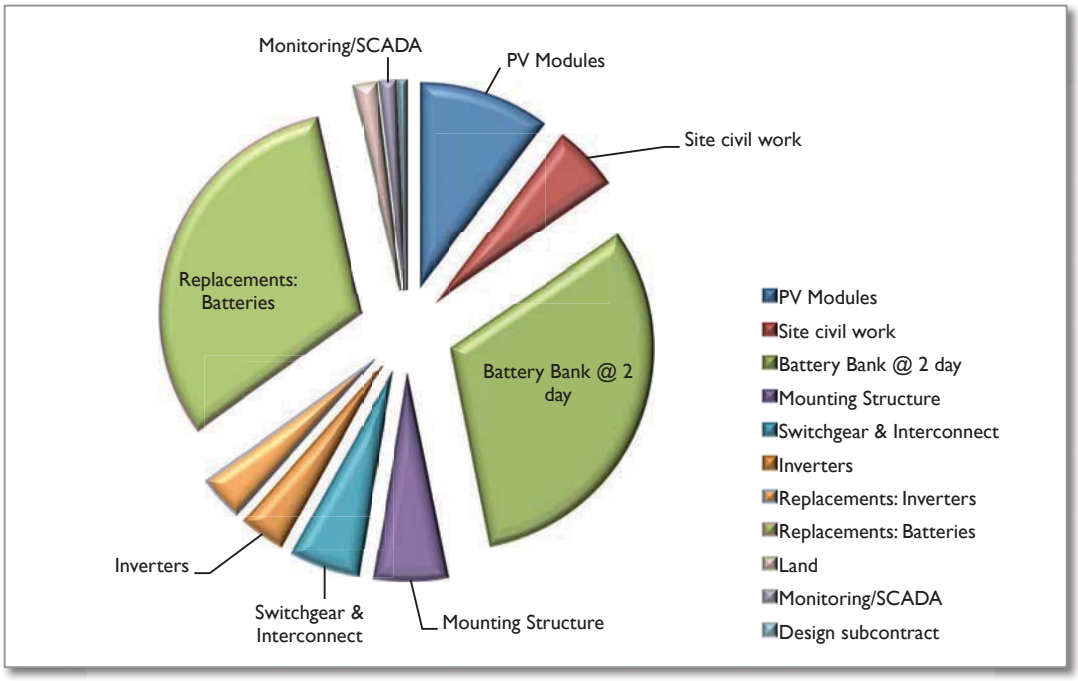


Figure 31: Estimated PV Cost System Breakdown.

According to the Potential EP Customers Windshield Assessment, there are 21,155 load centers (customers) within the area of interest from which only 2.77% are already EP customers. A conservative calculation in **Table 11** indicates that about 41,274 kWh/day (15,065 MWh/year) should satisfy the population energy needs 24 hours each day.

Figure 32 presents the linear relationships between energy demand and number of customers against the power capacity required from two (2)-day autonomy solar PV power systems. To satisfy the total demand of 41,274 kWh/day, a **17 MW** solar power system is required.

A one MW solar plant installed in Monrovia with no battery bank would produce about 1,218 MWh/year already dispatchable to consumers. A similar system that includes batteries would provide only 852 MWh/year (2,337 kWh/day) because the overall efficiency decreased from 71% to 50% due to the 70% added round trip efficiency of the battery bank.

Figure 33 presents the total estimated cost of solar PV power plants at different capacities. The solid line corresponds to the cost estimated based on the actual quotation we received on May 2013. **As system capacity increases the cost per installed watt at the customer's meter**. The dotted line corresponds to the estimated cost assuming a discount of 1.2% per extra MW installed. Taken as reference the dotted line, a 17 MW system with 2-day autonomy would cost about $74 million USD (with batteries).

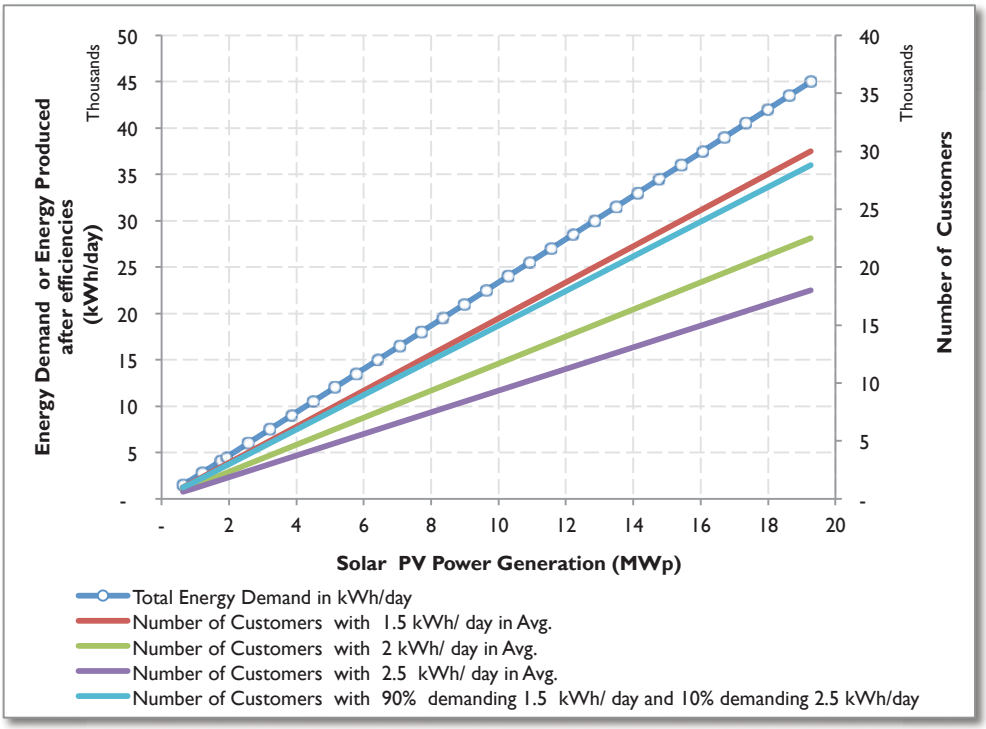


Figure 32: Energy demand and number of customers to be satisfied versus solar PV power plant capacity with 2-day autonomy storage.

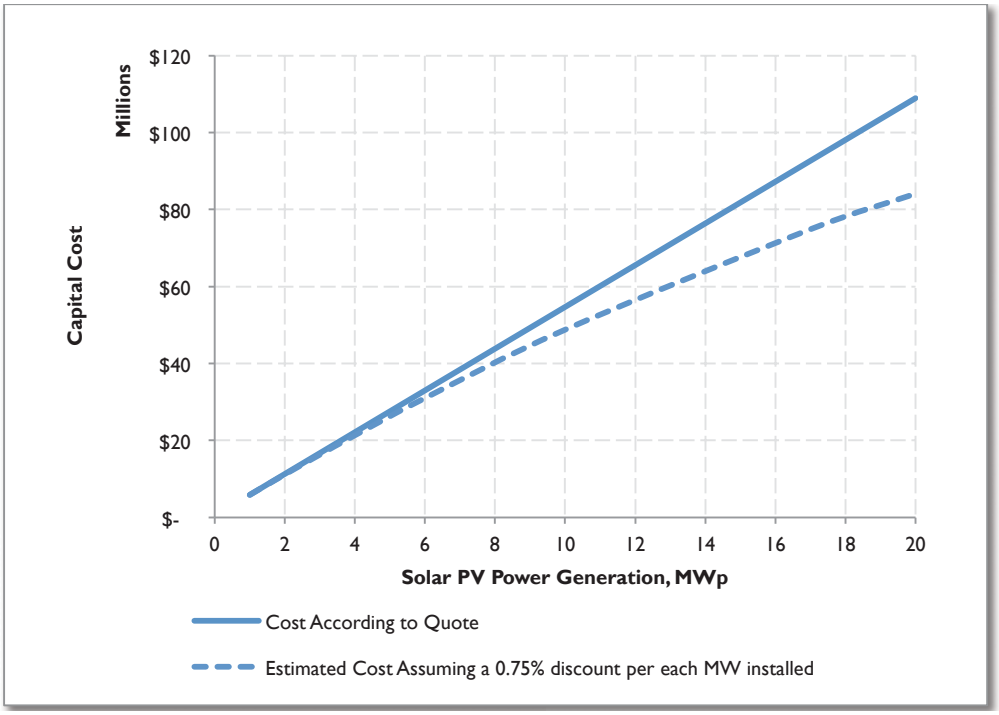


Figure 33: Capital cost of solar PV power plants with 2 day autonomy storage including design and construction versus power plant capacity.

5.2.2 Eagle Power Proposed Expansion Plan Scenarios

Under the original Scope of Work, Eagle Power expressed a desire to expand the provision of service by a factor of two and three. Their rationale is that they can cover more customers and reduce the unit cost of electricity to all customers in this plan. This is a correct assumption however Eagle Power has not sufficiently thought out the cost of effectively and efficiently managing this expanded system. Further tripling the size of the their customer base from 756 to say 2,200 customers still leaves 18,900 houses, businesses, and institutions without service in their service area. If Eagle Power wishes to serve this expanded service area, they need to have a plan to provide electricity or at least make it available to all the potential customers.

However for the purposes of this study, we first examine the provision of electricity to their existing 756 customers and then double and triple this number – the original scope of work. The provision of electricity to the larger 21,000 customers is then examined and discussed in a following section.

5.2.3 Solar PV Power Capacity

EP desires to double or triple the number of customers as well as to provide 24 h electricity service.

- Doubling the size: The system must provide 2,800 kWh/day with two days of autonomy. A 1.2 MW solar PV power system will be able to supply that demand at an investment cost of 7 million USD.
- Tripling the size: The system must provide 4,100 kWh/day (1,496 MWh/year) with two days of autonomy. A 1.76 MW solar PV power system will be able to supply that demand at an investment cost of 9.94 million USD.

Figure 34 and **Figure** 35 present the expected monthly energy that will be available from the proposed system.

5.2.4 Diesel Back Up System

Monrovia has four months of rainy season. During this period, it is possible that the solar power capacity will not be enough to satisfy all the energy demand; this will depend on the number of customers. The recommendation is to maintain the current power generation infrastructure as a diesel back up generation system. This will require special training for EP grid operators to manually isolate any of the communities whenever it is required. The backup system will only operate when:

- A portion of the PV array is disconnected for whatever technical reason; and/or
- Consecutive cloudy or rainy days.

5.2.5 Proposed Service Cluster Distribution Tie-In

A 15 km 22 kV electrical distribution line to interconnect the existing six independent EP electrical networks was proposed in Section 4.2.1. For EP to be competitive and reliable, it should minimally equal LEC standards. Technical specifications of the distribution system is presented in **Table 12**.

EP needs to undertake a program of replacing existing distribution lines and poles following LEC engineering standards. Currently EP distribution networks consist of 35 km total of

400/230 V electrical distribution system with 1,617 standing poles and 155 streetlights. Such proposed deferred maintenance program could be a four to five year program. Pole rerouting will be needed since the existing infrastructure installation was not in accordance to the Ministry of Public Works (MoPW) directions and Right of Way (ROW) permits. Further study is needed.

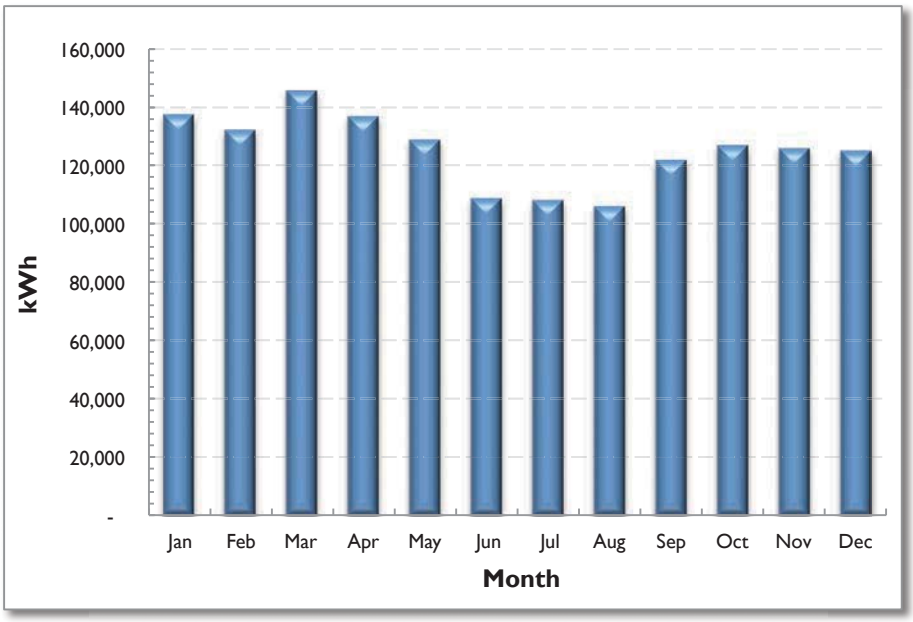


Figure 34. Expected monthly energy generation from a 1.2 MW PV power system including battery bank efficiency.

