

Republic of Liberia
Rural and Renewable Energy Agency

Catalyzing New Renewable Energy in Rural Liberia Program

Phase II Final Report



March 2014

Acronyms and Abbreviation

AFREA	Africa Renewable Energy Access Program
BSF	Business Support Facility
DC	Direct Current
DDLO	Drop-Down-Lift-Operate
Km	Kilometer
kV	kilovolt
kW	kilowatt
LESEP	Liberia Electricity System Enhancement Project
LLL	Lighting Lives in Liberia
LRPs	Local Retail Partners
LV	Low Voltage
MV	Medium Voltage
PLC	Programmable Logic Controller
PV	Photovoltaic
PVC	Poly vinyl chloride
RREA	Rural and Renewable Energy Agency
SSMF	Sustainable Solar Market facilitation
SSMP	Sustainable Solar Market facilitation
YEDC	Yandohun Electricity Development Cooperative

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Background of the Program

The program *Catalyzing New Renewable Energy in Rural Liberia* launched in July 2009 was aimed at helping to establish Liberia's first-ever Rural and Renewable Energy Agency (RREA) as a functioning agency that is able to mobilize new renewable energy services and investment for rural areas to meet demand in a technically reliable and affordable manner. Phase I of the program was Bank-executed and aimed at creating an enabling environment for the full functionality of the RREA, including recruiting and training of advisors who could eventually become RREA staff; development of initial and later full legislation; preparation of targeted energy access pilot projects; and outfitting of the Agency for full operation including strategic and foundational documents, and its office and logistical capabilities.

The Government of Liberia and the World Bank signed a two million United States Dollars (US\$ 2,000,000.00) grant agreement on March 15, 2011 to support the provision of modern renewable energy services in rural Liberia. The grant represented component C, "Providing Modern Renewable Energy Services to Off-Grid User" of the Liberia Electricity System Enhancement Project (LESEP). The component of the grant, which was implemented by the Rural and Renewable Energy Agency (RREA), supported the provision of modern renewable energy services to off-grid communities in rural Liberia. It represents Phase II of the "Catalyzing New Renewable Energy in Rural Liberia Program", which was recipient executed phase of the program. The project was financed by the Africa Renewable Energy Access (AFREA) Trust Fund Grant (No. 099017) administered by the World Bank.

Program Phase II Objectives

The objectives of the project are to provide modern renewable energy services to off-grid users in Liberia by:

- i. Establishment of a solar off-grid rural electrification program to electrify about 6-8 towns in rural Liberia, through the application of Sustainable Solar Market Packages (SSMPs) approach
- ii. Rehabilitation of one micro-hydro power plant in Lofa County; and
- iii. Provision of technical assistance to strengthen the capacity of the RREA and to undertake policy and strategy work

Description Program Activities

Key program activities as per the grant agreement are: (a) Sustainable Solar market Packages (SSMP), (b) Rehabilitation of Yandohun Micro-hydro Power, and (c) Technical Assistance and Capacity Building of the RREA.

Solar Off-Grid Rural Electrification

The solar off-grid rural electrification was aimed electrifying about 6-8 towns in rural Liberia, through the application of Sustainable Solar Market Packages (SSMP). The approach of the SSMP was to develop and establish a sufficient market size so as to attract private sector contractors, through donor support; and achieve a sustainable development impact, through incentivizing private sales. SSMP packages were designed for a cluster of contiguous towns/villages, for which solar photovoltaic (PV) systems are supplied for community facilities along with a long-term maintenance contract, including performance-based subsidies as part of the contract in order to improve affordability of systems and help to develop the market. However, the SSMP strategy was changed during the project implementation for the following reasons:

- a. None of the three bids received for the SSMP were complete or considered responsive
- b. It was not realistic to re-launch the bidding process due to the grant closure date
- c. Delay in securing Government of Liberia co-financing to cover post-installation maintenance costs for five year as per the program design; and

Due to the above constraints, the project team did restructure the SSMP plan to reflect the reality and the Grant timeline. The restructured SSMP effort, which was referred to as ***Sustainable Solar Market Facilitation (SSMF)***, and now called ***Lighting Lives in Liberia (LLL)*** drew from the paradigm of the initial SSMP approach as well as the World Bank and International Finance Corporation (IFC) Lighting Africa program.

Lighting Lives in Liberia (LLL) Project

The *Lighting Lives in Liberia (LLL)* Project is aimed at facilitating a commercial market for portable solar electric lighting devices while making such products more affordable to the local market. The project specifically targets off-grid population in the low income bracket, who generally rely on kerosene lamps, candles, and battery powered lights by providing on a commercial basis, high quality solar lanterns and lamps, some with mobile phone charging capabilities.

The *LLL* Project is implemented via two sequential phases: pilot and scale-up, in which the pilot phase provides valuable learning experience and helps in planning the scale-up phase of the project. The pilot phase of the project was officially launched by the Rural and Renewable Energy Agency (RREA) during an Off-Grid Solar Lighting Workshop in February 2012 and phased out on Feb 28, 2013. The scale-up phase commenced in early January 2014.

Critical activities of the pilot phase included the competitive recruitment and selection of local retail partners (LRPs) to participate in the phase, invitation of manufacturers/suppliers to supply solar lighting products, and bulk procurement of solar lighting products in two batches. The participants of the pilot phase were eight international manufacturers whose off-grid solar products have met the Lighting Africa Minimum Quality Assurance Standards, six LRPs and the RREA.

During the recruitment and selection process of LRPs, seven local institutions (which included non-governmental organizations and micro-finance institutions) were initially shortlisted. Following the short-listing of these local retail institutions, a technical and financial management capacity assessment was conducted, and the six LRPs did satisfy the minimum participation criteria of the phase and were selected from the pool of these seven retail institutions. It was decided to keep the entry bar low so that the retail partners could try out different business models as this is a pilot project. The six LRPs signed LLL Participation Agreement, an agreement that specifies roles and responsibilities, terms and conditions of participation, reporting, supervision and termination conditions, etc. of LRPs, with RREA in May 2012.

