Republic of Liberia

United Nations Development Programme (UNDP)

UNDP Global Project: Capacity Development for Policy Makers to Address Climate Change

Assessment of Investment and Financial Flows to Mitigate Climate Change in the Energy Sector in Liberia

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Investment and Financial Flows to Address Climate Change UNDP Global Project

Climate Change poses significant challenges to development and policy makers are faced with complex tasks to respond to them and to ensure sustainable development. Particularly in Least Developed Countries decision makers have to balance poverty alleviation, economic development as well as social and environmental questions, while also questions of costs that occur with associated policies and measures play a vital role.

To better understand the magnitude of funds needed to tackle climate change now and in the long term, developing countries are undertaking assessments of investment and financial flows (I&FF) to address climate change for key sectors in a groundbreaking UNDP Environment & Energy Group project: Capacity Development for Policy Makers to Address Climate Change.

Liberia is one of 19 countries participating in this project, which was launched in May 2008 with the generous contributions of the Government of Norway, Government of Finland, Government of Switzerland as well as the UN Foundation and UNDP.

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Acronyms and Abbreviations

BRE	Buchanan Renewable Energies
CBL	Central Bank of Liberia
CDM	Clean Development Mechanism
CSET	Center for Sustainable Energy Technology
ECOWAS	Economic Community of West African States
EPA	Environmental Protection Agency
EPP	Emergency Power Program
GDP	Gross Domestic Product
Gg	Gigagram
GHGs	Greenhouse Gases
GOL	Government of Liberia
IPPs	Independent Power Producers
LDCs	Least Developed Countries
LEC	Liberia Electricity Corporation
LPG	Liquefied petroleum Gas
LPRC	Liberia Petroleum Refining Company
MDGs	Millennium Development Goals
MLME	Ministry of Lands, Mines and Energy
MOCI	Ministry of Commerce and Industry
NACUL	National Charcoal Union of Liberia
NAPA	National Adaptation Programme of Action
NEC	National Energy Committee
NEP	National Energy Policy
NIC	National Investment Commission
NOCAL	National Oil Company of Liberia
NPHC	National Population and Housing Census
NREL	National Renewable Energy Laboratory
ODA	Official development Assistance
PPA	Power Purchase Agreement
PRS	Poverty Reduction Strategy
REFUND	Rural Energy Fund
RETs	Renewable Energy Technologies
RREA	Rural and renewable Energy Agency
SMEs	Small and medium Enterprises
SOE	State of the Environment Report
TJ	Terajoule
UNFCCC	United Nations Framework Convention on Climate Change
USTDA	United States Trade and development Agency
WAPP	West African Power Pool

Executive Summary

Sectoral Scope

This energy sector I&FF assessment report covers the following supply and demand side areas in both the baseline and mitigation scenarios for all three investment entities - households, corporations and government:

- Lighting
- Cooking, Heating, Cooling and Motive Power
- Charcoal Production
- Renewable Energy.

The above named areas consider domestic, commercial and industrial energy production and consumption. Electric and non-electric equipment and appliances are included.

Significance of Sectoral Scope

The energy market in Liberia is dominated by refined imported petroleum products, fuel wood and charcoal. The market for petroleum products is formal in nature while that of woody biomass is informal. The production of fuel wood and charcoal is also an important source of employment and sale of these goods is a source of supplemental income for many low income and poor families. In some cases, it supplements as much as 40 per cent of their total income (SOE, 2006). There is currently no reliable and sufficiently disaggregated data on the overall energy mix of Liberia from the production and consumption perspectives, including economic indicators such as its share of employment, contribution to GDP, fiscal revenues, trade and food security.

In Liberia, as in nearly all Sub-Saharan African countries, biomass, petroleum products, and electricity are widely used in the energy sector for a variety of applications such as domestic cooking and heating, lighting, transportation, motive power, and manufacturing. Annual consumption of woody biomass was estimated at about 10.8 million m^3 (CSET, 2004) for fire wood, and 36,500 tons (NACUL, 2005) for charcoal. The LEC increased its energy generation from 2,045,644 kW in 2006 to 19,554,334 kWh in 2009 with a total cumulative energy generation of 42, 672,158 kWh for the period. Petroleum products consumption for 2008 was equivalent to about 8,450 TJ of energy (LPRC, 2008).

The energy sector is a major driving force for nearly all socio-economic activities in Liberia because it underpins the delivery of basic social services and industrial production. Some of the key services that are inherently linked to the energy sector include transportation, electricity, communications, agriculture and fishery, health, education, and tourism. Besides its share of about 0.8% (CBL, 2008) of the overall gross domestic product (GDP) of Liberia as a sector, energy also contributes to employment, trade, fiscal revenues, food security, and regional and sub-regional development. For instance, Liberia is a member of the West African Power Pool (WAPP) which is aimed at creating an integrated energy market in ECOWAS states.

The unsustainable production and use of woody biomass energy also contributes to environmental degradation.

Base Year and Assessment Period

The base year for this assessment is 2005 and the assessment covers the period 2005-2030.

Mitigation Measures

Energy efficiency is one of two major mitigation options recommended in this assessment. Lighting, cooking/heating/cooling/motive power, and charcoal production were prioritized as efficiency measures for this assessment. Perusal of Table 11 indicates that Investment in these efficiency measures amounts to US$1.347 billion, of which efficient lighting is largest, accounting for 70% (US$946.51 million). This is followed by efficient cooking/heating/cooling/ motive power at 29% (US$385.93 million), and just 1% for improved charcoal production at US$14.61 million.

The other major option, renewable energy, accounts for the highest level of investments required to mitigate climate change in the energy sector. Investments in renewable energy, mainly hydro, followed by biomass plants and solar energy technologies, account for 50% (US$1.369 billion) of all investments, the largest of which will occur in 2011 and 2012 at US$ 124.61 million and US$113.70 million. See Table 11.

Summary of Results

The baseline scenario costs were subtracted from the mitigation scenario costs to obtain the changes or additionality. This was done for cumulative and annual IF, FF, and O&M costs. The tables generated from the calculations are Table 10 and Table 11. Total cumulative changes in IF&FF including O&M (Table 10) is US$1.297 billion of which investments in renewable energy and efficient lighting account for 44% (US$567.16 million) and 38% (US$493.07 million) respectively for the assessment period (2005-2030). More investments are therefore required in the above two subsectors. Equally significant are investments in improved cooking/ heating/ cooling/motive power methods, which account for 14 % (US$179.36 million), and efficient charcoal production, which amounts to 4% (US$ 57.73 million). Table 10 provides a detailed illustration of the incremental cumulative discounted estimates.

For incremental annual IF, FF and O&M (as seen in table 11 below), the total for all investment types is US$2.716 billion over the entire assessment period. Similarly, renewable energy investment accounts for about 50% (US$1.369 billion) of the total, followed by investment in efficient lighting at 35% (US 946.51 million). Investments in improved cooking/heating and efficient charcoal production methods account for only 14% (US$385.94 million) and 1% (US$ 14.6 million) respectively. These figures further confirm that investments in renewable energy and lighting are more required and collectively account for the largest portion of incremental annual investments in this report. The largest investments are expected to occur in 2011 at US$204.35 million and 2012 at US$189.44 million.

Policy Implications

The policy objectives are to:

- Promote energy efficiency measures; and,
- Increase the renewable energy portfolio in the national energy menu or mix.

The analysis of the policy implications is guided and informed by the table in the I&FF Methodology document entitled: Potential Policy Options to Encourage GHG Mitigation in the Energy Sector. Having assessed the I&FF in Liberia's energy sector in order to address climate change in the country, it is important to highlight some key policy implications which should induce the necessary changes consistent with the recommended mitigation measures.

