LIBERIA
INVESTMENT PLAN FOR RENEWABLE ENERGY

Rural and Renewable Energy Agency
Ministry of Lands, Mines and Energy
Republic of Liberia

REPUBLIC OF LIBERIA

INVESTMENT PLAN FOR RENEWABLE ENERGY (IPRE)

SCALING UP RENEWABLE ENERGY PROGRAM (SREP)

Abbreviations

AfDB	African Development Bank
AFT	Agenda for Transformation
CLSG	Côte d'Ivoire, Liberia, Sierra Leone and Guinea
Cts	Cents
EIB	European Investment Bank
EU	European Union
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GWh	Gigawatt-hour
HFO	Heavy Fuel Oil
IDA	International Development Association
IPRE	Investment Plan for Renewable Energy
JICA	Japan International Cooperation Agency
KfW	Kreditanstalt für Wiederaufbau
kWh	Kilowatt-hour
LCPDP	Least Cost Power Development Plan
LEC	Liberia Electricity Corporation
M&E	Monitoring and Evaluation
MDB	Multilateral Development Bank
MLME	Ministry of Lands, Mines and Energy
MW	Megawatt
NEP	National Energy Policy
NGO	Nongovernmental Organization

O&M	Operation and Management
PV	Photovoltaic
RAP	Resettlement Action Plan
RREA	Rural and Renewable Energy Agency
SREP	Scaling Up Renewable Energy Program in Low Income Countries
TA	Technical Assistance
USAID	United States Agency for International Development
WAPP	West African Power Pool
WB	World Bank

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Foreword

As the first female president of an African state, I'm particularly concerned about the disproportionate impact energy poverty has on women and girls. In many places without power, women and girls are forced to spend hours each day in the time-consuming task of hunting for fuel and firewood—often a key reason that girls spend less time in school than boys. Women are also disproportionately affected by respiratory illness as a result of indoor air pollution from open fires and kerosene used for cooking, heating, and lighting. Even the simple act of being outdoors becomes fraught with danger for women and girls in some places when the sun goes down and there are no streetlights.

Cowboys Stadium near Dallas, Texas, uses more electricity than the total installed capacity of my country. Small businesses in Liberia spend about 57 percent of their operational costs on power alone. At this rate, it is impossible for them to do much more than break even. And this is representative of the scale of the problem in many countries across the African continent.

African leaders are doing their part, putting in place bold plans to increase energy access for our people and committing to responsibly harness our own energy resources. As president, I signed an executive order establishing Liberia's Rural and Renewable Energy Agency (RREA) and a Rural Energy Fund (REFUND) to bring modern energy services to the country's rural areas. With support from the development partners, we are making progress toward getting the lights turned on in Liberia.

My commitment to this task is guided by the knowledge that reliable energy access is a basic precondition for almost all aspects of modern life—from reliable and efficient lighting, heating, and cooking, to manufacturing, agriculture, transportation, telecommunications, and self-sustaining economic growth.

President Sirleaf Johnson,
President of Liberia and winner of the 2011 Nobel Peace Prize,
Foreign Policy,
August 29, 2013.

EXECUTIVE SUMMARY

The Liberia Investment Plan for Renewable Energy (IPRE) aims to support the government's objective of increasing access to electricity and so accelerate the country's reconstruction and economic revitalization. The IPRE is fully aligned with the government's Agenda for Transformation, which aims to transform Liberia into a more prosperous, inclusive, middle-income society.

The high cost and lack of reliable access to electricity remain key obstacles to the country's stability and sustainable economic growth. As of 2013, Liberia has what is likely the world's lowest rate of access to public electricity—1.6 percent nationwide and 6.7 percent in the capital city, Monrovia. To assess the investment required to close the electricity gap and support economic development, the government is preparing a Least Cost Power Development Plan that aims to identify the scale and type of investments required to achieve 70 percent household coverage in greater Monrovia and to indicate the options to reach 35 percent in the rest of the country by 2030.

Complementing the Least Cost Power Development Plan, the IPRE focuses on off-grid areas where extending the main grid will not be cost-effective in the near future. It provides a road map for scaling up renewable energy interventions to increase access, reduce overreliance on imported fossil fuels and strike a balance between rural and urban areas in electricity provision. The IPRE will provide financial support and technical assistance to implement and test several business models for delivering renewable energy services outside greater Monrovia and will help create an enabling environment to attract the private sector in the medium and long term. International development partners are essential to help implement the plan.

In a country where fuel delivery is a major logistical and costly challenge, exploitation of local renewable energy resources offers a way to bring electricity services sooner and at lower costs to more remote communities.

Therefore, the Liberian government, with support from the international community, commits to adopting an aggressive and responsive access agenda by increasing the share of renewable energy in the provision of electricity.

Inclusive and Consultative Process in Defining Renewable Investment Priorities

Liberia is one of eight pilot countries participating in and benefiting from the Scaling Up Renewable Energy Program in Low Income Countries (SREP). As a requirement of SREP financing, this IPRE was developed by the government under the leadership of the Ministry of Lands, Mines and Energy, with the Rural Renewable Energy Agency (RREA) as the focal point. Throughout IPRE preparation, the government consulted with a wide array of stakeholders including government institutions, representatives of civil society and of the private sector, as well as development partners, via individual meetings and technical and consultation workshops. The IPRE also benefited from the experience and inputs of the African Development Bank (AfDB) and the World Bank Group. In addition, an online consultation was carried out for national stakeholders and an independent reviewer provided valuable comments during the final stages of IPRE preparation.

Drawing on technical demand analysis, gradual extension of the grid and the above consultative process, the government will focus IPRE investments outside greater Monrovia,

where two-thirds of the population live. This will offer greater balance in providing electricity outside the capital and will support poorer households.

The government used SREP and other national screening criteria to identify the renewable energy technologies and potential investments that correspond with national priorities, to ensure that SREP investments have optimal transformational impact. Three categories of technologies were considered: national grid power supply; mini-grid options; and stand-alone systems. The grid-connected and mini-grid technology choices were small hydro, solar and biomass power; the off-grid options were stand-alone solar. The two priority choices that emerged to support national development objectives were mini-grid systems based on small hydro and biomass—backed up by photovoltaic (PV) systems to compensate for seasonal variation—and stand-alone systems.

Renewable Energy Electrification Program

The proposed Renewable Energy Electrification Program (REEP) is based on an assessment of the potential and challenges in developing Liberia's renewable energy resources, which included preliminary economic analyses and consultative processes aimed at establishing priorities. To achieve 35 percent rural electrification by 2030, the REEP will support off-grid electricity solutions—***through mini-grids and stand-alone renewable energy services***—that will supplement the expansion of centralized generation and transmission facilities. The program will benefit 360,000 people (9 percent of the country's population in 2013) living outside Montserrado County—the most populous county and home of the capital.

Program Objective

REEP's objective is to meet the electricity needs of a part of the population outside Montserrado County. The program will use indigenous renewable energy resources and will tap into communities' and local institutions' innate capabilities wherever possible. It will build institutional, human and technical capacities, introducing sustainable business models and financing several projects to demonstrate the viability of their approach. It will target support to communities that will not be served by the grid of the national electricity utility—Liberia Electricity Corporation (LEC)—in the near term. REEP aims to create an approach that can be replicated and supported by different development partners.

Lead Implementing Agency

REEP will be managed by the RREA, an independent agency of the Liberian government responsible for promoting development and supply of modern energy products and services to rural areas. RREA manages all funds related to rural electrification received through domestic and international financial sources. A proposed Rural Electrification Fund (REFUND) will be managed by RREA.

Main Program Components

The program will be composed of the following activities to mainstream off-grid electrification approaches using renewable energy mini-grids and stand-alone systems:

- *Developing rules and regulations.* These include standard legal documentation and procedures for licensees and investors; service and safety standards; a methodology for tariff setting; and customer rights and obligations.

- *Preparing electrification projects.* RREA will contract for and set up a Transaction Advisory Services Facility that will provide support for project preparation and supervision.
- *Mini-grid and Stand-alone Solar PV projects.* Through REFUND facility, financing will be provided to develop mini-grid projects and stand-alone solar systems for households. It is expected that nine mini-grid and nine solar PV projects will be financed to benefit nearly 360,000 people.
- *Promoting productive uses of electricity and other technical assistance.* REEP will support program management; renewable energy assessments; training and capacity-building services; and other regulatory, planning and policy efforts. REEP will also promote productive uses of electricity to raise income generation in the community and to increase use of electricity, while also addressing gender issues.

Delivery Models and Ownership Options

The following potential delivery models will be pursued, in line with individual project needs and possible ownership arrangements:

- *Cooperatives and/or private non-profit entities*—for small, isolated mini-grids that self-generate and supply electricity to the cooperative's members or local populations. Where mini-grid network extension is not viable, stand-alone solar systems would be deployed.
- *Commercial/public enterprises (anchor consumers) operating existing businesses*—they would establish a renewable energy generation project to serve their own requirements and extend services to other consumers in the area. Where mini-grid network extension is not viable, stand-alone solar systems would be deployed.
- *LEC ownership of projects*—for the areas near to, and likely to be served by, LEC's grid.
- *Independent power producers*—for larger projects specifically set up as private companies or joint ownership under public–private partnership arrangements, to sell electricity to mini-grids.

Drawing from local capacity, it is expected that local entrepreneurs will provide operation and maintenance and commercial services for several delivery models.

Project Area

The investments will focus on area-based electricity service delivery to facilitate provision of operation and maintenance, management services needed to deliver electricity sustainably and cost-effectively. Within the service area, renewable mini-grids will be used to serve customers in areas with higher load densities—typically within 20 km of the generation source. Stand-alone solar PV will be used for communities with low load densities and for scattered consumers within the service area where mini-grid extension cannot be economically or technically justified.

Technology Choice

Demand analysis, technical viability and economic cost-effectiveness analysis will determine choice of technology. Site-specific analyses will be conducted during the feasibility stage to determine the most suitable renewable energy supply configuration for each mini-grid. Technology will be chosen according to several criteria, including technological complexity, cost of electricity, certainty of fuel or resource supply and ease of operation in local conditions. Solar PV will be the preferred choice for stand-alone systems.

Legal Framework and Tariff Structure

RREA (with guidance from the Ministry of Lands, Mines and Energy, as well as LEC) will set service and safety standards, technical specifications and tariff policy. Environmental and social safeguards will comply with frameworks agreed to with multilateral development banks. RREA will competitively and transparently tender and award projects to private firms or nongovernmental organizations.

The general principles for the tariff structure will be defined as the IPRE is implemented, in order to make electricity services affordable while ensuring investment sustainability. These principles include: poorer consumers benefiting from structured tariffs, including life-line rates for the poorest; electricity revenues and results-based financing recovering all recurrent costs, including operation and maintenance, management, fuel, contributions to a sinking fund for major repairs, debt service and a reasonable return on equity; and partial-capital investment-grant financing to reduce debt and equity to levels that will permit an affordable tariff (though these grants should gradually decline).

Financing Instruments

REEP is structured in two phases based on the financing available, its sources and the steps needed to set up a sustainable program. Given the risks associated with country conditions and the use of new technologies and untested business models, Phase I will rely mainly on public investment, developing the business framework, strengthening institutions and providing demonstration experience to attract greater private investment and other partners in Phase II. The IPRE is designed to use results-based financing as a means of keeping electricity affordable, while providing time-bound supplementary revenues for debt servicing (for, say, the first five or six years). It also considers public–private partnership financing where government support in the form of partial capital grant cofinancing is expected to attract private firms and nongovernmental organizations. It is expected that Phase II will be financed by private firms and development partners' support based on the experience of Phase I.

Indicative Program Portfolio

A portfolio consisting of nine mini-grid and nine solar PV projects is proposed. Each project will comprise a renewable energy mini-grid and stand-alone solar systems to provide electricity service a given area. For planning purposes, several project configurations were defined, although in practice projects will vary in size and configuration depending on the characteristics of the service areas (which will be selected during project preparation), on demand and on the renewable energy resources at the project locations.

Programmatic Approach

To achieve a geographic balance for electricity provision, the government and multilateral development banks have agreed to the following support: AfDB will focus on the four counties of the southeast region and the area covered by the Côte d'Ivoire cross-border interconnection, and the World Bank will support the rest of the country, more specifically Lofa County and the counties within the Côte d'Ivoire, Liberia, Sierra Leone and Guinea Regional Transmission Line.

Financing Plan

Total funds required are estimated at US$178.5 million, which includes investments, results-based financing and technical assistance (Table 1).

Phase I includes the full amount of SREP resources plus certain or likely financing sources, for a total of US$121.0 million. Besides SREP's US$50 million, AfDB is expected to provide US$13 million and the World Bank US$10 million. Funding from other development partners of about US$6.8 million is required during Phase I, primarily to finance the REFUND debt facility. The developers would be expected to contribute about US$12.8 million in equity while consumes would pay nearly US$6.4 million for connection. Under Phase I,private sector participation will be sought although it is recognize that under current conditions this will be challenging.

Funding from Norway Energy+ for results-based financing for the first six years of operation of the mini-grid facilities and stand-alone solar systems is estimated at US$18 million during Phase I, which will supplement revenues and help debt servicing. Energy+ would contribute another US$1.5 million for technical assistance. Reflows from the Energy+ funding will contribute to REFUND and will be used for financing additional projects in the future, including some Phase II projects.

Phase II assumes a further US$57.5 million. Phase I, which will help overcome barriers to developing mini-grids through testing business models, putting in place the required legal and regulatory framework and building capacities, should have leveraged additional financing from other development partners. SREP funds are leveraged 1:2.6 from other sources.

Table 1 Financing Plan (US$ million)

Components	SREP	AfDB	World Bank	NOR Energy + TA	Other Partners TBD	Private Equity TBD	Govt. of Liberia	Customer connections	Investment & TA Total	Energy+ Results-based Payment	Other Results-based Financing	Grand Total
Phase I	**50.0**	**13**	**10**	**1.5**	**6.8**	**12.8**	**2.5**	**6.4**	**103.0**	**18.0**		**121.0**
Project Preparation Grant	**1.0**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1.0**		**-**	**1.0**
Investment Phase I	**46.5**	**12.5**	**8.5**	**-**	**6.8**	**12.8**	**-**	**6.4**	**93.5**	18.0	-	**111.5**
Investments—Phase I Mini-grids	41.7	12.5	8.5	-	6.8	12.8	-	1.6	83.9	-	-	101.9
Investments—Phase I Stand-alone PV	4.8	-	-	-	-	-	-	4.8	9.6	-	-	9.6
Technical Assistance	**2.5**	**0.5**	**1.5**	**1.5**	**-**	**-**	**2.5**	**-**	**8.5**	**-**	**-**	**8.5**
Transaction Advisory Services	1.0	-	1.0	-	-	-	-	-	2.0	**-**	**-**	2.0
Renewable Resource Assessment	-	-	-	0.5	-	-	-	-	0.5	**-**	**-**	0.5
Regulatory/Policy Support	-	-	0.5	0.5	-	-	-	-	1.0	**-**	**-**	1.0
Training & Capacity Building	0.5	0.5	-	0.5	-	-	-	-	1.5	**-**	**-**	1.5

Knowledge Management—M&E	0.5	-	-	-	-	-	-	-	0.5	-	-	0.5
Program Management	0.5	-	-	-	-	-	2.5	-	3.0	-	-	3.0
Phase II	**-**	**-**	**-**	**-**	**32.5**	**6.1**	**-**	**4.4**	**43.1**	**-**	**14.4**	**57.5**
Investments—Phase II Mini-grids	-	-	-	-	28.9	6.1	-	4.4	35.9	-	14.4	50.3
Investments—Phase II Stand-alone PV	-	-	-	-	3.6	-	-	3.6	7.2	-	-	7.2
Total	**50.0**	**13**	**10**	**1.5**	**39.3**	**18.9**	**2.5**	**10.8**	**146.1**	**18.0**	**14.4**	**178.5**

M&E = monitoring and evaluation; TA = technical assistance; TBD = to be determined.

Source: RREA estimates

Transformative Outcomes and Co-benefits

Renewable energy investments planned under REEP are expected to help reduce poverty and contribute to economic growth. Electricity supplied by renewable energy sources could reach 28 gigawatt-hours a year, or an annual saving of US$12.7 million in diesel fuel.

Significant co-benefits include enhanced energy security and reduced dependence on imported fossil fuels. Further, the investments will help build and sustain management and technical skills within rural communities, promote new economic activities and jobs and so raise incomes, and support decentralization. Other co-benefits stem from improved access to communications, enhanced quality of life in rural areas through better education, health and public security, and improved gender equality and women's socioeconomic status.

PREAMBLE

The Liberia Investment Plan for Renewable Energy (IPRE) aims to support the government's objective of increasing access to electricity to accelerate the country's reconstruction and economic revitalization. The IPRE is fully aligned with the government's Agenda for Transformation (AFT), a long-term vision to transform Liberia into a more prosperous, inclusive, middle-income society.

The AFT is based on five strategic pillars emphasizing the government's key priorities and actions for 2012–17, particularly the following three:

- *Peace, justice, security, and rule of law:* providing electricity services will create an atmosphere of peaceful coexistence based on reconciliation and security.
- *Economic transformation:* leveraging donor support by using public power and transport resources more efficiently will support economic growth and employment.
- *Cross-cutting issues:* advancing equality, particularly gender equality, for all Liberian citizens will ensure equal rights, opportunities and access to electricity.

The high cost and lack of reliable access to electricity remain key obstacles to the country's stability and sustainable economic growth. As of 2013 Liberia may have the world's lowest rate of access to public electricity—1.6 percent nationwide and 6.7 percent in the capital city, Monrovia. To assess the investment required to close the electricity gap and support economic development, the government is preparing a Least Cost Power Development Plan (LCPDP) that aims to identify the scale and type of investments required to achieve 70 percent household coverage in greater Monrovia and 35 percent in the rest of the country by 2030.

Complementing the LCPDP, the IPRE focuses on off-grid areas where extending the main grid will not be cost-effective in the near future. It provides the road map for scaling up renewable energy interventions to increase access, reduce overreliance on imported fossil fuels and strike a balance between rural and urban areas in electricity provision. The IPRE will provide financial support and technical assistance to test and implement business models for delivering renewable energy services outside greater Monrovia and help create an enabling environment to attract the private sector in the medium and long term. International development partners are essential to help execute the plan (Annex 1).

In a country where fuel delivery is a major logistical and costly challenge, exploitation of local renewable energy resources offers a way to bring electricity services sooner and at lower cost to more remote communities.

Therefore, the Liberian government, with support from the international community, commits to adopting an aggressive and responsive access agenda by increasing the share of renewable energy in the national energy mix.

1. COUNTRY CONTEXT

Economic Outlook and Liberia Agenda for Transformation

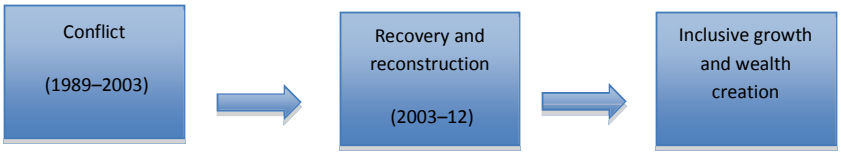
The Republic of Liberia still suffers from the effects of 14 years of civil war (1989–2003). The war destroyed human capital, institutions and infrastructure in most areas, including the energy sector. Since 2006, when President Ellen Johnson Sirleaf took office, there has been substantial progress in restoring the country: broad price stability has been achieved, structural reforms to reinforce public financial management accomplished, poverty reduced at the national level and electricity reestablished in key areas of Monrovia. However, much remains to be done. With a population of 4.1 million and a nominal gross domestic product (GDP) per capita of US$374 in 2011, Liberia ranks as the world's third poorest country.[1]

Since the end of the war, the economy has grown steadily, exceeding prewar levels in 2007; although weakened by the global economic crisis and fuel and food price crises in 2008–09, the economy has recovered. Economic growth has been sustained by expanded construction activities; increased foreign direct investment related to concessions; and favorable export prices for rubber, palm oil and iron ore exports. Agriculture and services were the leading growth sectors up to 2010, but since iron ore mining resumed in 2011, its contribution to GDP has almost tripled (from 4.5 percent in 2011 to 12 percent in 2012). The Liberian economy is expected to grow at an average annual rate of about 7 percent between 2013 and 2015 if the external environment remains favorable and if foreign direct investment in natural resources keeps increasing, particularly forestry, palm oil and iron ore mining.

Despite progress, Liberia's recovery remains fragile and key challenges must be addressed for the country to embark on a sustainable development path. Macroeconomic gains and growth have been significant (Annex 2), but poverty remains pervasive, affecting 84 percent of the population.[2] The economy remains vulnerable to external shocks owing to limited diversification, commodity price volatility and dependence on imported foods and fuel. Inequality and unemployment, particularly among youth, remain high and are exacerbated by the nationwide dearth of infrastructure and social services and the focusing of reconstruction efforts on Monrovia, where only around a third of the population lives.

In response to these challenges, the Liberian government has adopted its Agenda for Transformation (AFT) for 2012–17. The AFT aims to transform the country into a more prosperous, inclusive society and achieve middle-income country status with a per capita income of between $1,000 and $3,000 by 2030. Figure 1.1 outlines Liberia's recent past and potential future.

Figure 1.1. Liberia's Recent Past and Potential Future



[1] World Bank 2011.
[2] Based on the $1.25 a day poverty line rather than the national poverty line.

Source: Authors' illustration.

To achieve this goal, the AFT focuses on an investment of $3.3 billion over five years (2012–17), supporting five strategic pillars: peace, justice, security, and rule of law; economic transformation (focusing on infrastructure, agriculture, food security, forestry, mineral development and private sector development); human development; governance and public institutions; and cross-cutting issues, including gender equality. The AFT prioritizes energy and roads investment to address the infrastructure gap and attract private sector investment for growth and job creation.

AFT Implications for Electricity

Investment in electricity is a major component of the AFT. The AFT aims to "increase access to renewable energy services and affordable power for community and economic transformation."[3] It identifies the constraints in the energy sector as high capital cost of investment; lack of knowledge about alternatives; and poor coordination between government agencies, international donors and investors. The strategic objectives are to supply affordable power from the grid to micro-, small and medium enterprises, and to industries and households in urban areas, while supporting alternative modes of generation in off-grid areas using small-scale thermal, solar and hydro technologies and ensuring that energy services are accessible to both women and men in rural communities.

The AFT also calls for using public–private partnerships, consolidating the government's decision-making process, improving development partner coordination and securing agreement from mining companies to support or invest in power generation. The IPRE will support this objective by aligning with development partners and public and private sectors in a national electrification program and proposes several delivery models to provide electricity with renewable resources.

IPRE as Support of the AFT Pillars "Peace, Justice, Security, and Rule of Law" and "Gender Equality"

The civil war left the country's infrastructure ruined and its human capacity diminished. Instability and conflict remain the primary risks to long-term wealth creation in Liberia. The conflict aggravated youth unemployment, furthering the risk that unemployed, frustrated youth will be mobilized for political gain. Conflict increased poverty, particularly in rural areas, severely affecting the provision of basic social services and damaging the social fabric. Lack of access to infrastructure represents one dimension of poverty. Electricity deficiency for lighting stands at about 95 percent. Almost all households depend on traditional energy sources: charcoal and fuelwood for cooking; diesel or gasoline generators for powering small appliances; and candles, kerosene and battery-powered lamps for light.

Conflict and fragility can also undermine governance and vice versa: state weakness and poor governance are often mutually reinforcing trends, both in government and in state-owned entities such as power utilities or rural electrification agencies. Inclusive approaches must be developed as infrastructure and services are rebuilt.

To ensure regional equity, social stability, economic growth and job creation, the IPRE offers opportunities to improve social inclusion. The IPRE will support measures to ensure gender empowerment by providing women with increased access to affordable energy, which in turn

[3] Republic of Liberia 2012, p. 56.

will improve the well-being of women and their families. This contributes to one of the outcome indicators of the AFT: "There will be fewer households in extreme poverty or with inadequate nutrition. More poor, vulnerable households and groups, especially women, youth and children, will have access to and utilize basic social services and social insurance."[4]

Geography and Demography

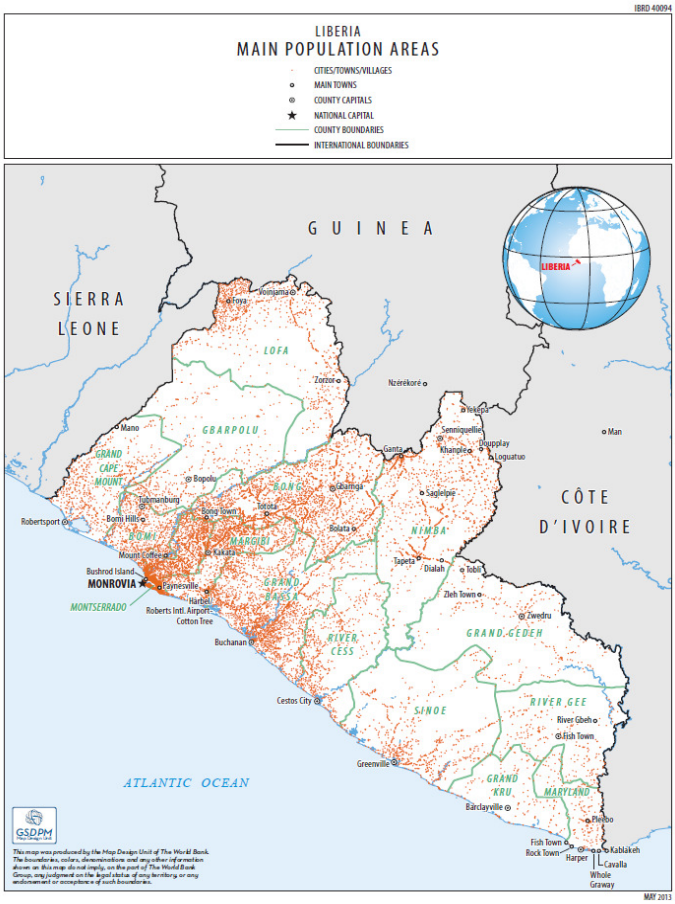
Liberia lies on the west coast of Africa, bordering Sierra Leone to the west, Guinea to the north and Côte d'Ivoire to the east. It has a tropical climate in the north and an equatorial climate in the south, with a wet season from May to October and a dry season from late October to April. Temperatures have little monthly variation, ranging from 27ºC to 32ºC during the day and from 21ºC to 24ºC at night.

The main features of Liberia's topography are tropical rain forest, mountainous plateaus, coastal lagoons and mangrove marsh lands. Almost 49 percent of the territory is forest land (the source of its timber), and the plateaus (27 percent of the land) are dedicated to agriculture. Liberia is rich in mineral resources, including iron ore, gold and diamonds, with most mining sites in the small mountains. It also has important hydropower resources, with an estimated potential of 1,000 megawatts (MW), although high hydrological seasonality reduces its energy potential.

The country occupies a territory of 111,370 km^2, with a population estimated at 4.1 million as of 2011, growing at an annual rate of 2.6 percent. There are 17 different ethnic groups, from indigenous people to descendants of the freed American slaves who founded Liberia in 1822. It is divided into 15 administrative regions, or counties. Montserrado County, home of the capital, Monrovia, is the most populous (Figure 1.2).

[4] Republic of Liberia 2012, p. 92.

Figure 1.2 Population Density by County



Source: National Population and Housing Census 2008.

Although the population growth rate is quite high (higher than in other post-conflict countries in Africa), population density is still low, with some counties presenting densities below 50 persons per square mile. In the last 50 years, annual population growth has been above 3 percent, except during the civil war years, when growth dropped to 2.1 percent due to massive migration and numerous casualties (Table 1.1).

Table 1.1 Population Trends, 1962–2008

	1962	1974	1984	2008
Population	1,016,443	1,503,368	2,101,628	3,489,072

Source: National Population and Housing Census 2008.

Some of the main population centers are found along the 579 km coastline (Monrovia, Harbel–Cotton Tree or Buchannan) and on a band running from Monrovia to the north end of Nimba County (Gbarnga, Ganta), with a further concentration of people in the north of Lofa County (Foya Town) in the northwest, and in Maryland County (Harper City) in the southeast.

Liberia is urbanizing quickly at an estimated 3.4 percent per year over 2010–15.[5] In 1975 around 27.6 percent of the population lived in urban centers. During the war, large internal migration from rural to urban areas resulted in an urban population of 48 percent in 2012.[6] But most urban areas in Liberia are still isolated from the economy and deprived of basic services. In 2013 one-third of the population lives in the capital. High dispersion and low population density pose additional challenges to electricity delivery and investment, requiring a different program for operating and maintaining the new infrastructure to make investments sustainable.

[5] UN data: http://data.un.org.
[6] UN data: http://data.un.org.

2. LIBERIA ENERGY SECTOR

Energy Sector and Consumption

Liberia is highly dependent on fuel imports. Petroleum product imports in 2012 came to 76.6 million US gallons, or 11,132 terajoules (TJ).[7] These products consist mostly of gasoline and diesel fuel and, to a lesser extent, jet fuel and kerosene. Their final use is mainly in transport, electricity generation and domestic lighting.

Around 90 percent of the population's energy needs are still covered by biomass, principally for cooking. In the mid-2000s, annual consumption of wood biomass was estimated at 10.8 million m^3 for firewood and 36,500 tons for charcoal.[8] The Liberia Electricity Corporation (LEC)—the national electricity utility—reported that it generated 178 TJ or 49.54 gigawatt-hours (GWh) in 2012. Significant captive power is also met by self-supply generation: according to the U.S. Energy Information Administration, total electricity generation was 340 GWh in 2010, and net consumption 310 GWh.