No.	Institution	Address	Email address	Tel/Cell No.
1	Solar Eid Liberia	Hard Rock Compound, Mamba Point Monrovia, Liberia	reid@solareidliberia.com	0886631830
2	Liberty Finance	BMC Building Capitol Bypass, Monrovia, Liberia	kulahruth@yahoo.com	0777021137
3	Sangel Technologies International	BOKAT ICT Solutions Old Matadi Road Monrovia Liberia	info@sangeltech.com	0777514584
4	EDUCARE	Rock View Building Snapper Hill, Broad Street Monrovia, Liberia	educare_liberia@yahoo.com	0886512145
5	Universal	Empowerment House	U_empowerment2006@yahoo.com	0886533506

	Empowerment Missions	ELWA, Paynesville Liberia		
6	Liberia Energy Network	Mechlin Street B/w Ashmun & Front Sts. Monrovia, Liberia	Rpfahey1@yahoo.com	0886412792/0880838453

The project provided a financing facility (hereafter refer to as Business Support Facility – BSF) for the six LRPs to enhance their business and market development capabilities. It was anticipated that the BSF grant will foster the penetration of solar products in the local market. The project covered up to 75 percent of the cost of eligible BSF expenses (not to exceed US\$25,000). Eligible service for the BSF did include: (i) Market development activities; (ii) Business Improvements support; (iii) Market entry assistance. The project prepared the Guidelines for the BSF, the BSF Application and Grant Agreement, which provided details on the BSF. During pilot phase implementation, the project imported a total of 16,564 pieces of solar lighting products in two batches. The first batch constituted 26% (4,284 pieces) while the second batch constituted 74% (12,264 pieces) of the total products. These improved lighting products entered the Liberian market and were sold at affordable prices, thereby meeting critical energy needs and also creating jobs. The RREA did ensure that retail partners penetrated the interior market segment especially in communities that are heavily reliant on traditional energy sources, via its monitoring scheme. The LRPs were required to provide bi-monthly reports to the RREA on sales, consumers’ reactions and other information useful for a future program scale-up.

Currently, 100% of the first batch of products were sold by the six LRPs, while 27% of the second batch of products has been distributed to three of the six LRPs and is being sold at a readily moderate.

Business Support Facility (BSF)

The six LRPs, at the request of the project and consistent with the BSF guideline, during the month of June 2012, submitted individual BSF proposals/applications to the RREA for assistance to improve their business and market development capabilities in the sale of the solar lighting products. The BSF proposal stated the retailer intent for the BSF and the sum of money required for supporting business and market development of the institution. It highlights the total sum of money requested by LRPs and delineated RREA’s contribution and the retailer’s contribution to the matching grant. Following submission of the BSF proposals, they were reviewed by RREA to ensure compliance with the BSF Guidelines. Proposals that required further works were reworked and resubmitted by the concerned retailers. The total BSF, including RREA and retailers contributions proposed by the LRPs, summed up to US\$141,046.02.

BSF Grant Agreement

Following review and acceptance of the LRPs' BSF proposals, the RREA and LRPs, in July 2012 entered into a BSF grant agreement. The BSF Grant agreement was more specific to the project's contribution toward the LRPs' proposed BSF proposal. It specifies among other things the total BSF proposed by the LRPs, RREA's contribution and the terms and conditions of payment. The total contribution of the project towards the BSF grant equaled US\$103,839.87 (approximately 75% of LRPs' proposed BSF), while the LRPs' contributions totaled US\$37,206.15 (that is 25% of the proposed BSF). The project's component of the BSF was stipulated to be paid in three tranches of 25%, 50% and 25% predicated on LRPs performance.

Disbursement of BSF Grant

During the pilot phase execution, the RREA (following the signing of the BSF grant agreement with the LRPs) disbursed the total sum of US\$73,516.82 to the LRPs. This amount constitutes approximately 71% of RREA's total contribution towards the BSF grant. A detail description of this BSF payment action and result is shown in Table 1.

Table 1: RREA's BSF disbursement action and result

Payment terms	Number of LRPs per actual disbursement	
1 st tranche (25%)	6	
2 nd tranche (25%)	5	
3 rd tranche (30%)	1	
Disbursement Summary ** For all BSF payment terms		
Baseline	\$103,839.87	
Actual	\$73,516.82	71%
Remaining/not utilized	\$30,323.06	29%

RREA Disbursement of BSF Grant: Baseline vs Actual

	1st tranche	2nd tranche	3rd tranche
Baseline Disbursement	\$25,959.97	\$51,919.94	\$25,959.97
Actual Disbursement	\$25,959.97	\$42,919.94	\$4,636.91

Notes:

1. Disbursement of the first tranche BSF to a LRP is based on signing the BSF grant agreement between the RREA and the retailer.
2. Disbursement of the second tranche BSF to a LRP is predicated on the LRP submission of documentary evidence that he/she has incurred his/her cost-shared expenses and expended the first tranche BSF grant received from the RREA.
3. Disbursement of the third tranche is paid to a LRP on submission of a report and documentary evidence that the LRP has incurred the expenses claimed for the second tranche BSF grant.

LRPs' Expenditure and Reporting of BSF Grant

The LRPs began receiving their first tranche BSF grant in August 2012 following the submission of their BSF proposal and signing of the BSF grant agreement. Most of the LRPs were considerably delinquent in reporting their expenditure of BSF grant received. However, as earlier depicted in Table 1, only one LRP received the third tranche BSF grant. Some of the retailers submitted early reports of the first tranche expenditures but fell short of expending their full cost share of the BSF grant as required by the BSF guideline. Table 2 presents a summary for the submission record of BSF expenditure reports by the LRPs.

Table 2: Submission record of BSF expenditure by LRPs

LRPs	Reporting terms		
	1 st tranche	2 nd tranche	3 rd tranche
EDUCARE	√	x	
Universal Empowerment Missions	√	√	√
Liberty Finance	√	x	
Liberia Energy Network	√	x	
Sangel Technology International	√	√	
Solar EID	xx		
Note: √ - LRP received BSF grant from RREA, and LRP's BSF expenditure report submitted. xx - LRP received BSF grant from RREA, and LRP's BSF expenditure report submitted but not compliant with the BSF guideline and the BSF grant agreement. x - LRP received BSF grant from RREA, and LRP's BSF expenditure report not submitted.			