Firstly, the Cabinet-approved National Energy Policy of Liberia (NEP) should be passed into law as the legal platform to achieve the necessary changes. Besides the issue of energy access, quality, standard and cost mentioned in the NEP, the establishment of the legal and regulatory framework as outlined in the policy is crucial. The policy mentions the restructuring of the Ministry of Land, Mines and Energy (MLME) by upgrading the energy section to a Deputy Ministerial level. The NEP also recommends the establishment of an Energy Regulatory Board (ERB), the Rural and Renewable Energy Agency (RREA), the Rural Energy Fund (REFUND), the unbundling of the LEC and the reform of LPRC and NOCAL. The RREA is already established and being currently run with GOL and donor assistance.

Investment in energy efficient products and services, will require massive nation-wide awareness and sensitization targeting different categories of end-users (households, commercial and institutional facilities), financial advisory services to banking and other financial institutions for loans to energy enterprises investing in the provision of efficient energy products and services. This should also be buttressed or complemented by enforcing the use of energy efficient equipment and providing tax incentives to importers of such products. Key energy efficient products include compact fluorescent lamps (CFLs) for lighting; liquefied petroleum gas (LPG), improved charcoal cook- stoves, solar cookers, and efficient charcoal kilns for charcoal production. Other energy efficient domestic, commercial and industrial equipment for the aforementioned energy services as well as for motive power will induce the necessary changes or additionality mentioned in the assessment.

In order to realize the potential of end-use energy efficiency improvements, appropriate targets for every five years should be set up to 2030. Setting such targets will be consistent with the NEP and the Poverty Reduction Strategy PRS), which strive, among other things, to reduce poverty by providing access to modern energy services in rural and peri-urban areas. End-use energy efficiency norms, legislative and regulatory considerations should be integrated into national energy policy and planning. Building capacity is critical to the formulation of energy efficiency policy and regulation, the establishment of standards and norms, the promotion and implementation of plans and programs at national and local levels. Equally significant is disseminating the requisite information and knowledge needed to deploy appropriate energy-efficient technology options.

On the basis of national circumstances and needs, agreed standards and labeling criteria should be established. Investment entities will need to use innovative business and financing mechanisms to promote standards and labels.

Policy to induce energy production, using renewable energy technologies as Liberia is endowed with potential renewable energy resources such as solar, biomass and hydro, will significantly contribute to mitigating climate change. The current alternatives are inefficient, costly, and unreliable and contribute to the emissions of carbon and other greenhouse gases, which are the major causes of global warming or climate change. Raising awareness of the issues, involving all investment entities and the public in general with the aim of increasing access, use, and investment in renewable energy will help promote climate change mitigation over the period under review.

In addition to the establishment of the legal and regulatory framework, there are other key policies important in mitigating climate change. Private investment should be attracted in the energy sector through technology transfer, fiscal and tax incentives. Needed is building local capacity through training in clean and efficient energy technology applications as well as developing and expanding the country's emerging fledgling energy market through public and private partnership.

The contribution of renewable energy in the national primary energy mix should be progressively increased during the remaining years of the assessment period (2011-2030.)

General Policy Implications

Some general issues must be prioritized that are crucial to climate change mitigation in the energy sector. Firstly, there should be annual national budgetary allocation to climate change activities for both adaptation and mitigation. The Government of Liberia (GOL), through the EPA, should put in place monitoring mechanism for climate change activities. In addition, effective enforcement mechanisms for environmental laws should be developed at national, county and local levels in a coordinated manner (e.g. County inspectors). Furthermore, training and research on climate change issues should be prioritized.

Importantly, there should also be an improved and effective inter-ministerial, agency and local government coordination regarding climate change mitigation issues and challenges.

Public awareness about GHG emissions in simple English and local languages should be implemented in the print, broadcast and folk media channels. These could be in the forms of radio/TV messages, jingles, drama as well as other information education communication/behavioral change communication (IEC/BCC) materials and messages for posters, flyers, billboards, wall writing, etc.

The Government should raise community awareness (conduct regional workshops), ensure development and implementation of regulations on charcoal production and keep promoting sustainable alternatives.

Significant Uncertainties and Methodological Limitations

No mechanism (database system) is yet available to record, monitor and measure progress or development in Liberia's energy sector. Therefore, data paucity which was and still is a major constraint, led to projections made over the assessment period after obtaining data for only a few years. Annual projections made for the assessment period were based on population growth rates.

Due to lack of adequate data, the assessment did not include the calculations and estimates of projections in respect of annual carbon emissions, energy produced and consumed over the assessment period for the various scenarios.

The setting up of a standard energy sector development database system may help reduce significantly these uncertainties and limitations, leading to a more improved future assessment of investment and financial flows.

Table 1: Incremental Cumulative (2005-2030) Discounted Energy Sector IF & FF for All Investments in the Energy Sector, by Investment Entity and Funding Source (million 2005 US$)

Category of Investment Entity	Source of I&FF Funds		Mitigation	
			∆IF	∆FF
Households	Domestic	Equity and debt		
	Total Household Funds (all domestic)		802.35	80.24
Corporations	Domestic	Domestic equity (including internal cash flow)		
		Domestic borrowing (bonds and loans)		
		Total Domestic Sources		
	Foreign	Foreign direct investment (FDI)		
		Foreign borrowing (loans)		
		Foreign aid (ODA)		
		Total Foreign Sources		
	Total Corporation Funds		30.80	3.08
Government	Domestic	Domestic funds(budgetary)		
	Foreign	Foreign borrowing (loans)		
		Bilateral foreign aid (bilateral ODA)		
		Multilateral foreign aid (multilateral ODA)		
		Total Foreign Sources		
	Total Government Funds		127.82	12.78
Total Funds			**960.98**	**96.10**

Chart 1: Incremental Cumulative Discounted

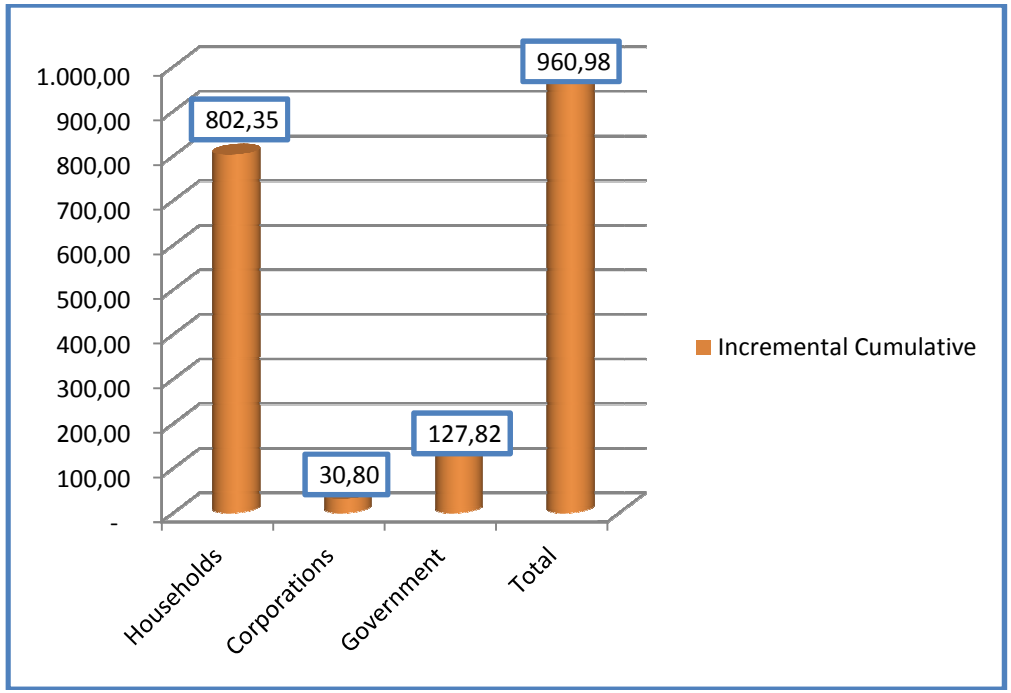
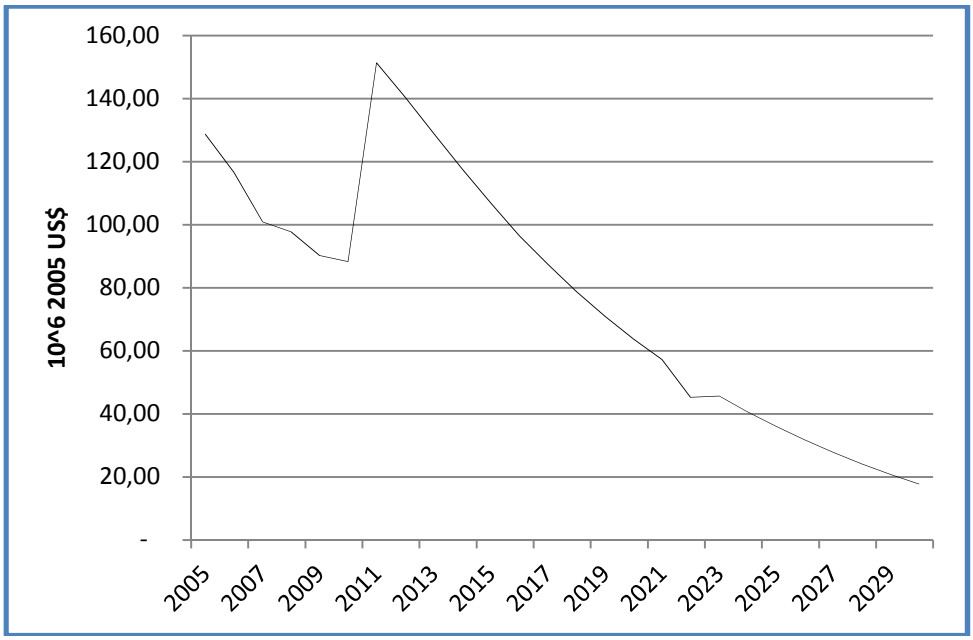