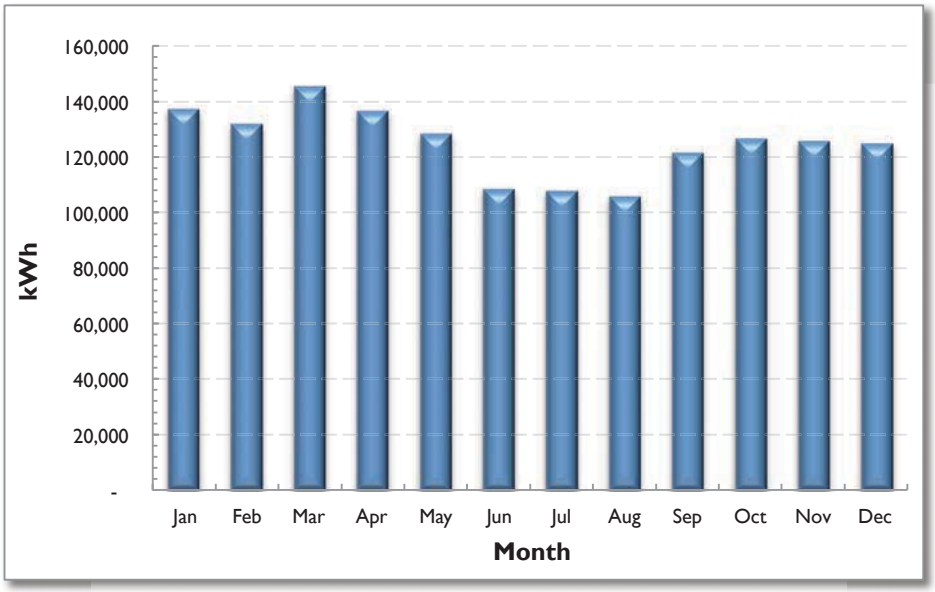


Figure 35: Expected monthly energy generation from a 1.76 MW PV power system including battery bank efficiency.

5.3 Concept Level Cost Estimate and Implementation Schedule

The final decision on the capacity of the PV power plant will depend on financial factors. As EP aspirations are to double or triple the number of customers, costs estimates were prepared for two sizes. **Annex D** presents the BOQ and Cost Estimate for:

- 1.2 MW solar PV power system plus 15 km of MV 22 kV distribution line to interconnect the current served communities; and
- 1.76 MW solar PV power system plus 15 km of MV 22 kV distribution line to interconnect the current served communities.

A cost estimate for the required 15 km MV distribution system is about $.75 Million. This cost estimate remains the same in both BOQs and includes material, equipment, hardware, civil works and construction. As for the solar infrastructure and installation, **the estimated costs are $ 6,959,383 and $ 9,997,095 for 1.2 and 1.76 MW respectively.**

Figure 33 can be used to determine the capital cost for any other PV power system with two-day autonomy.

The total cost for the implementation of the proposed new facilities for Eagle Power will include T&D lines and other costs such as permits, taxes, fees, route surveys, material testing allowance and contractor's overhead and fees (35%). The total estimated costs for the two proposed PV power plant sizes are:

- **1.2 MW: $ 10,440,335 (estimated)**
- **1.76 MW: $ 14,541,246 (estimated)**

An alternative and less risky approach is to simply provide enough PV generation capacity to provide 24 hours of electricity to the currently subscribed customers. **This option with a 0.64 MW PV system with 2-day autonomy is also examined in Table 22 presenting a total estimated cost of $6,339,423.** This option may be attractive if insufficient investment funds are available for the proposed expansion.

Table 22: Capital cost for three power generation capacities, considering 2 days autonomy and T&D electrical distribution system and construction costs. Yearly O&M cost and replacement cost is also included in today's money.

Solar PV Capacity in MW	$/W @ 2 days autonomy	Energy Available kWh/year	Estimated Capital Cost (PV + T&D + Construction) $	O&M (today's Money) $/year	Replacement Cost (today's money) $
a	*b*	*C*	*d*	*e*	*f*
0.64	$ 5.87	872,971	$ 6,339,423	$ 5,120	$ 1,916,471
1.2	$ 5.60	1,636,821	$ 10,440,335	$ 9,600	$ 4,791,817
1.76	$ 5.57	2,400,671	$ 14,541,246	$ 14,080	$ 5,270,295

For a well-established Power Company, with enough connections to accept this electricity generation, a PV system this size would start avoiding the high consumption of fossil fuel immediately after commissioning. Receivables would start making up for the investment recovery. **Table 23** presents the cost of power production and the recommended tariff.

The generation cost not only includes the capital cost and PV power plant operation cost over the system lifetime but also the 15 km 22 kV electrical distribution line to interconnect the existing six electrical networks, the proposed deferred maintenance program to replace the existing electrical distribution system, and the replacement and disposal of the exhausted batteries at the year 12 and the power company operations and customer service. It is assumed that EP has attracted enough customers by the time of starting operations of the PV plant.

Table 23: Generation cost and tariff recommended.

Solar PV Capacity in MW	**Generation Cost** $/kWh	**Recommended Tariff**
a	*b*	*c*
.64	0.508	0.580
1.2	0.470	0.550
1.76	0.415	0.474

The plot in **Figure 36** shows that the investment recovery time for the 1.76 MW system with 2-day autonomy would be reached in 12.5 years. If the system proposed did not include batteries the recovery period would decreased to 7 years.

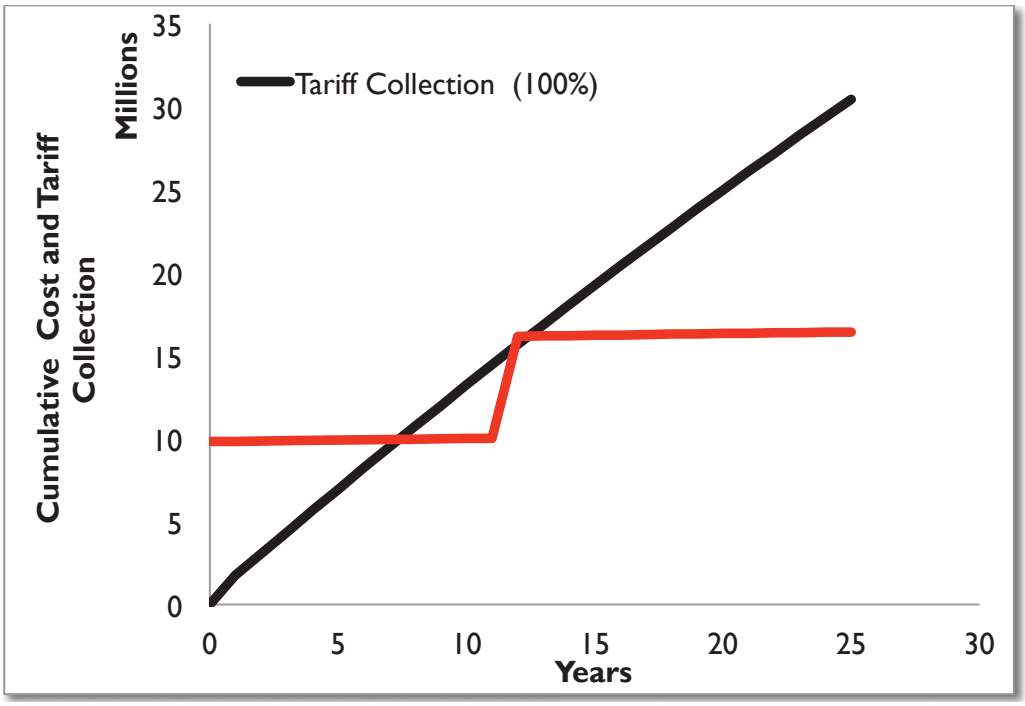


Figure 36: Recovery time for the 1.76 MW PV system with 2-day autonomy is reached at 12.5 years.

Annex E presents a comprehensive schedule for the implementation of the Eagle Power Generation Expansion Project. This preliminary schedule includes timeframes for financing design work, procurement, civil work and implementation highlighting interdependencies between tasks and milestones. A contractor prequalification process has also been included. The schedule shows that once funding has been secured, procurement and implementation could be completed in 20 months. We estimate here that an aggressive schedule of two calendar months are needed to complete the final design and obtain environmental approvals and concurrence from a financing institution. The solar panel production and shipping activity will require an estimated four months once the order has been placed. Customs clearance and site transport will take another month.

5.4 *Non Original Scope of Work Alternative* – Eagle Power as an LEC Franchised Independent Power Producer (IPP)

Given the current electricity situation in the Monrovia urban area today and in the foreseeable future, and give recent discussions with USAID, the MLME, and the LEC, another opportunity may be presenting itself here. If Eagle Power wishes to provide solar generated electricity to the customers in its proposed expanded service area, and if LEC is willing to franchise Eagle Power to do so, are there other generation scenarios that not only allow Eagle Power to succeed in its mission but also to partner beneficially with LEC? Are any such possibilities also attractive to the GOL, the international donors, and private investors?

Monrovia, which is the home of nearly 1.5 million people, currently receives about 8.6 MW of peak power through the LEC electrical distribution system that benefits 14,079 customers. Besides the 22 MW diesel fueled high-speed power generation capacity installed in Monrovia, the reconstruction of the Mt. Coffee hydropower plant will provide an additional 64 MW of electricity during the high water runoff season. This project is scheduled to be completed by 2016. Standby power generation through Heavy Fuel Oil (HFO) generators is also planned to compensate for the decrease of power output during the dry season. Electricity grid rehabilitation and expansion in Monrovia is in progress through multiple international funding agencies.

A quick calculation to estimate energy demand using power distribution on **Figure 21** leads to the conclusion that the total of 1.5 Million Monrovians (assuming 7 people in average per household) would not be covered with the existing and the future Mt. Coffee electricity production – 214,286 household connections are estimated. Extra assumptions for this estimate were:

- That the total households conform 82% of the load centers;
- That businesses and institutions add 9% each to the connections;
- Conservative peak loads for each type of consumer were assumed to be 150, 300 and 400 W respectively;

The total estimated energy demand is almost 800 MWh/day where 74.3% correspond to domestic use, 12.8 % to businesses and 12.9% to institutions. Assuming a flat generation of 64 MW in rainy season, it gives a total energy production of 1,536 MWh/day and this would cover the conservative total energy estimated above. However, in dry season, the hydro plant will drop its production up to 35% for at least seven months. The non-expensive hydro-electricity will not be enough to satisfy the Monrovia energy demand. HFO power

generation will be available however at much higher operation cost due to the high consumption of imported expensive oil.

The development of Liberia highly depends on the energy availability. Cheaper energy sources will also speed up electricity affordability for low-income families, which is important for the city today. **A higher contribution of RE sources in the overall energy mix will lower the cost per kWh.**

Solar PV electricity, although not considered in LEC's generation plan today, becomes much more competitive, economically speaking than diesel and heavy fuel oil, when a reliable electrical grid is in place and where no battery bank is needed (day time electricity only).

As LEC has not been able to cover Monrovia and the surrounding area, many informal electricity providers are significantly contributing to the supply of basic electricity to Monrovians for about 11 hours every day. MLME, aware of these community needs, have as well informally allowed this private sector to exist although only LEC has the legal standing to generate, transmit, distribute and sell electricity.

Therefore, a more economically and technically feasible approach for Eagle Power expansion is to ensure future interconnection with LEC and to sell cheap day time solar power for import into the grid. Eagle Power could sell cheap solar electricity during the day and buy LEC diesel generated electricity during the night. This scenario means that Eagle Power would eliminate the cost of batteries in their generation system.

By implementing this approach, EP will be able to satisfy 24 h energy demand of the isolated service area by using batteries only in the first few years it begins its new RE operations. As soon as LEC service area expansion reaches the new EP service area, interconnection should be allowed. This will avoid future cost for the replacement of batteries and decrease the cost per kWh. EP will provide daytime electricity and will buy LEC electricity at night to provide to its customers. Once again, cheaper electricity cost is the reason for EP to be able to obtain the concession from MLME and to be franchised with LEC.

Figure 37 shows the results of the engineering and economic analysis applied to different solar PV power plant capacities with interconnection to LEC electrical grid. **Note that the scenarios studied here are those both in the original SOW and those outside the Scope**. For this analysis, it is assumed that LEC will reach EP current service area in four years.

By focusing on the red line, it can be seen that the investment was made for a 1.7 MW (first data point) and this will provide energy for about 1,900 connections; then the horizontal path indicates that EP has interconnected to LEC about the time the number of customers doubles (second mark), then the line steps up with a 45 degree slope up to a point where the PV capacity doubles as well as the number of customers (third point). At this point there are four times the initial number of customers; the final stage corresponds to doubling of the PV capacity once again and increasing the number of connections since the solar system will provide daytime electricity and LEC will cover the night time service through the terms of the LEC franchise.

Significantly, the plot highlights that the higher the number of connections, the less expensive the cost per kWh becomes as expected. The cost decreases exponentially from $0.508 to $0.27 per kWh to service initially 700 to about later the full 22,000 customers in the service area. Eagle Power generation capacity falls in the left lower corner of the plot with 756 connections. The green, gray and red lines

correspond to the EP aspirations for expansion. Yet these scenarios will not nearly be able to provide electricity to the potential total customers in the area (21,155 connections) as shown in **Table 10**. A 5 MW investment on solar PV with 2-day autonomy battery bank (only for the first 10 years of operation) could ramp up the number of customers from around 5,000 to 10,000 in the first 5 years by interconnection to the LEC electrical grid.

Table 24 summarizes different scenarios for EP expansion through PV power. It includes estimated capital costs for the solar system but also for the transmission and distribution system that will interconnect the six currently isolated EP service areas; as well as for land requirements and engineering. Also all the power company management, customer service and plant operation costs, salaries, and deferred maintenance program to equal EP distribution system to LEC standards are included.

The LCCA analysis helped to estimate the $/kWh in a 25 life cycle. The table indicates the number of connections per installed capacity and at various stages of the project. Different type of customers and respective percentages were also considered based on the windshield assessment performed for this study and summarized in **Table 10** and **Table** 11. A tariff and a monthly connection fee is suggested for each type of consumers from which the average monthly bill is also calculated.

LESSP developed this economic analysis tool that can be used to run different scenarios. If loans are needed to finance the project, amount requested, years of financing and loan interest rate should be entered to calculate the annual mortgage payment, cash flow and net savings.

The tool considers providing solar electricity 24 h by using batteries or only during daylight. When buying electricity at night, part of the tariff collection is used to pay the other power company for the electricity service.