Table 3. LRPs' expenditure activities for BSF grants

BSF Expenditure Activities	LRPs					
	EDUCARE	Sangel Int.	Solar Eid	LEN	Liberty Finance	UEM
Advertisement/Promotional/Awareness creation/road shows	√	√	√	√	√	√
Business planning, development and marketing			√	√		√
Development of sales and after-service networks	√		√		√	√
Staff Training	√	√		√	√	√
Market entry, including establishing new outlets and networks demonstrations, road shows		√	√	√	√	
Consumer/market survey					√	
Supply chain management		√				
Capital assets for product delivery			√			
Business Management – establishment management systems/controls/reporting						√

Table 4. Summary of BSF contributions and disbursements

Summary of BSF Contributions and Disbursements														
No.	Expenditure	Retailers												Total
		Educare Liberia		Liberty Finance		UEM		Sangel Tech.		LEN		Solar Eid		
		Approved Budget	Disb.	Approved Budget	Disb.	Approved Budget	Disb.	Approved Budget	Disb.	Approved Budget	Disb.	Approved Budget	Disb.	
1	Retailer's Total Proposal	\$24,941.00		\$ 16,108.10		\$24,997.20		\$25,000.00		\$ 24,999.72		\$ 25,000.00		\$ 141,046.02
2	Retailer's Contribution	\$ 6,250.00	25.06%	\$ 4,601.60	28.57%	\$ 6,449.55	25.80%	\$ 6,600.00	26.40%	\$ 6,305.00	25.22%	\$ 7,000.00	28.00%	\$ 37,206.15
3	RREA's Contribution	\$18,691.00	74.94%	\$ 11,506.50	71.43%	\$18,547.65	74.20%	\$18,400.00	73.60%	\$ 18,694.72	74.78%	\$ 18,000.00	72.00%	\$ 103,839.87
4	RREA 1st Tranche	\$ 4,672.75	\$ 4,672.75	\$ 2,876.63	\$ 2,876.63	\$ 4,636.91	\$ 4,636.91	\$ 4,600.00	\$ 4,600.00	\$ 4,673.68	\$ 4,673.68	\$ 4,500.00	\$ 4,500.00	\$ 25,959.97
5	RREA 2nd Tranche	\$ 9,345.50	\$ 9,345.50	\$ 5,753.25	\$ 5,753.25	\$ 9,273.83	\$ 9,273.83	\$ 9,200.00	\$ 9,200.00	\$ 9,347.36	\$ 9,347.36	\$ 9,000.00		\$ 51,919.94
6	RREA 3rd Tranche	\$ 4,672.75		\$ 2,876.63		\$ 4,636.91	\$ 4,636.91	\$ 4,600.00		\$ 4,673.68		\$ 4,500.00		\$ 25,959.97
Total RREA's Disbursement			\$ 14,018.25		\$ 8,629.88		\$ 18,547.65		\$ 13,800.00		\$ 14,021.04		\$ 4,500.00	\$ 73,516.82

Sales of Solar Lighting Products

The RREA imported a total of 16,564 pieces of solar lighting products in two phases, based on the purchase orders of the LRPs. For the first phase, a total of 4,284 pieces of solar lanterns were imported while 12,264 pieces of solar lighting products were imported under the second phase. The solar lighting products under the first phase were distributed to the six LRPs while only three of the six LRPs are participating in the sales of products under the second phase. The sale of the solar products under the first phase is 100% completed while 27% of the products of the second phase has been distributed to LRPs and presently has a sales rate of 15%, i.e., 15% of the products of the second phase has been sold. Figure 1 shows a clear depiction of the solar lighting products sales record per order in the pilot phase. Also, Tables 5 and 6 provides a summary of the product received by RREA for the two orders.

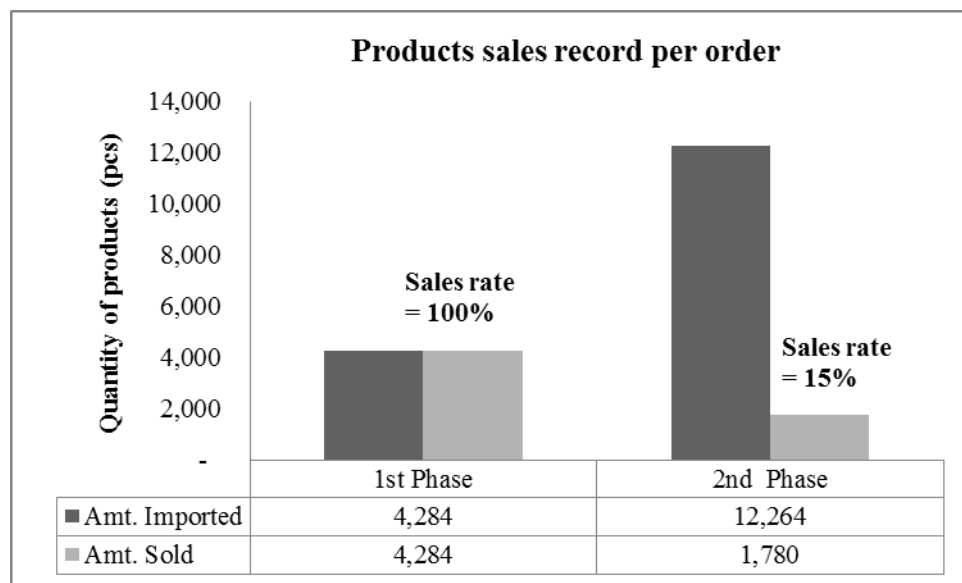


Figure 1. Products sales record per order

Table 5. Summary of solar lighting products ordered by the project – 1st consignment