At the moment Liberia has no tracking system for national energy consumption or production. During implementation, the IPRE will help develop and establish a monitoring and evaluation (M&E) framework to support policy and investment decisions (Section 8).

Prewar Electricity Sector

Before the civil war (1989–2003), Liberia's total installed capacity was 191 MW (98 percent in and around Monrovia) serving around 35,000 customers—that is, around 7 percent of the population.[9] The system was operated by LEC. The LEC system's low reliability, exacerbated by diminished hydropower generation during the dry season, forced the private sector (industries, mining and commercial services) to secure their own generation, which reached 216 MW. Access to electricity in rural areas was limited to 10 isolated mini-grids based on units fired by heavy fuel oil (HFO), with a total installed capacity of 13 MW.

During the war, the Mount Coffee hydropower plant and other generation facilities, as well as transmission and distribution networks, were destroyed or looted. In the war's immediate aftermath, LEC ceased operations.

Emergency Response and Postwar Phase

The new government's efforts focused on reconstructing the electricity sector and developed the National Energy Policy (NEP) in 2009, setting clear goals for the sector. The NEP called for universal, sustainable access to affordable, reliable energy to foster Liberia's economic, political, and social development.[10] One of the NEP's key elements has been the creation of the Rural and Renewable Energy Agency (RREA). In 2009 the government also ratified the Economic Community of West African States Energy Treaty, which now makes Liberia a full member of the West African Power Pool community.

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[7] U.S. Energy Information Administration.
[8] Center for Sustainable Energy Technologies 2004; National Charcoal Union of Liberia 2005.
[9] The generation mix was composed of a hydropower plant at Mount Coffee with a supply capacity of 63 MW during the wet season and 5 MW during the dry season (six months).The remainder was based on HFO (31 percent) and diesel (21 percent).
[10] The four pillars of the NEP are universal energy access, including developing an energy master plan; least-cost energy production and protection of most vulnerable households; adopting international best practices in the electricity sector; and accelerating public and private partnership in the electricity sector.

During implementation, the Liberian government, supported by development partners, focused on emergency investments to reestablish LEC's operations. Emergency Power Programs I and II allowed for the construction of a small grid with an installed capacity of 9.6 MW (diesel generators) and a 66 kilovolt (kV) transmission line circuit. This program was supported by the European Union (EU), United States Agency for International Development (USAID), Norwegian Agency for Development Cooperation and the World Bank.

Following the principle of public–private partnerships as set out in the NEP, the government engaged a management contractor to bring LEC to full functionality as a power utility with fully trained staff, and build the customer base to a target level of some 33,000 customers. The government awarded a management contract in July 2010 to Manitoba Hydro International. The International Finance Corporation provided advisory services for structuring a performance-based contract and the government of Norway, USAID, and the World Bank provided a financing package of $50 million to LEC for the investments to be implemented by the management contractor.

As of July 2013 LEC had around 13,875 customers, compared with 2,469 in July 2010. Despite this progress, by the end of 2012 Liberia still had possibly the world's lowest rate of access to public electricity—1.6 percent nationwide and 6.7 percent in the capital city—and the highest electricity tariff in Sub-Saharan Africa (and among the highest in the world) at more than $0.50/kWh. Additionally, LEC reports high commercial and technical losses ranging from 25 to 40 percent.

Transformative Programs Based on a Comprehensive Energy Strategy

The government has established a high priority for key transformative projects, particularly in electricity and transport. In electricity, priority has been given to the following:

- Rehabilitating the Mount Coffee hydropower plant, which will provide 80 MW of additional hydropower production in the wet season and about 20 MW in the dry season. It is expected to be commissioned by the end of 2015.
- Developing thermal power to compensate for the high seasonality of hydropower. The government has secured financing for 38 MW of HFO units; commissioning of 20 MW is expected by mid-2015.
- Developing the West African Power Pool Project–Côte d'Ivoire, Liberia, Sierra Leone and Guinea (WAPP–CLSG) Regional Transmission Line, an initial stage in enabling power trade in the region as well as transforming domestic power systems by building backbone transmission lines in Liberia. It is expected to be commissioned by 2017.
- Developing the cross-border connection with Côte d'Ivoire to electrify towns in the border area of Liberia.
- Establishing RREA in 2010. RREA commissioned the first mini-grid system based on a 60 kW micro-hydro plant in rural Yandohun May 2013, is executing the Lighting Lives in Liberia program to advance commercial availability of high-quality, efficient solar-powered light-emitting diode (LED) lighting.
- Mano River Initiative, supported by the African Development Bank, where Mano River Union Member States (Liberia, Cote D'Ivoire, Guinea and Sierra Leone) plan to further integrate their regional development, especially in the energy and transport sectors.

Recognizing the need to transition from emergency response to sustainable management, the Liberian government is preparing a Least Cost Power Development Plan (LCPDP) for expanding the electricity services required to support economic growth. This plan expects to identify the type and scale of investments needed to increase electricity coverage to 70 percent of the greater Monrovian population and 35 percent of the national population by 2030.

The LCPDP focuses on investments in generation and transmission required to expand the grid. This constitutes only a first approximation to do so, given the very limited information available (for example, technical and economic data of some generation options), uncertain demand estimations and the role of large self-producers, particularly the mining sector. The LCPDP's formulation is therefore part of a dynamic process that requires a strategic approach adaptable to changing conditions as data improve and uncertainties are resolved.

Serving the whole population of Liberia with integrated power delivery will be a long-term process. Distributed generation and stand-alone systems based on renewable energy technologies are a sound strategy for near- and medium-term rural development. There have been some efforts to set up a viable commercial market for renewable energy technologies, but country risks, a nascent power sector, limited human and institutional capacity, and lack of access to capital impede private electricity provision in rural areas. The IPRE incorporates lessons learned from these efforts to move from a pilot basis to a national program.

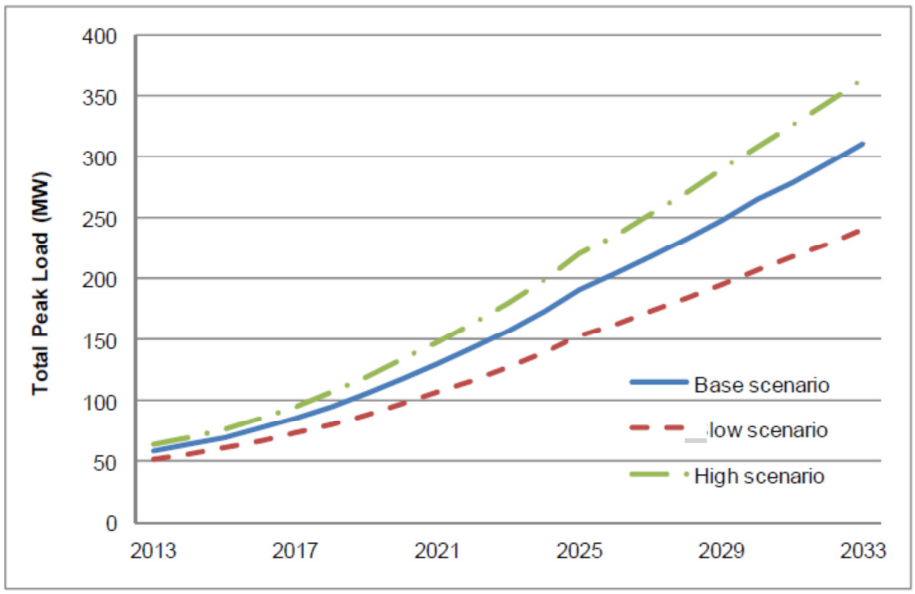
Electricity Demand

The limited development of power network operations in the Monrovia area implies poor statistical information for demand projections. In rural areas, there has been no public electricity supply for about two decades; therefore, data on customer energy characteristics are unavailable. Accordingly, demand forecasts are highly uncertain.

Relying on the previous forecasting efforts of LEC (2013), NORAD (2009), Norconsult (2012), and World Bank (2011), the LCPDP provides electricity demand projections for three different scenarios—base, high and low—for the next 20 years (Figure 2.1), including the current unsatisfied demand but excluding the mining sector. This forecast for electricity demand indicates a potential for fast growth (at an annual rate of 10 percent in 2013–23), consistent with the country's economic growth expectations and the incorporation of large suppressed demand in the power system. It is expected that the peak load will reach 311 MW by 2033 and the corresponding energy demand will be 1,672 GWh. Monrovia will remain the primary load center, accounting for about two-thirds of the country's demand.

Nationwide demand is much larger if the prospective mining companies' electricity requirements are considered. Four major iron ore projects are being prepared, the most advanced being those of ArcelorMittal and China Union. These two mining companies will require around 300 MW in the next five years. Two other companies, Putu Iron Ore and Western Cluster, will require up to 400 MW in the next 10 years. While mining companies will develop their own generation facilities to satisfy their demand, their connection to the national power grid could be an attractive supply option. But the development and timing of these projects depend on various (mostly exogenous) factors, such as the price of iron ore.

Figure 2.1 Peak Demand of the Liberian Power System, 2013–33



Source: Ministry of Lands, Mines and Energy 2013

Electricity Supply

The government, with the support of development partners, mobilized resources to supply power generation for the emergency situation (2008–12) and has secured financing for transformational generation projects for the short term (2013–18). Today the installed capacity of LEC's grid is 23 MW, based on high-speed diesel generators. Projects under design and procurement are rehabilitating the 80 MW Mount Coffee hydropower plant; installing 48 MW of HFO-based generation; and construction of the CLSG Regional Transmission Line, with a transmission capacity of 130 MW, which will allow the country to import electricity from neighboring countries.

In rural areas, electricity provision is taking place at a slower pace. Three pilot projects have started: a mini-grid based on a micro-hydropower plant of 60 kW in Yandohun led by RREA and funded by the World Bank was commissioned in May 2013; two pilots led by USAID, based on small and micro-hydro and biomass, are under preparation; and market development for distributing solar lanterns was begun in 2012. Most rural areas depend on self-supply generated by those users who can afford the investments and fuel. These users include businesses, plantations, mines and timber operations. The challenges of urban electrification are so enormous that rural electrification has been left to users, which the IPRE aims to overcome by providing solutions for efficient rural electrification.

As the electricity sector evolves, medium- and long-term supply options need to be developed to sustainably meet market demand for modern energy services. For 2013–21, the LCPDP considers installation of HFO units (the only option available at short notice) and rehabilitation of the Mount Coffee hydropower plant. Thereafter, additional hydropower plants, with reservoirs in St. Paul's river basin, would be commissioned, complemented by more HFO units and imports of energy from neighboring countries through the CLSG Regional Transmission Line. This plan envisages capacity expansion of 446 MW over 20 years and an investment in generation facilities of $1,181 million. The weighted average

levelized unit cost of the expansion would be $0.141/kWh, excluding transmission and distribution costs. But the plan implies a heavy reliance on imported fuels and consequently high vulnerability to fuel price fluctuations. For that reason, the government is also considering the following two options:

- *Importing power:* in the context of regional integration, a favorable power purchase agreement with Côte d'Ivoire could help reduce supply costs as well as vulnerability to fuel price fluctuations.
- *Integrating self-producer capacity, particularly at mining companies:* the mining companies could be used as anchor customers that facilitate the generation and/or transmission investments needed for large infrastructure projects, benefiting all consumers in the system. The mines' self-supply generation and/or the independent power producer selling electricity directly to the mines could sell their surplus energy to the utility. This could provide economies of scale, share reserve capacity and enable better hydro-thermal operations, as well as reduce project risks and the financial burden on the power sector.

The LCPDP also considers an expansion in transmission along the already planned transmission and subtransmission lines, namely the CLSG Regional Transmission Line 225 kV interconnector, and three 66 kV projects in the country's most densely populated areas (which will allow electrification of surrounding areas at relatively low cost).

Legal, Regulatory, and Institutional Framework

The electricity subsector in Liberia now comprises the Ministry of Lands, Mines and Energy (MLME), LEC and RREA.

The MLME was established by a 1972 Act of Legislature to administer all activities related to land, mineral, water and energy resource exploration, coordination and development. In adherence with its statutory mandate, it formulates and implements policies and regulations with other sector-related agencies to deliver efficient services to the public from the above sectors. The ministry's three functional areas—lands, minerals and energy—are clustered under a deputy minister of operations. The Department of Energy has an oversight role over the energy sector, as well as the mandate to direct and supervise—through policy making and planning—efficient development of the energy sector. The Department consists of the Bureau of Hydrocarbons and the Bureau of Energy Technology and Policy Development. The MLME is part of the board of directors of LEC and RREA.

LEC is a public corporation established in 1973 to generate, transmit and distribute electricity throughout Liberia. To ensure its efficient operation after the war, a five-year management contract was signed between LEC, the MLME and Manitoba Hydro International in 2010.[11] The contract focuses on improving LEC's performance and expanding the consumer base in Monrovia.[12] LEC's board is responsible for setting electricity tariffs for the power grid.

RREA—an independent agency of the government established in January 2010—has been operating so far under an Executive Order issued by the president. Its role is to facilitate and accelerate the economic transformation of rural Liberia by promoting the commercial

[11] The management contract is financed by the government of Norway, with a grant package provided also by the government of Norway, USAID and the World Bank.
[12] The management contract has a delimited area of services within Monrovia, and runs from 2011 to 2016.

development and supply of modern energy products and services to rural areas through community initiatives and the private sector with an emphasis—though not exclusive reliance—on locally available renewable resources. RREA was established in response to the 2009 NEP, which also called for the establishment of a Rural Energy Fund (REFUND) that would manage all domestic and international funds for electrifying rural areas. REFUND will be managed by RREA when legally established. The government is fully committed to electrifying the country, and legally establishing RREA is a key priority for this effort. A bill to establish RREA and the REFUND has been submitted to Parliament.

Energy Sector Law

The existing Energy Law is under review trying to respond to the current needs to reconstruct the power sector. Today, LEC has the mandate to oversee the country's power generation, transmission, and distribution. However, some investments and arrangements under implementation are regulated by contract, such as LEC's management contract with Manitoba Hydro International.

The draft energy law (yet to be submitted to Parliament) has the following key principles for energy policy; a system of licenses for generation, transmission and distribution; permission for licensees to be public, private or joint ventures, provided they are "qualified"; an independent energy regulatory board responsible for monitoring all energy policies and standards, including reviewing and approving tariff methodologies and granting licenses; and guaranteed open access to transmission by third parties.

Electricity Pricing

Grid-connected System. Electricity tariffs are set by LEC's board. A single tariff is applied for all types of consumers, based on a revenue requirement approach, which considers the revenues needed to meet all the utility's operating expenses and capital costs. Tariffs are calculated quarterly, taking into account the price of equipment, service schedule, maintenance, distribution costs and 20 percent of technical and nontechnical losses.

The principle of cost-recovery electricity pricing and fuel price adjustment is a key instrument for expanding the electricity sector. But tariffs in Liberia, at over $0.50/kWh, are among the highest in the world and are the highest in Sub-Saharan Africa.[13] The main reasons are a system based on high-speed diesel generation units and high commercial and technical losses of about 25–40 percent. Organizing human resources to enforce antitheft measures, such as laws prohibiting electricity theft, remains a challenge for LEC.

Off-grid Systems. In government or donor-sponsored electrification or electricity services projects, the principles to date have been to grant-fund all or a substantial portion of the capital investment while operation and maintenance costs, as well as repairs, are borne by the beneficiary.[14]

[13] The average cost of generation for countries in Sub-Saharan Africa is about $0.15/kWh, ranging from about $0.05/kWh in energy-rich countries such as Nigeria to about $0.25/kWh for less energy-endowed countries such as Cape Verde. The cost of generation in Liberia is about $0.40/kWh.

[14] Examples of such projects are the Yandohun micro-hydro project, the USAID-funded projects, and the EU-funded health facilities electrification project where capital investments were borne by the EU with maintenance services to be transferred to the Ministry of Health.

Electricity Pricing Review

The government is revising the tariff structure to support the investments needed to expand the electricity sector while minimizing the tariffs' impact on the poor. The IPRE will support the definition and establishment of principles and methodology for a tariff for renewable energy projects according to the different delivery models.

3. RENEWABLE ENERGY DEVELOPMENT STATUS

Renewable energy resources play a key role in meeting energy demand in a sustainable and affordable manner.

Large Hydropower Generation

Liberia has six major rivers, which drain two-thirds of the country's water.[15] This intensive drainage pattern indicates considerable potential for hydroelectric power in Liberia of up to 1,000 MW. But with no elevated terrain, the preferred technological option is run-of-river plants. Additionally, Liberia's hydrological resources for power generation vary greatly between seasons. Thus large-scale hydropower generation will require a combination of upstream reservoirs as well as thermal power generation.

Feasibility studies in 1976–83 identified 11 sites larger than 20 MW in the six main rivers and eight sites of 10–20 MW. Four sites (Table 3.1) have been further analyzed at prefeasibility level but will require in-depth analysis to assess the potential environmental and social impact, particularly the Via Reservoir, which offers a more even distribution of water throughout the year. The scale (617 MW in all) and links between these sites suggest a sequential implementation that will have to be studied in further detail, taking into account the country and region's demand for power, improved hydrological data, more advanced designs and cost estimates, as well as the environmental and social impacts.

Table 3.1 Potential Availability of Hydropower in Liberia (MW)

	Mt. Coffee	Saint Paul-1B	Saint Paul-2	Via Reservoir	Total
Step 1	66	—	—	—	66
Step 2	66	78	120	—	264
Step 3	122	143	220	132	617

Source: Stanley Consultants (2008); Main (1979); and Geoscience (1998)

The MLME is leading the rehabilitation of the Mount Coffee hydropower plant, which will provide around 80 MW of continuous hydropower in the wet season and about 20 MW in the dry season. Its commissioning is expected by the end of 2015. The rehabilitation cost, around $230 million, is being financed by the Liberian government, the Norwegian government, the European Investment Bank and Kreditanstalt für Wiederaufbau (KfW). The MLME is leading the prefeasibility study of the Via Reservoir with support of the European Commission.

Small Hydropower Generation

Two desk reviews—DECON (1983) and Geoscience (1998)—identified 31 sites for small hydroplants (Annex 3; Annex 4 presents a list of renewable energy pilots of all types). Before the war, only two sites had been developed: Firestone Plantation has a 4 MW hydropower plant in operation, providing electricity to its factories and several other villages, and a 60 kW micro-hydro in Yandohun in Bong County, which was destroyed during the war.

Table 3.2 displays information on the first mini-grid pilots based on small and micro-hydro. The Yandohun micro-hydro, implemented by RREA and financed by the World Bank,

[15] The Mano, Saint Paul, Lofa, Saint John, Cestos, and Cavalla rivers.

involved the rehabilitation of 60 kW to serve 240 households and was commissioned in May 2013. It is the country's first community-owned power system. The Mein River Hydropower Project in Suakoko District, financed by USAID through the Liberia Energy Sector Support Project (LESSP), and the Nimba County project, supported by UNIDO and aiming to install multipurpose mini-hydro infrastructure, are still at the feasibility stage.

Table 3.2 First Mini-grid Pilots Based on Small and Micro-hydro Experience

Project Name	Yandohun Micro-hydro	Mein River Mini-hydro	Nimba County Project
Location	Yandohun, Lofa County	Mein River, Suakoko district, Nimba County	St John River, Gampa water falls, Garr Bain district, Nimba County
Implemented by	RREA	Winrock (USAID, UNIDO)	UNIDO
Power output/ plant capacity	60 kW (average)	1 MW (7 months) and 0.3 MW (dry season)	10 MW
Budget	US$ 0.47 million, including the connection of 240 households	US$ 5.8 million	US$ 26 million
Distance to load centers	3 km	20–32 km	Around 20–32 km
Load centers	Yandohun, Dangalahun 1 and Dangalahun 2 village. 240 households	Gbarnga town and Suakoko district. 2500 households, 250 commercial consumers, Cuttington University and Phebe Hospital	Ganta city, Sanniquellie town, Zuluyee town, Gbedein village, Kapawleh-Snoh village
Ownership structure	Community operated and owned	Community operated and owned	To be determined
Project status	Commissioned May 2013	Procurement ongoing. Construction to be initiated by end of 2013. To be commissioned in 2015.	Technical feasibility analysis completed. Project on hold due to lack of capacity to implement the project.

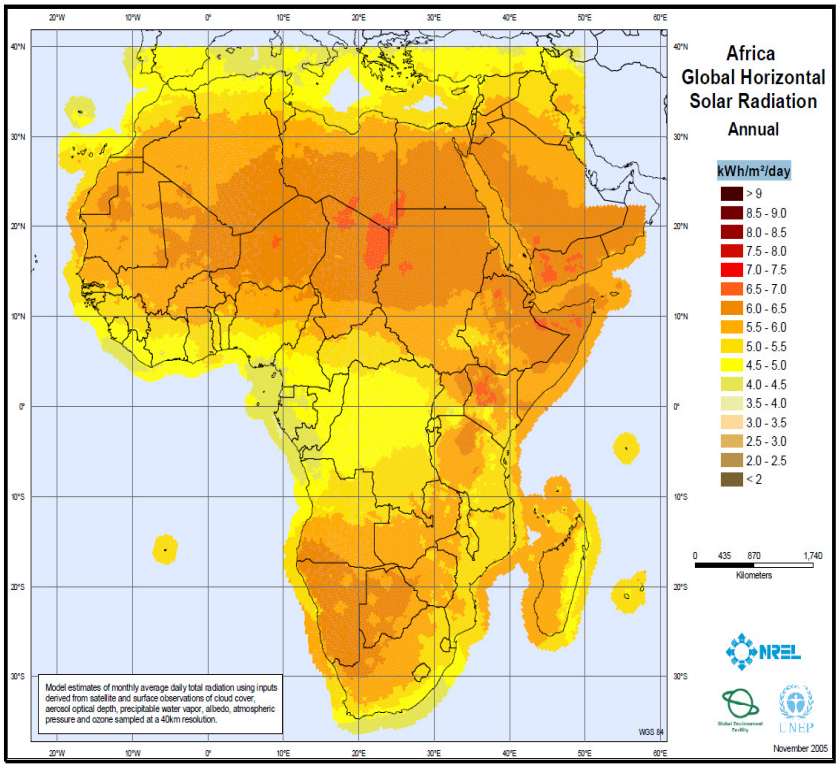
Source: RREA 2013

Solar Energy

There are no national data on solar resources for Liberia, but based on international global weather data, Liberia has an annual global horizontal solar radiation of 4.5–5.0 kWh/m²/day (Figure 3.1), similar to Spain and higher than Germany or Japan.[16] During the rainy season, insolation averages are reduced. However, solar radiation shows good prospects for applying solar technologies such as photovoltaic (PV) systems.

[16] NREL; global horizontal solar radiation is the measure of the density of available solar resources per unit of surface area.

Figure 3.1 Africa Global Horizontal Solar Radiation



Source: International Energy Agency 2011.

Liberia has tested various models of solar projects, including the sustainable solar market package. This is a contracting mechanism that provides for the supply and installation of PV systems, along with a maintenance-and-repair contract (five years with an option to extend) in a defined area. PV systems to meet electricity needs in schools, clinics and other community facilities are bundled with requirements and incentives for commercial sale to households, businesses and other nonpublic customers. RREA has prepared two packages, one in Bong County and the other in Lofa County, to be financed by the EU and the World Bank. The two tendering processes did not receive any responsive bids, however, indicating the challenge for getting capable firms to bid for projects in rural Liberia.

Another model is the public solar program for health facilities. An EU-funded project in partnership with the Ministry of Health, it is providing electricity to 205 health clinics for lighting and communication. Led by an nongovernmental organization (NGO)—MERLIN—the project procures and installs these systems, builds health clinic staff capacity to undertake basic maintenance and system management, and is establishing a maintenance unit at the ministry. Such a business model could be expanded to cover the remaining 300 rural health facilities and extended to staff housing, as it helps retain qualified staff at remote locations. The MERLIN and RREA will apply for funds to finance this second phase.

Market development for cost-efficient distribution of solar lanterns presents another approach. Positive results are emerging from the Lighting Lives in Liberia World Bank–funded project, which is developing retailer capacities to market and sell high-quality solar LED lights—a superior, low-cost replacement to candles, kerosene lanterns or disposable batteries. RREA services have been used to introduce retailers to such products and their

suppliers, aggregate orders from retailers, import products on their behalf, build their capacity, and monitor and evaluate performance. In the subsequent phase, with funding from the Global Environmental Facility, RREA will move toward a more commercial setting by encouraging wholesale importers to deal directly with retailers. RREA will continue to support the program through capacity building and offsetting some costs, such as taxes and duties. The option to work with a commercial bank willing to offer trade finance to wholesalers, if a guaranteed facility is available, is being considered.

Finally is a grid-tied solar PV installation. The project is in the design phase, and would be owned by LEC and financed by USAID. The first phase has 500 kilowatt peak (kWp) and, based on the experience, a second 500 kWp component could be added.

Biomass

Biomass resources meet about 90 percent of the Liberian population's energy needs and are therefore vital to basic welfare and economic activity. Traditional biomass products, such as firewood and charcoal, are the primary energy sources used for domestic cooking. But there are other more efficient biomass technologies that could open opportunities for agriculture and rural development and provide other socioeconomic and environmental benefits.

Despite significant biomass resources in Liberia, there is no consensus on the amount of power that can be sustainably generated. Liberia has a theoretical energy production potential from biomass of 27,452 GWh per year.[17] Other independent assessments identified five sites of rubber plantations with the potential to support 80 MW of biomass-fired power plants, which require around 2,500 hectares of rubber trees per year.[18] However, the economic and financial feasibility of biomass power has yet to be assessed, which depends on the type of technology, the size of the power plant and fuel-transport costs.

Charcoal production in Liberia in 2005 stood at 36,500 tons. There are no firm data on firewood consumption for the country, but findings from a survey conducted by the Center for Sustainable Energy Technologies in 2004 indicated that firewood scarcity is a serious problem in most parts of Liberia. About 960,000 trees are cut down annually for charcoal to serve the Monrovia area alone. Forecasts for the country estimate an annual demand increase of about 0.6 m^3 per household.

Logistical challenges, pricing, competitive uses and the social dimension of fuelwood have limited its commercial use for power generation. Some large plantations allow charcoal producers to get waste rubber wood during replanting programs. Establishing a biomass power plant will require a fuel supply agreement with the rubber plantation that would compete with charcoal producers for the use of waste rubber wood and waste from palm oil factories.

As Liberia's dependence on its biomass resources will increase, measures must be put in place for sustainable harvesting and replanting practices, as well as for reduced consumption. In addition, the impact of firewood shortages needs to be researched to formulate a policy to

[17] Assuming up to 10 percent of the available cropland would be dedicated to palm oil, coconut or sugarcane, covering 3.7 million hectares; Milbrandt 2009.
[18] Aah-Kee 2009; Krishnan 2009. The proposed sites include Kakata, Guthrie Plantation, Saint Paul River, the Fendell Campus of the University of Liberia and the Firestone Plantation. At the Guthrie Plantation site, there are sufficient confirmed supplies of water and rubber trees for a 20 MW wood-fired power plant.

protect the resource. Failure to meet this demand sustainably will eventually lead to deforestation, environmental degradation and desertification.

A past initiative for biomass power generation of around 30 MW faced significant difficulties, particularly due to the commercial arrangements requiring a take or pay contract when the demand of power was below of 10MW. Additional challenges were found on the social, environmental and land use aspects that such a project entailed. Smaller biomass power plants (5–10 MW) could be more suitable, given the power sector's current development and scale. The size can later be scaled up as the sector gains experience in this technology.

Village-scale initiatives are conducted with donor assistance, such as a proposed 60 kW Sorlumba Biomass Power Project in Lofa County. The project has a crude palm oil-fired generator to serve some of the 19 villages within 5 km of the project site, identified by the LESSP USAID-funded program. Such small schemes may be developed using a community model, similar to Yandohun, where an "electricity consumer cooperative" can manage and operate the electricity service. Capable organizations in the service area may be interested in managing and operating a larger mini-grid (hundreds of kilowatts or larger), if support were offered for project development, capital investment and capacity building. They may include universities, plantations, forest-based industries, mining companies, hospitals or other service agencies.

Examples of projects identified in the USAID LESSP project are Liberia Company rubber plantation near Cocopa in Nimba County, where the replanting program could supply 3 MW of power.

Other Sources

Data are scarce on wind speeds because no assessment has been performed, although global and regional wind maps indicate that wind is a poor resource for West Africa. Mechanical turbines for water pumping could, however, be well suited for Liberia. There does not appear to be a geothermal resource in Liberia. Though higher heat flow values are found offshore to the south and west in the Guinea and Sierra Leone Basins, and are attributed to possible tectonic activity, the activity's thermal effects are not thought to extend inland to the Liberian Shield.

Barriers, Challenges and Mitigation Measures for Renewable Energy Development

Scaling up renewable energy resources in Liberia will require barriers to be overcome, possibly via mitigation options drawn from experiences in other countries as well as Liberia itself (Table 3.3).

Table 3.3 Scaling Up: Barriers and Mitigation Measures

Main Barriers and Constraints	Mitigation Measures
A politically fragile situation in some areas of Liberia. This raises issues of governance and security.	The government has initially invested in roads to connect the major cities and economic centers. This will facilitate provision of different services. Through the proposed program it is expected to overcome this barrier by providing electricity services.