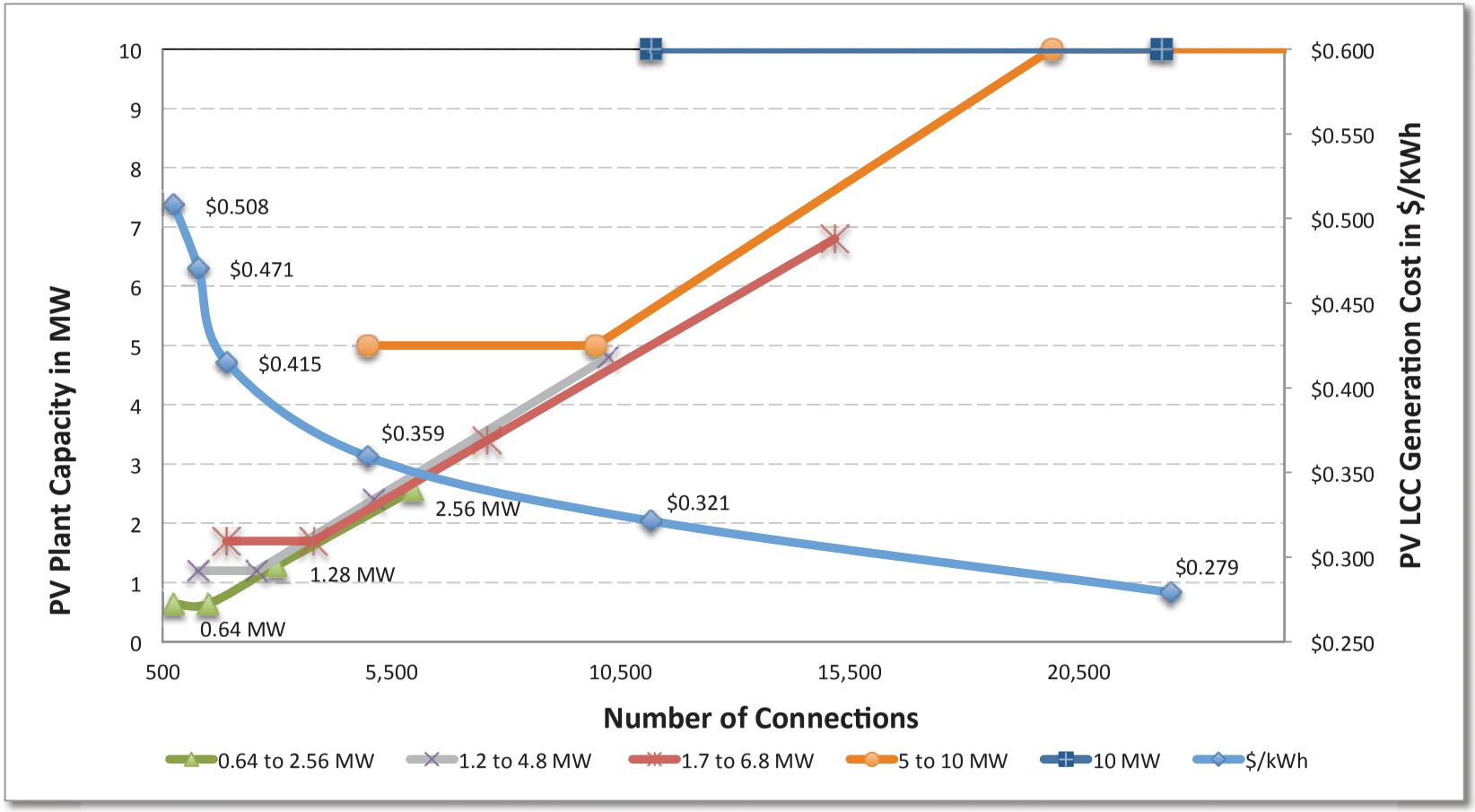


Figure 37. Solar PV power plant capacity and electricity generation cost per kWh versus number of connections. The $/kWh decreases exponentially when increasing the number of connections. Eagle Power initially has planned to operate in the left lower corner of the plot. Currently it has only 756 connections and would like to double or triple the number of customers. The green line corresponds to EP aspirations for expansion. Yet such scenarios will not nearly be able to provide electricity to the total potential customers in the area (21,155 connections) as shown in Table 10. A 5 MW investment on solar PV with 2-day autonomy battery bank (only for the first 10 years of operation) could ramp up the number of customers from around 5,000 to 10,000 in the first 5 years by interconnection to the LEC electrical grid.

Table 24. Summary of economic analysis applied to different scenarios for implementation of PV power generation plants in Monrovia. Initial investments include a 2 day autonomy storage system, which will not be replaced when batteries become exhausted since it is assumed that LEC partnership are possible for the benefit of Liberia economic growth.

Item	Cost Estimates, System Characteristics, Rates	0.64 A	0.64 B	0.64 C	1.2 A	1.2 B	1.2 C	1.7	5	10
a	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*j*	*k*
1	**Total Capital Cost**	**$ 4,515,869**	**$ 4,515,869**	**$ 4,515,869**	**$ 7,553,581**	**$ 7,553,581**	**$ 7,553,581**	**$ 10,265,824**	**$ 28,166,628**	**$ 55,289,058**
	Subtotal Capital Cost PV Generation	$ 1,951,200	$ 1,951,200	$ 1,951,200	$ 3,396,000	$ 3,396,000	$ 3,396,000	$ 4,686,000	$ 13,200,000	$ 26,100,000
	Subtotal Cost of Batteries	$ 1,724,471	$ 1,724,471	$ 1,724,471	$ 3,233,383	$ 3,233,383	$ 3,233,383	$ 4,580,626	$ 13,472,430	$ 26,944,860
	Subtotal Cost of Land	$ 96,000	$ 96,000	$ 96,000	$ 180,000	$ 180,000	$ 180,000	$ 255,000	$ 750,000	$ 1,500,000
	Subtotal Capital Cost Sub Service Area Distribution Lines	$ 744,198	$ 744,198	$ 744,198	$ 744,198	$ 744,198	$ 744,198	$ 744,198	$ 744,198	$ 744,198
2	**Investment Recovery Time**									
	Years	6.5	6.5	6.5	7	7	7	7	6	7
3	**Total O&M Cost and Other Costs Assuming No Downtime**									
	Fuel (5%genset run time)									
	Existing Salaries	$ 59,040	$ 59,040	$ 59,040	$ 136,416	$ 136,416	$ 136,416	$ 150,528	$ 245,784	$ 392,784
	New Salaries (Improvements)	$ 59,040	$ 59,040	$ 59,040	$ 136,416	$ 136,416	$ 136,416	$ 330,445	$ 365,784	$ 512,784
	Admin Expenses	$ 7,960	$ 7,960	$ 7,960	$ 9,234	$ 9,234	$ 9,234	$ 10,189	$ 16,637	$ 26,587
	New O&M program Equipment									
	Other O&M Costs	$ 15,000	$ 15,000	$ 15,000	$ 17,400	$ 17,400	$ 17,400	$ 19,200	$ 31,350	$ 50,100
	Reserve at 5%									
	Profit at 5%									
	Subtotal 35 km of distribution lines									
	Year 1	$ 120,000	$ 120,000	$ 120,000	$ 120,000	$ 120,000	$ 120,000	$ 120,000	$ 120,000	$ 120,000
	Year 2	$ 150,000	$ 150,000	$ 150,000	$ 150,000	$ 150,000	$ 150,000	$ 150,000	$ 150,000	$ 150,000
	Year 3	$ 180,000	$ 180,000	$ 180,000	$ 180,000	$ 180,000	$ 180,000	$ 180,000	$ 180,000	$ 180,000
	Year 4	$ 200,000	$ 200,000	$ 200,000	$ 200,000	$ 200,000	$ 200,000	$ 200,000	$ 200,000	$ 200,000
4	**Cost per kWh (Present Value at 25 years) Assuming No Downtime**									
	PV Life Cycle Cost of electricity production ($/kWh) Including T&D and Land	**$ 0.508**			**$ 0.471**			**$ 0.415**	**$ 0.359**	**$ 0.321**
	Weighted Average tariff per kWh	**$ 0.594**			**$ 0.563**			**$ 0.482**	**$ 0.431**	**$ 0.375**
	Tariff for Low Income Residential ($/kWh)	$ 0.588			$ 0.550			$ 0.474	$ 0.419	$ 0.370
	Tariff for Medium Income Residential ($/kWh)	$ 0.612			$ 0.572			$ 0.493	$ 0.436	$ 0.384
	Tariff for High Income Residential ($/kWh)	$ 0.628			$ 0.586			$ 0.506	$ 0.447	$ 0.394
	Tariff for Commercial ($/kWh)	$ 0.732			$ 0.684			$ 0.590	$ 0.522	$ 0.460
	Tariff for Industrial ($/kWh)	$ 0.588			$ 0.550			$ 0.474	$ 0.419	$ 0.370
	Tariff for Institutional and Government ($/kWh)	$ 0.612			$ 0.572			$ 0.493	$ 0.436	$ 0.384
5	Total Connections									
	Phase 1: SOLAR POWER	746	746	746	1,278	1,278	1,278	1,898	4,980	11,160
	Low Income Residential	92.0%	92.0%	92.0%	83.7%	83.7%	83.7%	86.8%	80.3%	87.8%
	Medium Income Residential	1.3%	1.3%	1.3%	3.9%	3.9%	3.9%	3.2%	1.6%	1.8%
	High Income Residential	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.1%	0.2%	0.4%
	Commercial	2.7%	2.7%	2.7%	8.2%	8.2%	8.2%	5.8%	9.6%	5.4%
	Industrial	0.0%	0.0%	0.0%	0.2%	0.2%	0.2%	1.1%	0.2%	0.2%
	Institutional and Government	4.0%	4.0%	4.0%	3.9%	3.9%	3.9%	3.2%	8.0%	4.5%
	Phase 2: INTERCONNECTION WITH LEC	**1,493**	**1,493**	**1,493**	**2,556**	**2,556**	**2,556**	**3,796**	**9,960**	**22,320**
	Low Income Residential	92.0%	92.0%	92.0%	83.7%	83.7%	83.7%	86.8%	80.3%	87.8%
	Medium Income Residential	1.3%	1.3%	1.3%	3.9%	3.9%	3.9%	3.2%	1.6%	1.8%
	High Income Residential	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.1%	0.2%	0.4%
	Commercial	2.7%	2.7%	2.7%	8.2%	8.2%	8.2%	5.8%	9.6%	5.4%
	Industrial	0.0%	0.0%	0.0%	0.2%	0.2%	0.2%	1.1%	0.2%	0.2%
	Institutional and Government									
	Phase 3: DOUBLE THE SOLAR POWER CAPACITY	**-**	**2,985**	**2,985**	**-**	**5,112**	**5,112**	**7,592**	**19,920**	
	Low Income Residential		92.0%	92.0%		83.7%	83.7%	86.8%	80.3%	
	Medium Income Residential		1.3%	1.3%		3.9%	3.9%	3.2%	1.6%	
	High Income Residential		0.0%	0.0%		0.1%	0.1%	0.1%	0.2%	
	Commercial		2.7%	2.7%		8.2%	8.2%	5.8%	9.6%	
	Industrial		0.0%	0.0%		0.2%	0.2%	1.1%	0.2%	
	Institutional and Government		4.0%	4.0%		3.9%	3.9%	3.2%	8.0%	
	Phase 4: 4 TIMES THE SOLAR POWER CAPACITY		**-**	**5,970**			**10,224**	**15,184**	**39,840**	
	Low Income Residential			92.0%			83.7%	86.8%	80.3%	
	Medium Income Residential			1.3%			3.9%	3.2%	1.6%	
	High Income Residential			0.0%			0.1%	0.1%	0.2%	