Summary of Retailers' Orders and Cost - 1st Consignment																	
Suppliers	Product Type	Product Price	Retailers												Total Quantity	Total Cost (US\$)	Additioinal Quantity Supplied
			Liberty Finance		Educare		UEM		Sangel Tech.		LEN		Solar Eid				
			Qty.	Cost	Qty.	Cost	Qty.	Cost	Qty.	Cost	Qty.	Cost	Qty.	Cost			
D.Light	D.LightS250	19.75	650	12,837.50	100	1,975.00	200	3,950.00			150	2,962.50			1,100	21,725.00	4
	D.LightS10	6.80	150	1,020.00	119	809.20	200	1,360.00			100	680.00			569	3,869.20	7
	D.LightS1	4.95	200	990.00			500	2,475.00	100	495.00	100	495.00			900	4,455.00	
Barefoot	Firefly Mobile Lamp	19.00			100	1,900.00	195	3,705.00	100	1,900.00			320	6,080.00	715	13,585.00	5
	PowaPack Junior Matrix	49.90									100	4,990.00			100	4,990.00	
	PowaPack 5W	89.10			100	8,910.00							100	8,910.00	200	17,820.00	
Deutres 818	Red Lamp	35.00					100	3,500.00	100	3,500.00					200	7,000.00	
Green Light	Sun King TM Pro	24.00							100	2,400.00	100	2,400.00			200	4,800.00	
Planet	Sun King TM	12.25							100	1,225.00					100	1,225.00	
Tough Stuff	TSI - 500	17.20							100	1,720.00					100	1,720.00	
Trony	TSL 01 Sundial	28.00							100	2,800.00					100	2,800.00	
Total			1,000	14,847.50	419	13,594.20	1,195	14,990.00	700	14,040.00	550	11,527.50	420	14,990.00	4,284	83,989.20	16

Table 6. Summary of solar lighting products ordered by RREA – 2nd consignment

Summary of Retailers' Orders and Cost - 2nd Consignment												
Suppliers	Product Type	Product Price	Retailers								Total Quantity	Total Cost (US\$)
			Liberty Finance		Educare Liberia		UEM		LEN			
			Qty.	Cost	Qty.	Cost	Qty.	Cost	Qty.	Cost		
D.Light	D.LightS300	19.75	2,175	42,956.25	1,800	35,550.00	936	18,486.00	1,749	34,542.75	6,660	131,535.00
	D.LightS20	6.80	300	2,040.00			1,000	6,800.00	300	2,040.00	1,600	10,880.00
	D.LightS2	4.95			500	2,475.00	450	2,227.50	1,700	8,415.00	2,650	13,117.50
Barefoot	Firefly Mobile Lamp	19.00			400	7,600.00	925	17,575.00			1,325	25,175.00
Total			2,475	44,996.25	2,700	45,625.00	3,311	45,088.50	3,749	44,997.75	12,235	180,707.50

Retailers' Request for Solar Lighting Products from Warehouse

As per the participating agreement signed between RREA and the LRPs, the solar lighting products (under the first phase) were issued to the six LRPs in two batches. Between August 8, 2012 and September 7, 2012, all six LRPs requested and received their first batch of solar lighting products totaling 2,153 pieces, which constituted fifty percent of their orders. In most instances, the products are requested and received on the same day. A LRP was allowed access to his/her second batch of products based on the sales progress of the first batch of solar products received from the RREA, and a minimum payment of 40% of the cost of the second batch of products requested from RREA. The first of the second batch of solar lighting products was received on October 1, 2012.

As at December 19, 2012, four of the six retailers requested and received their second batch of solar lighting products totaling 1,731 pieces. On January 17, 2013, one retailer requested and received his second batch of solar lighting products. One retailer (Sangel Technologies International (Liberia) Limited) did not pick up its second batch of solar lighting products. Till June 2013, a total of 3,884 pieces of solar lighting products (constituting 90.7% of the 4,284 pieces of solar lighting products ordered on behalf of the retailers) were released to the retailers. By August 2013, all of the remaining solar products under the first consignment were distributed to the LRPs.

Under the second phase of the pilot, four of the six LRPs were selected (based on sales and reporting performance) to further participate in the market and sales of solar lighting products. As at the completion date of the pilot phase, three of the four LRPs requested and received their first batch of products (3006 pieces of solar lights), one LRP received 27% of its first batch of products (507 pieces of solar lanterns), and one LRP has not yet committed to product distribution and payment terms due to managerial problems.

Sales of Solar Lighting Products

The LRPs, as per the participating agreement signed between them and RREA, are required to submit to RREA, monthly reports on their sales of the solar lighting products. Though the six LRPs submitted reports over the period August – December 2012, all of them fell short of the monthly submission. By December 31, 2012, only five of the six LRPs had reported on their sales of the solar lighting products. As at this reporting, Sangel Technologies International (Liberia) Limited did not submit any report on the sales of the solar lighting products.

As at December 31, 2012, the five LRPs reported the sale of the total of 2,845 pieces, which represents 73.25% of the 3,884 pieces of solar lighting products received from RREA. Information obtained from the sales reports revealed that the D.Light S250 solar lamp was the most preferred among the products during this period. Other products that were preferred by the consumers included D.Light S10, Barefoot Firefly Mobile Lamp, Barefoot Powapack 5W, Barefoot Powapack Junior Matrix, and D.Light S1. Other products could not be rated because they were exclusively ordered by Sangel Technologies International (Liberia) Limited and no reports were made on them as at this time. By December 31, 2013, all the products of the first consignment were sold by the LRPs and their respective reports were submitted to the RREA.

Prior to the importation of solar products under the second phase of the pilot, the performance analysis/ market demand of products showed that D-lights and Barefoot lights were the most preferred product types in the market. Other product types had slow penetration in the local market and low sales rate. Hence, RREA only imported solar lights from D-light and Barefoot as per the LRPs request during the second phase. Tables 7 - 9 below summarize the areas of sales and LRPs' prices of the solar lighting products during this period.