Table 2: Incremental Annual Energy Sector IF & FF for All Investments in the Energy Sector (million 2005 US$)

Year	∆IF	∆FF
2005	128.65	12.86
2006	116.47	11.65
2007	100.90	10.09
2008	97.73	9.77
2009	90.27	9.03
2010	88.27	8.83
2011	151.37	15.14
2012	140.33	14.03
2013	128.94	12.89
2014	117.68	11.77
2015	106.91	10.69
2016	96.56	9.66
2017	87.34	8.73
2018	78.80	7.88
2019	70.96	7.10
2020	63.78	6.38
2021	57.21	5.72
2022	45.24	4.52
2023	45.69	4.57
2024	40.63	4.06
2025	35.99	3.60
2026	31.73	3.17
2027	27.80	2.78
2028	24.18	2.42
2029	20.84	2.08
2030	17.76	1.78
Total	**2,012.04**	**201.20**

Chart 2: Incremental Annual



Key Findings

The key findings of the Energy Sector Assessment are summarized as follows:

- The Baseline Scenario Annual Ivestment Flow in Million 2005 US$ is 370.06;
- The Mitigation Scenario Annual Investment Flow in Million 2005 US$ is 2,382.10;
- The Additionality is 2,012.04 Million 2005 US$ (See Table 2 and Chart 2); and,
- The Additionality discounted at 9% per annum (following BRE's lead) is 960.98 Million 2005 US$. (See Table 1 and Chart 1).

Four (4) investment types were selected as a result of the analysis of several major national policy documents, including but not limited to the following: The National Energy Policy, Poverty Reduction Strategy (PRS), 2008 National Population and Housing Census, and publications of the Central Bank of Liberia (CBL). The four (4) investment types are lighting, cooking/heating/cooling/motive power (or cooking for short), charcoal production and renewables.

The available data on energy sector activities was and still is scanty. The figures in the tables are basically projections of a small and limited quantity of data that the team was able to collect. The 2008 Population and Housing Census and CBL publications provided the basic information such as population growth rate and harmonized consumer price indexes (HCPI) for the investment projections contained in the Excel tables, which are included as annexes. As the US dollar is a legal tender in Liberia, the issue of exchange rate did not arise. The CBL documents provided HCPI figures for 2005-2009. The discount rate used is 9% per annum because this is the discount rate Buchanan Renewables, the corporation that has so far presented the single largest biomass-fired power plant proposal, used in its project financial analysis.

Historical Period Data

The period 1995-2005 was selected as the historical period for the I&FF assessment in the energy sector. Data for this period is rare principally because nearly all databases and relevant documents were either looted or destroyed during the 14-year civil war in the country, which started in December, 1989. See Table 3 for the historical IF&FF data. The base year figures are given in Table 5 and Chart 3.

Lighting

Households

To determine the figures for households, a growth rate of 2.4% was used for 1995-2007, utilizing information in the 2008 NPHC document. The numbers of households relying on kerosene lamps, palm oil lamps and incandescent bulbs for lighting were constructed. The numbers for 1995 were 150.028, 156,242 and 15,523, respectively. It was assumed that each household used two kerosene lamps at a cost of US$1.50, two palm oil lamps at US$0.15 and five incandescent bulbs at US$1.00. The results were then projected for 1995-2005. The total figure for households is approximately 9.50 million 2005 US$.

Corporations

Using information from the UNEP Desk Study on the Environment in Liberia, we reckoned that there were 23, 871 small and medium businesses during historical period with each unit spending 70.00US$ on a small generator, amounting to 1,670,970.00US$, which was taken to be the domestic lighting component. In respect of large businesses, five units were operating during the historical period, with a combined installed generation capacity of 8MW or roughly with a dollar value of 8,000,000.00US$. Fifteen percent (15%) of 8,000,000.00 US$ or 1,200, 000.00 US$ was assumed to be the foreign component of lighting. Adding 1,200,000.00 and 1,670,970.00 US$ gave the figure for lighting. This sum was projected from 1995 to 2005. The total corporate lighting figure for the historical period is about 47 million 2005 US$.

Government

During the 1995-2005 period, the government received foreign assistance of 6.200.000.00 US$ for electricity projects. It was assumed that 15% or 930, 000. 00 US$ of this investment was for lighting.

Cooking/Heating/Cooling/Motive Power

This investment type (IT) is abbreviated for convenience as “cooking”, creating the impression that every activity under this IT is about household cooking only.

Households

An approach similar to that for determining household lighting figures was used for this IT. The numbers of households using gas, kerosene and charcoal stoves were 4,709, 12,020 and 186, 086 respectively. The results of the calculations, which are found in the Excel were then used to determine a total cooking figure of about 29 million 2005 US$.

Corporations

Only the domestic aspect of this IT was considered in the analysis. Fridges, air conditioners and electric motors were not considered directly because information on these was not available and it was very difficult to make a projection regarding these appliances; however, we took 85% of the US$8,000,000.00 to account for corporations' share of this IT. The total for the period is about 112 million 2005 US$.

Government

We took 85% of 6,200,000.00US$ or 5,270,000.00US$ to account for government's investment flow under this IT. Government's total for 1995-2005 is about 87 million 2005 US$.

Charcoal Production

Households

Households did not produce charcoal for sale, and hence, their figure is naught for the period.

Corporations

Only corporations, often consisting of small firms or individuals, using traditional dirt-mound method, produced charcoal for sale. It assumed that each charcoal producer invested US$1,250 in power saw and tools, producing about 1,200 bags on average annually. Each charcoal-consuming household was assumed to use on average 36 bags per annum. Utilizing appropriate population projections, we calculated the figures for 1995-2005. The total investment for 1995-2005 is roughly 30 million 2005 US$.

Government

Government did not produce charcoal for sale, and hence, its figure is naught for the period.

Renewables

Households

Households did not invest in renewables during the period (1995-2005).

Corporations

During this period only Firestone was producing energy from a renewable energy resource, that is, a 4-MW small hydro power plant on the Farmington River in Margibi County. The projected investment for the period is approximately 66 million 2005 US$.

Government

Government's investment in renewable was naught! The civil war resulted in the destruction of the only government-owned 64-MW Mount Coffee Hydro Power plant.

Baseline Scenario Data

Total IF for the baseline period is 370.06 million 2005 US$, of which lighting accounts for about 44 million; cooking and related activities, 107 million; charcoal production, 178 million; and renewables, 41 million 2005 US$.