Item	Cost Estimates, System Characteristics, Rates	0.64 A	0.64 B	0.64 C	1.2 A	1.2 B	1.2 C	1.7	5	10
a	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*j*	*k*
	Commercial			2.7%			8.2%	5.8%	9.6%	
	Industrial			0.0%			0.2%	1.1%	0.2%	
	Institutional and Government			4.0%			3.9%	3.2%	8.0%	
6	**Average Billing per month**									
	Phase 1: SOLAR POWER									
	Low Income Residential	$ 56.0	$ 63.2	$ 80.0	$ 53.9	$ 61.3	$ 78.1	$ 50.0	$ 47.1	$ 44.4
	Medium Income Residential	-	$ 99.6	$ 130.1	$ 82.6	$ 96.0	$ 126.7	$ 75.4	$ 70.1	$ 65.4
	High Income Residential	-			$ 112.1	$ 131.7	$ 176.7	$ 101.6	$ 93.8	$ 86.9
	Commercial	$ 190.4	$ 211.6	$ 260.5	$ 184.5	$ 205.8	$ 255.2	$ 172.9	$ 164.4	$ 156.8
	Industrial	-			$ 250.3	$ 275.7	$ 334.3	$ 236.6	$ 226.5	$ 217.4
	Institutional and Government		$ 147.8	$ 199.4	$ 119.1	$ 141.7	$ 193.7	$ 106.9	$ 98.0	$ 89.9
	Phase 2: INTERCONNECTION WITH LEC									
	Low Income Residential	$ 35.5	$ 35.5	$ 35.5	$ 35.5	$ 35.5	$ 35.5	$ 35.5	$ 35.5	$ 34.7
	Medium Income Residential		$ 48.4	$ 48.4	$ 48.4	$ 48.4	$ 48.4	$ 48.4	$ 48.4	$ 47.7
	High Income Residential				$ 61.3	$ 61.3	$ 61.3	$ 61.3	$ 61.3	$ 60.9
	Commercial	$ 124.7	$ 124.7	$ 124.7	$ 124.7	$ 124.7	$ 124.7	$ 124.7	$ 124.7	$ 124.7
	Industrial				$ 186.5	$ 186.5	$ 186.5	$ 186.5	$ 186.5	$ 183.7
	Institutional and Government	$ 61.2	$ 61.2	$ 61.2	$ 61.2	$ 61.2	$ 61.2	$ 61.2	$ 61.2	$ 60.0
	Phase 3: DOUBLE THE SOLAR POWER CAPACITY									
	Low Income Residential		$ 30.3	$ 30.3		$ 30.3	$ 30.3	$ 30.3	$ 30.3	
	Medium Income Residential		$ 39.2	$ 39.2		$ 39.2	$ 39.2	$ 39.2	$ 39.2	
	High Income Residential					$ 48.2	$ 48.2	$ 48.2	$ 48.2	
	Commercial		$ 112.3	$ 112.3		$ 112.3	$ 112.3	$ 112.3	$ 112.3	
	Industrial					$ 168.3	$ 168.3	$ 168.3	$ 168.3	
	Institutional and Government		$ 45.6	$ 45.6		$ 45.6	$ 45.6	$ 45.6	$ 45.6	
	Phase 4: 4 TIMES THE SOLAR POWER CAPACITY									
	Low Income Residential			$ 27.6			$ 27.6	$ 27.6	$ 27.6	
	Medium Income Residential			$ 34.6			$ 34.6	$ 34.6	$ 34.6	
	High Income Residential						$ 41.6	$ 41.6	$ 41.6	
	Commercial			$ 106.2			$ 106.2	$ 106.2	$ 106.2	
	Industrial						$ 159.1	$ 159.1	$ 159.1	
	Institutional and Government			$ 37.8			$ 37.8	$ 37.8	$ 37.8	
7	**Monthly Fee to provide service**									
	Low Income Residential	$ 25	$ 25	$ 25	$ 25	$ 25	$ 25	$ 25	$ 25	$ 25
	Medium Income Residential	$ 30	$ 30	$ 30	$ 30	$ 30	$ 30	$ 30	$ 30	$ 30
	High Income Residential	$ 35	$ 35	$ 35	$ 35	$ 35	$ 35	$ 35	$ 35	$ 35
	Commercial	$ 100	$ 100	$ 100	$ 100	$ 100	$ 100	$ 100	$ 100	$ 100
	Industrial	$ 150	$ 150	$ 150	$ 150	$ 150	$ 150	$ 150	$ 150	$ 150
	Institutional and Government	$ 30	$ 30	$ 30	$ 30	$ 30	$ 30	$ 30	$ 30	$ 30
8	**Loans**									
	Loan 1	$ 5,000,000	**$ 6,000,000**	$ 6,000,000	$ 8,000,000	$ 8,000,000	$ 8,000,000	$ 10,000,000	$ 30,000,000	$ 55,000,000
	Loan 2	$ -	$ -	$ 4,000,000	$ 4,000,000	$ 3,000,000	$ 2,000,000	$ 4,000,000	$ 11,000,000	$ -
	Loan 3	$ -	$ -	$ -	$ 4,000,000	$ -	$ 2,000,000	$ 2,000,000	$ -	$ -
	Loan 4	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Interest Rate									
	Loan 1	5%	5%	5%	5%	5%	5%	5%	5%	5%
	Loan 2	0%	0%	5%	5%	5%	5%	5%	5%	0%
	Loan 3	0%	0%	0%	5%	0%	5%	5%	0%	0%
	Loan 4	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Years of financing									
	Loan 1	25	25	25	25	25	25	25	25	25
	Loan 2	0	0	12	19	19	19	19	12	26
	Loan 3	0	0	0	10	0	12	15	24	24
	Loan 4									
9	**Cumulative Earnings at Y25**	**$ (2,929,081)**	**$ 8,242,117**	**$ 14,133,921**	**$ (6,949,999)**	**$ 18,240,682**	**$ 32,786,360**	**$ 49,671,360**	**$ 136,419,199**	**$ 97,607,910**

6 FINDINGS, RECOMMENDATIONS, RISKS

6.1 General Findings

- **Level of Effort**: The original estimated amount or "level of effort" (LESSP staff time) required to carry out this study was insufficient due to the amount of work required to gather and analyze existing Eagle Power operational and cost data. This study remains somewhat incomplete as data quality issues prevent full reliable analysis of operational characteristics and costs. Additional study is needed.
- **LESSP Professional Qualifications in Utility Management**: The study included significant amount of work in examining a private utility and then discussing the results of these findings and conjecturing about needed business utility improvements. LESSP staff have years of public utility O&M and management experience and had access to electric utility managers during this study, however LESSP staff are not expert in urban electric utility management and operations and as such our findings and recommendations in this area should be considered preliminary with a need for additional study.
- **Informal Electricity Provision Sector in Monrovia**: Conjecturing, Eagle Power may be the largest "informal" electricity service provider in the Monrovia service area today. We have also found during this study that a large number of people in the Monrovia urban area receive electricity from informal providers today. We estimate that there are probably, by a wide margin more informal electricity service connections in the Monrovia urban area today than there are customers of the Liberia Electricity Corporation (LEC). However we could find no data on this.
    - How many homes and small businesses in the Monrovia urban area today receive some electricity from informal sources today?
    - What is the average cost in $/kWh of this informal electricity per customer?
    - How many people work and have jobs in this market?
    - How much diesel fuel is being used for this annually? Who is selling this fuel? What does this use do to diesel prices?
    - How much tax money is the government losing by not taxing these mini-grids?
    - What level of service is provided by these mini-grids?
    - What is the break-down of customers in terms of residential users to commercial users? Do these mini grids affect the commercial economy? How?
    - Will customers of informal mini grids want to move from their existing service to LEC provision of electricity when they have access to it?
    - Does the practice of informal provision of electricity by entrepreneur mini grids extend to the County capitals and other larger cities and towns in Liberia?

- How does this affect consumer safety? How does this affect the physical environment in Liberia?
- Could a new Energy Law in Liberia that allows, promotes and regulates the private sector utility market ram up these private sector investors to provide more reliable, safer, and environmentally sound electricity that would benefit Monrovia and Liberia?

- **Private Sector Provided Electricity in the Monrovia Urban Area**: It would seem that the private electricity sector is alive and well in the Monrovia urban area. Initial surveys of professional Liberians living throughout the urban area indicate that all sectors of the City today are served by informal electricity providers who sell electricity during some hours of the day, normally in the evenings, by some type of amperage subscription arrangement. As noted previously, we cannot estimate the number of customers served through such arrangements, how much the cost of service is or how does it compare to LEC provided electricity.

  However, perhaps the first thing that one reads at the beginning of every written piece about electricity in Liberia where it is reported that "less than 10% of Monrovians enjoy electricity" is incorrect. Conjecturing, it may be that and estimated 30-50% of Monrovians enjoy some level of electrical service provided by others in mini grids.

- **Private Mini-Grid Regulation**: Because there is no regulation authority in Liberia, this informal electricity market is totally unregulated. No service standards exist. No consumer bill-of-rights exist. No government incentives exist. No government oversight of customer safety exists. No environmental management of any mini grid operations exits. No taxes are collected.

- **The Future?**: The original Scope of Work (SOW) calls for LESSP to examine and report on switching EP generation to renewable energy and perhaps slightly expanding the service area and the total number of its existing customer base. This study addresses that scenario. It is clear however that the future electricity requirement in the area where EP wants to operate is significantly higher than what they propose to provide. The fact is that Eagle Power will not be allowed to provide electricity as a boutique operation over the long term. The future for EP must include accounting for the needs of all the connections in its service area. This issue needs to be addressed with MLME and LEC and is key to EP's future.

6.2 Eagle Power Findings and Recommendations

6.2.1 Administration

Eagle Power should be organized, as are most power companies. The company is lacking a Board of Directors to whom the CEO should report and advise. A **Board of Directors is needed to prevent a conflict of interest** and for too much power being concentrated in the hands of one person. **Figure 38** shows a proposed organization chart that would improve operations of the company. The owner and other interested parties should propose and elect a Board of Directors, with meetings of the owners annually at a minimum to select new Board Members and to discuss and act upon major governance issues. The Board shall hire a general manager for the day-to-day operations, and the General Manager shall hire the EP staff. EP departments should include administration, commercial, engineering, and operations.

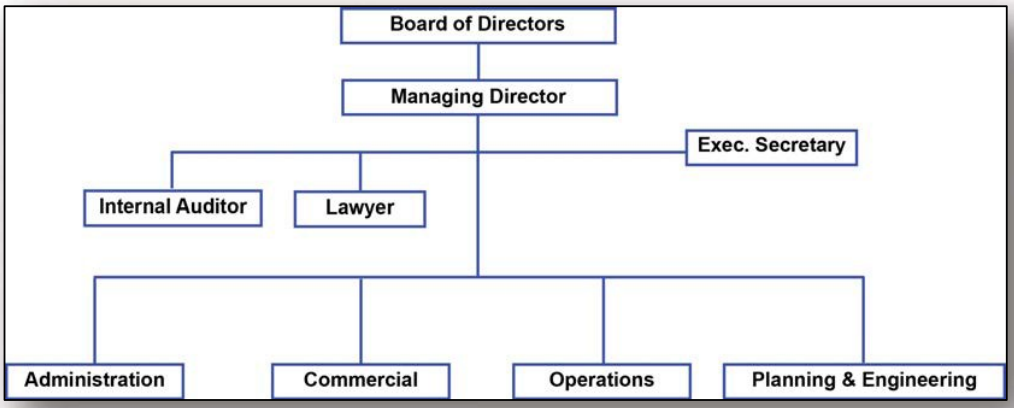


Figure 38: Proposed Organization Chart for Eagle Power.

The most urgent issue confronting EP is the need to take measures to carry out audits, improve accounting procedures and clarify financial statements since the inception of EP. This includes:

- Financial policies and procedures should be implemented to ensure an adequate financial control, accountability, and transparency;
- 2012 and 2013 audits are needed to understand financing, accounts, and to accurately calculate the cost of electricity production and to redefine the tariff to a more affordable one for consumers keeping congruent profits; and
- EP must adopt Cost Accounting Standards (CAS). An external accounting firm could implement new bookkeeping practices and provide training to EP managerial staff for them not only to be able to understand financial reports but also to learn about their responsibilities for their preparation.

Regarding employees, establishment of coherent employee policies is of critical importance toward the long-term success of the company. Some recommendations of the policy provisions that should be included within the EP employee policies are:

- Employee ethics and code of conduct;
- Recruitment procedures;
- Benefit plans;
- Salary plan;
- Training program;
- Safety program;
- Annual work calendar, holidays and leave policy;
- Annual evaluation procedures;
- Conflict of interest policy; and
- Employee privacy rights.

6.2.2 Operations and Other Utility Improvements

The main objective of EP should be to provide reliable electric service to EP customers at the lowest possible cost to the consumer. The technical improvements in the short term are:

- Base billing on metered electricity use and not on subscribed amperage limits;
- Hire professional engineering management staff;
- Better tracking and filing system for fuel use, maintenance costs, and operational data per generator; and
- Increase the number of connections within the currently served areas to be able to lower the cost of service.

In the long term,

- EP must adopt LEC engineering standards to be competitive;
- EP needs to implement a deferred maintenance program to replace existing distribution lines and poles; and
- Generate and sell electricity 24/7.

6.2.3 Customers

EP must have a better understanding of its customers; this will allow developing a suitable strategy for

- Increasing connections within currently served areas;
- Expanding service area;
- Defining adequate tariffs for different types of consumers; and
- Remittance collection of delinquent accounts;

Other urgent measures that should be addressed include:

- Develop a customer database that shows accurately kept, managed and updated account histories
- WTP survey
- ATP survey

6.3 Future Works

6.3.1 Employment;

The EP mission should be to provide highly reliable and economical electric service to its customers through its valued workforce. EP plans for expansion will require it to increase its number of employees in administration, commercial, engineering and operations. EP staffing levels will be a function of the number of consumers to be served and the geographic scope of the service territory. The larger the geographic scope, the greater will be the need for regional commercial and operations offices. EP should provide the necessary training to accomplish its commitment to service, accountability and transparency in all of EP operations.

EP will also need to locate and engage one or two experienced electricity utility managers from aboard to manage the transition of EP from its current state to that of a professional utility.

Implementation of a PV solar power plant will give EP recognition in the advancement of RET in Liberia. This will incentivize future projects in the area of solar technologies. On-the-Job Training (OJT) during construction works will create a pool of human resources, engineers and technicians who will be able to maintain RE and distribution systems in the future of Liberia.

Higher education institutions such as University of Liberia, Stella Maris Polytechnic, and Booker Washington Institute are adopting RE courses within their curricula, including solar energy topics. **EP expansion project is an opportunity to contribute to the creation of high-qualified technicians and professionals with real practical knowledge** capable of responding to national development needs. Internships should be promoted for both university and vocational students to experience the construction stage of the project.

6.3.2 Customer Profiles and Retention Strategy

The commercial plan must be in synch with the business plan. EP needs to increase the number of connections for all the planned energy to be generated. When the expansion is a taken decision, and construction works start, EP has the construction period to attract new customers and make the service drops.

EP will need to engage a highly skilled and motivated marketing team to inscribe future customers in the six-month period prior to the commercial operation date. Launching and effective connection campaign and providing a reliable and affordable service will ensure a rapid attraction of customers. Currently there is no competition for EP in providing electricity service within the area. Strategies for increasing the number of customers should be based on how the company can best provide the electricity service and great understanding of the customers. WTP and ATP surveys are of critical importance for developing an appropriate strategy.

Metering system is the only acceptable option for the new billing approach to achieve high customer retention.

6.3.3 Electricity Tariff Strategy

By becoming more efficient in overall operations, and having effective financial and administrative control, expenses are expected to decrease. With customer retention strategy in placed, number of connections should increase to the maximum technically possible by EP infrastructure. A periodic re-evaluation of the tariff, considering all the necessary technical factors and also equity and cultural issues will make electricity more affordable to customers.