Geographical Areas Covered by the Retailers

Table 7. Geographical areas covered by the LRPs

County	LRPs				
	EDUCARE Liberia	LEN	Liberty Finance	Solar Eid	UEM
Montserrado	√	√	√	√	√
Bong		√	√		
Lofa	√			√	
Nimba	√		√		√
Gbarpolu	√				
Cape Mount	√				
Grand Kru	√		√		
Grand Bassa					√
Grand Gedeh	√		√		
Margibi		√	√		
Sinoe			√		
Maryland	√		√		

Rehabilitation of the Yandohun Micro-hydro Power Project

Rehabilitation of the Yandohun Micro-hydro Project commenced in late May 2011 and was completed on March 31, 2013, and became operational On April 30, 2013. The project was officially inaugurated by President Ellen Johnson Sirleaf on February 19, 2014.

The Rural and Renewable Energy Agency monitored and supervised the rehabilitation of the hydropower scheme. Construction works covered the rehabilitation of the weir, intake, headrace channel, forebay tank, penstock, powerhouse and transmission and distribution networks. The micro hydro power scheme is owned, operated, managed and maintained by the Yandohun Electricity Development Cooperative, Incorporated, on behalf of Yandohun Community. The community provided in kind contributions (sweat equity) that translated to approximately 10% of the total project cost for the construction of the Micro Hydro Power Plant



President Sirleaf Dedicates the Micor-Hydropower Project

The then 30 kW hydropower plant which was totally destroyed as a result of the civil crisis, has been upgraded to 60 kW. A total of approximately 220 homes and business centers in the villages of Yandohun, Dangalahun I and Dangalahun II are expected to benefit from the off-grid modern renewable energy facility. To date, approximately 75% of these structures have been connected to the system.

Rehabilitation of the Micro-Hydropower Plant was undertaken by ENCO (PVT) LTD. of Sri Lanka. This followed an international competitive recruitment process in which ENCO (PVT) LTD. emerged as the preferred contractor. The contract agreement for the rehabilitation of the hydropower plant was signed on January 5, 2011, and was amended as shown in the below table as was deemed necessary.

No	Description of Amendment	Date of Amendment
1	Waiver of advance payment guarantee and modification of letter of credit	July 29, 2011
2	Modification of terms of payment	February 29, 2012
3	Extension of the validity of contract and increase in contract amount	July 20, 2012
4	Extension of contract validity period	October 1, 2012

As part of the Yandohun Micor-Hydropower scheme, a four-room guest house with a training center, office space and storage facilities have been constructed alongside the micro-hydropower system.

Profile of the Yandohun Micro Hydro Power Project

Project Name	Yandohun Micro Hydro Power
Location	Yandohun Town, Kolahun District, Lofa County (N 8°6'20" W 10°21'28")
Site description	Located about 54km south west of Voinjama City, Lofa County
Project type	Project type Run-of the river
Source	Yando Creek
Gross head	59 m
Design Flow	0.1m ³ /sec
Power output	60 kW (rainy season), 10-30 kW (dry season)
Distance to load centers	Yandohun, Danglahun I & II (4.6 km)
Total number of customers	approximately 220
Ownership	Yandohun Community – Yandohun Electricity Development Cooperative, Incorporated (YEDC)
Environmental & Social Impact	Negligible

Schedules of Activities for the Construction of the Yandohun Micro Hydro Power Plant

Construction of the Yandohun Micro Hydro Power Plant covered four major schedules of activities:

1. Schedule No. 1 - Plant and Mandatory Spare Parts Supplied from Abroad
2. Schedule No. 2 - Plant and Mandatory Spare Parts Supplied from Within the Employers Country
3. Schedule No. 3 - Design Services
4. Schedule No. 4 - Installation and Other Services

Schedule No. 1 – “Plant and Mandatory Spare Parts Supplied from Abroad” consists of the supply of the following:

1. Weir Stop-logs
2. Intake Trash Rack and manual operated sluice gates
3. Forebay Tank manual operated flush gate and trash rack
4. Ultraviolet PVC Penstock

5. Powerhouse building auxiliary equipment, such as an overhead traveling crane, doors, windows, furniture, lighting and sockets system and other necessary accessories
6. Turbine inlet valve
7. Mini hydro unit with Turbo turbine directly couple to a 400 V, 50 Hz, 0.8 pf, 3-phase synchronous generator with AVR and flywheel
8. PLC to control the unit, an ELC and a water cooled 60 kW ballast load
9. LV electrical auxiliary equipment with 400 V bus bar, LV panel with main air circuit breaker and feeders to the powerhouse auxiliary equipment, DC system and all necessary other equipment
10. Protection panel with generator protection relays (earth fault, under/over voltage, under/over frequency, over current, phase failure)
11. MV Power House substation with one 75 kVA, 0.4/11 kV, step up transformer, insulator, DDLO HT fuse, lighting arrestor, earthing and other auxiliary devices
12. Single circuit MV Transmission Line, Weasel conductor overhead on wooden or galvanized steel poles, length 4.6 km
13. Three step down transformer substations pole mounted, each with respectively 75, 25 and 25 kVA transformer, 11/0.4 DDLO HT fuse, lighting arrestor and earthing
14. LV Distribution system on poles, service connections to households and industrial and bulk consumers
15. In house and inside the building electric systems including limiting circuit breakers, sockets, bulb lamp support and high efficiency CFL bulb lamp
16. Spare parts

Schedule No. 2 – “Plant and Mandatory Spare Parts Supplied from Within the Employer’s Country”

All plants and mandatory spare parts were supplied from abroad as bulk consignment. No parts were supplied from within the employer’s country.

Schedule No. 3 – “Design Services” consists of the supply of the following:

1. Hydraulic and Civil Design of the Micro Hydro Power Plant
2. Electromechanical Design of the Micro Hydro Power Plant
3. Design of the MV and LV Networks
4. As Built of the above

Schedule No. 4 – “Installation and Other Services” consists of the following:

1. Widening road to weir and power house
2. Reconstruction of weir and intake to headrace channel
3. Reconstruction of headrace channel
4. Reconstruction of forebay tank and spillway channel
5. Ultra PVC Penstock
6. Reconstruction of single floor power house

7. Turbine inlet valve, generating unit, LV electrical auxiliary equipment, LV panel, DC system, protection panel and all other power house components
8. MV power house substation
9. Single circuit MV transmission line
10. Three step down transformer substations
11. LV distribution system on poles
12. In house and inside the building electrical systems

Construction Works at Yandohun Micro Hydro Power Plant

Rehabilitation of the Yandohun Micro-hydro Project commenced in late May 2011, following the arrival of the construction engineers from Sri Lanka. At the onset of the construction works, the Community of Yandohun contributed sweat equity toward the project by providing 25 laborers, which included 20 men and five women. Figure 1 below shows the women preparing meal for the workers and the men assembled for work.