Main Barriers and Constraints	Mitigation Measures
Absence of adequate legal and regulatory framework. There are legal gaps due to the lack of a comprehensive legal and regulatory framework establishing commercial conditions, incentives and obligations of private investors and/or operators. The perception of project risks associated with legal and regulatory uncertainty will have to be resolved to attract private investors in the medium to long term. In the meantime, regulation by contract is viable, case by case. Two associated problems are: • **Ratification by Parliament of the legislation pertaining to RREA**. RREA has operated under a series of executive orders. RREA's ratification as a government implementing agency is required for government resources to be allocated for its long-term operation. • **No clear legislation for private sector participation**. LEC has the mandate to oversee the country's power generation, transmission and distribution.	Regulation-by-contract approaches will be used to jump-start investments. As a first stage, skills to deal with the private sector need to be created among civil servants of the Liberian government. The Transaction Advisory Services Facility (see *Phase I* in Section 5) is expected to support the government on such transactions while also building capacity within the MLME, LEC and RREA. Though the proposed program, it expected to support the government in presenting to Parliament a comprehensive plan on how renewable energy will contribute to increasing access and striking a balance for service provision between rural and urban areas. While the overall legal and regulatory framework is not in place, it will be necessary to develop credible and transparent commercial arrangements, with the necessary risk mitigation measures to increase attractiveness for the private sector in these investments, at least in the program's initial phase. Some instruments such as guarantees and payment by results can be used and will be designed based on the conditions of each project.
The energy sector strategy is not coherent enough. The government has often been forced to address day-to-day emergencies at the expense of coherent long-term policies, and usually focuses on the Monrovia area.	Recognizing the need for long-term planning and policies, the MLME has engaged in parallel and complementary efforts to develop the sector and balance the provision of urban and rural electricity services. These include the LCPDP, the IPRE and the upcoming Liberia Energy Master Plan.
Lack of access to capital and financing. Off-grid electrification is expensive, especially in Liberia where transport difficulties and limited human capacities add to the challenge. Long-term financing will be needed. The private sector and banking system have neither the expertise nor the willingness to finance these types of projects.	A substantial share of the initial capital required for IPRE projects will be grant-based, similar to many of the electricity investments that primarily serve Monrovia. Low-cost, low-risk financing through credit lines established for projects will also be used.
High cost of projects. Capital requirements for off-grid electrification using renewable energy are steep anywhere in the world, given high capital costs. In Liberia, due to the limited scale of projects and site access difficulties, project costs are expected to be even higher.	Though the proposed program , it is expected to build a portfolio of projects taking advantage of economies of scale. It will also introduce lower cost methods using international best practices. Strengthened capacity and lowered risk will also reduce project costs.

Main Barriers and Constraints	Mitigation Measures
Limited affordability. Most households in Liberia have little disposable income, so their ability to pay for electricity will be weak.	To increase affordability, capital investments will be substantially grant-funded. Low-cost electricity supply solutions will be developed, especially for meeting basic electricity needs. Income-generating opportunities will be supported. To achieve sustainability, recurrent costs for operation and management and fuel will be minimized and fully recovered from consumers. Supplementary funding such as results-based financing from sources like Energy+ will also be considered.
Difficulty attracting investors and financiers. Without substantial donor support, privately owned and operated mini-grids are unlikely to be viable due to high country risk, steep project costs, and perceived limited market potential.	Public–private partnerships and grant funding will be used to lower capital at risk. O&M could be carried out by NGOs, communities, local governments or private firms with a presence and stake in the community or region. Though the proposed program, it is expected to support capacity building of O&M personnel.
Difficulty attracting qualified contractors and suppliers. Given the small scale and number of previous projects, coupled with a difficult working environment and a lack of domestic experience/knowledge, it is difficult to attract experienced firms with deep knowledge of the types of projects envisaged.	With the resources funding the IPRE and government contributions, scale economies will be increased, thus creating greater interest among highly qualified international contractors and suppliers. Though the proposed program, it is expected to package several projects expecting to achieve the economies of scale needed to attract qualified suppliers.
Limited human and institutional capacity. Emerging from a civil war that destroyed much of the institutions and infrastructure and displaced many people, Liberia is faced with severely depleted human and institutional capacity for designing, developing, operating and managing mini-grid electricity programs. Particularly challenging is finding the expertise for O&M of power systems and mini-grids.	Progressive training will be provided, starting from the basics and moving to the most specialized training. This requires long-term commitments to ensure knowledge transfer. The Though the proposed program , it is expected to tap into expertise available in selected localities with mining, agriculture and forestry operations by incentivizing engagement. International expertise will be tapped, as with LEC, to support the development of mini-grid electricity programs. O&M capacities and business models suited to the challenging conditions in rural Liberia will be developed and supported.
Too little information of sufficient quality and duration on renewable resources. Data on hydro resources were collected prior to the civil war. In some locations, changes in land use patterns have led to changes in stream flow patterns. Liberia also has many rubber and palm oil plantations and timber concessions that can provide fuel for biomass power, but reliable information on them is lacking.	Though the proposed program, it is expected to support renewable resource assessment and site reconnaissance, particularly where mini-grid development is foreseen.

Source: RREA

4. Screening and Prioritization of Renewable Investments Options To Be Supported Under The IPRE

Renewable Energy in the Power System

The LCPDP analysis indicates that Liberia will require a combination of HFO units and hydropower plants to satisfy power generation needs for 2013–33, but it will not be cost-effective in the medium term to extend the power grid to rural areas and remote small and medium towns. Hence developing domestic renewable energy resources is an attractive option for meeting the population's demand for energy, sustainably and affordably, particularly in mini-grids where fossil fuel solutions face extremely high prices and unreliable supply. Renewable energy will also contribute to an environmentally sound energy balance and reduced exposure to price fluctuations of imported fuels.

Major Population Demand Centers and Priority Focus

Based on the 2008 national census, one-third of the population lives in Montserrado County, which contains Monrovia; another third lives in the major population centers; and the other third is spread around the rest of the country. More than a million people live within 20 km of the major population centers, excluding Monrovia (Table 4.1).

Table 4.1 Major Population Centers

Major Population Center	Population in the major population center	Population within 20 kms of that major population center
Buchanan	49,935	69,323
Foya	20,569	101,529
Ganta	42,077	83,890
Gbarnga	38,970	95,190
Greenville	12,768	26,451
Harbel	50,926	114,573
Harper	24,018	44,915
Kakata	34,608	114,078
Karnplay	7,989	66,879
River Gbeh	2,139	9,888
Sacleapea	13,765	88,596
Sanniquellie	11,854	49,888
Tubmanburg	14,576	45,668
Voinjama	15,312	47,903
Zorzor	5,899	32,987
Zwedru	25,349	38,417
Total	**370,754**	**1,030,175**

Source: National Population and Housing Census 2008

Mining and plantation companies place a heavy demand on the country's power supplies, although most of them meet their energy requirements through self-generation based on fuel-oil power plants. Only two plantations are using renewable energy to reduce fuel-oil consumption (a small 4 MW hydropower system and a 5 MW solar system).

Against this backdrop, the IPRE will focus on providing electricity for major population centers rather than business consumers such as mining operations or plantations. However, some of them, particularly plantations, can turn into a source of supply option if the right financial incentives are provided.

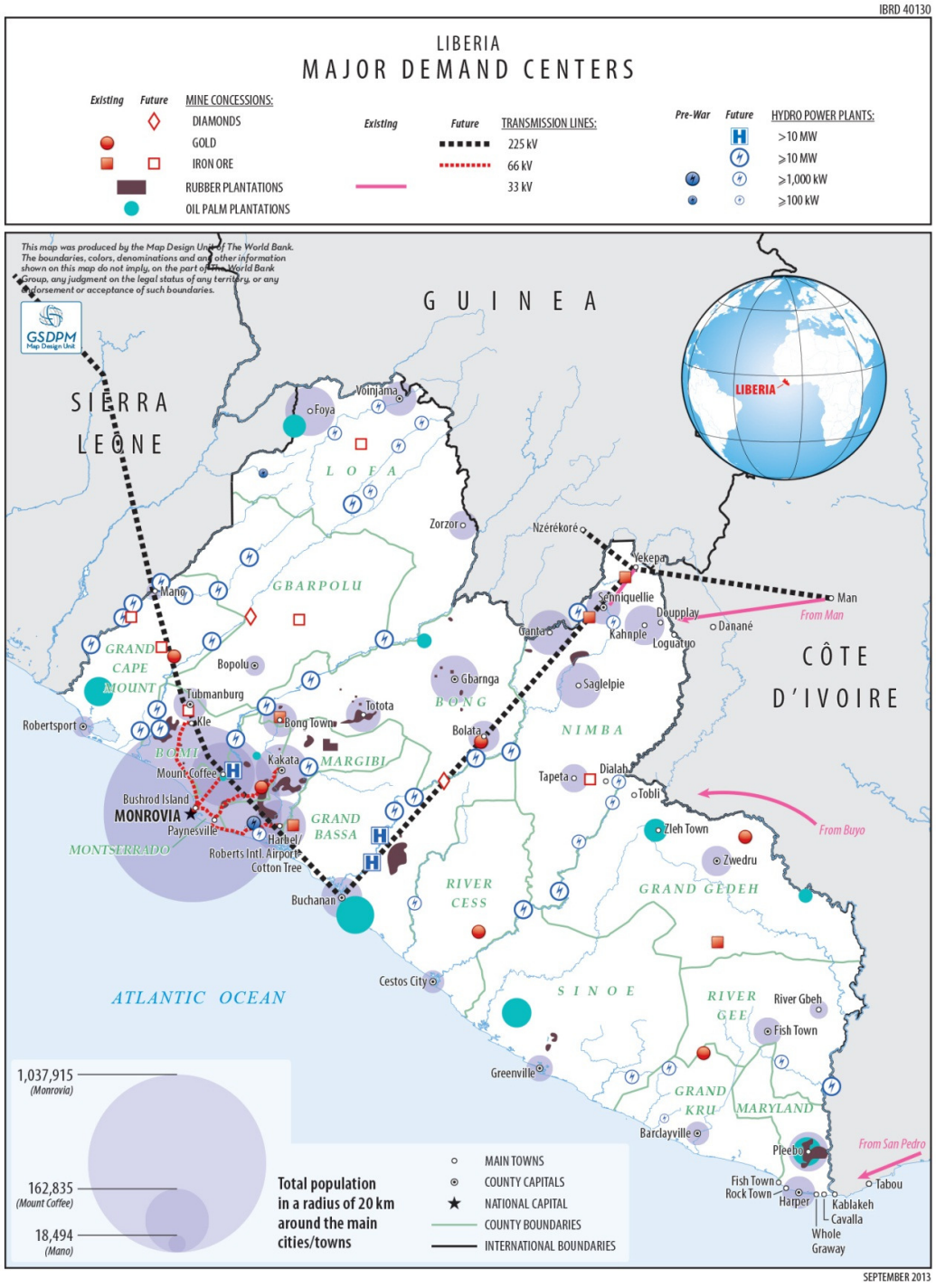
Most of the major population centers do not have any electricity system, and only a few have diesel generation but are unable to operate them continuously given their high operating costs (around 40 US$ cents/kWh) and low reliability and costly fuel supply and transport.[19]

As the current efforts are focused on developing the electricity sector around Monrovia and preparing the CLSG Regional Transmission Line as a backbone for the country, the IPRE will focus on the major population centers and within 20km, where one-third of the population lives. This will, in turn, make possible a more equitable and balanced provision of electricity outside of Monrovia as well as supporting poorer households.

Figure 4.1 presents the larger demand centers including larger population centers, mining sites and plantations. This figure also shows the potential sites for hydropower generation and the larger plantations of rubber, timber and palm oil. Given the limited information available in Liberia, an initial analysis was conducted only on small hydro potential (see Annex 3).

[19] Some of these towns, such as Ganta, were supplied by diesel engines but high operating costs (around 47 cents/kWh), as well as high diesel transport costs, make electricity unaffordable to the majority of the population, including government entities.

Figure 4.1 Major Demand Centers in Liberia, 2012



Source: RREA

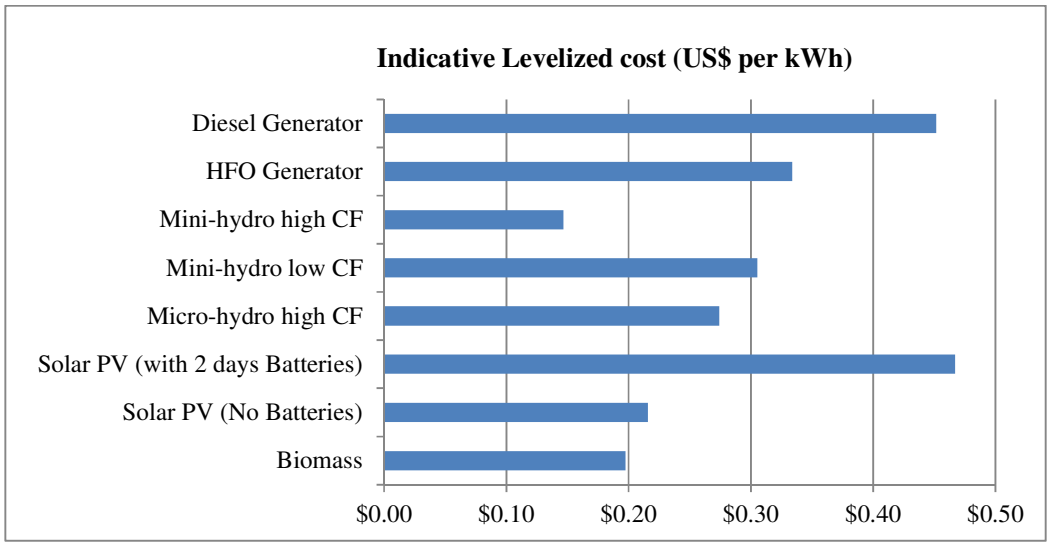
An analysis was carried out during the preparation of IPRE of the renewable energy sources to identify options that have greater potential to meet the government's energy targets outside of Montserrat County. The analysis considered hydro, biomass and solar options, as well as a combination of these to compensate for hydropower's seasonal variation, and adopted an

economic approach and a screening consultative process to prioritize renewable energy options.

Economic Analysis of Technology Options

The economic review was conducted to assess the economic levelized cost (Annex 5) of the options. The analysis was based on actual costs of pilot projects (small and micro-hydro, PV, diesel and HFO) and did not include the additional cost of transporting fuel to the sites. The economic levelized cost of electricity is an indicative tool to identify the most attractive options (Figure 4.2). Actual costs will be determined based on the conditions of each project. However, it is expected that packaging projects together will reduce costs from the Liberian experience in implementing projects. The supply curve shows that PV, small hydro and biomass power plants (5 MW) are highly competitive compared with thermal units of similar scale.

Figure 4.2 Economic Levelized Cost of Electricity for Renewable Technologies in Liberia



Note: The levelized cost estimations consider high and low capacity factors for the hydropower options.
CF = capacity factor.
Source: RREA

Screening Process of Strategic Investment

The Liberian government, guided by MLME and RREA, carried out a consultative process to define priority investments under the IPRE. It consulted with development partners, NGOs and the private sector, including plantation companies, mines and local banks. Multilateral development banks (MDBs) assisted in the consultative process (Annex 6). The Liberian government used screening criteria to identify renewable technologies that can best meet its objectives and benefit from financing from the Scaling Up Renewable Energy Program in Low Income Countries (SREP) and the potential delivery model. The following options were analyzed.

Renewable Energy Power Projects to Feed the LEC Grid or CLSG Regional Transmission Line Substations

Three main project types stand out:

a) solar PV grid connected;
b) small hydro (sites of less than 10MW, given funding restrictions); and
c) biomass (using sustainably harvested rubber wood, palm oil waste, sugar bagasse or municipal solids in Monrovia).

Two main delivery models can be considered for the on-grid projects: a private project with commercial financing selling electricity to LEC under a power purchase agreement, with or without a partial risk guarantee; or ownership by LEC, and O&M contracted out to a private firm with fuel purchased from nearby rubber plantations.

Renewable Energy Mini-grids

Given the small power grid system, the timing for executing the CLSG Regional Transmission Line and the dynamic extension of the system, mini-grid solutions were considered in screening, primarily those with small hydro and biomass as the primary resource, with compensating PV. Capable organizations might be interested in O&M (see the *Biomass* section, above). For smaller mini-grids, a cooperative model was also included.

Stand-alone System

For more isolated or dispersed communities where connection to a mini-grid is costly or not feasible, stand-alone solar PV offers a lower cost alternative. These installations could be served by adequately trained communities or local electricity service groups.

Evaluating Investments and Ranking Options

Although most options rank high in environmental indicators, such as low emissions development, their expected performance in leveraging additional resources is much lower (as summarized in Table 4.2, which is based on the national objectives and the SREP financing requirements). This reflects the difficulties a renewable energy program will face in attracting private investors in the short to medium term, due to perceived risks associated with new markets and technologies and project development in remote areas, in addition to overall country risks. The IPRE is expected to help overcome some of these barriers by providing the required financing and establishing and testing business models that will help leverage additional resources.

Table 4.2 Evaluation of Potential Investments

Criteria	Grid Connected			Renewable Energy Mini-grids	Off-grid
	Solar	Small Hydro	Biomass Power		Stand-alone Solar
SREP Criteria					
Increased installed capacity from renewable energy	**Moderate**	**High**	**High**	**Moderate**	**Low**
	Potential limited by maximum share (about 30 percent) that can be grid connected without introducing instability	Relatively high small hydro potential estimated at ~200 MW	High potential of about 27,000 GWh estimated. Waste only from rubber/oil palm around 80 MW	Potential limited by demand from isolated communities and distance of good, small hydro sites from isolated population centers	Applicability across both rural and urban populations is high, but total demand, given affordability, will be for small sizes. For example, 250,000 households at 50 W each = 12.5 MW
Increased access to energy through renewable energy	**Moderate**	**Moderate**	**High**	**High**	**Moderate**
	Contributes to increased access to electricity particularly to commercial/industrial uses as resources are available in daytime at zero marginal cost	Helps access but seasonality requires firm power back up	Contributes to increase access with firm power	Directly increases access in hard-to-reach areas. Hydro and PV limited by seasonality	Directly increases access to hard-to-reach isolated consumers. Given small size, primarily used for lighting, mobile phone charging and small appliances
Low emissions development	**High**	**High**	**Moderate**	**Moderate**	**High**
	No greenhouse gas (GHG) emissions	No GHG emissions	Full emissions offset not available	No GHG emissions from small hydro and solar, but full emissions offset not available for biomass power	No GHG emissions

Criteria	Grid Connected			Renewable Energy Mini-grids	Off-grid
	Solar	Small Hydro	Biomass Power		Stand-alone Solar
Productive use of energy	**Moderate**	**Moderate**	**High**	**High**	**Moderate**
	Daytime availability matches commercial and industrial demand well. But without storage, it functions principally as a fuel saver to reduce diesel or HFO use	Seasonal intermittency has to be backed up to supply reliable power needed for productive uses	Firm power helps provide reliable electricity needed for productive uses	Quality and quantity of power suitable for productive uses	Primarily used for lighting, communications and small appliances due to affordability of isolated consumers
Economic, social and environmental impact	**High**	**Moderate**	**Low**	**High**	**Moderate**
	Avoided cost less than diesel or HFO on economic basis. Environmental footprint low as installable capacity is limited by grid daytime peak demand. Should not cause social conflicts	May conflict with water use for other needs. Must be designed to avoid environmental issues related to water use/diversion. Social conflicts related to land use and transmission right of way have to be resolved	Economic benefits high in local communities in supplying fuel. Impact on competitive use for biomass such as for charcoal production must be managed. Proper environmental control of emissions and water discharge must be ensured	High-value electricity brought to community sooner than by grid extension. Income generation potential supported by electricity supply	High value of electricity for lighting. Environmental impact of improper battery disposal must be managed
Economic and financial viability	**Moderate**	**High**	**Moderate**	**High**	**High**
	Levelized economic electricity cost less than avoided fuel cost from diesel or HFO. However, financial viability depends on financing terms available to Liberian investors	Less costly economically than diesel and HFO thermal generation. Good financial returns if risks mitigated	Can be less costly economically than diesel and HFO thermal generation if biomass fuel is reasonably priced. Fuel supply risk must be mitigated	Far less costly than diesel generation. Subsidies needed for affordability	Far less costly than using small gasoline/diesel generators or use of kerosene and batteries. Subsidies may be needed for affordability

Criteria	Grid Connected			Renewable Energy Mini-grids	Off-grid
	Solar	Small Hydro	Biomass Power		Stand-alone Solar
Leveraging of additional resources	**Low**	**High**	**Moderate**	**Low**	**Moderate**
	Some development partners interested. Commercial interests limited by scale of projects and country/commercial risks	Good development partner interest. Some commercial interest, if development partners can offer risk mitigation instruments	Some development partner interest. But fuel supply price and availability uncertainties and competition with supplies of charcoal, especially near-urban areas limits interests	Scale of projects, remoteness and accessibility of sites, perception of limited willingness to pay of customers means that these projects mainly interest development partners	Mainly development partner interest. Commercial interest limited based on the experience of Liberia by perception of limited ability to pay, and market scale. This could be changed by appropriate design
Gender	**Moderate**	**Moderate**	**Moderate**	**High**	**High**
	Inclusion of women in energy supply chain (job creation) and electricity access improves lives of both women and men due to drudgery reduction	As left	As left	Benefits women and children as predominant users are households. Women and men in the community can be trained to help develop and maintain energy services	Benefits women and children as target users are households. Women and men in the community can be trained to help develop and maintain energy services
Co-benefits of	**Moderate**	**Moderate**	**High**	**High**	**Moderate**

Criteria	Grid Connected			Renewable Energy Mini-grids	Off-grid
	Solar	Small Hydro	Biomass Power		Stand-alone Solar
renewable energy scale up	Offsets diesel and HFO use, but amount limited by small technically viability capacity due to low daytime peak demands. Few employment opportunities	Offsets diesel and HFO fuel use. Better employment opportunities during construction and operation than other options	Significant potential to offsets diesel and HFO use. Creates additional income streams for farmers and plantations through sale of agricultural waste, fuelwood cultivation	Increased energy security to vulnerable and small communities and enhanced socioeconomic conditions. Danger from kerosene fires avoided. High-cost diesel avoided	Increased safety to households and enhanced socioeconomic conditions. Danger from kerosene fires avoided
Additional National Criteria					
Contribution to national electrification goals	**Moderate**	**Moderate**	**High**	**High**	**Moderate**
	Increase in low-cost electricity supplies supports grid-tied access. But capacity limited due to low peak daytime demand	Increase in low-cost electricity supplies supports grid-tied access	Increase in low-cost electricity supplies supports grid-tied access. Ability to offer firm, dispatchable power and can also displace capacity as well as energy	Important for meeting national electrification goal of 30 percent rural access by 2030	Applicable for a smaller segment of off-grid consumers. But in near term good potential even in urban areas where grid access will take time
Project readiness	**Low**	**Moderate**	**Low**	**Moderate**	**High**
	USAID supporting 500 kW project and planning for another 500 kW of solar PV. Given current low daytime peak demand, potential for additional capacity addition is low	Some sites that will have access to CLSG Regional Transmission Line once constructed are available. But require further resource confirmation and design and feasibility studies	Few sites that will have access to CLSG Regional Transmission Line once constructed are available. But require further resource confirmation and design and feasibility studies	A number of sites with access to CLSG or LEC is available. But require further resource confirmation as well as design and feasibility studies	RREA is supporting commercial sale of solar lighting. It has prepared two solar PV electrification projects for Bong and Lofa counties. EU-funded health sector project provides a replicable model

Source: RREA

Selection of Renewable Energy Options

Based on the consultations and economic analysis, the government identified the following options as a priority to support the government's objectives through the IPRE (Table 4.3).

Table 4.3 Ranking of SREP Priority Renewable Energy Technologies

	Technology	Economic Cost Range (US$ per kWh)	Focus for Liberia SREP Investment Plan	Justification
Grid connected	**Solar**	0.24	No	USAID is supporting a 1 megawatt peak (MWp) project with the first phase 500 kWp feasibility study and tender document preparation underway. Given current low daytime peak demand, potential for additional capacity is low.
	Small hydro	0.22–0.44	No/Yes	At present no grids are close to potential small hydro sites. Hydro based mini-grids supported by SREP could be interconnected to the national grid in the future.
	Biomass power	0.18–0.2	No/Yes	Focus will be on using biomass waste from rubber and palm oil plantations. Given transport logistical challenges, plants must be close to biomass source. Predictability of fuel availability and pricing has to be verified during design phase. Competing use for charcoal production and for timber needs to be assessed which may limit its potential utilization for power generation. There are no grids close to potential plantations/concessions (except Firestone), but biomass based mini-grid could be connected to the CLSG Regional Transmission Line and cross-border interconnections.
Mini-grid/ Off-grid	**Mini-grids powered by small hydro, solar PV, biomass and hybrids**	0.32–0.52	Yes	Directly increases access to communities in hard-to-reach areas. Importantly supports higher power productive and commercial loads. By using locally available renewable energy instead of diesel, fuel supply logistics and diesel fuel costs are avoided thus reducing costs and increasing supply reliability. Renewable energy mini-grids are critical for meeting national electrification goal of 30 percent rural access by 2030 and to support economic activities outside Monrovia.
Stand-alone system/ Off-grid	**Stand-alone solar PV, ranging from solar LED**	Monthly economic cost range per	Yes	Directly increases "access" to communities in hard-to-reach areas to provide basic electricity services for lighting, communications and other low-power applications. Complements mini-grid and grid

	lanterns to larger systems of, for example, 100 watt peak (Wp)	household of about $3/month for solar lantern to $20/month for 100 Wp solar home system	electrification by offering infilling solution to serve consumers who cannot be electrified cost-effectively by grid network, thus maximizing electricity coverage in an area. Applicable to both unelectrified rural and urban populations. Infrastructure built to operate and manage mini-grids can support stand-alone systems to provide repairs and spares, thus reinforcing sustainability.

Source: RREA

5. PROGRAM DESCRIPTION: RENEWABLE ENERGY ELECTRIFICATION PROGRAM

The Liberian government is committed to achieve 35 percent rural electrification by 2030. Off-grid electricity—through mini-grids and stand-alone renewable energy services—will be needed to supplement expansion of centralized generation and transmission facilities. Renewable energy technologies are well suited to this application as they use local and sustainable resources, and are cost-effective. As the national electricity grid expands, off-grid networks or mini-grids will be connected to the main grid. Within an area covered by, or adjacent to, mini-grids there may be consumers who cannot be reached as their connection may be impractical or too costly. These consumers can be served by stand-alone systems such as solar PVs.

Program Objective

The objective of the proposed Renewable Energy Electrification Program (REEP)—supported by SREP financing and development partners—is to meet the electricity needs of a significant part of the population living outside Montserrado County (Annex 7). The REEP will use indigenous renewable energy resources and will tap into communities' and local institutions' innate capabilities wherever possible. It will help enhance institutional, human and technical capacities, introducing sustainable business models and financing several projects to demonstrate viability. Support will be targeted to communities that will not be served by LEC's grid in the near term. REEP aims to create an approach that can be replicated and supported by different development partners. Details of the REEP are further elaborated in Annex 7.

Electrification Priority and Project Area

Communities for REEP electrification are isolated communities, as in Lofa Counties, where interconnection to LEC's grid is not expected for many years; and communities within the CLSG Regional Transmission Line's service corridor and the cross-border areas to be electrified through interconnection with Côte d'Ivoire. The isolated communities will rely on ***renewable energy mini-grid and stand-alone services*** for the foreseeable future. These communities, which have no option other than diesel generation, will eventually be interconnected, thus increasing renewable energy utilization within LEC's grid. This approach will permit communities to gain electricity services sooner than would be possible if they had to wait for main grid services.

To achieve a geographic balance for electricity provision, the government and MDBs have agreed on the following support:

- The African Development Bank (AfDB) will focus on the four southeast counties, as well as those in the area covered by the cross-border interconnection (including Nimba county).[20]
- The World Bank will focus on the rest of the country, more specifically on Lofa County and the counties within the CLSG Regional Transmission Line.

[20] Investments will be done in coherence with the activities carried out under the Mano River Initiative which will address some of the causes of fragility, including through energy access.

The investments will focus on area-based electricity service delivery to facilitate provision of operation and maintenance needed to deliver electricity sustainably and cost-effectively. Within the service area, renewable mini-grids will be used to serve customers in areas with higher load densities—typically within 20 km of the generation source. Stand-alone solar PV will be used for communities with low load densities and for scattered consumers within the service area where mini-grid extension cannot be economically or technically justified.

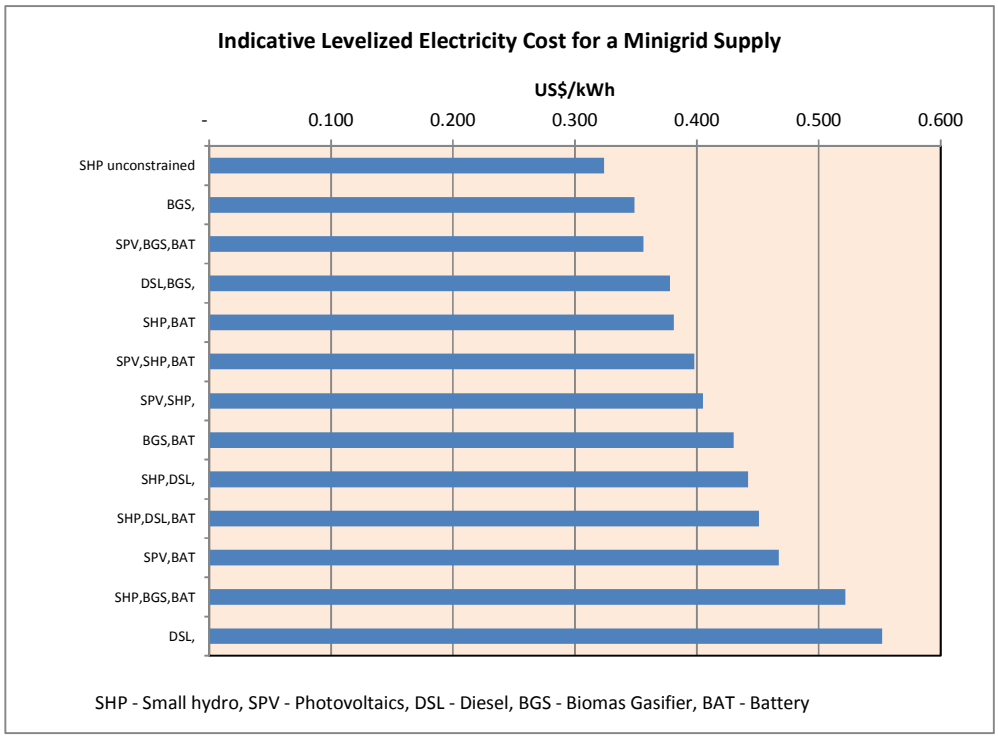
Technology Choice

Demand analysis, technical viability and economic cost-effectiveness analysis will determine choice of technology. Site-specific analyses will be conducted during feasibility assessments to determine the most suitable electricity supply configuration for the mini-grids. Technology choice will be determined using several criteria, including technological complexity, levelized cost of electricity, fuel or resource supply certainty, operational flexibility and ease of operation in local conditions. Solar PV will be the preferred choice for stand-alone systems.