The tariff structure is key to the long-term financial sustainability of EP. Tariff could decrease with

- Increase number of connections;
- Billing based on metering system;
- Reduce fossil fuel consumption;
- High customer retention;
- Adequate categorization of customers (Residential, Residential – low income, Commercial, Commercial – low income, institutional); and
- Effective revenue collection.

6.4 Risks and Risk Management

Eagle Power infrastructure can be upgraded however there are risks that need to be addressed prior to making major financial decisions on such infrastructure. At a minimum these include:

1. **Eagle Power Legal Right to Generate, Transmit, and Sell Electricity**: Eagle Power currently has a business license and it states that EP provides electricity but EP does not have the legal right to do so under Liberia's laws today. EP is providing electricity informally. For EP to provide electricity lawfully under current Liberia law it would need perhaps a concession from the MLME.

   Risk Mitigation: Prior to any funding of new and proposed EP infrastructure, the MLME must provide such a concession to EP. EP needs to operate for a minimum of 12 years to pay back the investment on its new infrastructure as described herein.

2. **Operating Within LEC Service Area**: EP is operating close to LEC's existing service area and probably within LEC's soon to be expanded service area. It would seem that LEC would not want nor would the MLME want competing service providers operating so closely for several reasons especially since EP's projected service area is probably a bubble within LEC's planned expanded service area that should extend all the way and past Roberts Airfield.

   Risk Mitigation: Prior to any funding of new and proposed EP infrastructure, EP would need to negotiate some kind of arrangement with LEC where EP compliments LEC operations and service and this complementarity makes sense for both parties – perhaps a power purchase agreement or some other beneficial arrangement. Again, EP needs to operate for a minimum of 12 years to pay back the investment on its new infrastructure as described herein.

3. **Eagle Power Operational Standard**: Eagle Power utility management, business, accounting, customer services, planning, engineering, and O&M is weak. The EP business works today and provides a needed and desired service to its customers but if it wishes to grow and improve, there will have to be changes that bring this organization into compliance with generally acceptable professional utility business management, accounting/auditing, engineering and legal standards. Discussions have been held with EP ownership about this and we believe they are committed to doing this however this cannot be done with a viable and considered plan. A management team that is experienced in this business is also required to be added to implement it.

Risk Mitigation: Prior to any funding of new and proposed EP infrastructure, EP would need to carry out a study to develop an approach to converting the EP business into an electric utility that is managed and operated in accord with basic levels of professionally acceptable practices and standards. There will also have to be at least two experienced electric utility managers (one overall manager with an engineering background and one finance officer) hired and in place to lead this transition and also guide EP to be an acceptably proficient utility. This can be done and it can be funded as part of the infrastructure program financing. But financing new infrastructure without this being done concurrently is not recommended. EP needs internal professional engineering, accounting and auditing in place before any financing is arranged.

4. **Other Property Legal Requirements**: Eagle Power has other legal requirements that they need to bring under control while they are implementing any infrastructure improvement plan. Two relate to obtaining property: (1) Eagle Power must have the ability to obtain/procure in a legal fashion to build any new generation facilities; and (2) EP must comply with GOL laws regarding rights of way and easements in public road and other utility corridors.

   Risk Mitigation: EP needs to hire an attorney who can study these issues and ensure that EP work complies with the laws and procedures of the GOL, the MLME and the PWD.

5. **Environmental Approval**: EP needs to obtain required environmental permits and approvals from the Liberia EPA for all construction and for all operations. To date, EP is lacking in this area. For any new work this is a strict requirement.

   Risk Mitigation: EP needs to hire a consultant environmental specialist or firm who can advise them of the laws and procedures or the study these issues and ensure that EP work complies with the laws and procedures of the GOL and the Liberia EPA

ANNEX A. DOCUMENTATION

A.1 Business Registry Documentation

LIBERIA BUSINESS REGISTRY

A JOINT INITIATIVE OF THE MINISTRY OF COMMERCE AND INDUSTRY, THE MINISTRY OF FOREIGN AFFAIRS, THE MINISTRY OF FINANCE AND THE NATIONAL SOCIAL SECURITY AND WELFARE CORPORATION

Date of issuance: 05/Aug/2013 *Enterprise code:* 050996115

TIN: 420498004

Certificate of Business Registration (Business corporation)

Initial registration date: 21/Aug/2009
Registration date: 02/Jul/2012
Enterprise name: 2 G COMPANIES LTD
Ownership: Liberian
Registered address: Margibi, DUAZON, ROBERTFIELD HIGHWAY

Enterprise activity:

No.	Code	Description	Main
1.	D3510	Electric power generation, transmission and distribution	Yes

Important: *This certificate is not valid after* ***27/Jun/2014.***
It may, however be renewed upon application.
It is not transferable and should not be considered ***as guarantee of financial standing.***
The slightest erasure or alteration renders it ***invalid.***
For inspection purposes, this Certificate must at all times be displayed at a conspicuous place where business is being operated.

Seal

Signature 2013-08-05

Abu Kamara
Registrar

A.2 Customer Application Form and Contract

EAGLE POWER

A Community Electrification Project Of 2G Companies, Ltd.
Robertfield Highway - Duahzon, Margibi County

APPLICATION FOR SERVICE

FORM NO: EPCAF/01/13

Customer No: **«EPVA-1001»**

1. Name of Applicant/Business: _____

2. Address or location: _____

3. Major Landmark *(something that will help us identify your location)*: _____

_____

4. Telephone Number: _____

5. Type of application *(Please check the appropriate space)*
   Application is for: ____ New Connection ____ Temporary Connection ____ Reconnection

6. Nature of Connection:
   ____ Residential ___ Business/Commercial (Brief Description):
   _____

7. How many amps are you applying for? _____amps. Please note that all connections are single phase. Persons desiring three phase connections will need to discuss this with management.

8. Please check all known appliances in your home or business and their corresponding power rating:

Appliance	Quantity	Wattage	Appliance	Quantity	Wattage
• Light bulbs	_____	_____	Air Conditioner	_____	_____
• Fans	_____	_____	Vacuum Cleaner	_____	_____
• Microwave Oven	_____	_____	Washing Machine	_____	_____
• Cookers	_____	_____	Dryer	_____	_____
• Food Processor	_____	_____	Welding Machine	_____	_____
• Water heater	_____	_____	Electric saw	_____	_____
• Television	_____	_____	Computer/Printer	_____	_____
• Refrigerator	_____	_____			

• Other Appliances_____, _____, _____

Terms and Conditions:

Eagle Power services are provided on a prepaid basis. We provide **11 hours** of night time electricity *(with a guaranteed uptime is +-95%)* from **7pm** to **6am** 365 days a year unless interrupted by incidents beyond our control. Our service cost per amp is **$57.50** USD(two amps and above), but may be adjusted up or down depending on market factors such as fuel price. A non-refundable registration fee of **$25.00** is required per application. As a community electrification company, the security of your community is a paramount concern to us. Apart from servicing your individual home or business electrification needs, Eagle Power will provide security lights throughout the community at strategic locations. We will also maintain these lights and replace them on a regular basis. For your convenience, Eagle Power will provide feeder poles and low tension distribution lines along the main roads and alleys within your community. If additional poles are needed to reach your residence or business, a fee of **$20.00** will be charged for each additional pole for locations not immediately accessible to our lines. Service cables needed to reach your home or business from the nearest pole may be purchased from **Eagle Power** or at a local vendor. For quality purposes and for your safety, we recommend **#8** AWG or European copper wires for customer connections. If you choose to purchase your wire from a vendor, please obtain a sample from Eagle Power before proceeding. Should your line become disconnected due to delinquency or non-payment of bills, a reconnection fee of **$30.00** must be paid before reconnection. A grace period of **3 days** is given to all subscribers beyond your due date. After three days, your account will be considered delinquent and subject to disconnection action.

Goods and Services Tax : In compliance with the 2007 Goods and Services tax code of the Government of Liberia, **a tax levy of 7% will be applied to your monthly Eagle Power Electricity Bill** representing your GST payment to the Liberian Government**. Please note that this is not an increment in the electricity bill but rather an imposed tax by the Government of Liberia (GOL).** Eagle Power will subtract your taxes from any amount paid for onward submission to government in order to remain compliant with Ministry of Finance (MOF) regulations.

By signing this form, you agree that you understand the terms and conditions of our service and indicate your willingness to comply with these conditions.

Applicant Signature: _____ Date: _____

A.3 Example of Monthly Bill

Eagle Power

Duazon City
Lower Margibi County
Republic of Liberia

Bill To:
Customer J. Giddings
Duazon City
Margibi County

Monthly Payment Invoice

Invoice #	5464
Invoice Date:	7/1/2013

Date Of Connection 04/05/2011

Subscribed Amperage	8-amps

Your payment is due on or before: 7/5/2013

Please bring or send this invoice along with your payment for accurate recording and documentation of your account information.

Item	Description	Quantity	Cost/Unit	Amount
Subscribed A...		8	50.00	400.00
GST Tax			7.00%	28.00

Subscriber Information Center

Total	USD 428.00
Payments/Credits	USD 0.00
Balance Due	USD 428.00

Important Information! Please Read!!

Lightening Advise!

On several occasions, Eagle Power installations have suffered severe setback and financial lose due to lightening strikes despite the availability of Lightening Arresters at our Power Plants. Some customers have also experienced damages to major equipment and appliances during such strikes. To protect our installations and be able to continue serving you, Eagle Power will turn off all Power Plants during severe lightening activities for the duration of those activities. Power will be restored immediately after the lightening passes. Please turn off and unplug your important appliances such as TV, Freezers, etc. during severe lightening. Our system may be off, but your appliances could get demaged with a very strong lightening strike. Lightening is attracted to metals or anythng that conducts electricity. Lightening is a very powerful form of electricity.

Goods and Services Tax or GST!

The Goods and Services Tax that will be appearing on your bill has been imposed by the Government of Liberia, through the Ministry of Finance. It is not an increment in Eagle Power Electricity Bill. Our Taxes help our government to provide basic services for us such as hospitals, schools, etc. We thank you for cooperating with us to meet this national responsibility

Important Numbers to Know:

Technical Support - 0886-510-570
Mr. Emerson Jacobs, Senior Technical Supervisor

Account Related: 0886-821-006
Call Mr. Anthony Barwu, Jr. for all bill and account related matters

ANNEX B. EAGLE POWER EXPENSES

B.1 EP Staff Salaries

No	Job Title	Station	Current Monthly Salary	Proposed Monthly Salary	Current Yearly Salary	Proposed Yearly Salary	Variance Proposed
			$				%
a	*b*	*c*	*d*	*e*	*f*	*g*	*h*
1	President/CEO	HQ	$-	$-	$-	$-	
2	Accountant/Commercial Officer	HQ	$300	$600	$3,600	$7,200	100%
3	Customer Service Rep/Cashier	RH	$150	$250	$1,800	$3,000	67%
4	Customer Service Rep/Cashier	RC	$125	$250	$1,500	$3,000	100%
5	Customer Service Rep/Cashier	GH	$125	$250	$1,500	$3,000	100%
6	Customer Service Rep/Cashier	VA	$150	$250	$1,800	$3,000	67%
7	Customer Service Rep/Cashier	TV	$125	$250	$1,500	$3,000	100%
8	Receptionist/Cashier	DZ/HQ	$150	$250	$1,800	$3,000	67%
9	Office Assistant	HQ	$75	$200	$900	$2,400	167%
10	Security	RH	$65	$200	$780	$2,400	208%
11	Security	RC	$60	$200	$720	$2,400	233%
12	Security	TV	$65	$200	$780	$2,400	208%
13	Security	HQ	$80	$200	$960	$2,400	150%
14	Security	HQ	$60	$200	$720	$2,400	233%
15	Security/Senior Citizen	TV	$25	$100	$300	$1,200	300%
16	Senior Technical Supervisor	AST	$500	$850	$6,000	$10,200	70%
17	General Supervisor	RH	$150	$400	$1,800	$4,800	167%
18	Project Supervisor	DZ/VA	$125	$300	$1,500	$3,600	140%
19	Project Supervisor	RC	$140	$300	$1,680	$3,600	114%
20	Project Supervisor	GH	$125	$300	$1,500	$3,600	140%
21	Project Supervisor	TV	$140	$300	$1,680	$3,600	114%
22	Technician	RH	$100	$200	$1,200	$2,400	100%
23	Technician	DZ	$130	$200	$1,560	$2,400	54%
24	Technician	GH	$100	$200	$1,200	$2,400	100%
25	Technician	RC	$140	$200	$1,680	$2,400	43%
26	Technician	RC	$100	$200	$1,200	$2,400	100%
27	Chief Mechanic	AST	$300	$500	$3,600	$6,000	67%
28	Mechanic	AST	$125	$200	$1,500	$2,400	60%
29	Mechanic/Welder	AST	$100	$200	$1,200	$2,400	100%
30	Operator Supervisor	AST	$110	$300	$1,320	$3,600	173%
31	Operator	RH	$70	$150	$840	$1,800	114%
32	Operator	RC	$80	$150	$960	$1,800	88%
33	Operator	DZ	$70	$150	$840	$1,800	114%
34	Operator	DZ	$70	$150	$840	$1,800	114%
35	Operator	GH	$80	$150	$960	$1,800	88%
36	Operator	VA	$70	$150	$840	$1,800	114%
37	Operator	TV	$80	$150	$960	$1,800	88%
38	Chief Plumber/Logistics	AST	$200	$300	$2,400	$3,600	50%
39	Driver (part time)	AST	$50	$75	$600	$900	50%
40	Driver	AST	$85	$150	$1,020	$1,800	76%
41	Customer Relations Personnel	AST	$125	$250	$1,500	$3,000	100%
			$4,920	**$9,875**	**$59,040**	**$118,500**	**101%**