Lighting

Households
Having determined the values for 1995-2005, the baseline figures for 2005-2030 were projected using 2005 as the base year and population growth rates of 2.4% for 2005 2007 and 2.1% for 2008-2030. The use of population growth rates is justified because as population grows, so must investment to meet rising demands for commodities. In fact, at 2.1%, the Liberian population is expected to double by 2041 to about 7 million. Households are expected to invest about 3 million 2005 US$.

Corporations
Corporations are anticipated to invest about 16 million 2005 US$.

Government
Government is expected invest about 25 million 2005 US$. It is important to note that during the baseline period, a number of energy projects worth approximately 160 million US$ is planned to be implemented from 2006 to 2015. This baseline energy investment was taken into account. Indeed, this is reflected by the peak of the baseline scenario graph in Chart 5.

Cooking/Heating/Cooling/Motive Power

Households will have to invest 9.7 million 2005 US$ while corporations will require 37 million 2005 US$ and government, 61 million 2005 US$ during the period 2005-2030 to implement activities related this investment type.

Charcoal Production

Households and government will not be involved in the commercial production and sale of charcoal. Corporations will be the only investment entities that will produce and sell charcoal. Corporations will require about 178 million 2005 US$ to produce during the period (2005-2030).

Renewables

Households
Households will not invest in renewables in the baseline scenario.

Corporations
Corporations will require an investment of about 22 million 2005 US$. This is a projected figure based on the base year value of 5 million 2005 US$.

Government
Remember that the base year value for government is naught. However, as has been explained, an investment in the energy sector of approximately 160 million US$ is planned to be made from 2006 to 2015. Government's investment flow during the baseline period is about 19 million 2005 US$.

Mitigation Scenario Data

Total IF for the baseline period is 2,382.10 million 2005 US$, of which lighting accounts for about 745 million; cooking and related activities, 393 million; charcoal production, 189 million; and renewables, 1,055 million 2005 US$.

Efficient Lighting

Households
Households are expected to invest in compact fluorescent lamps (CFLs) and solar lamps, The respective base year investments are 31 and 31 million 2005 US$. Households' IF for the period is about 683 million 2005 US$.

Corporations
Corporations are also anticipated to invest in compact fluorescent lamps (CFLs) and solar lamps, starting with a base year investment of about 5 million 2005 US$. Corporations' total IF Is projected to be 53 million 2005 US$.

Government
The government's projected base year investment in compact fluorescent lamps (CFLs) is 0.750 million 2005 US$ and for the entire period is 8 million 2005 US$.

Efficient Cooking/Heating/Cooling/Motive Power

Households
Households' calculated base year investment in efficient charcoal stoves and liquefied petroleum gas (LPG) stoves is roughly 30 and 4 million US$, respectively. The period total is about 375 million 2005 US$.

Corporations
Corporations' projected base year investment in liquefied petroleum gas (LPG) stoves is roughly 4 million 2005 US$. The period total is about 18 million 2005 US$.

Government
Government's planned base year investment in liquefied petroleum gas (LPG) stoves is roughly 0.100 million 2005 US$. The period total is about 1.05 million 2005 US$.

Efficient Charcoal Production

Households and government are not expected to invest in this investment type.

Corporations
Corporations' projected base year investment in efficient charcoal production is roughly 17 million 2005 US$. The period total is about 189 million 2005 US$.

Renewables

Households
Households are expected to invest about 37 million 2005 US$ in 200-Wp solar panels in the base year. The period total investment flow is about 486 million 2005 US$.

Corporations
Corporations are expected to invest about 12 million 2005 US$ during the mitigation period, beginning in 2011with one million 2005 US$.

Government
Upon the analysis of various documents and based on information we received following discussions with government authorities, knowledgeable people in the donor community and several energy experts, the government will construct a number of micro hydro, mini hydro, small hydro and large hydro power plants to mitigate climate change in the energy sector. We then deduced from the various discussions that the government would construct hydro power plant in the following categories: micro, 10000kW at 4800.00US$/kW; mini, 15000kW at 4200.00US$; 50000kW at 3600.00US$; and large hydro, 617000 at 1200.00US$. Reckoning that each plant would be operated for 7008 annually, we calculated a total annual energy generation of 4850GWh – micro (70080MWh), mini (105,120MWh), small (350,400MWh), and large hydro (4,336,936). The calculation of demand is based on the assumption that household demand is 500kWh/month and there are 700,000 households. We derived a total national energy demand of 4,200GWh per annum. Using an annual capital recovery factor (ACRF) of 0.1175, we computed the annual investment in hydro as follows: micro, 5,6 million US$; mini, 7.4 million US$; small, 21.2 millions, and large hydro, 87.0 million US$. We also assumed that each investment would require a foreign component of 80%.

The research also revealed that there were 361 public health facilities and 1,546 public schools that needed 1,000-Wp solar panels each. We assumed each solar panel would cost US$5,000.00.
The projections of those figures gave us the following result: the government will need to invest approximately 557 million US$ in renewables to mitigate climate change in the energy sector.

During the period (2005-2030), a number of relatively large incremental annual investments are anticipated to be made in the energy sector between 2010 and 2016, ranging from about 150 million US dollars in 2011 to approximately 108 million US dollars in 2015 (See Table 2 and Chart 2). Thereafter, incremental annual investments begin to fall steadily.

Table 1: Incremental Cumulative (2005-2030) Discounted IF & FF for All Investments in the Energy Sector, by Investment Entity and Funding Source (million 2005 US$)

Category of Investment Entity	Source of I&FF Funds		Mitigation	
			∆IF	∆FF
Households	Domestic	Equity and debt		
	Total Household Funds (all domestic)		802.35	80.24
Corporations	Domestic	Domestic equity (including internal cash flow)		
		Domestic borrowing (bonds and loans)		
		Total Domestic Sources		
	Foreign	Foreign direct investment (FDI)		
		Foreign borrowing (loans)		
		Foreign aid (ODA)		
		Total Foreign Sources		
	Total Corporation Funds		30.80	3.08
Government	Domestic	Domestic funds(budgetary)		
	Foreign	Foreign borrowing (loans)		
		Bilateral foreign aid (bilateral ODA)		
		Multilateral foreign aid (multilateral ODA)		
		Total Foreign Sources		
	Total Government Funds		127.82	12.78
Total Funds			**960.98**	**96.10**

