ECREEE

National Bioenergy Action Plan

LIBERIA

Period [2022-2030]

CONSOLIDATED REPORT

Within the implementation of the

ECOWAS Bioenergy Policy (EBEP)

Date: April 2022

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ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE)

http://www.ecreee.org

For the Ministry of Mines and Energy, Republic of Liberia

Developed with technical assistance of:

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ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE)
http://www.ecreee.org

Within the framework of

SUSTAINABLE ENERGY FOR ALL

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ABBREVIATIONS AND ACRONYMS

AfDB	African Development Bank
AFR	Africa Forest Restoration (AFR100)
AfREA	Africa Renewable Energy Access (AFREA) Trust Fund
ARA	African Refinery Association
BERE	Bureau of Electricity and Renewable Energy
BH	Bureau of Hydrocarbon
BRP	Bureau of Research and Policy
CC	Climate Change
CFMAs	Community Forest Management Agreements
CLSG	Ivory Coast-Liberia-Sierra Leone-Guinea (CLSG) T&D Line
CSOs	Civil Society Organisations
DDO	Distillate Diesel Oil
DOE	Department of Energy
EBEP	ECOWAS Bioenergy Policy
ECEU	Efficiency, Conservation and Environment Unit
ECOWAS	Economic Community of West African States
ECOW-GEN	ECOWAS Programme on Gender Mainstreaming in Energy Access
ECREEE	ECOWAS Centre for Renewable Energy and Energy Efficiency
EE	Energy Efficiency
EEEP	ECOWAS Energy Efficiency Policy
ELWA	Eternal Love Wining Africa (Radio Station – community)
EPA	Environmental Protection Agency
EREP	ECOWAS Renewable Energy Policy
ERSIM	Energy Research, Statistics and Information Management Unit
ETBE	Ethyl-tertio-butyl-ether
EU	European Union
FDA	Forestry Development Authority
FIT	Feed-in-Tariff
FSPU	Facility Siting Permit Unit
GAVI	Global Alliance for Vaccines and Immunization
GDP	Gross Domestic Product
GEF	Global Environmental Fund
GFU	Gender Focus Unit
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
GIZ/EnDev	GIZ/ Energising Development
GOL	Government of Liberia
GON	Government of Norway
GPU	Grid Power Unit
GWh	Giga Watt Hours
ha	hectare
HCFs	Health Care Facilities
HCS	High Carbon Stock
HCV	High Conservation Value
HFO	Heavy Fuel Oil
HV	High Voltage transmission system
ICS	Improved Cookstoves
IDA	International Development Association
IPP	Independent Power Producer
KfW	Bank of Germany

KToe	Thousands of Tons of Oil Equivalents
kV	kilo Volt
kVA	kilo Volt Amperes
kW	kilo Watt
LACEEP	Liberia Accelerated Electricity Expansion Project
LACEEP-AF	Liberia Accelerated Electricity Expansion Project (LACEEP) plus Additional Financing
LEAP	Liberia Energy Access Practitioners
LEC	Liberia Electricity Company
LERC	Liberia Electricity Regulatory Commission
LESEP	Liberia Electricity System Enhancement Project
LISGIS	Liberia Institute for Statistica and Geoinformation System
LPG	Liquefied Petroleum Gas
LPRA	Liberia Petroleum Regulatory Authority
LPRC	Liberia Petroleum Refining Corporation
LRA	Liberia Revenue Authority
MCC	Monrovia City Corporation
MDG	Millennium Development Goals
MFP	Multi-Functional Platform
MME	Ministry of Mines and Energy
MOHSW	Ministry of Health and Social Welfare
MPW	Ministry of Public Works
MTBE	Methyl-tertio-butyl-ether
MW	Mega Watt
MWh	Mega Watt hour
NBEAP	National Bioenergy Action Plan
NBEAPL	National Bioenergy Action Plan for Liberia
NBCC	National Bioenergy Coordinating Committee
NEEAP	National Energy Efficiency Action Plan
NEEAP	National Energy Efficiency Action Plan
NEP	National Energy Policy
NEPL	2009 National Energy Policy of Liberia
NERC	North American Electric Reliability Council
NGOs	Non-Governmental Organizations
NIP	National Implementation Plan
NOCAL	National Oil Company of Liberia
NPRA	National Liberia Petroleum Regulatory Authority
NREAP	National Renewable Energy Action Plan
NREL	National Renewable Energy Laboratory
OGPU	Off-Grid Power Unit
PEPU	Petroleum Exploration & Production Unit
PET	Polyethylene terephthalate
PHFs	Public Health Facilities
POP	Stockholm Convention on Persistent Organic Pollutants
PPA	Power Purchase Agreement
PPMU	Petroleum Processing & Marketing Unit (PPMU).
PPO	Pure Plant Oil
PSCs	Production Sharing Contracts
PV	Photovoltaic
RE	Renewable Energy
REDD+	Reducing Emissions from Deforestation and Forest Degradation (UN) - Strategies to enhance the sustainable forest management in Liberia
RPU	Research & Policy Unit
RREA	Rural and Renewable Energy Authority
SE4AII	Sustainable Energy for All
SSHP	Small Scale Hydro Power
SVO	Straight Vegetable Oil
TGC	Tradable Green Certificates
TPES	Total Primary Energy Supply
UMCC	USA Millennium Challenge Corporation
UN	United Nation

UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Program
UNFCCC	UN Framework Convention on Climate Change
UNHDR	United Nations Human Development Report
UNICEF	United Nations International Children ' s Emergency Fund
UNIDO	United Nations Industrial Development Organization
USAID	United States of America International Development
VAT	Value Added Tax
VRA	Volta River Authority
WACCA	West African Clean Cooking Alliance
WAGP	West Africa Gas Pipeline
WAPP	West African Power Pool
WB	World Bank
WDFs	Waste Disposal Facilities

FORWARD BY THE MINISTER OF MINES AND ENERGY

The Ministry of Mines and Energy (MME) is charged with the statutory mandate as government of Liberia (GOL) Leader to oversee the Mineral, Water and Energy Sectors of the Republic of Liberia. As the policy arm of the GOL for these sectors, the MME is responsible for the efficient and sustainable exploration, development and exploitation of the natural resources of these sectors and formulating policies, laws and regulations, standards and targets for high quality and positive development impacts on the Liberian economy. The Ministry is engaged in several activities principally aimed at strengthening energy services and mineral and water sectors to promote economic growth, enabling environment and sustainable social development for the people of Liberia. The Ministry collaborates with other relevant government ministries, legislators, agencies, corporations, authorities, commissions, and international donor partners and implementing NGOs and private sector investors and population in regulating, coordination, monitoring, implementing and undertaking programs, projects, investments and activities towards achieving its mandates.

Thus, the Ministry of Mines and Energy in fulfilment of Liberia's obligations as Member State of ECOWAS participated in the process leading to the adaptation by the ECOWAS Members States in December 2016 and the ECOWAS Heads of States on 4 July 2018 the ECOWAS Bioenergy Policy in the effort to approach the challenges of providing sustainable and efficient Bioenergy services without compromising food security, which necessitate the development of the National Bioenergy Development Action Plan for Liberia (BEAPL) required for all other member states of ECOOWAS.

The National Bioenergy Action Plan for Liberia (NBEAPL) promotes the involvement of a multi-sectorial approach with active participation of all the major stakeholders of Energy, Agriculture, Forestry and the Environment, inclusiveness within its programs and services for all stakeholders. The NBEAPL will ensure that the country's bioenergy access expansion programs of the GOL incorporate community members and business owners as visible players, producers and participants in the policymaking in the bioenergy sector.

We recall the support to the GOL of the ECREEE through which in 2021, the MME developed the National Action Plan for Policy on Gender Mainstreaming in Energy Access and Liberia Act on Gender Assessments in Energy Projects-2020; the NREAP and the NEEAP in 2016; and the Liberia Sustainable Energy for All (SE4All) Action Agenda in 2015 among other support.

The Ministry's bioenergy and social inclusion programs in the NBEAPL also incorporate among other activities, the development of Bioenergy Policy that provide policy-makers with instrumental and technological standards and efficiency framework indicators and make rigorous efforts to insure through spearheading pilot research, training and technology transfer programs as well as proposition for adoption of appropriate legislation, monitoring, training and coordination that ensures that all the energy sector players and stakeholders align their bioenergy access projects.

The NBEAPL also aims to promote widespread understanding of the technology and social inclusion issues such that all policies programs and institutions of the Ministry and other collaborating government agencies and stakeholder institutions should involve private sector participation to address the prerequisite for nationwide bioenergy access to be sustainable, affordable, and reliable energy services for all. The NBEAPL is also intended to undertake collaboration with the Training Unit of the Ministry and other DOE Bureaus and sections in carrying out training and capacity building for all employees of the Ministry.

The goal of the NBEAPL is also intended to identify and mitigate issues of, conflict of interest and other issues affecting the internal workforce and external stakeholders of the sector and to promote bioenergy institutional development focusing on addressing the existing and future barriers that may hinder equal participation of the public, private and local entrepreneurs in obtaining bioenergy access. The Ministry shall also encourage the critically needy local institutions and professionals to help bridge the development gaps and contribute to Liberia's Pro-Poor Agenda for Development and Prosperity.

The GOL is committed to supporting and providing the enabling environment for the initiatives for Bioenergy Sector Development in Liberia and hereby expresses thanks to ECREEE for the technical assistance provided for the development of the NBEAPL and hereby call upon all our other international partners to assist the GOL in support for its implementation as soon as possible.

HON. GESLER E. MURRAY
MINISTER
MINISTRY OF MINES AND ENERGY, RL

02 May 2023
DATE

ACKNOWLEDGEMENT

The Ministry of Mines and Energy (MME) acknowledges with much thanks the support from the ECOWAS Programme on Bioenergy Action Plan and Policy, who provided support for the local Consultant Expert working closely with the Technical Working Team (TWT) and the Department of Energy (DOE), MME and the Rural and Renewable Energy Agency (RREA) staff for its realization. This was written in connection with on-going efforts of the DOE, MME.

The Ministry also acknowledges with much appreciation the staff of the LEC, and other Governmental Ministries, Agencies and Commissions (MACs), and some key experts from other Implementing Organizations and stakeholders who provided valuable data and comments and others who responded to our interviews during the data collection exercise and the NBEAPL preparation; a draft version of which we gratefully appreciate the review made by the ECREEE Project Coordinator Mr. Guei Guillume Kouhie – ECREEE and other International Experts. We also appreciatively acknowledge the enthusiastic Bioenergy Access Sector Stakeholder Institutions that engaged with the TWT in its work to make a current status assessment of bioenergy access for Liberia and highly appreciate all participants who provided such treasured comments and valuable data during our validation workshop held on Monday March 20, 2023 for the final preparation and revision of this NBEAPL.

The Ministry also acknowledges with much thanks and appreciation the level of understanding, cooperation, technical exchange and technology transfer exercised between the Consultant and the Ministry's staff during the efforts to finalize the NBEAPL. The Ministry and its relevant senior staff and departments are the key stakeholders of this NBEAPL as the primary government representatives in the sector to make sure that this ambitious plan is implemented by the involvement of all national policymakers.

EXECUTIVE SUMMARY

The NBEAP Baseline Report for Liberia presents the ECOWAS Bioenergy minimum targets for Universal access to clean, safe and affordable cooking energy, electricity from renewable energy sources and population benefiting for development up to 2025 and 2030 and policy targets for domestic applications, transportation and financing as well as minimizing health and environmental risks enhancing and agriculture productivity**.**

Considering Liberia's current socio-economic situation, population, geography, poverty rate and available natural resources and industrial level, the paper goes on to present the Primary Energy Supply and Consumption for the Liberian energy sector analysing the main energy demand trends, annual growth rates and sectorial quantities per year for the 2010 – 2018 period including the national energy balance for 2018.

The total primary energy supply and consumption in Liberia for the year 2010 was estimated to be 34,879,003.33MWh equivalents (3,031KToe – thousands of tons of oil energy equivalents) which was analysed by fuel type and by end use demand sectors in a national energy balance for 2018 tabulation by fuel type (fuelwood, hydro, charcoal, electricity, and petroleum products and by sector, including the

residential, commercial and government, transportation, mining & industry, and agriculture & forestry sectors; discussed with accompanying tables and graphical representation. The paper notes the data gaps for the recent years as the Ministry of Mines and Energy has undergone several structural changes separating key departments (renewable energy, hydrocarbon, etc.) from the Ministry and resulting institutional capacity gaps.

The paper goes on to discuss a summary of the current bioenergy situation including the institutional arrangements of the public and research institutions of the energy sector of Liberia, as well as clean cooking, institutional framework and initiatives of other private sector institutions dealing with Bioenergy programs and projects. Furthermore, it discusses the interactions between these institutions followed by information on current policies, IPPs, programs, and projects.

The electrification sector is discussed presenting the central city generation and the Monrovia grid T&D projects of the LEC's Grid, as well as the Cross Border Power & WAPP CLSG Transmission Line. The rural electrification program being operated under the RREAs Mini-Grid programs, among other Private IPPs Solar and Bioenergy projects across the country are presented along with the LEAP member organizations.

The paper further discusses the key national priorities, legal and regulatory framework including the LERC licensing and authorization services, and overview of policy framework for bioenergy promotion.

The bioenergy technologies and services are summarized followed by a review of the trends in cooking fuel consumption and prices and introduction of improved cook stoves technologies (ICTs) in Liberia over the 1990 – 2018 period. The baseline report ends with a listing of the biomass resources technologies, the development challenges and opportunities in Liberia.

Following intensive deliberations, exchanges among the workshop participants and consideration of relevant inputs, a motion to declared the NBEAPL validated was made and was unanimously endorsed by the participants. The required GOL high level endorsement of the National Bioenergy Action Plan for Liberia (NBEAPL) was achieved.

The Validation Workshop was successfully held on Monday March 20, 2023 at the Musu Spot Conference Hall, Congo Town, Monrovia; attended by several government agencies, international and private energy sector organizations, development partners, civil society organizations, media institutions and journalists. Wide publicity was accorded the program on radio and television

CHAPTER 1 INTRODUCTION

The ECOWAS Bioenergy Policy (EBEP) was adopted by the ECOWAS Member States in December 2016 and the ECOWAS Heads of States on 4 July 2018. In an effort to approach the challenges of providing sustainable and efficient Bioenergy services without compromising food security, it is necessary to develop appropriate and adequate policy instruments for Bioenergy at both regional and national levels. ECREEE, together with its partners, therefore elaborated and validated a Regional Bioenergy Strategy in Bamako Mali on the 22 March 2012. The Bioenergy Strategy document was adopted by the ECOWAS Ministers of Energy in Accra, Ghana on the 31 October 2012. One of the principal components of the Strategy Framework is the development of a regional Bioenergy policy. The ECOWAS Bioenergy Policy was developed with the financial support of UNDP and involved a multi-sectorial approach with active participation of all the major stakeholders of Energy, Agriculture, Forestry and the Environment. The ECOWAS Bioenergy Policy (EBEP) was finally adopted by the Authority of the ECOWAS Heads of State and Government in Monrovia in July 2017.

This policy seeks to promote a modern, sustainable and vibrant bioenergy sector in the region by creating an enabling environment that can unlock the potentials by removing the institutional, legal, financial, social, environmental and capacity gaps and barriers. It is aimed at addressing the needs and constraints of the governments, the private sector and the local communities in using existing biomass resources including household, agricultural and industrial processing wastes and residues.
The policy document was prepared with technical support of the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) and a broad range of international partners (UNDP, Austria, and Spain). The policy includes minimum targets and scenarios for bioenergy and measures, standards and incentives to be implemented at both regional and national levels.

The following targets are proposed for the modern bioenergy sector:

Table 1: ECOWAS Bioenergy Policy Targets

ECOWAS BIOENERGY POLICY TARGETS			
Main Bioenergy target by 2020 / 2030	**Baseline: 2012**	**2020**	**2030**
Share of efficient charcoal production	17%	60 %	100 %
Share of population using alternative modern fuels for cooking	27%	36 %	41 %
Biodiesel and bioethanol as share of fossil fuels consumption	<1%	5%	10%
Bioelectricity	+/-100 MW	634 MW	2008 MW
Fuel-wood saved from 2012[1]	NA	700million tons	3billion tons

[1] Saving 700 million tons of fuels wood correspond to roughly 18 billion USD based on current price of wood in Burkina Faso

Table 2: ECOWAS Bioenergy Policy Targets with LPG and ICS Alternative (With LPG and ICS as Alternative to reduce Traditional Wood energy consumption)

Main Bioenergy target by 2020 / 2030 (for LPG & ICS)	Baseline: 2012	2020	2030
Share of population using improved cook stoves[2]	29%	60%	100%
Share of efficient charcoal production	17%	60 %	100 %
LPG penetration household level[3]	8%	20	26

1.1 Bioenergy Policy Targets by 2020:

1) Universal access to clean, safe and affordable cooking energy, including 20% of LPG users. Such a scenario represents:
   a. over 10 million of additional household users of LPG as primary fuel in comparison with the 2012 situation,
   b. about 15 million additional households using ICS as main cooking device and/or sustainable biomass fuel as primary fuel,
   c. 700 million tons of wood saved between 2012 and 2020 e.g. 18 billion USD

2) 26 % of electricity from Renewable Energy source (2,425 MW) in the region; of which 634 MW is generated from biomass residues or dedicated plantations with the deployment of sustainable and efficient technologies and application including:
   a. Biomass heat and power: systematic approach to sugar processing companies and other large-scale producer of biomass to valorise their waste stream to electricity.
   b. Waste-to-energy: connecting with cities/municipalities, agro-industries, slaughterhouses, and waste water treatment plant to convert waste into electricity, biogas, pellets/briquettes, etc.
   c. Electricity from wood plantation in countries such as Liberia, Guinea and Sierra Leon
   d. Biogas production, gasification of agricultural residues for energy (electricity, heating and cooking) in association with NGOs and local communities, including women in the rural areas.

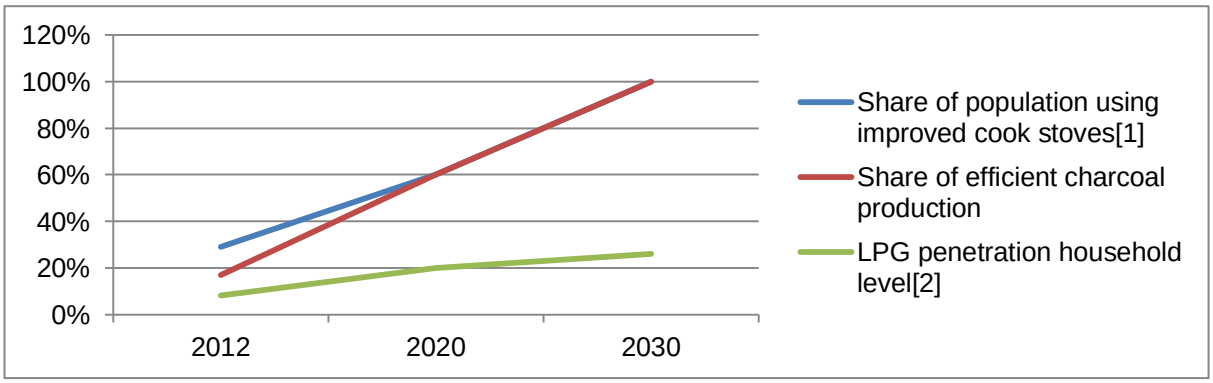
1.2 Bioenergy Policy Target by 2030:

1) Universal access to clean, safe and affordable cooking energy, including 26% of LPG users and 100% of improved cook stoves (ICS) and/or sustainable biomass

[2] Improved cook stoves refer here to wood and charcoal burning stoves
[3] LPG is taken here in the table because of its capacity to replace traditional biomass use

fuels users. Such a scenario represents almost 3 billion tons of wood saved between 2012 and 2030. The graph below represents the expected situation by 2020 and 2030 with regards to improved solid biomass fuels, the dissemination of improved stoves and the sustainable production of biomass.

Figure 1: Projected target share of population using the three types of stoves in the household (2012-2030).



2) Electricity from biomass will account for 5 % of the total installed capacity in the region, which corresponds respectively to 686 MW by 2020 (28% of RE capacity) and 2008 MW (13% of RE Capacity) by 2030.

For domestic applications, transportation and financing:

- Ensure universal access to improved cook-stoves to 100% by 2020;
- Increase the share of the population served with modern fuel alternatives for cooking to 36% by 2020 and 41% by 2030;
- Increase the penetration of LPG for cooking to 20% by 2020 and 26% by 2030;
- Increase the share of efficient charcoal production to 60% by 2020 and 100% by 2030;
- Introduce blending ratios for Ethanol/bio-diesel in transport fuels of 5% by 2020 and 10% by 2030;
- Conduct research on the use of ethanol and other fuels as domestic cooking fuels;
- Reduce fuel-wood consumption, as a result of the Policy implementation, by 700 million tons by 2020 and 3 billion tons by 2030;
- Create instruments for financing sustainable energy, including carbon finance in the longer term; establish a regional fund for the development and implementation of sustainable energy projects.

For minimizing health risks, gender imbalance and improve socio-economic wellbeing

- Reduce health risks associated with smoke inhalation and long distances travelled by women and children by introducing very efficient burners for cooking and heating that consumes less wood fuels and reduce travel time;

- improve livelihoods through involving small-scale farmers as direct producers or out-growers enabling them to generate new income, opening up employment opportunities, and thereby alleviating poverty and boosting rural incomes;
- Use of agricultural residues can lead to more investments and modernization of the agricultural sector by increasing mechanization, but taking measures to minimize the impact on biodiversity, land use, soils, and water resources.

For enhancing Agricultural productivity

- reduce the poor practices of “slash and burn” as a way to clear land, as such practices negatively impact on biodiversity (insects, plants, etc.) and contribute to soil erosion;
- The use of slurry (residue of biogas production) and nutritive ash (residue of controlled combustion processes or bio-char) can greatly improve the soil and increase agriculture yields.

For enhancing the Environment:

- Stimulating farmers to collect and/or use agricultural waste, rather than burning it as an additional source of income and/or increase energy access and reduce dependence on the natural forest;
- Use of agro-industrial waste coupled with use of efficient devices and systems will help save 700 million tons of wood by 2020 and 3 billion tons by 2030

Part A: BASELINE REPORT

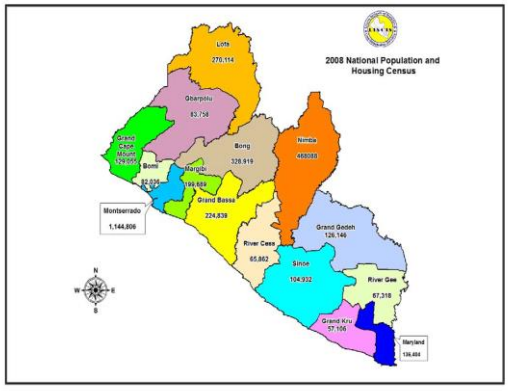
The EBEAP foresees the development of Bioenergy Action Plans (NBEAPs) by the end of 2020 by all fifteen ECOWAS Member States. The five-year rolling NBEAPs will contribute to the achievement of the regional EBEP targets by 2020; 2025 and 2030. The NBEAP for Liberia has been prepared by Liberia a member of ECOWAS in accordance with a template provided by ECREEE. The NBEAPL include baseline data on the status of bioenergy development, and propose attainable bioenergy targets, incl. gender, based on national potentials and socio-economic assessments. Moreover, an overview on concrete laws, incentives and measures to be implemented by the country to achieve the targets will be included. The implementation of the NBEAPL will be monitored by the Ministry of Mines and Energy (MME) and ECREEE on behalf of the ECOWAS Commission during a continued consultative process. The NBEAP template was prepared with technical assistance of ECREEE. The NBEAP development process has been supported by our partner, the Governments of Austria.

CHAPTER 2 SOCIO-ECONOMIC SITUATION

Current impediments to growth include a small domestic market, lack of adequate infrastructure, high transportation costs, poor trade links with neighbouring countries and the high dollarization of the economy. Liberia used the United States dollar 100% as its currency from 1943 until 1982 when the Liberian dollar was introduced, and continues to use the U.S. dollar alongside the Liberian dollar. Liberia is a low income country heavily reliant on foreign assistance for development revenue. Richly endowed with water, mineral resources, forests, and a climate favourable to agriculture, Liberia has been a producer and exporter of basic products, primarily raw timber and rubber and is in the process of reviving those sectors. The **natural resources of Liberia** include iron ore, rubber, timber, diamonds, gold, and tin. Agriculture products include coffee, cocoa, sugarcane, rice, cassava, palm oil, bananas, plantains, citrus, pineapples, sweet potatoes, corn, and a variety of vegetables. The types of industrial sectors in Liberia consist of agriculture, iron ore mining, rubber tapping, forestry, diamonds, gold, beverages, construction and small scale industries. Local manufacturing, mainly foreign owned, has been small in scope.

2.1 Political Context

The Republic of Liberia (GOL), the oldest independent nation in West Africa, was independent on July 26, 1847. The current New Constitution was approved on January 6, 1986. There are currently (December 2021) 18 approved political parties, 2,080 voting precincts, 5,911 polling places, and 2,476,356 registered voters in Liberia.



Map of Liberia showing the 15 Counties

The population of Liberia consists of 17 ethnic groups or indigenous languages including indigenous populations and descendants of repatriated American freed slaves who settled in Liberia in 1822. English is the official language. There is also a sizable number of Lebanese, Indians, and other West African nationals who comprise part of Liberia's business community. The capital city, Monrovia is the seat of the central government and the country is further divided into 15 administrative divisions known as counties: Bomi, Bong, Gparbolu, Grand Bassa, Grand Cape Mount, Grand Gedeh, Grand Kru, Lofa, Margibi, Maryland, Montserrado, Nimba, River Cess, River Gee, and Sinoe. The most populous county is Montserrado County, which houses the capital, followed by Bong, Nimba, Lofa and Grand Bassa.

2.2 Geography & Demography

The West African country of Liberia sits along the coast near the Gulf of Guinea and shares its borders with Sierra Leone, 306km, Guinea 563km, and the Ivory Coast716km. Liberia claims an Exclusive Economic Zone of 249,734 km^2 (96,423 sq mi) and 200 nmi (370 km; 230 mi).The last census done in Liberia was in 2008 with the population of 3,489,072 million.

Liberia's terrain consists of three areas: mangrove swamps and beaches along the coast; wooded hills and semi-deciduous shrub lands along the immediate interior; and dense tropical rain forests and mountainous plateaus in the interior. Liberia has 40% of West Africa's rain forest. The newest updated survey for 2020 by World Bank reports that the rain forest occupies roughly 76,174 km^2 which is nearly 68% of Liberia's 111,369 Sq. Km (43,000 sq. mi. of land and is the source of its timber resources. The plateaus are cultivated for agriculture (27% of land) and the mountains (including Mount Nimba and Putu Mountain) are home to mineral resources – especially iron ore, gold and diamonds.

2.3 Population

The current (December 2021) population of Liberia is **5,231,764** based on projections of the latest United Nations data and the annual growth rate of 2.46%. Of this last official population, 1.1 million people lived in Montserrado County, which is the most populous county and home to the capital, Monrovia. The Greater Monrovia area is home to about 29% of Liberia's population. Montserrado County has the highest population density of 1,540 persons per square mile and can be much higher in Monrovia and its environs. The next most populous area is Nimba County with about 500,000 residents. Liberia has a population density of just 139.29 people per square mile or 53.78 people per square kilometer. The city, Monrovia, is the business as well as political capital. Other Urban areas of 5,000 or more persons in 2008 including Monrovia accounted for 49% of the population while the remaining 61% was the rural population. In Liberia, a settlement is urban when its population is 2,000 and above.

In terms of geographic spread, the major urban settlements are unevenly spread across the country. Thirteen of the settlements are found in the western half of the country, leaving the eastern half with only five major urban centers. Nimba County has four of the 18 large urban complexes followed by Lofa with three. But for Margibi and Maryland having two a piece, the rest of the counties have either one or none.

A key characteristic of the Liberian population distribution is that, apart from Monrovia, the population is overwhelmingly rural, residing in thousands of very small villages and few medium sized towns. As this table shows, nearly 30% of all settlements in the country have fewer than 25 people. Small villages with fewer than 100 people comprise 65% of settlements; 80% have fewer than 250 people (villages); 98% have less than 1,000 residents; and nearly 99.9% have fewer than 5,000. Only 21 settlements have between 5,000 and 100,000; and only one, Monrovia, is greater than 100,000, at approximately 1 million.

2.4 Socio-Economic Situation

Table 3 below presents the population, GDP and poverty rate for Liberia. from the world bank and LISGIS figures on the Population and GDP it is observed that the population growth rate for the years 2015 – 2021 has been progressively declining on the average of -2.2% per year during the six years period. This could be attributed to the Ebola and Covid-19 pandemics and also the decline in the economy and resulting poverty rates.

A world bank report indicated that in 2016, more than 2.2 million Liberians were unable to meet their basic food needs, of which almost 1.5 million (68%) resided in rural areas, 1.6 million were below the food-poverty line, and 670,000 lived in extreme poverty. The World Bank reports that regional and urban-rural disparities in poverty rates widened in the wake of the Ebola crisis and the collapse of global commodity prices. It is also observed that the per capita GDP has been declining by an average of about -3% per year.

Table 3: Socio-Economic Situation

Year	Population			GDP(B$)[1]	GDP per capita[3]	Poverty Rate	Population growth rate[1]
	Total[1]	Urban[2]	Rural				
2021	5,231,764	*2,040,388*	3,191,376	2.88	606.00	n/a	2.46%
2020	5,057,681	*1,972,496*	3,085,185	2.95	608.52	68.9%[4]	2.44%
2019	4,937,374	*1,925,576*	3,011,798	3.22	641.77	n/a	2.46%
2018	4,818,973	*1,879,399*	2,939,574	3.26	671.24	n/a	2.48%
2017	4,702,226	*1,833,868*	2,868,358	3.29	681.24	n/a	2.52%
2016	4,586,787	*1,788,847*	2,797,940	3.28	681.56	93.2%[1]	2.56%
2015	4,472,230	*1,744,170*	2,728,060	3.18	710.38	n/a	2.82%

Sources

1 *World Population Prospects (2019 Revision) - United Nations population estimates and projections.*
2 *Liberia Institute of Statistic and Geo-Information Services (LISGIS) and GeoNames*
3 *source: World Bank*
4 under the (moderate) downside scenario

2.4.1 Poverty Rate

The Poverty Rate is defined as the percentage of the population living on less than $5.50 a day at 2011 international prices.

The Liberia's poverty rate for 2016 was **93.20%**, a **0.9% decline** from 2014 which was **94.10%**, a **3.7% decline** from 2007 rate **97.80%**. The mean **household size** declined from 6.2 in 1984 to 5.1 in 2008. In 2008 the Population Census reported the population to be 1,764,555 males (51%) and 1,724,517 females (49%). Average number of households was estimated to be 747,670 households in 2010. For the 2021 population at the main household size of 5.1, the number of households in Liberia is estimated to be 1,025,836 households.

Liberia is a low-income country which is heavily reliant on foreign assistance for revenue being among the poorest countries in the world ranking 75/189 in the United Nations Human Development Report (UNHDR, 2020). It is richly endowed with water, mineral resources, forests, and a climate favorable for agriculture. . This region is one of the most biologically diverse and was originally covered by continuous, dense tropical rainforest, ranging from Guinea, south through to Ghana. Liberia has a predominantly equatorial climate, with three distinct topographical belts.: The low coastal belt is about 40 kilometer (km) wide, and constitutes tidal creeks, shallow lagoons, and mangrove swamps and beaches along the coast; the second belt includes rolling hills that reach elevations of 60 – 150 meter (m) (200–500 feet); Moving inward, the third belt, comprises the bulk of Liberia, is marked by abrupt changes of elevation in a series of low mountains and plateaus, which are less densely forested. Wooded hills and semi-deciduous shrub lands along the immediate interior; and dense tropical rain forests and mountainous plateaus in the interior;

The country has dry and rainy seasons with the dry season stretching from November to April and the rainy season from May to October. The heaviest rainfall occurs between June and September. It is hottest between the months of January to March before the onset of the rains. In Liberia 65% of the population practices farming as smallholders on fragmented customary land and shifting cultivation which affects the forest and contributes to deforestation. The plateaus are cultivated for agriculture (27% of land) and the mountains (including Mount Nimba and Putu Mountain) are home to mineral resources; especially iron ore, gold and diamonds.

CHAPTER 3 PRIMARY ENERGY SUPPLY AND CONSUMPTION

This Chapter presents Liberia's energy sector, and the analysis, the main sources of energy in Liberia, demand and current energy trends, etc. This is accompanied with several tables and corresponding graphical and narrative analysis.

Table 4 below presents the Primary Energy supply per year for the period 2010 – 2018. The annual growth rate of primary energy consumption in kilotons of oil equivalents (KToe) per year has averaged 2.8% over the eight years period (2010 – 2018). This means that energy consumption rate per year is increasing faster than the population growth rate.

3.1 Primary Energy Supply and Consumption

Table 4: Total Primary Energy Supply

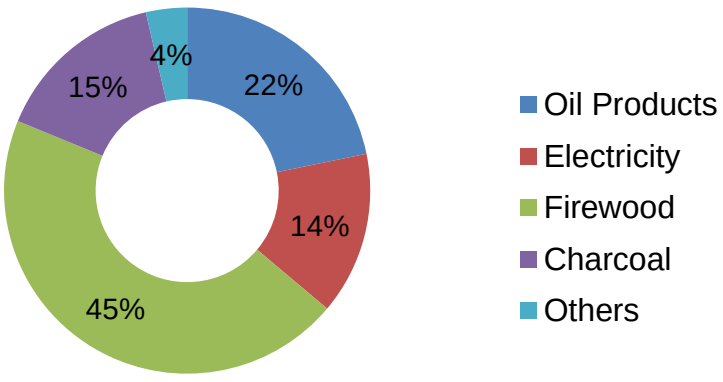
Table 4: Total Primary Energy Supply		
Year	**(KToe)**	**% Increase**
2018	3,753	2.5%
2017	3,662	2.5%
2016	3,573	2.6%
2015	3,483	14.9%
2010	3,031	0

The total primary energy consumption in Liberia for the year 2010 was estimated to be 34,879,003.33MWh equivalents (3,031KToe – thousands of tons of oil energy equivalents). The distribution of primary energy in percent of total energy consumption by fuel type is shown on table 5 below. In 2018 firewood represented approximately 45% of the total primary energy; petroleum came second with a little over 22% and charcoal third about 15%; electricity generation 14% while the rest (hydro and others) total to slightly less than 4%. Firewood and Charcoal consumption together constituted up to 60% of the energy mix. See the table 5 below.

Table 5: RIMARY ENERGY BY FUEL TYPE in 2018

TABLE 5: PRIMARY ENERGY BY FUEL TYPE in 2018		
Fuel Type	MWh (in Thousands)	Percent
Petroleum Products	5,361	22%
Electricity Generation	3,540	14%
Fire Wood*	11,092	45%
Charcoal	3,733	15%
Others(Hydro)	893	4%
TOTAL	**24,619**	**100%**

Figure 2: ENERGY CONSUMPTION IN % BY FUEL TYPE 2018



This section presents the analyses of the energy situation showing the energy balance for Liberia followed with narratives and graphics for each of the sectors. Table 10 below presents the estimated Liberia National Energy Balance sheet for 20218. There was no complete data available from the MME for the current years so we are using the most recent data (2018) that was complete.

3.2 The 2018 Liberia Energy Balance (Thousands of MWh)[4]

The National Energy Balance is the official record of how energy is used in Liberia for the most recent year 2018 that we could find more complete data in Liberia. (others date as far back as 1981-1986). It shows how up to ten different fuels are used in seven different sectors of society, including residential, transport, mining & industry, agriculture & forestry, commercial, and government services. It shows the flow of energy from imports and production to generation and on to final consumption.

The energy data is presented in units of thousands of megawatt hours (MWh) per year. On the energy balance table below, production refers to the energy produced in Liberia and not imported. Under this category, Fuel-wood, Charcoal and Hydro are the only energy sources produced in Liberia, all others (petroleum) are imported. There is no production or importation of crude oil since there is no functioning petroleum refinery in Liberia since 1980 and all petroleum products are imported. Electricity on this energy balance table is considered as secondary energy product since it is generated from hydro, petroleum products and some fuel-wood. The production losses in the conversion process from fuel-wood to charcoal and generation of electricity form petroleum products and some fuel-wood to electricity are shown in each case based on the standard conversion efficiencies of the generation technologies.

Stock Draw/Down & Other Imports represent the estimated products in stock at the beginning of the year 2018 which are then added to the respective imports to derive the total available for each case. After taking into account the exports (mainly cross-border transportation transaction) which in this case is under transport sector, from Liberia to neighboring countries, the net domestic consumption is determined for each product.

Transportation is broken down into rail, sea, air and land and the respective quantities are determined based on the type of fuel utilized in each case. The transportation sector energy demand was analyzed based on the Liberia - Safer Mobility » Vehicles » Number of Registered Vehicles 1,085,075.00 numbers in 2017;[5]

[4] Sandikie, Jacob S.: Energy Supply - Demand Situation and Energy Policy Issues in Liberia - October 1988, Publish by World Bank as an EDI Energy Series Working Paper.

[5] WHOGSRS2019Jan/global-status-report-on-road-safety-2018?tsId=1092850 and vehicles registration statistics

The electricity generation consists of the LEC Generation from hydro, heavy fuel oil, and diesel and the generation from the Mining, Industrial, Commercial and Agriculture & Forestry sectors and the accompanying generation losses (based on standard equipment efficiency) are accounted for in each case.

The residential sector energy accounts for most of the wood and charcoal consumption and a substantial amount of electricity. This is accounted for through the LISGIS Census figures of number of household's statistics, factoring the electricity access rates and rural energy assessment that determines rural households' energy demand[6].

The agriculture & forestry are combined to represent the agriculture & forestry sector. Some of the electricity generation is attributed to agriculture & forestry concessions (including the use of rubber wood, oil palm and logging concessions waste wood biomass for energy).

The Agriculture & Forestry[7] energy was estimated based on the number of Logging companies and Agriculture Concessions in Liberia list provided by the National Investment Commission (NIC) and petroleum importation statistics by the LPRC.
The Mining Sector consists of the Iron Ore Mining Companies (e.g., Arcelormittal Mining Company in Liberia, Gold & Diamond Class A concessions, etc.).[8] The footnote reference provides the generation capacities of the Mining, Industrial and Commercial sectors in Liberia.

The net and total energy distribution to each sector adds up to zero which represents the accountability of generation, losses, imports and consumption, meaning that the accounting (for production + imports – exports – losses – consumption = 0) is balanced.

The last two columns – total petroleum and total energy do not added up to zero because they are intended to show the total energy that was distributed to the sectors for the year.

See below Table 6: The 2018 Liberia Energy Balance (in Thousands of MWh)

[6] Rural Energy Needs Assessment & Strategic Planning of Five (5) Southeastern Counties By Jacob S. Sandikie & M. Hady Sherif Consultants, January 2012.

[7] Liberia ›› Agriculture ›› Timber Raw Materials ›› List of Logs Companies in Liberia – energy generation & consumption

[8] The 2015 electricity self-generation and independent power production capacity in Liberia, October 1, 2015 prepared for USAID review, by Prof. Jacob S. Sandikie, Transaction Advisor POWER AFRICA.

Table 6: 2018 Liberia Energy Balance (in Thousands of MWh) SOURCE: MME AND OTHER ENERGY SECTOR DATA/ENERGY BUREAU ESTIMATES[9]													
PRIMARY ENERGY					SECONDARY ENERGY								
	FUEL WOOD	HYDRO	CRUDE OIL	CHARCOAL	ELECTRICITY	FUEL OIL	GAS OIL	GASOLINE	KEROSENE	JET FUEL	OTHER PETROLEUM	TOTAL PETROLEUM	TOTAL ENERGY
PRODUCTION	11,092	893	0									0	11,985
IMPORTS			0			3,051	183	1,671	67	345	9	5,326	5,326
STOCK DRAW/DOWN & OTHER IMPORTS			0			0	10	10	3	10	0	34	34
TOTAL AVAILABLE	11,092	893	0			3,051	193	1,682	71	355	9	5,361	17,346
CHARCOAL PRODUCTION	-3,733			3,733				0					0
CHARCOAL PRODUCTION LOSSES				-2,800				0					-2,800
PETROLEUM REFINING								0					0
PETROLEUM REFINING LOSSES								0					0
EXPORTS							-14	-17		-312		-343	-343
DOMESTIC CONSUMPTION	7,359	893	0	933	0	3,051	179	1,664	71	43	9	5,018	14,203
LEC GENERATION		-830			1,030	-31	-169	0				-200	0
LEC GENERATION LOSSES					-714			0				0	-714
LEC TRANSMISSION LOSSES					-48			0				0	-48
SECTORIAL CONSUMPTION	7,359	64	0	933	267	3,020	10	1,664	71	43	9	4,817	13,441
TRANSPORTATION						-583	-10	-994	0	-43	0	-1,630	-1,630
ROAD						-428		-987				-1,414	-1,414
RAIL						-155						-155	-155
SEA							-10	-7				-17	-17
AIR										-43		-43	-43
MINES END USE					-755	-200		-206				-406	-1,161

[9] The Energy Balance was derived from several sources as shone in foot notes references 4-7:

Table 6: 2018 Liberia Energy Balance (in Thousands of MWh)
SOURCE: MME AND OTHER ENERGY SECTOR DATA/ENERGY BUREAU ESTIMATES[9]

	PRIMARY ENERGY				SECONDARY ENERGY								
	FUEL WOOD	HYDRO	CRUDE OIL	CHARCOAL	ELECTRICITY	FUEL OIL	GAS OIL	GASOLINE	KEROSENE	JET FUEL	OTHER PETROLEUM	TOTAL PETROLEUM	TOTAL ENERGY
MINES GENERATION					2,358	-2,059		-298				-2,358	0
MINES GENERATION LOSSES					-1,602							0	-1,602
INDUSTRY	-120				-38	-7		-57				-64	-221
RESIDENTIAL CONSUMPTION	-7,165			-923	-166			-3	-59		-9	-71	-8,324
COMMERCIAL END USE	-19			-10	-54	-22			-12			-34	-118
COMMERCIAL GENERATION					36	-36						-36	0
COMMERCIAL GENERATION LOSSES					-28							0	-28
GOVERNMENT					-40	-33		-72				-105	-145
AGRICULTURE & FORESTRY	-30				-31	-53		-34				-88	-149
AGRICULTURE& FORESTRY GENERATION	-26	-64			116	-26						-26	0
AGRICULTURE & FORESTRY GENERATION LOSSES		0			-64							0	-64
NET ENERGY	0	0	0	0	0	0	0	0	0	0	0	15,196	43,360
												TOTAL ENERGY	**44,990[10]**

[10] In the Net Energy of 43360, Transportation is consumption and counted as negative, but for Total Energy it is added thus giving a figure that is hire by 1,630 form the Transportation.