B.2 Six Months Expense Report: Summary of Expense Accounts

		February	March	April	May	June	July	Total	Average	STD	Median
A	**Production & Operations**										
1	Materials & Supplies	6,186.00	1,383.75	2,069.01	4,231.75	6,149.36	2,731.71	22,751.58	3,791.93	2,067.58	3,481.73
2	Maintenance & Repairs	5,666.74	3,205.29	3,125.00	2,463.03	3,083.97	2,370.79	19,914.82	3,319.14	1,204.12	3,104.49
3	**Fuel & Lubricants**										
4	*- Generators - All Stations*	*15,263.48*	*22,500.00*	*29,215.00*	*27,787.33*	*27,675.00*	17,980.00	140,420.81	23,403.47	5,791.85	25,087.50
5	*- Vehicles(operations)*	*883.34*	*728.88*	1,152.16	939.93	1,059.43	1,011.95	5,775.69	962.62	147.76	975.94
6	Machinery & Equipment	515.00		350.00	330.00		24.45	1,219.45	304.86	204.50	340.00
7	Other Production Expenses	474.14	854.26	2,523.43	2,048.82	117.95	181.20	6,199.80	1,033.30	1,015.92	664.20
8	Sub-Total	28,988.70	28,672.18	38,434.60	37,800.86	38,085.71	24,300.10	196,282.15	32,713.69	6,139.46	33,394.78
B	**Administrative**										
1	Salaries & Wages *	4,540.00	4,555.00	4,485.00	4,652.50	4,677.50	4,700.00	**27,610.00**	4,601.67	86.71	4,603.75
2	Fuel & Lubricants:: Vehicle	236.79	114.85	272.50	255.13	274.70	415.02	**1,568.99**	261.50	95.94	263.82
3	Maintenance & Repairs	1,259.86	918.28	198.16	209.41	150.28		**2,735.99**	547.20	509.67	209.41
4	Communication	380.86	402.86	505.00	585.29	517.50	514.86	**2,906.37**	484.40	77.45	509.93
5	Office Supplies	123.29	232.00	255.00	160.00	230.00	76.97	**1,077.26**	179.54	70.79	195.00
6	Bank Charges				300.00	240.00		**540.00**	270.00	42.43	270.00
7	Janitorial Services	10.72	14.44	14.72	1.37	16.16		**57.41**	11.48	6.00	14.44
8	Rents/Leases	180.00		3,000.00		2,460.00		**5,640.00**	1,880.00	1,496.80	2,460.00
9	Professional Service Fees	100.00	275.00	200.00	70.00	92.84	1,374.18	**2,112.02**	352.00	506.77	150.00
10	Charitable Contribution			15.00	100.00	190.00	210.00	**515.00**	128.75	89.66	145.00
11	Local Travels		245.38	175.76	60.67	32.23	65.30	**579.34**	115.87	90.77	65.30
12	Corporate Income Taxes	678.00	678.00	678.00	678.00	678.00		**3,390.00**	678.00	-	678.00
13	Machinery & Equipment	65.71	10.68	27.15	76.03	-		**179.57**	35.91	33.54	27.15
14	Other	335.78	355.41	546.55	706.93	407.42	327.51	**2,679.60**	446.60	151.05	381.42
	Sub-total	7,911.01	7,801.90	10,372.84	7,855.33	9,966.63	7,683.84	51,591.55	8,598.59	1,226.07	7,883.17
	Six Months Total	36,899.71	36,474.08	48,807.44	45,656.19	48,052.34	31,983.94	247,873.70	41,312.28	7,076.33	41,277.95
C	Direct Investment **			$200,824.32	**$334,884**						
D	Direct Loans **			$134,060.65							

B.3 Monthly Planned Generators Maintenance Expense

	Zone	Use	Fuel Filter (Pri)			Fuel Filter (Sec)			Air Filter			Engine Oil			Oil Filter			Engine Flush			Total Cost
			Qty	Unit Cost	Total	Qty	Unit Cost	Total	Qty	Unit Cost	Total	Qty	Unit Cost	Total	Qty	Unit Cost	Total	Qty	Unit Cost	Total	
a	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*j*	*k*	*l*	*m*	*n*	*o*	*p*	*q*	*r*	*s*	*t*	*u*	*v*
1	RH	Main	1	40	$40	1	0	$-	1	150	$150	5	15	75	1	45	$45	2	10	20	$330
2	RH	Standby			$-			$-			$-			0			$-			0	$-
3	TV	Main	1	40	$40	2	40	$80	1	175	$175	6	15	90	2	45	$90	1	20	20	$495
4	GH	Main	1	20	$20	1	35	$35	1	150	$150	5	15	75	1	45	$45	2	10	20	$345
5	RB	Main	1	40	$40	1	0	$-	1	175	$175	6	15	90	1	45	$45	2	10	20	$370
6	RB	Standby			$-			$-			$-			0			$-			0	$-
7	VOA	Main			$-			$-			$-			0			$-			0	$-
8	VOA	Standby			$-			$-			$-			0			$-			0	$-
9	DZ	Main	1	40	$40	1	40	$40	1	175	$175	6	15	90	1	45	$45	2	10	20	$410
10	DZ	Standby	1	35	$35	2	35	$70	1	175	$175	6	15	90	2	45	$90	1	20	20	$480
11	HDQ											1	5	5							$5
12	CEO RES								1	5	$5	1	5	5							$10
13	GARAGE								1	5	$5	1	5	5							$10
14	Total				$215			$225			$1,010			525			$360			120	$2,455

	Zone	Generator Use	Capacity (KVA)	Diesel gal/night	Diesel gal/month	Diesel $/month
a	*b*	*c*	*d*	*e*	*f*	*g*
1	RKH	Main	82.5	35.39	1,062	$ 4,438
2	RKH	Standby	77.5			
3	TVL	Main	150	51.87	1,556	$ 6,505
4	GHR	Main	130	32.78	984	$ 4,111
5	RHB	Main	100	45.95	1,378	$ 5,762
6	RHB	Standby	36			
7	VOA	Main	18	18	540	$ 2,257
8	VOA	Standby	5			
9	DZN	Main	200	54.77	1,643	$ 6,868
10	DZN	Standby	100			
11	**Operating Capacity**		**681**			
12	**Diesel**				**7,163**	**$ 29,942**

ANNEX C. LIFE CYCLE COST ANALYSIS

Methodology

The Life Cycle Cost (LCC) method of economic analysis calculates a system's total cost over its useful life. This analysis is especially useful when project alternatives that fulfill the same performance requirements, but differ with respect to initial costs and operating costs, have to be compared in order to select the one that maximizes net savings. The purpose is to estimate the overall costs of project alternatives and to select the design that ensures the facility will provide the lowest overall cost consistent with its quality and function. The LCCA should be performed early in the design process while there is still a chance to refine the design to ensure a reduction in the LCC.

The typical study period for a LCCA applied to RET is 25 years. PV modules are guarantee by most manufacturers up to 25 years of rated wattage. For other RET such as biomass and hydropower systems project lifetime is also considered 25 years since civil works last as long.

There are numerous costs associated with acquiring, operating, and maintaining a power system whether it is RE or a diesel system. All costs are entered as base-year amounts in today's dollars; the LCCA method escalates all amounts to their future year of occurrence and discounts them back to the base date to convert them to present values. This method allows assessing the impact of changing economic variables such as interest rates and inflation. The LCC can be calculated as follows:

$$LCC = Cpv + O\&Mpv + Fpv + Rpv + Epv - Spv$$

where:

- Cpv is the present value of the capital investment, which includes cost of equipment, including systems design and installation costs. This is a one-time payment at the start of a project;
- O&Mpv is the present value of the total sum of annual operation and maintenance costs taken as a present worth for operator's salaries, equipment inspections, insurance, tax, prepaid maintenance. These costs here are not reflecting the cost of fuel consumption or replacing major equipment items. Estimations of personnel costs over the project lifetime, particularly in labor- intensive projects of long duration can be an important component of any LCC analysis. It is necessary to carefully consider any increase in these costs on the basis of the anticipated general inflation rate;
- Fpv is the present value of the total expenditures for fuel consumed by the system. These costs vary at a rate often quite different from operation and maintenance costs;
- Rpv corresponds to the replacement costs present value to include major repairs and equipment replacements that occur when the normal duty life of any system components is shorter than the life expectancy of the entire system;
- Epv is the environmental cost present value. These costs are not normal reflected in conventional economics that take into account the externalities associated with environmental damage and risks; and

- Spv is the present value of the recovery or salvage value of the equipment at the end of the system's service life. The salvage value of a plant and/or components is based on the possibilities of alternative uses at the end of the project lifetime.

When applying LCCA methodology, it is easiest to evaluate all costs from different years correlated to one year (e.g., net present value). Costs that arise in the future must be discounted due to the time value of money. Typically, all future costs are transformed to their present value. To calculate present worth, the following equation is used:

$$PV=FV/(1+i)^n$$

where:

- PV is the present value ;
- FV is the future value;
- i is the interest rate; and
- n is the number of years

Inflation and Discount Rates

Value increases or decreases with time, depending on interest rates for borrowing or saving and inflation. Diesel fuel costs have increased much faster than the rate of inflation by ~250% since 2000, so diesel fuels costs in the future should continue to increase faster than inflation. The same mechanism of determining future value of a given amount of money can be used to move value backward in time. If each cost and benefit over the lifetime of the system were brought back to the present and then summed, the present worth can be determined.

The discount rate determines how the money increases or decreases with time. Therefore, the proper discount rate for any life cycle cost calculation must be realistic. Sometimes the cost of capital (interest paid to the bank or, alternately, lost opportunity cost) is appropriate. Possibly the rate of return on a given investment perceived as desirable by an individual may be used as the discount rate. Adoption of unrealistically high discount rates can lead to exaggerated life cycle costs. The real discount rate is calculated as the difference between the discount rate and the inflation rate

ANNEX D. DETAILED COST ESTIMATES AND SCHEDULE

Preliminary Cost Estimate for Eagle Power Expansion (1.2 MW PV and 15 km 22 kV Distributtion System

Item	Description	Specification	Unit	Qty	Unit Rate $	Cost $
a	b	c	d	e	f	g
I	**T&D MATERIALS, HARDWARE AND ACCESSORIES**					
A	***Pole and Hardware***					
1	11 m Wooden pole	Minimum top dia 18 cm, CCA treated	Pc	273	$ 420.00	$ 114,660
2	13 m Wooden pole	Minimum top dia 20 cm, CCA treated	Pc	5	$ 446.25	$ 2,231
3	Metal cross arm (angle)	2.4 m Galvanized steel	Pc	294	$ 84.00	$ 24,696
4	Pair of Flat Metal cross arm brace	5 cm x 90 cm Galvanized steel	Pc	294	$ 13.13	$ 3,859
5	Galvanized m/c bolts	M16 x 50 mm Galvanized steel	Pc	588	$ 1.31	$ 772
6	Galvanized m/c bolts	M16 x 260 mm Galvanized steel	Pc	851	$ 1.84	$ 1,564
7	Galvanized m/c bolts	M16 x 300 mm Galvanized steel	Pc	32	$ 2.10	$ 67
8	Galvanized m/c bolts	M16 x 350 mm Galvanized steel	Pc	32	$ 2.36	$ 76
9	Galvanized nuts	M16 Galvanized steel	Pc	2,478	$ 1.58	$ 3,903
10	Galvanized square washers	Flat for M16 galvanized steel bolts	Pc	2,478	$ 1.05	$ 2,602
11	Galvanized round washers	Flat for M16 galvanized steel bolts	Pc	2,478	$ .53	$ 1,301
12	Galvanized lock washers	For M16 galvanized steel bolt	Pc	2,478	$ .53	$ 1,301
13	Galvanized eye bolt	M16 x 300 mm galvanized steel	Pc	84	$ 3.15	$ 265
14	Galvanized eye nut	For M16 galvanized eye bolt	Pc	84	$ 2.10	$ 176
15	Pole cap		Pc	278	$ 12.60	$ 3,503
			Sub-total - Poles and Hardware [A]			**$ 160,975**
B	***Pole Support***					
16	GI steel wire	10 mm	m	525	$ 2.10	$ 1,103
17	Stay insulator	Porcelain	Pc	53	$ 2.89	$ 153
18	Preformed guy grip	Galvanized steel, to fit 10 mm guy wire	Pc	210	$ 14.70	$ 3,087
19	Thimble	Galvanized steel	Pc	53	$ 5.25	$ 278
20	6 mm Galvanized steel plate	40 cm x 40 cm x 6 mm	Pc	53	$ 4.20	$ 223
21	Anchor rod	20 mm x 2000 mm	Pc	53	$ 21.00	$ 1,113
22	Yellow warning cover	Plastic	Pc	53	$ 84.00	$ 4,452
23	"Danger - High Voltage" sign		Pc	278	$ 36.75	$ 10,217
24	Anti climbing	Galvanized barbed wire	Roll	278	$ 36.75	$ 10,217
			Sub-total - Pole Support [B]			**$ 30,841**
C	***Insulators and Connectors***					
25	LV Spool insulator	Porcelain 75 mm Height	Pc	278	$ 2.10	$ 584
26	D – Iron bracket	Galvanized c/w hex. bolt & nut for spool	Pc	278	$ 3.15	$ 876
27	24 kV Pin Insulator	Porcelain or polymer	Pc	840	$ 13.65	$ 11,466
28	Crossarm pin	Galvanized steel	Pc	840	$ 2.10	$ 1,764
29	24 kV Disc insulator	Polymer	Pc	63	$ 15.75	$ 992
30	Strain clamp	Galvanized steel, bolt type	Pc	63	$ 9.45	$ 595
31	WS type socket clevis w/axle & pin	Galvanized steel	Pc	63	$ 10.50	$ 662
32	3 Bolt clamp	Parallel groove aluminum type	Pc	63	$ 3.68	$ 232
33	2 Bolt clamp	Parallel groove aluminum type	Pc	11	$ 2.63	$ 29
34	Preform tie wire	To fit 120 sq.mm AAAC conductor	Pc	840	$ 5.25	$ 4,410
35	Preform tie wire	To fit 95 sq.mm AAAC conductor	Pc	278	$ 5.25	$ 1,460
36	Staples	Galvanized steel	Pc	9,450	$ .11	$ 992
37	MV cable termination kit	120 sq.mm, for 3 core cables	set	4	$ 315.00	$ 1,260
38	Cable lugs	120 sq.mm Galvanized steel	Pc	32	$ 2.63	$ 84
39	Cable lugs	50 sq.mm Galvanized steel	Pc	21	$ 1.58	$ 33
40	Cable lugs	16 sq.mm Galvanized steel	Pc	21	$ .53	$ 11
			Sub-total - Insulators and Connectors [C]			**$ 25,449**
D	***Transformer, Lighting Arrestors, Cutouts and Accessories***					
41	3 Phase power transformer	1000 kVA, 50 Hz, 22 kV/0.4 kV	Pc	4	$ 18,000.00	$ 72,000
42	3 Phaset power transfoormer	15000 kVA, 50 Hz, 0.4/22 kV	Pc	1	$ 160,000.00	$ 160,000
43	Surge arrester	24 kV class arrester c/w mounting bracket	Pc	4	$ 105.00	$ 420
44	100 amp Cutout/disconnect	c/w mounting bracket	Pc	4	$ 131.25	$ 525
45	Fuse link	For 24 kV link (1000 kVA Transformer)	Pc	4	$ 3.15	$ 13
46	PVC Pipe and elbows	10 cm dia	Pc	5	$ 16.28	$ 81
47	Pipe clamp	For 10 cm dia PVC pipe	Pc	5	$ 2.63	$ 13
48	Ground rod	16 mm x 2400 mm c/w clamps	Pc	5	$ 19.95	$ 525
49	High voltage tape	1 kV or above	Roll	5	$ 10.50	$ 656
50	Current transformer	2000/5	Pc	4	$ 65.10	$ 260
51	3 Phase meter and box	c/w SS hinges and locking hasp	Pc	2	$ 273.00	$ 546
			Sub-total - Transformer and accessories [D]			**$ 235,040**
E	***Cables and Conductors***					