Based on known resources, small hydropower could become a key supply option for mini-grids (see Annex 7). Other resources to be considered include solar PVs, biogas from agricultural waste and gasifier generators using harvested biomass from rubber replanting or palm oil waste. Given the seasonality of some renewable energy resources, diesel generation (or batteries) may be included to provide the required levels of availability at least cost, but due to the practical difficulties of supplying diesel and its extremely high cost, it is considered only as a last resort.

Figure 5.1 provides an example of levelized electricity cost from different supply configurations. In this example, small hydropower is the least-cost solution if there is adequate year-round water supply. If hydro resources are constrained during the dry season, other options, including hybrids, may provide lower cost electricity.

Figure 5.1 Indicative Levelized Cost of Electricity for a Mini-grid, Various Supply Configurations



Source: RREA

Delivery Models and Ownership Options

RREA will consider a number of ownership structures, depending on local organizations' interest and capacity. In addition, RREA will assess the interest of LEC and private, nongovernmental and cooperative companies in owning and operating the mini-grids. Based on a consultative process, review of the existing legal framework, and the dynamic evolution and expansion of the sector, the following potential delivery models will be pursued based on the specifics of each individual projects:

- Cooperatives and/or private non-profit entities for small, isolated mini-grid projects (200 kW and smaller) that self-generate and supply electricity to the cooperative's members or local population. (One example is the Yandohun micro-hydro project.) They will be established under the Cooperative Societies Act of 1936 and the 1976 Associations Law of Liberia as amended.
- Commercial or public enterprises (anchor consumers) operating existing businesses. They would establish a renewable energy generation project to serve their own requirements and extend services to other consumers nearby. Electricity would be a subsidiary business of the commercial or public enterprise. Commercial enterprises may include palm oil or rubber plantations, timber or mining operations. Public enterprises may include schools or hospitals or local/municipal governments, such as in the Mein River Project. They would be established under the Business Corporation Act as amended in 1999 and 2002 and operate under the LEC Act of 1976.

- LEC ownership of projects in the areas served, or about to be served, by the LEC grid, including the CLSG service corridor and areas serviced by cross-border interconnection. (LEC is a public corporation under the LEC Act of 1973.)
- Independent power producers for larger projects specifically set up as private companies, or joint ownership under public–private partnerships (such as a private company with LEC). The producer will generate and sell electricity to retail customers and eventually to the LEC grid. These projects will be set up as a concession established under the Public Procurement and Concession Act of 2010 as amended.

Drawing on local capacity, it is expected that local entrepreneurs would provide operation and maintenance and commercial services, particularly where the owner lacks the required expertise (for example, cooperatives) or would prefer to outsource such activities (for example, to anchor consumers). The IPRE would provide technical assistance to local entrepreneurs.

Approach

REEP is structured in two phases based on the level of financing confirmed and the activities required to establish a program. Given the risks associated with country conditions and the use of new technologies/business models, Phase I will rely mostly on public sector investments, and will aim to establish the business framework and provide the experience to attract other development partners and private investment during Phase II.

Design Criteria

Due to the limited information available on energy demand and supply resources, several program design decisions will be made during project preparation and implementation, in line with the following criteria:

- An area-based electricity service delivery model will be used where possible to facilitate sustainable and cost-effective O&M, as well as management services to provide consumer-responsive services. Concentrating such services in a small area (say, a 20–30 km radius) will reduce costs and achieve more efficient service delivery.
- System load sizing and profile will be determined by consumer surveys to establish priority needs and expected usage patterns by consumer category, considering the electricity-efficient appliances appropriate and affordable in rural areas.
- RREA (with MLME and LEC) guidance will set service and safety standards, technical specifications and tariff policy. Environmental and social safeguards will comply with MDB-agreed frameworks. RREA will competitively and transparently tender and award projects to private firms or NGOs.
- An affordable tariff structure based on consumers' ability and willingness to pay will be offered. Poorer consumers will benefit from structured tariffs, including life-line rates for the poorest. Revenues and results-based financing must recover all recurrent costs, including operation and maintenance, fuel, contributions to a sinking fund for major repairs, and a reasonable return on equity. Partial-capital investment-grant financing will be used to reduce debt and equity to levels that will permit an affordable tariff to be charged. Based on progress, grants will gradually decline.

- A public–private partnership financing model with government support in the form of partial-capital grant cofinancing will attract private firms and NGOs to invest in and provide electricity services. Special attention will be paid to encouraging local firms/NGOs to provide electricity services.
- Results-based financing will help keep tariffs affordable and supplement revenues for debt servicing, for the first five or six years. Debt servicing flows will go to REFUND to finance later projects.

Main program components

The REEP will be composed of four major activities to mainstream off-grid electrification approaches using renewable energy mini-grids and stand-alone systems. The REEP is also structured in two phases based on the level of financing available, sources of financing and the steps required to establish a sustainable program. Given the risks associated with country conditions and the use of new technologies and untested business models, Phase I will rely mostly on public investment. Phase I will develop the business framework and strengthen institutions, and provide the necessary demonstration experience to attract other development partners and greater private investment during the Phase II

Phase I

This first phase—expected to be executed within four or five years—has the following activities to mainstream off-grid electrification.

Task 1. Development of Rules and Regulations. These include standard or model legal agreements and contracts; legal requirements for corporations that will build, own and operate the mini-grids; service and safety standards; methodology for tariff setting; licensing/approval procedures; guidelines for project development and implementation; and customer rights and obligations.

Task 2. Preparation of Electrification Projects. RREA will contract for and set up a Transaction Advisory Services Facility that will provide support for preparing prefeasibility studies, bidding documents, financial plans, legal agreements, and approvals, including land acquisition. For projects on private/concession lands, the Facility could provide similar services, or RREA will offer cost-shared preinvestment funding for project development. The Facility will support RREA in supervision and training activities. This task will likely also benefit Phase II projects.

Task 3. Mini-grid and Stand-alone Solar PV projects. REFUND will provide financing to develop these projects. It is expected that six projects of each type will be financed to benefit nearly 240,000 people. While stand-alone systems could be bid for independently from mini-grids, they will be part of a single electrification package where the anchor is the mini-grid providing electricity to customers that can be technically and cost-effectively reached by the network. The anchor will provide support to the stand-alone system to guarantee operational sustainability. Depending on the ownership structure, either RREA or the private company that holds the concession will award contracts, including those for supervision and oversight services.

Task 4. Promoting Productive Uses of Electricity and Other Technical Assistance. RREA will provide program management; renewable energy resource assessments; training and capacity-

building services (for project O&M, for example); and additional regulatory, planning, policy support, and monitoring and evaluation capacity building. RREA will also promote productive uses of electricity to raise income generation potential in the community and to increase utilization of available electricity. Targeted activities will also include gender-disaggregated surveys and consultations to better understand the barriers women may face (financial, information or physical) in accessing energy services or in participating in the energy services value/production chain, and to foster productive uses of these energy services among women and small business owners.

Phase II

With the following activities, Phase II will see additional project investments drawing on program experience and the certainties provided by the framework of regulation, which would enable private participation.

Task 2-II. Preparation of Electrification Projects. The Transaction Advisory Services Facility can be extended (based on performance in Phase I and specific project needs).

Task 3-II. Mini-grid and Stand-alone Solar PV projects. At least another three mini-grids and three stand-alone solar systems are expected to require financing to benefit nearly 120,000 people (depending on the results of Phase I and financing to hand).

Activities supported by MDBs seeking programmatic approach.

In order to avoid duplication of efforts and increase efficiency, the GoL has requested the MDBs to take the lead on some of these tasks to the benefit of the program – especially for "soft" investment. The division of work agreed is:

Tasks	World Bank	AfDB
Task 1.Developing rules and regulations.	Lead agency	AfDB will provide additional support through the African Legal Support Facility and Sustainable Energy Fund for Africa as needed
Task 2. Contracting and setting up a Transaction Advisory Services Facility	Lead agency	AfDB will provide additional support as needed through the African Legal Support Facility
Task 4. Minigrid electrification investments	Regional approach	Regional approach
Task 4. Promotion of productive uses of electricity and other technical assistance	WB will provide additional support as needed	Lead Agency

Indicative Project Portfolio

A portfolio of nine mini-grid projects and nine stand-alone solar PV projects is thus considered (Table 5.1).[21] For this exercise, Phase I includes projects that would be financed through confirmed SREP resources. Phase II would be made possible through additional financing leveraged by SREP.

Table 5.1 Portfolio of Projects

Supply Options		Hydro	Solar	Biomass	Cost per Project	Total Cost
	Number	Capacity (kW)			Cost ($ million)	
Phase I						
Small hydro	3	1,000	-	-	12.9	38.8
Small hydro–solar PV	2	1,000	500	-	14.6	29.2
Biomass–small hydro	1	1,000	-	1,000	15.9	15.9
Stand-alone solar PV	6	-	800	-	1.6	9.6
Phase II						
Small hydro	1	1,000	-	-	12.9	12.9
Small hydro–solar PV	1	1,000	500	-	14.6	14.6
Biomass	1	-	-	1,000	8.3	8.3
Stand-alone solar PV	3	-	600	-	2.4	7.2
Total	18	5,000	2,400	2,000		136.6

Note: Total cost components might not sum to total due to rounding.

Source: RREA

Financial Viability

The projects will have capital grants as well as access to low-cost credit and results-based financing. Financing instruments under SREP are expected to mitigate the risks in leveraging commercial investments and in attracting private capital. Financing structures, payment terms and tariffs will be tailored to specific project requirements.

An analysis carried out under the IPRE for a hypothetical supply option—a configuration of renewable energy sources to meet a community demand of 8,000 kWh/day—reached two conclusions for the independent power producer business model (a private company or joint ownership under public–private partnership arrangements).[22]First, because consumer

[21] The size and cost of these projects are based on HOMER (Hybrid Optimization Modeling Software) analysis to meet demand of 8,000 kWh a day, with a peak coincident demand of 800 kW. Hydro, solar and biomass resource availability is based on representative Liberian conditions. Projects will vary in size and configuration depending on characteristics of demand and local renewable energy resources.

[22] For an equity contribution of 25 percent, while RREA would offer a grant as well as access to credit financing.

willingness to pay is limited, additional time-bound, results-based financing (such as the Energy+ Facility) would be needed. Second, the contribution of results-based financing for six years could help support an electrification program with a tariff, permitting a debt service coverage ratio of 1.2, while achieving a reasonable return on equity.

Indicative Program Outcomes

Indicative outcomes are shown in Table 5.2. (Actual outcomes will be based on the projects developed.)

Table 5.2 Indicative Program Outcomes

Physical Outcomes	Phase I	Phase II	Program	Comments
Number of projects funded	12	6	18	Number of projects is indicative
Mini-grids	6	3	9	
Stand-alone solar PV	6	3	9	
Renewable energy capacity added	8.8	5.1	13.9	MW
Persons benefiting	240,000	120,000	360,000	
Share of national population benefiting (percent)	**6**	**3**	**9**	
Total electricity supplied	18,542	9,527	28,069	MWh/year
Cost effectiveness (US$/kWh)	0.375	0.359	0.370	US$/kWh versus diesel generation at $0.552/kWh
Diesel potentially offset	8,416	4,323	12,740	m^3/year (assuming diesel is offset)
Value of diesel offset	8.42	4.32	12.74	Millions of US$ per year at US$1/liter
Potential CO_2 emissions avoided	22,500	11,560	34,060	Tons CO_2/year (assuming diesel is displaced)

Source: RREA

Program Co-benefits

The IPRE will have a direct, positive impact on Liberian living conditions and economic productivity, helping to reduce poverty and GHG emissions. The IPRE will bring the following co-benefits to local communities:

- **Enhanced energy security**. Scaling up renewable energies will diversify the energy mix, helping reduce dependence on imported fossil fuels, and hence enhancing the security of energy supply in the country.
- **Improved access to electricity**. Hybrid mini-grids and stand-alone solar PV will increase access to electricity in isolated areas where the grid is not expected to reach in the short term. It will also ensure that a renewable energy delivery infrastructure is established before diesel generation becomes standard.
- **Capacity building**. SREP activities will build and sustain management and technical skills within rural communities.
- **Job creation and income generation.** The IPRE will maximize economic development opportunities, including new activities that create jobs and raise incomes, especially in rural towns.
- **Improved quality of life in rural areas.** Household and institutional access to electricity in rural communities can lead to better education, health and public security, especially for women and children.
- **Improved gender equality and women's socioeconomic status**. IPRE initiatives will improve women's access to productive uses of electricity, and reduce women's barriers to information and training options for new energy services and technology.
- **Support for decentralization** (in that SREP will contribute to technical, institutional and financial mechanisms to facilitate transfer of responsibilities to local governments and communities).
- **Improved access to communications.** Increased access to electricity will boost use of communications through mobile phones, televisions, and the internet, improving access to information and empowering local communities.
- **Others.** The reduction of kerosene and wood fuel consumed by households will reduce indoor pollution. Increased access to electricity will improve security and safety, transforming life in rural areas.

Management and Implementation Framework

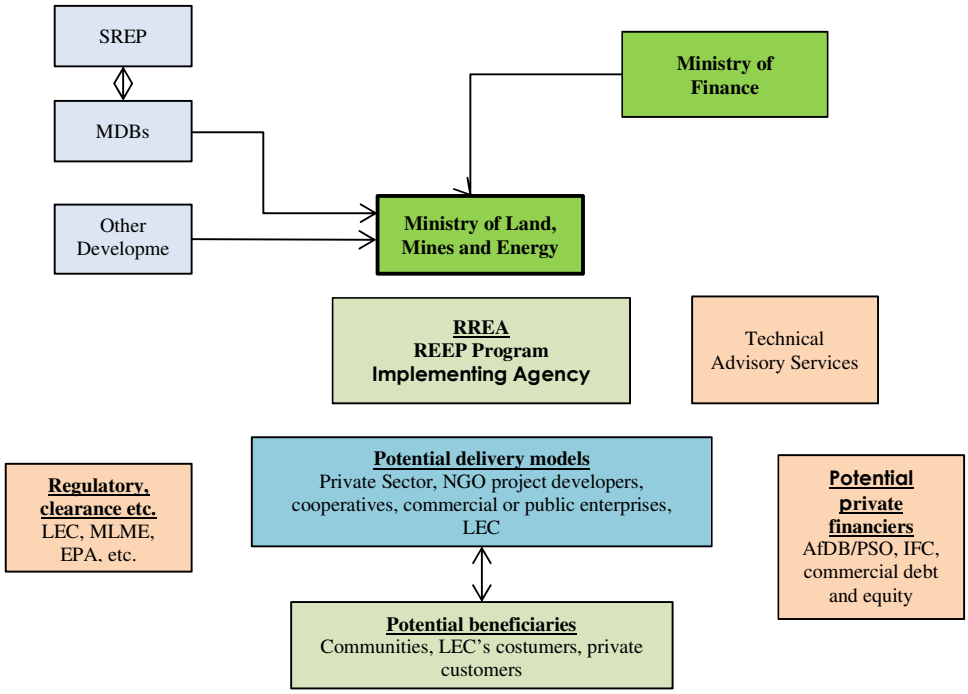
Role of the government. The MLME will ensure that all initiatives related to energy—including REEP—are aligned with the government's objectives in supporting access. RREA will be the implementing agency of REEP and will be supported by the Transaction Advisory Services Facility for preparing and implementing projects.

RREA will be responsible for program management and oversight. Specifically the MLME, with the technical arm RREA, will be responsible for selecting communities to be electrified (on the basis of national priorities and preidentified criteria), supporting project preparation, assisting in organizational arrangements for project O&M, coordinating donor support, financing capital investments with development partners and ensuring both that consumers receive acceptable quality services at affordable prices and that service providers meet their obligations.

Development partners. The key development partners are the AfDB, the World Bank, the International Energy and Climate Initiative Energy+ and the EU. Their role is to provide financing, offer guidance and supervise implementation. As REFUND is not permitted to provide debt financing, it is expected to enlist a commercial bank through a fee-based trust. The trustee bank will administer the debt funds for project investments. Grant financing could also be coursed through the trustee bank if necessary.

Further analysis will be carried out at the preparation phase to look at potential partners to implement the projects, particularly those which could be interconnected to LEC. Depending on the modalities described above, close collaboration is expected between RREA and LEC on projects that will be connected to the LEC grid.

Figure 5.2 Implementation Arrangements



Source: RREA

Role of communities. According to the business model for each site, cooperatives and communities will play a direct role in implementing the program, potentially supported by NGOs.

Role of the private sector. Although little private investment is foreseen during Phase I, the private sector will be present in the IPRE. It will play a key role in implementing components of the program, mainly through O&M services and subcontracting and consulting on feasibility studies, and on engineering and construction works. International expertise will have to be tapped, given the low level of capacity of the local private sector. SREP investments will make all efforts possible to facilitate technology and knowledge transfer from international private operators to local private operators.

Role of women. Acknowledging the role that women play in African rural areas in development, REEP will work to increase women's empowerment through gender-friendly activities.

6. FINANCING PLAN

To benefit around 360,000 people, based on the indicative supply configurations and analyses presented above for Phases I and II, the total funds required are estimated at US$178.5 million (Table 6.1). Considering Liberia's fragility, the government wishes to request the total SREP allocation in grants.

Phase I, which considers the mobilization of US$121.0 million, includes the full amount of SREP resources plus certain or likely financing sources. Besides SREP's US$50 million, AfDB is expected to provide US$13 million (including ADF13, the EU–Africa Trust Fund and the Sustainable Energy Fund for Africa) and the World Bank[23] US$10 million.[24] Funding from other development partners of about US$6.8 million is required during Phase I, primarily to finance the REFUND debt facility. The developers would be expected to contribute about US$12.8 million in equity while consumers would pay nearly US$6.4 million for their connections.

Funding from Norway Energy+ for results-based financing for the first six years of operation of the mini-grid facilities is estimated at US$18 million to supplement revenues and help debt servicing of Phase I, with another US$1.5 million sought for technical assistance.

During Phase I, SREP funds will be allocated in equal quantities to the World Bank and AfDB. SREP funds are primarily used for investment, with US$1.5 million each allocated to the World Bank and AfDB for the project preparation grant (Annexes 8 and 9). The US$2 million for the Transaction Advisory Services Facility will be funded in equal parts by SREP and the World Bank and executed by the World Bank. The other technical assistance will be executed by AfDB, including for programmatic M&E and knowledge-management activities.

Phase II considers the mobilization of an additional US$57.5 million. The implementation of Phase I, which will help overcome barriers to the development of mini-grids—through testing business models and putting in place the required legal and regulatory framework with support from the Transaction Advisory Services Facility—will leverage additional financing from other development partners as well as future investments. SREP funds are leveraged 2.6:1 from other sources.

Cofinancing is tentative and will be confirmed during project preparation. The government understands that these requests are subject to confirmation by the management of the MDBs and development partners. The financing modalities of the projects to be supported will primarily be grants and concessional loans, given the country's fragility. The modalities will be determined during project preparation, in accordance with relevant SREP guidelines and MDB procedures. The financing instruments selected will ensure that by lowering capital investment costs to the beneficiaries, electricity services can be provided at lower cost, while ensuring that beneficiaries bear the recurrent costs for fuel purchases and O&M.

[23] The International Development Association (IDA) allocation is indicative and will depend on the following IDA replenishment cycle. IDA envelop for Liberia is small compared to the needs of the country. In order to male more efficient the use of IDA resources, the government is requesting IDA funds to be allocated for transmission and distribution investments. However, the World Bank will additionally mobilize and rely on Sustainable Energy for All and the Public-Private Infrastructure Advisory Facility renewable-window funds to support the expansion of access to modern energy, establish planning functions at MLME, develop policy and regulatory frameworks, and mobilize investments for scaling up and accelerating energy-access programs

[24] Includes mobilized resources from dedicated trust funds.

Table 6.1 Indicative Financing Plan (US$ million)

Components	SREP	AfDB[a]	World Bank	NOR Energy+ TA	Other Partners TBD	Private Equity TBD	Govt. of Liberia	Customer Connections	Investment & TA Total	Energy+ Results-based Payment	Other Results-based Financing	Total
Phase I	**50.0**	**13.0**	**10.0**	**1.5**	**6.8**	**12.8**	**2.5**	**6.4**	**103.0**	**18.0**		**121.0**
Project Preparation Grant	**1.0**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1.0**	-	-	**1.0**
Investment Phase I	**46.5**	**12.5**	**8.5**	**-**	**6.8**	**12.8**	**-**	**6.4**	**93.5**	18.0	-	**111.5**
Investments—Phase I Mini-grids	*41.7*	*12.5*	*8.5*	-	*6.8*	*12.8*	-	*1.6*	*83.9*	*18.0*	-	*101.9*
Investments—Phase I Stand-alone PV	*4.8*	-	-	-	-	-	-	*4.8*	*9.6*	-	-	*9.6*
Technical Assistance	**2.5**	**0.5**	**1.5**	**1.5**	**-**	**-**	**2.5**	**-**	**8.5**	**-**	-	**8.5**
Transaction Advisory Services	*1.0*	-	*1.0*	-	-	-	-	-	*2.0*	-	-	*2.0*
Renewable Resource Assessment	-	-	-	*0.5*	-	-	-	-	*0.5*	-	-	*0.5*
Regulatory/Policy Support	-	-	*0.5*	*0.5*	-	-	-	-	*1.0*	-	-	*1.0*
Training & Capacity Building	*0.5*	*0.5*	-	*0.5*	-	-	-	-	*1.5*	-	-	*1.5*
Knowledge Management—M&E	*0.5*	-	-	-	-	-	-	-	*0.5*	-	-	*0.5*
Program Management	*0.5*	-	-	-	-	-	*2.5*	-	*3.0*	-	-	*3.0*
Phase II	**-**	**-**	**-**	**-**	**32.5**	**6.1**	**-**	**4.4**	**43.1**	**-**	**14.4**	**57.5**

Investments—Phase II Mini-grids	-	-	-	-	*28.9*	*6.1*	-	*4.4*	*35.9*	-	*14.4*	*50.3*
Investments—Phase II Stand-alone PV	-	-	-	-	*3.6*	-	-	*3.6*	*7.2*	-	-	*7.2*
Total	**50.0**	**13.0**	**10.0**	**1.5**	**39.3**	**18.9**	**2.5**	**10.8**	**146.1**	**18.0**	**14.4**	**178.5**

a. AfDB allocation includes concessional loans from ADF13 (about US$10 million to be confirmed), as well as funds from various Trust Funds including the EU-Africa Trust Fund and the Sustainable Energy Fund for Africa. International Development Association (IDA) allocation is indicative and will depend on the following IDA replenishment cycle. It is expected to be supported by additional Trust Funds currently targeting Liberia for renewable energy sources.

TA = technical assistance.

Source: RREA

7. Environmental and Social Framework for Energy Sector Development

The overall responsibility for overseeing the program is with the MLME, which has recently increased its environmental capacity by recruiting an environmental expert under the Liberia Accelerated Electricity Expansion Project. This expert will be the liaison between the ministry and the implementing agencies LEC and RREA. These agencies will be responsible for day-to-day operations and for implementing environmental and social safeguards.

Environmental and Social Management Framework

As specific investment locations will be determined during project design, an Environmental and Social Management Framework will be prepared for the subprogram supported by the World Bank, and a Strategic Environmental and Social Assessment for the subprogram supported by AfDB. Environmental and social specialists from the World Bank and AfDB will explore options for a joint nationwide assessment that can meet the requirements of both MDBs and the government. These frameworks define the environmental and social planning (screening of subprojects), review and clearing process that follows national legislation and MDB safeguard policies.

Resettlement Policy Framework

A Resettlement Policy Framework will establish the modalities for conducting subsequent resettlement action plans (RAPs) as necessary once exact intervention locations are known. The framework will outline components that must be integrated with RAPs, such as a legal and institutional framework, eligibility criteria, methodology for asset valuations and mechanisms for stakeholder consultations and grievance redress.

Detailed Environmental and Social Studies

For each of the SREP subprojects, separate comprehensive environmental and social assessments will be undertaken. These assessments will include detailed studies to uncover the specific environmental and social impacts and corresponding mitigating measures for each subproject (Table 7.1). The detailed studies include an Environmental and Social Impact Assessment, an Environmental and Social Management Plan and an RAP. Stakeholder consultations must be undertaken throughout the project lifecycle and will guide study development. The detailed studies must adhere to Liberian laws and regulations as well as MDB environmental and social safeguard policies. Additional, specialized environmental and social management plans and/or initiatives may also be required to address impacts associated with a given subproject.

Responsibilities

Subproject operators are responsible for compliance with national law and regulations and the MDB safeguard policies, guidelines and standards. These operators are also responsible for preparing the required detailed studies; obtaining clearances; implementing all required mitigation and monitoring measures; conducting monitoring activities; providing adequate budgets to sustain mitigation and monitoring activities; and complying with any directives issued by relevant parties. LEC and RREA have overall responsibility for implementing the environmental and social frameworks and any specialized management plans and/or initiatives.

Stakeholder Consultations

In preparing the detailed studies, the subproject operators must adhere to the requirements for ensuring participatory stakeholder consultations. Project-affected people and other critical stakeholders must be informed and consulted about the nature, timing and scope of the relevant project impacts and the mitigation measures. Participatory approaches must be used in organizing and conducting the consultations. Gender considerations must also be factored in, given the opportunities in improving women's access to lower-cost and cleaner energy while reducing the time that women and girls spend on fire wood collection and improving income-generating opportunities. Consultations will also feed into the design of a grievance-redress mechanism.

Table 7.1 Impacts and Mitigation Measures

Impact	Solar PV	Mini-hydro	Biomass
Environmental—construction and operation	• Construction waste and noise • Disposal of components at end of life (batteries, PV panels, inverters)	• Water flow disruption and diversion causing loss of aquatic habitat • Disturbance to the sediment flow • Increased sediment load during construction phase • Disturbance of traditional water usage • There might be some deforestation /destruction of vegetation and river/soil erosion • Temporary construction dust, noise and waste • Petroleum products associated with equipment maintenance (hydraulic fluids, oil, solvents) are used in small quantities. Spills damage aquatic organisms	• Air emissions (incl. NOx, SO_2, carbon monoxide, particulate matter) • Loss of soil fertility and soil organic matter • Construction dust, noise and waste • Ash management
Social	• Reduced fossil fuel-based power generation and reduced dependency on fuel import costs • Increased community resilience to change in fuel prices • Encouraging productive energy use in rural areas • Improving women's access to energy and reducing their work on fuelwood collection	• Reduced fossil fuel-based power generation and reduced dependency on fuel import costs • Increased community resilience to change in fuel prices • Encouraging productive energy use in rural areas • Possibility of land acquisition and/or restriction of access to resources and subsequent resettlement • Improving women's access to energy and reducing their work on fuelwood collection	• Reduced fossil fuel-based power generation and reduced dependency on fuel import costs • Increased community resilience to change in fuel prices • Encouraging productive energy use in rural areas • Loss of soil fertility may impact crop yields and household revenue/food security • Improving women's access to energy and reducing their work on fuelwood collection

Mitigation measure	Solar PV	Mini-hydro	Biomass
Environmental	• Proper disposal of construction waste • To minimize adverse social impacts, employ local populations during project construction and operation stage • Proper siting decisions can help prevent aesthetic impacts to the landscape. Siting decisions will be taken in consultation with all local stakeholders • Good construction management practices in place that reduce negative environmental impacts • Arrange for safe disposal of solar panels and batteries on decommissioning and replacement	• Excavation should be done in dry season and river bank vegetation should be restored to mitigate river bank erosion • Proper disposal of construction waste • To minimize adverse social impacts, employ local populations during project construction and operation stage • Good construction management practices in place that reduce negative environmental impacts, including risk of chemical spills	• Best practice of air pollution control • Leave portion of biomass to reduce soil fertility loss • Proper disposal of construction waste • Acceptable disposal site in place for ash disposal • To minimize adverse social impacts, employ local populations during project construction and operation stage • Good construction management practices in place that reduce negative environmental impacts, including risk of chemical spills
Social	• Maintaining site cleanliness during construction • Carrying out work during acceptable hours of the day in consultation with households; contractor prepares schedule of activities and keeps public informed of schedule and any changes • Equipment and machinery kept in good condition to meet acceptable noise standards • Public complaint registration system	• Maintaining site cleanliness during construction • Conducting social and environmental impact assessment to identify potential impacts and prepare a mitigation plan (including a RAP for land acquisition or resettlement) • Assistance to communities in case of disturbance to livelihoods or access to resources • Carrying out work during acceptable hours of the day in consultation with households; contractor prepares schedule of activities and keeps public informed of schedule and any changes • Equipment and machinery kept in good condition to meet acceptable noise standards • Public complaint registration system	• Maintaining site cleanliness during construction • Carrying out work during acceptable hours of the day in consultation with households; contractor prepares schedule of activities and keeps public informed of schedule and any changes • Equipment and machinery kept in good condition to meet acceptable noise standards • Public complaint registration system

Source: RREA

8. MONITORING AND EVALUATION FRAMEWORK AND KNOWLEDGE MANAGEMENT

Monitoring and Evaluation

The IPRE will closely coordinate MLME and the national statistical agency. The M&E framework will respond to country needs to track the results in the energy sector and will try to align the monitoring requirements of SREP, MDB projects, Energy+, Sustainable Energy for All, and others. It is expected that the M&E information will feed the electricity sector's planning process to support policy and investment decisions.