3.2.1 Total Primary Energy Supply (TPES)

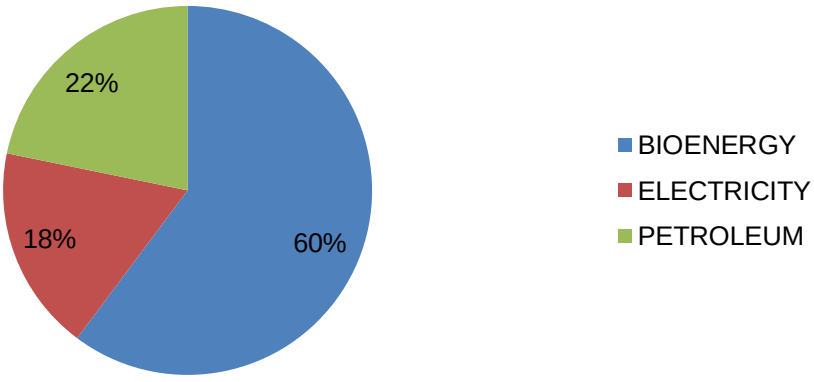
Further discussion of the above energy balance shows the following: Total Primary Energy Supply (TPES) is composed of: National production + imports - exports - international maritime bunkers - international aviation bunkers +/- stock changes.

TABLE 7: TOTAL PRIMARY ENERGY BY SOURCE IN 2018 & 2021

TABLE 7: TOTAL PRIMARY ENERGY BY SOURCE IN 2018 (in thousands of MWh)			IN 2021
SOURCE OF ENERGY	**MWhX1000**	**PERCENTAGE**	**MWhX1000**
BIOENERGY	14,825	60%	14,188
ELECTRICITY	4,433	18%	4,243
PETROLEUM	5,361	22%	5,131
TOTAL	**24,619**	**100%**	**23,561**

There has been approximately 4% decline in the energy supply in Liberia from 2018 to 2021. A pi-graph of the above table 7 is shown in figure 3 below. This is also supported by the population growth rate and GDP declines as seen in 4 table above.

Figure 3: TOTAL ENERGY IN 2018 BY FUEL TYPE IN THOUSANDS MWh



The above figure 3 chart reveals that Bioenergy constitutes the biggest source of primary energy in Liberia. Note that the electricity figure in table 7 includes the generation from petroleum + hydro which are listed separately on table 5. This substantiates the need for development of a National Bioenergy Action Plan.

The Primary Energy Consumption by fuel type consists of 64% Firewood, Charcoal and Hydro combined. The rest consists mainly of petroleum products (mainly for transportation), 22% and direct electricity 14%.

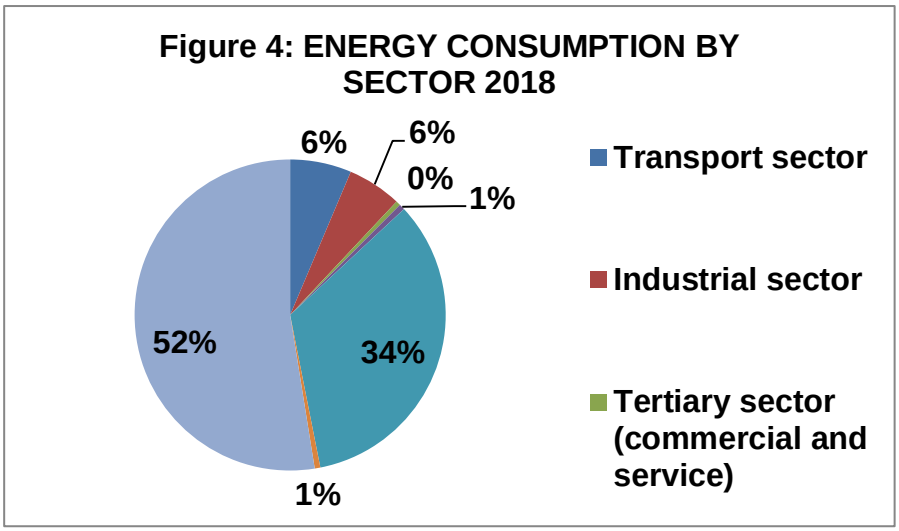
The quantity of energy consumed per end use sector is presented in table 8 below. From the available data for 2018, a total of 43.36×10^6 MWh of energy equivalent

consumption was reported by the Energy Department, MME distributed by sector as shown on Table 8 below and illustrated in the pie-chat below.

3.2.2 Energy Consumption by Sector in GWh for 2018

Table 8: Energy Consumption by sector in GWh for 2018 (or the most recent year for which data are available)

Table 8: NET Energy Consumption by Sector and Energy Carrier in Thousands of MWh (2018)								
Sector	**Oil Products**	**Electricity**	**Fire Wood**	**Charcoal**	**Coal**	**Others**	**Total**	**Percent of Total**
Transport sector	1,570	0	0	0	0	-	1,570	6%
Industrial sector	470	793	120	0	0	-	1,383	6%
Tertiary sector (commercial and service)	34	54	19	10	0	-	118	0.5%
Agriculture and fisheries sector	88	31	30	0	0	0	149	1%
Residential sector	71	166	7,165	923	0		8,324	34%
Other sectors	105	40	-	0	0	-	145	0.6%
No energy use	3,024	2,456	3,759	2,800	0	893	12,932	53%
Total	**5,361**	**3,540**	**11,092**	**3,733**	**0**	**893**	**24,619**	**100%**
Percent of Total	**22%**	**14%**	**45%**	**15%**	**0%**	**4%**	**100%**	**24,619**



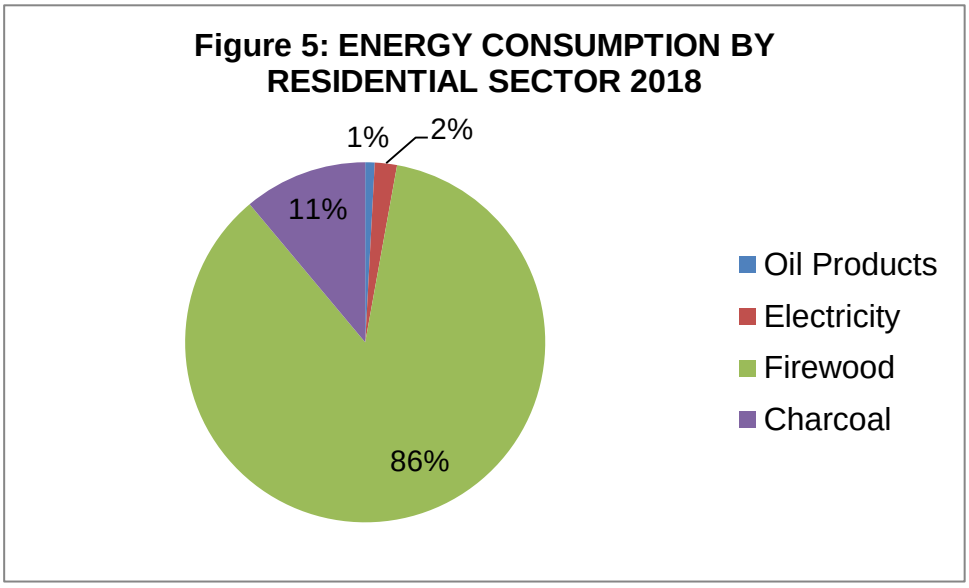
On the sectorial basis, 52% of the energy was for non-energy uses (including generation losses). Residential accounted for 34% while transport and industry 6% each and the rest for tertiary, agriculture and others.

3.2.3 Residential Energy Consumption

The next section presents the fuels (including biofuels) consumed in households for energy applications. This will account for where applicable, the number of households and the quantity of fuel they use, in pie chart format, such as Figure 4 above for the various energy sectors discussed in the energy balance.

Households: The total households in 2018 as the size of 5.1 persons per household are estimated to be 925,899 households with the average energy consumption of 8kWh total energy per household per year. Of this total 97% is in the form of household fuel-wood and charcoal (Biomass energy) and electricity is only 2% and petroleum products mainly for transportation account for 1% or residential energy. The overall energy consumption of the Residential sector s in the case of the Primary energy production sources declined by 4% overall due to the economic and population growth rate decline.

Table 9: RESIDENTIAL ENERGY CONSUMPTION BY SOURCE OF ENERGY AND % OF 2018 TOTAL			OF 2021
SOURCE	**MWhX1000**	**% OF TOTAL**	**MWhX1000**
Oil Products	71	1%	68
Electricity	166	2%	159
Firewood	7,165	86%	6,856
Charcoal	923	11%	883
TOTAL	**8,324**	**100%**	**7,966**



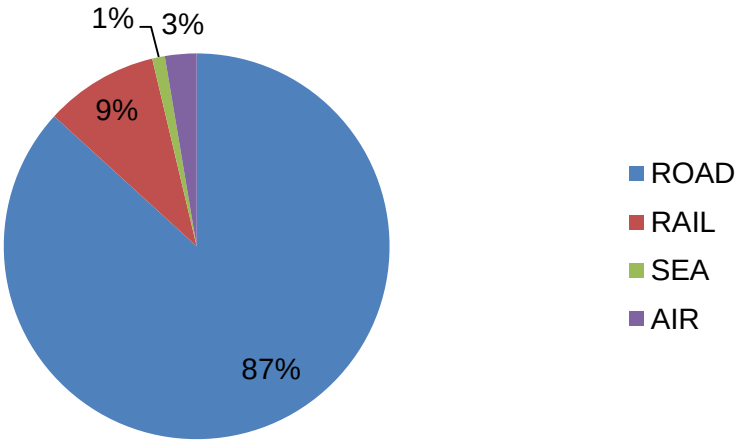
The above table 9, and the corresponding figure 5 chart presents the residential energy consumption by fuel type. The Residential sector is the sector that depends on Bioenergy (fuel-wood and charcoal) for up to 97% of its energy. This calls for extensive plans for the residential sector relevant to Bioenergy. The use of such huge quantities of fuel-wood and charcoal makes huge contributions to the Climate Change through the huge emissions of GHG and especially CO_2equ resulting to environmental, health, agriculture, water and other impacts in the economy which is becoming serious in Liberia.

3.2.4 Transportation Energy Consumption

Table 10: TRANSPORTATION ENERGY IN MWh PER MODE and % FOR 2018			FOR 2021
SOURCE	**MWhX1000**	**% OF TOTAL**	**MWhX1000**
ROAD	1,414	87%	1,353
RAIL	155	10%	148
SEA	17	1%	16
AIR	43	3%	41
TOTAL	**1,630**	**100%**	**1,559**

The above table 10 accounts for the transport sector energy all from petroleum (mainly gasoline, and diesel) consumption of which 87% was for road, 10% rail and 30% air. Only 1% went to sea bunker fuel export (sale).

Figure 6: TRANSPORT ENERGY BY PERCENT MODE IN 2018



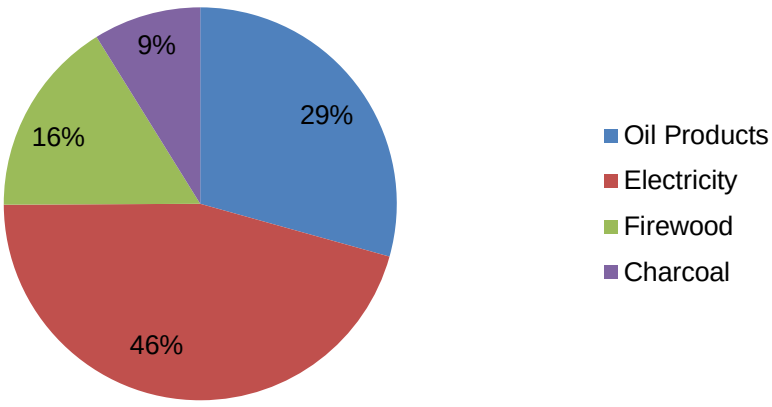
The transport mode energy consumption is shown in the pi-chart Fig. 6 above. Road and Rail transports are the biggest consumption modes in the transport sector.

3.2.5 Tertiary - Commercial and Service Including Government

TABLE 11: TERTIARY SECTOR (COMMERCIAL AND SERVICE INCLUDING GOVERNMENT) CONSUMPTION BY SOURCE OF ENERGY IN THOUSANDS OF MWh FOR 2018			FOR 2021
SOURCE OF ENERGY	MWhX1000	PRECENT OF TOTAL	MWhX1000
Oil Products	34	29%	33
Electricity	54	46%	52
Firewood	19	16%	18
Charcoal	10	9%	10
TOTAL	117	100%	**113**

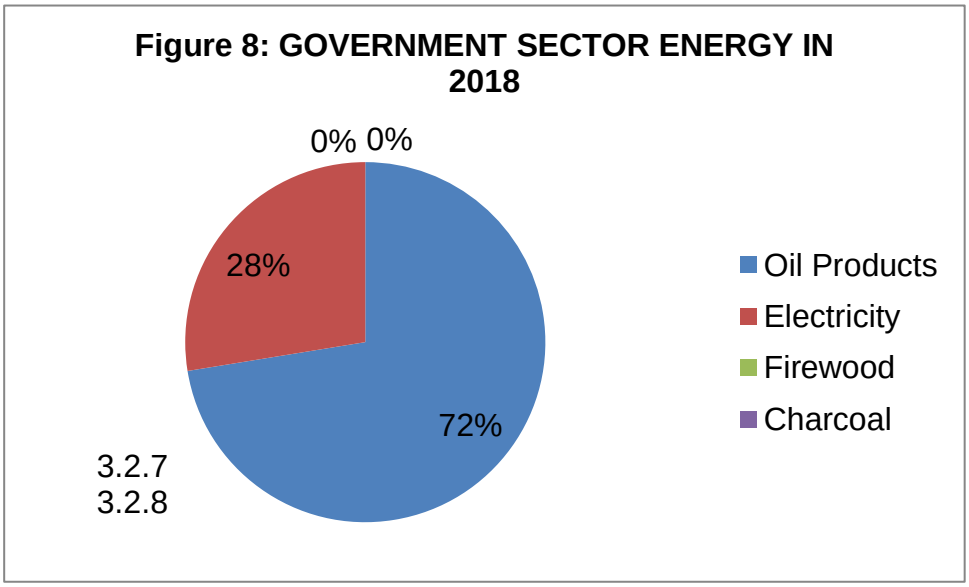
The tertiary Sector (Commercial) account for 118 X 10^3 MWh of energy in 2018, of which 46% is electricity and 29% petroleum products. The rest (25%) is from fuel-wood and charcoal, used especially for cooking and heating in commercial activities.

Figure 7: Tertiary Sector (Commercial and Government)



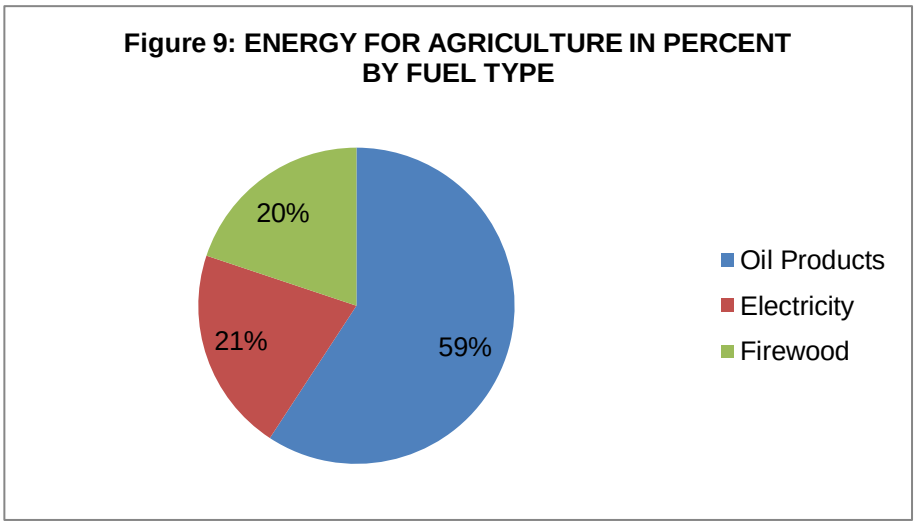
3.2.6 Government Sector Energy

Table12: GOVERNMENT SECTOR ENERGY IN THOUSANDS OF MWh FOR 2018			IN 2021
SOURCE OF ENERGY	MWh X 1000	PERCENT OF TOTAL	MWh X 1000
Oil Products	105	72%	100
Electricity	40	28%	38
Firewood	0	0%	-
Charcoal	0	0%	-
TOTAL	145	100%	**139**



3.2.7 Agriculture Sector Energy Consumption By Fuel

TABLE 13: AGRICULTURE SECTOR ENERGY CONSUMPTION IN THOUSANDS OF MWh BY FUEL TYPE IN 2018			IN 2021 THOUSANDS OF MWh
Oil Products	88	59%	84
Electricity	31	21%	30
Firewood	30	20%	29
TOTAL	**149**	**100%**	**143**



The above table 13 and accompanying Figure 9 Chart reveals that petroleum products constitute the highest (over 59% of the energy being consumed by the agriculture sector of Liberia. This calls for a national Bioenergy action plan to develop alternatives that will substantially reduce petroleum use in the agriculture sector which is already the sector that has the largest endowment of Bioenergy Resources but need innovations, technical knowledge and equipment to develop alternative energy applications for the sector. For example, the factory that heats and process latex rubber from the large rubber farms (Firestone, LARC, Gotridge, etc.) could use steam boilers that use a wood burning furnace instead of oil to produce steam.

CHAPTER 4 SUMMARY OF THE CURRENT BIONERGY SITUATION

4.1. Institutional Arrangement- Public and Research Institutions

This section presents briefly the institutional situation of the bioenergy sector including clean cooking, institutional framework and other institutions dealing with Bioenergy programs and projects. In addition, it discusses the interactions between these different institutions followed by information on current policies, IPPs, programs, and projects.

4.1.1 Ministry of Mines and Energy (MME)

The Ministry of Mines and Energy (MME) was established by an Act of Legislature in 1972 to administer all activities related to land, mineral, water and energy resources exploration, coordination and development in Liberia. In adherence to its statutory mandate, the Ministry formulates and implements policies and regulations in collaboration with other sector related agencies for the delivery to the public, efficient services from the land, mineral, water and energy sectors. Over the years, the Land Sector was made autonomous from the Ministry and the Land Commission was created, thus reducing it from the Ministry of Lands, Mines & Energy to its current status of Ministry of Mines and Energy, no longer responsible for Lands. The Ministry now consists of the Department of Mining and Department of Energy.

4.1.2 The Department of Energy (DOE), MME

Based on the plans of the 2009 National Energy Policy of Liberia (NEPL) the Ministry's Department of Energy (DOE) is aspiring to be organized efficiently and resourced adequately to discharge its mandates. The Department of Energy (DOE) under the MME has an oversight role over all the different energy sub-sectors, as well as the mandate to direct and supervise, through policy making and planning, the efficient development of the energy sector as a whole. The DOE is headed by the Deputy Minister for Energy assisted by the Assistant Minister for Energy. The Energy Department originally consisted of the Bureau of Hydrocarbons (responsible for Upstream Petroleum Exploration licensing, monitoring and regulation) and the

Bureau of Energy Technology and Policy Development (presently called Bureau of Alternative Energy). In 2000, the Bureau of Hydrocarbon was terminated and the National Oil Company of Liberia (NOCAL) was created to take the functions of the Bureau of Hydrocarbon.

This left the Department of energy with only the Alternative Energy Bureau. With the creation of the Rural and Renewable Energy (RREA), the remaining functions of the Department of Energy performed by the Alternative Energy Bureau were effectively transferred to the RREA leaving the DOE's Bureau's mandate for the energy sector restricted to policy, regulations and monitoring of the energy sector. Recently the DOE created a Gender Focus Unit (GFU) to be responsible for undertaking Gender Mainstreaming and Energy-Gender Assessment under the Ministry. The MME and DOE play an essential policy guidance role, complementing other players such as the LEC, NOCAL, LPRA and RREA in the energy sector. The MME is part of the Board of Directors of LEC, NOCAL and RREA.

The current institutional framework shows that the DOE has some technical and professional capacity gaps and does not meet with challenges and requirements of the projected national energy policy and strategy. It is therefore a part of this national bioenergy action plan (BEAP) for the DOE to be staffed with engineers, technicians and consultants and reorganized taking into account the challenges, tasks and deadlines deriving from the NREAP, NEEAP and the SE4ALL Action Agenda and this BEAP strategy adopted by the Government.

As a part of the staffing and training process for the DOE it shall be a requirement embedded into a Technical Assistance program. There is need for Expert recruited internationally to train and transfer knowledge to local staff. Supporting the administrative staff and provision of office resources mobilized simultaneously. The transfer of knowledge and training of the local staff in the procedures and practices in the fields of project appraisal, international procurement of goods and services, consultancy services contracts, tender documents analysis and bid evaluations in the power sector is a must. This internationally recruited expert staff must be permanently based at the DOE and fully dedicated to the task of liaising with the community of donors.

The following GOL energy sector institutions operate under the DOE Policy Oversight and Monitoring:

In carrying out its mandates, the Ministry of Mines and Energy and the DOE operate through the following state/government agencies:

- Liberia Electricity Corporation (LEC)
- Rural and Renewable Energy Agency (RREA)
- National Oil Company of Liberia (NOCAL)
- Liberia Petroleum Refining Corporation (LPRC)
- Liberia Electricity Regulatory Commission (LERC)
- Liberia Petroleum Regulatory Authority (LPRA)

The operational relationships between DOE & Agencies/Departments are shown in the organizational chart below figure 9.

4.1.3 General Profile of the Department of Energy

The Department of Energy (DOE) derives its mandates from the National Energy Policy (NEP) of Liberia as well as the 2015 Electricity Law of Liberia (ELL). These documents have accordingly guided the vision, mission, policy goals and objectives of the DOE. This is to be achieved by addressing the obstacles and challenges that are limiting private sector investments in all aspects of the energy supply value chain in the country. The key obstacles that have to be addressed, as priority, are the human resource and other institutional challenges in the sector.

Leadership of DOE

The leadership of the Department of Energy (DoE) is provided by the Ministry of Mines and Energy (MME) and consists of the following:

- Minister for Mines & Energy
- Deputy Minister for Energy
- Assistant Minister for Energy

In order to deliver on its mandates, in accordance with the NEP, the following operational organogram has been proposed for the DOE, comprising of three Bureaus each supported by a number of specialized technical Units and the following Key Responsibilities:

1. **Bureau of Research and Policy (BRP) responsibilities:**

    - Coordinating all energy research, energy planning and the implementation and monitoring of associated policies and strategies;
    - Developing policies and programs for Energy Efficiency and Conservation as well as climate change;
    - Mainstreaming Gender issues in energy sector activities/projects;
    - Providing advice and liaison for regulatory policy and strategy as well as monitoring the implementation of related recommendations.

    The Bureau of Research and Policy (BRP) has four (4) Units

    (a) Research & Policy Unit (RPU);
    (b) Gender Focal Unit (GFU).
    (c) Efficiency, Conservation and Environment Unit (ECEU);
    (d) Energy Research, Statistics and Information Management Unit (ERSIM); and

2. **Bureau of Electricity and Renewable Energy (BERE) responsibilities:**
    - Developing and reviewing policies, quality standards and master plans for grid and off-grid and renewable energy investments
    - Coordinating the establishment of criteria for licensing operators in the electricity and renewable energy sub-sector
    - Combating Power Theft
    - Providing oversight over public and private sector operators in the electricity and renewable energy sub-sector

    The Bureau of Electricity and Renewable Energy (BERE) has three (3) Units

(a) Grid Power Unit (GPU);
(b) Off-Grid Power Unit (OGPU); and
(c) Facility Siting Permit Unit (FSPU).

3. Bureau of Hydrocarbons (BH) responsibilities:

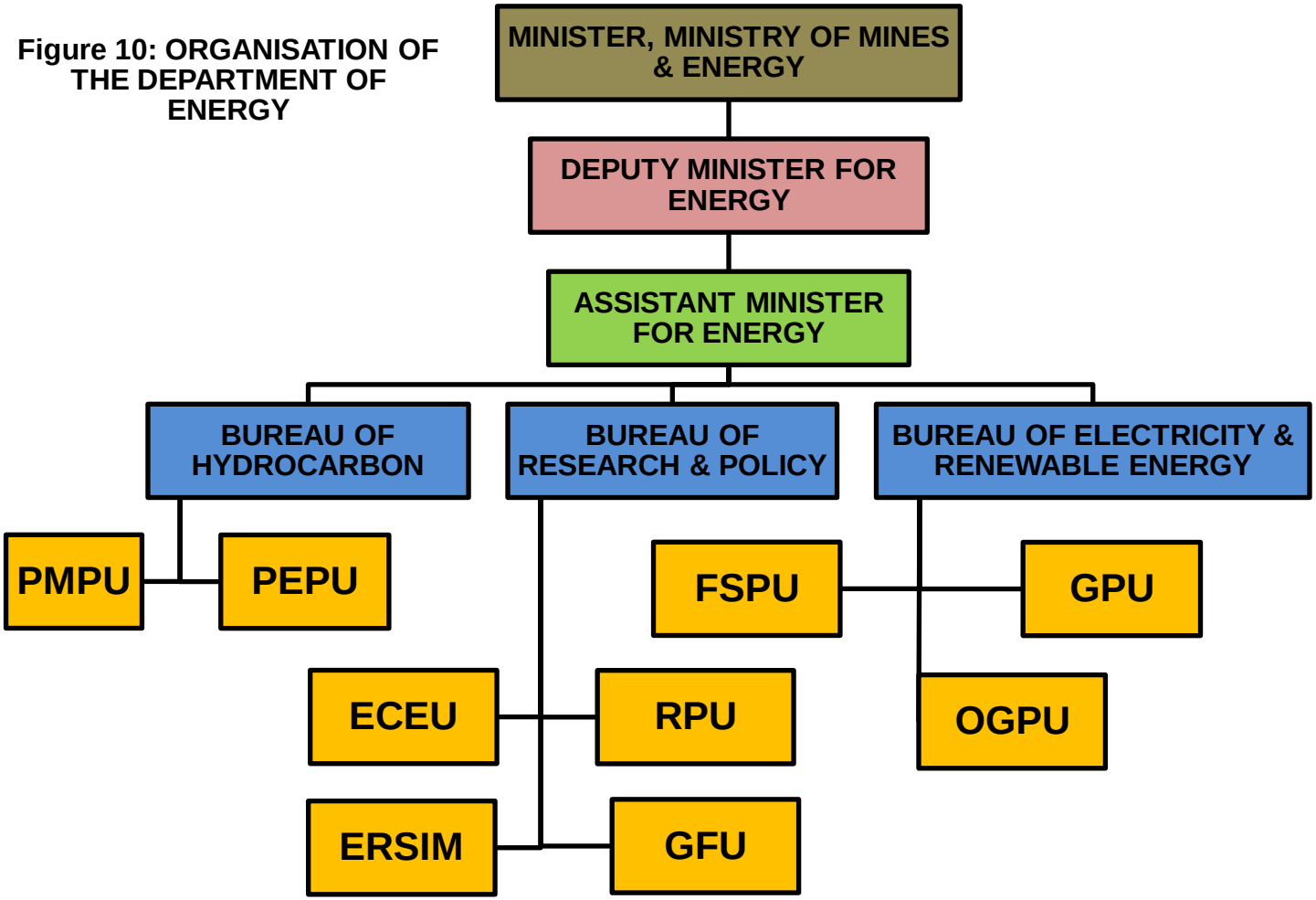
- Developing and reviewing policies, quality standards, and master plans for the hydrocarbon sub-sector
- Coordinating the establishing licensing criteria and procedures for upstream and downstream operations
- Promoting investments in the hydrocarbon sub-sector
- Providing oversight over public and private sector operators in the hydrocarbon sub-sector

Bureau of Hydrocarbons (BH) has two (2) Proposed Units

(a) Petroleum Exploration & Production Unit (PEPU); and
(b) Petroleum Processing & Marketing Unit (PPMU).

Figure 10: ORGANISATION OF THE DEPARTMENT OF ENERGY

Figure 10: ORGANISATION OF THE DEPARTMENT OF ENERGY



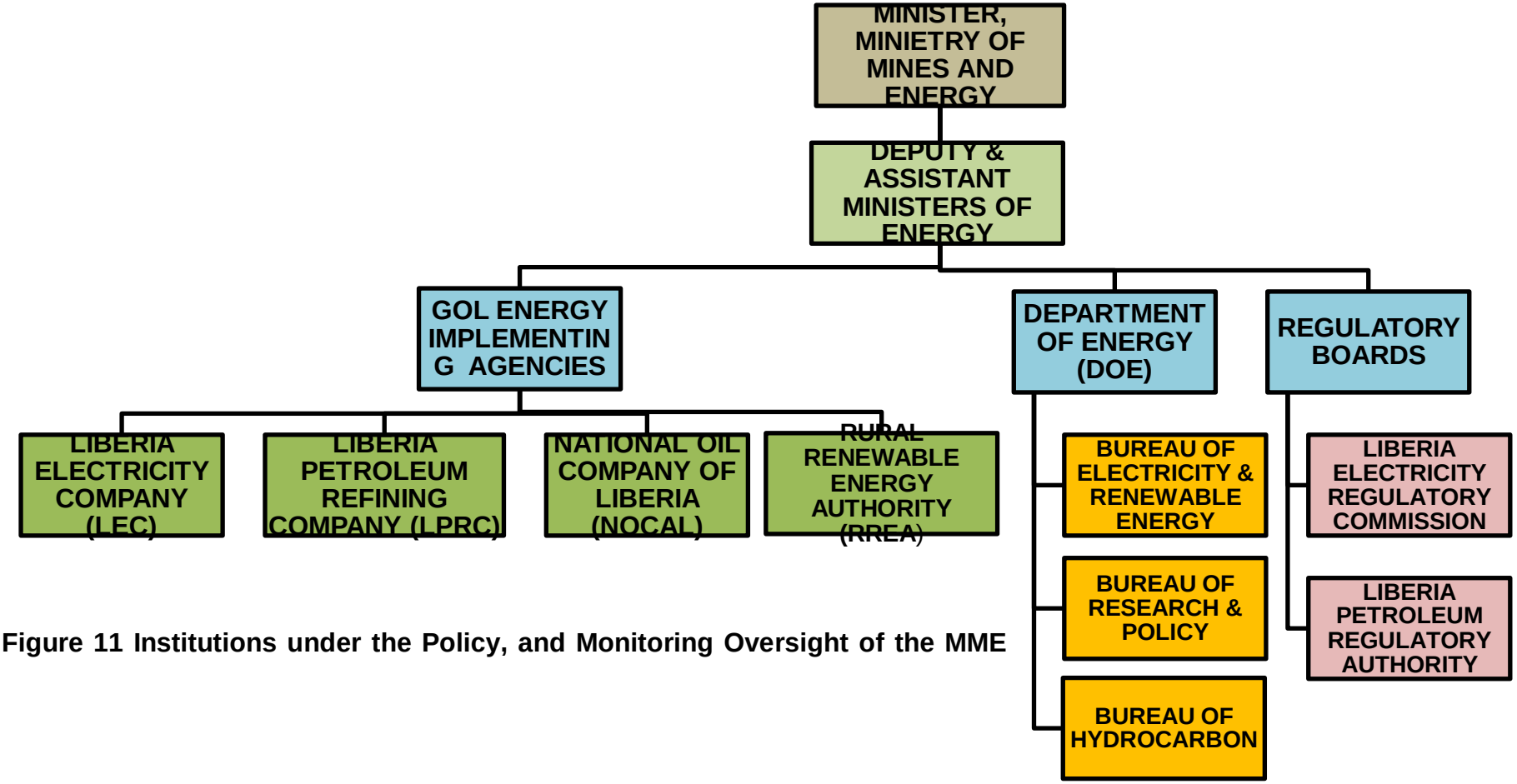


Figure 11 Institutions under the Policy, and Monitoring Oversight of the MME

4.1.4 Liberia Electricity Regulatory Commission (LERC)

The national energy policy of Liberia (NEPL) commits the GOL to balance the interests of consumers with those of firms and would-be investors engaged in the importation, production, transportation, distribution, and sale of energy products and services be done through the creation of an autonomous regulatory body, enabled by legislation, to eliminate distortions in energy-related markets through transparent, predictable and stable oversight. The Liberia Energy Regulatory Commission (LERC) formally referred to as the Energy Regulatory Board (ERB) is currently responsible for monitoring all energy policies and standards established by the MME. In fulfilment of this policy, the 2015 Electricity Law was enacted by the legislature resulting to the appointment of a ***Liberia Electricity Regulatory Commission (LERC)*** **("Regulator")** replacing the ERB, which consists of a Chairperson and two members, appointed by the President of Liberia with the consent of the Senate.

The Regulator has the authority to investigate alternative forms of regulation such as flexible tariffs, incentive based regulations, and the use of competitive markets.The LERC shall be an independent agency and shall act independently from any regulated entity and shall not seek or take directions from any Government or public or private entity when carrying out its regulatory tasks other than as required under this Law. LERC shall be qualified, within the scope of its legal authority and jurisdiction, to make final adjudicatory and administrative decisions, subject only to the appellate process.

4.1.5 Liberia Electricity Company (LEC)

LEC is the state owned entity created by Chapter 85 of the Public Authorities law of the Republic. From October 26, 2015, the date that the 2015 Electricity Law of Liberia came into effect, LEC was considered to be subject to the provisions of the 2015 Electricity Law of Liberia (LERC), and the LEC became a transmission system operator and national grid company and is now required to operate as a licensed, regulated and competitive corporate entity in Liberia and is required to propose fair, reasonable rates, fees and charges to the Regulator for review and approval and to require LEC to allow third party access to the grid, consistent with this law.

4.1.6 Liberia Rural and Renewable Energy Agency (RREA)

The electrification of all public health institutions is one of the key priorities of the Rural Energy Master Plan of the Rural and Renewable Energy Agency (RREA). The survey interview with the RREA revealed that the RREA along with the ELCA and other donors, undertook the Skip the Grid project in 2017 with donations for electrification through solar power to public health facilities

The Rural and Renewable Energy Agency (RREA) is mandated by its Legislation to develop in collaboration with the Ministry of Lands, Mines & Energy and other stakeholders a Rural Energy Strategy and Master Plan for Liberia. The Master Plan shall be formulated on the basis of well-defined project selection and prioritization criteria designed to ensure enhanced energy access with equity, sustainable development and optimal use of indigenous and renewable resources, and ensure that these are integrated into the national energy Master Plan. Liberia's Rural Energy Strategy and Master Plan (RESMP) for the period until 2030 aims to set clear

targets, to identify least-cost projects and technologies, to propose concrete investments for funding and implementation by investors, donor organizations, and government with appropriate institutional framework and capacity to increase energy access and renewable energies to the country's rural areas and population – meaning all areas and population outside of greater Monrovia.

The RREA legislation provides little support to bioenergy technologies, with incentives limited to ad-hoc import duty waivers on solar and battery technologies granted to the RREA but this agency is not currently funded to do further bioenergy systems imports that would supply the BEAP.

The organizational Structure received from the RREA is presented below.

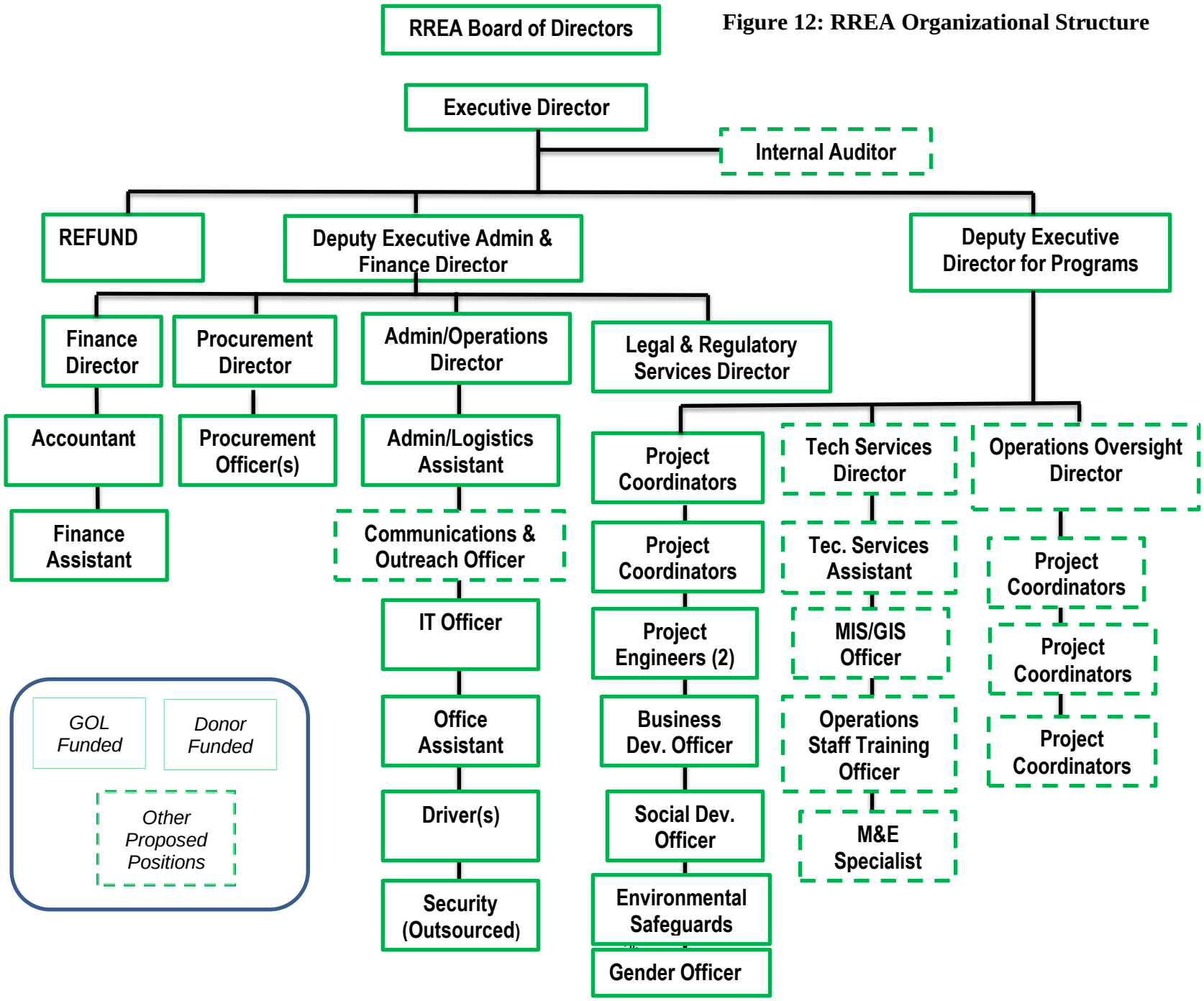


Figure 12: RREA Organizational Structure

4.1.7 Liberia Petroleum Refining Corporation (LPRC)

The Liberia Petroleum Refining Company (LPRC) was established in 1978 by the Liberian Business Corporation Act. The primary purpose for which the company was formed is to carry out the business of producers, refiners, stores, suppliers and distributors of petroleum and petroleum products in all its branches in Liberia.

An Act of the National Legislature granting exclusive rights to the LPRC for the importation, sale and distribution of petroleum products within the Republic of Liberia was promulgated on July 26, 1989. In the discharge of its mandate, the act authorized the LPRC to enter into supply agreements with domestic and/or foreign corporations. Years ago, LPRC purchased and refined crude oil at its now dormant refinery, located on the Somalia Drive near the Chicken Soup Factory community. Today, the company only stores petroleum products procured by registered Petroleum Importers and levies storage fees on products stored in its facilities. Its two main activities are, therefore handling and storage of petroleum products. Its plant facilities of jetty lines, storage tanks and pumps were severely damaged during the Liberian conflict. Collaterally, they are largely obsolete and in a state of disrepair. The maintenance function of the company works overtime to ensure that they provide a modicum of capacity to service the needs of importers and distributors. Today the Company has in its employment 270 employees. There is a nine (9) member Board of Directors that directs the activities of the Corporation. The Board formulates policies, discusses and approves budgets, development plans, and principal changes to the organizational structure of the company. A management team headed by a Managing Director manages the daily work of the company. The environment of the corporation is dynamic. With oil exploration to commence soon in Liberia, hopes are high that commercial quantities of crude oil will be found. The corporation must now reposition itself to provide leadership in the downstream sector of the industry. Its overall goal is to contribute to Liberia's agenda for transformation with an output to provide support to the Government's Medium Term Economic Growth and Development Strategy, Millennium Development Goals (MDG).

Its basic objective is to restore LPRC's pre-war capacity so as to meet statutory mandate, increase revenue, reposition and strengthen the company's image in the developing oil industry of Liberia. Furthermore, it will ensure our role as voting member of the African Refinery Association (ARA).

4.1.8 National Oil Company of Liberia (NOCAL)

On September 28, 1982 the then ruling People's Redemption Council of the Armed Forces of Liberia published the Act Amending the Petroleum Act of the Republic of Liberia Approved March 18, 1969 to regulate the operations of Petroleum Industry in Liberia approved April 18, 1969 which granted the GOL through the MLME the authority to hold title to hydrocarbons and authorization of operations and to grant explorations, development and operations permits in the territorial onshore and offshore limits of Liberia. The Ministry was also authorized to make regulations and have the responsibility for execution and to grant licenses for petroleum exploration, development, production, transportation and other related activities. Based on these activities and responsibilities, the Ministry created the Bureau of Hydrocarbon under the ministry.

The National Oil Company of Liberia (NOCAL) was created by an act of Legislature and made effective in April 2000. When the Corporation was created it was given all the mandates, rights and powers exercised under the Ministry's Bureau of Hydrocarbon, among others to: enter into, perform and modify contracts, lease, production sharing contracts (PSCs), agreements or other transactions on such terms as may be deemed appropriate with any agency or instrumentality of the Republic of Liberia, with any foreign government agency, or with organization or other entity, public or private, singly or in combination. The purpose of NOCAL is for holding all of the rights, title and interest of the Republic of Liberia in the deposits and reserves of liquid and gaseous hydrocarbons within the territorial limits of the Republic of Liberia, whether potential, proven, or actual with the aim of facilitating the development of the oil and gas industry in the Republic of Liberia.

NOCAL Bill of 2000 specified its functions being to: organize, conduct, arrange, and supervise all relevant research and exploration for liquid and gaseous hydrocarbons in Liberia, and to delineate, establish, and issue licenses for particular areas, fields, and blocks, as the case may be, on such terms and conditions as shall be deemed appropriate, subject to the approval of the Board of Directors and final ratification by the President of Liberia.

In addition, NOCAL had among others, the functions to undertake and/or facilitate the exploitation of established deposits of liquid and gaseous hydrocarbons in Liberia, where economically feasible, through the negotiation and conclusion, subject to approval as otherwise herein provided, of appropriate agreements, loans financing, and exploitation arrangements with potential investors other relevant parties, corporations, or foreign governments, in collaboration with the relevant ministries and agencies of the Republic of Liberia. All such agreements and arrangements shall require the final approval of the President of Liberia.

In view of the above, the GOL considered that the functions of NOCAL as granted in the petroleum law and its act constitute overlapping of regulatory, policy and implementing functions for the Petroleum Licensing, Regulating, and Operations. The GOL therefore decided to separate the Policy Functions and grant them to the Ministry of Mines and Energy, the Regulatory functions were taken from NOCAL and the Petroleum Regulatory Authority (LPRA) was created.

Liberia as yet does not have a well-developed upstream oil and gas industry. Hydrocarbon exploration activities in Liberian territorial waters started in the late 1960s, but those activities ceased due to a variety of factors. Liberia has a number of offshore oil blocks, some of which have been licensed to multinational oil companies.