Figure 1: a. Community women engaged in food preparation. b. Men assembled for work



a. Community women engaged in food preparation



b. Community dwellers assembled for work

Widening of road to hydro power site

Construction works at the project site commenced with the widening of the access road from the community of Yandohun to the hydro power site. This aspect of the work was undertaken by the Community in partial fulfillment of their sweat equity contribution to the project. Figure 2 below shows the road from Yandohun Community to the power plant after it has been cleared by the Community.

Figure 2: Motor road from Yandohun Community to hydropower plant widened



Road from Yandohun Community to hydropower site widened by Community workers

Reconstruction of weir and intake to headrace channel

Civil works at the project site commenced with the reconstruction of the weir, intake and headrace channel. Civil works were performed within prescribed specifications as contained in the project description. Specific activities considered in the civil works include the survey of the sub-soil, foundation design, soil classification and design parameters, grade of reinforce concrete, concrete materials, concrete mix design, placing of concrete, compaction of concrete, steel reinforcement, form works, etc.

The weir and intake to headrace channel were designed to specification. The weir contains three gates – two flush gates and the intake water control gate. The intake at the weir is fitted with a trash rack. The intake to headrace channel contains two gates – a flush gate and the channel water control gate. The gates have different sizes based on their designed specifications.

The height of the weir was initially 0.8 meter. It was however redesigned to 1.8 meters as per the designed specification. The width of the weir was also increased by one meter as per designed specification. The length of the weir remained unchanged. The weir and intake to headrace channel have been completed and designed as per contract specification.

Figure 3 below present graphical images of the weir and intake at different phases - prior to reconstruction, during reconstruction and upon completion.

Figure 3: Reconstruction of the weir and intake to headrace channel



Reconstruction of headrace channel

The headrace channel constitutes part of the civil works. It is that part of the system that conducts water from the intake to the forebay tank. Reconstruction works were maintained in the original path of the old channel. Unlike the new channel, the old channel consisted only of a path dug in the earth without concrete basement and concrete walls. Reconstruction works on the headrace channel were performed in line with the technical specifications of the project description. Between the intake and the forebay tank, the headrace channel traverse a distance of 172 meters at a downward slope of 0.011 meter toward the forebay tank. Except at the extremes, the channel is covered with wooden slabs to prevent debris from falling into it. Figure 4 below presents photographs depicting the reconstruction of the headrace channel

Figure 4: Reconstruction of the Headrace Channel



Reconstruction of the Headrace Channel

Reconstruction of forebay tank and spillway channel

The forebay tank was reconstructed as part of the reconstruction of the Yandohun Micro-hydropower scheme. The old forebay tank was entirely abandoned and new one built just after the old one. The forebay tank is fitted with a trash rack, a spill way and a flush gate. Annexed to the forebay tank is a spill channel that conducts excess water that spills out of the forebay tank back into the river. The figure below exhibits the reconstruction works carried out on the forebay tank. The forebay tank was built as per specification and is fully operational. Figure 5 below shows construction works on the forebay tank and spill way and the completed segments in full operation.

Figure 5: Reconstruction of the Forebay Tank and Spill Way



Reconstruction of the Forebay Tank and Spillway

Reconstruction of the Ultra PVC Penstock

Reconstruction works on the penstock is completed and it is in operation. The old penstock was entirely replaced with a new one. The path of the old penstock was changed slightly to conform to the configuration of the new powerhouse. Diagonally, the penstock traverses a distance of 86.52 meters at a vertical height (gross head) of 59 meter. The internal diameter of the penstock pipes is 0.279 meter. Though completed and in operation, there are seepages along the path of the penstock, especially around some of the joints. The Contractor contributed the seepages to the quality of adhesive material available on the local. The Contractor has accepted to repair the leakages and has already imported the adhesive elements require to remedy the defects. Figure 6 below presents exhibits of the penstock during and after construction.

Figure 6: Reconstruction of the Ultra PVC Penstock



Reconstruction of the Ultra PVC Penstock

Reconstruction of Single Floor Powerhouse

Reconstruction works on the single floor power house is completed. The power house contains the turbine and generator, the control board and ballast Load. As per the project description, the powerhouse is also fitted with an overhead travelling cream with a single hook for erection and maintenance purposes. The powerhouse contains a store room and an office space. Figure 7 below presents exhibits of the powerhouse during and after construction.

Figure 7: Reconstruction of Single Floor Powerhouse



Reconstruction of Single Floor Powerhouse

Turbine inlet valve, generating unit,

Consistent with the contract, the contractor supplied and installed a single nozzle horizontal Turgo Turbine, a gear operated butterfly inlet valve, an 80 kW, 1000 rpm, 400V/50Hz, generating unit, with the equipment necessary to protect and operate the generator, including a PLC electronic governor with load dump control, a switchgear for 75 kW generator in indoor cabinet, control switches and display, metering and a 17 kW water cooled ballast load, LV electrical equipment, LV panel, DC system, a protection panel and all other required powerhouse components. The system is fully installed and is in operation. The generating unit is directly coupled to the turbine through a direct shaft. Figure 8 below presents exhibits of some of the aforementioned elements contained in the powerhouse. The powerhouse is fitted with a separate direct current section that include two 24 V batteries, a battery charger and feeder.

Figure 8: Turbine inlet valve, generating unit, LV electrical auxiliary equipment, LV panel, DC system, protection panel and all other power house components



Turbine inlet valve, generating unit, Turgo Turbine, panel, protection panel, ballast load, etc.,

MV Powerhouse Substation

The medium voltage (11.0 kV) powerhouse substation (step up transformer) constitutes a part of the Yandohun micro-hydropower scheme. The substation consists of a 100 kVA, 0.4/11.0 kV, oil immersed transformer. The substation is equipped with 11.0 kV drop-down-lift-off (DDLO) fuses, lighting arrestors, disconnect switches and earthing devices. The powerhouse substation is fully installed and is functioning satisfactorily. The substation transformer is seated on a concrete basement and placed in an enclosure as a protection against unwanted entries. Figure 9 below presents exhibits of the medium voltage powerhouse substation.