The ministry's M&E capabilities are at a very early stage of development. Nor is there a sectorwide consolidated tracking system. The IPRE will support an M&E system to collect, analyze, process and communicate key information related to program activities, as well as results, impacts and lessons learned. Based on consultations and gender-specific analysis, the IPRE will develop a practical gender-related indicator that can track the activities and impacts on women's lives. IPRE investment in M&E activities will harmonize with the national system. Resources provided under the IPRE will complement existing MLME-supporting programs funded by USAID, the Norwegian Water and Energy Directorate and the World Bank.

MLME—the ministry with statutory oversight of the energy sector—will be the coordinator/focal point for the SREP M&E system. Table 8.1 summarizes the proposed SREP M&E results framework, which is in line with the program's expected outcomes.

During project preparation, AfDB will take the lead in designing the M&E manual and system for the overall SREP program, the objective being to have an operational framework once project implementation starts.

Knowledge Management

Information sharing and lesson exchange are critical for informed decisions when designing and executing renewable energy investments. IPRE will support an Information Sharing and Lessons Learning component to enable energy stakeholders to build on existing experience, lessons learned and best practices while implementing renewable energy projects. The programmatic ISL component of the IPRE will be prepared and executed within the AfDB-supported project; however, each of the two MDBs-supported projects will have some capacity building activities embeded in them. This component will aim to:

- Enable production and dissemination of information among renewable energy stakeholders and partners to support capacity building and awareness creation.
- Improve communication and awareness rising on IPRE results and achievements, but also on key related issues such as electricity theft.
- Strengthen flow of communication on renewable energy in Liberia and with neighboring countries to share success stories.
- Increase capacity of relevant stakeholders to design better renewable energy investments.
- Enhance visibility of scaled-up renewable energy efforts in Liberia and additional funding mobilized for renewable energy.
- Facilitate technology transfer in order to build capacity of the local private operators and service providers to increase their competitiveness and ability to respond to demand.

As the business and delivery models tested under Phase I will provide lessons that will be used under Phase II to scale up the most efficient investment schemes, the Information Sharing and Lessons Learning component will increase successful development of renewable energy rural electrification in Phase II. It will also consolidate and disseminate information to address the lack of reliable data/information on renewable energy.

The IPRE will support development of local energy expertise to facilitate replication and scaling up of good energy practices. The capacity-building program will strive for inclusiveness and consider strengthening capacity of a wide array of energy sector stakeholders at different levels, including the private sector, government agencies and ministries, civil society organizations and local communities.

Table 8.1 Proposed SREP M&E Results Framework

Result	Indicators	Baseline	Targets by 2020	Means of Verification
SREP Transformative Impacts				
Support for low-carbon development pathways by reducing energy poverty and/or increasing energy security	National measure of energy poverty.	MEPI = no information available Electricity used in 2012: 384 kWh per household per year	MEPI = This will be calculated based on the M&E component Electricity used (based on electricity demand forecasts): 800–1,300 kWh per household per year[a]	Country-based reporting using household survey data, MLME
	Electricity output from renewables in GWh per year	0 GWh per year as of 2012	438,000 MWh per year	LEC and MLME
	Increased annual public and private investments (US$) in targeted subsector(s) per country	$0 million as of 2012	$178.5 million beyond the baseline	National M&E system
SREP Program Outcomes				
Increased supply of renewable energy	Increased annual electricity output (GWh) as a result of SREP interventions	0 GWh per year	28,069 MWh/year	SREP project M&E systems
	Averted GHG emissions (tons CO_2e per GWh) as a result of SREP interventions	0	34,060 tons CO_2e per year once SREP projects are operational[b]	SREP project M&E systems
Increased access to modern energy services	Increased number of women, men, businesses and community services benefiting from improved access to	0	360,000 (9 percent of the population as of 2013)	SREP project M&E systems

Result	Indicators	Baseline	Targets by 2020	Means of Verification
	electricity due to SREP interventions			
New and additional resources for renewable energy projects	Leverage factor: US$ financing from other sources compared with SREP funding	0	Other financing to SREP financing: 1:2.6	SREP project M&E systems
Improved macroeconomic/fiscal situation and policy framework	Quantity of diesel avoided	0	11,935 million liters per year	Government M&E framework
	Amount of subsidy provided to public utilities for diesel relative to 2012 subsidy	0	No subsidy provided for diesel-based generation	
	Number of elements of the regulatory framework in place that incentivize private operators to invest in the subsector (standard power purchase agreements, and the like)	0	At least two elements of the regulatory framework are in place	

MEPI = Multidimensional Energy Poverty Index.

a. Specific consumption for off-grid households is estimated at 216 kWh per year according to the Least Cost Power Development Plan.

b. According to Document SREP/SC.8/4 on the SREP Revised Results Framework, a proxy-based method (emission equivalent based on diesel-generated electricity: 793.7 tons CO_2e per GWh) has been used to measure the co-benefit of averted GHG emissions.

Source: RREA

9. RISK ANALYSIS

The overall implementation risk is moderate/high, summarized along legal, regulatory, institutional, technology, environmental, social and financial lines in Table 9.1.

Table 9.1 Program Risk Assessment

Risk	Description/Mitigation	Residual Risk
Legal and regulatory risks	A comprehensive legal and regulatory framework has yet to be established. There is no regulatory body or independent tariff-setting process. Further, there is uncertainty associated with the legality of power producers other than LEC. SREP will support the establishment of the required legal and regulatory framework as well as project design for mini-grids and off-grid projects (for example, required contractual agreements) until this framework is in place.	High
Institutional capacity risks (risks related to institutional capacity)	Energy sector institutions are weak. There is a lack of relevant knowledge and expertise in most aspects of the energy business. Implementing agency institutional capacity—including capacity to handle procurement, financial management and environmental and social safeguards—will be assessed before project appraisal and, where necessary, developed.	Moderate
Technology risks (risks related to technological complexity)	While technology for small hydropower and solar lighting projects is proven and less complex to handle, technology for hybrid mini-grids will require investment in technical expertise due to lack of local skills. Expertise in biomass power—though a mature and proven technology in some African countries—is lacking in Liberia and would have to be built. This risk will be partly mitigated by the capacity-building component to be supported under SREP and other development partners.	Moderate
Environmental risks (risks related to environmental impact)	In 2009 the government carried out a Sectoral Environmental Impact Assessment, which identified environmental policies that will be triggered by various sector investments. It also specified potential cumulative environmental and social impacts as well as possible mitigation measures.	Low
Social risks (risks related to social issues)	By providing affordable electricity to more people and improving the quality of supply, the project will promote greater economic growth and equity. Public consultations are a mandatory part of environmental impact assessments, which will also include social impact assessment. The National Environmental Management Authority makes available all draft environmental assessments and provides the public 40 days for feedback. The project proponent's addressing of feedback is a condition for approving environmental assessments. Appropriate social development measures will be incorporated in project design.	Low

Risk	Description/Mitigation	Residual Risk
Financial risks (risks related to financial viability of the sector/entities)	The electricity sector is financially dependent on donor contributions, but this is expected to change as more clients receive quality energy and can pay the cost of operations and some of the investments. The standardized power purchase arrangements will also provide more certainty to financiers. However, successful business models for small hydropower projects, hybrid mini-grids and solar lighting systems will require a well-balanced program of grants and subsidies—tailored to each case—that guarantees their financial sustainability while incorporating incentives for quality service.	High
Private sector participation/investment climate	Perception of country risk, the absence of an adequate legal and regulatory framework, the use of technologies new to the country and too few local entrepreneurs are substantive constraints in mobilizing private investors. SREP will help create an enabling environment for investments by supporting the required legal and regulatory framework, the preparation and grant financing of projects and the use and testing of diverse business delivery models that will help attract investors.	High
Renewable resource uncertainty	Information on renewable energy resources is limited, but evidence indicates that hydropower, biomass and solar resources are available in the target regions. Project preparation supported by SREP will take special care in assessing the seasonal availability of hydropower resources and biomass, and design projects accordingly.	Moderate

Sources: RREA

ANNEX 1 DEVELOPMENT PARTNERS' SUPPORT FOR LIBERIA'S ENERGY SECTOR

Table A1.1 Development Activities in the Energy Sector

Area	Generation	Transmission	Distribution	Rural electrification/ renewable energy	Planning	Capacity building/institutional strengthening	Legal and regulatory framework
Completed	• 3 MW Diesel at Bushrod, Norway • 6 MW Diesel at Bushrod, USAID	• Monrovia network circuit 66 kV, EU	• Connections in Monrovia, 22 kV, 15,000 households as part of MC, Norway, WB	• PV installation at 19 schools, clinics and public building, USAID	• Option study, WB • LEC 5-year master plan • Gap Analysis, EU	• Training in planning, data gathering and data management to MLME, LEC, RREA and LIGSIS, WB	
Ongoing	• 10 MW HFO at Bushrod, WB • 18 MW HFO at Bushrod, government • 10 MW HFO at Bushrod, JICA • Rehabilitation of Mt. Coffee hydroelectric plant, 80 MW, Norway, KfW, EIB • Reconnaissance study of Via Reservoir ~30 MW,	• Regional interconnection/ WAPP CLSG 225 kV, WB, AFDB, EIB, KfW	• Connections in Monrovia, 22 kV, 18,000 households as part of MC, Norway, WB • Côte d'Ivoire Interconnection for connection of rural communities in Nimba, Grand Gedeh, and Maryland, 22 kV, 25,000 households, EU • Additional connection in Monrovia, Norway, USAID	• 60kW, 240 households, mini hydropower system in Lofa, WB • Commercial sale of 120,000 lighting products nationwide, WB • PV installation in public clinics nationwide, EU, MoH • Four pilots to create micro-grids in rural areas based on biomass and hydro	• Least Cost Power Development Plan, WB	• Support of management contract for LEC to improve performance and financial viability, Norway • 3-year on-the-job training program for LEC staff, WB, Norway • Institutional strengthening and capacity building to MLME, incl. gender aspects, 5-year program, Norway	• Preparation of a legal and regulatory framework incl. electricity law, Norway, USAID, WB

Area	Generation	Transmission	Distribution	Rural electrification/ renewable energy	Planning	Capacity building/institutional strengthening	Legal and regulatory framework
	EU			sources, USAID		• Upgrading of the national hydrometric network and database. Capacity building in hydro and biomass site identification, Norway	
Planned	• 1 MW PV at Bushrod, USAID • 10 MW HFO at Bushrod, Arab Bank • Rehabilitation of HFO storage and off-loading infrastructure, WB	• Monrovia–Kakata 66 kV, WB	• Connection along Monrovia-Kakata corridor and in Kakata city, WB	• PV installation in public buildings in Lofa, EU	• Rural Renewable Master Plan, EU		

Sources: RREA

ANNEX 2 ASSESSMENT OF ABSORPTIVE CAPACITY

Liberia's strong economic growth is driven by natural resource extraction; non-resource sector growth is constrained by insufficient energy and transportation infrastructure. Despite its limited capacity to implement large public sector projects, the government is taking steps to address bottlenecks in project management. With Heavily Indebted Poor Countries (HIPC) debt relief, the government can borrow for investment in priority projects.

Macroeconomic Performance and Prospects

Liberia's macroeconomic management has improved since armed conflict ceased in 2003, but challenges remain. Real GDP growth has been strong in recent years, reaching an estimated 8.3 percent in 2012 due to strong iron ore production, construction and service sector growth. FDI in mine construction, iron, rubber and timber exports will contribute to continued strong growth, although the concessions sector, particularly palm oil, timber and oil, has experienced governance challenges in the past year. But, as in the past, growth in these capital-intensive enclave sectors is unlikely to create substantial employment opportunities as they have limited linkages to the rest of the economy. Moreover, the country's reliance on primary exports, FDI and development aid make it vulnerable to external shocks.

Severely inadequate infrastructure constrains private sector growth outside of concession sectors, with potentially the highest electricity costs in the world (54 percent of business operating costs are attributable to energy costs), an energy access rate of around 2 percent, and a road network that is largely impassable during the rainy season. This is exacerbated by human capacity constraints, limited entrepreneurship development, poor protection of property rights and land tenure, an ineffective judiciary and limited access to finance, especially for the long term. Therefore, non-resource sector growth will depend on public investment in key infrastructure bottlenecks, in addition to further legal and institutional reforms.

Inflation has been contained in single digit levels since 2011, and was at 8.7 percent in April 2013. Monetary policy has had a reduced role in the economy due to extensive use of the US dollar, estimated at 75 percent of the money supply. Since May 2013 the Central Bank has issued, for the first time, both Treasury bills and Central Bank bills, expanding its policy tools beyond exchange rate interventions.

Debt Sustainability

A critical macroeconomic milestone for Liberia was reaching the HIPC Initiative completion point in June 2010, after which Liberia received around $4.6 billion in debt relief. Current public external debt is around 12 percent of GDP, and the risk of future debt distress is considered low. The current debt strategy limits annual debt increases to 4 percent of GDP (on a net present value basis), and imposes a total debt ceiling of 60 percent of GDP. Over the next three years, this allows the country to accrue from $300 million to $400 million in nominal debt (depending on concessionality level).

Fiscal Policy and Public Expenditure Effectiveness

Government expenditure has expanded rapidly from $200 million in FY2007/08 to $514 million in FY2011/12, but capital expenditure has been slow. Fiscal deficits were well contained within 2 percent of GDP up through FY2011/12, when overspending on operating activities led to an estimated 6 percent deficit, which was partially financed by the Central

Bank. Deficits are expected to continue in coming years as the government continues strong infrastructure investment, to be financed mostly by foreign concessional loans. Nonetheless, budget execution in the first half of FY2012/13 was weaker than expected, especially for capital spending. Various factors affected this performance, including delays in approving the budget, delays in securing and ratifying external financing, tying capital expenditure to contingent revenue that did not materialize, limited readiness of capital projects, and ongoing bottlenecks in procurement. While the government is under pressure to implement its Agenda for Transformation (AFT) for 2012–17 focusing on infrastructure—largely energy and roads—continued weaknesses in technical capacity, institutions and governance continue to test the government's plans. At the end of 2012, the government established a project management office at the Ministry of Finance, to help evaluate, select and monitor the implementation of priority projects.

Over the last three years the government has taken steps to improve economic governance, specifically in public financial management, to restore fiscal stability and increase transparency and accountability in public resource management. The government has passed key reforms, including the Public Financial Management Act, a revised Revenue Code, an amended Investment Code, and the Public Procurement and Concessions Act of 2005 (updated in 2010), but progress on implementation has been slowed by constraints in institutional and human capacity. The 2012 PEFA Assessment showed progress since 2007 in 12 of 30 indicators, particularly in revenue administration, arrears, debt management, procurement and accounts reconciliation, but 16 indicators were rated at "D" or "D+," including problems in budget and financial reporting, the extent of unreported government operations, weaknesses in internal and external auditing, effectiveness of tax collection, and donor reporting.

Energy Investment in the Agenda for Transformation

Improving energy access and lowering electricity tariffs are among the government's top priorities in its Agenda for Transformation for 2012–17. The government will rehabilitate the Mount Coffee Hydroelectric plant during the AFT, in addition to developing the transmission backbones for the West African Power Pool interconnection project. Publicly supplied energy access has increased from only 2,170 connections in July 2010 to 13,500 as of February 2013. The Liberia Electricity Corporation (LEC) expects connections to continue increasing, to around 90,000 by 2016, although this will still represent access for less than half of Monrovia. Electricity expansion and tariff reduction have been hampered by high losses—29.8 percent cumulative YTD as of March 2013. High rates of electricity theft are the largest contributor to losses; the incentive to steal electricity will only increase with lower tariffs, and can only be offset by area-based saturation of connections. Tariffs are expected to roughly halve once Mount Coffee comes online in early 2016.

Given the country's low level of existing debt, the government is planning substantial borrowing for energy and transportation infrastructure. It should therefore have some capacity to absorb financing for SREP investments, although there are substantial competing priorities. Human and institutional capacity constraints could also present a challenge for rapid program implementation, so SREP should include plans to support capacity development at the Ministry of Lands, Mines and Energy as well as RREA and LEC.

ANNEX 3 PRIORITIZATION OF SMALL HYDRO SITES

A desk review has been carried out based on the DECON (1983) and Geoscience (1998) analyses identifying 25 and 8 sites, respectively, with an overlap of two sites. The desk review's objective was to identify small hydro sites less than 10 MW to conduct prioritization analysis based on the following criteria:

- Proximity to load centers.
- Reliability of hydrological data.
- Flow duration curves (behavior of the river in the dry season).
- Available level of information for the project.
- Qualitative unit cost estimate.
- Possibility of alternative trans-border interconnection.

The review of 31 sites led to the selection of six initial sites as interesting and suitable for subsequent review for implementation. The review will be extended to the South East part of the country to identify interesting options based on recent information. The installed capacities for these six sites were evaluated based on preliminary hydrologic data (Table A3.1). An estimation of the cost of the proposed works, either civil or equipment, was made, applying a set of international unit costs expressed in US$ (Table A3.2). A prefeasibility analysis of the sites will be carried out, including four additional sites that are close to the larger demand centers. This will initiate a project pipeline for further development.

Table A3.1 Mini-hydro Plant Features and Energy Production

HYDROELECTRIC PLANT:	Units	ZELIBA	LOFA	YA CREEK	MR5	FR1	FARG.TON	TOTAL PLANTS
Weir operation level	m a.s.l.	458.00	502.00	327.00	524.00	94.00	8.00	
Tailrace average level	m a.s.l.	452.05	492.00	319.15	519.05	88.75	2.80	
Gross head	M	5.95	10.00	7.85	4.95	5.25	5.20	
TYPE OF TURBINE:		KAPLAN	KAPLAN	KAPLAN	KAPLAN	KAPLAN	KAPLAN	
Turbine maximum efficiency	Percent	92.0	92.0	92.0	92.0	92.0	92.0	
Number of installed units	N°	2	2	2	2	2	2	12
Total turbine discharge	m^3/s	25.00	42.00	25.00	15.00	18.00	50.00	175.00
Minimum limit of turbine operation	m^3/s	1.88	3.15	1.88	1.13	1.35	3.75	
Waterway maximum losses	M	2.06	2.40	1.88	2.55	3.68	3.37	
Installed capacity	**kW**	**1,160**	**3,370**	**1,580**	**550**	**670**	**1,860**	**9,190**
Average yearly harnessed flow	m^3/s	18.31	23.94	14.46	10.38	10.81	45.78	123.68
95 percent duration flow	m^3/s	7.64	2.78	4.58	4.15	2.28	25.40	

HYDROELECTRIC PLANT:	Units	ZELIBA	LOFA	YA CREEK	MR5	FR1	FARG.TON	TOTAL PLANTS
Turbine volume per year	10*6 m3	577.73	755.62	456.39	327.49	340.99	1,444.76	3,902.97
Yearly average energy production	MWh	6,470	14,962	7,575	2,816	2,327	7,926	42,075
Energetic coefficient	kWh/m3	0.011	0.020	0.017	0.009	0.007	0.005	0.011
Plant utilization factor	Percent	63.6	50.6	54.7	58.4	39.6	48.6	52.2
Yearly hours of plant capacity	hours	5,577	4,440	4,794	5,119	3,474	4,261	4,578
HYDROELECTRIC PLANT:		ZELIBA	LOFA	YA CREEK	MR5	FR1	FARG.TON	
Length of power tunnel	m	220.00	635.00	130.00	790.00	790.00	1,780.00	
Average diameter of power tunnel	m	3.40	4.50	3.40	3.00	3.00	5.00	
Length of the penstock	m	12.00	15.00	12.00	12.00	12.00	12.00	
Average diameter of penstock	m	2.80	3.60	2.80	2.15	2.15	3.90	

Table A3.2 Estimated Costs of Proposed Works

SUMMARY OF PLANTS EVALUATIONS	TOTAL PLANT	ZELIBA	LOFA	YA CREEK	MR5	FR1	FAR.GTON
	US$ in thousand						
CIVIL WORKS							
DAM	6,709	803	1,757	1,012	517	1,018	1,601
SPILLWAY (included in the dam)	0	0	0	0	0	0	0
CARE OF WATER DURING DIVERSION	1,840	220	481	277	142	279	440
POWER INTAKE AND GATE SHAFT	1,519	163	449	246	117	136	409
POWER TUNNEL OR CHANNEL EQUIVALENT	14,224	584	2,414	381	1,516	1,541	7,787
PENSTOCK	105	15	23	17	10	16	23
POWERHOUSE	8,970	1,518	1,916	1,491	893	1,027	2,125
ELECTRIC SUBSTATION	110	17	25	19	13	15	22
TAILRACE TUNNEL	446	67	106	68	33	46	126
LAND ACQUISITION	98	12	23	12	12	12	29
ACCESS ROADS	3,938	669	894	818	445	890	223
TOTAL	**37,959**	**4,067**	**8,088**	**4,340**	**3,698**	**4,981**	**12,785**
	US$ in thousand						
ELECTROMECHANICAL WORKS							
SPILLWAY (included in the cam)	0	0	0	0	0	0	0
POWER INTAKE	1,801	190	480	244	165	170	552
PENSTOCK	423	68	88	68	52	52	95
POWERHOUSE	21,343	3,189	6,270	3,537	1,643	1,947	4,757
SUBSTATION & TRANSMISSION LINE	0	0	0	0	0	0	0
TOTAL	**23,567**	**3,447**	**6,838**	**3,850**	**1,860**	**2,170**	**5,403**
	US$ in thousand						
DIRECT COST OF CIVIL WORKS	37.96	4.07	8.09	4.34	3.70	4.98	12.78

SUMMARY OF PLANTS EVALUATIONS	TOTAL PLANT	ZELIBA	LOFA	YA CREEK	MR5	FR1	FAR.GTON
DIRECT COST OF EQUIPMENT	23.57	3.45	6.84	3.85	1.86	2.17	5.40
TOTAL DIRECT COST	**61.53**	**7.51**	**14.93**	**8.19**	**5.56**	**7.15**	**18.19**
ENGINEERING & ADMINISTRATION	4.31	0.53	1.04	0.57	0.39	0.50	1.27
INTERESTS DURING CONSTRUCTION	4.20	0.54	1.08	0.59	0.30	0.38	1.31
TOTAL CAPITAL COST	**70.04**	**8.58**	**17.05**	**9.35**	**6.24**	**8.03**	**20.77**
OPERATION & MAINTENANCE COSTS	0.38	0.04	0.08	0.04	0.04	0.05	0.13
RECOVERY CAPITAL FACTOR	4.44	0.54	1.08	0.59	0.40	0.51	1.32
TOTAL ANNUAL COST	5.29	0.65	1.30	0.71	0.47	0.60	1.55
INSTALLED CAPACITY COST	7,621.01	7,398.55	5,058.78	5,920.03	11,354.16	11,992.30	11,168.51
TOTAL COST OF ENERGY [US$ cent/kWh]	**0.126**	**0.1011**	**0.0868**	**0.0942**	**0.1670**	**0.2591**	**0.1960**

Note: The above levelized cost assumes 100 percent utilization of electricity produced from each renewable energy option. But a mini-grid project will be designed to meet the system's load profile. As an example, a small hydro mini-grid is different from a grid tied to small hydro. The latter is most likely to have plant factors of about 35–45 percent whereas a stand-alone small hydro feeding a mini-grid would need to have a plant factor in excess of 90 percent. **The above numbers are indicative and will be confirmed at project feasibility**.

Source: RREA

The installed capacity costs arrange from a minimum of $5,060 to a maximum of $12,000 per kW, with an average of $7,600 per kW. The cost of energy ranges from $0.086 to $0.259 per kWh, with an average equal to $0.126, but these values must be taken as preliminary until confirmation of renewable resources on each site and appropriate design maximizing the value of investments.

Next Steps

Site Survey

A brief site survey (approximately three days per site) for each of the six sites shall be carried out tentatively by a team of individual consultants and/or RREA or LEC staff including a hydropower expert, a local geologist and a local topographer. The team shall produce a brief report and sketches for each site. A later review of these reports and sketches may be necessary.

The Norwegian Water and Energy Directorate (NVE) has an ongoing program for strengthening MLME and RREA's capacities in eight programmatic areas. Renewable assessment assistance is carried out to build capacity on hydrology measurements to identify hydro potential. Eight young Liberian engineers have been trained over two years and have conducted measurements on four main rivers. Information will be made publicly available through a website at the hydrological center in Liberia. NVE and SREP agreed to collaborate on the assessment of hydrological resources for the identified sites under SREP. This collaboration will be critical for the prefeasibility and feasibility stages of SREP's investments.

Updating Hydrological Data

Only very limited updated hydrological data will be available for the last few years/months from Liberia's newly reestablished hydrological services. RREA/LEC staff may be involved in this activity.

Increasing the Level of Detail of Site Prioritization

It may be preferred to increase the level of detail of site prioritization, developing analysis of other sites to the same level as that of the six sites already analyzed. It would also be advisable to develop a small hydrologic study of eastern Liberia, where gauging stations are very limited and data for defining site potential very poor.

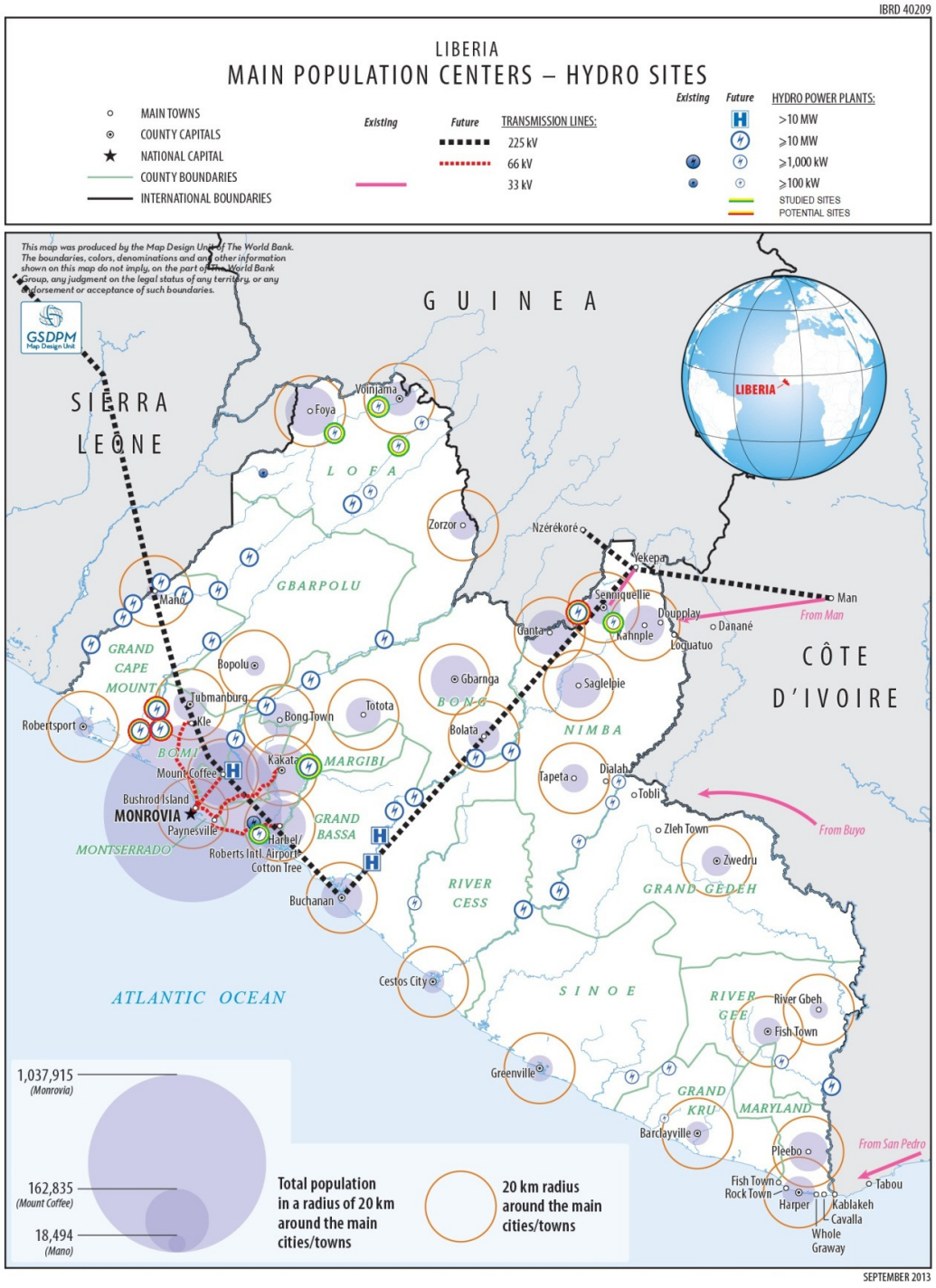
Terms of Reference for Six Feasibility Studies and Six Bidding Documents

The Terms of Reference for six feasibility studies and, after approval of the feasibility studies, six bidding documents will be prepared in parallel with the investment plan.