4.1.9 Liberia Petroleum Regulatory Authority (LPRA)

The Liberia Petroleum Regulatory Authority (LPRA) was established by the New Petroleum (Exploration and Production) Reform Act 2014 (NPRL), as an independent regulatory entity responsible to conduct technical evaluation of the areas to be opened up for petroleum operations, supervise and manage bid rounds and all other associated processes, enter into petroleum agreements and monitor petroleum operations, administer petroleum rights either through direct negotiations

or bid rounds, supervise petroleum data storage, assist the Liberia Revenue Authority (LRA) in collecting lawful revenue accruing to the state under all petroleum-related agreements or licenses, etc. This leaves NOCAL to operate only as Petroleum Company to hold the exploration, development and production rights for the Republic of Liberia.

4.1.10 Private Sector Solar PV Supply Systems Initiatives

The table 14 below presents a list of existing solar PV supply systems initiatives in Liberia provided by the RREA, the GIZ supported by the KfW, the UNDP and other NGO's operating in all 15 Counties of Liberia. The total KW Solar Power Capacity installed and specific localities of services they supplied is not known.

Table 14: List of Existing Solar PV Supply Systems Initiatives in Liberia by RREA and Other Organizations for Electrification of RHFs Through Solar PV[11]

NO.	ORGANIZATION	MAJOR SOLAR PV SYSTEMS	NO.
1	Rural and Renewable Energy Agency	World-Bank funded Liberia Energy Sector Support and Access Project	All 15 counties
2	GIZ/KfW	Electrification of healthcare facilities	Southeast Liberia
3	UNDP	Solar for Health	All 15 counties
4	We Care Solar/GIZ	Solar suitcases for maternity centers	All 15 counties
5	GAVI	Vaccine refrigeration for healthcare facilities	All 15 counties
6	Global Fund	Electrification of reference laboratory	Montserrado
Source: RREA response on the assessment interview by the S4H Project Local Expert			

Table 15: Electrification of rural health care facilities through PV systems[12]

Name	Key activities	Implementer	Region	Funded by	Duration
Skip the Grid	Electrification: Bringing solar power to health facilities.	RREA, ELCA	Liberia	Donations	Started in 2017
Technical Assistance for reduction of maternal mortality in Liberia	Telemedicine support for midwives, trainings, solar installations, smartphones	Epos, MOHSW, GIZ/EnDev	Grand Gedeh	EU	2017
Light Every Birth	Solar suitcases for maternity wards	We Care Solar, UNICEF, GIZ/EnDev, Africare, PHIL	Nation-wide	UNDESA, UBS Optimus Foundation, Gilead Foundation and private donors	2016-18

[11] RREA response on the assessment interview by the S4H Project Local Expert
[12] MOHSW Listing of Electrification of Rural Health Care Facilities Through PV Systems

Table 15: Electrification of rural health care facilities through PV systems[12]					
Name	**Key activities**	**Implementer**	**Region**	**Funded by**	**Duration**
Renewable Energy Sources to Rural Primary Health Care Facilities	204 health facilities in 15 counties received DC solar installations, 410 health facility staff were trained in maintenance of solar systems.	Merlin, Save the Children International-Liberia	Nationwide	EU Energy Facility II and the Government of Liberia	August 2011 – August 2014
Source: URL of Project Website: Renewables Liberia.info and MOHSW					

Table 16: Electrification of rural health care facilities through PV systems					
Name	**Key Activities**	**Implementer**	**Region**	**Funded by**	**Duration**
Barbara Ann Health Center	Install, validated and commissioned of 36 solar panels, 16 pieces of deep cycle batteries with cables, 1 solar inverter, 2 solar controllers	Union Strong Solar Power company	Montserrado	Global Fund	2017 - 2018
Bernardsville Health Center	Install, validated and commissioned of 36 solar panels, 16 pieces of deep cycle batteries with cables, 1 solar inverter, 2 solar controllers	Union Strong Solar Power company	Montserrado	Global Fund	2017 - 2018
Redemption Hospital	Install, validated and commissioned of 36 solar panels, 16 pieces of deep cycle batteries with cables, 1 solar inverter, 2 solar controllers	Union Strong Solar Power company	Montserrado	Global Fund	2017 - 2018
Martha Tubman Memorial Hospital	Install, validated and commissioned of 36 solar panels, 16 pieces of deep cycle batteries with cables, 1 solar inverter, 2 solar controllers	Union Strong Solar Power company	Grand Gedeh	Global Fund	2017 - 2018
C. H. Rennie Hospital	Install, validated and commissioned of 36 solar panels, 16 pieces of deep cycle batteries with cables, 1 solar inverter, 2 solar controllers	Union Strong Solar Power company	Margibi	Global Fund	2017 - 2018
Liberia Government Hospital	Install, validated and commissioned of 36 solar panels, 16 pieces of deep cycle batteries with cables, 1 solar inverter, 2 solar controllers	Union Strong Solar Power company	Grand Bassa	Global Fund	2017 - 2018
Liberia Government Hospital	Install, validated and commissioned of 36 solar panels, 16 pieces of deep	Union Strong Solar Power company	Bomi	Global Fund	2017 - 2018

Table 16: Electrification of rural health care facilities through PV systems					
Name	**Key Activities**	**Implementer**	**Region**	**Funded by**	**Duration**
	cycle batteries with cables, 1 solar inverter, 2 solar controllers				
C.B. Dunbar Hospital	Install, validated and commissioned of 36 solar panels, 16 pieces of deep cycle batteries with cables, 1 solar inverter, 2 solar controllers	Union Strong Solar Power company	Bong	Global Fund	2017 - 2018
Tellewoyan Memorial Hospital	Install, validated and commissioned of 36 solar panels, 16 pieces of deep cycle batteries with cables, 1 solar inverter, 2 solar controllers	Union Strong Solar Power company	Lofa	Global Fund	2017 - 2018
435 Facilities	Installation of solar suitcase	ENDEV	Bomi, Bong, Gbarpolu, Gr. Bassa, Gr. Cape Mount, Gr. Gedeh, Gr. Kru, Lofa, Margibi, Maryland, Montserrado, Nimba, Rivergee, Rivercess, Sinoe	UN Women, Endev, Africare, PHIL, UNICEF	2016 - 2019
52 Facilities	3.5KVA – 10 KVA	Pickering Energy Solution	Gr. Cape Mount, Sinoe, LOFA, Nimba, Montserrado, Bong	Charles Pickering of the USA	2010 -2022
6 Clinics, 3 HC	3.9KW – 35KW	GIZ/ENDEV	Gr. Gedeh, Rivergee, Sinoe	WHH	2019
3 Hospital, Gbediah Hospital	35KW – 70KW	GIZ/ENDEV	Rivercess	WHH	2019 – 2021
Liberia Institute of Biomedical Research	110KVA	Africa Electric	Margibi	Global Fund	2020 - 2021
443 Facilities	760 Watts for Vaccine fridges	B. Medical, Global Lifeline Company, MOHSW Trained pool Technician with support from UNICEF	15 Counties	GAVI	2017 - 2022
Skip the Grid	Electrification: Bringing solar power to health facilities.	RREA, ELCA	Liberia	Donations	started in 2017
Technical Assistance for	Telemedicine support for midwives, trainings, solar	Epos, MOHSW,	Grand Gedeh	EU	2017

Table 16: Electrification of rural health care facilities through PV systems					
Name	**Key Activities**	**Implementer**	**Region**	**Funded by**	**Duration**
reduction of maternal mortality in Liberia	installations, smartphones	GIZ/EnDev			
Light Every Birth	Solar suitcases for maternity wards	We Care Solar, UNICEF, GIZ/EnDev, Africare, PHIL	Nation-wide	UNDESA, UBS Optimus Foundation, Gilead Foundation and private donors	2016-18

The table below presents the current Solar PV Systems power capacities of the Public Health Care Facilities (PHCFs) in Liberia by category of PHCF. A total of 1,871 assorted small Solar PV System units amounting to 1,858KW across the country are estimated from the above tables and other information obtained from the MOHSW and RREA.

Table 17: CURRENT (2022) SOLAR PV SYSTEMS FOR PUBLIC HEALTH CARE FACILITIES									
POWER SOURCE AVAILIBILITY	**PUBLIC HOSPITALS**	**HEALTH CENTERS**	**PHC-1 CLINICS**	**PHC-2 CLINICS**	**PHC-LEVEL1**	**PHC-LEVEL2**	**COLD CHAIN STORAGE**	**OTHERGOL PHCFs**	**TOTAL**
SOLAR CAPACITIES									
No. of PVC Units (Assorted)	531	354	207	449	5	10	1	315	1,871
Current Capacity (kW)	444	296	173	393	162	281	110	n/a	**1,858**
Solar PV (kW/HCF)	17	8	11	11	2	3	11	m/a	**6**

CHAPTER 5 THE ELECTRIFICATION SECTOR AND ENERGY

5.1 Electricity Generation

Before the civil crisis in Liberia (1990-2003), the Liberia Electricity Corporation (LEC) power generation installed capacity was approximately 191megawatts (MW) supplying all over the country, while that of private sector and concessionaires total was approximately 212 MW. Liberia has considerable potential for hydroelectric power. At the onset of the civil war there were three operational hydroelectric power plants in Liberia: Harbel (Firestone) - 4MW; Mount Coffee (LEC) - 64MW; and Yandahun (a community micro hydro in Lofa County) - 30KW. The Mount Coffee and Yandahun plants were destroyed during the war, and have been reconstructed recently with higher capacities.

Under the previous legislation creating the LEC, the corporation was responsible for generation, transmission, and distribution of electricity throughout the country (almost a monopoly). By 2004, prior to the restoration of the Mt. Coffee Hydro Power Plant destroyed during the war, the LEC capacity was destroyed down to less than 23 MW of diesel plant as the sole source of Liberia's national grid generation capacity, forcing larger consumers such as hotels, restaurants, and office buildings to rely on diesel self-generated electricity. The key indicator that brought very tangible results and impacts to the electricity sector from 2012 to now 2022 has been the interventions of donor partners (including the WB, EU, USAID, Norway, Japan, Sweden, AfDB, etc.). Currently, the Liberia Electricity Company operates the Mt. Coffee Hydroelectric Plant which has four (4) new hydro turbine units upgrading the old 64 MW hydro plant capacity to 88 MW of available generation capacity. The rehabilitation was co-financed by USA Millennium Challenge Corporation (UMCC), the Government of Norway, AfDB, and the European Investment Bank. In addition to the hydro rehabilitation, the Government of Liberia, the Japan International Cooperation Agency, and the World Bank funded a 38 MW heavy fuel oil (HFO) plant to complement the 22MW high speed diesel generation plant in Bushrod Island (currently only 5MW operational of which 2.5MW is available). Currently, the LEC generation capacity totals to 131MW as National Grid power in the country.

In view of the above described significant progress in restoring the shortage of generation capacity resulting from the civil unrests. The challenge now is not more grid generation capacity but the insufficient transmission and distribution infrastructure that is currently transmitting only part of the capacity. On November 8, 2017, a new management services contract was executed to operate and manage the LEC as a utility company towards commercial viability.

5.1.1 Cross Border Power & WAPP CLSG Transmission Line

The Government of Liberia (GOL) in 2013 signed a power purchase agreement (PPA) with Cote d'Ivoire through the WAPP to supply several townships along the Liberia Cote d'Ivoire border with imported power for the period of 25 years (the "Cross-Border" project) as a means of electrifying rural areas. It is estimated that a potential of 8MW of electric power could be available through the Cross-Border power scheme. The Cross-Border Project consists of Connection for imported electricity from Cote d'Ivoire reaching Nimba, Grand Gedeh and Maryland counties of Liberia. The connection is being extended to Gbanga, Bong County and is still rising. This cross-border project has been supported by the EU.

The second cross-border power source project is the West African Power Pool (WAPP) Cote d'Ivoire, Liberia, Sierra Leone, and Guinea (CLSG) transmission interconnection project is under implementation. It consists of a new 225 kV transmission line inter-connecting the power networks of the CLSG countries. Adding to the current capacity, the Ivory Coast-Liberia-Sierra-Leone-Guinea (CLSG), interconnection project now under construction, holds potentials for Liberia to import several MW of power through the 225kV HV transmission system. This is projected to upgrade Liberia's total power supply capacity to at least 150MW when completed.

At the short term (until 2022 – 2025) generation capacities are adequate to respond to the demand/load resulting from the new connections (planned to reach 45,000 in Monrovia in 2022). During the dry season, the Mt. Coffee hydro output capacity drops down to less than 30% (from 88MW) which has to be mainly supplemented by the LEC thermal heavy fuel oil (HFO) plant during the dry season when the hydro power level is down. For this reason, LEC is considering a project to develop a 20MW Solar VP Plant near the Mt. Coffee Hydro Plant.

5.1.2 Empowering the Electricity Business Environment

The Government of Liberia (GOL) realized that to quicker improve the electricity supply for the country after the war, the old LEC's mandate must be changed and there must be empowerment legislations for the energy sector. LEC's manpower, technological, and financial capacity, and the growing population and development demands were unsustainable for LEC to continue to hold the virtual "monopoly" over the electricity business industry over the entire rural and urban Liberia. In June 2015, the **Rural Renewable Energy Agency (RREA)** was enacted into Law to address the rural electrification through renewable energy. In addition, the **2015 Liberia Electricity Law** was enacted in September 2015. These two laws opened the opportunities to modernize the electricity sector and give authorization for private sector participation in the electricity business in Liberia. LEC's monopoly on the electricity business was also repealed to make LEC a Company that can be regulated as any other player in the energy sector and not a government Corporation as before.

The RREA launched its **Rural Energy Strategy and Master Plan for Liberia** in August 2016, which can be accessed on www.liberiaruralenergy.org. In July 2017, the **Liberia Electricity Regulatory Commission (LERC)** was formally established as enacted in the 2015 Electricity Law of Liberia as the independent regulator of the electricity sector of Liberia. The LERC became operational in September 2018.

5.1.3 Transmission and Distribution - Grid Expansion Projects

With the achievement of nearly 131 MW of LEC Grid installed capacity, the GOL realized that only about 30-35% of the capacity is being transmitted and distributed. For this reason, the condition in the power sector remained highly critical, and the continued absence of electricity had the propensity to derail the fragile security situation in the country. Due to limitations in the overall transmission and distribution lines for the LEC's grid power, most of which were also destroyed during the war, many households, health, and commercial facilities in many parts of Monrovia city, peri-urban and rural areas, currently still rely on self-generation of electricity rather than Grid or Mini-Grid supply. This situation is also applicable to the majority of hospitals and clinics around the country relying on diesel self-generated electricity as the main source or must-have stand-by power supply. It became clear that the most urgent need for the Electricity Sector presently is for transmission and distribution of the current generation capacity which is reported to be underutilized.

This underutilization plus other compelling reasons, including the urgent need to invest in the electricity sector as a key driver for the economic transformation of the

country and a major component of Liberia's Agenda for Transformation, lead the World Bank to be currently funding the Liberia Electricity System Enhancement Project (LESEP), an International Development Association (IDA) financing, in collaboration with other international donors, including the Government of Norway (GON), Japanese International Cooperation Agency (JICA), the United States Agency for International Development (USAID) and the European Union (EU).

Given the critical nature of the Liberian power sector, request for extension and expansion of LESEP was presented to the Bank and the Bank began the process under the Rapid Response to Crisis and Emergency OP/BP 8.00 in 2010 with the aim of financing distribution services and enhancement of supply generation options, on-grid and off-grid. The LESEP was supplemented by funding provided from the Global Partnership for Output Based Aid (GPOBA) and the Africa Renewable Energy Access (AfREA) Trust Fund. This gave rise to LESEP Additional Financing (LESEP-AF) and further extended financing under the Liberia Accelerated Electricity Expansion Project (LACEEP) plus LACEEP Additional Financing (LACEEP-AF).

Liberia Accelerated Electricity Expansion Project (LACEEP)

The World Bank funded LACEEP project is expanding electricity from the City of Paynesville in Montserrado County to the City of Kakata in Margibi County and up to Wheala Town. The project is divided into three lots, which entail the construction of 66/33 kV substation in Kakata, the expansion of the existing 66/22 kV substation in Paynesville, and the construction of distribution lines in communities in Paynesville and Kakata. The project is connecting 25,000 new customers to the national power grid.

Liberia Energy Efficiency Access Project

The Liberia Energy Efficiency Access Project (LEEAP) is jointly funded by the African Development Bank (AFDB), the European Union (EU) and the Global Environmental Fund (GEF). The project is divided into two corridors and will expand and increase access to 45, 000 new users and will extend access to electricity within the ELWA to RIA corridor and the Pleebo to Fish Town corridor and is also intended for development of the institutional capacity at LEC, RREA and MME.

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Liberia Accelerated Electricity Expansion Project – Additional Financing (LACEEP-AF)

The LACEEP-AF enhances the impact of the LACEEP original by scaling up the activities to connect new residential, commercial, and industrial users and strengthen the capacity of LEC. This will be done through the addition of activities under component 1 (transmission and Distribution) and component 3 (strengthening sector institutional capacity) which ensures increase in generation capacity that comes on line in the coming years that translates into increased and improved electricity services in Greater Monrovia and in Bomi and Grand Cape Mount Counties. The Project is divided into three lots. Lot 1: The construction of 66 kV transmission lines (Areas: 66 kV lines route: Bushrod SS-Virginia SS-Klee and Stockton Creek SS-Gardnersville SS-Paynesville).

This will include the construction of new and rehabilitation of existing transmission and distribution networks (substations and lines), and connection of new customers. Up to 33,000 new customers in all categories, including 13 industrial plants in the areas served by the Gardnerville, Stockton Creek, and Virginia substations are expected to be connected under this project.

The subcomponent will finance construction of the main electricity transmission and distribution infrastructure of the corridor, as well as connection of about 6,800 new users in the economic zones of Bomi and Grand Cape Mount Counties. The project will finance the construction of a transmission line at 66kV; distribution lines at 33kV and 22kV; and the upgrade of several substations, and construction of some new substations. Newly connected customers will include households, small businesses and several larger prospective users, such as large palm oil plantations and mining companies. Local health and educational centres are also expected to be connected under the project. This sub-component will enable access to cheaper electricity for the large consumers in this corridor which currently relies on expensive self–generated diesel based electricity. LEC could therefore broaden its customer base by incorporating these medium and large users to its customers' portfolio.

This sub-component will cover the cost of preparing, managing, and auditing the component. It will include the financing of the necessary preparatory and safeguards studies and the costs of supervising the works. It will also provide the resources needed by LEC to manage implementation.

Electrification and Grid Upgrade Project

The Electrification and Grid Upgrade project is funded by K_fW Bank of Germany and is expected to deliver 16,000 new connections that will fill the gaps between the larger projects in areas such as Clay Ashland – Bentol-Fendell, Double Bridge-Pipeline-Police Academy, and Duport Road – Rehab communities.

The Monrovia Consolation of Electricity Project

The Monrovia Consolation of Electricity project is funded by the European Union (EU), and it is expected to expand and increase access to electricity to 38,000 new users in areas covering Central Monrovia up to The RLJ Hotel Junction in ELWA, Paynesville. The project is divided into two lots;

Lot 1: entails the supply and installation of a 66kV transmission line and expansion works in six substations (Bushrod, Stockton Creek, Kru-Town, Capitol Sub, Congo Town and Paynesville).

Lot 2: entails the supply and construction of 22/0.4kV distribution network from Central Monrovia to Kenejah.

5.2 Rural Electrification Program

The rural areas that are not currently reached by the LEC Grid are essentially running with diesel generators and the self-generation or private mini-grids provide

electricity to customers not hooked to the national grid. IPPP's became justification during the period when emergency actions were the accepted alternatives until the national utility can resume its activities. With the coming into force of the 2015 Electricity Law and the LERC, IPP's are gradually beginning to develop with recognition. Currently, the LERC has given License to two Mini-Grids which have so far met the requirements and capacity to operate as licensed electric power operators. They are, Jungle Power in Nimba County, and Totota Electric Company in Bong County. When access to the national grid reaches these areas, they can become distributors through the grid line selling their power through the LEC grid.

On the longer term, given the uncertainties on the trend of fossil fuel costs which are reasonably assumed to continue to increase, it will be legitimate to consider other sources of energy, preferably Bioenergy which is a renewable and more environmentally friendly nature, to achieve a better balanced mix of future generation capacities in Liberia.

It can be predicted that for the next 5 years, the involvements and commitments of the international community Donors Partners will be the main backup support base to satisfy Liberia's expected demand growth rates in generation, transportation and distribution/connections. In other words, the electricity sector is currently "crowded" by financing partners for the development of the electricity sector and for satisfying most of the demand up to 2025. After this period, new projects in the fields of generation, transmission and distribution will require additional support by LEC, the Government and the donors or private investors.

With the opening of the Electricity Sector through the 2015 Liberia Electricity Law, it is expected that by 2025, a number of private investors and IPPs will be active in the electricity sector of Liberia. According to preliminary studies (Stanley Consultants), one of the first actions which will require major investors is the creation of a reservoir on the Via River (a confluent to the St Paul River) upstream of the Mount Coffee hydropower plant. Such a reservoir would drastically increase the dependable capacity of the Mount Coffee power plant which is currently very low, given the seasonal variation of the St Paul River. Implementing other reservoirs/dams and power plants cascade along the St Paul River will increase the hydro power installed capacity to over 1,000MW and ensuring yearly average of over 2,700GWh of energy. The Liberia electricity sector could then become an exporter of electricity through the CLSG transmission line if we take the initiative to develop the hydropower potential of the St Paul River basin in the medium and long terms.

5.2.1 NGO/Civil Society or Other Association

Overall Objective: The NGOs and Liberian Civil Society Organisations (CSOs) contribute to inclusive wealth creation for a more equal and transparent society in support of Liberia's 2030 Agenda for Transformation. The project aims to achieve this objective by strengthening bonding, bridging and linking social capital at multiple levels of Liberian society. A number of organizations have funded Liberian Energy Sector Support and Access Project to electrify rural health care facilities through empowerment of local energy entrepreneurial entities and the RREA.

5.2.2 Mini-Grids Powered By Renewable Energy IPPs

The below table 18 lists some Mini-grids IPP arrangements in place, some aspiring and others are operational with minimum success at their level. Several challenges exist with some of them including lack of spare parts (replacement batteries especially) and lake of management initiatives, lack of loan financing and dependency on donor support, etc. Any healthcare, education, offices, and business facilities in Liberia struggles with unreliable access to electricity and off-grid solutions have yet to come to the scale that they can sustain the customers' demands.

The table below presents the updated list of current IPPs renewable energy activities operating or aspiring in Liberia with support for specific projects under development around the country. A total of 2,852.6KW is under development by various organizations including local corporative arrangement to manage the facility.

Table 18: Mini-grids IPP Arrangements in Place and Some Aspiring[13]

Community/ County	Technology	Funder	Implementer	Operated By	Capacity	Start Date	Status
Yandahun/ Lofa	Hydro	World Bank	RREA	local cooperative	60KW	2013	operational
Kwendin/ Nimba	Biomass (wood)	USAID	NRICA	local cooperative	60KW	2016	operational
Sorlumba/ Lofa	Biomass (palm oil)	USAID	NRICA	local cooperative	25kw	2017	almost operational
Totota/ Bong	solar/diesel	USAID	Totota Operator	private operator	25KW	2016	operational, plans for extension
Kolahun-Voinjama/ Lofa	hydro/diesel	World Bank	RREA	private operator	2.5MW	2019	planned
Langbemba/ Lofa	solar	EU	PLAN & VOSIEDA	local cooperative	31.1KW	2017	Needs repair after fire
Taninahun/ Lofa	solar	EU	PLAN & VOSIEDA	local cooperative	28.5KW	2017	operational
Mamikonedu/ Lofa	solar	EU	PLAN & VOSIEDA	local cooperative	25.5KW	2017	operational
Koiyama/ Lofa	solar	EU	PLAN & VOSIEDA	local cooperative	22.5KW	2017	operational
Nyengbelahun/ Lofa	hydro	EU	PLAN & VOSIEDA	local cooperative	50KW	2017	operational
Gbarnway/ Lofa	solar	USAID	NRICA	local cooperative	24KW	2015	almost operational
Koon Town/ Montserrado	solar	EU	Mercy Corps	IPP business	n/a	2018	planned

[13] Donor Supported IPPs Initiatives www.renewables-liberia.info/index.php/projects-new/project-sector-strenthening/156-mini-grids-in-liberia.

Table 18: Mini-grids IPP Arrangements in Place and Some Aspiring[13]							
Community/ County	Technology	Funder	Implementer	Operated By	Capacity	Start Date	Status
Karto Town/ Montserrado	solar	EU	Mercy Corps	IPP business	n/a	2018	planned
Block Pad Montserrado	solar	EU	Mercy Corps	IPP business	n/a	2018	planned
TOTAL					2,852.6KW		

5.2.3 Mini-Grid Power Supply to Health Care Facilities

The below table gives the total number of existing and potential Mini-Grids/IPPs in Liberia, however, we do not have data on their electricity generation and experiences on energy supply to local customers, nor whether any of them is supplying a Health Care Facility (HCF) in their locality in Liberia. It is therefore premature for us to indicate the level of off-grid or mini-grid supply to HCFs. Their capacities are also so small they may only be catering to a specific facility of few local customers nearby, if any.

Table 19: MINI-GRIDS AND ASPIRING IPPs IN LIBERIA			
Total Capacity (KW)	No. of Functional & Potential IPPs	Operational Capacity (KW)	Average (KW)/IPP Facility
354.1	**9**	**274**	**30.4**

LIST OF LEAP LIBERIA MEMBER ORGANIZATIONS

Table 20: LIST OF LEAP LIBERIA MEMBER ORGANIZATIONS		
Company	Objective	Contact
Alternative Energy	Retailor of affordable solar products and clean cook stoves	Email: aeliberia@yahoo.com
LIB Solar	LIB Solar installs, finances, and maintains solar systems for rural. Households receive lights, radio, and USB charging for $8 per month. Public buildings receive free lighting. The community owns the system after 2-3 years.	Manfred Zbrzezny, Managing Director 0775898890 Email: manfred@lib.solar Location: Broomcamp East Road, Brewerville, Montserrado
Liberia Gateway Inc.	Retailor of affordable solar products and clean cook stoves	Vera T.K. Harris 0777811046 Email: baysaye@yahoo.com
Liberia Energy Inc.	Retailor of affordable solar products and clean cook stoves	Email: scholarrabbas@yahoo.com
MEPEC Group Inc.	Retailor of affordable solar products and clean cook stoves distribution business.	Theo M. Nyeayea 0778360361 Email: saawallo@yahoo.com K. M. Nyenpan Email: kmsandikie@gmail.com
SJEDI Green Energy	Sjedi disgtributed improve cook stove and solar home systems in urban and rural community. We finance,	Royston Gbelia +231-777-448-542/+231-880-747-924

Table 20: LIST OF LEAP LIBERIA MEMBER ORGANIZATIONS		
Company	**Objective**	**Contact**
	install and maintain the products we distributed.	Email: royston.s.gbelia@gmail.com
Lodisha Solution Inc.	Sale and distribute solar product	Email: info@lodicha.net
Jurrut Energy Inc.	Retailor of affordable solar products and clean cook stoves	S. Wilmont K. Kulah +231-777-021-137 0777021137 Email: rck@gmail.com
Total Liberia Inc.	Wholesale of solid, liquid, and gaseous fuels and related products	Monique Styewart +231-776-609-142 Email: monique.stewart@total-liberia.com
Eco Power	Retailor of affordable solar products and clean cook stoves	Comfort M. Korlewala +231-770-347-594
We4Self	Retailor of affordable solar products and clean cook stoves	Estella M.N. Suah +231-886-518-340 Email: we4selfsinoe1@yahoo.com
Bill Johnson Business Center	Retailor of affordable solar products	Bill Johnson +231-886-474-349/+231-770-362-157 Email: charlesettswjohnson410@gmail.com
Biolight Renewable Energy (BRE)	Install and repair solar systems	Willey Mcgill willieymcgill@gmail.com +231-880-282-528
Universal Empowerment Mission	Retailor of affordable solar products and clean cook stoves	Irene K. George +231-776-789-870 Email: irenek.george@gmail.com
Sun Star Green Energy	Retailor of affordable solar products and clean cook stoves	Kare Hayes +231-778-158-517/+231-886-971-085 Email: sunstargreenenergy@gmail.com
BWI	Office solar technology course	Moses Lablah Email: lablahmoses@yahoo.com
Battery Factory Plank Field Metal Shop	Produce cook stove, bucket, top hoe, pinbar, and pot	
MVTC	Office solar technology course	Lazaarus Tolbert Karhou Email: ikarhou1972@gmail.com
Stella Marris Polytechnic	Office solar technology course	J Eric D'Base Pyne +231-777-988-865

CHAPTER 6 KEY NATIONAL PRIORITIES, LEGAL & REGULATORY FRAMEWORK

This section describes and analyse existing policies and measures for enabling sustainable Bioenergy service delivery (including biomass conservation, clean cooking, forestry, environment, agriculture, transport, etc.). A list of some of the measure/policy or regulatory mechanism is also presented.

This overview of the national policies considers the Bioenergy action plan commitments and presents a highlight of Liberia's plans and policies that the BEAP shall consider such as Developing low carbon sustainable energy systems.

- Raising the voice of energy professionals as advocates for stronger ambition on renewable bioenergy entrepreneurship.
- National Energy Policies and Rural Energy Master Plans, etc.

The GOL has a National Energy Policy (NEP) the principal objective to ensure universal access to modern energy services in an affordable, sustainable and environmentally-friendly manner in order to foster the economic, political and social development of Liberia and contains the national vision in the energy sector and economic development, with the following summary of priorities:

- Building Capacity and development phases which lays the foundation
- Creating enabling environment to attract private sector capital to the energy sector,
- Restructuring and reforming energy institutions,
- Decentralizing energy service administration,
- Fully utilizing domestic energy resources including renewable energy and, most importantly,
- Ensuring that all parts of Liberia have access to affordable and modern energy services.

The NEP addresses the strategic issues that are implied in the principal policy objective – **access, quality, cost, and institutional framework**. These policy issues refer to the need for the various technologies and delivery options for energy products and services to be **available, acceptable, affordable, and adequate.** The NEP gives priority to empower development by enhancing the creativity and productivity of human capital, modern energy to support the effective delivery of agriculture, energy, health and education services, increase labor productivity, and alleviate the disproportionate burden on women (gender mainstreaming). The GOL has also developed and adopted the national energy-gender mainstreaming policy and action plan and the energy-gender assessment act.

The NEP long-term strategy is to make Liberia a carbon neutral country within a specified target period. The GOL shall seek to leverage the country's biomass resources as a source of carbon credits for energy development. The GOL shall promote the use of renewable energy, solar energy and wind systems in power plants and all large commercial facilities such as supermarkets, hotels, restaurants, entertainment services as well as health and education services and large retail shops and stores throughout the country.

Further, in line with the international community, and based on the principles of extending energy access to all Liberians through careful consideration of the environmental and health costs and benefits, and with the goal of maximizing efficiency to minimize costs and any adverse environmental and climate change impacts, the Government of Liberia (GOL) states the following additional legal and regulatory priorities to be achieved to a target percentage within a specified target period:

- Reducing greenhouse gas emissions;
- Improving energy efficiency;
- Raising the share of renewable energy to 30% of electricity production and 10% of overall energy consumption by a specified period;
- Increasing the level of biofuels in transport fuel
- Implementing a long-term strategy to make Liberia a carbon neutral country within a specified target period.

The NEP emphasizes that the Government does not have adequate budgetary resources to develop the energy infrastructure to deliver modern energy to all Liberia's. Private resources must be attracted to Liberia's energy sector, and that investment will not be realized without adoption of appropriate reforms. Drawing on technical demand analysis, gradual extension of the grid and consultative process, the government will focus on Independent Private Renewable Energy (IPRE) investments outside greater Monrovia, where two-thirds of the population live. The electrification of all public health institutions is one of the key priorities of the Rural Energy Master Plan of the Rural and Renewable Energy Agency (RREA). The survey interview with the RREA revealed that the RREA along with the ELCA and other donors undertook the Skip the Grid project in 2017 with donations for electrification through solar power to public health facilities.

The NEP subscribes to the UN Framework Convention on Climate Change (UNFCCC) to mitigate, abate or reverse emissions of carbon dioxide (CO_2) and other harmful greenhouse gases (GHG) in the atmosphere.

6.1 The LERC Licensing and Authorization

The Liberia Electricity Regulatory Commission (LERC) created under the 2015 Liberia Electricity Law of Liberia is currently empowered to issue regulations for the registration and licensing of persons engaged in the electricity supply industry including generation, transmission, distribution, electricity trade, import or export transmission, interconnected, or Grid system operation, and supply services in Liberia.

The Liberia Electricity Regulatory Commission (LERC) is an independent regulator created by chapter 13 of the 2015 Electricity Law of Liberia with functions such as: licensing operators in the sector, issuing regulations, tariff approval, and establishment and monitoring of technical standards and codes, as well as resolution of service or license related disputes, among others.[14]

Requirement for a License, Permit or Authorization: Permit or Authorization is issued based on established thresholds such as for generation capacity between 100 kW and 1MW;

- Self-supply permit is required for plants with a capacity of above 100kW; and Self-supply facility with capacity above 2MW will follow the procedure for the issuance of a license.

- Authorization is required for generation at a capacity of 10kW and 100kW;

[14] S4H Project Assessment Questionnaires Analysis Report for Liberia in the Appendix II

- A Self Supplier that generates electricity from a facility with an installed capacity between 10kW and 100kW for its sole use is exempt from the Licensing requirements but must register to obtain Authorization;

The current national procedures for seeking approval of an energy infrastructure project consist of submission of a proposal, concept paper, plan or investment tender. Such Developer or investor is required to submit the said energy project proposal to the Ministry of Mines and Energy (MME) who, by the approved National Energy Policy is the Energy Sector Leader for the Government of Liberia.

Some of the other key pieces of national legislations among others, governing the approval of major energy infrastructure projects include but not limited to the following applicable international standards and relevant Liberia regulatory framework that set the context within which the Project will operate. The Environmental Protection Agency (EPA) is the environmental regulatory authority in charge of issuing environmental guidelines and reviewing the Environmental Impact Assessment process.

Table 21: Key National Policies, Legal & Regulatory Framework

Title	Year	Description
Conservation of the Forests of the Republic of Liberia	1953	This Law provided the framework for the use of forest and wildlife resources and allowed for the creation of government reserves, native authority reserves, commercial forests, national parks and wildlife refuges.
Supplementary Act for the Conservation of Forests	1957	This Supplementary Law also provided the framework for the use of forest and wildlife resources and allowed for the creation of government reserves, native authority reserves, commercial forests, national parks and wildlife refuges.
The Act that created the Forestry Development Authority (FDA)	1976	The Act established and defined the responsibilities of the FDA, outlined forest offences and penalties; made provision for an Advisory Conservation Committee and specified powers of forest officers with regard to trees in reserve areas.
Public Health Act	1976	It contains provision for the protection of drinking water resources and the inspection of potential sources of pollution.
The Natural Resources Law of Liberia	1979	This Law includes chapters on forests, fish, and wildlife, soil, water, and minerals.
Wildlife and National Parks Act	1988	The Act identifies a number of protected areas; specifies policies and objectives regarding wildlife and conservation in the country.
The Environment Protection Agency (EPA) Act	2002	The Act provides the Agency with the authority of government for the protection and management of the environment in Liberia. It provides for an Environmental Administrative Court to hear from

Table 21: Key National Policies, Legal & Regulatory Framework		
Title	**Year**	**Description**
		aggrieved parties. It requires that an Environmental Impact Assessment (EIA) be carried out for all activities and projects likely to have an adverse impact on the environment.
The Environment Protection and Management Law	2002	The Act enables the Environment Protection Agency to protect the environment through the implementation of the Law. It arranges the rules, regulations, and procedures for the conduct of EIA. It establishes regulations for environmental quality standards, pollution control and licensing, among others.
The National Environmental Policy Act	2002	It defines policies, goals, objectives, and principles of sustainable development and improvement of the physical environment, quality of life of the people and ensures coordination between economic development and growth with sustainable management of natural resources.
National New Forestry Reform Law	2006	The administration of this Act provides for the Forestry Development Authority to exercise the power under the Law to assure sustainable management of the Republic's forestland, conservation of the forest resources, protection of the environment, sustainable economic development with the participation of and for the benefit of all Liberians and to contribute to poverty alleviation in the country.
The National Energy Policy of Liberia	2009	The national energy policy of Liberia (NEPL) commits the GOL to balance the interests of consumers with those of firms and would-be investors engaged in the importation, production, transportation, distribution, and sale of energy products and services be done through the creation of an autonomous regulatory body, enabled by legislation, to eliminate distortions in energy-related markets through transparent, predictable and stable oversight.

6.2 Overview of Policy Framework & Measures Promoting Bioenergy in Liberia

This section outlines the policy measures for the promotion of sustainable bioenergy resources in Liberia. The development of bioenergy around the world is fast growing to be the main alternative to fossil fuel. The baseline analysis present the current status of bioenergy in Liberia which has shown that Liberia is currently dependent on bioenergy for over 90% of its residential energy and several other key socio-economic activities. These calls for a highlight of the nation's adopted policy measures and analyses of particularly the key features of the GOL NEP of 2009,

including how the RREA is implementing the NEP through its Master Plan and the proposed improvements, implementation targets and measures of the key policies are presented.

The table below presents a brief overview of policies and measures, describing the type of measure, expected results, target group, sector or activity and planned dates to start and end each of the planned bioenergy development measures in Liberia. The measures include policies, instruments adopted; required support to promote bioenergy development, specific goals, targets for generation of energy from bioenergy resources, benefits harnessed from bioenergy policy implementation given that bioenergy sources in Liberia remain the main contributor for energy generation from renewable energy sources. We also identify some challenges that need experienced in the implementation of the national energy policy measures for energy generation from bioenergy sources. The key challenges include high cost of imports of equipment for renewable energy, conflicts that exist in different policy goals set by the government, and increasing competition between bioenergy and fossil fuel.

Table 22: Overview of Policies and Measures

Table 22: Overview of Policies and Measures					
Name of Measure	**Type of Measure***	**Expected Results****	**Target Group*****	**Sector or Activity**	**Start-End Dates**
1. Undertake the assessment of current technical and manpower capacity and forecast the human resources requirements for the bioenergy program; assess a full inventory of the bioenergy resources available and develop talent strategies; Plan for a periodic review, evaluation and monitoring for sustainable project management plan and implementation process; Assess the fate of environmental impacts and the potential and actual risk of bioenergy development for ecosystems in relation to other environmental and climate change stresses	Impacts of Bioenergy on deforestation, land use, soil erosion and degradation, desert encroachment, water resources, environment impacts and ecology, climate change, hazards and weather characteristics, and biomass waste and residue generation; Economic impacts of bioenergy Identification of appropriate technologies for bioenergy in Liberia, Review of published data in Liberia Discussion with stakeholders both urban and rural areas	Agro-ecological zoning indicating areas designated as suitable and available for bioenergy development, and designating agriculture farming areas There is need to protect and enhance this natural capital, which sets out the priorities for environmental policy and includes an outlook up to 2050	a. Resources assessment and mapping, based on a methodological framework b. Catalogue experiences relating to: c. Complemented by assessment and sharing of experiences, and an inventory of existing maps	- resource inventory; - climatic and weather scenarios; and - resource availability and utilization such as land, water and other environment considerations; - Resource potential uses and threats, e.g. Climate Change Adaptation needs; - Socio-economic context evaluation; and - rapid assessment methodologies; and	2022-2024
2. Develop systematic	Policy and	regulations,	targets for	Establish a	2022-

Table 22: Overview of Policies and Measures					
Name of Measure	**Type of Measure***	**Expected Results****	**Target Group*****	**Sector or Activity**	**Start-End Dates**
action plan to tackle the challenging issues for **bioenergy** and develop appropriate ppolicies and undertake planning and drafting for enactment of policy and where required, passage into law and strengthening the implementing institutions/stakeholders for action.	regulatory frameworks on bioenergy have to be developed and adopted by the GOL Cabinet and where necessary by the legislature	codes and quality standards	Bioenergy services penetration, incentives for their widespread adoption and implementation	sustainable bioenergy development vision and bottom up political will	2023
3. Study the local context, social practices and culture of the community and provide all concerned the information and knowledge with aappropriate modifications to enable the capacities and culture of the social sectors and communities included in the program.	Information, education and communication on bioenergy products and services	creation of a database and an observatory; transferring (communication tools), - put in place knowledge management system	farmers, policy makers to bankers; to a different audience ranging from farmers, policy makers to bankers.	identify knowledge holders; - knowledge management, sharing and - knowledge monitoring; and	2023-2024

Table 22: Overview of Policies and Measures					
Name of Measure	**Type of Measure***	**Expected Results****	**Target Group*****	**Sector or Activity**	**Start-End Dates**
4. Undertake research and development of bioenergy technologies and projects at local and national levels with innovation to building capacity and technology transfer including skills and cultural acceptance through involvement of the rural and peri-urban application of the technology and market transfer market. We believe that technology transfer is first and foremost a matter of skills, competences, and cultures.	Education and training skills in Bioenergy technologies	Professionals profiles in bioenergy technologies, availability of sustainable bioenergy tools. Existing programs in bioenergy upgraded	cuts across the entire industry for both institutional and human resources and across the different levels of society, including literate and illiterate individuals and farmers	Gender mainstreaming in Bioenergy programs and projects, Capacity building activities to: - Increasing in agriculture and energy; - Reinforcing existing institutional and human structures; - Providing professional and on the job training; - Transferring knowledge and promoting innovation and technology across all levels of production; and - development of job training and professional development	2022-2025
5. Develop Innovative financing mechanisms as key components in bioenergy resource development and mobilization technical and innovative local entrepreneurial support for the attainment of the objectives set by major donors and stakeholders, notably as these pertain to the Millennium Development Goals and Sustainable pro-poor development in Liberia.	Rolling out Bioenergy technologies and services - mapping of financing schemes for every step of the Bioenergy value chain; - identifying barriers to accessing financing schemes; - capitalizing on innovative financing mechanisms and experiences such as climate related financing	Subsidies and grants, financial guarantee funds, and participation of international and local financial institutions.	rural and peri-urban applications	requires innovative and tailored funding mechanisms and schemes, especially for	2023-2025

Table 22: Overview of Policies and Measures					
Name of Measure	**Type of Measure***	**Expected Results****	**Target Group*****	**Sector or Activity**	**Start-End Dates**
	mechanisms; - mobilizing local finance institutions, particularly private sources of capital; and - Coordination of donor **Biomass** Energy, Electricity, Renewable Energy. A wide range of **bioenergy technologies** are available for realizing the energy potential of biomass wastes, fuel-wood and charcoal				
** Indicate if the measure is (predominantly) regulatory, financial or soft (i.e. information campaign).* ***Is the expected result behavioural change, installed capacity (MW; t/year), energy generated (MWh/year)?* ****Who are the targeted persons: investors, end users, public administration, installers, urban or rural population, health centres etc.?*					

CHAPTER 7 OVERVIEW OF BIOENERGY TECHNOLOGIES & SERVICES IN LIBERIA

Biofuels can come as Solid biofuels, Liquid biofuels and Gaseous biofuels. A wide range of bioenergy technologies are available for realizing the biomass energy potential (e.g. solid biofuels such as fuel-wood, charcoal, municipal waste, etc.), however only a few bioenergy technology applications are being utilized in Liberia and no advanced technologies such as gasification, pelletizing, pyrolysis and biodiesel fuel, etc. Those applicable in Liberia, mainly thermal technologies include: Three principal methods of thermo-chemical conversion of fuel-wood energy content are combustion in excess air, gasification in reduced air, and pyrolysis in the absence of air. Direct combustion is the best established and most commonly used technology for converting wood fuel or wastes to heat.