Preliminary Cost Estimate for Eagle Power Expansion (1.2 MW PV and 15 km 22 kV Distributtion System

Item	Description	Specification	Unit	Qty	Unit Rate $	Cost $
a	b	c	d	e	f	g
52	Conductor	120 sq. mm AAAC	m	47,250	$ 1.79	$ 84,341
53	Conductor	95 sq. mm AAAC	m	15,750	$ 1.26	$ 19,845
54	Under Ground Cable	XLPE 24 kV, 3 phase armor cable	m	53	$ 16.80	$ 890
55	Cable	120 sq.mm ABC armor cable	m	158	$ 8.40	$ 1,327
56	#6 AWG Cu wire	1 x #6 AWG bare conductor	m	32	$ 3.15	$ 101
57	Earthing wire on poles	Galvanized steel	m	3,612	$ 2.10	$ 7,585
58	Riser wire	For cutout and arrester connection	m	11	$ 10.50	$ 116
					Sub-total - Cables and Conductors [E]	**$ 114,205**
					TOTALT&D MATERIALS, HARDWARE AND ACCESSORIES (I)	**$ 566,510**
II	**T&D CIVIL WORKS & CONSTRUCTION**					
A	***Pole and Transformer Installation***					
1	Job superintendent		2 day	96	$ 12.00	$ 2,304
2	Storekeeper		1 day	96	$ 7.00	$ 672
3	Skilled labor		2 day	96	$ 5.00	$ 960
4	Unskilled labor		14 day	96	$ 3.00	$ 4,032
5	Drivers		5 day	96	$ 5.00	$ 2,400
6	Security guards		6 day	96	$ 4.00	$ 2,304
7	4 Runners w/fuel		3 day	96	$ 23.33	$ 6,720
8	Dump truck w/fuel		2 day	60	$ 70.00	$ 8,400
9	Flat bed truck w/fuel		2 day	60	$ 75.00	$ 9,000
10	Excavator (John Deere 510)		day	40	$ 70.00	$ 2,800
11	Concrete mixer (1 CM capacity)		day	60	$ 35.00	$ 2,100
12	Generator (25 Kiva) w/fuel		day	60	$ 30.00	$ 1,800
13	Rent laydown yard		day	72	$ 66.67	$ 4,800
14	Shipping from port to laydown yard		LS	1	$ 5,000.00	$ 5,000
15	Misc materials and equipment		LS	1	$ 10,000.00	$ 10,000
16	Plum concrete	.5 m3 PCC, 1.5 m3 cobbles	Ea	260	$ 200.00	$ 52,000
17	Site prep and site clean up	around each pole	Ea	260	$ 25.00	$ 6,500
18	Install transformers	complete	Ea	1	$ 20,000.00	$ 20,000
					Sub-total - Pole Installation [A]	**$ 141,792**
B	***Cable Installation (some staff and equipment from Pole Installation not included)***					
1	Job superintendent		2 day	96	$ 12.00	$ 2,304
2	Skilled labor		3 day	96	$ 5.00	$ 1,440
3	Unskilled labor		14 day	96	$ 3.00	$ 4,032
4	Drivers		5 day	96	$ 5.00	$ 2,400
7	4 Runners w/fuel		3 day	96	$ 23.33	$ 6,720
5	Flat bed truck w/fuel		2 day	60	$ 75.00	$ 9,000
6	Misc materials and equipment		LS	1	$ 10,000.00	$ 10,000
					Sub-total - Cable Installation [B]	**$ 35,896**
					TOTAL T&D CIVIL WORKS AND CONSTRUCTION (II)	**$ 177,688**
III	**SOLAR PV POWER SYSTEM**					
1	Equipment					
2	PV Modules	1 MW Solar PV Power System	W	1,200,000	0.88	$ 1,056,000
3	Site civil work		W	1,200,000	0.44	$ 528,000
4	Battery Bank	2 day autonomy	W	1,200,000	2.69	$ 3,233,383
5	Mounting Structure		W	1,200,000	0.49	$ 588,000
6	Switchgear & Interconnect		W	1,200,000	0.47	$ 564,000
7	Inverters		W	1,200,000	0.3	$ 360,000
8	Land		W	1,200,000	0.15	$ 180,000
9	Monitoring/SCADA				$ 300,000	$ 300,000
10	Design subcontract				$ 150,000	$ 150,000
					TOTAL SOLAR PV POWER SYSTEM (III)	**$ 6,959,383**
IV	**OTHER COSTS**					
1	Permits, taxes and fees		LS	1	$ 5,000.00	$ 5,000
2	Route surveys		LS	1	$ 10,000.00	$ 10,000
3	Material testing allowance		LS	1	$ 7,500.00	$ 7,500
4	IT equipment allowance		LS	1	$ 7,500.00	$ 7,500
					TOTAL OTHER COSTS (IV)	**$ 30,000**
					TOTAL (I + II+III + IV)	**$ 7,733,581**
VI	**CONTRACTOR'S OH AND FEES**		35.0%			$ 2,706,753
					GRAND TOTAL (I + II + III + IV + OH and Fee)	**$ 10,440,335**

Preliminary Cost Estimate for Eagle Power Expansion (1.76 MW PV and 15 km 22 KV Distributtion Syste

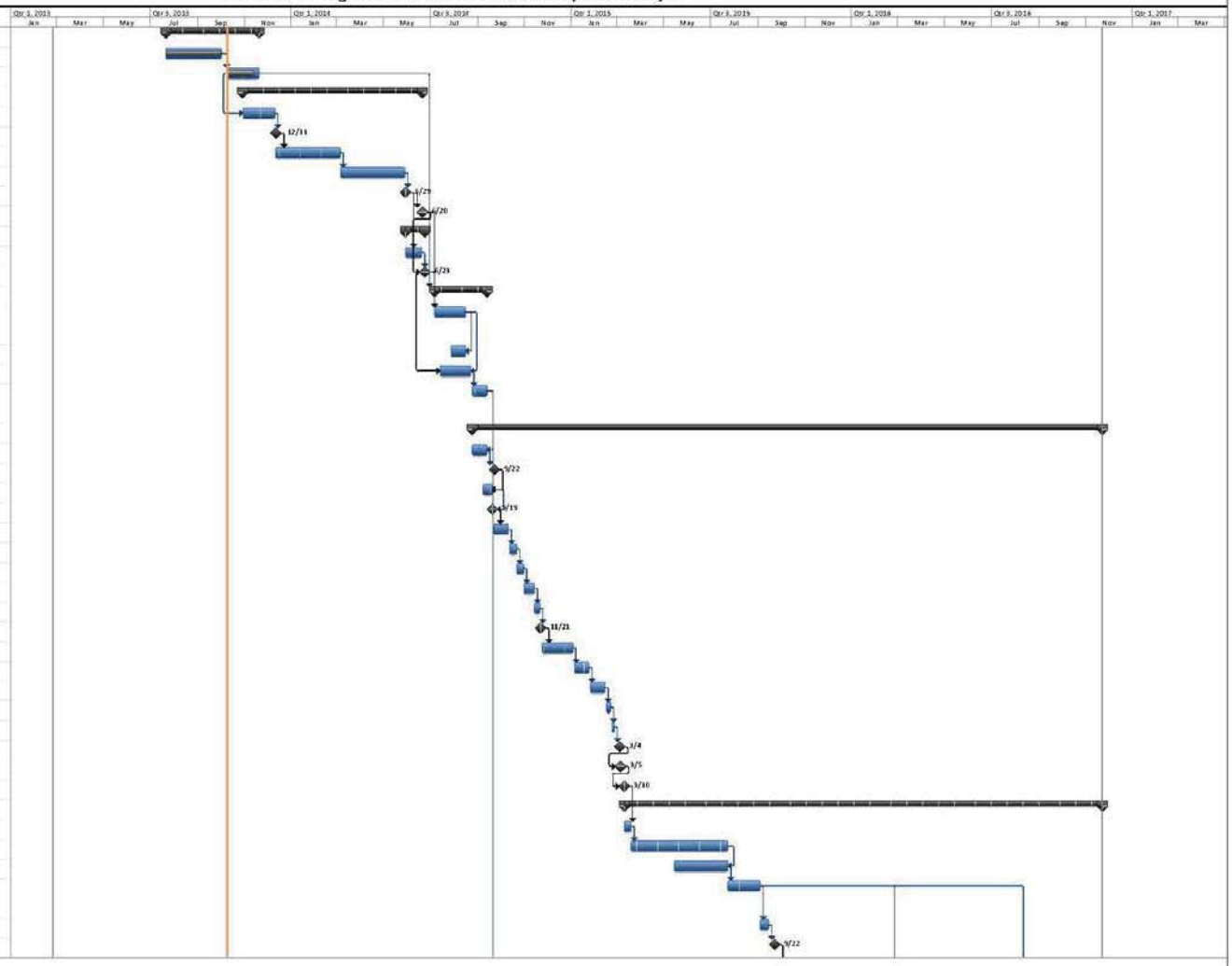
Item	Description	Specification	Unit	Qty	Unit Rate $	Cost $
a	*b*	*c*	*d*	*e*	*f*	*g*
I	**T&D MATERIALS, HARDWARE AND ACCESSORIES**					
A	***Pole and Hardware***					
1	11 m Wooden pole	Minimum top dia 18 cm, CCA treated	Pc	273	$ 420.00	$ 114,660
2	13 m Wooden pole	Minimum top dia 20 cm, CCA treated	Pc	5	$ 446.25	$ 2,231
3	Metal cross arm (angle)	2.4 m Galvanized steel	Pc	294	$ 84.00	$ 24,696
4	Pair of Flat Metal cross arm brace	5 cm x 90 cm Galvanized steel	Pc	294	$ 13.13	$ 3,859
5	Galvanized m/c bolts	M16 x 50 mm Galvanized steel	Pc	588	$ 1.31	$ 772
6	Galvanized m/c bolts	M16 x 260 mm Galvanized steel	Pc	851	$ 1.84	$ 1,564
7	Galvanized m/c bolts	M16 x 300 mm Galvanized steel	Pc	32	$ 2.10	$ 67
8	Galvanized m/c bolts	M16 x 350 mm Galvanized steel	Pc	32	$ 2.36	$ 76
9	Galvanized nuts	M16 Galvanized steel	Pc	2,478	$ 1.58	$ 3,903
10	Galvanized square washers	Flat for M16 galvanized steel bolts	Pc	2,478	$ 1.05	$ 2,602
11	Galvanized round washers	Flat for M16 galvanized steel bolts	Pc	2,478	$ .53	$ 1,301
12	Galvanized lock washers	For M16 galvanized steel bolt	Pc	2,478	$ .53	$ 1,301
13	Galvanized eye bolt	M16 x 300 mm galvanized steel	Pc	84	$ 3.15	$ 265
14	Galvanized eye nut	For M16 galvanized eye bolt	Pc	84	$ 2.10	$ 176
15	Pole cap		Pc	278	$ 12.60	$ 3,503
			Sub-total - Poles and Hardware [A]			**$ 160,975**
B	***Pole Support***					
16	GI steel wire	10 mm	m	525	$ 2.10	$ 1,103
17	Stay insulator	Porcelain	Pc	53	$ 2.89	$ 153
18	Preformed guy grip	Galvanized steel, to fit 10 mm guy wire	Pc	210	$ 14.70	$ 3,087
19	Thimble	Galvanized steel	Pc	53	$ 5.25	$ 278
20	6 mm Galvanized steel plate	40 cm x 40 cm x 6 mm	Pc	53	$ 4.20	$ 223
21	Anchor rod	20 mm x 2000 mm	Pc	53	$ 21.00	$ 1,113
22	Yellow warning cover	Plastic	Pc	53	$ 84.00	$ 4,452
23	"Danger - High Voltage" sign		Pc	278	$ 36.75	$ 10,217
24	Anti climbing	Galvanized barbed wire	Roll	278	$ 36.75	$ 10,217
			Sub-total - Pole Support [B]			**$ 30,841**
C	***Insulators and Connectors***					
25	LV Spool insulator	Porcelain 75 mm Height	Pc	278	$ 2.10	$ 584
26	D – Iron bracket	Galvanized c/w hex. bolt & nut for spool	Pc	278	$ 3.15	$ 876
27	24 kV Pin Insulator	Porcelain or polymer	Pc	840	$ 13.65	$ 11,466
28	Crossarm pin	Galvanized steel	Pc	840	$ 2.10	$ 1,764
29	24 kV Disc insulator	Polymer	Pc	63	$ 15.75	$ 992
30	Strain clamp	Galvanized steel, bolt type	Pc	63	$ 9.45	$ 595
31	WS type socket clevis w/axle & pin	Galvanized steel	Pc	63	$ 10.50	$ 662
32	3 Bolt clamp	Parallel groove aluminum type	Pc	63	$ 3.68	$ 232
33	2 Bolt clamp	Parallel groove aluminum type	Pc	11	$ 2.63	$ 29
34	Preform tie wire	To fit 120 sq.mm AAAC conductor	Pc	840	$ 5.25	$ 4,410
35	Preform tie wire	To fit 95 sq.mm AAAC conductor	Pc	278	$ 5.25	$ 1,460
36	Staples	Galvanized steel	Pc	9,450	$ .11	$ 992
37	MV cable termination kit	120 sq.mm, for 3 core cables	set	4	$ 315.00	$ 1,260
38	Cable lugs	120 sq.mm Galvanized steel	Pc	32	$ 2.63	$ 84
39	Cable lugs	50 sq.mm Galvanized steel	Pc	21	$ 1.58	$ 33
40	Cable lugs	16 sq.mm Galvanized steel	Pc	21	$ .53	$ 11
			Sub-total - Insulators and Connectors [C]			**$ 25,449**
D	***Transformer, Lighting Arrestors, Cutouts and Accessories***					
41	3 Phase power transformer	1000 kVA, 50 Hz, 22 kV/0.4 kV	Pc	4	$ 18,000.00	$ 72,000
42	3 Phaset power transfoormer	15000 kVA, 50 Hz, 0.4/22 kV	Pc	1	$ 160,000.00	$ 160,000
43	Surge arrester	24 kV class arrester c/w mounting bracket	Pc	4	$ 105.00	$ 420
44	100 amp Cutout/disconnect	c/w mounting bracket	Pc	4	$ 131.25	$ 525
45	Fuse link	For 24 kV link (1000 kVA Transformer)	Pc	4	$ 3.15	$ 13
46	PVC Pipe and elbows	10 cm dia	Pc	5	$ 16.28	$ 81
47	Pipe clamp	For 10 cm dia PVC pipe	Pc	5	$ 2.63	$ 13
48	Ground rod	16 mm x 2400 mm c/w clamps	Pc	5	$ 19.95	$ 525
49	High voltage tape	1 kV or above	Roll	5	$ 10.50	$ 656
50	Current transformer	2000/5	Pc	4	$ 65.10	$ 260
51	3 Phase meter and box	c/w SS hinges and locking hasp	Pc	2	$ 273.00	$ 546
			Sub-total - Transformer and accessories [D]			**$ 235,040**
E	***Cables and Conductors***					
52	Conductor	120 sq. mm AAAC	m	47,250	$ 1.79	$ 84,341