Single Circuit Overhead MV Transmission Line

The single circuit overhead medium-voltage transmission line is fully installed, energized and operational. The MV transmission line spans a distance of 4.6 km and connects the communities of Yandohun, Dangalahun I and Dangalahun II. Constituents of the transmission line include galvanized steel poles, 34 mm² steel reinforced aluminum conductors, porcelain insulators and other transmission line components. Figure 9 below presents exhibits of the single circuit overhead medium-voltage transmission line.

Three step down transformer substations

Three step-down transformer (11.0/0.4 kV) substations have been erected in the communities of Yandohun, Dangalahun I and Dangalahun II, rated at 100 kVA, 25 kVA, and 25 kVA respectively, as part of the transmission and distribution system. Each of the three substations is equipped with 11.0 kV drop-down-lift-off (DDLO) fuses, lighting arrestors, disconnect switches and earthing devices. The three step-down transformers are erected on concrete basement and placed in an enclosure as a protection against unwanted entries. Figure 9 below presents exhibits of the step-down transformer substations.

Figure 9: MV Powerhouse Substation; Single Circuit Overhead MV Transmission Line and step down transformer substations



LV distribution system on poles

A total of 213 households and other facilities including a school, health facility, and industrial and business centers totaling 220 facilities are targeted to be electrified. As at this reporting, a total of 169 facilities have been connected. Though earmarked to be electrified, some of the residential, business and industrial facilities destroyed as a result of the civil conflicts are either undergoing reconstruction or yet to be reconstructed, thus, not all facilities targeted have been electrified. The voltage to residential facilities is 220 volts, single-phase, and 400 volts, three-phase for

industrials points. Figure 10 below presents exhibits of the low voltage distribution system on poles.

Figure 10: Low Voltage distribution system on poles

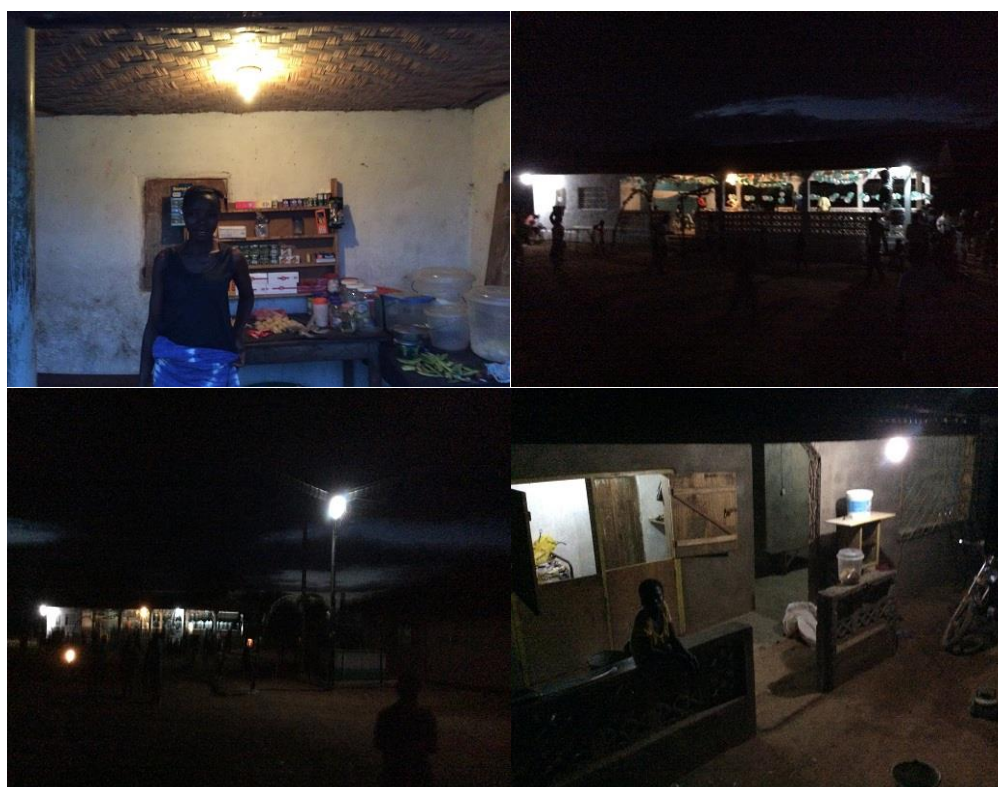


Low Voltage distribution system on poles

In house and inside the building electrical systems

A total of 169 residential facilities within the communities of Yandohun, Dangalahun I and Dangalahun II, accessed and found to be suitable for connection have all been electrified. As contained in the contract agreement each residential facility was supplied with a 5-ampere limiting circuit breaker, one socket, one bulb holder and 1 energy efficient bulb. In addition to the residential facilities, 9 public facilities (town halls, school, clinic, mosques, church, etc.) were also electrified and equipped with circuit breakers, sockets, bulb holders and energy efficient bulbs. Furthermore, 14 street lights or public lighting were erected on poles at suitable points in the communities. Figure 11 below presents exhibits of lighted residential and public facilities and public lighting.

Figure 11: In house and inside the building electrical systems



In house and inside the building electrical systems

Spare parts

As contained in the contract agreement, all required spare parts were acquired by the Contractor and made available to RREA. The spare parts were turned over to the Management Committee of the Yandohun Electricity Development Cooperative, Incorporated. Table 1 below presents the list of spare parts turned over to the Chairman of the Management Committee.