1. "**Open-fires**"

"**Open-fires**" **stoves** (figure 10): Very simple excess air combustion of dry fuel-wood or other waste biomass materials using three stones open for holding the cooking pot over the fire. This is one kind of cooking stove commonly used in the rural areas, especially on the farms and in the village kitchens. The open fire fuel is burning for cooking utilizes only about 1-5% of the energy content of the fuel-wood;

wasting 95-99% of the energy.

Figure 13: Traditional "Three-stones Open-fire" Stove

2. "**Cole-pot**"

The **traditional** "**Cole-pot**" charcoal stove technology (Figure 11a and b below) is the most common cooking stove technology utilized in nearly all households in Liberia. The design may vary including one with double "fire-hearts" which takes two cooking pots at the same time.


(a)

(b)

(c)

Figure 14: Common Traditional "Coal-Pot" Charcoal Stoves utilized in Liberian households - (a) & (b), and the improved Gyapa charcoal cook stove (c)

3. **Improved Cook Stoves**

The Gyapa Improved charcoal cook stove (above figure 10 c), is one improved stove designed in Kenya and was researched on by some NGOs in Liberia (e.g. EnDev/GIZ and others). It includes thermal insulation to reduce the heat losses in the fire-heart, thus making it more efficient than the above (a) model There is need to conduct further research on the efficiencies of coal-pot stoves in Liberia.

The SmartSaver is a **charcoal burning stove** that is reported to cook more for less fuel burned, having higher fuel efficiency. It is being advertised on the internet as featuring an easy-light door that enables easy lighting and cleaning, this portable **stove** is said to help one to cook quickly and burn less fuel. In addition, the

Figure 15: ***EnviroFit Smatter Living stove***

4. **EnviroFit:**

The EnviroFit Smatter Living stove (Figure 12) being advertised on the internet, if available for public users at affordable costs, appears to be a higher energy efficient improved stove technology.

The NBEAP includes a plan and policy for the Department of Energy, MME to encourage the use of Improved Cooking Stoves that meet standards with higher efficiency. Specific measures for the promotion of efficient cook-stoves will be instituted and training materials will be presented/disseminated to stove producers,

implemented in coordination with the initiatives and investments relevant to international and local donor institutions, NGOs and entrepreneurs goals for efficient, sustainable, and affordable clean cooking technologies in Liberia.

5. **Charcoal Production**


(a)

(b)

(c)

Figure 16: "Mud-Pit" Charcoal production method in common use in Liberia

Charcoal Production in Liberia is the process where the cut fuel-wood from logging waste or fuel-wood cut from agriculture land clearing or retired old rubber trees for charcoal production (above figure 13a) are converted into Charcoal under reduced air combustion process thus turning the wood into charcoal while burning a percentage of the original wood.

Figure 17: Metal Kiln charcoal production by the National Charcoal Union of Liberia (NCUL) lead by Mr. Richard T.A. Dorbor

6. "**Mud-Pit Pile**"

The technology utilized in Liberia for charcoal production involves the "**mud-pit pile**" (above figure 13 b & c) which consists of a shallow pit dug in the ground where the cut wood is piled, then covered with leaves and scrubs and mud is covered over the pile to reduce air inflow into the combustion process, however, it cannot be completely airtight. The wood is then lighted and burning takes 24 hours to 48 hours depending on the quantity and the burning control process. The Charcoal yield ranges from 10-25% by mass of the wood feed depending on the experience of the producers and the equipment.

7. "**Metal Kiln**"

Charcoal production method (above Figure 14): Charcoal Production technology which allows for better control of the air flow into the burning process and thus increases the charcoal production yields to 20-45% of the wood feed. This metal kiln method is being used by the National Charcoal Union of Liberia (NCUL). The Forestry Development Authority (FDA) has plans to shall allocate resources and pursue information sharing and training for sensitization of enterpreneures of the charcoal production industry including the NCUL. The NCUL estimates that their union produces approximately 36,500 tons of charcoal annually. Many other thousands of charcoal producers are operating across the country almost all using

the mud-pit method. The BENAP also includes a plan for the Forestry Development Authority (FDA) to introduce fast growing firewood plantations for energy purposes. The Food and Agriculture Administration (FAO) conducted research investigators which reported to show that charcoal is an important part of the Liberian energy portfolio, economic activity, and livelihood of the rural population. This reveals the rationalization for interventions to curtail the impacts of charcoal production losses and the need to increase affordable and available improved charcoal production kilns and thus the well-being of charcoal producers and stakeholders across the country.[15]

8. **Other Complex Bioenergy Generation Technologies**

Waste or fuel-wood biomass can be converted to energy using complex technologies capable of dealing with large amounts of industrial waste. Generally biomass wastes are converted through thermo-chemical or bio-chemical processes, or through physical and chemical methods like wood gasification and pelletizing technologies which may have higher fuel effencies than the direct fuel combustion but such advanced tachnologies are not yet in use in Liberia. **Co-firing or co-combustion of biomass expired rubber wood wastes** with fossil fuels are used to provide a low-cost option for producing renewable energy while simultaneously reducing the use of fossil fuels for rubber processing factory. Co-firing involves utilizing existing steam generating plants that are fired with fossil fuel (in Liberia generally fuel), and displacing proportion of the fossil fuel with renewable biomass fuels. **Gasification** systems operate by heating biomass wastes in an environment where the solid waste breaks down to form a flammable gas. This technology is not yet in operation in Liberia.

9. **Biochemical Technologies**

Biochemical processes, like **anaerobic digestion**, can produce clean energy in the form of biogas which can be converted to power and heat using a gas engine. Anaerobic digestion is a series of chemical reactions during which organic material is decomposed through the metabolic pathways of naturally occurring microorganisms in an oxygen depleted environment or anarobic digester process which stabilizes organic waste in the absence of air and transforms it into biogas and biofertilizer. In addition, wastes can also yield liquid fuels, such as cellulosic **ethanol and biodiesel**, which can be used to replace petroleum-based fuels.

Almost any organic material can be processed with anaerobic digestion. This includes biodegradable waste materials such as municipal solid waste, animal manure, poultry litter, food wastes, sewage and industrial wastes. An anaerobic digestion plant produces two outputs, biogas and digestate, both can be further processed or utilized to produce secondary outputs. Biogas can be used for producing electricity and heat, as a natural gas substitute and also a transportation fuel.

A variety of fuels can be produced from biomass wastes including liquid fuels, such as ethanol, methanol, biodiesel, and gaseous fuels, such as hydrogen and methane. The largest potential feedstock for ethanol is lignocellulosic biomass wastes, which

[15] Food and Agriculture Organization study 2014

includes materials such as agricultural residues (corn stover, crop straws and bagasse), herbaceous crops (alfalfa, switchgrass), short rotation woody crops, forestry residues, waste paper and other wastes (municipal and industrial). Biomass is pretreated to improve the accessibility of enzymes. After pretreatment, biomass undergoes enzymatic hydrolysis for conversion of polysaccharides into monomer sugars, such as glucose and xylose. Subsequently, sugars are fermented to ethanol by the use of different microorganisms. In Liberia, sugar cane production is common and if promoted, will be an economic means for the sugarcane farmers to produce for ethanol feedstocks. Bioethanol production from biomass feedstocks can also be an alternative for disposal from residues. Importantly, lignocellulosic feedstocks do not interfere with food security.

CHAPTER 8 COOKING FUELS

In this Chapter, we present tables and corresponding graphs analysing the fuels and devices along with narrative of the past, present and future trends of the bioenergy situation.

8.1 Domestic Fuels Consumption

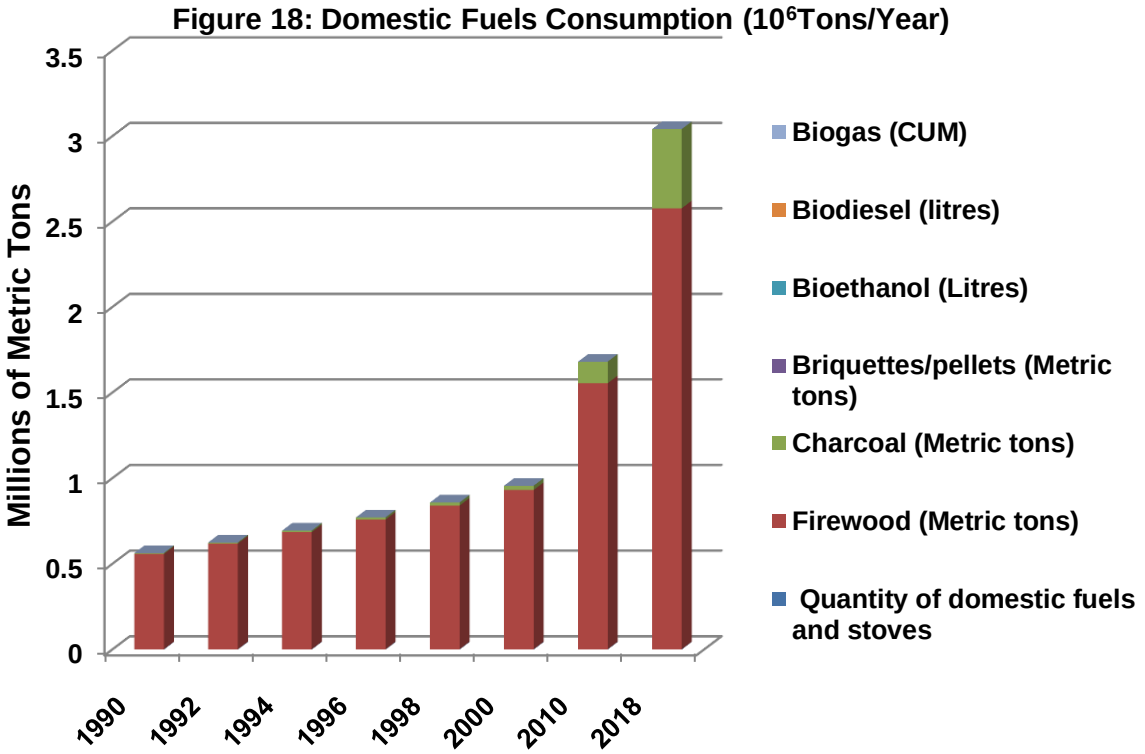


Figure 15 above and the accompanying table 23 below give the trend in the major cooking fuels consumption over the past 3 decades (1990-2018). The figures in millions of tons range from approximately 0.5 to 3.0 million tons per year in fuel wood and charcoal consumption range from approximately 5 to thousand to 463 thousand tons per year. The agriculture wastes amount to approximately 30 to 1,240 tons per year over the time periods. Briquettes/pellets, Bioethanol, Biodiesel and Biogas are currently not, and if any, are in negligible quantities used currently in Liberia. Some research has been done and potentials estimated which we discuss later in this paper.

8.2 Cooking Fuels Consumption

Available data indicates that the fuel consumption is mainly fuel-wood, charcoal and agro-industrial waste and no data of substantial use of Briquettes/pellets, Bioethanol, Biodiesel and Biogas are available or their use is considered negligible. Over the past nearly three (3) decades period, fuel-wood consumption rate has grown at the average rate of approximately 9% per year while charcoal consumption increased approximately 36% per year, and the agro-industrial waste consumption grew at the average of 22% per year.

Table 23: Cooking fuels consumption over the past 3 decades

Quantity of domestic fuels and stoves	1990	1992	1994	1996	1998	2000	2010	2018
Firewood (Metric tons)	556,626	616,760	683,391	757,220	839,025	929,667	1,552,714	2,576,206
Charcoal (Metric tons)	4,894	6,774	9,376	12,977	17,961	24,860	126,274	463,407
Briquettes/pellets (Metric tons)	-	-	-	-	-	-	-	-
Bioethanol (Litres)	-	-	-	-	-	-	-	-
Biodiesel (litres)	-	-	-	-	-	-	-	-
Biogas (CUM)	-	-	-	-	-	-	-	-
Agro-industrial waste (Metric tons)*[16]	30	39	50	66	86	112	427	1,241

[16] * Estimates from previous MME studies - **Note**: Charcoal weighs 0.208 gram per cubic centimetre or 208 kilogram per cubic meter, i.e. density of charcoal is equal to 208 kg/m^3. In Imperial or US customary measurement system, the density is equal to 12.985 pound per cubic foot [lb/ft^3], or 0.1202 ounce per cubic inch [oz/inch^3]

Figure 19: Domestic Cooking Fuels Consumption

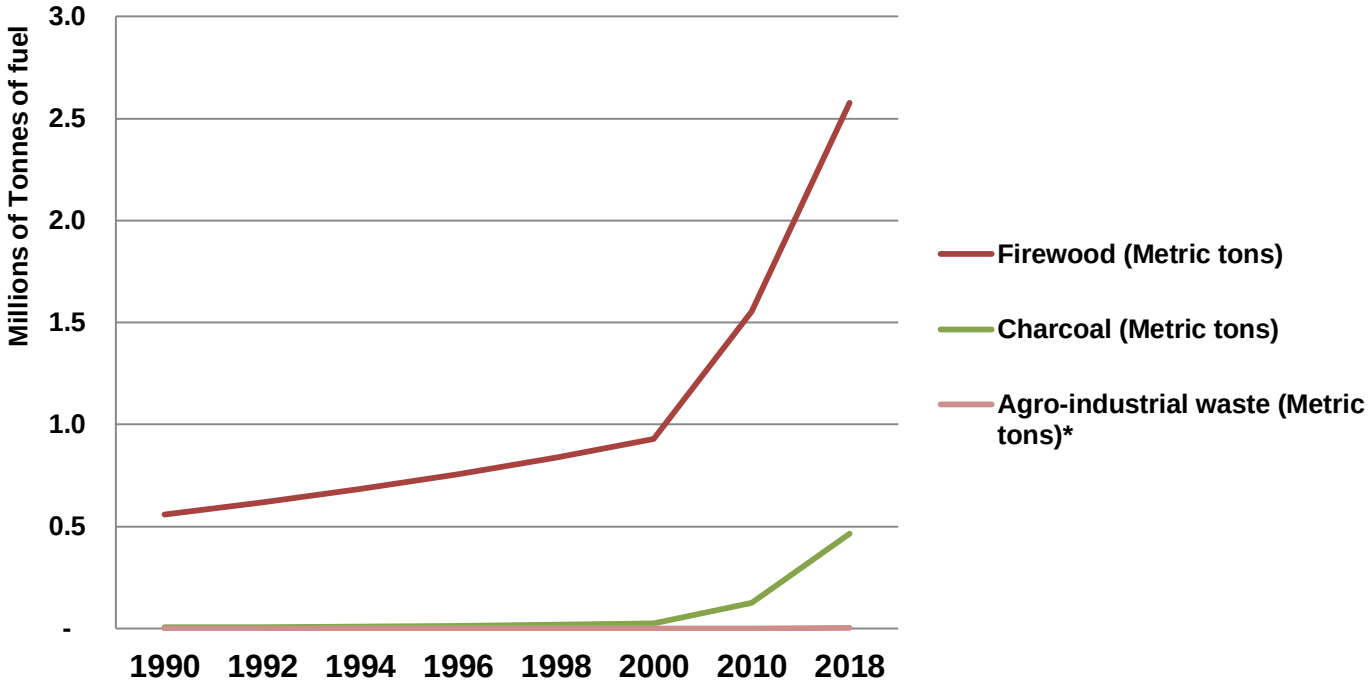
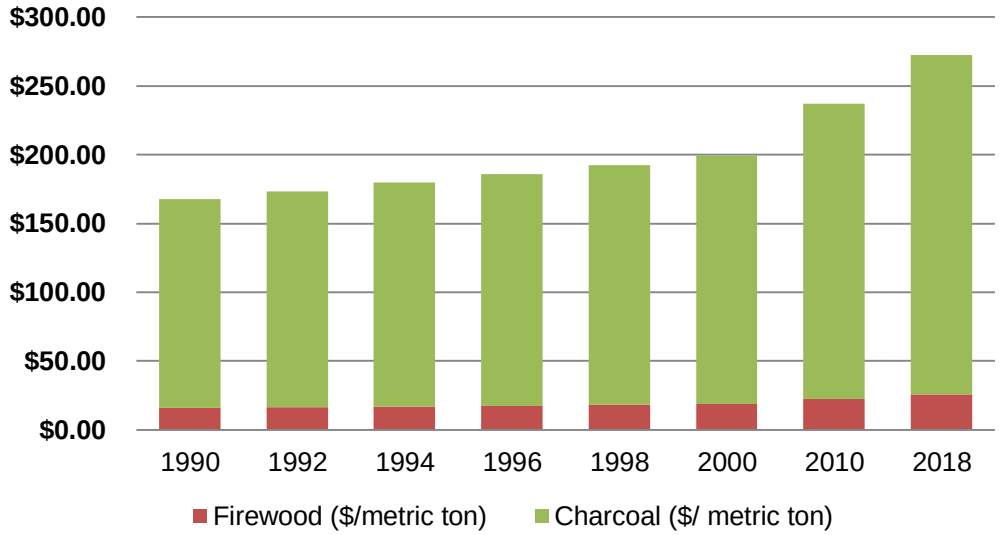


Table 24: Price of Cooking Fuels (USD/Ton)

	1990	1992	1994	1996	1998	2000	2010	2018
Firewood ($/Metric tons)	$15.92	$16.48	$17.07	$17.67	$18.29	$18.93	$22.52	$25.86
Charcoal ($/Metric tons)	$151.65	$156.99	$162.53	$168.26	$174.19	$180.33	$214.43	$246.30
Briquettes/pellets ($/Metric tons)	-	-	-	-	-	-	-	-

Figure 20: Annual Average Prices of domestic fuels ($/Ton)



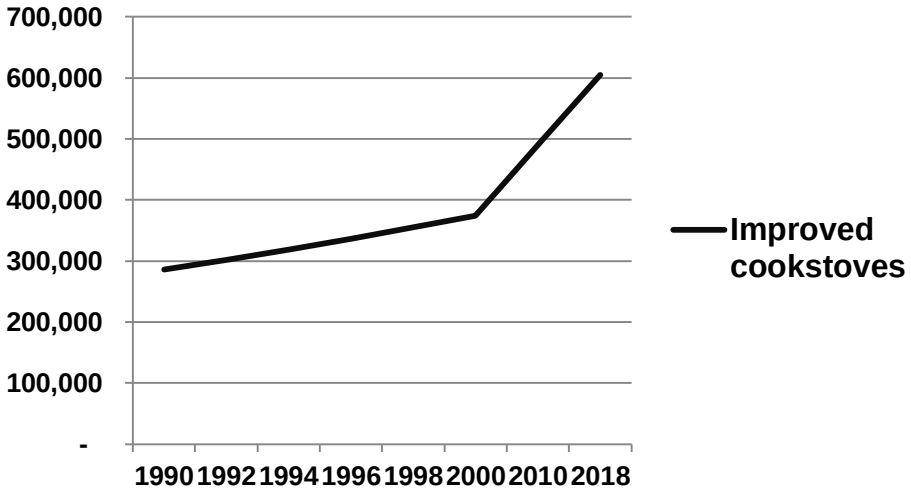
8.3 Bioenergy Devices

Table 25: ICS and others cookers (Units per year)

Quantity produced	1990	1992	1994	1996	1998	2000	2010	2018
Solar cookers								
Improved Cook Stoves	286,242	302,052	318,735	336,341	354,920	374,526	490,066	604,657
Ethanol Cooker								

Improved cooking stoves (ICS) are far below the 20% of the national households scenario predicted by ECREEE for Liberia and consist of the metal charcoal coal-pots and improved wood stoves are only minimum; We estimated 12% of households using ICS and LPG cookstoves. The trend of ICS increase per year is 2%. We predict that by 2030 Liberia could attain 24% of households with access to ICS if we continue at this rate. This will be 2% below the ECREEE projected target of 26% ICS access to households in Liberia.

Figure 21: Improved Cookstoves (ICS) Production/Year



The graph shows a sharp slope rise from 2000 to 2010 and 2010 to 2018 but that is because data for the 18 years between was not available. It calculates to an average 12% growth rate per year.

Table 26: Price of Devices ($/Unit)

Prices	1990	1992	1994	1996	1998	2000	2010	2018
Solar cookers	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Improved Cook Stoves	$4.21	$4.76	$5.39	$6.10	$6.91	$7.82	$14.51	$25.00
Ethanol Cooker	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

The prices of ICS devices have grown by 8% per year over the study period. It is noticed however that improvement in the design and technology has been negligible and very slow changes. In some cases one can find a few ICS with improved quality of construction materials but no design modifications. This could be due to the customers not willing or inability to pay higher prices when improved design introduced. The knowledge of the needs for energy efficiency improvements and resulting reduction in the expenses for the fuel used is very minimal if any and there is need to do public awareness.

Figure 22: Annual Average Prices of Cooking Devices

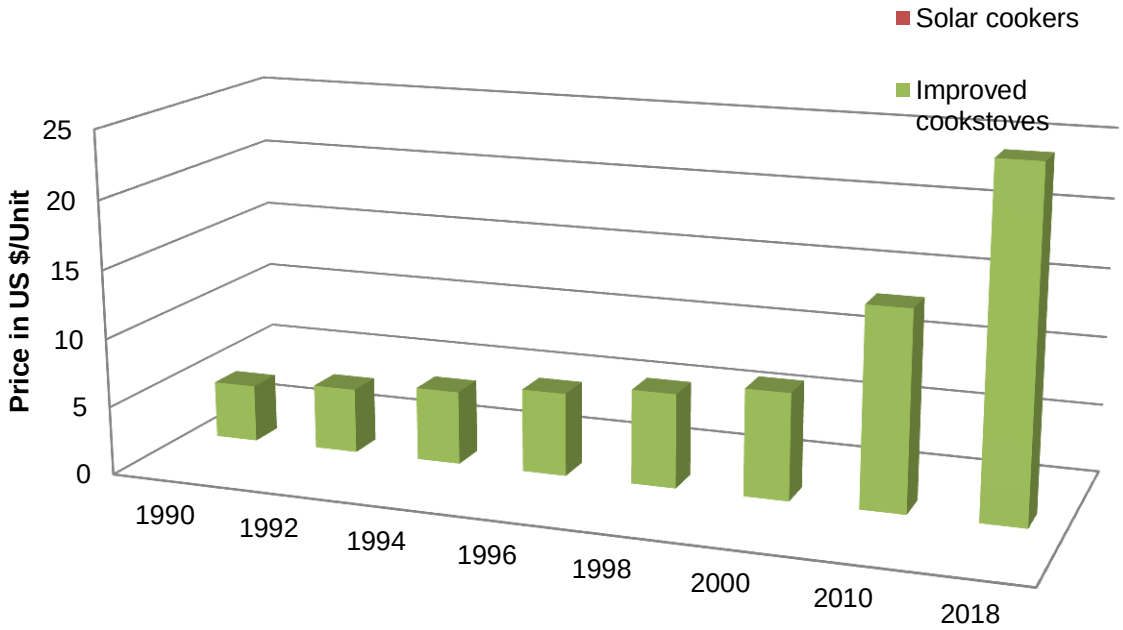


Table 27: Number of Installed Bio-digesters per Capacity

Biogas technology is currently not in appreciable use (if any) in Liberia and data on Biogas was not available at the time of this writing.

Capacity (m^3)	1990	1992	1994	1996	1998	2000	2010	2018
10 m^3	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20 m^3	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30 m^3	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Total number								

Table 28: Price of Installing Biogas Digesters

Capacity	1990	1992	1994	1996	1998	2000	2010	2018
10 m^3	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20 m^3	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30 m^3	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

In the early 1980's a group constructed a biogas digester of approximately 10m^3 to generate biogas to supply a village (Galai Village in Bong County) but there was major disagreement for the technology from the village residents when they realized that manure (from human, cattle and pigs, etc.) was being used to generate the gas that was being piped to the community kitchen for cooking. They could not accept that the gas generated from manure was safe. Support for the project was discontinued and the group that developed it could not expand, and withdrew their investment and left the country. To date, we have not seen any major interest in this technology in Liberia. This is another bioenergy technology where there is need for serious support and public awareness programs in Liberia.

Table 29: LPG Cylinders (Existing Capacities in the Liberia)

Table 29: LPG Cylinders (Kg) (Existing Capacities in the Liberia)								
Cylinder	1990	1992	1994	1996	1998	2000	2010	2018
3kg	23,355	24,822	26,381	28,038	29,799	31,671	42,948	54,799
6kgl	7,785	8,274	8,794	9,346	9,933	10,557	14,316	18,266
9kg	3,893	4,137	4,397	4,673	4,967	5,279	7,158	9,133
12.5kg	3,581	3,806	4,045	4,299	4,569	4,856	6,585	8,403
25kg	3,270	3,475	3,693	3,925	4,172	4,434	6,013	7,672
38 kg	1,537	1,633	1,736	1,845	1,960	2,084	2,826	3,605
Total	43,420	46,147	49,046	52,127	55,401	58,881	79,846	101,878

Current estimated access rate of LPG use in the households in Liberia is approximately 11% of the national households and we are far below the predicted 20% scenario projected by ECREEE for Liberia by 2020. The annual growth rate is 3.4% of cylinders per year. At this rate, Liberia may reach to only 25% households

LPG access by 2030. Major empowerment and public awareness programs are needed for Liberia to arrive at the 26% minimum households LPG access.

A relatively small quantity of LPG is being used for cooking by a negligible number of households and commercial establishments. Currently, LPG is estimated at about 3,100 households using an average of 16.2Kg of cylinders purchasing average 150 cylinders per month. This represents only a small percentage (11%) households currently utilizing LPG energy.

Table 30: LPG Cylinder prices (USD Per Equivalent Kg Cylinder)

Cylinder	1990	1992	1994	1996	1998	2000	2010	2018
3kg ($/Unit)	n/a	n/a	n/a	n/a	n/a	$2.89	$3.92	$5.00
6kgl	n/a	n/a	n/a	n/a	n/a	$5.78	$7.84	$10.00
9kg	n/a	n/a	n/a	n/a	n/a	$8.67	$11.76	$15.00
12.5kg ($/Unit)	n/a	n/a	n/a	n/a	n/a	$12.04	$16.33	$20.83
25kg	n/a	n/a	n/a	n/a	n/a	$20.23	$27.43	$35.00
38kg ($/Unit)	n/a	n/a	n/a	n/a	n/a	$31.79	$43.11	$55.00

8.4 Heating Fuels

Table 31: Fuel Used for Boilers/Hotel, Laundry, Bakery and Fishing Industry

Quantity fuels	1990	1992	1994	1996	1998	2000	2010	2018
*Agro industrial waste (metric tons)	18	23	30	39	52	67	256	745
Biogas (M^3)	779,589	863,810	957,130	1,060,532	1,175,105	1,302,055	2,174,670	3,608,132
LPG (metric tons)	n/a	n/a	n/a	n/a	n/a	234	317	405
Ethanol (Kilo litres)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

*** Includes fuel-wood, charcoal, residues, and sawdust from sawmills; etc.**

Fuel use for boilers/hotels, laundry, bakery and fishing industries are extensive mainly utilizing fuel-wood, charcoal, and waste residues – sawdust and wood scrubs from sawmills, logging, etc. There is currently no major project for biogas production so that figures for biogas in m^3 on table 31 above are basically from fuel-wood and charcoal fuels.

NOTE: Density Charts of Different Wood Types		
Type of wood	Density Dry Wood [kg/m3]	Density Dry Wood [lb/ft3]
Alder	400-680	24.97 – 42.45
Hornbeam	990	61.80
Cherry	600	37.45
Oak	600 – 900	37.45 – 56.18
AVERAGE	**714Kg/m^3**	**43.38 lb/ft^3**

Source	startwoodworkingnow.com/density-of-wood/

8.5 Electricity Production

The electricity production section next, presents analysis of the electricity generation from various biomass resources, including the waste resources where applicable, their installed grid connected and mini-grid connected capacities and power generation over the study period. The name and location of the plant and capacity installed is presented where available. The power generation fuel source including co-generation (or multi-functional platform - MFP) facilities where applicable are specified.

Table 32: Installed Capacities (Grid Connected)

Capacity Installed (MW)	1990	1992	1994	1996	1998	2000	2010	2018
Total installed capacity	**69**	**5**	**5**	**5**	**5**	**5**	**69**	**93**
RE (including medium and large Hydro)	68	4	4	4	4	4	68	92
Total Bioenergy	**1**	**1**	1	1	1	1	1	1
Biogas	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Biodiesel	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Bioethanol	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Agro-industrial waste (Bagasse, sawdust, etc.)	1	1	1	1	1	1	1	1
Pellets/briquettes	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Municipal solid waste	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

On the above table 32, grid connected bioenergy total installed capacities constitute of 13% from agriculture-forestry industrial waste (sawdust, logging company waste wood shrubs, and rubber plantations expired trees, etc.). The installed capacity for medium and large hydro consists of 4.3% from the Firestone Rubber Plantation Company hydro and 1.1% fuelwood steam plant and 94.6% the LEC Mt. Coffee hydro power plants.

Table 33: Energy Production (Grid Connected)

Table 33: Energy Production (Grid Connected)								
Production (GWh)	**1990**	**1992**	**1994**	**1996**	**1998**	**2000**	**2010**	**2018**
Total Production	**604.44**	**43.8**	**43.8**	**43.8**	**43.8**	**43.8**	**604.44**	**814.68**
RE (including medium and large Hydro)	595.68	35.04	35.04	35.04	35.04	35.04	595.68	805.92

Total Bioenergy	**8.76**	**8.76**	**8.76**	**8.76**	**8.76**	**8.76**	**8.76**	**8.76**
Biogas	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Biodiesel	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Bioethanol	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Agro-industrial waste (Bagasse, sawdust, etc.)	8.76	8.76	8.76	8.76	8.76	8.76	8.76	8.76
Pellets/briquettes	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Municipal solid waste	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

The energy production from Bioenergy sources was constant or zero growth rate over the 1990 – 2018 period. It was observed that only rubber concessions and few logging companies continued and maintained their capacities but made no increases. The logging industry experienced major changes when deforestation concerns and the international community intervened and a number of policies and legislations were put in place. The energy supply for the logging industry needs to be seriously assessed and the utilization of the waste to generate energy should be regulated and programs for empowered including the introduction of appropriate technologies, public awareness, and technical capacity development need to be introduced.

Table 34: Installed Capacities (Off Grid)

Capacity Installed (MW)	**1990**	**1992**	**1994**	**1996**	**1998**	**2000**	**2010**	**2018**
Total Capacity (MW)	**0.035**	**0.035**	**0.035**	**0.085**	**0.110**	**0.110**	**0.183**	**2.853**
RE (including medium and large Hydro)	0.035	0.035	0.035	0.035	0.035	0.035	0.085	2.6100
Total Bioenergy (MW)	**0.000**	**0.000**	**0.000**	**0.050**	**0.075**	**0.075**	**0.098**	**0.243**
Biogas	0	0	0	0	0	0	0	0
Biodiesel	0	0	0	0.05	0.075	0.075	0.098	0.243
Bioethanol	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Agro-industrial waste (Bagasse, sawdust, etc.)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Pellets/briquettes	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Municipal solid waste	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Biodiesel energy is a new technology for many of the businesses in Liberia for energy production and the competition between investing into a new biodiesel technology and that of diesel fossil fuel generation makes diesel to more competitive option to a few developing Independent Power Producers (IPP). The Biodiesel projects were supported through the aid of USAID. But some of the companies listed on table 34 above are yet to be completed.

Figure 23: Off-Grid Installed Capaciy Per Year

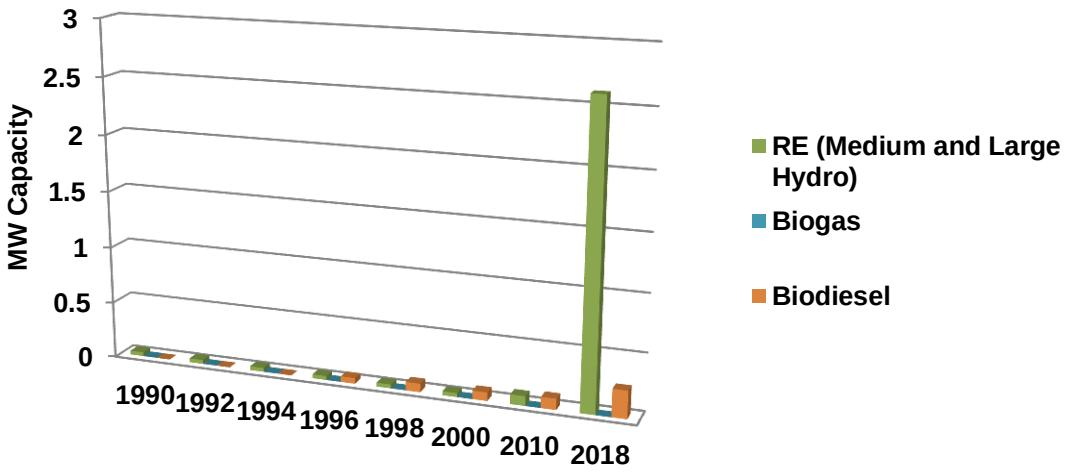


Table 35: Energy Production (off-grid)

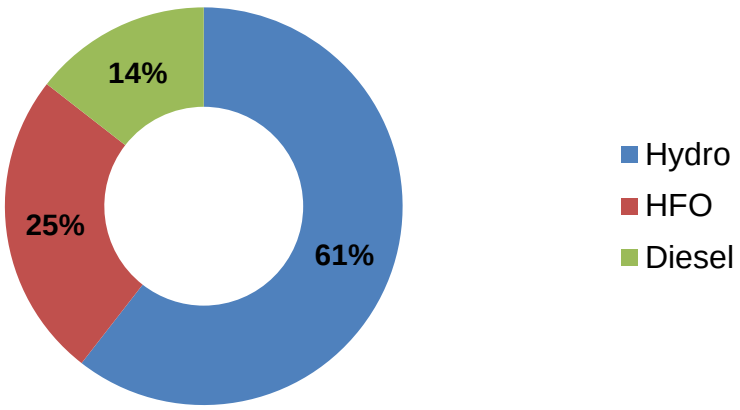
Table 35: Energy Production (off-grid)								
Production (GWh)	**1990**	**1992**	**1994**	**1996**	**1998**	**2000**	**2010**	**2018**
Total Production (GWh)	**0.307**	**0.307**	**0.307**	**0.745**	**0.964**	**0.964**	**1.603**	**24.992**
RE (including medium and large Hydro)	0.307	0.307	0.307	0.307	0.307	0.307	0.745	22.864
Total Bioenergy (GWh)	**-**	**-**	**-**	**0.438**	**0.657**	**0.657**	**0.858**	**2.129**
Biogas	0	0	0	0	0	0	0	0
Biodiesel	-	-	-	0.438	0.657	0.657	0.858	2.129
Bioethanol	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Agro-industrial waste (Bagasse, sawdust, etc.)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Pellets/briquettes	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Municipal solid waste	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Off-grade energy production experienced a growth rate of only 0.61% per year over the 28 years study period mainly from the hydro development in recent years after the war. Small scale hydro (mini-hydro) capacity has not grown over the period.

Table 36: Existing Plant for Grid Electricity or Mechanical Generation

Table 36: Existing Plant for Electricity or Mechanical Generation					
Name of Plant	Location of Plant,	Installed Capacity (KW)	Type of Biofuel	LEC Grid Generation	Status (Operating/Not Operating
St. Paul Hydro	Mount Coffee	88,000	Hydro	Grid Generation	Operating
Firestone Hydro	Harbel, Montserrado	4,000	Hydro	Firestone Self-Generation	Operating
Heavy Fuel Oil (HFO) plant	Bushrod Island	38,000	HFO	LEC Grid Generation	Operating
High Speed Diesel (Gas Oil) generation plant	Bushrod Island	22,000	High Speed Diesel (Gas Oil)	LEC Grid Generation	Only 5MW Operating
TOTAL (KWh)		**152,000**			

Figure 24: Electricity Grid Generation By Fuel Type



Electricity grid generation instilled capacity is mainly from the Mt. Coffee hydro (61%) and Bushrod Island HFO (25%) high speed gas oil plants (14%) and the Firestone Rubber Plantation Company has a 4MW hydro capacity adding to the total hydro accounting for about 4.35% of total hydro capacity.

8.6 Transportation

Table 37: Production/Import/Year

Table 37: Production/Import/Year								
Quantity	**1990**	**1992**	**1994**	**1996**	**1998**	**2000**	**2010**	**2018**
Gasoline (10^6Litres)	37.62	39.72	41.79	43.67	45.54	47.376	61.194	75.24
Diesel (10^6Litres)	25.74	26.81	27.86	28.78	29.70	31.58	38.49	45.54
Bioethanol (10^6Litres)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Biodiesel (10^6litres)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Figure 25: Transportation Furls Import (Liters per Year)

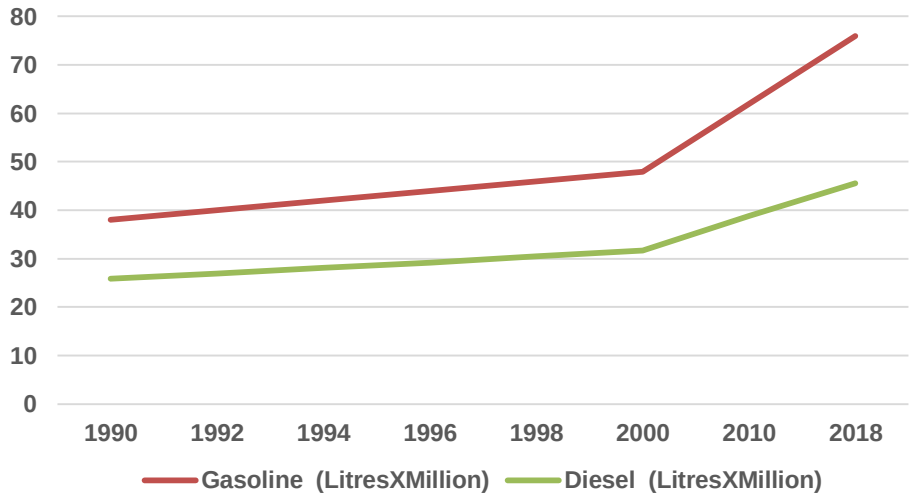


Table 38: Export

Table 38: Export								
Quantity	**1990**	**1992**	**1994**	**1996**	**1998**	**2000**	**2010**	**2018**
Gasoline (10^6Litres)	0.38	0.28	0.21	0.33	0.46	0.62	0.81	0.76
Diesel (10^6Litres)	0.26	0.19	0.14	0.22	0.30	0.42	0.51	0.46
Bioethanol (Litres)	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**
Biodiesel (litres)	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**

The export of Gasoline and Diesel from Liberia is negligible and is estimated and for the purpose of this paper it consist only of informal cross-border transactions of fuels through transport vehicles (mostly trucks and large buses) and others for neighbouring power generation by business facilities along a few border towns. The total Imports would therefore include the sum of table 37 and table 38 above for total Gasoline and Diesels imports.

Table 39: National Petroleum & Biofuels Consumption

Table 39: National Petroleum & Biofuels Consumption								
Quantity (Millions of Litres)	**1990**	**1992**	**1994**	**1996**	**1998**	**2000**	**2010**	**2018**
Gasoline (10^6Litres)	63	67	70	74	77	81	105	129
Diesel (10^6Litres)	141	147	153	159	166	173	212	249
Bioethanol (10^6Litres)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Biodiesel (litres)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Gasoline consumption Table 39 above in millions of litters increased by a 2.8% annual growth rate while Diesel consumption grew by about 2.2% per year over the 28 year period (1990-2018).

Figure 26: National Fuel Consumption Per Year

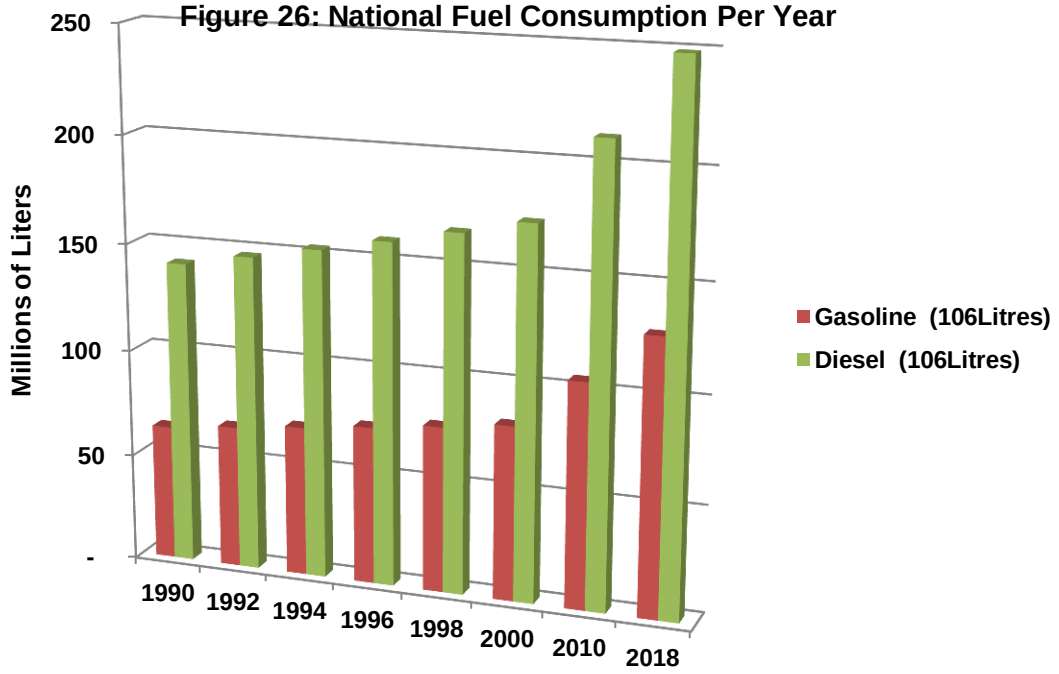
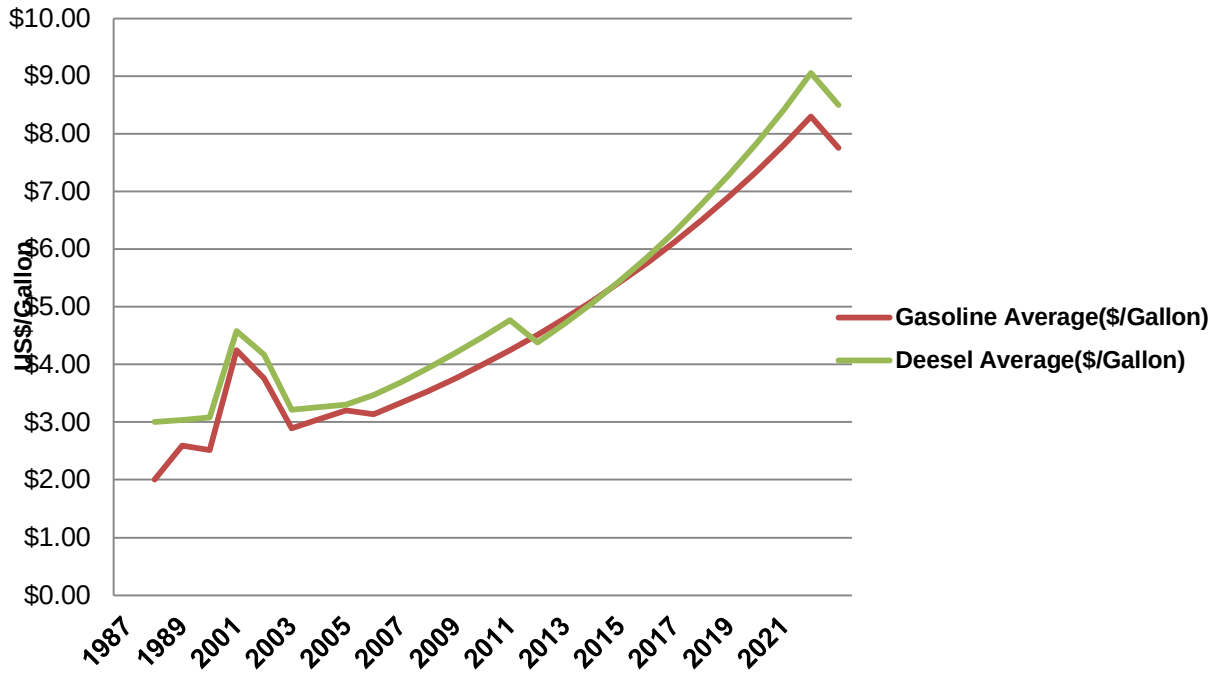


Table 40: Prices of Petroleum & Biofuels per Litre (USD/L)								
Price/litre	**1990**	**1992**	**1994**	**1996**	**1998**	**2000**	**2010**	**2018**
Gasoline ($/gallon)	$2.63	$2.90	$3.20	$3.33	$3.76	$2.63	$4.25	$6.91
Diesel ($/gallon)	$3.13	$3.21	$3.30	$3.55	$4.04	$3.13	$4.77	$7.28
Bioethanol ($/L)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Biodiesel ($/L)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

The gasoline prices increased at an annual average of 4.0% over the period (1990-2018) while diesel prices grew at the annual rate of 2% and experienced the greatest increase in dollars per gallon especially during 2000 – 2001, 2010 -2011 and 2018 to

now. The petroleum fuel prices have more than doubled in recent weeks and the government attribute it to the international economic problems resulting from the Ukraine war. See figure 27 below.