Preliminary Cost Estimate for Eagle Power Expansion (1.76 MW PV and 15 km 22 KV Distributtion Syste

Item	Description	Specification	Unit	Qty	Unit Rate $	Cost $
a	b	c	d	e	f	g
53	Conductor	95 sq. mm AAAC	m	15,750	$ 1.26	$ 19,845
54	Under Ground Cable	XLPE 24 kV, 3 phase armor cable	m	53	$ 16.80	$ 890
55	Cable	120 sq.mm ABC armor cable	m	158	$ 8.40	$ 1,327
56	#6 AWG Cu wire	1 x #6 AWG bare conductor	m	32	$ 3.15	$ 101
57	Earthing wire on poles	Galvanized steel	m	3,612	$ 2.10	$ 7,585
58	Riser wire	For cutout and arrester connection	m	11	$ 10.50	$ 116
					Sub-total - Cables and Conductors [E]	**$ 114,205**
					TOTALT&D MATERIALS, HARDWARE AND ACCESSORIES (I)	**$ 566,510**
II	**T&D CIVIL WORKS & CONSTRUCTION**					
A	***Pole and Transformer Installation***					
1	Job superintendent		2 day	96	$ 12.00	$ 2,304
2	Storekeeper		1 day	96	$ 7.00	$ 672
3	Skilled labor		2 day	96	$ 5.00	$ 960
4	Unskilled labor		14 day	96	$ 3.00	$ 4,032
5	Drivers		5 day	96	$ 5.00	$ 2,400
6	Security guards		6 day	96	$ 4.00	$ 2,304
7	4 Runners w/fuel		3 day	96	$ 23.33	$ 6,720
8	Dump truck w/fuel		2 day	60	$ 70.00	$ 8,400
9	Flat bed truck w/fuel		2 day	60	$ 75.00	$ 9,000
10	Excavator (John Deere 510)		day	40	$ 70.00	$ 2,800
11	Concrete mixer (1 CM capacity)		day	60	$ 35.00	$ 2,100
12	Generator (25 Kiva) w/fuel		day	60	$ 30.00	$ 1,800
13	Rent laydown yard		day	72	$ 66.67	$ 4,800
14	Shipping from port to laydown yard		LS	1	$ 5,000.00	$ 5,000
15	Misc materials and equipment		LS	1	$ 10,000.00	$ 10,000
16	Plum concrete	.5 m3 PCC, 1.5 m3 cobbles	Ea	260	$ 200.00	$ 52,000
17	Site prep and site clean up	around each pole	Ea	260	$ 25.00	$ 6,500
18	Install transformers	complete	Ea	1	$ 20,000.00	$ 20,000
					Sub-total - Pole Installation [A]	**$ 141,792**
B	***Cable Installation (some staff and equipment from Pole Installation not included)***					
1	Job superintendent		2 day	96	$ 12.00	$ 2,304
2	Skilled labor		3 day	96	$ 5.00	$ 1,440
3	Unskilled labor		14 day	96	$ 3.00	$ 4,032
4	Drivers		5 day	96	$ 5.00	$ 2,400
7	4 Runners w/fuel		3 day	96	$ 23.33	$ 6,720
5	Flat bed truck w/fuel		2 day	60	$ 75.00	$ 9,000
6	Misc materials and equipment		LS	1	$ 10,000.00	$ 10,000
					Sub-total - Cable Installation [B]	**$ 35,896**
					TOTAL T&D CIVIL WORKS AND CONSTRUCTION (II)	**$ 177,688**
III	**SOLAR PV POWER SYSTEM**					
1	Equipment					
2	PV Modules	1.76 MW Solar PV Power System	W	1,760,000	0.88	$ 1,548,800
3	Site Civil Work		W	1,760,000	0.44	$ 774,400
4	Battery Bank	2 day autonomy	W	1,760,000	2.69	$ 4,742,295
5	Mounting Structure		W	1,760,000	0.49	$ 862,400
6	Switchgear & Interconnect		W	1,760,000	0.47	$ 827,200
7	Inverters		W	1,760,000	0.3	$ 528,000
8	Land		W	1,760,000	0.15	$ 264,000
9	Monitoring/SCADA				$ 300,000	$ 300,000
10	Design subcontract				$ 150,000	$ 150,000
					TOTAL SOLAR PV POWER SYSTEM (III)	**$ 9,997,095**
IV	**OTHER COSTS**					
1	Permits, taxes and fees		LS	1	$ 5,000.00	$ 5,000
2	Route surveys		LS	1	$ 10,000.00	$ 10,000
3	Material testing allowance		LS	1	$ 7,500.00	$ 7,500
4	IT equipment allowance		LS	1	$ 7,500.00	$ 7,500
					TOTAL OTHER COSTS (IV)	**$ 30,000**
					TOTAL (I + II+III + IV)	**$ 10,771,293**
V	**CONTRACTOR'S OH AND FEES**		35.0%			$ 3,769,953
					GRAND TOTAL (I + II + III + IV + OH and Fee)	**$ 14,541,246**

Schedule for Eagle Power Power Generation Expansion Project

ID	Task Mode	Task Name
1		**Concept Studies**
2		Engineering Plan by USAID LESSP
3		Business Plan by USAID IBEX
4		**Finnacing**
5		Proposal Writing by EP and IBEX
6		Proposal Submission
7		Search for financing
8		Perspective Funding due diligence
9		Funding approval
10		Funding Available
11		**Land acquisition**
12		Negociation
13		Land acquisition
14		**Design**
15		Produce Design Studies,Drawings and Specifications
16		Complete BOQ and Engineer's Estimate
17		Environmental Impact Study and Approval
18		EP and Financing Institution Approval for Construction
19		**PV Power System (PVPS)**
20		Gathering contractor information
21		Contractor information meeting
22		Prepare prequalification documentation
23		Publish prequalification notice
24		Receive prequal requests
25		Review and name prequalified contractor
26		Prequalification protest and resolution
27		Prepare RFPs, IFBs, Pre-bid Mtg format
28		Prepare form of contract
29		RFP Released
30		Receive bids
31		Bid evaluation
32		Bid Review/Approval by EP
33		Bid Negotiation
34		Write Memorandum of Negotiation
35		Seek Funding Institution Approval
36		Financing Institution Approval
37		Make Contract Award / Sign Contract
38		**PVPS Construction**
39		Equipment execute
40		Solar panel production/shipping
41		Other PV components shipping
42		Arrives in Monrovia/customs/clearence
43		Acceptance of equipment/Ship to site
44		Preconstruction Conference



Project: EP Schedule
Date: Thu 10/30/13

Task | Split | Milestone | Summary | Project Summary | External Tasks | External Milestone | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | Deadline | Progress

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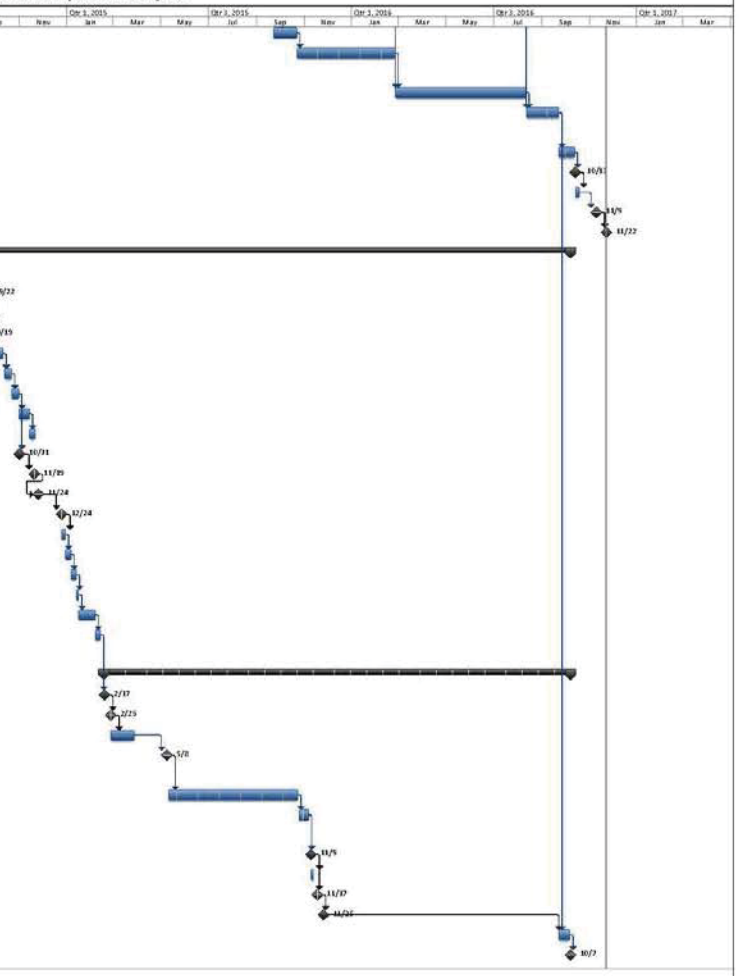
Schedule for Eagle Power Power Generation Expansion Project

ID	Task Mode	Task Name
45		Mobilization
46		Civil Construction Activities and building for control room
47		Installation of PV and Other Equip
48		Install Inverters, Scada, Transformers and back up generator
49		Commissioning of Plant
50		Substantial Completion
51		Punch List Inspection
52		Final Inspection
53		Handover to Eagle Power
54		**T&D**
55		Gathering local contractor information
56		Contractor information meeting
57		Prepare prequalification documentation
58		Publish prequalification notice
59		Receive prequal requests
60		Review and name prequalified contractor
61		Prequalification protest and resolution
62		Prepare RFPs, IFBs, Pre-bid Mtg format
63		Prepare form of contract
64		Release RFPs
65		Pre-bid meeting
66		Answer RFP questions
67		Receive bids
68		Preliminary bid evaluation
69		Bid negotiation
70		Evaluate bids
71		Write Memorandum of Negociation
72		Seek Funding Institution approval
73		Seek Financing Institution Review and Approval
74		**T&D construction**
75		Make contract award/execute contract
76		Preconstruction conference
77		Mobilization
78		Delivery of Electro Mechanical and T&D Equipment
79		Construction Activities
80		Testing and Commissioning of the Power Line
81		Substantial Completion
82		Punch List Inspection
83		Final Inspection
84		Handover to EP
85		Hook up, testing, commisioning
86		On-grid system operation



Project: EP Schedule
Date: Thu 10/10/13

Task | Split | Milestone | Summary | Project Summary | External Tasks | External Milestone | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | Deadline | Progress

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