Site Location

Figure A3.1 presents the location of the potential sites in Liberia, including those sites that might be developed based on confirmation of the hydro resources and project economics.

Figure A3.1 Hydro Sites in Liberia's Main Population Centers



Source: RREA

ANNEX 4 RENEWABLE ENERGY PILOTS IN LIBERIA

	Name	Project description	Capacity	Location	Cost (US$m)	Financed by	Status	Grid-connected	Off-grid	
									Mini grid	Stand-alone solar
Biomass	Liberia Company Rubber Plantation	Feasibility study. COCOPA biomass project. Issues relating to concession continuity may delay project development in the immediate future.	3MW	Nimba County		USAID	Feasibility Completed		✓	
	Sorlumba Biomass Power Project	600 households, crude palm oil. Serve some of the 19 villages within 5 km of the project site identified by LESSP USAID-funded program	60kW	Sorlumba, Foya District, Lofa County		USAID	Feasibility Ongoing		✓	
	Buchanan Renewable (BR) Energy	Biomass energy plant using rubber wood chips. The Buchanan Renewables activities have wound down and as of May 2013 no activity is visible in Liberia. Commercial and technical terms not appropriate for development of the nascent power sector.	31-35MW	Kakata, Margibi County	170	BR, OPIC, Mr. McBain	Cancelled	✓		
Hydropower	Yandohun Micro-hydro Project	240 households, mini-hydropower system	60kW	Lofa County	0.47	WB	In operation since May 2013 Completed		✓	
	Firestone Plantation	Hydropower system. Private company providing self-supply to business operation and villages in their plantation.	4MW				In operation before the war Completed		✓	
	Wayavah Falls Micro Hydropower	Hydropower system	15kW	Wayavah falls Lofa County		USAID	Feasibility Ongoing		✓	
	Mein River	500 households and 250 commercial	1MW	Suakoko	5.8	USAID	Feasibility		✓	

	Name	Project description	Capacity	Location	Cost (US$m)	Financed by	Status	Grid-connected	Off-grid	
									Mini grid	Stand-alone solar
	Hydropower Project	consumers, hydropower system		District, Bong County			Ongoing			
	Installation of multipurpose mini-hydro infrastructure	Load centers: Ganta city, Sanniquellie town, Zuluyee town, Gbedein village, Kapawleh-Snoh village Project on hold due to lack of capacity in country to implement the project.	10MW	St John River, Gampa water falls, Garr Bain district, Nimba County	26	UNIDO	Technical Pre-Feasibility Analysis Completed		✓	
	Mt. Coffee Hydropower Plant	Rehabilitation on prewar HEPP	64–80MW and 20MW dry season	St. Paul River	230	Government, Norway, Germany, EIB	Procurement Ongoing	✓		
Solar	Liberia Energy Assistance Program (LEAP)	PV installation at 19 schools, clinics and public buildings.				USAID	Installation Completed			✓
	Renewable Energy for Health Care Facilities	PV installation in 205 public health facilities with support from RREA and implemented by Merlin NGO.	---	Nationwide	2	EU 75 percent, Ministry of Health 25 percent	Ongoing			✓
		PV installation in public buildings.		Lofa County		EU	Planned			✓
	LESSP Urban	PV installation to be implemented under LESSP project in 2013.	1MW	Bushrod	2.7	USAID	Planned	✓		
	Lighting Lives in	Market development for cost-effective	120,000	Nationwide	1.45	WB	Distribution			✓

	Name	Project description	Capacity	Location	Cost (US$m)	Financed by	Status	Grid-connected	Off-grid	
									Mini grid	Stand-alone solar
	Liberia	distribution of solar lanterns through private retailers.	units				Ongoing			

Source: RREA

ANNEX 5 ASSUMPTIONS AND ESTIMATES USED IN LEVELIZED COST ANALYSIS OF RENEWABLE ENERGY OPTIONS FOR LIBERIA

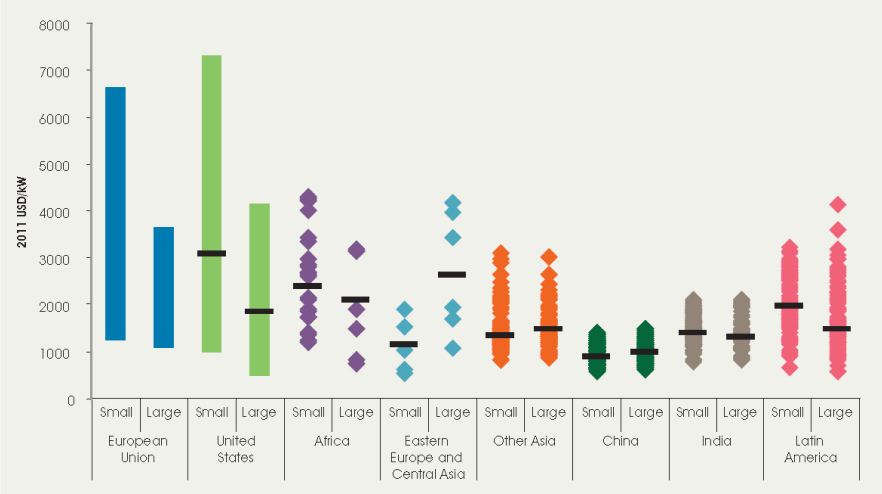
Primary sources of data is the series of reports issued by IRENA in June 2012 in their series, Renewable Energy Technologies: Cost Analysis Series, specifically reports for Biomass (Volume 1), Small Hydro (Volume 3), and Solar PV (Volume 4), and their overview report, Renewable Energy Power Generation Costs in 2012: An Overview. The IRENA data is from the renewable energy database that is compiling cost data from projects in various countries. Majority of the data is from China, India and Other Asia. Data from Africa countries is also included, but for a small share of the data.[25]

Other sources referenced included: data on micro and mini-hydro costs compiled by AfDB for a number of African Countries, primarily West African; cost estimates made by Winrock International in undertaking feasibility studies for a few small biomass and mini-hydro projects in Liberia; costs for the World Bank-assisted 60 kW Yandohun micro-hydro project in Lofa County, Liberia; stand-alone solar costs from Bangladesh. As costs in Liberia tend to be higher due to weak human capacities, difficult transport conditions, and difficult conditions for construction during the lengthy rainy season, costs estimates at the upper end of the ranges were used for estimating the levelized cost of renewable electricity or margins of about 50 percent higher was added to account for these Liberia-specific conditions.

Small Hydropower

The hydropower capital cost ranges are summarized below:

Figure A5.1 Hydro Cost Ranges



Source: IRENA Renewable Energy Cost Database.

[25] Reports can be downloaded from:
http://www.irena.org/Publications/ReportsPaper.aspx?mnu=cat&PriMenuID=36&CatID=141

Cost estimates compiled by AfDB for a range of African countries and reconnaissance level estimates prepared for specific sites by the World Bank as input to the preparation of the IPRE are given below:

Table A5.1 Range of Capital Costs for Small Hydro Projects in Various African Countries

Country	Small Hydro Capital Cost (US$ per kW			Average Size (kW)
	Maximum	Average	Minimum	
Bénin	8,606	6,229	2,625	140
Burundi	6,923	6,024	4,733	260
Cameroon	7,658	2,888	1,002	850
Congo	6,399	4,113	3,752	410
Gabon	18,244	4,465	3,591	140
Mali	14,788	8,499	3,505	60
RCA	16,854	6,249	4,238	525
RDC	4,762	3,345	2,128	385
Rwanda	7,768	5,314	4,086	130
Togo	8,644	6,812	5,620	75
Liberia	**11,985**	**8,812**	**5,059**	**1150**
Sources: All countries except Liberia from AfDB survey. Liberia based on reconnaissance level study undertaken during IPRE preparation by World Bank				

Operation and maintenance cost is estimated at about 1.5 percent of capital cost per annum.

Solar Photovoltaics

Grid-connected solar photovoltaic costs have been declining rapidly, especially for projects in India and China in the 10-100 MW scale projects due to scale economies, and module cost reductions due to overcapacity in module manufacturing. IRENA survey in 2012 compiled the following:

Figure A5.2 Total Installed Cost of Solar PV by Country and Sector

Source: IRENA Renewable Energy Cost Database.

Reportedly, the more recent bids in India for projects in the 100 MW range, costs as low as US$ 1.70 per Wp have been reported (note however, such low US dollar costs may be partly due to the significant depreciation of the Indian rupee against the US dollar that has taken place this year). In analyzing the installed cost of grid-tied solar PV for Liberia for projects in the 500 to 1000 kW range, an estimated cost of US$2700 per kW was assumed.

Small stand-alone PV systems are more expensive as they include a battery, are much smaller in size and are installed in dispersed households in rural areas. In Bangladesh, where 100,000 solar home systems are being installed monthly, the installed cost is now about US$ 8 per Wp. As the scale of business is much smaller in Liberia, and access is more difficult, a 50 percent higher cost, of US$ 12/Wp was assumed.

Biomass Power

Biomass power technologies are available in various configurations. Cost estimates compiled by IRENA are given below:

Table A5.2 Unit Capital Cost Ranges for Biomass Power Technologies

Technology	**Installed Cost per kW [US$/kW]**
Stoker boiler	1,880–4,260
Bubbling and circulating fluidized boiler	2,170–4,500
Fixed and fluidized bed gasifier	2,140–5,700
Stoker CHP	3,550–6,820

Gasifier CHP	5,570–6,545
Landfill gas	1,917–2,436
Digesters	2,574–6,104

Source: IRENA 2012.

The likely technologies for grid tied biomass power plants in Liberia would most likely be stoker boiler or circulating fluidized bed boilers with traditional steam turbines. For the smaller scale mini-grid applications, fixed or fluidized bed gasifiers with dual fuel reciprocating engine-generators will be used. The unit installed cost assumed for Liberia was US$ 3,000/kW. O&M cost of US$ 0.05 per kWh and a biomass fuel cost of US$ 50/ton was assumed.

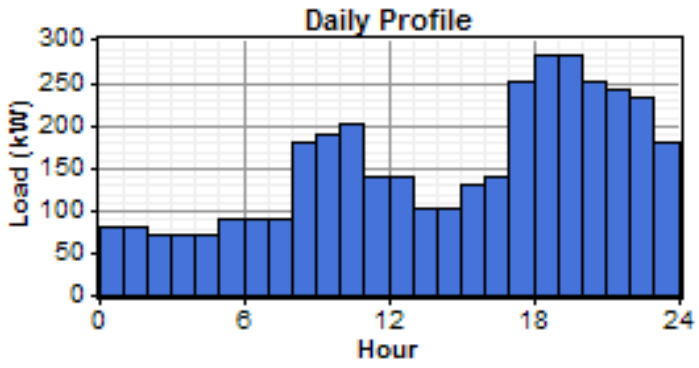
Diesel Generation

Installed cost of a diesel generator was assumed at US$ 2,000 a kW. Operation and maintenance cost was assumed at US$ 0.03 per kWh. Fuel cost was assumed at US$ 1 per liter. Specific fuel consumption varies with diesel loading.

Mini-grid Load Profile

A mini-grid load profile with a maximum peak load of about 470 kW and daily variation typical of groups of rural communities with about 2,000 customers comprising mainly of households as well as commercial, telecommunications and small industrial loads was assumed. The average load profile (it is allowed to vary randomly from day to day in analysis), is given below:

Figure A5.3 Assumed Average Load Profile for Mini-grid



Source: RREA

Actual Grid Connection Cost in Monrovia

The connection cost for consumer in Monrovia are for the LEC system is US$1000.

Economic analysis assumptions

For mini-grid installations, HOMER (Hybrid Optimization Modeling Software) simulations were conducted to identify the optimal configurations of small hydro, solar PV, biomass, diesel and various hybrid configuration sized and operated to meet the defined loads. A 10 percent discount rate was used for the economic analysis. For renewables for LEC grid-connected applications, a 10 percent economic discount rate was also used in calculating levelized electricity cost. The analysis was conducted in constant 2012 US dollars. Not real cost escalation for O&M or fuels was assumed.

Results

Table A5.3 presents a summary of the results from the HOMER analysis.

Table A5.3 Results from the HOMER analysis

Illustrative Assessment of Renewable Energy Options for an Isolated Community of about 2000 households															
		Component Sizes						Costs							
No.	Energy Supply Configurations	PV (kW)	Hydro (kW)	Diesel Generator (kW)	Biomass gasifier (kW)	6 kWh Batteries (No.)	Inverter (kW)	Initial capital cost (US$)	Operating cost (US$/year)	Total Net Present Cost (US$)	Levelized Cost of Electricity ($/kWh)	Renewable energy share	Unmet load	Diesel (Liters)	Biomass (tons/year)
1	SHP (Hydro resource unconstrained)		500					3,800,000	54,000	4,290,160	0.324	100%	0%		
2	BGS,				500			1,500,000	344,697	4,628,827	0.349	100%	0%		5,513
3	SPV,BGS,BAT	500			500	240	400	3,210,000	156,099	4,626,914	0.356	100%	3%		2,376
4	SPV,DSL,BGS,	500		100	400		400	2,750,000	222,684	4,771,312	0.366	82%	4%	115,367	1,842
5	DSL,BGS,			200	400			1,600,000	367,751	4,938,089	0.378	51%	3%	264,656	1,965
6	SHP,BAT		500			240	400	4,460,000	63,788	5,039,009	0.381	100%	0%		
7	DSL,BGS,BAT			150	400	240	400	2,160,000	323,268	5,094,316	0.393	72%	3%	145,139	2,995
8	SPV,SHP,BAT	100	500			240	400	4,670,000	65,888	5,268,071	0.398	100%	0%		
9	SPV,SHP,	250	500				400	4,625,000	63,548	5,201,832	0.405	100%	5%		
10	BGS,BAT				600	600	400	3,000,000	283,664	5,574,828	0.430	100%	3%		4,563
11	SHP,DSL,		500	500				4,800,000	115,881	5,851,859	0.442	96%	0%	66,217	
12	SHP,DSL,BAT		500	500		240	400	5,460,000	57,371	5,980,763	0.451	100%	0%	1,152	
13	SHP,DSL,BGS,		500	100	400			5,200,000	91,448	6,030,075	0.455	100%	0%	3,472	722
14	SPV,BAT	1,500				1,200	400	5,250,000	84,834	6,020,038	0.467	100%	3%		
15	SHP,BGS,		500		500			5,300,000	97,240	6,182,652	0.468	100%	1%		883
17	SPV,SHP,DSL,BAT	100	500	500		240	400	5,670,000	58,453	6,200,580	0.468	100%	0%		
18	SPV,DSL,BAT	1,000		500		600	400	4,300,000	211,645	6,221,114	0.469	83%	0%	141,899	
19	SPV,SHP,DSL,	100	500	500			400	5,310,000	113,894	6,343,816	0.479	97%	0%	58,231	
20	SHP,DSL,BGS,BAT		500	100	400	240	400	5,860,000	96,202	6,733,226	0.508	100%	0%		692
21	SPV,SHP,BGS,	100	500		500		400	5,810,000	103,569	6,750,102	0.510	100%	0%		881
22	SHP,BGS,BAT		500		500	240	400	5,960,000	106,164	6,923,652	0.522	100%	0%		866
23	SPV,SHP,BGS,BAT	100	500		500	240	400	6,170,000	108,264	7,152,714	0.540	100%	0%		866
24	DSL,			500				1,000,000	695,048	7,308,978	0.552	0%	0%	663,041	
In solution 1, Hydro resources are unconstrained while hydro resources are constrained in other simulations. Biomass gasifier is forced to run during peak hours as starting and stopping such gasifiers is															
SHP - Small hydropower, SPV - Photovoltaics, DSL - Diesel Generator, BGS - Biomass Gasifier-generator, BAT - Battery															
Source: IPRE Preparation Team calculations using HOMER															

ANNEX 6 STAKEHOLDER CONSULTATIONS

The Scaling Up Renewable Energy Program in Low Income Countries (SREP) Liberia Investment Plan has been developed following a series of participatory consultations led by the Liberian government under the stewardship of the Ministry of Lands, Mines and Energy (MLME) and, more specifically, the Rural and Renewable Energy Agency (RREA), and with the participation of government representatives, the private sector, development partners and civil society.

The activities undertaken were (a) a Scoping Mission (September 2012) to present the program and gather sector information, (b) a Technical Mission (February 2013) to discuss the technical aspects of the investment options with stakeholders, and (c) a Joint Mission (August 2013) through the stakeholder workshop to validate the suggested investment priorities.

The lists of stakeholders consulted during the joint missions are available in various Aide-Mémoire posted on the Climate Investment Funds (CIF) website https://www.climateinvestmentfunds.org/cifnet/country/liberia.

SREP Scoping Mission

The on-the-ground consultation activities kicked off with a Joint MDB Scoping Mission to Liberia on 11–14 September 2012 to assist the Liberian government in planning and preparing for the development of the SREP Liberia Investment Plan.

The Scoping Mission held consultation meetings with diverse stakeholders from the government, the private sector, development partners and civil society. In addition, the mission met with the Norwegian Delegation and Energy+ representatives to discuss possible areas of collaboration and the need for coordination with the Liberia SREP program to avoid duplication of efforts. Development partners advocated for stronger coordination; stakeholders expressed their concerns about the many strategies and plans being developed in the energy sector with support from various development partners (Master Plan, Access Plan, Energy and Climate Plan). It was agreed that the SREP Investment Plan would build on existing work and be used as an implementation instrument with the proposed investments being consistent with ongoing planning exercises.

There are a number of large private companies active in Liberia, notably in the palm oil, forestry and mining sectors, all of which also rely on captive power. There may be potential to combine new or increased captive power generation using biomass or small hydro resources with community-level electrification or even feed into the WAPP or LEC. However, the domestic private sector has limited capacity and expertise for investing in the renewable energy sector. Conditions for foreign investment are also weak due to perceived country risk, currency risk, payment risks, lack of credible data, perceived limited prospects for scale up, among others.

SREP Technical Mission

During the Technical Mission (4–15 February 2013), the Liberian government and MDBs consulted with government agencies, development partners, civil society, the private sector, plantations and local banks about existing and potential renewable energy initiatives to be analyzed under the SREP Liberia Investment Plan. There were consultations on barriers, cost

and potential schemes to replicate renewable energy pilots into programs, as well as discussions with donors about their areas of interest in the SREP Liberia program.

The components included renewable energy power projects to feed the Liberia Electricity Corporation (LEC) grid, off-grid electrification and technical assistance. It was agreed that these options would be further explored as IPRE develops.

The need to increase electricity supply to the Southeast Growth Corridor was mentioned, especially the areas of the River Gee, Grand Kru, Sinoe, Grand Dedeh, and Maryland, in support of the AFT's "security and peace" pillar.

SREP Joint Mission

The joint mission took place on 5–9 August 2013 in Monrovia. It focused on validating the suggested investment priorities and developing a concept program to be financed under SREP.

A one-day working session was organized on 6 August 2013 and attended by about 50 people, including representatives from the Ministry of Lands, Mines and Energy (MLME), Ministry of Finance, Liberia Electricity Corporation (LEC), Ministry of Health, Ministry of Education, Ministry of Internal Affairs, World Bank, AfDB, International Energy and Climate Initiative Energy +, development partners,[26] NGOs and the private sector. The working session was participatory and comprised three interactive sessions aimed at in-depth understanding of the renewable energy situation in Liberia and the proposed SREP Investment Plan for Liberia. The three sessions were delivered through technical presentations and thematic breakout group sessions followed by moderated Question & Answer sessions. A workshop report is available upon request.

Main results and findings from the Joint Mission discussions are as follows:

- The SREP Investment Plan will focus on investments required to extend electricity services through off-grid systems based on renewable energies, which is consistent with the government's objectives. The IPRE will focus on providing electricity services to unelectrified communities that are unlikely to be reached by the grid system in the long term and to consumers in areas targeted to be connected under the LCPDP in the medium term. For the second, the mini-grid will increase access to electricity services faster while building the load as the grid is extended.
- Mini-hydro, biomass and solar PV technologies were confirmed as the best options for Liberia in the coming years to increase access to electricity services while also reducing reliance on costly fossil fuels.[27] Stakeholders also confirmed that, in line with power sector development, mini-grid and off-grid systems will have a catalyzing impact that can be replicated, but some of them may be connected to the main national grid or the cross-border grid in the coming years as the grid is extended.

[26] Norwegian Water and Energy Directorate (NVE), European Union, U.S. Power Africa Initiative and the U.S. Agency for International Development (USAID), Japan International Cooperation Agency (JICA), German Technical Cooperation/Energizing Development (GIZ/EnDev).

[27] Tariffs in Liberia are among the highest in the world and the highest in Sub-Saharan Africa at over $0.50/kWh. The cost of generation in Liberia is around $0.42/kWh while the average cost of generation for countries in Sub-Saharan Africa is about $0.15/kWh, ranging from about $0.05 in energy-rich countries such as Nigeria to about $0.25 for less energy-endowed countries such as Cape Verde. The main reason for high electricity costs in Liberia is the dependence on high-cost diesel generation.

- The World Bank, AfDB and interested bilateral partners will support the establishment of a program to scale up renewable energy based on mini-grids and off-grid systems by developing guidelines, supporting simplified and transparent administrative procedures, encouraging light-handed regulations given sector evolution, and designing financing incentives based on project particularities and technical standards. This process aims to create a homogenous and standardized approach that can be replicated and supported by development partners.
- Following discussion with the Liberian government that sought to achieve a geographic balance for electricity provision, and in alignment with the World Bank Country Assistance Strategy and the AfDB Country Strategic Paper, MDBs committed to support the implementation of the SREP Investment Plan as follows:
    - AfDB will support the Liberian government in developing renewable potential in the four counties of the southeast region, as well as in the area covered by the cross-border grid (border with Côte d'Ivoire, including Nimba county).
    - The World Bank will support the Liberian government in developing renewable potential in the rest of the country, specifically in Lofa County and the counties encompassed within the CLSG Regional Transmission Line.

In both areas, a mix of technologies will be developed, including small/micro-hydro, biomass and solar, depending on the resources available in the project areas.

- The 14-year civil war left the country's infrastructure in ruins and diminished the level of human capacity. Efforts should be made to strengthen the institutional capacity to plan and implement projects in the energy sector with a practical approach and avoiding duplication. Financing instruments under SREP are expected to mitigate risks to leverage commercial investments and attract private capital. There is a need to carefully design the financing incentives with a phased approach to maximize the chance of attracting private sector investment.
- In the absence of an overall legal and regulatory framework for private investment, it is necessary to develop credible and transparent commercial arrangements, with the necessary risk mitigation measures, to attract private sector investment. On the other hand, not all renewable energy projects may be attractive to for-profit investors, especially when focusing on off-grid electrification. In these cases, it may be necessary to depend on public sector investment with private sector O&M or direct involvement from the communities in operation and maintenance. While the electricity law is approved, it was agreed that SREP would support the government by reviewing the different business models for implementing mini-grids and analyze the incentives and light-handed regulations that could be adopted in Liberia. In collaboration with Liberian lawyers, about four different business/delivery models were explored during the mission and are reflected in the IPRE; they will be refined during project preparation once the IPRE has been approved.

Comments Received on the Draft Investment Plan Posted on RREA Website

To facilitate review by national stakeholders, the Investment Plan was made available on the RREA website (http://www.rrea.gov.lr) from 2 to 15 September 2013. No comments were received from on-line consultation. However, some stakeholders involved in the energy sector provided their feedback to improve the IPRE.

ANNEX 7 CONCEPT NOTE: LIBERIA RENEWABLE ENERGY FOR ELECTRIFICATION PROGRAM (REEP)

Problem Statement

The Agenda for Transformation indicates that the high cost of and lack of reliable access to electricity remain key obstacles to the country's stability and sustainable economic growth. Despite some progress, by the end of 2012 Liberia had possibly the world's lowest rate of access to public electricity—at 1.6 percent nationwide and 6.7 percent in the capital city—and the highest electricity costs in Sub-Saharan Africa (and among the highest in the world) at over $0.50/kWh. As of July 2013 Liberia Electricity Corporation has around 13,874 customers, compared with 2,469 customers in July 2010. But LEC still reports losses ranging from 25 to 40 percent. Consequently, the vast majority of people have to depend on kerosene and candles or dry cell batteries for lighting and small generators that are very expensive to operate—few have access to small solar photovoltaic kits.

Current Efforts

The Agenda for Transformation aims to "increase access to renewable energy services and affordable power for community and economic transformation." It also calls for using public–private partnerships, improving development partner coordination, consolidating the government's decision-making process and securing agreement from mining companies to invest in (or otherwise support) power generation. To support the renewable energy and electrification goals of the Agenda for Transformation, a number of disparate activities have taken place that do not yet offer a cohesive strategy to meet Liberia's energy needs. These include:

- Establishment of the Rural and Renewable Energy Agency (RREA) in 2010.
- A Least Cost Power Development Plan (LCPDP) to meet the government's objective to increase electricity coverage to 70 percent of greater Monrovia's population and 35 percent of the national population by 2030.
- RREA in July 2010 signed a $50,000 Project Cooperation Agreement with the UNDP in support of energy needs assessment in two of five counties targeted by the Southeastern Energy Needs Assessment Project.
- Projects being undertaken with World Bank assistance include (a) implementation of a 60 kW micro-hydro mini-grid in Yandohun, Lofa County to benefit 240 families; (b) Lighting Lives in Liberia project to support the commercial marketing and sales of high-quality solar LED lighting; (c) design and bid document preparation of Sustainable Solar Market Packages to electrify schools, clinics and other public facilities in several districts in Bong and Lofa counties.
- Projects being undertaken with USAID assistance include (a) development of the 1 MW Mein River Hydropower Project in Suakoko District, Bong County; (b) identification of a 3 MW biomass power project using waste wood from the Liberia Company rubber plantation near Cocopa, Nimba County; (c) development of the 60 kW Sorlumba Biomass Power Project using crude palm oil-fired generators in Lofa County to serve 19 villages; and (d) capacity building.
- Providing solar electricity services to 205 health clinics to meet their lighting and communication needs through an EU-funded project in partnership with the Ministry of Health.

- Undertaking a prefeasibility study of a 10 MW small hydro project on St. John's River in Nimba County with UNIDO support.
- Capacity building of MLME staff to improve their ability to undertake legal and regulatory design, generation planning, hydrological assessment, renewable energy development activities/programs with support from the Norwegian Agency for Development Cooperation.
- Gender Mainstreaming and Women's Empowerment in the Energy Sector is one of the components of the bilateral cooperation agreement between Liberia and Norway

Program Objective

The proposed SREP-supported Renewable Energy Electrification Program (REEP) objective is to meet the electricity needs of a subset of the population living outside of Montserrado County using local renewable energy resources and tapping into the local communities' and institutions' innate capabilities, wherever possible. The objective will be met by providing financing and technical assistance to identify, design, develop and invest in a number of renewable energy-based electricity schemes to meet the needs of populations that will not be served by the LEC grid in the near term. The program will also establish institutional and regulatory structures, strengthen capacities and set up legal frameworks necessary for mainstreaming and scaling up such interventions and can be supported by different partners.

Scope of Work

Renewable Energy Technologies

A range of mini-grid supply options will be considered to meet electricity needs. Small hydropower is likely to be a key renewable resource for generating electricity. But other resources could be used, including solar photovoltaics; biogas from agricultural wastes; and gasifier generators using sustainably harvested biomass, such as from rubber replanting programs, depending on local renewable sources and community characteristics. For individual small loads outside the mini-grids' technical and economic reach, stand-alone systems will be deployed, most likely solar PV systems.

Geographic Focus

The regional focus will be areas such as Lofa County, where the LEC grid is not expected to reach in the foreseeable future, as well as communities within the CLSG Regional Transmission Line in Liberia and communities that will be reached through cross-border electricity connection to Côte d'Ivoire. For communities in areas that may be interconnected later, interconnection projects will be developed so more reliable and lower cost services can be facilitated through power exchange with LEC.

The investments will focus on area-based electricity service delivery to facilitate provision of operation and maintenance needed to deliver electricity sustainably and cost-effectively. Within the service area, renewable mini-grids will be used to serve customers in areas with higher load densities—typically within 20 km of the generation source. Stand-alone solar PV will be used for communities with low load densities and for scattered consumers within the service area where mini-grid extension cannot be economically or technically justified.

Delivery Models and Ownership Options

RREA will consider a number of ownership structures, depending on local organizations' interest and capacity. RREA will assess the interest of LEC and private, nongovernmental and

cooperative companies in owning and operating the mini-grids. Based on a consultative process (Annex 6), review of the existing legal framework, and the dynamic evolution and expansion of the sector, the following potential delivery models will be pursued based on the specifics of each individual projects:

- Cooperatives and/or private non-profit entities for small, isolated mini-grid projects (200 kW and smaller) that self-generate and supply electricity to the cooperative's members or local population. (One example is the Yandohun micro-hydro project.) They will be established under the Cooperative Societies Act of 1936 and the 1976 Associations Law of Liberia as amended.
- Commercial or public enterprises (anchor consumers) operating existing businesses. They would establish a renewable energy generation project to serve their own requirements and extend services to other consumers nearby. Electricity would be a subsidiary business of the commercial or public enterprise. Commercial enterprises may include palm oil or rubber plantations, timber or mining operations. Public enterprises may include schools or hospitals or local/municipal governments, such as in the Mein River Project. They would be established under the Business Corporation Act as amended in 1999 and 2002 and operate under the LEC Act of 1976.
- LEC ownership of projects in the areas served, or about to be served, by the LEC grid, including the CLSG service corridor and areas serviced by cross-border interconnection. (LEC is a public corporation under the LEC Act of 1973.)
- Independent power producers for larger projects specifically set up as private companies, or joint ownership under public–private partnerships (such as a private company with LEC). The producer will generate and sell electricity to retail customers and eventually to the LEC grid. These projects will be set up as a concession established under the Public Procurement and Concession Act of 2010 as amended.