Figure 27: AVERAGE ANNUAL PETROLEUM PRODUCTS PRICES



Bioethanol and Biodiesel have not been in major use in Liberia however an initial study of the potential resources has been done through USAID. The study found that totaling from all the 15 counties of Liberia, Biodiesel resources have the potential to generate 3.995million m^3.and 26,926 GWh of power per year (see table 40 below).

8.7 Biomass Resources

The National Renewable Energy Laboratory (NREL) in 2009 conducted an initial Assessment of Biomass in Liberia for USAID under the Liberia Energy Assistance Program (LEAP). Sustainably available biomass residues from crops such as rice (rice husks), coffee (husks), coconut (shells), and from the timber industry can be used in efficient stoves, gasifies (thermal energy) and gasification cogeneration (combined biomass heat and diesel power) units. Also, crops can be grown for the purpose of energy supply, such as high-fiber sugar cane and Jatropha (one species of plant - Jatropha curcas which produces seeds that can be used in the production of biodiesel). These options need to be assessed to provide updated inventories of water, land, forest and agriculture resources for energy in Liberia, both to provide quantitative assessment of the energy potential and tradeoff for food, fodder (from agricultural residues and forest products as well as from crops grown for energy-related purposes).

The objective of the LEAP study was to estimate the biomass resources currently and potentially available in the country and evaluate their potential contribution for power generation and the production of liquid Bioethanol and Biodiesel fuels.

The findings of the NERL study indicate that a variety of biomass resources exist in Liberia in large quantities with opportunities for expansion for electric power generation opportunities. While the contribution of food crop residues, animal manure, and municipal solid waste is small in comparison to other resources at a national level, they could play a valuable role in stand-alone electric power generation technologies that utilize biomass as fuel and be particularly effective for households in remote rural areas. On the other hand, cash crop and forest residues, resulting mainly from medium and large enterprises, such as retired rubber trees from rubber concessions provide opportunities for large-scale centralized power generation to supply power for special industrial energy needs and avoid the current waste of potential energy resources.

Other resources, such as oil palm, coconut, and sugarcane are in Liberia that could be further produced. It is necessary to evaluate their potential for fuel and power production potential from their waste residues on available cropland for their processing power needs. In addition to utilizing the land for afforestation most of the land could be maintained as forest ecosystems and their unique biodiversity, or be used for food crops production and other agricultural activities, or be converted to urban land and the crop residues are used for energy to supply their operational power needs. The projected potential biodiesel, ethanol, and bio-power cash crop residues resources estimate for use in electric power generation is presented in table 41 below. Liberia has biomass resources such that it would not need to import of biomass supply, rather has the potentials for export of biomass (e.g. charcoal export from efficiently produced supply using well-designed efficient kilns method).

The table 41 below presents the calculated existing bio-power resources for Liberia.

TABLE 41: BIO-POWER AND BIO-FUELS FROM EXISTING AND POTENTIAL BIOMASS RESOURCES IN LIBERIA

	POTENTIAL RESOURCES		
COUNTY	**Biodiesel** (dam3/yr)**	**Ethanol*** (dam3/yr)**	**Bio-Power Cash Crop Residues**** (GWh/yr)**
Bomi	152	94	1,660
Bong	499	308	5,435
Grand Bassa	318	196	3,465
Grand Cape Mount	147	91	1,604
Grand Gedeh	21	13	231
Grand Kru	93	57	1,012
Lofa	287	177	3,121
Margibi	148	92	1,614
Maryland	73	45	793
Montserrado	0	0	0
Nimba	461	286	5,053
River Cess	57	35	620
Sinoe	27	17	292
River Gee	24	15	261
Gbarpolu	162	100	1,764
TOTAL	**2,469**	**1,526**	**26,926**

1 dry tonne of biomass = 1.5 MWh of electricity (20-40% efficiency);
* The total doesn't add up to total for the whole country. The analysis by county excludes residues

TABLE 41: BIO-POWER AND BIO-FUELS FROM EXISTING AND POTENTIAL BIOMASS RESOURCES IN LIBERIA			
POTENTIAL RESOURCES			
COUNTY	Biodiesel** (dam3/yr)	Ethanol*** (dam3/yr)	Bio-Power Cash Crop Residues**** (GWh/yr)

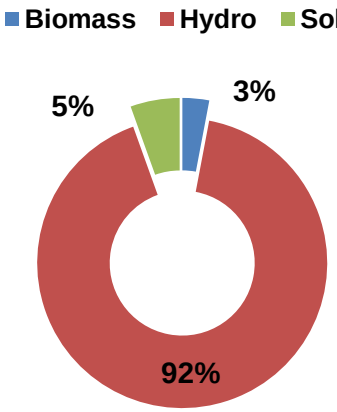
from replanting. There would be different removal rates depending on local tree stock conditions;
** Includes palm and coconut oil -using 10% of available cropland for oil palm and 10% for coconut tree;
*** Using 10% of available cropland for sugarcane;
**** Includes oil palm, coconut, and sugarcane residues -using 30% of available cropland -10% for each crop.

Table 42: Existing Biofuels Producing Off-Grid Companies				
Plant Name	*Plant Location*	*Capacity of Production (KW)*	Biomass Type	Status (Operating/Not Operating
Yandahun Mini-Hydro	Lofa County	60	Hydro	Operational
Kwendin - NRICA	Nimba County	60	Biomass (woodfuel)	Operational
Totota Mini-Hydro	Bong County	25	Solar/Diesel	Operational
Lofa Power	Lofa County	2,500	Hydro/Diesel	Under Construction
Solumba-Lofa	Lofa County	25	Biomass (Palm Oil)	Almost Operational
Langbemba	Lofa County	31.1	Solar	Under Repairs
Taninahn	Lofa County	28.5	Solar	Operational
Mamikonedu	Lofa County	25.5	Solar	Operational
Koiyama	Lofa County	22.5	Solar	Operational
Nyengbelahun	Lofa County	50	Hydro	Operational
Gbarnway	Lofa County	24	Solar	Operational
TOTAL(KW)		**94,852**		

The above table 42 lists the eleven Biofueled production off-grade entrepreneurs private companies (IPPs and aspirants) in operation in Liberia some of which were being assisted by donor organizations (e.g. USAID, EU, WB, AfDB, etc.). For example the hydro/diesel co-generation power plant under construction in Lofa County by the WB will develop generation facilities (medium hydro-diesel co-generation) project consisting of 2.5MW Hydro in Kolahun connected to a 1 MW Diesel power plant in Voinjama for dry season stand by power when the run-of-the-river hydro will be too low to supply the demand. The project is expected to be a new empowerment scheme in which the donors and GOL provide funding for the feasibility studies, costs of planning, procurement, and complete construction of the hydro plant, the diesel back-up plant, transmission and distribution lines. The RREA is developing an appropriate management structure which will include the competitive award of the operations and management contract to a private company

that wins the contract and licence to operate the facilities and sell the power to customers and pay for the facilities to the RREA overtime at no interest as the amounts for developing the facilities are considered to be grant to the RREA which they are to receive through collection of the payments for the equipment and development costs. This schemed is applicable for other mini-grid development projects under development or planned for other parts of the country.

Figure 28: Off-Grid Electricity Generation Installed Capacity by Type of Biofuel



From the above Table 42: Biofuels/RE Installed Electricity Generation Capacities: Hydro is 92%; Solar 5%; and Biomass is 3% of the total capacity. Solar and Hydro off-grid power generation appear to have higher potentials for development in Liberia at this point.

8.8 Biomass Waste Resources

8.8.1 Biomass from Forestry Residues

The rain forest occupies roughly 76,174 km^2 (31%) of Liberia's 111,369 sq. km. (43,000 sq. mi.) land area and is the source of its timber resources. The plateaus are cultivated for agriculture (27% of land) and the mountains (including Mount Nimba and Putu Mountain) are home to mineral resources – especially iron ore, gold and diamonds.

Liberia is endowed with a large variety of **biomass resources** believed to be more than enough to meet the country's energy needs if developed. About 85% of the current annual household energy consumption in the urban coastal regions is charcoal and 5% is firewood, while the households in the rural hinterland uses up to 90% firewood and 5% charcoal as the sources of fuel for cooking, heating and drying. The charcoal cook-stove in general use in Liberia is referred to as "Coalpot" with the efficiency believed to be less than 20%. However, other more efficient biomass technologies (including biofuels, gasification, steam boilers and charcoal production kilns technologies, etc.) are available that could open opportunities for energy efficiency improvements and agriculture and rural development, and provide other socio-economic and environmental benefits.

8.8.2 Industrial Wood Fuel

Moderately sized wood-fired steam electric plants might prove to be very attractive for certain applicable industrial operations and demand centres in Liberia. There is a need to demonstrate this technology for agro-forestry processes and rural electric stations. This would be particularly feasible when attached to a readily available energy resource base or introduced along with a fuel wood plantation for sustainability such as a power plant that is a part of a rubber or oil palm plantation (growing agriculture enterprises in Liberia) using old expired rubber trees or dry scrubs from palm trees for energy production for their process factories. Prior to the civil war in Liberia, a few agriculture and forestry concessions operated wood-fired steam generators for electric power production and for process heat. These include the Firestone Rubber Plantation Company which operates a British manufactured steam boiler of approximately 1 MW capacity fired by wood from expired rubber trees to generate electricity and process heat for rubber processing, the Liberia Agriculture, and the Gothrie Rubber concession, each utilized wood fuel in their rubber processing operations. Two logging companies (Bomi Wood and Maryland Logging Companies) were producing electricity of 0.5 MW to 1.0 MW capacity each, respectively for their sawmill operations, among few other cases. The technology for biodiesel, ethanol, and bio-power from cash-crop residues (including old rubber and palm trees plantations) needs to be encouraged especially where the scrap wood is available. Table 43 below lists the existing resources for bio-power from food-crops residues, cash crops, and cash forest in each of the 15 counties of Liberia in GWh per year amounting to over 1,233GWh/year.

TABLE 43: BIO-POWER AND BIO-FUELS FROM EXISTING AND POTENTIAL BIOMASS RESOURCES IN LIBERIA

COUNTY	EXISTING RESOURCES		
	Bio-Power From Food Crops Residues (GWh/yr)	**Bio-Power From Cash Crops Residues* (GWh/yr)**	**Bio-Power From Cash Forest Residues (GWh/yr)**
Bomi	1.4	25.1	0
Bong	32.6	105.5	0.04
Grand Bassa	8.2	66.2	0.15
Grand Cape Mount	1.6	32.5	0.15
Grand Gedeh	6.4	9.8	3.88
Grand Kru	1.8	5.5	1.15
Lofa	18.9	46.9	0.88
Margibi	8.8	114.7	0
Maryland	8.8	32.2	0.24
Montserrado	35.8	184.9	0
Nimba	45.6	313.3	1.76
River Cess	2.1	8.5	2.88
Sinoe	5.1	32.1	0.97
River Gee	3.9	12	2.19
Gbarpolu	7.4	40.5	0.98
TOTAL	**188.4**	**1,029.7**	**15.3**

TABLE 43: BIO-POWER AND BIO-FUELS FROM EXISTING AND POTENTIAL BIOMASS RESOURCES IN LIBERIA			
	EXISTING RESOURCES		
COUNTY	Bio-Power From Food Crops Residues (GWh/yr)	Bio-Power From Cash Crops Residues* (GWh/yr)	Bio-Power From Cash Forest Residues (GWh/yr)
1 dry tonne of biomass = 1.5 MWh of electricity (20-40% efficiency); * The total doesn't add up to total for the whole country. The analysis by county excludes residues from replanting. There would be different removal rates depending on local tree stock conditions; ** Includes palm and coconut oil -using 10% of available cropland for oil palm and 10% for coconut tree; *** Using 10% of available cropland for sugarcane; **** Includes oil palm, coconut, and sugarcane residues -using 30% of available cropland -10% for each crop.			

Socio-Economic and Environmental Implications

The local production and use of biomass resources as substitute for fossil-based fuels offers many socio-economic and environmental benefits for Liberia including energy security, investment opportunities, job creation, rural development, decreased greenhouse gas (GHG) emissions, waste utilization, and erosion control. However, if not managed properly, biomass resource development could have negative impacts, particularly to the environment. These include deforestation, increased GHG emissions, climate change impacts (including drought, high temperatures, sea level rise, deforestation, excessive rains, floods, erosion, etc.), loss of biodiversity, scarcity of traditional household firewood and charcoal supply resulting to price inflations and soil erosion. The socio-economic and environmental implications should be studied in details to assess the impact of biomass resources development in order to guide appropriate national policies and measures. **Steam boiler** operations using firewood as feedstock could have huge potentials for power generation. Another technology having potentials is **Gasification Energy System by** gasification of the wood and subsequently using it in piston engines or gas turbines for driving generators.

a) Degraded Land and Deforestation Rates, etc.

Because of Liberia's high dependence on its forest resources for both energy (fuel-wood and charcoal production), agricultural and forestry operations, etc. parts of Liberia are experiencing deforestation. Studies have shown that about 37,000 hectares (1 percent of total forest area) are lost annually to deforestation caused by activities such as subsistence farming through shifting cultivation, road construction, and human settlement (FDA, 1986)[17].

There is therefore a need to introduce fuel wood plantation practices among farmers, and around high population centers as well as other environmental measures in Liberia.

[17] Forestry Development Authority (FDA) of Liberia, Forest resources assessment 1986

The deforestation rate is estimated at **0.6%** of the forest land area deforested annually in Liberia and this rate is so high to the extent that it is about three times the global average. With the continuation of deforestation, Liberia is being considered to be vulnerable to climate change and extreme weather events. Liberia's forest is under serious threat. There are massive legal and illegal logging activities everywhere in the forest. Chain-sawing is at its highest level. Protected forest areas are being invaded on the quest for mineral resources, firewood, and human settlement. The availability of trucks transportation opens more markets for wood and charcoal and logging timber trade all over the country and even exports.

(c) Arable Land Not Used for Forestry Resources:

There is an estimated 147,000 or more acres of savanna encroaching on the upper parts of Liberia (Lofa County) in the past 15 to 25 years. Fuel-wood supplies are being depleted around population centers, and surveys conducted around population centers by the Department of Energy show that residents are having to travel further distances each year than they were a few years ago to collect fuel-wood or produce charcoal. Just about 3% of the total land area of Liberia is estimated by the Ministry of Agriculture to remain arable (land for good farming). Some of the major environmental issues facing Liberia today include rampant deforestation of the tropical rain forest, pollution of the coastal waters from industrial and agricultural runoffs and also raw sewage, soil erosion, loss of biodiversity, etc.

(d) Specific Policies to Promote Reforestation

Reforestation Program[18]:

Liberia has committed 0.75 million hectares of degraded forestland for forest restoration to the Bonne Challenge, New York Declaration, Paris Agreement and Africa Forest Restoration (AFR100)

In addition, the Government of Liberia through the Forestry Development Authority has taken several measures to maintain the forest carbon stocks including:

- Establishment of community involvement program in forestry management by the communities living at the fringes of the forests;
- Collaborate with the Ministry of Agriculture to enhance smart agricultural practices and encourage farmers to get involve in lowland farming to reduce shifting cultivation in the high forest areas;
- Introduce Reduced Impact Logging practices in production forests;
- The FDA has established and earmarked several protected areas around the country.

By 2020, the FDA promoted the implementation of sustainable management of all types of forests to halt deforestation, restore degraded forests and substantially increased afforestation and reforestation with the objectives to:

- Diversify forest management objectives into commercial, conservation and community forest management practices;

[18] FDA National Forestry Policy and Implementation Strategy 2006

- Introduced benefit sharing mechanism with the communities and other stakeholders;
- Develop Codes of Forest Harvesting to ensure that forest harvesting is done sustainably and environmental integrity is maintained;

Liberia has committed to TFA2020 especially Principle 1 (achieve zero net deforestation by 2025 through the adoption of HCS and HCV designations). It encourages concessionaires to work collaboratively with other stakeholders, including those with legal land ownership, to achieve responsible stewardship of land contained within both concessions and the adjacent landscapes that are designated as conservation areas – High Conservation Value / High Carbon Stock.

- The resilience and adaptive capacity of all types of forests to natural disasters and the impacts of climate change is significantly strengthened worldwide.
- The legal frameworks put in place to ensure that forest cover and forest resources are adequately managed to enhance the livelihood of communities that are dependent of forest for survival;
- Implementing the REDD+ Strategies to enhance the sustainable forest management in Liberia;
- Formulation of Land Right and Tenure Law to establish security of rights to land in Liberia;
- Increase the forest monitoring and reporting on the forest cover, deforestation and forest degradation;
- Enhancing inter-sectorial coordination and policy dialogue amongst the natural resource management sectors especially stakeholders dealing with landscape managements

Liberia commercial forestry tenure is twenty-five (25) years rotational cycle and therefore only 4% of the total area is allowed for annual coupe production and **diameter cut-limit** is strictly observed by all commercial forest enterprises.

Community Forest Management Agreements (CFMAs) are awarded for fifteen years management period but commercial forest enterprises have to observe all regulations that restrict Forest Management Contracts including observing the annual coupe of maximum 4% of the awarded concession forestland areas.

The public Forests Plantations continued to be established while the old growth planted forests have been contracted for harvest by the private forest based enterprises. This has the objective to contribute to the increase in forest area by 3%, Liberia is developing reforestation and afforestation policy to ensure that these practices are consistent with other protocol of maintaining forest cover and increase efforts to prevent forest degradation and contribute to the global effort of addressing climate change.

Reforestation project has commenced to combat the encroaching Sahel savannah from the neighbouring country – Guinea to Liberia. This project is supported under the Liberia Government and the Norwegian fund for sustainable development.

Previous and Existing Policies and Legislations

The Forestry Policy builds upon existing government policies and legislations and reflects Liberia's commitments under international conventions and treaties. However, in some areas, it is expected that new forestry legislations will be developed. Table 44 below presents a summary of some of the relevant policies developed for some of the more important legislations affecting the forestry sector in Liberia over the last 50 years.

Table 44: Summary of Policy Developments Affecting the Forestry Sector Since 1953

Year	Development
1953	Creation of Bureau of Forests and Wildlife Conservation
1956	Liberia Code of Law, Subset 2, permits the creation of government reserves, native authority reserves, communal forests and national parks
1976	Creation of Forestry Development Authority
1983	Creation of Sapo National Park
1988	Wildlife and National Parks Act
2000	The New National Forestry Law
2002	Production of the National Environmental Strategy and the Environmental Protection and Management Law
2003	Proclamation of the East Nimba Nature Reserve
2003	United Nations Security Councils places sanctions on the export of timber and timber products originating from Liberia
2003	Establishment of the Environmental Protection Agency
2003	Establishment of a protected areas network
2003	Extension of Sapo National Park
2006	National Forestry Reform Law is passed and timber sanctions are lifted

International Commitments

The national forestry policy will fully take into account the commitments and obligations that Liberia must meet as a member of the international community. The government will also take advantage of the range of technical, financial and other types of support that are available through these and other international mechanisms.

Liberia is a party to the following international conventions and agreements:

- The Convention on Biological Diversity;
- The International Tropical Timber Agreement;
- The United Nations Framework Convention on Climate Change;
- The United Nations Convention to Combat Desertification;
- The Convention on International Trade in Endangered Species; and
- The RAMSAR Convention on Wetland Management.

8.8.3 Biomass from Municipal Waste

(a) Number of Municipal Waste Dumpsites in Liberia;

There are two engineered landfill sites and infrastructure for waste management; they are the Mount Barclay, Paynesville, Liberia WDF and the Stockton Creek Somalia Drive, Monrovia WDF. Waste disposal activities are focused on a small number of dump-sites, the majority of which are inappropriately located within wetlands and swamps, such as the Fiamah Site (that used to service much of Monrovia until it was relocated to Mount Barclay); the Boulevard dump-site in Congo Town, and the dump-site located within Kakata City.

The generation rates of municipal wastes have increased greatly over the years in Monrovia due to rapid changing economy and population. Waste remains uncollected resulting in open dumping and burning of wastes. Waste management challenges are increasing due to insufficient technology to ensure proper management, low budgetary allocations for effective waste management, lack of skilled professionals, poor implementation of regulations to ensure adequate management, and poor public awareness[19].

Monrovia, with an estimated population of 1.3 million, the average generation rate is estimated at 780/tones/day. The Fiama Dump Site which was only 4 Km from the city centre became overly full and extended on the main road to Matadi Estate and the surrounding mangrove swamp and was inadequate to cope with the huge amount of waste during that period.

A new landfill site was selected at the Mount Barclay about 25Km from the city centre and constructed within three years. Findings[20] showed that some of the problems of the Mt. Barclay Dump Site are the highly swampy site location and surrounding mangrove swamp and the relative distance from the city centre exposing the garbage trucks to heavy highway traffic congestion. The site has however been able to handle much more waste from Monrovia for the past several years through the installation of 120 skip-bins collection points placed around many parts of the city and the provision of eight skip-trucks to the Monrovia City Corporation (MCC). These are not sufficient to deal with the rising amount of waste generated in Monrovia.

The Government of Liberia through its Infrastructure Implementation Unit at the Ministry of Public Works (MPW) through World Bank supported undertook the Urban Sanitation Project in Monrovia for the Solid Waste Transfer Stations (SWTS) from the continuing dumping at Fiamah to Stockton Creek located off Somali Drive and the Mount Barclay Dump Site. The mass of municipal solid waste projected for collection in the Greater City of Monrovia by the year 2025 is estimated to be 975 tons/day[21] The Stockton Creek transfer station will be able to handle 120t/d up to 415 tons per day; may be by 2025 another WDF will need to be developed.

(b) Waste Dump Sites for Power Generation, Biogas, or Landfills

One investor started a waste-to-energy project on the Somalia Drive & Shoe-Factory Junction in 2015 that was expected to generate methane gas from garbage. The

[19] Assessment of Solid Waste Management in Monrovia, UNEP July 2007

[20] Solid Waste Management In Monrovia, Liberia*:* Implications for Sustainable Development*;* Victor Emery David Jr.A, Jiang Wenchaoa, Yasinta Johna, Daniel Mmereki

[21] Concepts Development Report, Pöyry Environment GmbH, March 2008

project constructed a sorting facility to separate the fermentable matter from other garbage however, the project ran into problems when the garbage disposal trucks began to overflow the facility dumping as though it was a general dumping site and the separating equipment shut down. The facility was later removed when the Somalia Drive four-lean road project came along. There are currently no biogas or landfills biogas projects in operation in Liberia.

(C) Policy or Mandate for Municipalities to Improve Municipal Waste Transformation into Energy

Liberia has no official policy or mandate for municipalities to improve municipal waste transformation into energy. The three main legal dispositions that grant authority in the field of environment, including the waste management sector, are the three acts creating the Environmental Protection Agency (EPA), and adopting the framework Environmental Protection and Management Law and Policy of the Republic of Liberia:

- The National Environmental Policy of Liberia
- Environment Protection Agency Act of the Republic of Liberia
- Environment Protection and Management Law of the Republic of Liberia

The Municipalities have been granted the responsibility for cleaning and sanitary environmental conditions of their cities and towns by the Public Health Law of 1975 (still valid). In theory, City Corporations are to receive their annual operating budget from the Government, through the Ministry of Internal Affairs, but these financial transfers are currently non-existent.

The city corporation operate under internal regulations of the Monrovia City Corporation but no policies currently exist for municipalities to undertake or transform municipal waste treatment or transformation into energy. There is therefore need for an enabling environment and a policy on waste management, treatment and transformation into energy.

Waste Generation

A significant proportion of the waste generated in Monrovia is organic refuse followed by plastic. The increasing number of plastic waste is due to the increased use of plastic products on the market in Monrovia (plastic sachet water, polyethylene terephthalate (PET) bottles and plastic bags). The rate of waste generated consist mainly of a plastic 14.2%, glass/ceramics 10.5%, metals 3.0%, rubber 10.0% and batteries 9.9 %, and others. See table below.

Table 45: Composition of solid waste generated in Monrovia

Composition	Percentage
Paper	12.2
Plastic	14.2
Glass/ Ceramics	10.5
Metal	3.0
Organic refuse, vegetables	40.2
Rubber	10.0

batteries	9.9
Total	100
Source: Victor Emery David Jr & A, Jiang *fieldwork 2017*	

The Victor Emery David study[22] indicates that 50% of the sample studied had waste collected by private companies for disposal at the landfills while 20.2% buried waste in their backyards. 17.2% practiced open burning in the backyard, 8.8% give their waste to scavengers, 2% dump wastes into rivers and 1.8% dumps their waste into swamps.

8.8.4 Biomass from Agricultural-Industrial Waste

(a) Agro-Industrial Waste Sites

Most of the agro-industrial waste such as sawdust generated from sawmills and carpentry shops; rice husks from mills, coconut production husks and shells, peanut shells, cassava backs, and logging company trees waste branches, etc. are mostly burned or where applicable, farmers may dump some in their gardens or swamps dump sites. There are no consistent efforts to convert this waste into energy which in some areas is very substantial and even becomes pollution of their working environment.

The only examples of energy production from agro-industries are those presented earlier for rubber plantations (old rubber trees) and logging companies that convert some of their waste into steam or electric power generation mentioned above. A small portion of solid waste is collected from designated collection points by the Monrovia city corporation for disposal at the WDFs.. Subcontracted private companies responsible for picking up litters only pick up litter along the streets and finally dispose at the landfill. Waste collected is not sorted before disposal all disposed to the landfill. From the data gathered, 45.6% of waste was transported by private companies, 35% of the waste wasn't transported which explains the problem of open dumping in the city; 11.4% of waste was transported by the Monrovia city corporation (MCC) and 8% by the Paynesville city corporation.

(b) Policy or Mandate to Reuse the Wastes from Agro-Industrial Processes

There is presently no policies or mandates in Liberia for Agro-Industries to reuse the waste from their processes. This is one area that a plan should be developed for the MME to do an assessment and a policy and eventually propose for enactment, appropriate laws. Abattoir owners have a shared responsibility to ensure that their activities do not infringe upon the environmental right of others. It is therefore important that abattoir waste is not released into the natural community environment, i.e. illegal dumping, burying on farms and discharging untreated effluent into swamps, creeks or rivers should be legislated as the our communities.

The Municipal authorities seek to modernize legislations, improve the regulatory environment, build capacity and attract private capital for waste management. There is urgent need for policies and dissemination of energy generation technical knowledge to be undertaken for farmers, particularly industrial agricultural

[22] IDEM: Solid Waste Management in Liberia

development, for food and nutrition security matters. The Policies and regulations must be dynamic, demand driven, and clients oriented, and encourage participatory, decentralized, and pluralistic extension services.

The GOL must encourage public and private sector partnerships in:

- The provision and cost sharing of bioenergy services for increased competitiveness in the value chains of selected food and cash commodities;
- A conducive and enabling environment for the provision of Bioenergy services by the private sector, NGOs and other organizations;
- Effective communication and dissemination of the technologies and technical knowledge to all users; and
- An extension energy technicians workers system characterized by a continuous flow of appropriate technology innovations and data collection from a variety of sources including local and foreign technologies for empowerment of energy generation IPPs and for policy analysis and development planning.

(c) Type and Number of Facilities that Generate Waste from Agro-Industrial Activities

The following are potential and a few existing agro-industries that could develop energy generation facilities:

- Logging Waste – there are around 15 logging companies and many chain saw operators in Liberia all of them generate a lot of waste wood;
- Retired old rubber trees from rubber plantations – Firestone Natural Rubber Company location — covering almost 200 square miles is the largest single natural rubber operation in the world. At least 10% of the Firestone rubber plantation of which millions of rubber trees are retired every year could be available annually They already utilize some of their waste for energy and could be a source of additional supply.;
- In addition to the Firestone rubber plantation, there are many Liberian privately owned rubber farmers. Firestone Liberia provided 5.6 million free natural rubber stumps (planting material) to 2,100 Liberian rubber farmers in an effort to help revitalize the country's natural rubber industry devastated by the prolonged civil wars. This assistance has resulted in the replanting of an estimated 25,000 acres of rubber trees by private Liberian rubber farmers. This has also generated an equivalent or more number of retired rubber trees and other forest cleared wood materials to provide fuel wood and charcoal resources for the population and entrepreneurs.

- Oil Palm Plantation is another large potential for generating agro-industrial waste in Liberia. Land Clearing results to cutting down thousands of trees and hard wood to clear the land. In addition, the palm trees generate a lot of dry scrubs and a lot of husk and shells during the oil processing. This is or could be needed by some of the oil palm processing factories for energy.

- Shifting cultivation farming practices are another source of a lot of agro-industrial waste materials every year in Liberia that contribute to fuel-wood and charcoal energy resources yearly.

8.8.5 Biomass from Animal/Abattoir Waste

There are no standard methods of waste management at the Cow Factory to give us reliable estimates of the current quantities of waste. Interviewees were not willing to disclose or provided limited information. The estimate from a factory worker indicates that approximately 76 tonnes of abattoir waste was produced in the Jimica Road Junction Cow Factory 2018/2019.

Studies show that up to 30% tonnes of livestock (including condemns on farms) is lost during the food supply chain. This amounts to about 23 tonnes of waste from an initial. There are no known designated waste disposal facilities for abattoirs in Liberia. Waste from abattoirs are often disposed of at general waste disposal facilities (WDFs) or buried on farms or private land as common practice. Other practices include incineration, composting, rendering, and anaerobic digestion. There is a need to standardise the practice of waste management in the abattoir industry and one way would be the development of a guideline for the management of abattoir waste.

Livestock is a source of many valuable products and by-products (meat, milk, eggs, leather etc.) and contributes to food security and sustainable agriculture by converting forages and crop residues into organic fertilizers and by providing manure for bio-gas. Major livestock product chains also provide the cattle, sheep, goats, skin, poultry, swine and the animal health industries. It also constitutes inflation free investment channel, while fulfilling cultural roles particularly throughout rural Liberia. There was also a large scale domestic poultry sector prior to Liberia's civil crisis, suggesting a scope for expansion in the near future. Nevertheless, domestic livestock production falls far short of demand, and import of meat and live animals is substantial.

The solid waste of slaughter houses can be broadly classified into two categories i.e. vegetable matter such as rumen, stomach and intestine contents, dung, agriculture residues, etc. and animal matter like inedible offal's, tissues, meat trimmings, waste and condemned meat, bones etc. These waste streams can be segregated and treated separately.

The slaughterhouse – Cow Factory that was at the Jimica Road and Somalia Drive Junction on the Bushrod Island has been relocated to the Mount Barclay after the UL Fendall campus. It is now out of town about 30 miles away from the city, even though the old site is still active with reduced operations. New laws emerged and slaughterhouses started spreading to the periphery, out of sight and out of mind. The combination of slaughterhouses becoming more isolated and the urbanization of society began what has now become an enormous disconnect between people and their food. The isolation of the Cow Factory and urbanization of the Somalia Drive has created a great disconnect between the people and their meet supply source.

a) Number of Animal/Abattoir Waste Sites (Number of Agricultural Farms with Animals, Poultry, etc. that Generate Animal/Abattoir Waste)

An estimated 26,000 heads of live cattle (3000 metric tons) and 15,000-16,000 of live sheep (312 metric tons) and goats were imported from neighbouring countries in

2005/2006. This does not account for frozen meat imported by supermarkets in Monrovia which is another major source of animal/abattoir waste.

Liberia has an estimated 2 million hectares of pasture land, and the livestock sector accounts for an estimated 14% of food and agriculture GDP, far below potential. Cognizant of the vast potentials of these sub-sectors to contribute to the recovery and reconstruction of the country and particularly to pro-poor growth and sustainable development, the government is placing emphases on the development of:

- Pig Farms
- Pottery Farms
- Importation and growing of sheep, goats and cows;
- Fishery sector as Liberia has a growing fishing industry, being a costal country.

(d) Policy or Mandate to Reuse the Wastes from Animal/Abattoir Waste

Policies

There is no policy in Liberia requiring the reuse of he waste from animal/abattoir; Livestock regulation is characterized largely by out-dated legislations (regulation and operational rules) and there is absence of adequate policy measures to boost the sector activities, and promote effective environmental, animal and human health. However, some of the relevant applicable policies in Liberia are as follows:

- The Animal/Fishery Sector of the Ministry of Agriculture is making efforts into livestock and fisheries, in line with similar developments already taking place in forestry.
- An enabling environment and security for agricultural investments, growth and development is one of the key policies for animal/abattoir waste management system.
- Stockholm Convention on Persistent Organic Pollutants (POP) Signed 2002
  - To strengthen National Capacity and to enhance knowledge and understanding amongst decision makers, managers, industry and the public at large on POPs
  - To develop a National implementation Plan (NIP) to manage the elimination of POPs.

Ramsar Convention on Wetlands of International Importance Signed 2003 to encourage and support countries to develop and implement national policy and legislative frameworks, education and awareness raising programs, as well as inventory, research and training projects.
The NEP addresses the following strategic issues that are implied in the principal policy objective – access, quality, cost, and institutional framework. These issues refer to the need for the various technologies and delivery options for energy products and services to be available, acceptable, affordable, and adequate. Another key policy and strategy is develop livestock restocking policy, focusing on small ruminants short cycled animals; and reduced production costs. The main strategy would be revitalizing the value chains in livestock production.

Agriculture related imported products, of which food and life animals account for over a third amounted to well over half (50%) of total imports in the post before the Liberian civil war period, second only to petroleum products.

(c) Waste Resources Used for Power Generation, Cooking or Heating (Domestic/Institutional)

Specifying the waste-to-energy projects and the location and capacities from animal/abattoir activities, is currently not possible because data is not available. There are no known domestic institutions utilizing major quantities of waste resources for power generation, cooking or heating.

8.9 Overall Summary of the National Bioenergy Situation

8.9.1 Baseline and Analysis Findings

The BEAP includes a review of the baseline data and analysis on the status of bioenergy development, and propose attainable bioenergy targets, including gender, required national potentials and socio-economic assessments. The BEAP also makes an analysis of the current policies and overview on concrete laws, incentives and identifies the gaps and outlines measures to be implemented by the country to achieve the targets.

The current Socio-Economic Situation of Liberia is characterized by a small domestic market, lack of adequate infrastructure, high transportation costs, poor trade links with neighboring countries and the high dollarization of the economy

Liberia is currently heavily reliant on foreign assistance for its major development revenue after the 14 years conflict resulted to the destruction of all the major companies that provided large numbers of employment and revenue, leaving the government to be the only major source of employment.. On the other hand, Liberia is richly endowed with water, mineral resources, forests, and a climate favorable to agriculture, Liberia has been a producer and exporter of basic products, primarily raw timber and rubber and is in the process of reviving those sectors. The types of industrial sectors in Liberia consist of agriculture, iron ore mining, rubber tapping, forestry, diamonds, gold, beverages, construction and small scale industries. Local manufacturing, mainly foreign owned, has been small in scope.

Liberia has 40% of West Africa's rain forest. The newest updated survey for 2020 by World Bank reports that the rain forest occupies roughly 76,174 km^2 which is nearly 68% of Liberia's 111,369 Sq. Km (43,000 sq. mi. of land and is the source of its timber resources. The current (December 2021) population of Liberia is **5,231,764** based on projections of the latest United Nations data and the annual growth rate of 2.46%. In 2008 the population ratio was 51% male and 49% female and the mean **household size** declined from 6.2 in 1984 to 5.1 in 2008.

The Poverty Rate is defined as the percentage of the population living on less than $5.50 a day at 2011 international prices. The Greater Monrovia area is home to about 29% of Liberia's population. A world bank report indicated that in 2016, more than 2.2 million Liberians were unable to meet their basic food needs, of which almost 1.5 million (68%) resided in rural areas, 1.6 million were below the food-poverty line, and 670,000 lived in extreme poverty.

The annual growth rate of primary energy consumption in kilotons of oil equivalents (KToe) per year has averaged 2.8% over the eight years period (2010 – 2018). This

means that energy consumption rate per year is increasing faster than the population growth rate.
In 2018 firewood represented approximately 45% of the total primary energy; petroleum came second with a little over 22% and charcoal third about 15%; electricity generation 14% while the rest (hydro and others) total to slightly less than 4%. Firewood and Charcoal consumption together constituted up to 60% of the 24,619 X 10^6MWh net energy mix.
This reveals that Bioenergy constitutes the biggest source of primary energy in Liberia and substantiates the need for development of a National Bioenergy Action Plan.
The Primary Energy Consumption by fuel type consists of 64% Firewood, Charcoal and Hydro combined. The rest consists mainly of petroleum products (mainly for transportation), 22% and direct electricity 14%.
Households: The household size in 2018 was 5.1 persons per household accounting for 925,899 households with the average total energy consumption of 8kWh per household per year. Of this total 97% is in the form of household fuel-wood and charcoal (Biomass energy) and electricity is only 2% while petroleum products mainly for transportation and possibly some LPG account for only 1% residential energy. This can reveal why household LPG and other cooking and heating energy amount to small access ratio.

The Residential sector is the sector that depends on Bioenergy (fuel-wood and charcoal) for up to 97% of its energy. This calls for the development of extensive action plans for the development and promotion of the residential sector relevant to Bioenergy. The use of such huge quantities of fuel-wood and charcoal makes huge contributions to the Climate Change, emissions of GHG and especially CO_2equ resulting to health impacts, agriculture, water and other environmental impacts in the economy which is becoming serious in Liberia.

The institutional structure, interactions and framework in Liberia that have the opportunities for Bioenergy programs and projects are as follows
The Ministry of Mines and Energy (MME) has the mandate to develop policies and action plans and monitor all activities related to minerals, and energy resources exploration, coordination and development in Liberia. In adherence to its statutory mandate, the Ministry formulates and implements policies, monitoring, coordination and action plans in collaboration with other sector related agencies particularly those listed below for the delivery to the public, efficient services from the energy sector. and the DOE under the MME operates through the following state/government agencies:

Liberia Electricity Corporation (LEC), Rural and Renewable Energy Agency (RREA), National Oil Company of Liberia (NOCAL), and Liberia Petroleum Refining Corporation (LPRC) are the four institutions, GOL owned companies and agencies responsible to implement specialty areas of the energy sector with the mandate to provide public services and the opportunity for public-private partnership and competitive investments opportunities for the private sector in the relevant energy and fuels resources exploration, development, refining, transportation, transmission and distribution and access services in Liberia.

The Liberia Electricity Regulatory Commission (LERC), and the Liberia Petroleum Regulatory Authority (LPRA) are the two institutions mandated and empowered to

issue regulations for the registration and licensing of persons engaged respectively in the electricity and in the petroleum supply industry including generation, transmission, distribution, electricity or petroleum trade, import or export transactions, interconnected, or Grid system operation, and supply services in Liberia. for the relevant energy sector operations and provide the empowerment and enforcement for competitive private sector participation in the energy relevant sectors

A number of private sector institutions, IPPs and NGOs and aspiring IPPs have received support from the international donor community and NGOs and five solar PV Supply Systems projects initiatives have been undertaken

Before the 1990s, the Liberia Electricity Corporation (LEC) power generation installed capacity was approximately 191megawatts (MW) supplying all over the country, while that of private sector and concessionaires total was approximately 212 MW. Liberia has considerable potential for hydroelectric power. All these capacities were destroyed down to less about 22MW.
Currently, the Liberia Electricity Company operates the Mt. Coffee Hydroelectric Plant which has four (4) new hydro turbine units upgrading the old 64 MW hydro plant capacity to 88 MW. The rehabilitation was co-financed by USA Millennium Challenge Corporation (UMCC), the Government of Norway, AfDB, and the European Investment Bank. In addition to the hydro rehabilitation, the Government of Liberia, the Japan International Cooperation Agency, and the World Bank funded a 38 MW heavy fuel oil (HFO) plant to complement the 22MW high speed diesel generation plant in Bushrod Island (currently only 5MW operational of which 2.5MW is available). Currently, the LEC generation capacity totals to 131MW as National Grid power in the country.
At the short term (until 2022 – 2025) generation capacities are adequate to respond to the demand/load resulting from the new connections. During the dry season, the Mt. Coffee hydro output capacity drops down to less than 30% (from 88MW) which has to be mainly supplemented by the LEC thermal heavy fuel oil (HFO) plant. For this reason, LEC is considering a project to develop a 20MW Solar VP Plant near the Mt. Coffee Hydro Plant.

With the achievement of nearly 131 MW of LEC Grid installed capacity, the GOL realized that only about 30-35% of the capacity is being transmitted and distributed. The current grid connected electricity access rate in Liberia is rated at approximately 12-14% of the population. For this reason, the condition in the power sector remains highly critical, and the continued absence of electricity has the propensity to derail development progress. To address this severe shortage of electricity, a number of transmission and distribution projects are in progress through international donor support to the LEC.
Transmission and Distribution - Grid Expansion Projects gave rise to the LESEP and the LESEP Additional Financing (LESEP-AF) and further extended financing under the Liberia Accelerated Electricity Expansion Project (LACEEP) plus LACEEP Additional Financing (LACEEP-AF), the Electrification and Grid Upgrade Project and the Monrovia Consolation of Electricity Project.