Chart 1: Incremental Cumulative Discounted

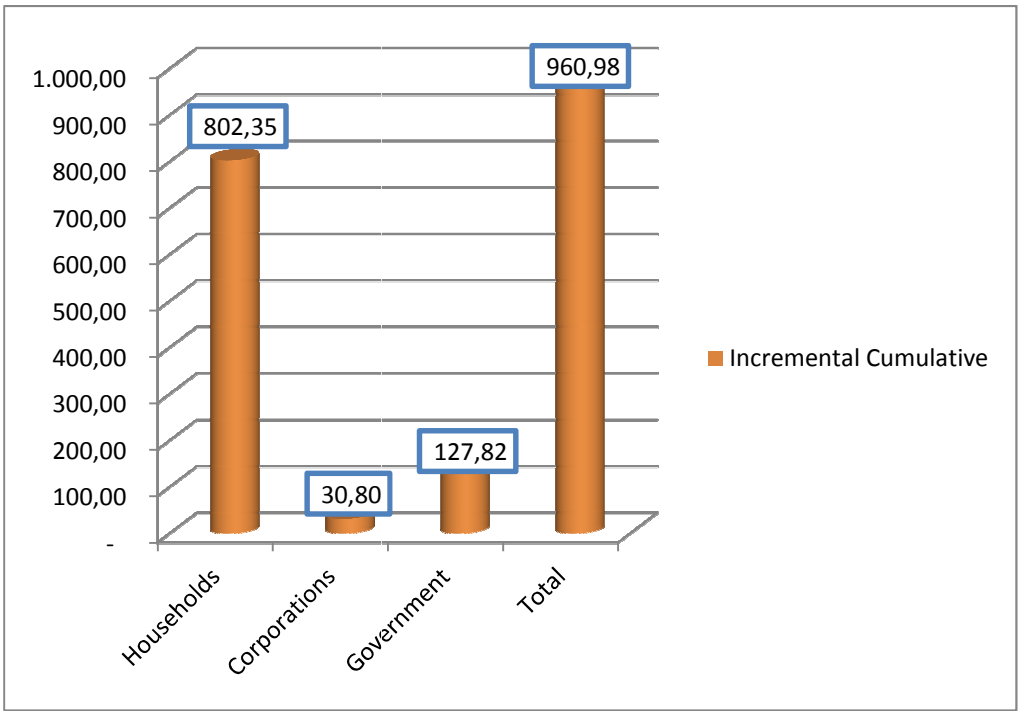
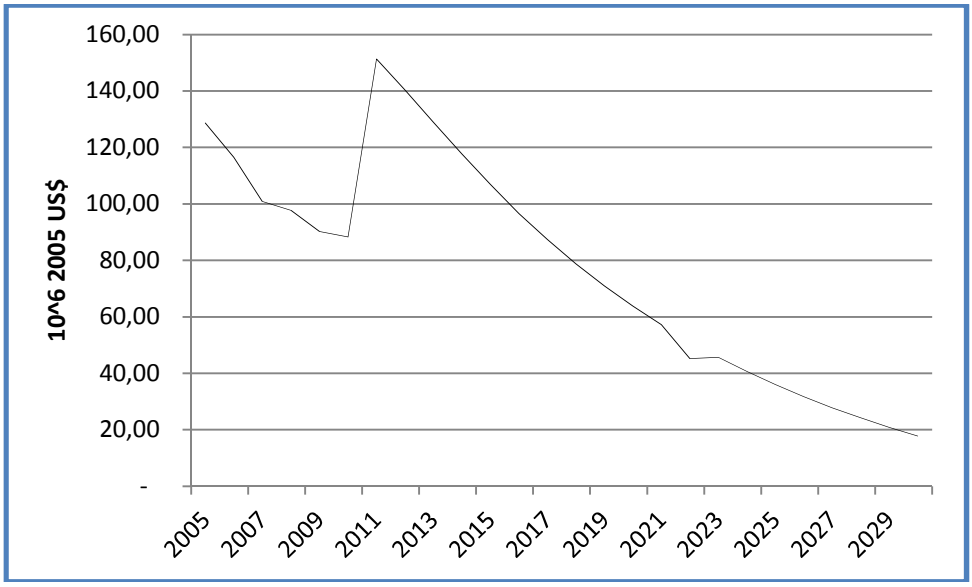


Table 2: Incremental Annual IF & FF for All Investments in the Energy Sector (million 2005 US$)

Year	ΔIF	ΔFF
2005	128.65	12.86
2006	116.47	11.65
2007	100.90	10.09
2008	97.73	9.77
2009	90.27	9.03
2010	88.27	8.83
2011	151.37	15.14
2012	140.33	14.03
2013	128.94	12.89
2014	117.68	11.77
2015	106.91	10.69
2016	96.56	9.66
2017	87.34	8.73
2018	78.80	7.88
2019	70.96	7.10
2020	63.78	6.38
2021	57.21	5.72
2022	45.24	4.52
2023	45.69	4.57
2024	40.63	4.06
2025	35.99	3.60
2026	31.73	3.17
2027	27.80	2.78
2028	24.18	2.42
2029	20.84	2.08
2030	17.76	1.78
Total	**2,012.04**	**201.20**

Chart 2: Incremental Annual



1. Introduction

Liberia is a signatory to the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol. In fulfilment of its obligations under these international instruments, Liberia prepared three major documents, namely, the National Adaptation Program of Action (NAPA) in 2008, which recommended, among other things, promoting **energy efficiency and conservation in the energy sector**, and the Draft First National Communication**.**

Liberia's **"First State of the Environment Report"** broadly recommends a series of workshops on sustainable energy for potential economic, social and environmental benefits by developing and adapting small-scale decentralized power supplies that **use renewable energy resources**.

This Investment and Financial Flow (I&FF) assessment drew on the results of the previous works mentioned above and is a general requirement to be fulfilled under the UNDP-sponsored project, entitled "Capacity Development for Policy Makers from Developing Countries to Address Climate Change in Key Sectors". The assessment is aimed at duly accounting for Liberia's national circumstances, capacities, and resources.

The analysis of investment and financial flows (I&FF) for greenhouse gas mitigation and climate change adaptation is an important activity for the development of effective and appropriate national responses to climate change. The project seeks not only to strengthen policy making capacity in Liberia and other participating countries, but also to enable the country produce analytical results that could serve as inputs to negotiating positions under the United Nations Framework Convention on Climate Change (UNFCCC). The project was launched and intended to run in tandem with the "Bali Action Plan" process – the UNFCCC negotiations on long-term cooperative action on climate change.

A key issue, especially for Liberia as a non-Annex I (NAI) Party to the United Nations Framework Convention on Climate Change, is how much need to be done nationally to reduce greenhouse gas emissions and to adapt to the looming adverse impacts of climate change as well as the implications of the national efforts for future investment and financial flows (I&FF) – including how foreign direct investment (FDI) and official development assistance (ODA) will be affected.

There are two main reasons for which these assessments of future investment and financial flows are principally significant for Liberia and similar developing countries: first, because it is important for the country to have a long-term perspective on the activities required to address climate change in respect of additional costs or investment shifts for the agriculture, energy and forestry sectors – the key sectors identified and chosen for this I&FF assessment; and second, because it is also crucial to determine the relevant sources of finance and investments required for developing specific policies and articulating the related needs.

Specifically, this report addresses the investment and financial flows (I&FF) required in Liberia's energy sector to mitigate GHG emissions.

The report on inventory of GHG emissions in the energy, LULUCF, agriculture and waste sectors indicated a total energy-sector CO_2 emission of about 3.7Mt (EPA, 2007). The emissions of other GHG gases were negligible. This result is consistent with the general trend in Africa as regards the continent's contribution to global emissions.

However, given Liberia's population growth rate and ongoing revitalization of the economic infrastructure and hence the improvement in the investment climate , it needs not be overemphasized that the energy demand in the country will rise sharply in subsequent years which could impact climate change in the absence of mitigation programs.

Therefore, investment decisions today in the energy sector as in many other sectors, have important long-term implications because facilities, equipment, and infrastructure affect climate for the duration of their operating lives, which in many cases is 20 years or longer. In addition, investment in a facility or infrastructure project that proves to be maladapted to future climate may result in additional socio-economic costs and inefficient operation or wasteful use of available but scarce investment capital.

In Liberia, all infrastructure development projects including those in the energy sector are subject to environmental impact assessment and the Government encourages the use of renewable energy resources and promotes the conservation of non-renewable energy resources (Environmental Protection and Management Law, 2002).This law, including energy efficiency programs among others, is in line with mitigation policies and measures proposed in this study to mitigate GHG emissions in Liberia.

1.1. Objectives

The rationale for Liberia's investment and financial flows (I&FF) assessment is to quantify the investments and associated financial flows required to mitigate and adapt to the effects of climate change in the agriculture, energy and forestry sectors.

The specific objectives are as follows:

- To collect, analyze and compile broad information on the investment and financial flows required in the three key sectors;
- To project future investment and financial flows in the baseline (business as usual or non-policy) case, that is, in the absence of policy to address climate change;
- To identify, screen and select mitigation measures consistent with national sustainable development priorities to address climate change;
- To assess the types and magnitudes of changes in investments in physical assets and in programs, and associated operation and maintenance costs, needed to implement the mitigation measures;
- To determine the entities that are responsible for those investments and the sources of their investment funds;
- To project future investment and financial flows associated with the implementation of the selected mitigation measures; and,
- To provide information needed to evaluate policy instruments that might be used to induce those entities to invest in the proposed measures.

1.2. Background

1.2.1. Previous Analyses Utilized

For the energy sector assessment, various sources of data and information were consulted as indicated below.