Drawing on local capacity, it is expected that local entrepreneurs would provide operation and maintenance and commercial services, particularly where the owner lacks the required expertise (for example, cooperatives) or would prefer to outsource such activities (for example, to anchor consumers). The IPRE would provide technical assistance to local entrepreneurs.

Program Structure

To achieve a geographic balance for electricity provision, the government and multilateral development banks have agreed in the following geography support: the AfDB focus on the four counties of the southeast region, as well as in the area covered by the cross-border grid (border with Côte d'Ivoire, including in Nimba county), and the World Bank will focus in the rest of the country, more specifically in Lofa County and the counties encompassed within the CLSG Regional Transmission Line.

The REEP has been designed in the context of a true programmatic approach to ensure efficient use for resources and avoid unnecessary duplication of efforts in a country that already lacks capacity. Therefore, some of the REEP "soft" activities will, whenever possible, bundled in order to benefit both World Bank- and AfDB-supported projects.

Design Criteria

Due to the limited information available on energy demand and supply resources, several program design decisions will be made during project preparation and implementation, in line with the following criteria:

- An area-based electricity service delivery model will be used where possible to facilitate sustainable and cost-effective O&M, as well as management services to provide consumer-responsive services. Concentrating such services in a small area (say, a 20 km radius) will reduce costs and achieve more efficient service delivery.
- System load sizing and profile will be determined by consumer surveys to establish priority needs and expected usage patterns by consumer category, considering the electricity-efficient appliances appropriate and affordable in rural areas.
- RREA (with MLME and LEC) guidance will set service and safety standards, technical specifications and tariff policy. Environmental and social safeguards will comply with MDB-agreed frameworks. RREA will competitively and transparently tender and award projects to private firms or NGOs.
- An affordable tariff structure based on consumers' ability and willingness to pay will be offered. Poorer consumers will benefit from structured tariffs, including life-line rates for the poorest. Revenues and results-based financing must recover all recurrent costs, including operation and maintenance, fuel, contributions to a sinking fund for major repairs, and a reasonable return on equity. Partial-capital investment-grant financing will be used to reduce debt and equity to levels that will permit an affordable tariff to be charged. Based on progress, grants will gradually decline.
- A public–private partnership financing model with government support in the form of partial-capital grant cofinancing will attract private firms and NGOs to invest in and provide electricity services. Special attention will be paid to encouraging local firms/NGOs to provide electricity services.
- Results-based financing will help keep tariffs affordable and supplement revenues for debt servicing, for the first five or six years. Debt servicing flows will go to REFUND to finance later projects.

***Main program components*.**

The REEP will be composed of four major activities to mainstream off-grid electrification approaches using renewable energy mini-grids and stand-alone systems. The REEP is also structured in two phases based on the level of financing available, sources of financing and the steps required to establish a sustainable program. Given the risks associated with country conditions and the use of new technologies and untested business models, Phase I will rely mostly on public investment. Phase I will develop the business framework and strengthen institutions, and provide the necessary demonstration experience to attract greater private investment during the Phase II

Phase I is composed of the following activities to mainstream off-grid electrification approaches using renewable energy mini-grids and are expected to be implemented within 4-5 years:

Task 1. Development of Rules and Regulations.

RREA in consultation with key agencies, including MLME and LEC, will develop the following:

- Standard or model legal agreements and contracts, including a distribution services agreement to permit SPV or commercial/public enterprise to distribute electricity to retail customers; a concession agreement to gain rights to use a hydro resource to generate and sell electricity under a distribution services agreement or sell power to LEC under a small power purchase agreement; fuel supply agreements for use in biomass projects where fuelwood would have to be purchased; agreement with bordering country for projects that span country borders; grant and credit agreement(s) to permit funds to be given to specific projects through a capital grant or a results-based grant; standardized power purchase agreement for sale of power to the LEC grid under a bulk supply tariff; and other legal agreements required by Liberian law.
- Corporate legal requirements, including articles of incorporation, audit requirements, registration with tax authorities, reporting requirements, business registration, and corporate bylaws.
- Service and safety standards and their enforcement, including grid code.
- Tariff methodology to establish the rules and procedures for retail and bulk supply tariff.
- Licensing and approval procedures, including compliance with environmental and social safeguards.
- Procedures and guidelines for project development and implementation, including bid and award procedures for projects and grant setting and award rules.
- Customer bill of rights.

Task 2. Preparation of Electrification Projects

RREA will contract for and set up a Transaction Advisory Service Facility that will provide support for preparing prefeasibility studies, financial plans, and legal agreements and obtain various approvals. As necessary, the TASF will support implementation, supervision and training. Where possible, services will be bundled to leverage economies of scale. Transaction advisory services will be provided to prepare 10–15 electrification projects, principally renewable energy mini-grids with stand-alone renewable energy systems deployed to serve more dispersed consumers within the designated service territory. For projects on private/concession lands, the TASF could provide services, or RREA will offer cost-shared pre-investment funding for project development support to cover prefeasibility, financial plans, legal agreements, various approvals, and the like.

This component will also support the government's decision to attract private investments and will provide the resources needed for structuring the project, considering the transaction's legal, technical and commercial aspects.

Task 3. Mini-grid and Stand-alone Solar PV Projects

Through the RREA REFUND facility, financing will be provided to develop mini-grid and stand-alone projects prepared with REEP assistance. The projects will be principally powered by small hydro and biomass and complemented by solar power. Consumers in service areas

that cannot be interconnected will be offered stand-alone solar systems. It is expected that 6-7 mini-grid projects and 6 stand-alone solar PV projects will be financed to benefit nearly 240,000 people. These first few projects, when successful, will build confidence in the business model and be the foundation for scale up.

The support provided includes capital cost grants and access to credit financing on concessional terms. The grants will be given based on the number of electricity connections. Concessional loans will be available to supplement the equity that project developers/owners contribute. The credit facility will be managed and operated by a commercial bank on behalf of RREA on a trust arrangement.

The Norwegian Energy+ Program will offer results-based financing (for example, on a per kWh basis or per connection) once the projects are delivering electricity. It will supplement the electricity sales revenues in the early years of project execution to allow the project owner to offer electricity at lower tariffs. The additional Energy+ revenues can be used to service the debt and to encourage investors/entrepreneurs to participate.

Task 4. Promoting Productive Uses of Electricity and Other Technical Assistance

To successfully implement these renewable energy projects, RREA will provide training and capacity-building services to mini-grid operations and management organizations and their staff. In addition, hydro, biomass and solar resource assessments will be conducted, particularly in streams and rivers in the vicinity of towns and villages targeted for mini-grid electrification. Rubber and palm oil plantation concessions and timber operations will also be surveyed to estimate waste wood residues and their pricing and seasonality.

The objective of the Promotion of Productive Uses of Electricity is to contribute to increase the productivity of rural businesses by promoting use of electricity, which would in turn improve living conditions in rural areas of Liberia as well as improve the utilization of electricity supply infrastructure and electricity service company revenues. Under Phase I is expected:

(i) to conduct diagnostics to screen for promising areas/communities with significant opportunities for increased productive uses of electricity within the local context,
(ii) to identify constraints to productive uses in these areas,
(iii) to conceptualize and devise the most promising and cost-effective marketing and technical assistance strategies, alliances and methods in the different areas, given the types of productive uses prevalent in the area,
(iv) to identify partners and NGOs that can develop links between entrepreneurs with private and public sector entities to address skills and finance constraints.
(v) Targeted activities will also include gender disaggregated surveys and consultations to better understand the barriers women may face to accessing energy services (financial, information, physical) or participating in the energy services value/production chain; or fostering the promotion of potential opportunities for productive uses of these energy services for women and small business owners,
(vi) To strengthen the monitoring and evaluation framework related to the energy sector and will try to align the monitoring requirements of SREP, MDB projects, Energy +, SE4ALL, etc. The Norwegian Water and Energy Directorate (NVE) is currently providing assistance to MLME on these aspects, and SREP resources will complement this effort as needed.

In Phase II, additional project investments will take place based on program experience and certainties provided by the regulation framework achieved under Phase I. Phase II is composed of the following activities:

Task 2-II. Preparing of Electrification Projects

The TASF can be extended based on the performance achieved during Phase I and the needs for the specific of the projects.

Task 3-II. Mini-grid and Stand-alone Solar PV Projects

It is expected that minimum 3 additional mini-grids and 3 stand-alone solar PV projects will be financed to benefit nearly 120,000 people. This will depend on the results of implementing Phase I and the level of financing available.

Task 4-II. Promoting Productive Uses of Electricity and Other Technical Assistance

Based on the results of Phase I, the program is expected to provide financing to test several marketing pilots.

Implementation Readiness

RREA is a functioning Liberian government agency, operating since 2010 under a presidential decree. It will become a statutory body once the energy law is passed. The government is placing a high priority on having the law passed and the necessary regulations formulated. RREA has been successfully implementing a number of World Bank projects and therefore has the requisite experience and capabilities to implement the REEP Program, though their capacities would have to be strengthened. RREA's implementation capacity, including for procurement and financial management, has been rated satisfactory for the World Bank and partially for the AfDB. A fiduciary assessment will be carried out to address the agency's limitations while implementing the project.

While there are several mini-grid and off-grid electrification projects undertaken, none has been done systematically, including crating the required enabling environment for project scale up. But experiences to date show promise and the national interest and government commitment are strong. Therefore, the REEP will be the first in systematically and comprehensively supporting the mini-grid electrification approach.

Rationale for SREP Financing

While some renewable energy investments would still occur sporadically, such approaches are inadequate to satisfy the government's ambitious electrification needs. SREP support will help demonstrate that renewable energy for electrification is indeed a readily scalable option by creating the enabling environment and demonstrating success in the early project with additional financial resources. In the face of development priorities and political pressure to rapidly expand coverage, the government may be forced to choose second-best options, such as diesel generators or extending grids to nonviable areas (thus increasing costs, incurring higher transmission and distribution losses, and possibly adding more fossil fuel–based power plants). Not only are these options detrimental to the global environment, but the status quo would also be harder to change at a later stage.

SREP resources will be used to catalyze and significantly leverage development partner and government funding for renewable energy electrification. SREP's catalytic role is crucial to

building the human capital and infrastructure and the enabling environment needed for renewable energy–based electrification.

SREP's establishment of the TASF, offering additional financing and new financial instruments, creating the essential enabling environment, and continued capacity building will establish a comprehensive support package for investments in renewable energy that will allow the government to sustainably meet its ambitious electrification targets.

The project meets all of the criteria needed to justify use of SREP resources. It will use renewable energy to provide electricity services to a significant share of the target population. It will catalyze additional investments in a market that would otherwise be unattractive to investors. CO_2 emissions are avoided, and in addition, local environmental conditions are improved and danger of fires from open-wick lamps is avoided. Women and children will particularly benefit. Where electricity is supplied to enterprises, productivity is improved. With household access to electricity, productivity is indirectly improved through higher educational attainment, better access to communication and enhanced personal security. Other co-benefits include the protection of watersheds that must maintain the hydrologic conditions needed for small hydro projects, support for sustainable forestry by supplying fuel for biomass power projects, and increased agricultural value added since agricultural residues can be sold for power generation.

Results Indicators

Table A7.1 presents the physical outcomes for the project.

Table A7.1 Indicative Program Outcomes

Physical Outcomes	Phase I	Phase II	Program	
Number of Projects Funded	12	6	18	Number of projects are indicative
Mini-grids	6	3	9	
Stand-alone solar PV	6	3	9	
Renewable Energy capacity added	8.8	5.1	13.9	MW
Persons benefiting	240,000	120,000	360,000	
Share of national population benefiting (percent)	**6**	**3**	**9**	
Total Electricity Supplied	18,542	9,527	28,069	MWh/year
Cost effectiveness (US$/kWh)	0.375	0.359	0.370	US$/kWh versus diesel generation at $0.552/kWh
Diesel potentially offset	8,416	4,323	12,740	m^3/year (assuming diesels are offset)
Value of diesel offset	8.42	4.32	12.74	Millions of US$ per year at US$1/liter
Potential CO_2 emissions avoided	22,500	11,560	34,060	tons CO_2/year (assuming diesel is displaced)

Source: RREA

Program Co-benefits

The IPRE will have a direct, positive impact on Liberian living conditions and economic productivity, helping to reduce levels of poverty, and also ensuring a reduction in greenhouse gas emissions. The IPRE will bring the following co-benefits to local communities:

- **Enhance energy security**. Scaling up renewable energies will diversify the energy mix, helping to reduce dependence on imported fossil fuels, and hence enhancing the security of energy supply in the country.
- **Improve access to electricity**. Hybrid mini-grids and stand-alone solar PV will increase access to electricity in isolated areas of Liberia where the grid is no expected to reach in the short term.
- Ensure that the renewable energy delivery infrastructure is established at the earliest stage before the status quo becomes diesel generation.
- **Capacity building**. SREP activities will build and sustain improved management and technical skills within rural communities.

- **Jobs creation and Income generation**: the IPRE will maximize economic development opportunities, including creating new economic activities that can create new job opportunities and raise incomes, especially in rural towns.
- **Improve rural people's quality of life** through household and institutional access to electricity. In rural communities, the availability of electric lighting can lead to better education, health and public security, especially for women and children.
- **Improve gender equality and women's socioeconomic status**. The IPRE initiatives will improve women's access to productive uses of electricity, and reduce women's barriers to information and training options for new energy services and technology, for example communications.
- **Support to decentralization** in so far as SREP will contribute to develop technical, institutional and financial mechanisms to facilitate the transfer of responsibilities to local governments and communities.
- **Improve access to communications.** Increased access to electricity will boost productive usage of power for communication purposes through mobile phone, television and internet, thus improving access to information and empowering local communities.
- **Other social and environmental co-benefits.** The reduction of kerosene and wood fuel consumed by households will reduce indoor pollution. Also, an increased access to electricity will improve security and safety conditions, transforming the life in rural areas.

Financing Plan

Table A7.2 summarizes the financing plan.

Table A7.2 Financing Plan

Components	SREP	AfDB[a]	WB	NOR Energy + TA	Other Partners TBD	Private Equity TBD	Govt. of Liberia	Customer connections	Investment & TA Total	Energy+ Results-based Payment	Other Results-based financing	Grand Total
Phase I	**50.0**	**13**	**10**	**1.5**	**6.8**	**12.8**	**2.5**	**6.4**	**103.0**	**18.0**		**121.0**
Project Preparation Grant	**1.0**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1.0**			**1.0**
Investment Phase I	**46.5**	**12.5**	**8.5**	**-**	**6.8**	**12.8**	**-**	**6.4**	**93.5**	18.0	-	**111.5**
Investments—Phase I Mini-grids	*41.7*	*12.5*	*8.5*	-	*6.8*	*12.8*	-	*1.6*	*83.9*	*18.0*	-	*101.9*
Investment—Phase I Stand-alone PV	*4.8*	-	-	-	-	-	-	*4.8*	*9.6*	-	-	*9.6*
Technical Assistance	**2.5**	**0.5**	**1.5**	**1.5**	**-**	**-**	**2.5**	**-**	**8.5**	**-**		**8.5**
Transaction Advisory Services	*1.0*	-	*1.0*	-	-	-	-	-	*2.0*			*2.0*
Renewable Resource Assessment	-	-	-	*0.5*	-	-	-	-	*0.5*			*0.5*
Regulatory/Policy Support	-	-	*0.5*	*0.5*	-	-	-	-	*1.0*			*1.0*
Training & Capacity Building	*0.5*	*0.5*	-	*0.5*	-	-	-	-	*1.5*			*1.5*
Knowledge Management—M&E	*0.5*	-	-	-	-	-	-	-	*0.5*			*0.5*
Program Management	*0.5*	-	-	-	-	-	*2.5*	-	*3.0*			*3.0*
Phase II	**-**	**-**	**-**	**-**	**32.5**	**6.1**	**-**	**4.4**	**43.1**	**-**	**14.4**	**57.5**
Investments—Phase II Mini-grids	-	-	-	-	*28.9*	*6.1*	-	*4.4*	*35.9*	-	*14.4*	*50.3*
Investment—Phase II Stand-alone PV	-	-	-	-	*3.6*	-	-	*3.6*	*7.2*	-	-	*7.2*
Total	**50.0**	**13**	**10**	**1.5**	**39.3**	**18.9**	**2.5**	**10.8**	**146.1**	**18.0**	**14.4**	**178.5**

a. AfDB allocation includes concessional loans from ADF13 (about US$10 million to be confirmed), as well as funds from various Trust Funds including the EU-Africa Trust Fund and the Sustainable Energy Fund for Africa. IDA allocation is indicative and will depend on the following IDA replenishment cycle. It is expected to be supported by additional Trust Funds currently targeting Liberia for renewable energy sources.

Source: RREA

Lead Implementing Agencies

AfDB will lead project implementation in southeastern Liberia in the counties to be served by cross-power interactions with Côte d'Ivoire. The World Bank will lead project implementation in Lofa County and in areas to be covered by the CLSG Corridor.

ANNEX 8 PROJECT PREPARATION GRANT FOR RENEWABLE ENERGY FOR ELECTRIFICATION PROJECT

North and Center

SREP INVESTMENT PROGRAMME Project Preparation Grant Request			
1. **Country/Region**:	Liberia	2. **CIF Project ID#**:	(Trustee will assign ID)
3. **Project Title:**	**Renewable Energy for Electrification Project North and Center**		
4. **Tentative SREP Funding Request (in US$ million total) for Project[a] at the time of Investment Plan submission (concept stage):**:	Grant: $25 million	Loan:	
5. **Preparation Grant Request (in US$):**	Approximately US$ 1,000,000 for the government	MDBs: World Bank Group	
6. **National Project Focal Point**:	Augustus Goanue, Executive Director, Rural and Renewable Energy Agency, Ministry of Lands, Mines and Energy		
7. **National Implementing Agency (project/programme):**	Rural and Renewable Energy Agency, Liberia		
8. **MDB SREP Focal Point and Project/Programme Task Team Leader (TTL)**:	Headquarters-CIF Focal Point: Gevorg Sargsyan, World Bank	TTL World Bank: Zayra Romo, Energy Specialist, Sub-Saharan Africa Region, World Bank	

9. **Description of activities covered by the preparation grant:**

The following activities will be needed for the preparation of the Renewable Energy for Electrification Project—North and Center. The below table indicates the activities, source of financing and the implementing agency. Results from the below activities will be made publicly available through a website at RREA, MLME and the hydrological center in Liberia.

Activity	Amount (US$)	Source of financing	Implementing agency
Preparation of mini-grid investments, including the identification and selection of project pipeline and pre-feasibility assessment of 2–4 investment projects as well as outreach to prospective investors/developers.	200,000	Trust Fund SE4ALL	WB
Demand analysis of the preselected sites. This activity will be conducted in parallel for the preparation of the project pipeline.	200,000	SREP	RREA
Formulation of transaction instruments including mini-grid business models, implementation rules, standard/model legal agreements and tariff methodology, grid/distribution electrical codes, guidelines	200,000	Trust Fund SE4ALL	WB
Detailed implementation planning, including design of financing instruments for mini-grid and stand-alone systems (credit line, performance grants and/or payment by results).	75,000	Trust Fund AFREA[b]	WB

SREP INVESTMENT PROGRAMME Project Preparation Grant Request			
Preparation of the transaction advisory services facility (TASF), including the design, implementation plan, project selection criteria, monitoring and evaluation framework, stakeholder consultations and administrative structure,	75,000	Trust Fund SE4ALL	WB
Feasibility of the selected sites, including biding documents for mini-grid and stand-alone systems	800,000	SREP	RREA
Total	1,550,000		

10. **Outputs: Policy framework**	
Deliverable	**Timeline (CY)**
(a) Identification pipeline for mini- projects and pre-feasibility for 2–4 projects for early implementation	Q1 2014
(b) Demand analysis	Q2 2014
(c) Transaction instruments	Q2 2014
(d) Detailed Implementation and Financing Plan	Q3 2014
(e) Transaction advisory services facility	Q3 2014
(f) Bidding documents for mini-grid and stand-alone systems	Q1 2015

11. **Budget (indicative):**	
Expenditures[c]	**Amount (US$) -** estimates
Consultants	US$ 1,550,000
Total Cost	**US$ 1,550,000**
Other contributions:	
• Government: RREA	US$ 50,000 (including in-kind staff support, organization of stakeholder consultations)
• MDB	US$100,000 (including staff time)
• Others (Sustainable Energy for All, the Public-Private Infrastructure Advisory Facility, Africa Renewable Energy and Access)	US$550,000 from Trust Funds.

12. **Timeframe** (tentative)
SREP Sub-Committee Approval for project: Q2 2015

Expected Board/MDB Management[d] approval date: Q3 2015

SREP INVESTMENT PROGRAMME Project Preparation Grant Request
13. **Other partners involved in project design and implementation**[e] Following consultations with various stakeholders and partners, it is expected that the Project will be supported by several bilateral partners. They include Norwegian Energy+ Program, USAID, Government of Norway and the Norwegian Water and Energy Directorate (NVE) based in Monrovia. NVE has an ongoing program with the Ministry of Land Mines and Energy and RREA to build capacity on hydrology measurements to identify hydro potential. A team of 8 Liberian young engineers have been trained over two years and have conducted measurements in 4 main rivers.
14. **If applicable, explanation for why the grant is MDB executed:** Trust Fund Activities will be carried out by the Bank since the resources are Bank-executed. SREP-funded activities will be carried out by the Government since the implementing agency, RREA is familiar with Bank procedures and it is currently implementing two projects with financing from the World Bank.
15. **Implementation Arrangements** (incl. procurement of goods and services) All activities funded by SREP for the Renewable Energy for Electrification Project will be implemented by RREA, which is the national government agency in charge of planning and implementing both renewable energy grid and off-grid electrification projects. Activities funded through Trust Funds will be organized and managed by the Bank; however, RREA will be counter-part for all the activities and will play an active role on the implementation and decision-making process.

SE4ALL = Sustainable Energy for All. AFREA = Africa Renewable Energy and Access.

a. Including the preparation grant request.

b. A proposal has been submitted to analyze and define the options for payment by results programs in three pilot countries including Liberia.

c. These expenditure categories may be adjusted during project preparation according to emerging needs.

d. In some cases activities will not require MDB Board approval

e. Other local, national and international partners expected to be involved in design and implementation of the project.

Eastern Liberia

SREP INVESTMENT PROGRAMME *Project Preparation Grant Request*			
1. Country/Region:	Liberia	***2. CIF Project ID#:***	*(Trustee will assign ID)*
3. Project Title:	**Renewable Energy for Electrification in Eastern Liberia Project Eastern Liberia**		
4. Tentative SREP Funding Request (in US$ million total) for Project[a] at the time of Investment Plan submission (concept stage):	Grant: US$25 million	Loan:	
5. Preparation Grant Request (in US$):	US$ 1,500,000	African Development Bank	
6. National Project Focal Point:	Augustus Goanue, Executive Director, Rural and Renewable Energy Agency, Ministry of Lands, Mines and Energy		
7. National Implementing Agency (project/programme):	Rural and Renewable Energy Agency, Liberia		
8. MDB SREP Focal Point and Project/Programme Task Team Leader (TTL):	Headquarters-CIF Focal Point: Mafalda Duarte, Chief Climate Change Specialist, CIF Coordinator	Task Manager: Elise Akitani, Senior Power Engineer	

9. Description of activities covered by the preparation grant:

The grant will cover the following activities related to the preparation of the Project:

1) ***Sites confirmation and demand analysis***: including topographic survey and mapping, as well as geological analysis & demand analysis. Sites confirmation will be done both for mini-hydro and biomass resources.
2) ***Preparation of mini-grid investments,*** including the identification of projects pipeline, feasibility studies for 2–4 investment projects, Environmental and Social Impact Assessment (ESIA) for the identified sites, as well as outreach to prospective investors/developers.
3) ***Transaction advisory services for the planned 2–4 mini-grids,*** especially for all legal issues. This will be done through the African Legal Support Facility hosted by AfDB.
4) ***Preparation of the programmatic M&E framework, knowledge management component, and capacity building program,*** including identification of indicators' baselines, definition of M&E manual, preparation of a knowledge management/ISL program of activities, as well as a program for capacity building of key stakeholders involved in the execution of the REEP program.

10. Outputs: Policy framework

Deliverable	***Timeline (CY)***
(g) Sites confirmation & demand analysis studies	Q2 2014
(h) Pipeline identification for mini-projects and pre-feasibility for 2-4 projects for early implementation	Q4 2014
(i) Feasibility studies for the selected projects, including ESIA	Q2 2015

(j) Bidding documents for mini-grid and stand-alone systems	Q3 2015
(k) Project Appraisal Report to be approved by SREP Sub-Committee	Q3 2015

11. Budget (indicative):

Expenditures[b]	***Amount (US$) -*** *estimates*
Consultants/technical assistance	US$1,435,000
Equipment	-
Workshops/seminars/trainings	US$20,000
Travel/transportation	US$20,000
Others (admin costs/operational costs)	US$5,000
Contingencies (max. 5 percent)	US$20,000
Total Cost	**US$1,500,000**
Other contributions:	
• Government: RREA	US$50,000 (including in-kind staff support, organization of stakeholder consultations)
• MDB	US$50,000 (including staff time)
• Others (Sustainable Energy for Africa Fund, African Legal Support Facility)	Approximately US$200,000

12. Timeframe *(tentative)*

SREP Sub-Committee Approval: Q3 2015

Expected Board Approval date: Q4 2015

13. Other partners involved in project design and implementation:[c]

Following consultations with various stakeholders during the preparation of the Investment Plan, it is expected that this Project will be cofinanced—or supported through joint technical assistance—by various partners, including the Energy+ Program, the EU-Africa Infrastructure Trust Fund, the Sustainable Energy Fund for Africa Trust Fund (hosted by the AfDB), the African Legal Support Facility (hosted by the AfDB), the Power Africa Initiative, and USAID.

14. If applicable, explanation for why the grant is MDB executed:

RREA's capacity for procurement and financial management (FM) activities has been rated partially satisfactory by AfDB FM and procurement staff, highlighting the need to build internal capacity in order to execute AfDB's supported projects. Since RREA has never executed AfDB's projects before and since it would need to learn new FM and procurement procedures, there is a high risk for the project preparation to be delayed. Therefore, RREA is asking the Bank to execute this grant on its behalf, in order to speed up project preparation.

SREP INVESTMENT PROGRAMME   ***Project Preparation Grant Request***
15. Implementation Arrangements *(incl. procurement of goods and services):*   The activities of the PPG for the Renewable Energy for Electrification in Eastern Liberia Project will be executed by the Bank on behalf of RREA. RREA will contribute to the various procurement processes but the disbursements will be made directly from the Bank to the awarded contractors. The AfDB field office in Liberia has local FM and procurement experts who will support RREA as needed and will build their capacity during project preparation in order to make sure RREA can implement the project once it starts.

a. Including the preparation grant request.

b. These expenditure categories may be adjusted during project preparation according to emerging needs.

c. Other local, national and international partners expected to be involved in design and implementation of the project.

ANNEX 9 MDB REQUEST FOR PAYMENT FOR PROJECT IMPLEMENTATION SERVICES (MPIS)

<table>
<tr><th colspan="4">SCALING UP RENEWABLE ENERGY PROGRAM IN LOW-INCOME COUNTRIES
MDB Request for Payment of Implementation Services Costs</th></tr>
<tr><td>1. Country/Region:</td><td>Liberia/Africa</td><td>2. CIF Project ID#:</td><td>(Trustee will assign ID)</td></tr>
<tr><td>3. Project Title:</td><td colspan="3">Renewable Energy for Electrification Project North and Center</td></tr>
<tr><td>4. Request for project funding (US$ million):[a]</td><td colspan="2">At time of country program submission (tentative):

US$25.00 million</td><td>At time of project approval:</td></tr>
<tr><td rowspan="2">5. Estimated costs for MDB project implementation services (US$ million):</td><td colspan="2" rowspan="2">Initial estimate - at time of Country program submission:

US$0.X million

Final estimate - at time of project approval:</td><td>MDB: World Bank</td></tr>
<tr><td>Date: September, 2013</td></tr>
<tr><td>6. Request for payment of MDB Implementation Services Costs (US$ million):</td><td colspan="2">X First tranche:

☐ Second tranche:</td><td>US$690million</td></tr>
<tr><td>7. Project/program financing category:</td><td colspan="3">a - Investment financing - additional to ongoing MDB project ☐
b - Investment financing - blended with proposed MDB project ☐
c - Investment financing - stand-alone X
d - Capacity building - stand alone ☐</td></tr>
<tr><td>8. Expected project duration (no. of years):</td><td colspan="3">5 years</td></tr>
<tr><td>9. Explanation of final estimate of MDB costs for implementation services:</td><td colspan="3">If final estimate in 5 above exceeds the relevant benchmark range, explain the exceptional circumstances and reasons: Not Applicable</td></tr>
</table>

SCALING UP RENEWABLE ENERGY PROGRAM IN LOW-INCOME COUNTRIES
MDB Request for Payment of Implementation Services Costs

10. **Justification for proposed stand-alone financing in cases of above 6 c or d:**

The World Bank is supporting a large energy portfolio of over US$250M in Liberia. The Bank has been able to leverage small country IDA envelope (accounting for one third of our program) with a large amount of regional IDA as well as trust funds.

Concrete results of the IDA support since our reengagement in Liberia in 2008 include the restoration of thermal generation capacity in Monrovia, the expansion and enhancement of the distribution networks of LEC in Monrovia, the future construction of the CLSG Regional Transmission Line, the creation of the Rural and Renewable Energy Agency RREA and the construction of its first mini-hydro power plant for 200 households in a conflict area of Yandohun.