Concerning Mini-Grids and Renewable Energy Program, the rural areas that are not currently reached by the LEC Grid are essentially running with diesel generators and self-generation or private mini-grids to provide electricity to customers not hooked to

the national grid. IPP's became justification during the period when emergency electricity generation actions were the accepted alternatives until the national utility (LEC which had the monopoly at the time) could resume its activities. With the coming into force of the 2015 Electricity Law (which has removed LEC's monopoly), and the creation of LERC, the IPP's are gradually beginning to develop with recognition. Currently, the LERC has given License to two Mini-Grids which have so far met the requirements and capacity to operate as licensed electric power operators. The RREA which is mandated to undertake rural and renewable energy projects has developed a Rural Energy Master Plan form which it has received the international donor support to develop Mini-Grids and other relevant projects that are in progress in Liberia.

The Baseline analysis show that eleven (11) Mini-grid IPPs arrangements are currently in place and nine additional operating or aspiring renewable energy IPPs in Liberia with support for specific projects are under development around the country. Some aspiring and others are operational with minimum success at their level.

The Key National Policies, Legal and Regulatory Framework for the BEAP including programs for developing low carbon sustainable energy systems are summarized for two reasons:

- Raising the voice of energy professionals as advocates for stronger ambition on renewable bioenergy entrepreneurship.
- National Energy Policies and Rural Energy Master Plans, etc.

The GOL has a National Energy Policy (NEP) the principal objective of which is to ensure universal access to modern energy services in an affordable, sustainable and environmentally-friendly manner in order to foster the economic, political and social development of Liberia and contains the national vision in the energy sector and economic development, with the following summary of priorities:

- Building Capacity and development phases which lays the foundation
- Creating enabling environment to attract private sector capital to the energy sector,
- Restructuring and reforming energy institutions,
- Decentralizing energy service administration,
- Fully utilizing domestic energy resources including renewable energy and, most importantly,

8.9.2 Overview of Policy Framework and Promoting Bioenergy in Liberia

The baseline analysis in Liberia has shown that Liberia is currently dependent on bioenergy for over 90% of its residential energy and several other key socio-economic activities. In our overview of policy framework and promoting bioenergy measures in Liberia it is observed that Biofuels can come as Solid biofuels, Liquid biofuels and Gaseous biofuels. A wide range of bioenergy technologies and services are available for realizing the biomass energy potentials (e.g. solid biofuels such as fuel-wood, charcoal, municipal waste, etc.), however only a few bioenergy technology applications are being utilized in Liberia and no advanced technologies such as gasification, pelletizing, pyrolysis and biodiesel fuel, etc. are currently planned or even in noticeable operations These in application in Liberia, are mainly

thermal technologies conversion of fuel-wood energy content to produce fire for cooking or heating as follows:

"**Open-fires**" **stoves** (figure 10): Very simple excess air combustion of dry fuel-wood or other waste biomass materials using three stones open for holding the cooking pot over the fire. The open fire fuel is burning for cooking utilizes only about 1-5% of the energy content of the fuel-wood; wasting 95-99% of the energy.

The **traditional** "**Cole-pot**" charcoal stove technology is the most common cooking stove technology utilized in nearly all households in Liberia.
The Charcoal yield ranges from 10-20% by mass of the wood feed depending on the experience of the producers and the equipment.

"**Mud-Pit Pile**" technology utilized in Liberia for charcoal production involves the "**mud-pit pile**" which consists of a shallow pit dug in the ground where the cut wood is piled, then covered with leaves and scrubs and mud is covered over the pile to reduce air inflow into the combustion process, however, it cannot be completely airtight. The wood is then lighted and burning takes 24 hours to 48 hours depending on the quantity and the burning control process. The Charcoal yield ranges from 10-20% by mass of the wood feed depending on the experience of the producers and the equipment.

"**Metal Kiln**"
The Metal Kiln method is the Charcoal production technology which allows for better control of the air flow into the burning process and thus increases the charcoal production yields to 20-40% of the wood feed. This metal kiln method is being used by the National Charcoal Union of Liberia (NCUL)and not easily accessable to the rest of the charcoal producers relying on the inefficient Pit method. The GOL needs to provide support and empowerment forthe Metal Kiln to become accessable and affordable to all the other charcoal producers.
Liberia. **Co-firing or co-combustion of biomass expired rubber wood wastes** with fossil fuels are used to provide a low-cost option for producing renewable energy while simultaneously reducing the use of fossil fuels for rubber processing factory.

8.1.1 Biochemical Technologies

Biochemical processes technologies, like **anaerobic digestion**, can produce clean energy in the form of biogas which can be converted to power and heat using a gas engine. In addition, wastes can also yield liquid fuels, such as cellulosic **ethanol and biodiesel**, which can be used to replace petroleum-based fuels.

The agriculture wastes amount to approximately 30 to 1,240 tons per year over the time periods. Briquettes/pellets, Bioethanol, Biodiesel and Biogas are not, and if any, are in negligible quantities used currently in Liberia.

Available data indicates that the fuel consumption is mainly fuel-wood, charcoal and agro-industrial waste and no data of substantial use of Briquettes/pellets, Bioethanol, Biodiesel and Biogas are available or their use is considered negligible. Over the past nearly three (3) decades period, fuel-wood consumption rate has grown at the average rate of approximately 9% per year while charcoal consumption rapidly

increased approximately 36% per year, and the agro-industrial waste consumption grew at the average of 22% per year.

Improved cooking stoves (ICS) use is far below the 20% of the national households scenario predicted by ECREEE for Liberia and consists of the metal charcoal coal-pots and improved wood stoves are only minimum;

The baseline analysis shows that only 12% of households are using ICS and LPG cookstoves. The trend of ICS increase per year is 2%. We predict that by 2030 Liberia could achieve 24% of households with access to ICS if we continue at this rate. This will be 2% below the ECREEE projected target of 26% ICS share of households in Liberia.

The graph shows a sharp slope rise from 2000 to 2010 and 2010 to 2018 but that is because data for the 18 years between was not available. It calculates to an average 12% growth rate per year.

The prices of ICS devices have grown by 8% per year over the study period. It is noticed however that improvement in the design and technology has been and very negligible changes if any.

The prices of ICS devices have grown by 8% per year over the study period. It is noticed however that improvement in the design and technology has been negligible and very slow if any changes. In some cases one can find a few ICS with improved quality of construction materials but no design modifications. This could be due to the customers not willing or inability to pay higher prices when improved designs introduced. There is need for public awareness for energy efficiency improvements resulting to reduction in the expenses for the fuel used.

Current estimated access rate of LPG use in the households in Liberia is approximately 11% of the national households which is far below the 20% scenario projected by ECREEE for Liberia by 2020. The annual growth rate is 3.4% of households using LPG cylinders per year. At this growth rate, Liberia may reach only 25% households LPG access by 2030. Major empowerment and public awareness programs are needed for Liberia to arrive at the 26% minimum households LPG access.

A relatively small quantity of LPG is being used for cooking by a negligible number of households and commercial establishments. Currently, LPG is estimated at about 3,500 – 8,700 households using LPG cylinders purchasing the average of 220 – 540 cylinders per month. This represents only a small percentage (11%) households currently utilizing LPG energy.
The average price of a kg of LPG ranged from $0.55/kg to $1.58/kg and has increased on the average of 4.9% per year.

Installed grid and mini-grid connected power generation (or multi-functional platform - MFP) facilities capacities over the study period where applicable are specified. The power generation fuel source including co-generation. Grid connected bioenergy total installed capacities constitute of 13% from agriculture-forestry industrial waste (sawdust, logging company waste wood shrubs, and rubber plantations expired

trees, etc.). The installed capacity for medium and large hydro consists of 4.3% from the Firestone Rubber Plantation Company hydro and 1.1% fuelwood steam plant and 94.6% the LEC Mt. Coffee hydro power plants.

Electricity grid generation instilled capacity is mainly from the Mt. Coffee hydro (61%) and Bushrod Island HFO (25%) high speed gas oil plants (14%) and the Firestone Rubber Plantation Company has a 4MW hydro capacity adding to the total hydro accounting for about 4.35% of total hydro capacity.

Off-grade energy production experienced a growth rate of only 0.61% per year over the 28 years study period mainly from the hydro development in recent years after the war. The rate of Small scale hydro (mini-hydro) capacity has not grown over the period.

The gasoline prices increased at an annual average of 4.0% over the period (1990-2018) while diesel prices grew at the annual rate of 2% and experienced the greatest increase in dollars per gallon especially during 2000 – 2001, 2010 -2011 and 2018 to now. The petroleum fuel prices have more than doubled in recent weeks and the government attributes it to the international economic problems resulting from the Ukraine war.

The National Renewable Energy Laboratory (NREL) in 2009 conducted an initial Assessment of Biomass Resources in Liberia for USAID under the Liberia Energy Assistance Program (LEAP). The energy production from Bioenergy experienced zero growth rates over the 1990 – 2018 period. It was observed that only rubber concessions and few logging companies continued and maintained their capacities but made no increases. The logging industry experienced major changes when deforestation concerns and the international community intervened and a number of policies and legislations were put in place. The energy supply for the logging industry needs to be seriously assessed and the utilization of the waste to generate energy should be regulated and programs for empowerment including the introduction of appropriate technologies, public awareness, and technical capacity development need to be introduced.

Biodiesel energy is a new technology for many businesses in Liberia for energy production and diesel fossil fuel generation making diesel more competitive option to a few developing Independent Power Producers (IPP). The Biodiesel projects were supported through USAID. But some of the companies are yet to be completed or operational.

There are currently eleven Biofuel production off-grade entrepreneurs private companies (IPPs and aspirants) in operation in Liberia some of which were being assisted by donor organizations (e.g. USAID, EU, WB, AfDB, etc.). For example the hydro/diesel co-generation power plant under construction in Lofa County by the WB will develop generation facilities (medium hydro-diesel co-generation) project consisting of 2.5MW Hydro in Kolahun connected to a 1 MW Diesel power plant in Voinjama for dry season stand by power when the run-of-the-river hydro will be too low to supply the demand. The project is expected to be a new empowerment scheme in which the donors and GOL provide funding for the feasibility studies, costs of planning, procurement, and complete construction of the hydro plant, the

diesel back-up plant, transmission and distribution lines. The RREA is developing an appropriate management structure which will include the competitive award of the operations and management contract to a private company that wins the contract and license to operate the facilities and sell the power to customers and pay for the facilities to the RREA overtime at no interest as the amounts for developing the facilities are considered to be grant to the RREA which they are to receive through collection of the payments for the equipment and development costs. This schemed is applicable for other mini-grid development projects under development or planned for other parts of the country.

The export of Gasoline and Diesel from Liberia is negligible and is estimated and for the purpose of this paper it consist only of informal cross-border transactions of fuels through transport vehicles (mostly trucks and large buses) and others for neighboring power generation by business facilities along a few border towns. The total Imports would therefore include the sum of table 23 and table 24 above for total Gasoline and Diesels imports.

Moderately sized wood-fired steam electric plants might prove to be very attractive for certain Biomass Waste Resources from Forestry Residues applicable industrial operations and demand centres in Liberia. There is a need to demonstrate this technology for agro-forestry processes and rural electric stations. Efficient biomass technologies (including biofuels, gasification, steam boilers and charcoal production kilns technologies, etc.) are available that could open opportunities for energy efficiency improvements and agriculture and rural development, and provide other socio-economic and environmental benefits more than the current technologies
This would be particularly feasible when attached to a readily available energy resource base or introduced along with a fuel wood plantation for operated wood-fired steam generators for electric power production and for process heat. These include the Firestone Rubber Plantation Company which operates a British manufactured steam boiler of approximately 1 MW capacity fired by wood from expired rubber trees to generate electricity and process heat for rubber processing. In addition, few other Agriculture, Oil Palm and Rubber concession, utilized wood fuel in their processing operations. A few logging companies were producing electricity of 0.5MW to 1.0MW capacity each, respectively for their sawmill operations, among few other cases. The technology for biodiesel, ethanol, and bio-power from cash-crop residues (including old rubber and palm trees plantations) needs to be encouraged especially where the scrap wood is available. The existing resources for bio-power from food-crops residues, cash crops, and cash forest in each of the 15 counties of Liberia is estimated to have the potential for over 1,233GWh/year.

Summarizing the previous and existing policies and legislations, a number of relevant policies have been developed and some are important legislations affecting the forestry sector in Liberia over the last 50 years.

Waste Generation - significant proportion of the waste generated in Monrovia is organic refuse followed by plastic. The increasing number of plastic waste is due to the increased use of plastic products on the market in Monrovia (plastic sachet water, polyethylene terephthalate (PET) bottles and plastic bags). The rate of waste

generated consist mainly of a plastic 14.2%, glass/ceramics 10.5%, metals 3.0%, rubber 10.0% and batteries 9.9 %, and others.

Up to 50% of the biomass waste is collected by private agricultural-industrial companies for disposal at the landfills while 20.2% is buried waste in their backyards. 17.2% practiced open burning in the backyard, 8.8% give their waste to scavengers, 2% dump wastes into rivers and 1.8% dumps their waste into swamps.

There is presently no policies or mandates in Liberia for Agro-Industries to reuse the waste from their processes. This is one area that a plan should be developed for the MME to do an assessment and a policy and eventually propose for enactment, appropriate laws. Abattoir owners have a shared responsibility to ensure that their activities do not infringe upon the environmental right of others. It is therefore important that abattoir waste is not released into the natural community environment, i.e. illegal dumping, burying on farms and discharging untreated effluent into swamps, creeks or rivers should be legislated as the our communities.

Oil Palm Plantations are another large potential for generating agro-industrial waste in Liberia. Land Clearing results to cutting down thousands of trees and hard wood to clear the land. In addition, the palm trees generate a lot of dry scrubs and a lot of husk and shells during the oil processing. This is or could be needed by some of the oil palm processing factories for energy.

Shifting cultivation farming practices are another source of a lot of agro-industrial waste materials every year in Liberia that contribute to fuel-wood and charcoal energy resources yearly.

Concerning Biomass from Animal/Abattoir Waste, there are no standard methods of waste management at the Cow Factory to give us reliable estimates of the current quantities of waste. Interviewees were not willing to disclose or provided limited information. The estimate from a factory worker indicates that approximately 76 tonnes of abattoir waste was produced in the Jimica Road Junction Cow Factory 2018/2019.

Studies show that up to 30% tonnes of livestock (including condemns on farms) is lost during the food supply chain. This amounts to about 23 tonnes of waste from an initial. There are no known designated waste disposal facilities for abattoirs in Liberia. Waste from abattoirs are often disposed of at general waste disposal facilities (WDFs) or buried on farms or private land as common practice. Other practices include incineration, composting, rendering, and anaerobic digestion. There is a need to standardise the practice of waste management in the abattoir industry and one way would be the development of a guideline for the management of abattoir waste.

During the baseline analysis, we did not come across any specific policy or mandate in Liberia requiring the reuse of the waste from animal/abattoir; Livestock regulation in Liberia is characterized largely by out-dated legislations (regulation and operational rules) and there is absence of adequate policy measures to boost the sector activities, and promote effective environmental, animal and human health.

However, some of the relevant applicable policies in Liberia are as follows:

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- An enabling environment and security for agricultural investments, growth and development is one of the key policies to be developed for animal/abattoir waste management system.
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- Ramsar Convention on Wetlands of International Importance Signed 2003 is one of the policies for the GOL to adopt to encourage, support, develop, and implement national policy and legislative frameworks, education and awareness raising programs, as well as inventory, research and training projects.

The NEP addresses the following strategic issues that are implied in the principal policy objective – access, quality, cost, and institutional framework. These issues refer to the need for the various technologies and delivery options for energy products and services to be available, acceptable, affordable, and adequate. Another key policy and strategy is to develop livestock restocking policy, focusing on small ruminants short cycled animals; and reduced production costs. The main strategy would be revitalizing the value chains in livestock production.

Data and information on waste-to-energy projects, location and capacities from animal/abattoir activities, is currently not available and such information can not be supplied at this point. There are no known domestic institutions utilizing major quantities of waste resources for power generation, cooking or heating.

8.2 Main Challenges for Liberia

Gaps – From the assessment made during this baseline development, it was observed that the following gaps occurring in Liberia which need serious attention as part of this Bioenergy National Action Plan that need to be addressed:

Assessment; Policies; Plans for Biomass development and systematic data collection program for energy and particularly Bioenergy

Funding – Financing investments in the bioenergy resources is a challenge and needs support from all possible sources and directions;

Technology – it is clear that the coal-pot and mud-pit charcoal production methods are extremely essential technologies for the majority of the population, and there is therefore need for serious attention in introduction and promoting improved stoves and efficient charcoal production kilns. Advanced technologies for utilization of waste wood form agriculture and logging operations for power production is needed; Biogas, Bioalcohol, Biodiesel, and other solid, liquid, gaseous and radiation (solar energy) technologies exist and could be applicable in Liberia.

Policy, legislative framework, regulatory, action plans, programs and Institutional development – The government needs to strengthen its policies, investment

incentive regulatory framework, action plans and programs with appropriate institutional development for implementation of the appropriate plans to develop the bioenergy sector especially the need for sustainability, introduction of advanced technologies, promotion of investment incentives and encouragement of local farmers and local private sector IPPs producers in view of the major role bioenergy plays in Liberia;

Capacity Building - There is need for the government to undertake capacity development especially in the improvement of the cook stoves and charcoal production kilns technologies, efficiency improvements and need for business knowledge and accountability as well as the legal enforcement mechanism made available., economics and strengthening the capacities of entrepreneurial leadership and cooperative communication and therefore financial accountability among the farmers and bioenergy producers and consumers. Economic cost comparison and long-run savings need to be discriminated;

Trade-offs between bioenergy and fossil fuels – the lack of electricity access and transportation roads and vehicles are a challenge, and the trade-off between bioenergy and those of fossil diesel power generation is a challenge for the farming, agriculture and commercial private investors and need training, investment incentives, and improvements in the technologies;

Increase the bioenergy markets nationally, West Africa Region, and internationally for exports and imports of bioenergy resources, introducing standard improved technologies, and affordable pricing structure and accessibility;

Environmental and Climate Change Impacts – while bioenergy is in high demand in Liberia, the impacts of environmental and climate change hazards are real and need serious attention to address the challenges; Co-benefits for Climate Change adaptation and mitigation programs alongside the bioenergy initiatives. Climate Change for Bioenergy Co-benefits actions, assessments, training capacities, monitoring and climate change data surveillance communications equipment's, etc. must be put in place and appropriate activities undertaken under legal and internationally accepted logical framework:

Taking rapid and ambitious action to halt and reverse the climate crisis has the potential to bring many benefits, including for bioenergy programs.

Co-benefits are defined as: the positive effects that a policy or measure aimed at one objective might have on other objectives, thereby increasing the total benefits for society and the environment.

8.3 Opportunities

Support from International Donors: Liberia has had serious favourable, unprecedented attentions form the international donor institutions that have to-date made major support and continuous commitments for support of the energy sector development programs, plans, policies and legislative framework for Liberia. This is considered to be one of the main opportunities that Liberia has and needs to study and take appropriate steps to sustain.

Forest Reserves Endowment: The baseline analysis has shown that Liberia has abundant forest resources endowment which can be a sustainable source of bioenergy fuels supply if planned and implemented properly and systematically with appropriate technologies and manpower capacity under relevant standards and legislative and regulative policies.

Cultural Dependence Endowment: The dependence of the Liberian people on the use of fuelwood and charcoal for the greatest percentage of its residential and other energy needs can be considered as a cultural dependence, and an opportunity that will make the Liberian people readily accept and take ownership of the importance of Bioenergy Action Plan for Liberia and will be receptive to new energy technologies, improved stoves, kilns, and technical knowhow and the resulting benefits for developing the bioenergy as a major sector for Liberia.

Available Alternatives: While the cultural use of cheap technologies like “three-stones”, “coal-pot”, “Mud-Pit Pile”, etc. are currently in extensive use, there are a number of better, more efficient, and environmentally appropriate alternative technologies available and even of advanced technologies for electricity generation that can be introduced in Liberia.

Technological Efficiencies Improvement Programs: There are programs that could be undertaken for the technology efficiencies improvements, which opportunity can help Liberia to meet its targets and development goals in the bioenergy sector if the opportunity is taken advantage of.

GOL Acceptance and Taking Ownership and Political Will: The GOL has already demonstrated its acceptance and taken ownership and shown the political will to promote, encourage, and develop bioenergy technologies and the technical and manpower capacity as well as entrepreneur private sector empowerment, through its legislations and policy.

Manpower Potentials of Young People and Empowerment Policies: Liberia is endowed with growing numbers of young people, many of whom are interested in energy and related sector activities and disciplines. What the GOL needs to do is to take appropriate steps for their training and empowerment.

International Private Sector Empowerment Policies and Business Investment Incentives: Liberia has another major opportunity when it enacted and brought into full effect the 2015 Electricity Law and enabled the Liberian Electricity Regulatory Commission, all of which have opened the electricity sector for the local and international private sector participation, encouraging and attracting investment to the energy sector.

Will Power, Entrepreneurial Potentials, and Incentives: Liberia also has major opportunities of a number of local private sector IPPs and aspiring energy sector entrepreneurial potentials that need to be empowerment and given the support, opportunities, and incentives. to become operational and viable in Liberia; The Liberian people must demonstrate the willingness and ability to pay for energy developed by IPPs initiatives and investments and sustainability of operations and equipment.

Part B: NATIONAL BIOENERGY ACTION PLAN FOR LIBERIA

Within the Implementation of the ECOWAS Bioenergy Policy (EBEP)

CHAPTER 9 INTRODUCTION

This policy seeks to promote a modern, sustainable and vibrant bioenergy sector in the region by creating an enabling environment that can unlock the potentials by removing the institutional, legal, financial, social, environmental and capacity gaps and barriers. It is aimed at addressing the needs and constraints of the governments, the private sector and the local communities in using existing biomass resources including household, agricultural and industrial processing wastes and residues. The policy document was prepared with technical support of the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) and a broad range of international partners (UNDP, Austria, and Spain). The policy includes minimum targets and scenarios for bioenergy and measures, standards and incentives to be implemented at both regional and national levels.

The ECOWAS Bioenergy Policy includes the following minimum targets proposed for the modern bioenergy sector:

Table 46: ECOWAS Bioenergy Policy Targets

Main Bioenergy target by 2020 / 2030	Baseline: 2012	2020	2030
Share of efficient charcoal production	17%	60 %	100 %
Share of population using alternative modern fuels for cooking	27%	36 %	41 %
Biodiesel and bioethanol as share of fossil fuels consumption	<1%	5%	10%
Bioelectricity	+/-100 MW	634 MW	2008 MW
Fuelwood saved from 2012[23]	NA	700million tons	3billion tons

[23] Saving 700 million tons of fuels wood correspond to roughly 18 billion USD based on current price of wood in Burkina Faso

Table 47: Bioen Policy Targets with LPG and ICS Alternative Wood Energy

Main Bioenergy target by 2020 / 2030 (for LPG & ICS)	Baseline 2012	2020	2030
Share of population using improved cook stoves[24]	29%	60%	100%
Share of efficient charcoal production	17%	60 %	100 %
LPG penetration household level[25]	8%		26

9.1. Bioenergy Policy Targets by 2020

1) Universal access to clean, safe and affordable cooking energy, including 20% of LPG users. Such a scenario represents:

d. Over 10 million of additional household users of LPG as primary fuel in comparison with the 2012 situation,

e. About 15 million additional households using ICS as main cooking device and/or sustainable biomass fuel as primary fuel,

f. 700 million tons of wood saved between 2012 and 2020 e.g. 18 billion USD

2) 26 % of electricity from Renewable Energy source (2,425 MW) in the region; of which 634 MW is generated from biomass residues or dedicated plantations with the deployment of sustainable and efficient technologies and application including:

e. Biomass heat and power: systematic approach to sugar processing companies and other large-scale producer of biomass to valorise their waste stream to electricity.

f. Waste-to-energy: connecting with cities/municipalities, agro-industries, slaughterhouses, and waste water treatment plant to convert waste into electricity, biogas, pellets/briquettes, etc.

g. Electricity from wood plantation in countries such as Liberia, Guinea and Sierra Leon

h. Biogas production, gasification of agricultural residues for energy (electricity, heating and cooking) in association with NGOs and local communities, including women in the rural areas.

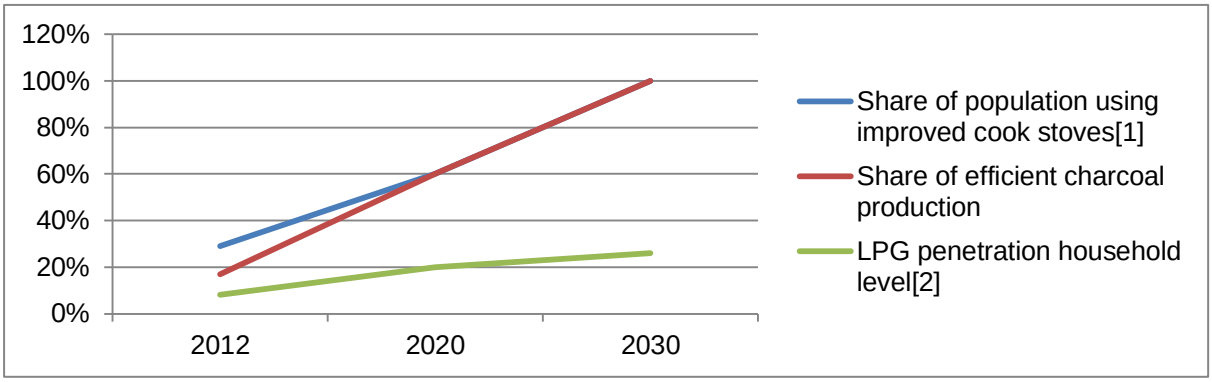
9.2. Bioenergy Policy target by 2030

[24] Improved cook stoves refer here to wood and charcoal burning stoves

[25] LPG is taken here in the table because of its capacity to replace traditional biomass use

3) Universal access to clean, safe and affordable cooking energy, including 26% of LPG users and 100% of improved cook stoves (ICS) and/or sustainable biomass fuels users. Such a scenario represents almost 3 billion tons of wood saved between 2012 and 2030. The graph below represents the expected situation by 2020 and 2030 with regards to improved solid biomass fuels, the dissemination of improved stoves and the sustainable production of biomass.

FIGURE 29: Projected Target Share of Population Using the Three Types of Stoves in the Household (2012-2030)



4) Electricity from biomass will account for 5 % of the total installed capacity in the region, which corresponds respectively to 686 MW by 2020 (28% of RE capacity) and 2008 MW (13% of RE Capacity) by 2030.

9.3. For domestic applications, transportation and financing

- Ensure universal access to improved cook-stoves to 100% by 2020;
- Increase the share of the population served with modern fuel alternatives for cooking to 36% by 2020 and 41% by 2030;
- Increase the penetration of LPG for cooking to 20% by 2020 and 26% by 2030;
- Increase the share of efficient charcoal production to 60% by 2020 and 100% by 2030;
- Introduce blending ratios for Ethanol/bio-diesel in transport fuels of 5% by 2020 and 10% by 2030;
- Conduct research on the use of ethanol and other fuels as domestic cooking fuels;
- Reduce fuelwood consumption, as a result of the Policy implementation, by 700 million tons by 2020 and 3 billion tons by 2030;

- Create instruments for financing sustainable energy, including carbon finance in the longer term; establish a regional fund for the development and implementation of sustainable energy projects.

9.4. For minimizing health risks, gender imbalance and improve socio-economic wellbeing

- Reduce health risks associated with smoke inhalation and long distances travelled by women and children by introducing very efficient burners for cooking and heating that consumes less wood fuels and reduce travel time;
- Improve livelihoods through involving small-scale farmers as direct producers or out-growers enabling them to generate new income, opening up employment opportunities, and thereby alleviating poverty and boosting rural incomes;
- Use of agricultural residues can lead to more investments and modernization of the agricultural sector by increasing mechanization, but taking measures to minimize the impact on biodiversity, land use, soils, and water resources.

9.5. For enhancing Agricultural productivity

- Reduce the poor practices of “slash and burn” as a way to clear land, as such practices negatively impact on biodiversity (insects, plants, etc.) and contribute to soil erosion;
- The use of slurry (residue of biogas production) and nutritive ash (residue of controlled combustion processes or bio-char) can greatly improve the soil and increase agriculture yields.

9.6. For enhancing the Environment

- Stimulating farmers to collect and/or use agricultural waste, rather than burning it as an additional source of income and/or increase energy access and reduce dependence on the natural forest;
- Use of agro-industrial waste coupled with use of efficient devices and systems will help save 700 million tons of wood by 2020 and 3 billion tons by 2030

CHAPTER 10 SUMMARY OF TARGETS

Table 48 below presents the status of bioenergy penetration in 2018 and specify the targets Liberia intends to achieve by 2020, 2025 and 2030 as contribution to the attainment of the targets of the ECOWAS bioenergy Policy (see targets in the EBEP above). The indicated targets in this section are approved through the respective energy sector institutions in Liberia.

The following targets are proposed for the Liberian modern bioenergy sector:

Table 48: ECOWAS Bioenergy Policy Targets and derived Achievable Targets for Liberia

Main Bioenergy target by 2020 / 2030	Baseline Penetration 2012	2020	2030	Current Situation (2018)	Present Growth Rate	2030 Expected Targets	Achievable Target for Liberia	
							2025	2030
Share of efficient charcoal production	17%	60%	100%	10%	<1%	100%	35%	50%
Share of population using alternative modern fuels for cooking	27%	36%	41%	12%	12%	41%	41%	50%
Biodiesel and bioethanol as share of fossil fuels consumption	<1%	5%	<%	<1%	0.4%	5%	2%	3%
Bioelectricity (Fuelwood, Solar & Hydro)	+/-100 MW	634 MW	2008 MW	93MW	25%	2008 MW	150MW	160MW
Fuel-wood saved from 2018[1]	NA	700million tons	3billion tons	n/a	-	7,212,000 tons/year	5,213,000 tons/year	6,000,000 tons/year

[1] Saving 5.2 million tons of fuels wood correspond to roughly 1.5 billion USD based on current price of wood in Liberia

Table 49: ECOWAS Bioenergy Policy Targets with LPG and ICS Alternative and the Derived Achievable Targets for Liberia								
(With LPG and ICS as Alternative to Reduce Traditional Wood Energy Consumption)								
Main Bioenergy target by 2020 / 2030 (for LPG & ICS)	**Baseline : 2012**	**2020**	**2030**	**Current Situation (2018)**	**Growth Rate**	**Expected Targets**	**Achievable Target**	
							2025	**2030**
Share of population using improved cook stoves[26]	29%	60%	100%	10%	2%	100%	35%	50%
Share of efficient charcoal production	17%	60%	100%	12%	<1%	100%	35%	50%
LPG penetration household level[27]	8%	20%	26%	11%	2%	26%	24%	26%

Efficient charcoal production: Efficient charcoal is the terminology used on this table for the charcoal produced by modern methods that are more efficient than traditional ones. The modern methods use sealed kilns and have higher efficiencies and thus higher yields. The targets and trajectory for efficient charcoal production is set out for the action plan. This is calculated by dividing the quantity of charcoal produced by improved carbonisation techniques with yield superior to 12% in tonnes by the total charcoal production in tonnes.

[26] Improved cook stoves (ICS) refer here to wood and charcoal burning stoves with improved designs and maximum achievable energy efficiency for household's uses.
[27] LPG is included in the table here because of its capacity to replace traditional biomass uses.

National Bioenergy Targets (with LPG and ICS as Alternative to reduce Traditional Wood energy consumption)

Table 50: National Bioenergy Targets (With LPG and ICS as Alternative)

The following targets are proposed for the Liberian modern bioenergy sector:

Table 50: Main Bioenergy Target by 2020 / 2030	Baseline: 2018	2020	2025	2030
Share of efficient charcoal production in %	10%	26%	37%	48%
Share of population using bioethanol (liquid/gel) for cooking in %	-	-	2%	5%
Share of population using biogas for cooking in %	-	-	4%	5%
Share of population using briquettes/pellets for cooking in %	-	-	5%	7%
Biodiesel as share of diesel fuels consumption in %	-	-	2%	5%
Bioethanol as share of gasoline fuels consumption in %	-	-	2%	5%
Bioelectricity (hydro + others) MW	93	95	150	160
Share of population using improved cook stoves[28]	12%	15%	37%	50%
LPG penetration at household level[29] in %	11%	21%	32%	43%
Fuelwood saved from 2018 in tons	-	-	5,213,000 tons/year	6,000,000 tons/year

[28] Improved cook stoves refer here to improved design wood and charcoal burning stoves with maximum efficiency
[29] LPG is taken here in the table because of its capacity to replace traditional biomass use

CHAPTER 11 BIOENERGY TARGETS AND TRAJECTORIES

The evaluation of the Bioenergy Achievable Targets for Liberia by 2025 and 2030 as Liberia's contribution to the attainment of the ECOWAS Bioenergy Policy Targets takes into consideration the ECOWAS estimated baseline in 2012 and the expected targets by 2030; Moreover, the baseline situation (2018) in Liberia and the respective access growth rates in the study period (1990 to 2018) is considered thus deriving the following Achievable Targets for 2025 and 2030.

- The share of efficient charcoal production refers to the number of charcoal producers using efficient charcoal kilns instead of inefficient "mud-pit pile" method. At least 35% of the producers will use efficient charcoal production kilns by 2025 and 50% by 2030. The investments cost for efficient charcoal production kilns is a major challenge for most of the producers, however, with Bioenergy Action plan interventions as specified herein, up to 50% of the producers are achievable target by 2030;

- Increase the share of efficient charcoal production to 60% by 2020 and 80% by 2030;

- The share of population households using alternative modern fuels for cooking instead of fuelwood and charcoal is targeted to increase from the current 12% to 41% by 2025 and 50% by 2030. The current challenges include the high prices of modern fuels (cost of electricity generation, LPG prices, bioethanol production cost, etc.) and the cost of manufacturing improved efficient charcoal and fuelwood burning stoves.

- Programs must be implemented to make the availability and cost of modern residential energy (electricity, solar energy, LPG, bioenergy, and efficient technologies accessible and affordable.

- Increase the share of solar water heating (SWH) technologies for sanitary hot water and preheating for commercial and industrial processes as prescribed in this action plan document;

- Biodiesel and Bioethanol as share of fossil fuels consumption in Liberia currently being <1% are targeted to constitute 0.4% by 2025 and up to 3% achievable by 2030. This target is below the ECOWAS projected target and the decline growth rate will more likely lead Liberia to 3% instead of 5%.

- The share of population households using alternative modern fuels (bioethanol and LPG) for cooking instead of fuelwood and charcoal will increase to 24% by 2025 and 26% by 2030

- Bioelectricity on the above table includes electricity generated using fuelwood and logging & agriculture wood waste residues and that from hydro power plants and the plans to undertake Medium and Low Voltage Distribution Networks, Customer Connections and Street Lights in Rural Areas in Liberia.

- LEC Mt. Coffee Expansion Project Plans to undertake three renewable energy projects namely a 20MW solar PV plant at the Mt. Coffee, a 44MW extension to the Mt. Coffee run-of-river hydro plant, and a new 150MW hydro dam on the St. Paul River

- With the successful implementation of various bioenergy conversion and utilization technologies, efficiencies improvement, substitution programs, and conservation alternatives the fuel-wood saved by 2025 is projected to be at least 5.213 million tons per year and will rise to 6 million tons or more by 2030.

11.1. Projected Alternative Scenario Achievable Targets for Bioenergy in Liberia

- Bioenergy Policy target by 2030 to meet the universal access to clean, safe and affordable cooking energy, including 26% of LPG users and 100% of improved cook stoves (ICS) and/or sustainable biomass fuels users in Liberia will enable the following activities and results:

- The table 48-50 above for the Bioenergy Targets for LPG and ICS Alternatives to reduce traditional wood energy consumption will eventually result to the following developments and required policies and action plans if the calculated alternative scenario achievable targets are considered for Liberia:

- Cooking and Heating Energy - With Liberia taking steps to meet Universal access to clean, safe and affordable cooking energy, and including raising the percentage of households using LPG to 26%, such a scenario represents the following targets:

- Over 152,000 additional household users of LPG as primary cooking fuel in comparison with the 2018 situation;

- About 291,000 additional households using ICS as main cooking device and/or sustainable biomass fuel as primary fuel;

- Up to 42 million tons of wood will be saved between 2018 and 2030 (i.e. 1.5 billion USD saved);

- Ensure universal access to improved cook-stoves to 100% by 2030;

- Increase the share of the population served with modern fuel alternatives for cooking to 36% by 2020 and 41% by 2030;

- Increase the penetration of LPG for cooking to 26% by 2030;

- Conduct research on the use of ethanol and other fuels as domestic cooking fuels;

- Reduce fuel-wood consumption, as a result of the Policy implementation, by 42 million tons by 2030;

- Increase the share of efficient charcoal production to 100% by 2030;

11.2. For domestic applications, transportation and financing:

- Introduce blending ratios for Ethanol/bio-diesel in transport fuels of10% by 2030;
- Increase blending ratios for ethanol/bio-diesel in transport fuels of 5% by 2020 and 10% by 2030;
- Conduct research on the use of ethanol and other fuels as domestic cooking or bioethanol fuels for transport;

11.3. For minimizing health risks, gender imbalance and improve socio-economic wellbeing

- Reduce health risks associated with smoke inhalation and long distances travelled by women and children to obtain fuelwood and charcoal by introducing very efficient burners for cooking and heating that consumes less wood fuels and charcoal and reduce travel time;
- Improve livelihoods through involving small-scale farmers as direct producers or out-growers enabling them to generate new income, opening up employment opportunities, and thereby alleviating poverty and boosting rural incomes;
- Use of agricultural residues can lead to more investments and modernization of the agricultural sector by increasing mechanization, but taking measures to minimize the impact on biodiversity, land use, soils, and water resources.

11.4. For enhancing Agricultural productivity

- Reduce the poor practices of “slash and burn” as a way to clear land, as such practices negatively impact on biodiversity (insects, plants, etc.) and contribute to soil erosion;
- The use of slurry (residue of biogas production) and nutritive ash (residue of controlled combustion processes or bio-char) can greatly improve the soil and increase agriculture yields.
- Excluding Liberia’s hydro power capacity, approximately 0.67% of electricity currently comes from biomass energy source (1.5MW); of which 0.5MW is generated from biomass residues or rubber plantations expired trees used at the processing plant:

- **Development of Sustainable Bioenergy Development Financing Instruments**
    - Create instruments for financing sustainable energy, including carbon finance in the longer term; establish a regional fund for the development and implementation of sustainable energy projects.

- Create instruments for financing sustainable energy, including carbon finance by the end of 2023 and in the longer term, establish a regional fund for the development and implementation of sustainable energy projects.

- **As part of this BEAP, Liberia needs to resolve the gaps in its current bioenergy policies, targets and action plans and develop the following:**

11.5. For Enhancing the Environment:

- Stimulating farmers to collect and/or use agricultural waste, rather than burning it as an additional source of income and/or increase energy access and reduce dependence on the natural forest;

- Use of agro-industrial waste coupled with use of efficient devices and systems will help save 5-6 million tons of forest wood resources by 2030

Reference to the National Renewable Energy Action Plan (NREAP 2016) where the energy access scenario measures to achieve universal access for Liberia are introduced, the share of population households using modern cooking devices starts from 26% for 2010 and 2015 each and rises up to 49% by 2020, 72% by 2025 and 95% by 2030. With the scenario measures trajectories, the share of population using LPG for cooking accounts for 10% of the population households for each of the years 2010 and 2015, but quickly takes off to 21%, 32% and 43% for the years 2020, 2025, and 2030 respectively.

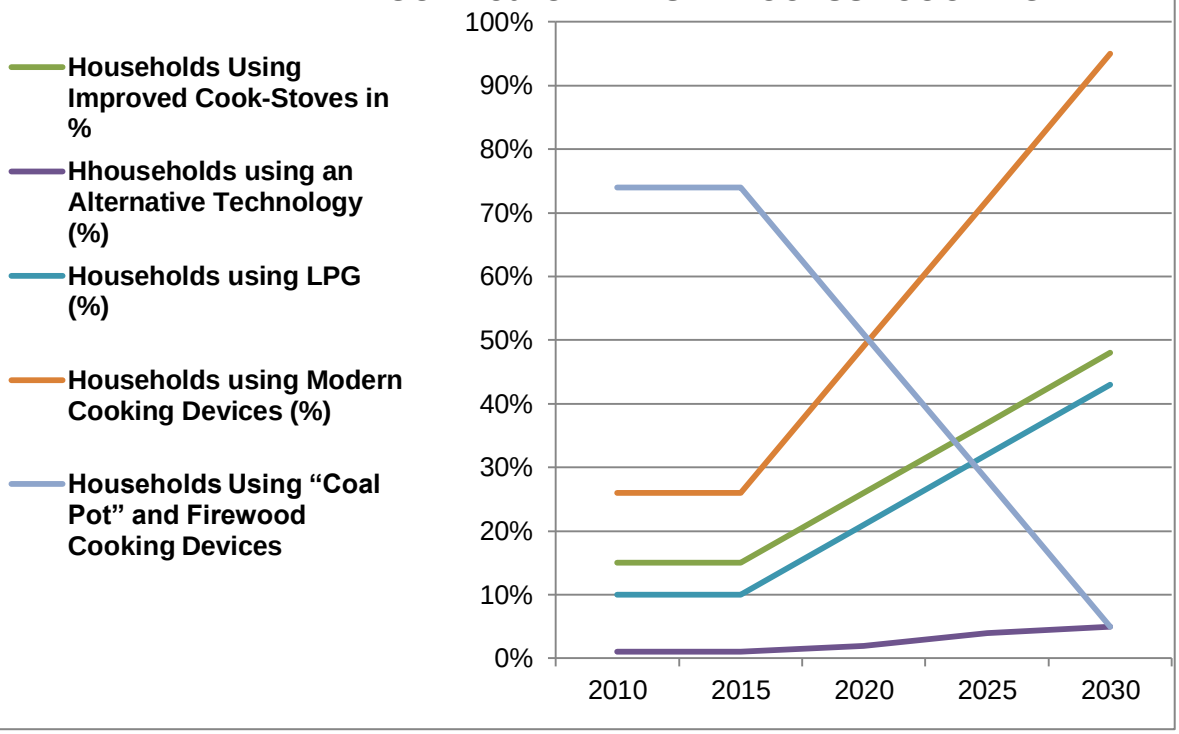
Charcoal and Firewood cooking devices are presently the predominant cooking technology (74% of the households) in 2010. The use of Charcoal Cooking Stoves commonly known in Liberia as “Coal Pots” and Firewood cooking devices will be replaced from the 2010 and 2015 percentage of 74% of households will reduce down remaining to 51% in 2020, to 28% in 2025 and only 5% in 2030. See table 5 below.