UNEP, 2004: Desk Study on the Environment in Liberia
Recommendations (pp. 84-93)

The loss of energy infrastructure during the civil war created adverse social and environmental impacts. Although, the supply of public electricity has been resumed in certain areas of Monrovia from a total installed generation capacity of 9.64 MW, households and offices still use their own private small generators (about 45,000 units with an estimated average capacity of 0.5 kW each) to meet their daily power need, thus increasing GHG emissions, air pollution and oil leakages. Increased reliance on fuel wood and charcoal contributes to excessive deforestation and irreversible sustained destruction of coastal mangroves, resulting in substantial wetland degradation. Major investments in the energy sector are necessary to reverse these trends. The Desk Study recommended, among other things, the development of environmentally-friendly sources of energy including the comprehensive assessment of Liberia's water, wind, wood, solar and tidal wave potential, taking into account the recommendations of the World Commission on Dams; the interconnection of ECOWAS electricity grids through the West African Power Pool (WAPP) initiative; investment in projects that improve efficiency of production and use of fuel wood and charcoal, focusing on **efficient charcoal kilns, efficient charcoal and wood stoves as well as improved fish smoking techniques**; the development of woodlots for biomass feedstock to relieve pressure on natural forests and protect forest biodiversity; the development and implementation of standards related to fuel storage and transport. Finally, the Desk Study recommended establishing properly engineered sanitary landfills in densely populated urban areas that generate huge quantity of solid waste with a view to harnessing the methane (CH_4) for power generation. The implementation of the last recommendation can result in GHG emission reduction, if little. A seminar on the environment jointly sponsored by GOL, UNMIL, UNDP and UNEP in collaboration with EPA to launch and discuss the Desk Study approved all of the recommendations mentioned above.

National Biodiversity Strategy and Action Plan (NBSAP), EPA, March 2004

This document was prepared by the EPA Liberia in collaboration with line GOL administrative agencies, civil society organizations and other non-GOL institutions in fulfillment of Liberia's commitment under the **Convention on Biological Diversity (CBD).** To commit the Liberian population to biodiversity conservation and sustainable use, six goals were approved along with several objectives and proposed actions. The NBSAP in particular recommended promoting energy conservation and developing alternative sources of energy, including:

- The rehabilitation of the war-damaged 64-MW Mount Coffee Hydroelectric Power Plant in White Plains (Goal 3, Objective 1-Action 2);

- The construction of small and mini hydroelectric facilities (Goal 3, Objective 1-Action3); GEF has already provided two million US dollars for this purpose;
- The use of wood waste for efficient charcoal production(Goal 3, Objective 5-Action 1).

AETS, June 2005: Final Report - Technical assistance to provide technical support related to production, distribution and customer supply to the tendering process of the new electricity sector in Monrovia. Reintegration Programme for Returnees and Displaced People of Liberia, Programme Management Unit, European Union, Nagel/Lib/18/2004, Framework Contract AMS/45, Lot N°4. Energy and Nuclear Safety.

After fourteen years of civil war, the electrical facilities and equipment of the state-owned company, Liberia Electricity Corporation (LEC), were vandalized or destroyed. However, with international donations, LEC partially resumed power generation, until June 2003, when operation was stopped because of renewed fighting in Monrovia. Left without power, the people in Monrovia produced their own electricity needs --as most persons still do --from small diesel generators. Some private entrepreneurs seized the opportunity to supply electricity to customers at expensive rates—and this trend though fading out -- continues today.

Lacking the required finance to resume electricity generation, the National Transitional Government of Liberia (NTGL) decided to privatize and reorganize the electricity sector. But the decision to privatize and re-structure the electricity sector was revised in 2006 when a new democratically-elected post-war government with donor financial support introduced a two–phase public electricity supply revitalization program known as the Emergency Power Program (EPP).

The process would have allowed private investors to participate in the rehabilitation and reconstruction of the electricity sector within a liberalization framework, and to finance, own and operate under a concession granted by the government.

Although the NTGL requested approximately 20 MW, a forecast evaluation carried out during the period of study indicated that installing 5x5-MW unit power station would cover a maximum demand of 22 MW. Keeping in mind the NTGL request to quickly fulfill the “Emergency Electricity Needs” of Monrovia, prefabricated medium speed diesel units, using heavy fuel oil, were selected to shorten the purchase and installation periods. The capacity of each unit was selected at 5 MW, based on operational reliability and flexibility needs, and optimization of maintenance expenses.

To keep the generation cost as low as possible using heavy fuel oil was recommended, though, this combustible had not been used in Liberia during 14 years of war. The ship unloading facilities, transfer pumps and storage facilities were damaged, and hence, are not in operating condition. There is plan to re-habilitate the ship unloading terminal, repair and extend the heavy fuel oil pipeline and revamp the fuel oil storage tanks.

National Adaptation Program of Action (NAPA) Liberia, EPA, 2008

Extensive stakeholder consultations during the NAPA preparation process resulted in the determination and selection of five national evaluation criteria. Following a scoring exercise, eight (8) of 28 adaptation projects that participating stakeholders proposed to be implemented in eight vulnerable sectors at various workshops hosted by the EPA were selected. The NAPA Document **recommended for the energy sector, in particular, promoting energy efficiency and conservation**. At a stakeholder validation workshop, the following three (3) priority projects were finally selected to address the most urgent and immediate needs, including reducing poverty:

- Integrated cropping and livestock farming;
- Improved monitoring of climate change;
- Coastal defense system for the Cities of Buchanan and Monrovia.

The estimated costs in 2008 of the first and second projects were US$ 5 and 3 million, respectively. Though not explicitly stated, the provision of modern energy services can certainly underpin national efforts to achieve the first priority project, while information from new gauging stations can facilitate implementation of small hydroelectric power and irrigation projects that will provide those modern energy services. For instance, the implementation of priority project # 1 will require, among other things, the use of energy for water pumping, product drying, cold storage and transport.

Schaffer & Associates International, LLC, Baton Rouge, Louisiana, USA, June 2008: Final Draft – Scoping Study Buchanan Renewable Power, Inc., Proposed Rubber Tree-Fired Cogeneration Plants, Monrovia, Liberia. [pp. 76-84]

The Government has granted Buchanan Renewable Energy (BRE) permission through a concession agreement to build, own and operate a 35-MW biomass-fired power plant:

- Total power plant and transmission line cost – **US$ 92,905,496.00 including EPC contingency of 10% and owner's contingency of 10%** (p.76);
- Estimated total project capital cost (including working capital, reserves, interest during construction, etc.)for the base case assuming a wood chip price of 60 USD per metric ton and a capacity factor of 85% is **148,849,000.00 in 2008 US$ inclusive of total annual average O&M cost of 6,715,000.00 US$;**
- The **base case schedule** depicts a typical project cycle and depends on orders being placed after financial closure. The commercial operations start date is scheduled at 11 February 2011 for unit 1 and 8 April 2011 for unit 2.

Recommendations of the National Inter-Ministerial Dialogue on Climate Change (NIMDCC), June, 2009
Outcome of the Inter-ministerial Dialogue

The National Inter-Ministerial Dialogue on Climate Change to raise awareness of policy makers and key stakeholders held in June 2009 in Monrovia had technical sessions dealing with the four pillars of the Bali Road Map (Mitigation, Adaptation, Finance, Technology Development and Transfer) as well as on the methodology to assess Investment and Financial Flows for key national development sectors (Agriculture, Energy and Forestry)

identified by the Government of Liberia. National experts presented three issue papers (on the three identified sectors) which were commissioned as part of the project entitled **"Capacity Development for Policy Makers to Address Climate Change in Key Sectors"**.

The participants through a series of plenary and working group sessions discussed the three issue papers. Based on the outcomes of these discussions, the participants re-dedicated themselves to the overall goals and objectives of the project and recommend the following key aspects of the project to the leadership of Government of Liberia for their kind perusal and follow-up action.