Given the small country IDA envelope for Liberia and the huge needs for reconstruction and peace stability of the country, the Government has requested the Bank to focus on the reconstruction of the nascent on-grid power system and the strengthening of the utility, Liberia Electricity Corporation. This will in turn support the economic activities in the country to support stability and job creation. In terms of off-grid sector, the Bank supported the Government on the establishment of RREA and the implementation of two first pilots that will serve as platform for the SREP-supported project.

In this context, the project supported by SREP will be a stand-alone operation. However, this will be supported by Trust Funds dedicated for renewables and off-grid activities such as Sustainable Energy for All, Africa Renewable Energy and Access, and the Public-Private Infrastructure Advisory Facility.

The indicative cofinancing for stand-alone SREP project comes from Energy + and will be design as payment by results.

If possible based on the new IDA allocation for Liberia, a potential cofinancing will also be mobilized for the SREP program.

SCALING UP RENEWABLE ENERGY PROGRAM IN LOW-INCOME COUNTRIES **MDB Request for Payment of Implementation Services Costs**			
1. **Country/Region**:	Tanzania	2. **CIF Project ID#**:	(Trustee will assign ID)
3. **Project Title:**	Renewable Energy for Electrification in Eastern Liberia Project Eastern Liberia		
4. **Request for project funding (USDmill.):**	*At time of country program submission (tentative): USD 25million*	*At time of project approval:*	
5. **Estimated costs for MDB project implementation services (US$ million):**	*Initial estimate - at time of Country program submission:* *USD 0.450million* *Final estimate - at time of project approval:*	*MDB: AfDB* *Date: May 2013*	
6. **Request for payment of MDB Implementation Services Costs (US$ million):**	X First tranche: ☐ Second tranche:	USD 0.250 million USD 0.200 million	
7. **Project/program financing category:**	a - Investment financing - additional to ongoing MDB project ☐ b- Investment financing - blended with proposed MDB project X c - Investment financing - stand-alone ☐ d - Capacity building - stand alone ☐		
8. **Expected project duration** (no. of years):	Five years		
9. **Explanation of final estimate of MDB costs for implementation services:**	***If final estimate in 5 above exceeds the relevant benchmark range****, explain the exceptional circumstances and reasons:*		
10. **Justification for proposed stand-alone financing in cases of above 6 c or d:**			

ANNEX 10 INDEPENDENT REVIEW AND GOVERNMENT ANSWERS
Independent reviewer Steve Thorne

Tuesday, September 24, 2013

General comments	
Investment Plan for Renewable Energy (IPRE - draft for consultation), Ministry of Lands, Mines and Energy, Rural and Renewable Energy Agency, September 3rd, 2013 *"The Liberia Investment Plan for Renewable Energy (IPRE) aims to support the government's objective of providing electricity to accelerate the country's reconstruction and economic revitalization. The Liberia IPRE is fully aligned with the government's Agenda for Transformation (AFT), a long-term vision to transform Liberia into a more prosperous, inclusive, middle-income society."* The Agenda for Transformation (AFT) aims to "increase access to renewable energy services and affordable power for community and economic transformation" and this also aligns with "*the Liberian government, with support from the international community, commits to adopting an aggressive and responsive access agenda by increasing the share of renewable energy in the national energy mix."*	Thank you.
Other document reviewed: 1. Project appraisal document on proposed credit facility US$35m for an Accelerated Electricity Expansion Project (LACEEP) May 2013. 2. Preparation of a Government of Liberia Least-Cost Power Development Plan (LCPDP) August 2013. 3. Options for the Development of Liberia's Energy Sector, Africa Energy Unit (AFTEG) Energy Sector Policy Notes Series, October 2011. The IPRE is a well-constructed simple and logical document with more detail in a number of annexures including a concept note (annex 3) entitled "Renewable Energy for	During the finalization process, the Investment Plan has been edited by a professional editor.

Electricity Programme (REEP). There are quite a few typos, but otherwise the document it is well written.	
General **The Investment Plan background** With a population of 4.1 million and a nominal GDP per capita of $374 in 2011Liberia is the 3rd poorest country in the World and emerging from 14 years of conflict ending in 2003 that decimated infrastructure which is slowly being rebuilt from a very low base. For a number of years no grid electricity was available and stand-alone generators were the only provider of electricity. Currently grid access is 1.6% (mostly close in the capital and close to other urban areas) to and total capacity as of 2013 is 23MWs. This electricity mostly generated from diesel is the most costly in Sub-Saharan Africa costing around $0.45/kWh and selling at $0.50/kWh. In Liberia, 90% of primary energy is from biomass, a level common to many African LDCs (e.g. Tanzania). Investment plans are being put together, including this RE investment plan and others for electricity generation, transmission and distribution. Other plans are looking to restore war-damaged dams and consider hybrid solutions where hydrology is uncertain into the future. A key co-benefit objective of this investment plan is to enhance the role RE in the Liberian energy sector in an attempt to avoid fossil lock-in (diesel and HFO) as it reestablishes itself. The RE Investment plan explains the institutional and policy environment referring to regulation, least-cost planning, an electrification fund and levels of institutional capacity. It calculates the levelized costs of the various supply options and rates qualitatively the priority areas for SREP focus considering grid and off-grid opportunities. The levelized cost assessment show that biomass, small hydro, PV, HFO and diesel range between US$ 0.18 to 0.5/kWh (not taking load factors into account).	Thank you for the summary. Load factors were included for the calculation of economic levelized cost for comparison purpose. This will be made clearer in the document. The details for each specific site will be done at project level.

• complies with the principles, objectives and criteria of the relevant program as specified in the design documents and programming modalities The investment plan complies with SREP principles, objectives and criteria.	Thanks for endorsing the proposed Investment Plans as this is aligned to both on national strategy and on SREP principles.
• takes into account the country capacity to implement the plan It recognizes the limited capacity to implement the programme and allocates resources to Technical Assistance. Transformation requires enabling policy, affirming demonstrations, dedicated finance, human skills and institutional capacity and indicators and monitoring to be undertaken in parallel. The SREP is strong on most of these but perhaps weakest on skills and capacity not only in public for policy implantation, monitoring and evaluation but also private institutions to bid for, finance and deliver good quality services. More emphasis needs to be put into institutional strengthening in terms of human skills and institutional capacity indicators, monitoring and reporting if sustainability and absorptive capacity is to be built in both public and private sectors. Of the full investment of US$161.7m, only $8.5m goes into technical assistance including: Transaction Advisory Services: $2.0m; Renewable Resource Assessment: $0.5m; Regulatory/Policy Support: $1m; Regulatory/Policy Support: $1m; Training & Capacity Building: $1.5m; Knowledge Management - M&E: $0.5m; and Programme Management: $3m.	The Government acknowledges the lack of technical and human capacity which could hinder the program implementation. This issue has been well taken into account while designing the investment plan and proposed REEP program. Under REEP, there will be one programmatic capacity building and knowledge management program, as well as project's specific technical advisory services. Compared to other SREP IPs, a lot of emphasis has been put on these aspects that will ensure efficient preparation and implementation of the program. It should also be taken into account that this technical assistance won't be done in isolation, but rather in collaboration with other existing programs (NVE, USAID/Winrock, other WB and AfDB projects, etc.); therefore, this technical assistance should be considered as part of the broader support provided for the development of the energy sector in Liberia.
• has been developed on the basis of sound technical assessments Technical assessments have been undertaken on the demand and supply potential, the refurbishment of the Mount Coffee and new oil based (HFO and Diesel) generation possibilities. There is out of date data on small hydro potential (where the hydrology needs to be assessed in the light of changing rainfall patterns), some of biomass residues	In order to avoid delaying the preparation of the Investment Plan, the Government and MDBs agreed to prepare the IPRE on the basis of existing information. Further assessment and analysis will be done on the renewable energy potential (especially mini hydro and biomass) during projects' preparation. The levelized cost at calculated with different capacity factors in the case of mini-grid.

and charcoal etc. Wind potential has not been assessed, but thought to be low and solar radiation, diffuse. There are levelized cost assessments that give a comparison of various options at full load factors. The calculations are not transparent, giving no indication of the discounting and interest rates and other assumptions etc.	This will be made more explicit as well as the assumptions considered. The IPRE supports more comprehensive renewable resource monitoring. An annex giving the assumption used in levelized cost calculations has been added
• demonstrates how it will initiate transformative impact The REEP is in two phases. The first includes activities to mainstream off-grid electrification approaches using renewable energy mini-grids has 4 parts, and planned over 4 to 5 years. It includes: • *Task A-I. Developing rules and regulations.* • *Task B-I. Preparing electrification projects.* • *Task C-I. Minigrid electrification investments.* • *Task D-I. Other technical assistance and promotion of productive uses of electricity.* The second phase includes additional project investments, and includes the following: • *Task B-II. Preparing electrification projects.* • *Task C-II. Mini grid electrification investments.* • *Task D-II. Promotion of Productive Uses of Electricity.*[28] These plans are not elaborated in much detail in the body of the report but annex 3 provides a REEP concept note that further elaborates tasks. These tasks in the concept note do not align fully with what is in the body of the text. This needs correction.	The program concept note, in annex, is where more information is required on the proposed investments; it is more detailed than the text in the Investment Plan. We have reworked on the investment Plan and concept note to make sure they are fully consistent and provide complementary information.

[28] This is not included in the body of the text, but is included in the annex.

It promotes a modest 8MW renewable energy technology investment – which is not small in terms of capacity of the entire country, but may contribute to the transformation achieving a affirming demonstrations of RE in electricity generation at a time when the entire electricity sector is being rebuilt. This affirming demonstration will be contingent upon good process/consultations, high quality equipment and good after sales services.	The 8 MW reference was erroneous. The correct figure should be12.8 MW. Given that the LEC capacity is only 23 MW presently, this proposed SREP target for areas outside of Liberia is ambitious. More importantly, these generation investments are expected to serve 9 percent of Liberian population.
• provides for prioritization of investments, stakeholder consultation and engagement, adequate capturing and dissemination of lessons learned, and monitoring and evaluation and links to the results framework After identifying the focus for investments in 3 technology options utilizing 8 SREP and 2 National criteria weighted 3=high, 2=moderate and 1=low alignments. It selects the RE investment opportunities using these criteria transparently, but qualitatively. Levelized costs are also used as a guide for selection.	Thank you. The Government has put some effort in carrying out the prioritization process that is based both on technical analysis and public consultations with key national stakeholders.
Stakeholder consultations and engagement The plan includes stakeholder consultations and insists on participatory processes to engage the immediately affected and other critical stakeholders specifically women. Annex 5 outlines the high level stakeholder consultations of SREP missions and those conducted by government. Stakeholders consulted by the SREP mission have been published in the Aide Memoire of the CIF technical mission.	Thank you. During IPRE preparation, the stakeholders' consultation process was led according to national and SREP objectives.

Capturing and dissemination of lessons learned The Investment Plan was posted on the RREA website for comments for a 2 week period ending the 15th September. Comments have not been elaborated in the investment plan.	The Government conducted in parallel a consultation process including, 2 weeks for national and energy stakeholder comments, and for the Independent Review of the IP. The Government has received comments from some stakeholders and Independent Reviewer and they have been taken into account while finalizing the Investment Plan.
Monitoring and evaluation Section 8 in the body of the report deals with monitoring, evaluation and knowledge management.	The Government and MDBs acknowledge the importance of a well-functioning M&E system to guide the development of the sector; SREP will support the strengthening of the existing system and complement it with specific RE data. Knowledge management will also be critical to share lessons learned from the pilot mini-grids and expand what will work best for scaling up the program.
Links to results framework MLME, the ministry with statutory oversight of the energy sector, will be the coordinator/focal point for the SREP M&E system. Table 8.1 summarizes the proposed SREP M&E results framework, which is in line with expected outcomes.	Thank you. The Government and MDBs expect to further strengthen the SREP results framework during projects preparation – see PPG of AfDB-supported project.
• adequately addresses social and environmental issues, including gender The plan addresses social and environmental issues and focuses on women as beneficiaries of modern energy access. The access to modern energy requires considerable emphasis on the receiving end of technology transfer so as to facilitate informed decision making on energy technologies and efficient use of modern energy. This is particularly important where many of the beneficiaries will be achieving access for the first time. The introduction of efficient lighting technologies and other appliances may require demonstration through energy shops or dedicated demonstrations.	The program builds on the experience on the pilots of mini-grids and efficient solar LED lantern project. This is already happening through Lighting Lives in Liberia project and in RREA participating in Lighting Africa program.

• supports new investments or funding is additional to on-going/planned MDB investments The Investment Plan leverages other finance in 'making market' for renewables. With the fragile state and the legal and regulatory gaps, and high risks it is early in the countries redevelopment. No doubt as the country stabilizes and the policy environment firms and enables (long, loud and legal), other investments from MDBs amongst others will follow.	SREP funds are leveraged 2.3:1 from other sources, including MDB concessional financing, trust funds, development partners, private operators, and Government contribution. This leverage takes into account the absorption capacity of the country at present. It is expected that further new investments will be generated under Phase 2 of the program once the enabling environment is in place.
• takes into account institutional arrangements and coordination The plan provides an organogram of the institutional arrangements for co-ordination for the government and its agencies. The plan talks to enabling private sector participation and transformational alignment with PPPs.	Thank you. The REEP program will build on existing institutional arrangements and strengthen them when needed. It also aims at putting in place the adequate enabling environment for private operators to invest more under Phase 2.
• promotes poverty reduction The very low-level access to electricity will be increased both through grid and non-grid extensions of access. The increased access will decrease energy poverty, however the extent to which electricity access and consumption is affordable for the very poor will depend upon the subsidy policy for access and whether poverty tariffs are included by the energy regulator. 240 000 people will gain access according to the plan, but these are unlikely to be the very poor. The key to poverty reduction will be in the capacity development through tasks DI and DII which deals with productive uses. Specifically, the degree to which the plan addresses women and their livelihoods will be a test on how the plan aligns coherently with the Govt's AFT. It is recommended that the tariff structure or the principles to design the tariff includes the capacity and willingness to pay during the project design in order to make sure that more people have access to the services?	**The program will benefit 360,000 people that represent 9 percent of the population**. The very poor whose needs are basic lighting and mobile phone charging (Tier 1 electrification as per ESMAP/SE4ALL classification) will benefit from Lighting Lives in Liberia project as well as stand-alone solar under IPRE. The Tier 2 and Tier 3 needs will be met by mini-grid power and the larger stand-alone PV. The tariff structure with lifeline tariffs for the low electricity consumers (poorest) will be determined during feasibility studies that include capacity and willingness to pay appraisals as indicated in the plan. The number of beneficiaries is revised based on the use of stand-alone systems.

• considers cost effectiveness of investments. The plan envisages investment of around $160m to deliver 8MW. In basic terms this is US$20 000/kW. Which is very high. However, according to the levelized cost assessments these are the least-cost options. Much of the spend will be buying down the transactional cost in 'making the market' for RE in the redeveloped energy economy of a post-conflict country.	It is incorrect to calculate the effectiveness of a program through the calculation of MW/total program cost. The total MW for the plan is 12.9 MW with a total capital investment of $136.1 million. This comes to $10,600 per kW including $48 million for T&D, connection cost for mini-grids and stand-alone solar. Without the T&D, connection cost and stand-alone solar, the investment cost is $6200/kW, which is high but considered reasonable given the high costs in electrification of rural areas in Liberia. Stand-alone systems are also planned as part of the program.
Specific to SREP	
Catalyze increased investments in renewable energy in total investment	
• Catalyze increased investments in renewable energy in total investment: It is estimated that the SREP investment of $50m leverages additional finance in ratio of 1: 2.2 to a total around $162m. These additional funds are tentative and will need to be secured during inception and beyond. There is much attention paid to creating an enabling environment for increasing private sector involvement in renewable energy. This aligns with the strategic transformation of the Liberia in which PPPs are a useful vehicle for early investments in infrastructure . The Investment plan describes how the investment options might be addressed in phases and how these may be financed in achieving 8MW of installations at a cost of US$162m. It concludes that most activities should be grid and off-grid solutions utilizing solar, biomass, and small hydro-power. It anticipates being able to affect the lives of around 240 000 beneficiaries. This is a small contribution in the context of what is required in Liberia that will need to demonstrate technology attributes as well as affordable	The potential of MW has revised and it is expected around 12.9MW (including stand-alone solar) that will be confirmed at feasibility level. These $162 million includes more than installation costs, includes T&D, connection to the end user and stand-alone system. Additionally, this will cover the feasibility of the sites, resource assessment, productive uses promotion, and building capacity needed in the institutions to carry out the program. The beneficiaries should be 360,000 when stand-alone PV is included. Given the fragile nature of Liberia, the GOL considers it prudent to take small steps, and learn from lessons and then take more ambitious steps to scale up. **However, this represents 9**

financing and enabling policy and institutional oversight that has the opportunity to make market to attract further public and private investments. A dedicated search for co-financing during and beyond the multi-year SREP investment plan period may be required to further engage public and private investors in renewable energy in Liberia.	**percent of the population in Liberia**. The GOL is actively working with the MDBs and bilateral partners to secure additional financing for the reconstruction of the whole sector.
Enabling environment	
Barriers to be addressed (reduced or removed) by the Govt. of Liberia generally and SREP specifically To create an enabling environment for investment in renewable energy technologies, barriers need to be identified and mitigation strategies developed and implemented. The investment plan list barriers and mitigation measures most of which are to do with the emerging and fragile Liberia. These barriers include: fragile situation; absence of adequate legal and regulatory frameworks (ratification of RREA, no clear private sector involvement in RE); not sufficiently coherent energy strategy; lack of access to finance/capital; high costs of projects; limited affordability; Liberia is not yet interesting for investors, financiers, contractors, and suppliers; human and institutional is limited; and renewable energy data unavailable of variable quality. Mitigation possibilities of each of these are considered. Some barrier reduction and others are rather general and will have modest efficacy with respect to the energy sector. The strengthening of policies and institutional capacity is certainly part of the SREP investment plan and this will need to be conducted with diligence and monitored so as to achieve the long, loud and legal attributes of an enabling environment for investors and beneficiaries alike. Two key issues that will need to be addressed include: 1. The regulation of the electricity sector needs to be independent and established	The GOL considers that in the light of limited resources, least cost solutions are of paramount importance. While a regulatory system is established, it plans to use existing institutions and regulation-by-contract mechanisms to support its electrification efforts. Many other countries have adopted such a stepped approach as it takes time to set up an effective and functioning regulator. Lack of a regulator must not hold up bringing electricity access to Liberians. These mini-grid and stand-alone electricity developments are the responsibility of RREA and not LEC. As the IPRE notes, grant support will be judiciously applied to make electricity services affordable to various segments on consumers.

outside of the Liberia Electricity Corporation and Government. I am sure that this is envisaged and will be implemented, but until that time transparent and least-cost investment need to be ensured (formal checking and external review may be required here in the interim). 2. Tariffs that facilitate cost recovery and provide equity will be necessary as the grid and off-grid electricity is expanded. Cross-subsidy will need to be facilitated between larger and smaller users. In the absence of a regulatory authority, this will need to be dealt with to ensure that LEC does not over recover. A key issue is to reduce economic and social fragility and create opportunities for the youth and other entrepreneurs so as to avoid potential for conflict. This issue pertains to much of Africa and beyond making the role of increasing modern energy, a key input to increasing livelihoods and contributing to economic and social stability.	The GOL considers this as a key element for IPRE. As such the IPRE supports mini-grids that can provide adequate energy to operate commercial and industrial enterprises while stand-alone solar is used for those requiring basic electricity services for lighting and perhaps communication. The TA plan also supports productive uses promotion in areas slated to get mini-grid services.
Increase Energy Access	
The SREP Investment plan develops 8MW of renewable energy delivering access to differing levels of modern energy services to 240 000 beneficiaries. Some of the general and specific barriers that are listed in the investment plan are mentioned above. These will have to be addressed programmatically by the energy sector and other Government agencies that have an economic development agenda in which energy is a precondition for development. The extent to which electricity access is considered as a right or precondition for development needs to be unpacked and translated into access subsidy (both for grid and off-grid). Consumption should not be subsidized, but poverty tariffs, inclining blocks, time of use tariffs and smart meters that provide pricing signals to drive efficiency and allow for transparent cross-subsidy should be (to the extent possible) in place going forward.	The potential of MW has revised and it is expected around 12.9MW, benefiting 360,000 customers through investments in mini-grids and stand-alone systems. This is in line with the tariff setting approach under consideration for mini-grids. Further tariffs studies will be done during projects preparation in order to come up with the most appropriate tariffs that ensure investments sustainability.

• Implementation capacity: The investment plan evaluates grid and off-grid technologies including: grid connected biomass, small-hydro, and stand-alone solar and hydro powered mini-grids. With the modest levels of energy investments required for the entire country's energy economy, the SREP investment (including what is being leveraged) needs to be considered in the light of what the Liberian energy economy can actually absorb and invest appropriately. The nature of the Liberian state necessitates small and modest investments plans to contribute to the transformative model. There is a focused attention on mobilizing private sector involvement, development partners but little is said about civil society organisations and their engagement in the project, which is critical to achieving the desired sustainability.	The REEP program will create the enabling environment for potential private participation. However, civil society is key in the design of the projects and it is expected to be the same through the implementation; this has been further elaborated in the revised Investment Plan. In the delivery models, it is expected to reach out civil groups that have certain level of organization that can facilitate the delivery of services. This is included in the delivery model section of the program description. The program also builds into the experience of civil society groups that were organized before the way and are now being regroup, as an example the rehabilitation of the Yandahun small hydropower plant that is based on a cooperative model.
• Improve the long-term economic viability of the renewable energy sector: The mobilization of the private sector either in PPPs or as bidders to take on the implementation of the project elements is included in the plan. The immaturity of the legal, regulatory and financial sector implies that private sector will consider the environment very risky. CIF SREP or MDBs may consider some guarantees to underpin early private sector movers' investments and payments from LEC (as they have done in SREP Tanzania wrt Geothermal energy). There is clearly the description of many activities that may achieve the elements of an enabling environment for private sector participation in the transforming economy generally and in the energy sector specifically.	Thank you. These instruments are included in the design of the program.
• Transformative impact: Increasing energy access is transformative in Liberia. The investment plan deals with	Thank you - The Government and MDBs have designed a REEP program that will both help achieve GoL's targets in terms of rural electrification, but also set the stage for future private investments,

increasing access, and facilitates the opportunity to avoid further fossil lock-ins. The plan provides an international precedent for energy leapfrogging away from fossils and this is internationally transformative if sustainability can be achieved – implying a requirement for the best opportunities for success through excellent process and subsequent delivery.	thus ensuring short- and medium- term transformation of the energy sector.
Recommendations	
More details are needed in the implementation plan, or the reviewer needs to know something about how the plan is to be developed beyond the concept in the annex. Human skills and institutional capacity, essential for the successful implementation, needs a good deal more attention in the document.	Some more information has been added in the Investment Plan; however, implementation details will be further detailed during projects preparation (see PPGs of both projects).
Long-term stability could be further secured by securing productive and livelihood activities in governance and policy research, the energy sector (electricity, biomass value chain, ESCO activities etc.) and downstream in productive activities, SMEs, commercial agriculture and other livelihoods opportunities. This is included in the investment plan, but should specifically focused at youth and entrepreneurs. Youth livelihoods as a result of modern energy access enjoys limited attention in the plan and is essential to achieve social stability in a country with fresh memories of war and a large un and under employed youth. However, electricity affordability and hence uptake is a chicken and egg situation that may require stimulation on the demand side for productive activities that may secure and maximize employment and livelihoods opportunities.	The GOL considers it their responsibility to ensure that all citizens benefit – women, youth and men. The REEP program will support work on the productive uses of electricity that will benefit all.
The Technical Assistance resources for capacity building are only available in the first phase (table 6.1) and appear too small for Liberia in regulatory/policy support, training and capacity building specifically and all TA items generally. The technical energy, finance, planning and process human skills and institutional capacity required for delivering electricity specifically and energy generally, will need building and strengthening so as to achieve sustainable energy services.	Though listed as being in Phase I, TA is available throughout the SREP project. These significant resources are allocated for transaction advisory services specifically to prepare projects and encourage private sector through PPP to bid for projects under SPRE financing. There is a whole section devoted to M&E and resources have been set aside for capacity building, knowledge management and M&E. These complement rather than duplicate

	similar work supported by other donors. Additionally, there is ongoing TA for capacity building that the program IPRE will benefit from. As an example, collaboration with the Norwegian Water and Energy Directorate (NVE) based in Monrovia for building capacity on hydrology measurements to identify hydro potential.
The levelized cost assessments need to be more transparent including interest/discount rates, assumptions and real load factors. It is recommended to make clear the assumptions for these calculations.	For mini-grids load factors were taken into account in calculating the levelized cost, this is clarified now in the new version of the IP and assumptions are included in an annex. HOMER was used in the simulations and optimizations. There is an Annex giving the assumptions and methodology used in mini-grid sizing and levelized cost calculations.
Modern biomass and improved thermal services (cookstoves and solar thermal applications etc.) should be extended alongside electrification. This synergy could work if good technical and consultative processes (to enhance informed decision making) are extended. Electricity is unlikely to meet (and should not meet) thermal service requirement particularly in off-grip situations.	The GOL took into consideration the principal challenges involved in improved energy services and how wide the scope of IPRE should be. GoL decided to focus attention on electricity services and stakeholder consultations supported this decision. Being too ambitious in scope, given the limited capacities in the country, could lead to unacceptable failures.
Hybrids and biomass cogeneration. The issues of hydrology and inconsistent water flows make hydro-power questionable but these hydro projects may require a back-up through fossil or biomass generation possibilities. This strategy is included in the LCPDP – but biomass is not present in the LCPDP. There is guidance on utilizing biomass for power generation, which may be result in leakage i.e. by removing from alternative usage. It is essential planning provision that biomass electricity generation does not result in such an outcome. Hybrid possibilities for multi-functional platforms (MFPs) for electricity and shaft power may be considered for agricultural applications. The strategy would to	The IPRE focuses on electricity services in areas not served by LEC. The LCPDP is a plan for LEC. The GOL is fully aware that use of biomass for power generation may compete with biomass currently used for charcoal production. These concerns will be addressed during projects preparation through detailed assessment and analysis (see PPGs). Supplying diesels to remote rural areas is enormously challenging.

initiate MFPs using diesel alongside the growing of fuel plants for fuel oil production to which the MFPs could switch.	It is not merely the logistics of such supply which can be daunting during the six month rainy season, but importantly the ability of the community to continue to pay for such diesel fuel consumed. Sustainability principles adopted during the IPRE preparation was to minimize such recurrent costs that would be unaffordable to the community.
I understand this to be a renewable electricity project, but why were thermal services not considered to be part of the renewable energy mix, like, for example, the biomass and charcoal value chain/s for cooking and other thermal services? While I agree that this can be addressed later and the current issue is to avoid fossil fuel electricity lock-in, some engagement in this sector that provides 90% of the primary energy may be warranted even if it is capacity for improved cook stoves and kilns and a carbon programme. In 2005 charcoal production was at 36500 tonnes per year (which seems a little low for an entire country). Biomass used for energy in Liberia is 97% non-renewable (Ref: CDM EB 67 Annex 22 11th May 2012) and thus intervention appears urgent as there is no current alternative for thermal services.	The calculated number of 97% of non-renewable biomass removal reported in CDM EB 67 Annex 22 11th May 2012, refers to biomass removal from forests for all purposes. By far the largest removal is for timber from forest concessions. While we agree that sustainable harvesting of forest resources is important, addressing this non-renewable biomass removal which is primarily due to timber harvesting is outside the scope of the SREP. This concern is being partly addressed by the multi-donor, Liberia Forest Initiative. See also response above to observation, "Modern biomass and improved thermal services (cookstoves and solar thermal applications etc.) should be extended alongside electrification."
The least-cost methodology should be transparent and developed with interim LEC regulators so that at some stage in the future it can be transferred to an independent regulatory authority for them to adapt and utilize the methodology as will hopefully be required by their mandate. Least-cost planning is a standard regulatory principle (however how the costs are apportioned may be at the regulators' discretion) in which levelized cost methodology is a key instrument. An algorithm would help show the principle decision making in a LCPDP. It should include fuel-switching options for	IPRE deals with electricity services in areas that LEC will not serve. The GOL appreciates the reviewer's recommendations. The power generation and electrification plans in the geographical areas served by LEC will be dealt with through the LCPDP. As the title implies, it will develop a least cost plan. Liberia has one of the lowest per capita electricity consumptions in the world at 78 kWh per capita per year, or merely 213 Watt-hours per person per

thermal services (e.g. biomass and solar thermal) and DSM, efficiency and conservation measures. How to deal with variable capacity factors from the demand side as well as how to deal with variable hydrology is essential. It is recommended to make clear the assumptions for these calculations.	day. While recognizing the value of efficiency improvements, the GOL considers that increasing access to higher electricity to meet living and economic development needs to be of paramount importance.
Generally traditional energy policy that begins with supply options results in large inefficiencies and a need to drive consumption. While demand is considerably suppressed and demand must grow in meeting sufficient levels of energy service, if this demand is to be delivered while achieving a more efficient energy system from the start, it may require analysis of the required energy services (lighting, thermal, shaft (pumping, milling, etc.) and then fitting the grid and non-grid supply solutions to delivering the required level of service can be efficiently planned. Such an approach would result in a maximization of efficiencies from primary to delivered and delivered to useful energy services.	A demand analysis will be conducted during projects preparation to optimize the design of the mini-grids. Demand analysis will be based on appropriate end-use devises consistent with the community needs and energy efficiency. Moreover, during project implementation, consumers will be provided with advise on adopting efficient appliances and efficient energy use practices.

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