Table 51: Scenario With Measures To Achieve Universal Access To Modern Cooking, "Cooking Plan"

	2010	2015	2020	2025	2030
Share of households population using improved cook-stoves in %	15%	15%	26%	37%	48%
Share of households using an alternative technology (%)	1%	1%	2%	4%	5%
Share of households using LPG (%)	10%	10%	21%	32%	43%
Total families using modern cooking devices (%)	**26%**	**26%**	**49%**	**72%**	**95%**
Remaining households using “coal pot” and firewood cooking devices	74%	74%	51%	28%	5%

The table 51 below from the Scenario results present the numbers of thousands of households achieved with measures for access to modern cooking for the selected years (2010, 2020, 2025 and 2030). The required investments to achieve these targets are calculated to amount to approximately 32.91 million US dollars. Required annual investments to achieve these targets are estimated to range from US$14 million 2015, US$18.87 million in 2030.

FIGURE 30: UNIVERSAL ACCESS "COOKING PLAN"



Liberia is behind schedule in reducing dependence on "Coal Pots" to be replaced by LPG and other modern cooking devices. By this year 2022, the % of Cole Pots should be far less than LPG Devices.

Table 52: Projected Modern Cooking					
Year	2010	2015	2020	2025	2030
Baseline Scenario ("Baseline") for cooking					
Total number of households (000)	**712**	**786**	**868**	**958**	**1,058**
No. of households using LPG (000)	71	79	87	96	106
No. of households using improved cookstoves (000)	107	118	130	144	159
No. of households using alternative technology (000)	7	8	9	10	11
Total: families using modern cooking devices, baseline scenario (000)	**185**	**204**	**226**	**249**	**275**
Scenario with measures to achieve universal access to modern cooking, "Cooking Plan"					
No. of households using LPG (000)	71	79	182	305	453
No. of households using improved cookstoves (000)	107	118	225	353	506

No. of households using an alternative technology (000)	7	8	20	34	50
Total: families using modern cooking devices, scenario "Cooking Plan" (000)	185	204	426	692	1,009
Annual investment LPG (000 000 Dollar)	0.00	0.94	4.03	5.71	7.68
Annual investment improved cookstoves (000 000 Dollar)	0.00	0.14	0.46	0.63	0.83
Annual investment alternative technology (000 000 Dollar)	0.00	0.09	0.45	0.64	0.86
LPG Technology Annual Investments (Millions of Dollars)	-	1.17	4.93	6.97	9.38
Accessories and Spare Parts in Millions of US$	-	0.01	0.06	0.09	0.12
Total investment (Millions of Dollars)	0	2.35	9.93	14.04	18.87

CHAPTER 12 DOMESTIC COOKING TARGETS IN METRIC

Table 53: Targets for domestic cooking energy in tons

Quantity of Domestic Fuels and Stoves	2018	2020	2025	2030
Firewood (Metric tons)	2,576,206	2,473,158	1,674,534	1,288,103
Efficient Charcoal (Metric tons)	463,407	444,871	301,214	231,703
Briquettes/pellets (Metric tons)	-	-	284	290
Bioethanol (Litres)	-	-	43,692	44,566
Biodiesel (litres)	-	43,686.80	44,561	44,997
Biogas (m^3)	1,241	1,246	1,271	1,309
Agro-industrial waste (Metric tons)	1,241	1,291	1,415	1,552
Municipal solid waste (Metric tons)	-	-	415.00	427.45

Table 54: ICS and other Cookstoves Projected Number of Units

Quantity of Domestic Fuels And Stoves	2018	2020	2025	2030
Quantity				
Solar cookers	-	-	1,209	2,419
Improved cookstoves	604,657	616,750	810,240	906,986
Ethanol cooker	-	5,116.43	15,419	15,881

Table 55: Projection of # of Bio digesters Installations number of Units

Capacity	2018	2020	2025	2030
10 m^3	-	-	1,271	1,309
20 m^3	-	-	847	873
30 m^3	-	-	195	201
Total	-	-	**2,313**	**2,383**

Table 56: LPG Cylinders Trajectory (Planned Capacities in Liberia)

Capacity	2018	2020	2025	2030
3kg	54,799	55,895	67,951	69,047
6kgl	18,266	18,631	22,650	23,015
9kg	9,133	9,316	11,325	11,508
12.5kg	8,403	8,571	10,420	10,588
28kg	7,672	7,825	9,513	9,667
38 kg	3,605	3,677	4,470	4,542
Total	**101,878**	**103,916**	**126,329**	**128,366**

Table 67: Bio-Fuels Targets for 2020 and 2030			
Bio-fuels Targets (1st generation)*	2010	2020	2030
Ethanol as share of gasoline consumption	0%	2%	5%
Biodiesel as share of Diesel and Fuel-oil consumption	0%	2%	5%
*Source: 2009 NEPL			

CHAPTER 13 BIOELECTRICITY TARGETS

Referencing from the NREAP[30] & NEEAP[31] for Liberia 2016, the total electricity production indicated here is from biomass resources for the base year 2018 and also indicate the targets for 2020, 2025 and 2030 already provided for both the electricity and energy targets.

Table 58: Base Year 2018 Indicated Targets for 2020, 2025 and 2030	2018	2020	2025	2030
Small hydro (up to 30 GWh) OFF/MINI-GRID	39.5	39.5	39.5	39.5
Medium and Large Hydro (more than 30GWh) GRID	236.5	394.2	788.4	788.4
Solar (OFF/MINI-GRID)((GWh)	136.6	227.7	455.4	455.4
Wind (OFF/MINI-GRID (GWh)	0.1	0.2	0.5	0.5

[30] National Renewable Energy Action Plans (NREAPs), LIBERIA, Period 2015-2020/2030, Within the implementation of the, ECOWAS Renewable Energy Policy (EREP); June 1, 2015 By Jacob S. Sandikie, B.Sc., M.E.R

[31] National Energy Efficiency Action Plan (NEEAP) , Republic Of Liberia, Period, Feb. 2016

Total RE Generation (GWh)	412.8	661.6	1,283.80	1,283.80
OTHER GENERATION (FF; Baseline)*	631.3	880.1	1,983.50	4,411.00
Total Generation RE Case (GWh)	**1,044.10**	**1,541.70**	**3,267.30**	**5,694.80**
*Note: Energy produced for mechanical power can be classified under Bioelectricity				

The targets for total power available from Grid Connected, Off/Mini-Grid generation and EE Savings will rise from the 2010 and 2015 quantities of 191GWh and 418GWh respectively to 1778GWh in 2020 and increase to 4,004GWh in 2025 and amount to 7,300GWh in 2030. Considering the baseline power generation quantity obtained for 2018 however, and comparing to the Scenario tool calculations of 2015, the new achievable targets quantities projection are shown in the table below.

Table 59: Power Projected Generation Targets (Gwh)[32]

	2010	2015	2018	2020	2025	2030
Total Energy Available (Baseline+RE Generation+EE Savings and projected)[33]	191	418	4,433	1,778	4,004	7,300
Current Achievable Targets	**191**	**418**	**4,433**	**5,063**	**5,784**	**6,607**
Fossil Fuels Generation (GWh)	151	378	3,059	880	1,984	4,411
Fossil Fuels share of total (%)	79%	91%	69%	50%	50%	60%
Bioenergy Generation Targets (GWh)	**39**	**40**	**1,374**	**4,171**	**3,773**	**2,148**

Table-59 above shows the electric power generation from grid and off-grid or mini-grid power sources for the planning period is targeted for 5,784GWh in 2025 and 6,607GWh in 2030. This confirms that the NREAP/NEEAP scenario projections (4004 and 7,300 respectively) are within acceptable quantities. The targets for total grid and off/mini-grid connected electricity distributed by source of generation shows that of the total generation, fossil fuel based generation shall accounts for 79%, 91%, 69% 50%, 60%, and 60% of total generation in the respective projection years: 2010, 2015, 2018, 2020, 2025 and 2030. This would account for a Bioenergy contribution to generation to: 3,773GWh and 2,148GWh in 2025 and 2030 respectively.

The Renewable Energy (RE) share of the total mix of electricity power generation sources mentioned above is projected to increase from

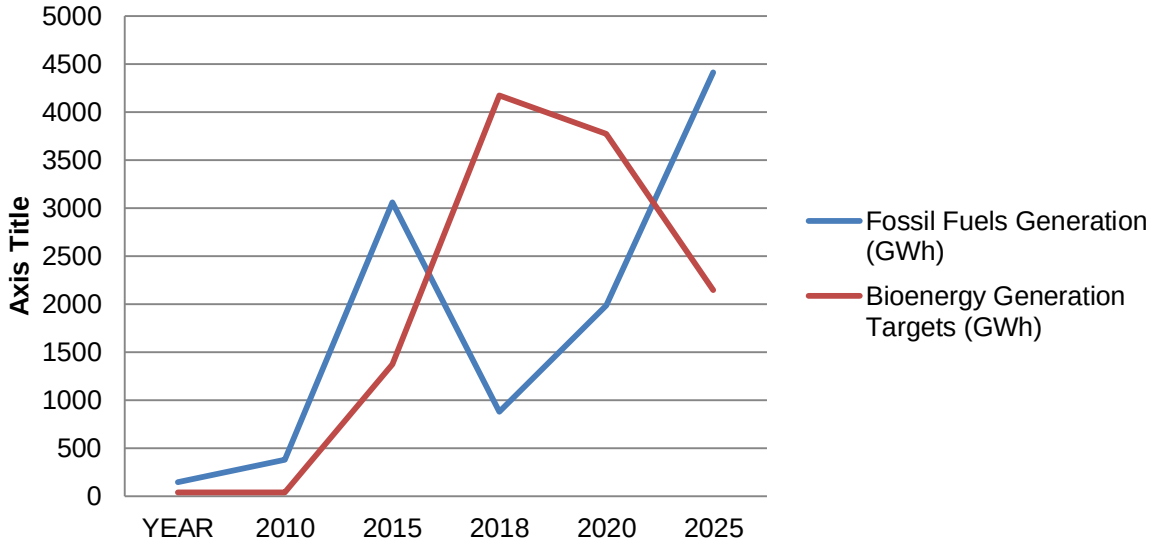
40GWh or 21% in 2010 to 40GWh or 9%,in 2015, 1,374GWh or 31%% in 2018 and 4,183GWh or 50% in 2020, 3,800GWh or 50% in 2025 and 2,196GWh or 40% in 2030. as shown on table 60 below. The NREAP measures are expected to enhance the deployment of renewable energy sources. The relative share of the expected

[32] NREAP

[33] The calculated targets for grid connected power by 2015, 2020 and 2030, based on the NREAP-NEEAP-SE4ALL scenarios tool and parameters chosen by the Liberia NREAP Project Team

energy from fossil fuels (FF) and renewable energy RE sources is illustrated in figure 3 below.

FIGURE 31: POWER GENERATION IN GWh FROM FOSSEL FUEL AND BIOENERGY PER YEAR



Fossil Fuels generation declined relative to biomass when biomass and hydro generation was increased but the plan for bioenergy conservation and improvement in efficiencies project a decline in the share of generation between Biomass and Fossil fuels and dependence on bioenergy reduces.

.Table 60: Targets for the share of grid-connected Bioelectricity for 2018, 2020, 2025 and 2030

Table 60 Installation Capacity (KW)	2018	2020	2025	2030
Biogas	-	-	**2**	**2**
Biodiesel	**0.2**	**0.6**	**76**	**76**
Bioethanol	-	-	**74**	**76**
Agro-industrial waste (Bagasse, sawdust, etc.)	-	-	**2**	**3**
Pellets/briquettes	-	-	**0.5**	**0.5**
Municipal solid waste	-	-	**1**	**1**
Others (specify)				
Total	**0.2**	**0.6**	**155**	**158**

The projected grid connected bioelectricity shown in the above table is expected to be very low (in KW instead of MW capacity) due to the low targets rates derived from the baseline conditions – noncurrent grid connections of bioelectricity.

Table 61: Electricity Production in GWh	2018	2020	2025	2030
Biogas	-	-	19	19
Biodiesel	2	4	662	669
Bioethanol	-	-	649	662
Agro-industrial waste (Bagasse, sawdust, etc.)	-	-	21	23
Pellets/briquettes	-	-	4	4
Municipal solid waste	-	-	6	6
Others (specify)				
Total	**2**	**4**	**1,362**	**1,384**

The electricity generation from bioenergy technologies and resources (biogas, biodiesel, bioethanol and bagasse and solid waste) are projected to be very low unless major focus and policy measures and action plans are undertaken.

Table 62: Estimated 2020 & 2030 Targets & Trajectory for Rural Population served

Table 62: Estimated 2020 & 2030 Targets	2018	2020	2025	2030
Total Rural Population (number of inhabitants, 000) Served by Bioelectricity	123	163	451	1100
Rural population served with electricity services (number of inhabitants, 000)	786	786	868	1058
Rural population served with electricity services (% of total)	1%	1%	10%	20%
Rural population served with bioelectricity services (bioenergy only and hybrid) (number of inhabitants, 000)	-	-	9	11
Rural population served with renewable electricity services (bioenergy only and hybrid) (%)	-	-	1%	1%

CHAPTER 14 BIOENERGY APPLICATIONS FOR DOMESTIC USES

In this section, Member States are required to set their targets regarding bioenergy applications for domestic uses in 2020 and 2030 as well as its trajectory.

Table 63: National 2020 and 2030 targets and estimated trajectory for domestic cooking energy

Table 63: National 2020 and 2030 Targets*	2018	2020	2025	2030
Population served with improved cookstoves (number of inhabitants, 000)	613.6	676	748.8	826.8
Share of population using improved cookstoves in %	1%	10%	15%	15%
Total charcoal production in tons	901,672	1,004,720	1,236,579	772,862
Charcoal production with efficient technologies (yield superior to 25%) in tons	231,703	301,214	444,871	463,407
Share of charcoal produced with efficient technologies in %	26%	30%	36%	60%
Population using modern cooking fuel alternatives (LPG, biogas, solar cookers,) (number of inhabitants, 000)	79	87	96	106
Population using LPG (number of inhabitants, 000)	410.8	452.4	499.2	551.2
Population using biogas (number of inhabitants, 000)	0	0	1	1
Population using solar cookers (number of inhabitants, 000)	0	0	1.5	1.7
Population using ethanol cookers (number of inhabitants. 000)	0	0	1.5	1.7
Others				
Share of population using modern fuel alternatives for cooking (e.g. LPG, biogas, solar cookers,) (% of the total population)	10%	15%	20%	25%
Share of Population using LPG (% of the total population)	10%	12%	15%	20%
Share of Population using	-	-	>1	.>1

Table 63: National 2020 and 2030 Targets*	2018	2020	2025	2030
biogas (% of the total population)				
Share of Population using solar cookers (% of the total population)	-	-	>1	.>1
Share of Population using ethanol cookers (% of the total population)	-	-	>1	.>1
Others	-	-	>1	.>1
* or the most recent year for which statistics are available				

14.1. Biofuel for Transportation

The table below presents Liberia's projected set biofuel usage targets by 2020, 2025 and 2030

Table 64: National targets and estimated trajectory of biofuel usage for 2020, 2025 and 2030

Table 64: National Targets and Estimated Trajectory of Biofuel	2018	2020	2025	2030
National gasoline consumption (Kilo liters)	164,880	174,243	200,042	229,661
National diesel consumption (Kilo liters)	19,044	20,125	23,105	26,526
Production of biodiesel and straight vegetable oil (SVO) or pure plant oil (PPO (litres), palm oil).	0	0	2,300	2,600
Production of ethanol (litres)	-	-	4,621	5,305
Bioethanol consumption (kilo litres)	-	-	1,617	1,857
Biodiesel consumption (Kilo litres)	-	-	323	371
Bioethanol as share of national gasoline consumption (%)	-	-	2%	5%
Biodiesel as a share of national Diesel consumption (%)	-	-	1.4%	1.4%

CHAPTER 15 MEASURES FOR ACHIEVING THE TARGETS

In the following chapter, the ECOWAS Member States are asked to include measures and activities how they intend to achieve the set targets in the previous chapter. The implementation of the activities will be monitored by ECREEE at regional level.

15.1. Summary tables of policies & measures to promote Bioenergy resources

Summary tables of all policies and measures to promote the use of Bioenergy resources for grid connected and off-grid electricity generation, cooking/heating energy, and transportation.

Charcoal and Firewood cooking devices are presently the predominant cooking technology (74% of the households) in 2010. The use of Charcoal Cooking Stoves commonly known in Liberia as “Coal Pots” and Firewood cooking devices will be replaced from the 2010 and 2015 percentage of 74% of households to 51% in 2020, to 28% in 2025 and only 5% in 2030. See table 65 below.

Table 65: Scenario With Measures to Achieve Universal Access to Modern Cooking, “Cooking Plan”

	2010	2015	2020	2025	2030
Share of Population Using Improved Cook-Stoves in %	15%	15%	26%	37%	48%
Share of households using an alternative technology (%)	1%	1%	2%	4%	5%
Share of households using LPG (%)	10%	10%	21%	32%	43%
Total families using modern cooking devices (%)	26%	26%	49%	72%	95%
Remaining Households Using “Coal Pot” and Firewood Cooking Devices	74%	74%	51%	28%	5%

Table 66: Value of Electric Power Generation And Required Investments in US$ for the NREAP-EEAP-SE4all[34]					
Developed On: 03.23.2015	**Value in Millions of US$**				
YEAR	2010	2015	2020	2025	2030
Value of electricity generation (in Millions of Dollar)	103	226	497	1,092	2,403
Value of fossil fuel consumption (in Millions of Dollar)	41	102	238	536	1,191
Rate of access to electricity					
Value of renewable electricity generation (in Millions of Dollar)	-	-	336	672	672
Value of savings (in Millions of Dollar)	-	-	127	398	867
Scenario with Efficiency + renewables (GWh)					
Value of EE + RE (in Millions of Dollar)	-	-	463	1,070	1,539
NPV of the set of action plans, in the starting year of implementation (in Millions of Dollar)	3,629				
Improvement in the national balance of payments = value of the reduction in fossil fuel consumption (in Millions of Dollar)	-	-	244	563	816
Rate of access to electricity (%)	1.4%	1.4%	34.2%	67.1%	100.0%
Total Investments (US$)	**144**	**328**	**1,660**	**3,768**	**5,949**

15.2. Overview of Policies and Measures

The overview of policies and measures planned for the BEAP for Liberia are presented in the following table 67 presenting their respective names and type of measures, expected results target groups and activities, and determination whether they are existing, planned and their start and end dates.

[34] Liberia Sustainable Energy for All (SE4all) Action Agenda Report 2015

Table 67: Overview of policies and measures

Name of The Measure	Type of Measure*	Expected Results**	Target Group And/or Activity***	Existing/ Planned	Start and End Dates
Policies and Measures for Grid Connected Bioenergy Electricity Generation					
Assessment and identification of areas for bioenergy power generation policies, policy analysis and identifying gaps and development of plans for biomass systematic data collection program to update the USAID assessment of national biomass resources and development potentials in Liberia done since 2009	Data Collection Regulatory Policy development	Energy Generation Reliable Data	Public Administration, Program Planners	Planned	2023 – 2025
Hydro-Solar Hybrid Systems projects development	Installation of at least the proposed 20MW Solar dry season supplement plant for the Mt. Coffee Hydro plant.; Additional Hydro development upstream Mt. Coffee	installed capacity development	LEC, Grid Power reliability	Planned	2023-2024
Assessment of the number and types of facilities that generate/have potential to generate waste and facilitate energy generation and technical facilities: Logging waste Retired old rubber waste Rubber farms waste in the country Oil-palm plantations waste Shifting cultivation waste	.Technology Promotion and Transfer Information campaign	General technology and installed capacity development	Forestry logging. Sawmills Rubber concessions Oil Palm Farms Municipal and Animal/Arbiter facilities operators	Planned	2023-onwards

Name of The Measure	Type of Measure*	Expected Results**	Target Group And/or Activity***	Existing/ Planned	Start and End Dates
Municipal & Animal/Arbiters waste					
Grid expansion T&D projects continued	LESEP Financing and LESEP-AF additional financing Grid Upgrade Project and the Monrovia Consolation of Electricity Project.	Accelerate Electricity access	Monrovia and Peri-urban areas	Existing	2022-2025
Briquettes/pellets production	Briquettes/pelletizer capacity development of wood pellets production facility equipment	Cooking Users grow from <1% to 7% by 2030. At least 1,857,000 litres of biodiesel with power generation of 4GWh or more	Monrovia and Peri-Urban areas	Planned	2023 onwards
Promote the use of solar thermal energy for domestic and productive activities	Support Schemes to promote solar thermal	Solar thermal capacity in the homes	Residential sector, health centres, hotels, guest houses	Planned	2016 – 2030
Policies and Measures to Increase Biomass Availability					
Biomass from Forest Residues Biomass generation facilities development by provision of long-term contracts; Develop flexible provisions for biomass production facilities	Regulatory; Financial empowerment	biodiesel production facility; bioethanol production facility	Investors and public administration	Planned	2023-2030 onwards

Name of The Measure	Type of Measure*	Expected Results**	Target Group And/or Activity***	Existing/ Planned	Start and End Dates
Development of efficient charcoal production Kilns	The use of efficient charcoal production kilns	projected to save 5.2 to 6.0 million tons of fuelwood resources; producing 44,000 to 463,000 tons of charcoal per year, raising the share of efficient technology kilns in use from 26% in 2018 to 60% in 2030.	Investors; IPPs	Existing	2023-2030
Biomass from Municipal Waste	Co-generation for heating and power generation	Installed Capacity, and Behavioural change	Government, Urban population	Planned	2023 onward
Biomass from Agricultural-Industrial Waste	Hybrid power generation system	Behavioural change; and increase installed capacity	Agriculture enterprises and investors	Existing	223-2030
Implement demonstration projects to show how to use agro-industry, forest logging and sawmills residues to produce energy	Waste Utilization and Energy Production	Biomass power generation plants,	Sawmills, agriculture concessions,	Planned	2016-2030

Name of The Measure	Type of Measure*	Expected Results**	Target Group And/or Activity***	Existing/ Planned	Start and End Dates
		increased power capacity available	forestry logging operators		
Biomass from Animal/Abattoir Waste Assess the availability of the animal/abetter waste and management processes, Propose policies for waste resources uses for power generation, cooking or heating and industrial applications. Develop policy on the reuse of the waste from animal/abattoir Develop enabling environment and security structure for agricultural investments, growth and development	Assessment of the potentials animal manure and municipal solid waste for energy generation, Information and regulatory	Development of targets and capacities for special industrial energy needs. Behaviour change	Municipal administration; Animal/Arbiter waste industry operators	Planned	2023-2030
Development of Biogas	Financial support for Biogas production facilities of 2KW or more capacities by 2030	Population using biogas is increased from less than 1% to 5% by 2030 Installed Capacity;	Peri-Urban Household population using biogas for at least 1000 inhabitants per year.	Planned	2024-2030
Policies and Measures for Off-Grade Connected Bioenergy Electricity Generation					
Feed-in-Tariffs (FIT)[35]	Installed Capacity and policy development for differentiating feed-in-tariffs (FIT) payment	Resource market; uncertainty through long-	IPPs capacity development	Planned	2023 – 2030 onward

[35] Feed –in-Tariffs (FIT) and other policies: Policies to Enable Bioenergy Deployment Key Considerations and Good Practices by Sharon Smolinski and Sadie Cox

Name of The Measure	Type of Measure*	Expected Results**	Target Group And/or Activity***	Existing/ Planned	Start and End Dates
	policies based on technology, fuel type; size of project; and Designing long-term contracts and guaranteeing grid access	term price-controlled agreements; and IPPs empowerment			
Off-grade enterprises (IPPs) assessment and development of empowerment scheme and management/ sustainability structure.	IPP management structure empowerment and cooperation	Local IPPs strengthened and made sustainable	Investors and Users in general	Planned	2023=2030 onward
Empower the legal status of a number of IPPs; Provide support for the National Energy Policies and Rural Energy Master Plans, etc.	The RREA and LERC empowerment program, licensing, tariff variation, import duties wavers and tax breaks as key national policies	Sustainable IPPs economic empowerment and rural energy access rate increase	Rural and peri-urban users; IPPs	Existing	2023 - 2030
Development and Policy: regulatory framework, action plans and programs with appropriate institutional development for implementation of the bioenergy sector	The sustainability, introduction of advanced technologies, promotion of investment incentives and encouragement of local farmers and local private sector IPPs producers in view of the major role bioenergy plays in Liberia	Sustainability of Biomass development	Public policy makers, MME, RREA, Energy Sector Stakeholders	Planned	2023-2025
Policies and Measures on Bioenergy for Cooking and Co-Benefits for Heating and Water Supply					

Name of The Measure	Type of Measure*	Expected Results**	Target Group And/or Activity***	Existing/ Planned	Start and End Dates
Bioenergy Heating Network	Develop network water heating facilities;	Change of behaviour	Network of adjacent household in working quarters developing water heaters for the network;	Planned	2024-onwards
Promote the use of RES technologies in the water supply infrastructure and in the agro-food sector	Promote Nexus: Energy-Water-Food	Solar and RE Irrigation and water supply	Agriculture and water supply sector	Planned	2016 – 2030
Efficient Cooking Stoves Introduce bioethanol cooking devices equipment and manufacturing facilities for efficient cookstoves and Kilns	Improve charcoal production and utilization efficiency; Production factories that produce bioethanol each with the capacity to meet the targets; Development of measures to raise the share of population using Efficient Charcoal production Kilns	Savings of 38% or more of the fuel raw materials used Resource conservation; Economic empowerment;	Quarters adjacent to waste wood and other fuel resources for water heating energy	Planned	2023-2030
Measures to raise the share of population using LPG for cooking	Facilities for production of LPG fuel nd Stoves devices	Developed facilities; Cooking Stoves	Pery-Urban and Rural Areas and entrepreneur	Existing	2023-2030 onwards
Universal access to cooking “cooking plan”; Access measures are introduced	Improved Cookstoves (ICS) development on the large scale	The share of improved cookstoves	Peri-Urban and Urban areas	Existing	2023-unwards

Name of The Measure	Type of Measure*	Expected Results**	Target Group And/or Activity***	Existing/ Planned	Start and End Dates
	Financial and Capacity development	increased from 630,000 in 2025 to 830,000 of ICS units per year in 2030.			
Policies and Measures on Bioenergy for TRANSPORTATION					
Develop Biofuel Standards and Policies	Regulatory	Behavioural change	Public administration	Planned	2023-2030
Modern Fuel Alternatives for Cooking	Installation, and Financial support	Behavioural change	Urban Population	Planned	2023-onward
Biodiesel	Biodiesel diesel fuel production facility equipment that will generate at least 1.9 million litres per day.	Biodiesel consumption will grow to 5% in 2025 and at least 7% in 2030	Transportation sector, fuel distributers	Planned	2023-onward
Bioethanol production	Develop the factory for bioethanol production	consumption of ethanol 5% of the gasoline consumption; and viable bioethanol production facility	Agricultural Industry and Transportation Sector	planned	2023-2030
Policies and Measures on Bioenergy for Broad Recommendations for RE Sustainability and Stakeholder Involvement					
Sustainable use of Biomass	Establishment of community involvement program for bioenergy	Administration; Public Information	Increase bioenergy monitoring and	Planned	2023 - 2030

Name of The Measure	Type of Measure*	Expected Results**	Target Group And/or Activity***	Existing/ Planned	Start and End Dates
	development and management		reporting and inter-sectorial cooperation		
Creation of Bioenergy Development Focal Institution	Administration, Regulatory; Capacity development	Developing Administration; Technical capacity, and management structure	Public administration Public information	Planned	2023-2030 Onward
Capacity Building – Training in Efficiency improvements; Develop Legal enforcement mechanism and made available; Develop Financial accountability	government to undertake capacity development; training in efficiency improvements Strengthening the capacities of entrepreneurial leadership and cooperative communication	Improvement of the cook stoves and charcoal production kilns technologies; Business knowledge and accountability;	Entrepreneurs; IPPs; Charcoal Producers ; Economic cost comparison and long-run savings discriminated;	Planned	2023-2030
Technology Research and development	Technical Capacity development	Publication of research developments and journal or newsletter	MME, RREA, LERC, MOA, FDA	Planned	2023 - Onward
Update the national energy policy and incorporate bioenergy development policies/programs	Develop appropriate bioenergy institution and policy framework; Develop Technological	Regulatory; Administrative	MME, RREA, LERC, MOA, FDA	Proposed	2023 - 2030

Name of The Measure	Type of Measure*	Expected Results**	Target Group And/or Activity***	Existing/ Planned	Start and End Dates
	capacity and provide Financial support				
Technology – coal-pot and mud-pit charcoal production methods are extremely essential technologies for the majority of the population; Advanced technologies for utilization of waste wood form agriculture and logging operations for power production empowerment; Introduce their manufacturing industry in Liberia	Serious attention in introduction and promoting bioenergy technologies; Financial support; Power generation capacity development	Improved stoves and efficient charcoal production kilns. Biogas, Bioethanol, Biodiesel, and other solid, liquid, gaseous and radiation (solar energy, heating and Solar VP) technologies exist and made in Liberia	IPPs, Producers and Rural areas Logging and Agriculture industries; Manufacturing industries	Proposed	2023 - onward
Update the National Energy Policy of Liberia to address Bioenergy development and sustainability	Policy Development, Regulatory Measures; Ensure harmonization of bioenergy and other RE development and investment and other sectors policies	Recognition and focusing on Bioenergy Sector, Harmonization policies on taxes, etc.	Public Administration	Existing	2023-2024
Policies and Measures on Financing for Bioenergy Sustainability					
Biomass Supply **Funding** – Financing investments in the	Develop varied sources of Bioenergy	Address the main	International Donor	Planned	2023-2025

Name of The Measure	Type of Measure*	Expected Results**	Target Group And/or Activity***	Existing/ Planned	Start and End Dates
bioenergy resources is a challenge and needs support from all possible sources and directions;	applications and fuel sources Financing new infrastructure over the long term	Bioenergy Challenges for Liberia	community and the Liberian Government		
Biomass Export Potentials	Assess and develop Potentials for Bioenergy export in Liberia; Financial resources	Charcoal and Wood pellets exports of Millions of dollars per year by 2030	Investors, Private sector involvement; Entrepreneurs and charcoal producers	Planned	2023 onward
Create Carbon credits for making bio-digesters more affordable and accessible for rural communities	Create instruments for financing sustainable energy, including carbon finance in the long term	Sustainable Carbon financing and Private sector involvement	International Donor community and the GOL	Planned	2023 onward
Create Climate finance that brings in private sector to scale up clean cooking models in Liberia Establish a regional fund for the development and implementation of sustainable energy projects. Create instruments for financing sustainable energy, including carbon finance by the end of 2023 and in the longer term, establish a regional fund for the development and implementation of sustainable energy projects	Financing; Administration Environmental Mitigation Behavioral change	investors involvement. Private sector empowerment	Liberian Government (GOL) IPPs, Investors	Planned	2023-2030 Onwards
Policies and Measures on Bioenergy Nexus Integration with water, land, agriculture and climate change					

Name of The Measure	Type of Measure*	Expected Results**	Target Group And/or Activity***	Existing/ Planned	Start and End Dates
Environmental Impacts Assessment	Carbon Tax Develop low carbon sustainable energy systems policies	Capacity for bioenergy Develop; climate change resilience and adaptation	Donor Organizations, private sector, legislation	Planned	2023 - onwards
Provide information on available land areas that can be used for the production of bio-fuels	Bio-fuels Production and sustainable resource base	Identified land and reserved areas for bio-fuel production	Land Commission, MOA, FDA LERC, RREA, MLME	Planned	20 24 - onwards
Collect and reuse agricultural and reusable municipal waste Use of agro-industrial waste Introduce efficient devices and systems for firewood and charcoal production and uses	There is need to improve the ability to pay for the consumers; Capacity building and Technology Transfer	Save 43-50 million ton of valuable fuelwood and charcoal resources	Public administration; Rural and Peri-Urban areas; Municipal Administration	Planned	2023 - Onward

* Indicate if the measure is (predominantly) regulatory, financial or soft (i.e. information campaign).
**Is the expected result behavioural change, installed capacity (MW; t/year), energy generated (MWh/year)?
***Who are the targeted persons: investors, end users, public administration, planners, architects, installers, urban or rural population, health centres etc.? or what is the targeted activity / sector: biofuel production, energetic use of animal manure, etc.)?
Please add lines as required.

15.3. Environmental and Food Security Concerns Linked With Palm Oil Trade

The oil palm sector has faced significant criticism in recent years for detrimental production practices which include clearing large swathes of land (frequently encroaching on allocation for other sectors that have a bearing on food security) for cultivation of oil palm for industrial usage/export; leading to the large-scale replacement of High Conservation Value (HCV) forest.

The main criticism in terms of oil palm's low sustainability will be its use as a feed stock for biodiesel production, which could constitute a significant percentage of total palm oil use. The criticism of palm oil use can become a part of the food sustainability concern when oil palm is used in the form of bio fuels for fossil fuel replacement. The BEAP takes into consideration the needs for food sustainability plan that insures that the food supply is taken as first priority before the biofuels uses of oil palm.

15.4. Specific measures for the promotion of efficient cook-stoves

- Promote collaboration with international partners to increase bioenergy production. Includes research and incentives that aim to reduce barriers to increased biofuels use and the commercialization of new technologies.
- Maximize efficiency through development of improved cooking devices (ICS) designs and heating devices
- Capacity development training workshops for Program Offices on Energy Efficiency and Renewable Energy
- Reduce the nation's dependence on cooking fuels through the importation and manufacturing of cleaner alternative fuels and greater efficient ICS devices
- Research on Efficiency of affordable Cooking devices and regulate the use of inefficient devices
- Develop plans and implementation of public awareness programs and messages to target the differentiated financial needs, interests and literacy levels of women and men in the charcoal production industry; Promote awareness on the use and effectiveness of affordable ICS and energy efficiency technologies.
- Develop policies for the sustainable production and standards for efficiency of charcoal production

15.5. Specific measures for the promotion of efficient charcoal production

- Marginal initiatives and public information campaigns for efficient production and utilization of charcoal (by the Forestry Development Authority) have been attempted but their results and impacts were not achieved due to lack of funding to complete the program..

- Efficient charcoal production technologies shall be promoted to achieve feedstock forest wood conservation;
- Promote programs for public awareness raising and other information campaigns for efficient production technologies targeting men and women charcoal producers in the various centres;
- Develop efficient and affordable charcoal production kilns and support their manufacturing and discrimination to charcoal producers;
- Target men and women charcoal producers for support and training on using efficient charcoal production Kilns and methodologies for packaging and marketing;
- Take into account and develop implementation plans to target the differentiated needs, interests and literacy levels of women and men in the manufacture and distribution of efficient Kilns.
- Support the work of the National Charcoal Union of Liberia (NCUL) and the Forestry Development Authority (FDA) plans to allocate resources and pursue information sharing and training for specialization and sensitization of enterpreneures of the charcoal production industry including the NCUL use of efficient Kilns;.

15.6. Specific measures promoting of modern fuel alternatives for cooking

- Develop and implement gender-responsive national policies and programs on clean and efficient cooking;
- Facilitate the adoption of standards for cooking technologies in accordance with international standards for Clean Cookstoves;
- Development and introduction of innovative instruments to finance energy efficient cooking equipment. These may include customer credit schemes, demand-side-management by ICS manufacturing industry, changes to the tax systems, etc. to provide incentives for energy efficient products or increases in duties for inefficient cookestoves;.
- Demonstrate to stakeholders the advantages and benefits of efficient cookstoves manufacturing and use
- Develop Standard labels for efficient cookstoves
- Develop public awareness program and capacity training workshops for promotion of modern fuel alternatives for cooking (LPG, biogas, ethanol, solar cookers, etc.)
- Develop and adopt fiscal instruments to reduce prices of modern alternative efficient cookstoves

15.7. Support schemes to promote the use of biofuels

The concrete obligations / targets per year (per fuel or technology) to promote the use of Biofuels (Biogas, Biomass, Biodiesel, Broethanol, LPG and Solar) are as follows:

- The use of efficient charcoal production kilns are projected to save 5.2 to 6.0 million tons of fuelwood resources between 2025-2030 and introducing an industry for the manufacture of efficient Kilns for producing 44,000 to 463,000 tons of charcoal per year, raising the share of efficient technology kilns in use from 26% in 2018 to 60% in 2030. Only 40% of charcoal production will be utilizing the inefficient “mud pit” method; There is need to improve the ability to pay for the consumers to pay for the new kilns production;

- Liberia has major opportunities of a number of local private sector IPPs and aspiring energy sector entrepreneurs with potentials that need to be empowerment and given the support, opportunities, and incentives. to become operational and viable in Liberia; The Liberian people must demonstrate the willingness and ability to pay for energy developed by IPPs initiatives investments and to ensure entrepreneurial sustainability of operations and equipment manufacturing and maintenance.

- The value of bioenergy electric power generation and required investments amount to 3.8 – 6.0 billion US dollars from 2025 – 2030. This amount can be offset by the huge environmental impacts mitigation and resources conservation and energy efficiency improvements savings that value more than 3 – 6 billion dollars that will be achieved from 2025 – 2030 years period.

- Liberia has the potential to export charcoal and that potential needs to be studied and properly regulated and strengthen;

- The concrete obligations / targets per year (per fuel or technology) are:

    - Biogas – Production of at least 19GWh of power and at least 1,000 households using biogas;

    - Biomass – Introduction of Gasifier, and other technologies for power production from biomass utilization of; Oil Palm tree residues, Coconut husks and crop residues (industrial waste) utilization for energy becoming systematic; Promote biogas generation technology and public education on the use of the biogas and introduction of appropriate technology for municipal solid waste conversion to energy; Electricity production from biomass/waste wood technology capacity development for agro-forestry sector;

    - Small and Medium Scale hydro/min-hydro) – Develop support/financial mechanism for the growth of small and medium scale hydro/min-hydro capacity in Liberia;

- Biodiesel – Demonstration facility for the producing of at least 76KW or 889Wh and at least 5% of monthly diesel consumption with facilities for biodiesel production from palm oil in Liberia;
- Bioethanol – Demonstration facilities for the production of ethanol from sugarcane and other agricultural products and blending facilities to attain 5% of the gasoline consumption and production of minimum of 1,857,000litters of bioethanol by 2030;
- Briquettes/Pellets – Develop facilities for briquettes/pellets production for cooking amounting to 7% of direct fuelwood consumption and power generation for specific industries;
- LPG - Develop entrepreneurs capacities for importation and eventual manufacturing/packaging capacity in Liberia for the utilization of LPG and gas storage tanks and LPG cookstoves; The LPG penetration is targeted to increase from 15% of the households in 2018 to 43% of the households in 2030; this will require annual investments in LPG modern cooking facilities technologies serving at least 96,000 to 1,006,000 households. LPG household uses call for local manufacturing facility. The complete set of a LPG cookstove and gas tank is between $100 -$125 and increasing by just 10% of the households using LPG will create LPG stoves supply market and the LPG gas supply market of at least 2.65 million Kg of LPG supply per month;
- Solar PV Home Systems - Develop entrepreneurs capacities for importation and eventual local manufacturing/packaging facilities and capacity in Liberia for the utilization of Solar home systems;
- Develop public promotion and information, capacity training and technology transfer programs for the use of Biofuels (Biogas, Biomass, Biodiesel, Bioethanol, Briquettes/pellets in Liberia,

- The above targets are made taking into account all local conditions (favorable/unfavorable) including but not limited to: population, cost of alternative fossil based technologies, food security, willingness and ability of users to pay for the energy; local technical capacity; availability of public and private capital, etc.;
- Conduct an update to the assessment of national biomass resources and development potentials in Liberia to update the 2009 USAID assessment;
- Develop the Efficiencies of stoves, gasifiers, co-generation, and potentials for biodiesel and assess the efficient production and trade-offs for food and energy related trees and crops production and their potential contribution to power generation, including cash crops residues, forestry and logging residues, etc. and agricultural and industrial retired rubber trees;

- Conduct aassessments of the potentials animal manure and municipal solid waste for energy generation and recommended targets and capacities and applicable technologies, and special industrial energy needs.

- Develop Oil palm potentials, coconut and sugarcane crop residues (industrial waste) and oil-palm potentials for bioenergy, biodiesel oil production to support oil processing industry energy needs.

15.8. Specific measures for promotion of sustainable use of biomass energy

Specific measures for the promotion of the sustainable use of energy from biomass are discussed. Biomass has an important role as primary energy in rural and peri-urban areas. National biomass strategy is crucial to promote the use of biomass sustainably. Therefore Liberia must assess the current level of consumption and domestic potential and, implement measures to promote the rational use of biomass.

In addition to the above measures, other specific measures for sustainable use of biomass in Liberia shall include:

- Assessment of Potentials for Bioenergy export in Liberia and development of the relevant policies and institutional structures and capacities;

- Off-grade enterprises (IPPs) assessment and development of empowerment scheme and management/ sustainability structure;

- Provide opportunities for energy efficient biomass technologies available for improvements and agricultural/rural development (biofuels, gasifiers, steam boilers, and charcoal production kilns);

- Industrial wood fuel technology for rural and agriculture & forestry energy sources and the availability of arable land for energy crops development;

- Establishment of community involvement program for bioenergy development and management.

    - Assess Climate change impacts on energy production from biomass and develop low carbon sustainable energy systems

    - Update the National Energy Policy (NEP) and incorporate bioenergy development policies/programs

    - Develop appropriate *Bioenergy Institution* and policy monitoring and evaluation framework. In this process, conduct feasibility assessment of the Capacity and institutional development of the existing applicable Bureau(s) under the Department of Energy at the Ministry of Mines and Energy for the coordination of Bioenergy Development in collaboration with the Rural and Renewable Energy Agency (RREA), as part of the feasibility study to be undertaken for creation of an institution for bioenergy in Liberia, to avoid duplication of function.

15.9. Biomass Supply

The Liberia BEAP Baseline report assess and has presented the level of biomass supply and presents the following activities and measures in addition to the above for the supply of biomass:

- Develop climate change resilience and adaptation capacity for bioenergy
- Increase bioenergy monitoring and reporting and inter-sectorial cooperation
- Develop a policy or mandates for municipalities to increase and improve municipal waste transformation into energy.
- Assess the quantity/potentials of biomass from agro-industrial waste and propose policy or mandate to reuse waste from agro-industrial processes.
- GOL Public and private partnership engagement
- Assessment of the number and types of facilities that generate/have potential to generate waste and develop waste-to-energy generation facilities:
  - Logging waste
  - Retired old rubber (industrial waste)
  - Rubber farms in the country
  - Oil-palm plantations (Industrial waste)
  - Shifting cultivation
- Biomass from Animal/Abetter wastes
  - Assess the availability of the animal/abetter waste and management processes, and development sites and volumes.
  - Propose policies for waste resources uses for power generation, cooking or heating and institutional applications.
  - Develop the legal status of a number of IPPs through the RREA and LERC improvements program, licensing, tariff/import duties wavers and tax breaks as key national policies.