Based on the outcomes of the discussions on the issue papers, the following key actions were recommended to be initiated within the energy sector, focusing on greenhouse gas mitigation measures, to address the causes of climate change:

- Promote efficient charcoal kilns and wood / charcoal stoves;
- Promote the use of energy efficient vehicles, equipment and appliances;
- Promote investments in small-scale hydro-power projects;
- Promote the establishment of rural renewable energy enterprises;
- Promote independent power producers (IPP) for new clean-energy investments;
- Provide incentives (tax, tariffs, and others) to promote investments in clean-energy project;
- Provide incentives for the sustainable use of biomass for electricity generation;
- Increase public awareness of energy conservation and energy efficiency at all levels (national, county, district, etc.); and,
- Develop human and institutional capacity at all levels related to renewable energy production and use, and energy efficiency.

For completeness, the recommendations for the agriculture and forestry sectors are included as indicated below.

Within the Agricultural Sector, focusing on adaptation measures to address the adverse impacts of climate change, it is recommended to:

- Provide adequate budgetary allocations to climate-proof the Liberian agricultural development programme within the framework of the Poverty Reduction Strategy (PRS);
- Establish an insurance facility for farmers affected by the impacts of climate change;
- Develop systematic awareness raising programmes to prepare people to appreciate the likely changing climate impacts in the sector as part of an early warning system;
- Promote food security to ensure the resilience of farming communities prone to climate-related hazards such as droughts, floods and pest infestation;
- Integrate issues related to gender equality within the agricultural sector to ensure the equitable and adequate access to land, credit and education;
- Create an enabling environment to attract investments into agriculture sector with a focus on those industries and endeavours that promote climate-resilience;

- Devise and implement appropriate on-the job training for farmers and extension workers to address climate-related issues in the agricultural sector;
- Develop a clearinghouse mechanism for climate information sharing amongst stakeholders in the agricultural sector;
- Use established local / traditional knowledge to promote effective adaptation to the adverse effects of climate change;
- Elaborate the scope of interventions in the Disaster Management Policy (DMP) as it relates to agriculture and food security, and the impact of climate change on the sector;
- Establish an inter-ministerial committee to coordinate the implementation of adaptation options, with strong emphasis on monitoring and evaluation systems in the agricultural sector;
- Develop, adopt and execute nationally appropriate adaptation action plans and programmes in the agricultural sector.

Within the Forestry Sector, focusing on mitigation measures to address the causes of climate change, it is recommended to:

- Strengthen forest management at all levels (national, county, district, etc) by providing additional financial, human and technical resources;
- Diversify livelihood opportunities of forest communities to reduce their dependency on forest resources through the development of micro-credit business development facilities;
- Enhance the effective management of forest resources through benefit sharing schemes involving forest communities;
- Develop human capacity to secure carbon finance in the forest sector;
- Promote reforestation and afforestation projects to secure carbon finance for national development.

Report on Inventory of GHG Emissions in the Energy, LULUCF, Agriculture and Waste Sectors, EPA (2007)

The key sectors included in the inventory are as follows:

- Energy;
- LULUCF;
- Agriculture;
- Waste.

The report indicated a total energy-sector CO_2 emission of about 3.7Mt. The emissions of other GHG gases are negligible. This result is consistent with the general trend in Africa as regards the continent's contribution to global emissions.

Draft Initial National Communication

This document recommends implementing a number of clean energy technologies, including efficient lighting, efficient refrigeration, solar-thermal technology, solar water heating, small hydro technology, wind energy technology, photovoltaic (PV) technology,

efficient charcoal kilns, improved charcoal/wood cook stoves and efficient gas cookers such as LPG stoves.

National Energy Policy

In the formulation of its development plans, the Government of Liberia has recognized that increased access to modern energy services by urban and rural dwellers can underpin efforts to reconstruct the country, revitalize the economy and achieve the Millennium Development Goals. The Government inherited a situation where there was no public electricity infrastructure or functioning utility. The petroleum company (LPRC) was looted and destroyed, petroleum exploration was at a standstill and there was no coordinated energy policy and strategy. The reform of the energy sector was also a key component of Liberia's commitment to the World Bank and other donors for debt relief under the program for Highly Indebted Poor Countries.

The NEP reaffirms the Government's conviction that economic development is possible only with access to reliable, accessible, and affordable energy. Increased commercial energy access and use will contribute to the growth of Liberia's economy and improved quality of life for Liberia's citizens. Secure energy supplies and basic infrastructure are essential for Liberia's economic transformation. Adequate and reliable energy supply will allow the mining sector, industries, and commercial concerns to expand their production and sales of goods and services, and in turn, increase employment. For the rural poor in the agriculture sector, modern energy access means increased productivity through improved production and processing methods, increased employment, and preservation of crops.

In consonance with the regional energy policy paper ECOWAS approved in January 2006, aimed at increasing rural and peri-urban populations' access to energy services as a prerequisite to achieve the Millennium Development Goals (by 2015) in the sub-region, Liberia has set the following targets:

- 40% of Liberian citizens living in rural and peri-urban areas and using traditional biomass for cooking shall have access to improved stoves and kerosene or efficient-gas cookers such as LPG stoves in order to cut indoor air pollution;
- 30% of the urban and peri-urban population shall have access to reliable modern energy services to meet their basic needs (lighting, cooking, communication, and small production-related activities);
- 15% of the rural population shall have access to reliable modern energy services to meet the same basic needs; and
- 25% of the schools, clinics, and community centers in rural areas shall have access to modern energy services for productive activities, efficient lighting, efficient refrigeration, and information communication technology.

Furthermore, in keeping with the policy of extending sustainable energy access to all Liberians, the Government of Liberia intends to achieve the following additional targets:

- Reducing greenhouse gas emissions to 90% by 2015.
- **Improving energy efficiency by 20% by 2015.**
- **Raising the share of renewable energy to 30% of electricity production and 10% of overall energy consumption by 2015.**

- **Increasing the level of biofuels in transport fuel to 5% by 2015.**
- Implementing a long-term strategy to make Liberia a carbon neutral country within a specified target period.

Liberia Poverty Reduction Strategy/Pillar IV: Rehabilitating Infrastructure and Delivering Basic Services (Energy, Sec. 9.4, p.103)

Today less than two (2) percent of rural residents and 10 percent of urban residents have access to electricity, which is produced mainly from private generators at prohibitive costs. More than 90 percent of Liberia's population depends on unreliable and low-grade sources of energy such as firewood, charcoal, candles, kerosene and palm oil. Public electricity (supplied by LEC) is currently expensive (0.43US$/kWh + 7% goods and services tax or 0.460 US$/kWh); so most micro and small enterprises have little or no access. The rehabilitation and development of the energy sector is an integral part of the **Poverty Reduction Strategy** which, together with rebuilding ports and improving water supplies, will also reduce costs and make Liberian firms more competitive.

1.2.2. Institutional Arrangement and Collaboration

Following a meeting organized by the Environmental Protection Agency of Liberia, the Climate Change Focal Point and the Energy and Environment Unit of the UNDP, it was decided that a letter of invitation be issued by the Acting Executive Director of the Environmental Protection Agency of Liberia to heads of institutions where participants for the I&FF training were to be chosen. Letters were duly sent out and the I&FF team members participating in the assessment process were nominated by their respective Government ministries, agencies, NGOs and academia. The energy (mitigation) team was formally constituted at that I&FF training workshop. In view of the institutional roles and responsibilities of the various team members, the team selected Mr. Matthew F. Konai, representing the Liberia Electricity Corporation (LEC), as the energy sector team leader to guide the team's efforts and work with the National Project Coordinator during the assessment.

The following persons were selected as members of the energy team:

- M. Hady Sherif – Center for Sustainable Energy Technology(CSET);
- Georsay Stevens - Center for Sustainable Energy Technology (CSET);
- Matthew Konai - Liberia Electricity Corporation (LEC), Team Leader.