Table 1: List of Spare Parts

TURBINE AND GENERATOR SPARE PARTS OF YANDOHUN MHPP		
No	DESCRIPTION	QTY.
1	Torque Wrench	1
2	Socket Set (Box Spanner)	1 Set
3	18" Pipe Wrench	1
4	Combination Spanner 1-5/16	1
5	Combination Spanner 30mm	1
6	Combination Spanner 15/16	1
7	Combination Spanner 24mm	1
8	Combination Spanner 19mm	1
9	Combination Spanner 17mm	1
10	Combination Spanner 9/16	1
11	Combination Spanner 13mm	1
12	Combination Spanner 10mm	1

13	Tester (Small)	1
14	Tester (Large)	1
15	Screw Driver Set (8 Pieces)	1 Set
16	Combination pliers	1
17	Cutting Pliers	1
18	Nose Pliers	1
19	Centre Punch	1
20	Half Round File	1
21	Flange hanging bolt	2
22	Runner Tool	1
23	Grease Gun	1
24	Allen Key 8mm	1
25	Allen Key 6mm	1
26	Allen Key 5mm	1
27	Allen Key 3/16	1
28	Cutting Knife	1
29	Scissors	1

Management, Operation and Maintenance of the Hydropower Scheme

One of the major challenges to the successful sustainability of a micro-hydropower system in a remote community such as Yandohun is the institution of a post-installation management, operation, and maintenance framework. To ensure the sustainability of the Yandohun MHP system, the leadership of Yandohun, with the guidance of the RREA, established the Yandohun Electricity Development Cooperative, Incorporated, unto which ownership is being transferred. The Cooperative will own, operated, managed and maintained the micro hydro power scheme on behalf of Yandohun Community. Activities carried out included the following:

- a. Setting up of a management team;
- b. Development of Management and Operational Guidelines
- c. Preparation of Handover Agreement
- d. Training of the management team;
- e. Setting up a Board of Directors to guide the management team.
- f. Legal establishment and business registration of the Yandohun Electricity Development Cooperative

Management of the Yandohun micro-hydropower system comprises overall administration (e.g. reporting, record keeping and ledgers, etc.), enforcement of policies and regulations, and personnel (employees) and financial management (tariff collection, accounting).

To enhance its operation, the Management team was provided two motorcycles by the project to facilitate its movement. In addition, four personnel of the Hydropower maintenance crew received an intensive 10-week training in basic electricity, which covered lines maintenance, house wiring, troubleshooting, etc.

Technical Assistance and Capacity Building

Capacity building under the project was focused on intense on-the-job training and learning by doing. The project management team received a number of training in procurement, financial management, communication, and related training by the World Bank Liberia country. Periodic supervision missions by the task team leader (TTL) and other staff from World Bank headquarters also ensured that specific training needs were addressed. Other donors, mainly the United States Agency for International Development (USAID), and the European Union (EU) have plans to conduct training

The RREA is providing refresher training and overall monitoring of the MHP scheme, including tariffs, management committee performance, plant operator performance, and productive end-uses. The project team also conducted a number of Financial and Administrative Management training for the management team. Other maintenance personnel received on-the-job training to transfer practical knowledge and acquire hands-on skills in micro-hydro power plant construction, operation and maintenance.

Construction of the Yandohun Multipurpose Guesthouse

As part of the Yandohun Micro-Hydropower Scheme, the project provided construction materials and supervised the community to construct a multi-purpose Guesthouse in the community of Yandohun. The facility contains four guest-rooms, a hydropower training facility and a storage facility. When completed, the multipurpose guesthouse will provide for accommodation for up to four guests. The training center is expected to be equipped with training equipment. This will allow for the conduct of training and workshops on small hydropower studies. The facility will also provide for the storage of spare parts, equipment and other items associated with the hydropower system. Being a community driven project, the management team is expected to complete the multi-purpose guesthouse by end of June 2014. Figure 12 below shows the status of the guesthouse up till February 28, 2014.

Figure 12: Construction of the Yandohun Multipurpose Guesthouse



Ongoing Construction of the Guesthouse

Socio-Economic Benefits of the Yandohun Micro Hydropower Scheme

Now that the hydropower plant is completed and operational, a student population in excess of 569 pupils is expected to benefit from extra hours of study, especially during night hours, which is expected to enhance their academic performance due to electricity supply. The community of Yandohun is considering administering adult literacy classes during evening hours, targeting persons requiring basic reading and writing skills. A health clinic destroyed during the war is almost completely renovated.

The restoration of electricity will ensure access to healthcare services during night hours, as well as the powering of modern electrical equipment, including vaccine fridge and microscope, and other medical equipment. A diesel-powered rice mill which is also used to process coffee is expected to benefit from the supply of the electricity. Other institutions that are expected to benefit from the supply of modern energy include two town halls, 1 church, 3 mosques, 1 tailoring shop, 1 garage, 1 blacksmith shop, among others. Other potential use of electricity identified in the community include general merchandise, radio cassette player, ice production, video club, television, electric stove, freezer, fan, cell phone charging, water heating, cooking etc.

It is expected that the availability of the electricity will free large amounts of human time and labor, while evening lighting will lengthen the community's work hours, thus allowing more time for productivity. On the overall, it is envisaged that the supply of modern energy will enhance the social and economic life of the community.

Lessons Learned

These pilot projects were designed to serve as a learning-by-doing practical experience and build the RREA's capacity to independently undertake similar future projects. This applies especially in the post-conflict background of Liberia where after 20 years of civil strife everything had to be done from scratch.

- a. Sufficient time must be allowed for stakeholder coordination and program/project buy-in and/or project ambitions need to be better adjusted to what can be achieved within a given timeframe. Design of the SSMP/SSMF project and buy-in of the key stakeholders was slow and required considerable stakeholders' analysis and capacity building. Budgetary support of the Government needs to be increased to expand and more public outreach on the part of the RREA.
- b. The bidding, contract effectiveness, and now mobilization and construction period of the Yandohun micro-hydro power plant were fraught with lessons learned. Among these are simple lessons such as "constructing micro-hydro in a remote village during the rainy season in Liberia is a major challenge as the road condition is very terrible." Another lesson is immigration and customs documentations and procedures for foreign contractors and supplies need to be handled far in advance and sorted out with both the contractors and relevant government authorities to avoid unnecessary bureaucratic delays.