15.9.1. Measures to increase biomass availability:

15.9.1.1. Biomass from Forestry Residues:

Mobilisation of new biomass sources:

(a) The measures planned to encourage the use of unused arable land, degraded land, etc. for energy purposes include the production of fast growing fuelwood species similar to the fast growing fuelwood species project in Kenya; Production of special sugarcane plantation for ethanol production for bioethanol, and production of

oil palm plantation for biodiesel production. This will begin with the above mentioned assessments and conduct of feasibility details, followed by demonstration farms;

(b) In efforts to improve forest management techniques in order to maximise the extraction of biomass from the forest in a sustainable manner the following measures are planned:

- Develop the policy for logging waste wood, retired rubber trees, sawmills waste sawdust and sustainable fuelwood production and utilization of waste utilization for energy production;
- The policies of the Forestry Development Authorities developed these for the forest protection and systematic logging procedures will be followed, and energy production will be restricted to waste wood harvest for energy production to insure that forest management will be improved in order to increase future growth and biomass sustainability;
- In order to maximise the extraction of existing biomass the existing logging/sawmills and rubber and oil palm plantation factories and power generators will be encouraged to convert their energy generation facilities to hybrid systems for co-generation of heat, electricity and mechanical power applied to these facilities that already have the resource supply to be put into practice.

15.9.1.2. Biomass from Municipal Waste

In measures and plans to improve the municipal waste management and minimise the environmental impact while maximising the extraction of bioenergy (biogas, landfill or electricity) the BEAP for Liberia provides herein to develop policy on waste collection by private companies for disposal at the landfills and policy or mandate to reuse the wastes from Agro-Industrial processes and municipal waste;

15.9.1.3. Biomass from agricultural-industrial waste

As measure to improve the reuse of waste in order to minimise the environmental impact and maximise their reutilisation the BEAP herein plans to develop policies and mandates in Liberia for Agro-Industries to reuse the waste from their processes. This will be initially applicable to forestry sawmills, and the agriculture industry to utilize old retired rubber trees for hybrid or co-generation system for the rubber processing factories, in addition, the use of oil palm industrial waste for energy in their processes will be encouraged.

15.9.1.4. Biomass from Animal/Abattoir Waste

Abattoir owners have a shared responsibility to ensure that their activities do not infringe upon the environmental right of others. It is therefore important that unprocessed abattoir waste is not released into the natural community environment to insure that the management of municipal waste mandated to generate energy from the waste and improve in order to plan for future growth of the energy and agro-industries. The BEAP measures therefore plans mandate and regulate animal/abattoir wastes management waste to utilize waste for biogas generation for

energy utilized in their respective industries to improve the reuse of waste in order to minimise the environmental impact and maximise their reutilisation.

CHAPTER 16 PREPARATION OF THE NATIONAL BIOENERGY ACTION PLAN

(a) Regional and/or local authorities and/or other stakeholders involved in the preparation of this Action Plan:

ECREEE provided the TOR and the backstopping comments and monitoring for the preparation of this BEAP:

Following the Kick-Off Meeting the Consultant made contacts on December 21, 2021 and the MME and RREA Counterparts and others were organized into the Technical Working Team comprising the following:

1. Mr. Jacob S. Sandikie – Consultant
2. Stephen V. Potter Sr. – Rural and Renewable Energy Agency (RREA) – Team Advisor
3. Prince C. Wilson – Team Counterpart for MME
4. K. Nelson Gonwoe – Team Counterpart for MME

Later on the following were added to the committee

5. Geroge Cooper – Representative from – RREA
6. Abraham Bility – Outreach Officer - RREA
7. Stephen Payma Representative from RREA
8. LEC Representative as stakeholder has been contacted from time-to-time on relevant information – LEC

ECREE Backstopping Reviewers on the Project:

1. Mr. Guei Guillume Kouhie – ECREEE Backstopping Expert for Reviews
2. Mr. John K. Yeboah – ECREEE Backstopping Expert for Reviews and Project Coordinator

The MME and RREA have contributed data, information, their relevant administrative energy structure Charts, and review of the Baseline report, etc.

(b) The BEAP includes the regional/local bioenergy plans and strategies for Liberia including among other things, the recommendation for establishment of Bioenergy Development Institution with the mandates to spearhead the implementation of the BEAP. It is also planned in the NEAP for training and support to develop relevant competences to be delegated to the coordination at the regional/local stakeholders levels, and monitor, evaluate and implement the planned mechanisms and measures along with relevant stakeholder institutions and IPPs to ensure national target `achievement.

(c) The consultation process shall include the organization of a validation workshop with the participation of all relevant GOL agencies, corporations, commissions, ministries, Private Sector IPPs and Civil Society Organizations and International Donor institutions and NGOs will be involved. This is in addition to the review process for the involvement of the MME, RREA, ECREEE and others to derive an acceptable Action Plan.

16.1. Actions Plan (aligned with Regional Policy)

In order to insure that the national priorities are aligned with EBEP pillars and identify actions at national level the following activities have been prioritized to achieve the bioenergy targets for Liberia:

16.1.1 Policy guideline 1: Policy support to enhance local governance

General Objective 1: Bioenergy Development Institution/Bureau

Expected outcome 1: Appointment of a Bioenergy National Director and Mandate

Action 1: Develop TOR and Mandates of the Bioenergy Development Institute

Objective	Creation of implementation and management institution
Justification	Focus and required attention must be given to Bioenergy development; Training in Efficiency improvements
Description	Bioenergy being utilized extensively by the majority of Liberians, demand focus and serious attention for development to address the need for sustainability and avoid waste, and eventual future shortages and energy crises
Expected Outcome	Appointment and training of Director and Technical, managerial, administrative and financial experts for bioenergy development, regulation, programs, support and coordination in Liberia
Target Population	Target Population is the entire Bioenergy sector of Liberia
Entity responsible for execution	The MME is responsible to implement and bring to reality of the above actions plan.
Cost of the action	Approximately USD 1080 thousands
Execution time	2023

Action 2: Bioenergy Resources, Technologies & Consumption Assessment	
Objective	Comprehensive assessment of the Bioenergy Sector and Potentials, Production & Consumption Technologies and Recommendations
Justification	• Especially important for the energy & environment; • Enable Bioenergy policymaking and coordination bodies, • Recommend Bioenergy energy services Production, Consumption Devices development • Technology, equipment and technical services providers baseline analysis and solution to the identified policy and technological gaps,
Description	Liberia has opportunities for solutions to develop a major bioenergy sector and standardized sustainable implementation of energy services through the BEAP Assess policy mechanisms to address the gaps in developing policies to aligned with complementary national policies that directly support the production of various fuels from biomass feed-stocks, and biofuel standards and mandates requiring the production of biofuels
Expected Outcome	- Validated Bioenergy resources, base applications, equipment needs, capacity requirement and recommended policies and alternatives, ensure alignment and support complementary energy in Liberia-based programs; - Identification of support for projects to be implemented and supported by development partners; - Ensure alignment with existing development activities reflected in the NREAP of the energy sector of Liberia and cross sectors (climate change, water, health, economic and social development and private IPPs empowerment program).
Target Population	Liberia Rural Areas and Bioenergy Sector Stakeholders
Entity responsible for execution	Ministry of Mines and Energy and the Rural Renewable Energy Agency
Cost of the action	~USD 1128 thousands
Execution time	2023

16.1.2. Policy guideline 2: Capacity Building and Technology Transfer

Action 3: Bioenergy Training Capacity Building and Technology Transfer	
Objective	Capacity Building and Technology Transfer programs for the use of and production of Biofuels (Biogas, Biomass, Biodiesel, Bioethanol, Briquettes/pellets) and equipment development, maintenance and manufacture in Liberia,
Justification	There is a limited capacity and lack of efficient and modern bioenergy technology and equipment in Liberia
Description	Develop realistic, implementable solutions that address energy access development Bioenergy competencies and transfer technology - Improved value-addition capabilities in the production and development of renewable energy export sector and training in manufacture, management and operations of a range of bioenergy technologies; IPPs empowerment, Management Structure, Coordination and support, Licensing and capacity building - Broad-ranging policy for bioenergy sector institutional development and technical capacity development and support for experts in the energy sector; - Cross-sector focus of the energy development programs and provide training for energy-climate change co-benefits
Expected Outcome	Trained technicians and entrepreneurs capable to train others and develop the Bioenergy Technology in Liberia
Target Population	Developing IPP Entrepreneurs of the Energy Sector, Charcoal Producers and Metal Kiln Manufacturers, Logging and Agriculture companies energy generation technological and managers
Entity responsible for execution	Donor Supporters, Consultants, RREA and MME to develop and support training program details
Cost of the action	~USD 1104 thousands
Execution time	2023 - 2025

16.1.3. Policy Guideline 3: Bioenergy Technology Transfer Pilot Programs

Action 4 : Bioenergy Technology Transfer Demonstration Pilot Programs for Production and Consumption Efficiency and Manufacturing Industry for Bioenergy	
Objective	Develop Bioenergy Technology Demonstration Pilot facilities
Justification	Technology Transfer can best be achieved through demonstration of the development and application of the

	technology, A demonstration facility will also become a sustainable program when the outputs begin to generate support for the program
Description	The program will develop one or more demonstration facilities where there will be the following technologies being manufactured, developed and or in operational use for the purposes of training and transfer of technology: - Efficient ICS and Charcoal production Kilns - LPG sets of gas containers and stoves production and gas filling - Biogas digesters in development and operations - Fuelwood Plantation and development of briquettes/pellets and equipment manufacture for the process - Biodiesel and Bioethanol oil and ethanol field growing demonstration farm (oil palms and sugarcane and production equipment for mixing ratios demonstration - Combustion demonstration for Hybrid power generation technologies
Expected Outcome	Technologies transfer to several Liberians and local entrepreneurs and availability of trained technicians and public awareness
Target Population	IPPs, GOL Staff, and general population
Entity responsible for execution	MME, RREA, EPA, and general public
Cost of the action	US$ 1488 thousands
Execution time	2023-2030

16.1.4. Policy Guideline 3: Knowledge Management

Knowledge management, communication and awareness raising program

Action 5 : Bioenergy Knowledge Management & Awareness Program

Objective	Communication and Coordination & Public Awareness
Justification	Ensure wide spread public awareness of the Bioenergy sector and get the acceptance of the population
Description	Development of Policy and regulatory framework and coordination Develop Bioenergy Knowledge management program
Expected Outcome	Development of Bioenergy website for Liberia, provision of reliable data base and information dissemination staff; ensuring knowledge on diverse applications and fuel sources, Support policymaking studies to develop policies or measures needed to promote production and use of biofuels including incentives for the production of biofuels, infrastructure grants for improved equipment necessary for biofuel supply, and tax credits for selling higher biofuel and

	ensure sufficient supply; provide training on national and international standards
Target Population	Technology Operators and Policy makers on Bioenergy
Entity responsible for execution	MME, RREA and the Bioenergy Institution when created
Cost of the action	~USD 1344 thousands
Execution time	2023-2025

16.1.5. Policy guideline 4: Environment, Land Tenure and Social Equity

Action 6: Bioenergy Environment, Land Tenure and Social Equity	
Objective	Program on Environmental, Gender Mainstreaming &Social Impact Assessment for the BEAP
Justification	Bioenergy uses have major impacts on the health and the environment and the gender & social equity of Liberia, especially the majority rural population; Policymakers can consider local factors when determining service area and infrastructure placement in order to supply cost-effective bioenergy, and stakeholder participation
Description	Identification of land areas for bioenergy crops (fast growing fuelwood species, oil palm for biodiesel oil, sugarcane for ethanol, etc.); Municipal Waste Animal/Arbiter waste issues and potentials; Rudimentary cookstoves using solid fuels like wood, coal, crop residues and animal dung are inefficient, unhealthy, and unsafe, and inhaling the choking smoke and fine particles they emit lead to severe health problems and death. Traditional cookstoves also place pressure on ecosystems and forests and contribute to climate change through emissions of greenhouse gases and clack carbon. The targets set for improved cookstoves, require policies, equipment and programs to address these issues as the pressure on the environment is leading to general global impacts.
Expected Outcome	Unlock the potentials by removing the institutional, legal, financial, social, environmental and capacity gaps and barriers for Bioenergy development, improved and support clean energy access.
Target Population	Rural and Peri-Urban population households and Charcoal producers and cross sectors (climate change, water, health, economic and social development and private IPPs).
Entity responsible for execution	FDA, MME, RREA and EPA, IPPs and Energy Sector experts
Cost of the action	~USD 960 thousands
Execution time	2023-2030

16.1.6. Policy guideline 5: Financial Instruments

Action 7: Bioenergy Financial Instruments Development and Management	
Objective	Develop Bioenergy Financing Instruments for Liberia
Justification	Bioenergy programs are not currently funded and there is a need to ensure sustainability of bioenergy development and address the policy gaps and advancing the energy sector environmental,
Description	Financing new infrastructure over the long term financial requirements, e.g. through long-term repayment mechanisms, such support from public utilities, policymakers, RREA REFUND and Creation of Bioenergy development fund remittance from logging and agricultural companies mechanism; applying taxation strategies with percentage allocation for bioenergy and financial incentives supportive of biomass usage and manufacture of efficient devices (stoves, kilns, hybrid power equipment, etc.).
Expected Outcome	Sustainable funding sources for bioenergy development and climate change funding for effects on bioenergy systems; Instruments/solutions such as carbon credits for supplying new sources, bioenergy experts and infrastructure supply; Standards and Policies created, Implementation of IPPs funding; and manufacturing of new efficient kilns and stoves supported, Implementation and enforcing mechanisms for non-compliance including penalties such as fines or alternative payments by suppliers/implementers who fail to meet standards, smog, etc.; Enforcement of bioenergy development funds payment sources; Tax mechanisms for bioenergy development
Target Population	IPPs, Productive Bioenergy Industries support, availability of products on the market from sustainable production
Entity responsible for execution	MME, Legislature, Donor Institutions, Users, Energy sector Stakeholders, Bioenergy Industry
Cost of the action	~USD 1248 thousands
Execution time	2023-2030

16.2. Monitoring and follow-up on implementation

(a) The national contact point/authority responsible for the implementation, monitoring, evaluation and follow-up of the Bioenergy Action Plan shall be the Rural and Renewable Energy Authority (RREA) of Liberia and the Bioenergy Director to be appointed under the supervision of the MME.

(b) The monitoring system shall be as follows: A National Bioenergy Coordinating Committee (NBCC) shall be appointed comprising of the following institutions:

- MME Minister as Chairman; and
- Bioenergy Director as Secretary;
- RREA as member
- Ministry of Agriculture member
- Forestry Development Authority member
- Liberia Electricity Regulatory Commission
- EPA as member

The MME shall put in place the NBCC which shall hold regular quarterly meetings or other called meetings as the situation may demand. The Bioenergy Directorate shall make regular reports and shall submit annual reports to ECREEE to meet the ECOWAS Policy mandates. For the purpose of monitoring, the member institutions of the NBCC shall make quarterly reports on the projects and Bioenergy activities that are implemented with their jurisdictional authorization or within their operational mandates. The progress shall be indicated by the compilation of comprehensive data for each of the measures and targets specified utilizing appropriate data measurement criterions, deliverables and achievements for the implementation of the BEAP.

Action 8: Bioenergy Monitoring and Evaluation of the BEAP	
Objective	National Bioenergy Coordinating Committee (NBCC) Activities, Designing long-term contracts and guaranteeing grid access for IPPs involved in Bioenergy, etc.
Justification	Developing the Bioenergy Directorate and Monitoring and Evaluation of the BEAP policies, programs and activities; Coordinating, implementing and complementary policies and stakeholders.
Description	The NBCC will meet regularly and empower the implementation of the BEAP, resolving any barriers and discussing implementation targets, deliverables and coordination to ensure successful and sustainable progress of the programs, designing flexible mandates, etc. Resolving barriers including tax breaks. Developing differentiating feed-in-tariffs (FIT) payments based on project size, fuel type, and technology, limiting compliance and permits costs, designing mechanisms to

	measure and track bioenergy power generation, etc. for Bioenergy promotion.
Expected Outcome	Appointment of Focal Persons for each Institution with the appropriate mandates and support for the NBCC activities, Increasing mandates, for data provision, communication, reports, licensing and permits for biofuels, operators and providers.
Target Population	The NBCC member institution and Bioenergy Directorate and Staff support, periodic reports to the ECREEE, Viable Data base
Entity responsible for execution	MME, Bioenergy Directorate and Member agencies of the NBCC
Cost of the action	~USD 1104 thousand
Execution time	2023-2030

Action 9: Bioenergy Action Plan Reporting and Periodic Review	
Objective	Periodic Assessment and Evaluation of the BEAP
Justification	There will be a need for periodic review of the BEAP mandates and implementation progress by independent consultants that will make appropriate recommendations on gaps, prospects and appropriate changes where applicable.
Description	ECREEE and the GOL will acquire an appropriate consultant with the TOR to conduct a periodic review and report. The MME and Bioenergy Directorate will make periodic reports to the GOL and ECREEE.
Expected Outcome	Periodic Review Reports and sustainable progress for the action plan, Support to resolve barriers.
Target Population	Government, ECREEE and the implementers of the BEAP
Entity responsible for execution	MME, ECREEE and Donor funding
Cost of the action	~USD 1056 thousands
Execution time	2023-2030

*Numbering of actions depend on the number of actions and policy guidelines

CHAPTER 17 ARTICULATION WITH REGIONAL INITIATIVES

The ECOWAS region has a series of on-going regional initiatives in the field of renewable energy:

- The ECOWAS White Paper on a Regional Policy for Increasing Access to Energy Services in Peri-Urban and Rural Areas by 2015;
- Establishment of ECREEE;
- ECOWAS Renewable Energy Policy (EREP) with targets for 2020 and 2030;
- ECOWAS Energy Efficiency Policy (EEEP) with targets for 2020 and 2030
- The ECOWAS Bioenergy Strategy
- ECOWAS Bioenergy Policy and Implementation Plan (EBEP) with targets for 2020 and 2030
- WACCA (West Africa Clean Cooking Energy) Concept Note
- ECOWAS Policy on Gender Mainstreaming in Energy Services
- WACCA Regional Action Plan
- Consolidated National Renewable Action Plan (NREAP)
- Consolidated National Energy Efficiency Action Plan (NEEAP)
- SEforAll Action Agenda
- Country National Action Plan for Clean Cooking

Besides the activities in renewable energy, the ECOWAS region has also a series of on-going activities in energy access:

- West Africa Power Pool (WAPP) and the ECOWAS Revised Generation and Transmission Master Plan ;
- The West Africa Gas Pipeline (WAGP);
- ECOWAS Rural Electrification Projects.

Synergies between these regional initiatives and the proposed measures in this Plan will be created.

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ANNEX I: ACTION PLAN, BUDGETS AND TIMELINE

TOTAL BUDGET: $10,512,000 USD

Policy Guideline 1: Develop TOR and mandates of the Bioenergy Development Institute
Objective1 : Creation of implementation and management institution
Outcome 1: Appointment of a Bioenergy National Director and Mandate
Total 1 : 1,080,000 USD

Action	**Indicator**	**Calendar (Year, Quarter)**																**Budget**
		Year 1				**Year 2**				**Year 3**				**Year 4**				**USDx10^3**
		1		**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1,080**
1.1 Action 1	Training																	**240**
1.2 Action 2	Structuring																	**72**
1.3 Action 3	Regulations and Mandates																	**192**
1.4 Action 4	Coordination & Stakeholder outreach																	**192**
1.5 Action 5	Operations																	**384**

Policy Guideline 2: Bioenergy Resources, Technologies & Consumption Assessment **Objective 2:** Comprehensive assessment of the Bioenergy Sector **Outcome 2**: Production & Consumption Technologies and Recommendations **Total 2 : 1,128,000 USD**																		
Action	**Indicator**	**Calendar (Year, Quarter)**																**Budget**
		Year1				**Year2**				**Year 3**				**Year 4**				**USDx10^3**
		1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1,128**
2.1 Action 1	Resources Assessment																	**240**
2.2 Action 2	Technologies Assessment																	**168**
2.3 Action 3	Policies analysis and gaps																	**216**
2.4 Action 4	Resource base Mapping																	**216**
2.5 Action 5	Policy Alignment analysis																	**288**

Policy 3: Bioenergy Training Capacity Building and Technology Transfer **Total 3 :1,104,000 USD**																		
Action	**Indicator**	**Calendar (Year, Quarter)**																**Budget**
		Year1				**Year2**				**Year 3**				**Year 4**				**USDx10^3**
		1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1,104**
3.1 Action 1	ICS & Kilns																	**216**
3.2 Action 2	Biogas CB/TT																	**216**
3.3 Action 3	Biomass CB/TT																	**240**
3.4 Action 4	Biodiesel CB/TT																	**216**
3.5 Action	Bioethanol																	**216**

5																		
3.6 Action 6	Briquettes CB/TT																	**216**

Policy 4: Bioenergy Technology Demonstration Plots Program Total 4 : 1,488,000 USD																	
Action	**Indicator**	**Calendar (Year, Quarter)**															**Budget**
		Year1				**Year2**				**Year 3**				**Year 4**			**USDx10^3**
		1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1,488**
4.1 Action 1	**ICS & Kilns**																	**312**
4.2 Action 2	**LPG & S**																	**288**
4.3 Action 3	**Biogas**																	**288**
4.4 Action 4	**Briquettes**																	**288**
4.5 Action 5	**Biodiesel**																	**312**
4.6 Action 6	**Wood-Hybrid**																	**288**

Policy Guideline 5 : : Bioenergy Knowledge Management & Awareness Program Total 5 : 1,344,000 USD																		
Action	**Indicator**	**Calendar (Year, Quarter)**																**Budget USDx10^3**
		Year 1				**Year 2**				**Year 3**				**Year 4**				
		1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1,344**
5.1 Action 1	Website Development																	**288**
5.2 Action 2	Staff Knowledge																	**288**
5.3 Action 3	Policy Studies																	**312**
5.4 Action 4	BE Equipment																	**240**
5.5 Action 5	Standards Development																	**216**

Policy Guideline 6 :Bioenergy Environment, Land Tenure and Social Equity Total 6 : 960,000 USD																		
Action	**Indicator**	**Calendar (Year, Quarter)**																**Budget USDx10^3**
		Year 1				**Year 2**				**Year 3**				**Year 4**				
		1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**960**
6.1 Action 1	Land Identification																	**336**
6.2 Action 2	Municipal & Animal/Arbiter Waste																	**192**
63 Action 3	Bioenergy Climate Change Mitigation																	**240**
6.4 Action 4	Policy Issues Resolution																	**192**
6.5 Action 5																		

Policy Guideline 7:Bioenergy Financial Instruments Development and Management Total 7 : 1,248,000 USD																		
Action	**Indicator**	**Calendar (Year, Quarter)**																**Budget**
		Year 1				**Year 2**				**Year 3**				**Year 4**				**USDx10^3**
		1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1,248**
7.1 Action 1	Infrastructure Financing																	**288**
7.2 Action 2	Bioenergy FUND creation																	**216**
7.3 Action 3	Funding Strategy Development																	**192**
7.4 Action 4	Enforcement																	**360**
7.5 Action 5	Industry Development																	**192**

Policy Guideline 8: Bioenergy Monitoring and Evaluation of the BEAP Total 8 : 1,104,000 USD																		
Action	**Indicator**	**Calendar (Year, Quarter)**																**Budget**
		Year 1				**Year 2**				**Year 3**				**Year 4**				**USDx10^3**
		1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1,104**
8.1 Action 1	NBCC Meetings																	**384**
8.2 Action 2	Barriers Resolution																	**192**
8.3 Action 3	Data Collection																	**192**
8.4 Action 4	Tracking Bioenergy																	**144**
8.5 Action 5	Policy Measures																	**192**

Policy Guideline 9:Bioenergy Action Plan Reporting and Periodic Review Program Total 9: 1,056,000 USD																	
Action	**Indicator**	**Calendar (Year, Quarter)**															**Budget USDx10^3**
		Year 1				**Year 2**				**Year 3**				**Year 4**			
		1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1,056**
9.1 Action 1	NBCC Empowerment																	**192**
9.2 Action 2	Barriers Research																	**192**
9.3 Action 3	Differential FIT Policy Development																	**192**
9.4 Action 4	Tracking Bioenergy																	**264**
9.5 Action 5	Reporting & Publications																	**216**

PROJECT NO.	**AMOUNT IN $USDX10^3**
1	1,080
2	1,128
3	1,104
4	1,488
5	1,344
6	960
7	1,248
8	1,104
9	1,056
TOTAL	**$10,512**

CONCLUSION

In other for Liberia to develop sustainable and efficient Bioenergy services without compromising its development and socioeconomic progress, it is necessary to develop appropriate and adequate policy instruments for Bioenergy and adopt policies to promote a modern, sustainable and vibrant bioenergy sector in Liberia.

It has been observed from the baseline situation that Liberia currently has a number of policy gaps and government financial constraints, and there is limited manpower capacity in bioenergy sector technologies, limited private sector involvement and the unawareness of the local communities in using new efficient biomass technologies for household, agricultural processes and industrial processing of wastes and residues for energy.

The ECREEE Bioenergy Policy includes minimum targets and scenarios for bioenergy, measures, standards and incentives to be implemented. Following our analysis of the Baseline Situation for Liberia and the various growth rates over the study period, revealed Liberia's challenges in achieving the expected targets and the below table presents comparison of the ECOWAS Targets expected for Liberia to achieve by 2030 with the current growth rates versus the calculated achievable targets by 2030 proposed for Liberia's BEAP.

The table 68 below presents some recommendations:

Table 68: Recommendations

Some BEAPs Recommendations	Policymakers	Liberian Institutions	Donors and Development Partners
- Develop realistic, implementable solutions that address energy access from Bioenergy competitively; - Improved value-addition capabilities in the production and develop renewable energy export sector; - Broad-ranging policy for bioenergy sector institutional development and technical capacity development and support for experts in	- Stakeholder involvement BEAP model of the bioenergy action plan underlines the Liberian ownership and political will for the implementation of the BEAP; - The BEAP Provides an instrument for periodic review, reporting, monitoring and adapting national policies to insure sustainability; - The BEAP is	- Comprehensive assessment of the Bioenergy Sector and Potentials, which is especially important for the energy & environment; - Close cooperation with: • Policymaking bodies, • Bioenergy energy services providers, and • Technology, equipment and technical services providers. - The baseline analysis has identified policy and technological gaps, as	- A robust needs assessment for development partners to ensure alignment and support Liberia-based program; - Activities in each Plan of Action to be converted into projects to be implemented and supported by development partners; - Alignment with existing development activity is ensured and

the energy sector; - Cross-sector focus of the energy development programs and provide assistance for climate change co-benefits beyond current baseline concerns for the energy sector.	aligned with the sustainability of the resource base and builds upon existing national policies and development plans, thus ensuring coherence of targets with future needs.	well as opportunities for solutions to develop a major bioenergy sector and standardized sustainable implementation of energy services through the BEAP for Liberia.	reflected in the Plans of Action of the energy sector of Liberia and cross sectors (climate change, economic and social development and private IPPs).

ANNEX 1 - DEFINITION OF TERMS USED IN THE ACTION PLAN

Agro-fuels: Solid biofuels obtained from crops, and residues from crops and other agricultural products. Residues from agricultural production include animal solid excreta, meat and fish residues. Agro-fuel is subdivided into bagasse, animal wastes and other biomass materials and residues (check definitions for bagasse, animal wastes and other agricultural residues).

Animal waste: Excreta of animals which, when dry, are used directly as a fuel. This excludes waste used in anaerobic fermentation plants. Fuel gases from these plants are under biogases (see biogas).

Bagasse: the fuel obtained from the fibre which remains after juice extraction in sugar processing

Biofuels: liquid or gaseous fuel for transport produced from biomass.

Other vegetable material and residues: biofuels not specified elsewhere and including straw, vegetable husks, ground nut shells, pruning brushwood, olive pomace and other wastes arising from maintenance, cropping and processing plants.

Solid biofuels: solid fuels derived from biomass.

Liquid biofuels: Liquids derived from biomass and generally used as fuels. Liquids biofuels comprise bio-gasoline, biodiesel and other liquid fuels (definitions of biogasoline, biodiesel and other liquid fuels are provided below).

Bio-gasoline: Liquid fuels derived from biomass and used in spark-ignition internal combustion engines. Common examples are: bioethanol; biomethanol; bio ETBE (ethyl-tertio-butyl-ether); and bio MTBE (methyl-tertio-butyl-ether).

Biodiesel: Liquid biofuels which are usually modified chemically so that they can be used as fuel in engines either directly or after blending with petroleum diesel. Biological sources of biodiesel include, but are not limited to, vegetable oils made from canola (rapeseed), soybeans, corn, oil palm, peanut, or sunflower. Some liquid biofuels (straight vegetable oils) may be used without chemical modification their use usually requires modification of the engine.

Biodiesel as a share of diesel and fuel-oil consumption (in %): The EREP sets conventional biofuels targets (1st Generation Biofuels) for the ECOWAS region as a whole, one of which is the biodiesel as a share of diesel and fuel oil consumption. In this template this is calculated by dividing the production of raw vegetal oil/biodiesel by the diesel oil/DDO/fuel oil consumption in the country.

Straight vegetable oil: When vegetable oil is used directly as a fuel, in either modified or unmodified equipment, it is referred to as straight vegetable oil (SVO) or pure plant oil (PPO).

Other liquid biofuels: liquid biofuels not elsewhere specified.

Biogas: gases arising from anaerobic fermentation of biomass. These gases are composed principally of methane and carbon dioxide and comprise landfill gas, sewage sludge gas and other biogases (check definitions for landfill gas, sewage sludge gas and other biogases). They are used mainly as a fuel but can be used as a chemical feedstock. It is particularly relevant for cooking purposes or in the context of industrial uses (e.g. breweries, slaughter houses).

Landfill gas: biogas from anaerobic fermentation of organic matter in landfills.

Sewage sludge gas: biogas from anaerobic fermentation of waste matter in sewage plants.

Other biogases: biogases not elsewhere specified including synthesis gas produced from biomass.

Biomass: biodegradable fraction of products, waste and residues from biological origin from agriculture (including vegetal and animal substances), forestry and related industries including fisheries and aquaculture, as well as the biodegradable fraction of industrial and municipal waste. The uses of biomass for energy are very diverse: from the traditional, low-efficiency burning of wood in open fires for cooking purposes to the more modern use of wood pellets for the production of power and heat, and the use of biodiesel and bioethanol as a substitute for oil-based products in transport.

Large hydro power is an important renewable energy source for the provision of base load in the ECOWAS region. The significance will grow with the implementation of the WAPP hydropower project pipeline.

Charcoal: The solid residue from the carbonisation of wood or other vegetal matter through pyrolysis. The amount of biomass (usually fuelwood) necessary to yield a given quantity of charcoal depends mostly on three factors:

- Parent wood density – the principal factor in determining the yield of charcoal from fuelwood is parent wood density, since the weight of charcoal can vary by a factor of 2 for equal volumes
- Moisture content - moisture content of the wood also has an appreciable effect on yields - the drier the wood, the greater is the yield - ; and
- The means of charcoal production: charcoal is produced in earth-covered pits, in oil drums, in brick or steel kilns and in retorts. The less sophisticated means of production generally involve loss of powdered charcoal (fines), incomplete carbonization of the fuelwood and combustion of part of the charcoal product, resulting in lower yields.

Traditional non-efficient charcoal production methods: traditional charcoal production methods include open pits, oil drums and kilns with lower efficiencies. In the ECOWAS charcoal is mainly produced by traditional methods in the informal sector

(e.g. open pits and kilns) which are inefficient (60-80% of the energy in the wood is lost) and has impacts on the health and on the environment.

Efficient charcoal production: efficient charcoal is the terminology used on this template for the charcoal produced by modern methods that are more efficient than traditional ones. The modern methods use sealed containers and have higher efficiencies and thus higher yields. Within the EREP, under the targets for domestic cooking, a target for efficient charcoal production is set: 60%/100% of the charcoal production should be by improved carbonisation techniques (yield >25% in 2020 and 2030, respectively. In this template the MS is asked to set out its target and trajectory for efficient charcoal production. This is calculated by dividing the quantity of charcoal produced by improved carbonisation techniques with yield superior to 25% in tonnes by the total charcoal production in tonnes.

Conservation: The reduction of energy usage through increased efficiency and/or reduced waste.

DDO: stands for Distillate Diesel Oil

Distributed and Microgeneration: This is when electricity is generated for local distribution and is not connected directly to the national grid. Microgeneration is typically used to describe smaller scale generating technology.

Energy Efficiency appliances: Electrical devices or appliances that perform their task, and use less electricity than lower-efficient devices. Electrical inefficiency in many devices is directly related to the heat they produce. For example, energy efficient light bulbs use most of the incoming electrical energy to produce light, not heat. Inefficient air conditioning is a major cause of peak hours in the ECOWAS region.

Electricity: The transfer of energy through the physical phenomena involving electric charges and their effects when at rest and in motion. Electricity can be generated through different processes: e.g. by the conversion of energy contained in falling or streaming water, wind or waves or by the direct conversion of solar radiation through photovoltaic processes in semiconductor devices (solar cells); or by the combustion of fuels.

Electricity demand: The total electricity consumption in GWh or MWh consumed by a country annually. This includes the demand of the complete system including the in circuital consumption and the losses.

Electricity mix: The range of energy sources of a region/country (either renewable or non-renewable) that is used to produce electricity,

Energy access: A universal and affordable access to modern means of energy. It implies access to modern cooking solutions defined as relying primarily on non-solid fuels for cooking. It also implies access to electricity, defined as availability of an electricity connection at home or the use of electricity as the primary source of lighting that can provide non-served communities and households with a modern life and economic development.

Energy Efficiency: the ratio of performance or output of performance of services, goods or energy to input of energy. The energy efficiency of a process is improved if

it produces the same service using less energy. Energy-efficient light bulbs produce the same amount of light but use up to 75% less energy to do so. Improving energy efficiency helps reducing energy use or bringing more energy services with the same amount of energy consumed.

Ethanol: also called ethyl alcohol, pure alcohol, grain alcohol or drinking alcohol, is a volatile, flammable, colourless liquid that can be used for several different purposes, being one of them as fuel. As fuel, ethanol is used as a motor fuel and fuel additive (e.g. Brazil relies in Ethanol as a motor fuel). Ethanol is also used for household heating as a relatively safe fuels.

Ethanol as share of gasoline consumption: The EREP sets first generation biofuels targets for the ECOWAS region as a whole, one of which is the ethanol as a share of the gasoline consumption. This is calculated by diving the quantity of ethanol produced by the quantity of gasoline consumed in the country and it is show in %.

Fossil Fuel: An energy source formed in the Earth's crust from decayed organic material. The common fossil fuels are oil, diesel, coal, and natural gas. Some ECOWAS countries are highly dependent on diesel electricity generation.

Fuelwood, wood residues and by-products: fuelwood or firewood obtained from natural or managed forests or isolated trees. Also included are wood residues used as fuel and in which the original composition of wood is retained. In the ECOWAS region fuelwood is the principal source of energy for cooking and heating, however statistics on fuelwood are generally poor as it is mainly produced and traded in the informal sector.

Grid-connected: a system (photovoltaic, hydro, diesel, etc.) that is connected to a centralised electrical power network (power grid).

Generation (electricity): This covers the production of electricity at power stations.

Heat: Heat is an energy carrier primarily used for warming spaces and industrial processes

Hybrid System: a power system consisting of two or more power generating subsystems (e.g. combination of a wind turbine or diesel generator and a photovoltaic system)

Improved cookstoves (ICS): (also called clean/efficient cookstoves): is a device that is designed to consume less fuel and save cooking time, convenient in cooking process and creates smokeless environment in the kitchen or reduction in the volume of smoke produced during cooking against the traditional stove; and thus addressing he health and environmental impacts associated with traditional cookstoves. Traditional cookstoves (open fires and rudimentary cookstoves using solid fuels like wood, coal, crop residues and animal dung) are inefficient, unhealthy, and unsafe, and inhaling the acrid smoke and fine particles they emit leads lead to severe health problems and death. Traditional cookstoves also place pressure on ecosystems and forests and contribute to climate change through emissions of greenhouse gases and clack carbon. Within the EREP targets are set for improved cookstoves, as the pressure on the ECOWAS woodland will grow exponentially. Thus the policy includes the banning of inefficient stoves after 2020, enabling 100%

of the population of the urban areas to use high efficient wood and charcoal stoves (with efficiencies higher than 35%) from 2020 onwards and 100% of the rural population to use high efficient charcoal stoves from the same date on. In this template the MS is asked to set a target for improved cookstoves measured in terms of the % of the population that uses efficient cookstoves. This is estimated by dividing the number of inhabitants that use improved cookstoves by the total number of inhabitants of the country.

Installed capacity: is the rated continuous load-carrying ability of a given electricity generation plant expressed in megawatts (MW) for active power, for example:

- Kilowatt (kW): 1,000 watts
- Kilowatt-hour (kWh): 1,000 watt-hours.
- Load: In an electrical circuit, any device or appliance that uses power (such as light bulb or water pump)
- Megawatt (MW): 1,000,000 watts
- Megawatt-hour (MWh): 1,000,000 watt-hours

Mini-grids: set of electricity generators and, possibly, energy storage systems interconnected to a distribution network that supplies the entire electricity demand of a localized group of customers. This power delivery architecture can be contrasted with single customer systems (e.g. solar home systems) where there is no distribution network interconnecting customers, and with centralized grid systems, where electrical energy is transmitted over large distances from large central generators and local generators are generally not capable of meeting local demand. Mini-grids are particularly relevant in the rural context of ECOWAS where renewable energy powered hybrids can be the more cost-effective alternative. The EREP includes mini-grid targets.

Modern fuel alternatives (for cooking): known as non-conventional or advanced fuels, these are any materials or substances that can be used as fuels for cooking, other than conventional solid fuels such as coal, fuelwood and charcoal. These alternatives cover Liquefied petroleum gas (LPG), biogas, ethanol, and solar power (e.g. solar cookers). In this template improved cookstoves are not considered within the modern fuel alternatives, as they are object of a separate analysis in this template.

Off-grid applications: is a designation for facilities that produce all their own energy and are not connected to any external source, such as the electrical power grid.

Power grid: a system of high-tension cables by which electrical power is distributed throughout a region

Renewable Energy (RE): ‘Renewable energy’ is used to describe the energy produced using naturally replenishing resources. This includes solar power, wind, geothermal, bioenergy, wave and tide and hydropower.

Renewable energy sources – in this template the renewable energy sources refer to the following renewable energy technologies:

- **Hydropower which includes:**
    - Small scale hydropower (small-hydro or SSHP) up to a maximum installed capacity of 30 MW;
    - Medium (capacity between 30MW and 100MW) and large hydropower (capacity higher than 100MW);

In the EREP hydropower is defined as follows: up to 30 MW small-scale, 30 to 100 MW medium-scale, more than 100 MW large-scale.

- **Bio-energy covering three different fields:**
    - Woodfuels (firewood and charcoal) used for domestic cooking purposes and commercial applications (restaurants, breweries, potteries, blacksmiths, brick makers). Excess woodfuels resources could be used for power generation with other biomass.
    - By-products from crops production for power generation (stalks, straw, husks, shells, kernels, etc.). These can serve as fuel for power generation when gathered together on an agro-industry site. Power can also be generated through biogas production using industrial or urban waste, manure and dung (resource concentration at dairies or slaughter houses or cattle and vegetable markets).
    - Energy crops for power generation or sustainable biofuels (e.g. sugar processing waste) offer some interesting perspectives.

Bioelectricity share in the electricity mix: - is the share of bioelectricity generation in the total electricity generation for a given year, measured in %. This is calculated in the template by dividing the electricity production from renewable energy sources (in MWh/year) by the total electricity production (in MWh/year) – renewable and non-renewable for the same year.

Rural Electrification: Provides a regular supply of electricity to rural residents. It implies the extension of power lines to rural areas, or the use of stand-alone, mini-grids or isolated power systems. The EREP includes targets for rural electrification.

Share of rural population served with off-grid (mini-grids) bioelectricity services: this is the percentage (%) of the rural population as defined above that is served with bioelectricity mini-grids. This is calculated by dividing the number of inhabitants served by bioelectricity off-grid applications by the number of rural inhabitants (as defined above).

Rural communities: These includes population living in rural centres and villages with population between 200 and 2,500 inhabitants and some larger cities that due to its peripheral geographical location are away from the national grid. The EREP refers as well that some of the off-grid rural localities supplied before 2020 might be included in the grid extension as they will potentially grow up.

Solar cookers: or solar oven, is a device which uses the energy of direct sun rays (which is the heat from the sun) to heat, cook or pasteurize food or drink.

Support scheme: means any instrument, scheme or mechanism applied by a Country or group of Countries, that promotes the use of energy from renewable sources by reducing the cost of that energy, increasing the price at which it can be sold, or increasing, by means of a renewable energy obligation or otherwise, the volume of such energy purchased. This includes, but is not restricted to, investment aid, tax exemptions or reductions, tax refunds, renewable energy obligation support schemes including those using green certificates, and direct price support schemes including feed-in tariffs and premium payments.

Some support schemes for renewable energy:

- **Production based incentives:**
    - Feed-in-Tariff ("FIT"): is an energy supply policy that promotes the deployment of renewable energy resources. A FIT offers a guarantee of payments to renewable energy producers for the actual electricity produced ($/kWh). These payments are generally awarded as long-term contracts.
    - **Quota system**: is an energy supply policy that awards the generator with certificates that can be sold into a market (with no price guarantee)
    - **Quota systems with competitive bidding**: is the fixation of mandatory production quotas for green electricity supply. These quotas are imposed on power generating utilities and / or electricity distribution utilities (calculated as a percentage of production/sales). Operators can meet these obligations in three ways: (i) by producing their own green electricity, (ii) by buying the electricity under long term contracts, and (iii) by acquiring on the financial market the "Green Certificates" corresponding to the amount of electricity required.
    - **Decentralized quota system with green certificate market also called tradable green certificates (TGC):** is the fixation of mandatory production quotas for green electricity supply. These quotas are imposed on power generating utilities and / or electricity distribution utilities (calculated as a percentage of production/sales). Operators can meet these obligations in three ways: (i) by producing their own green electricity, (ii) by buying the electricity under long term contracts, and (iii) by acquiring on the financial market the "Green Certificates" corresponding to the amount of electricity required.
- **Investment based incentives**
    - **Capital grants and loans**: investment instruments in which government provide grants or loans for the development of renewable energy projects. Grants do not have to be repaid, while loans have to be repaid.
    - **Microcredits:** is the extension of very small loans (microloans) to impoverished borrowers who typically lack collateral, steady employment and a verifiable credit history.
    - **VAT Exemptions**: allows households or investors not to have to pay VAT on renewable energy or energy efficiency equipment

Watt-hour (Wh): a measure of electric energy equal to the electrical power multiplied by the length of time (hours) the power is applied.

Waste: in energy statistics waste refers to the part of the waste that is incinerated with heat recovery at installations designed for mixed wastes or co-fired with other fuels. The heat may be used for heating or electricity generation. Certain wastes are mixtures of materials of fossil and biomass origin.

Industrial waste: non-renewable waste which is combusted with heat recovery in plants other than those used for the incineration of municipal waste. Examples are used tires, specific residues from the chemical industry and hazardous wastes from health care. Combustion includes co-firing with other fuels. The renewable portions of industrial waste combusted with heat recovery are classified according to the biofuels which best describe them.

Municipal waste: Household waste and waste from companies and public services that resembles household waste and which is collected at installations specifically designed for the disposal of mixed wastes with recovery of combustible liquids, gases or heat. Municipal wastes can be divided into renewable and non-renewable fractions.