1.2.3. Basic Methodology and Key Terminology

The Methodology Guidebook for the I&FF assessment prescribes an eight (8)-step approach as indicated below:

1) Establish key parameters of the assessment;
2) Compile relevant historical, current and projection data to elaborate future energy sector scenarios;
3) Define the baseline scenario, taking 2005 as the base year;
4) Estimate I&FF and O&M costs under the baseline scenario;
5) Define the mitigation scenario;

6) Estimate I&FF and O&M costs under the mitigation scenario;
7) Estimate changes in I&FF and O&M costs to implement the mitigation scenario;
8) Evaluate policy implications.

1.2.3.1 Basic Methodology

1. Establish the key parameters of the assessment

- Define the detailed scope of the sector;
- Specify assessment period and base year;
- Identify preliminary mitigation (or adaptation) measures;
- Select analytical approach.

2. Compile historical IF, FF, and O&M cost data, subsidy cost data (if included explicitly), and other input data for scenarios

- Compile historical annual IF and FF data, disaggregated by investment entity and source;
- Compile historical annual O&M cost data, disaggregated by investment entity and source;
- Compile historical annual subsidy cost data, if subsidies are included explicitly in the assessment;
- Compile other input data for scenarios.

3. Define the baseline scenario

- Describe socioeconomic trends, technological change, sectoral and national plans, and expected investments given current sectoral and national plans.

4. Estimate annual Investment Flow, Financial Flow, and Operation & Maintenance costs, and subsidy costs if included explicitly, for the baseline scenario

- Estimate annual IF and FF for each investment type, disaggregated by investment entity and funding source;
- Estimate annual O&M costs for each IF, disaggregated by investment entity and funding source;
- Estimate annual subsidy costs for each relevant investment type and for IF, FF, and O&M costs, if subsidies are included explicitly in the assessment.

5. Define mitigation (or adaptation) scenario

- Describe socioeconomic trends, technological change, mitigation (or adaptation) measures, and investments given implementation of mitigation (or adaptation) measures.

6. Estimate annual Investment Flow, Financial Flow, and Operation & Maintenance costs, and subsidy costs if included explicitly, for mitigation (or adaptation) scenario

- Estimate annual IF and FF for each investment type, disaggregated by investment entity and funding source;
- Estimate annual O&M costs for each IF, disaggregated by investment entity and funding source;

- Estimate annual subsidy costs for each relevant investment type and for IF, FF, and O&M costs, if subsidies are included explicitly in the assessment.

7. Calculate the changes in IF, FF, and O&M costs, and in subsidy costs if included explicitly, needed to implement the mitigation (or adaptation) measures

- Calculate changes in cumulative IF, FF, and O&M costs, by funding source, for individual investment types and for all investment types;
- Calculate changes in annual IF, FF, and O&M costs for individual investment types, for individual sources of funds, and for all investment types and funding sources;
- If subsidies are included explicitly, consider calculating changes in cumulative and/or in annual subsidies for IF, FF, and O&M for each investment type and all investment types.

8. Evaluate policy implications

- Re-evaluate the initial priority mitigation (or adaptation) measures undertaken in step #5;
- Analyze feasibility and compatibility with development and sector plans;
- Determine policy measures to encourage changes in I&FF;
- Consider a variety of instruments, including incentives, economic instruments (e.g., taxes), regulatory instruments (e.g., fuel portfolio standards), voluntary agreements, education, information dissemination and other instruments (e.g., research, development, and demonstration (RD&D) programmes).

1.2.3.2 Key Terminology

The definitions of key terms given in this section are taken from the Methodology Guide mentioned previously.

Investment Flow

An "investment flow" (IF) is the capital cost of a new physical asset with a life of more than one year, such as the capital cost of a new power plant, a new automobile, a new household appliance, or a new agricultural irrigation system. **Investment flows are limited to new physical assets** because such investments have climate change implications for the duration of the operating lives of the facilities and equipment purchased. Purchase of an existing physical asset, such as an existing vehicle, is excluded because its remaining life and its implications for climate change are not affected by the change in ownership. However, investment flows to retrofit, or considerably expand, an existing physical asset that significantly alter the climate change implications of that asset, such as the conversion of a traditional coal-fired power plant to a combined cycle gas turbine plant, are included. **Investments in financial assets (such as stocks and bonds), and in physical assets that do not affect climate or have no climate impact implications (such as metals and commodities),** are also excluded because they are unrelated to climate concerns.

Financial Flow

A "financial flow" (FF) is an ongoing expenditure on programmatic measures; financial flows encompass expenditures other than those for expansion or installation of new physical assets. Examples of financial flows include expenditures for an agricultural

extension program for farmers, a malaria prevention program to distribute mosquito nets, or the implementation of improved forest management techniques. These expenditures are "operation and maintenance" type costs, e.g., salaries and raw materials.

These investment and financial flows are NOT the same as the cost of addressing climate change; changes to the operating costs of investments are not considered nor is damage due to climate change estimated.

Investment Entity

An "investment entity" is an entity that is responsible for an investment. These are the entities that decide to invest in, for example, an array of wind turbines, a new household appliance, a public health program, a national park, or a sand dune stabilization program. Three types of investment entities are identified as follows: households, corporations, and government.

Sources of Investment and Financial Flow Funds

The "sources of I&FF funds" are the origins of the funds invested by the investment entities, e.g., domestic equity, foreign debt, domestic subsidies, and foreign aid. Identification of the entities responsible for the investment decisions, and the sources of the funds that are invested, is an important component of an I&FF assessment because this information is the starting point for the evaluation of policies to change those decisions. To design policies and measures to influence decisions about I&FF, the entities responsible for those decisions and the means by which they obtain their funds must be identified.

Households

Households are individuals or groups of individuals (e.g., families or communities) who act as one unit financially. Households invest in assets, such as homes, farms, vehicles, and facilities for small unincorporated businesses. All of their investment funds, which include equity (savings), debt (loans from friends, relatives, or financial institutions), and government support in the form of subsidies (e.g., rebates, tax deductions, or tax credits on purchases), are assumed to be domestic to simplify the I&FF assessment. Although remittances by family members working in foreign countries are substantial for some countries, and are likely to help finance household investments in the recipient countries, spending decisions are usually made by the recipients. Also, whether funds are domestic or foreign is less important for households than for other investment entities when evaluating policies and measures to influence investment decisions.

Corporations

Corporations include both financial corporations and non-financial corporations, and can be either for-profit or not-for-profit. Financial corporations are entities such as banks, credit unions, and insurance companies that provide financial services to non-financial corporations, households, and governments. Non-financial corporations produce goods (such as fossil fuels, electricity, food, and timber), and provide non-financial services (such as health care, private education, research, and hospitality services). Non-governmental organizations (NGOs) are a type of not-for-profit corporations. Corporations invest in both physical assets and programs. Their sources of investment funds are both domestic and foreign, and can be in the form of equity (equity in domestic financial markets and foreign

direct investment), debt (loans provided by commercial banks and bond sales in the capital market), domestic government assistance (subsidies), or foreign aid (foreign assistance in the form of grants and concessional loans; also known as ODA or official development assistance). All foreign direct investment (FDI) in a country is assumed to go to corporations because FDI tends to be made by multinational corporations seeking to establish or expand operations overseas. However, only part of the FDI is invested in new physical assets or programs; some is used to purchase existing assets through mergers or acquisitions. Only the portion of FDI that is invested in new physical assets or programs is included in the I&FF assessment.

Governments

Governments are the national, provincial, state, and local governments of a country. Financial and non-financial corporations owned wholly or in part by governments, such as public universities and research institutions, and publicly-held oil companies, utilities, and water authorities, are included in this category. Government entities invest in long-lived physical assets and public programs and services that provide public benefits. Examples of such assets include water supply systems, hospitals, and coastal infrastructure; examples of such programs and services include health care, energy research, and agricultural assistance. Note that government entities also invest indirectly (via subsidies) in assets that private entities (households and corporations) purchase (e.g., appliances and vehicles). The funds governments invest include both domestic sources (revenues from taxes and fees, loans from domestic financial institutions, and bond sales in the domestic market) and international sources (debt in the form of foreign loans and bond sales, and foreign aid). In the taxonomy of government sources of funds used here, foreign aid or official development assistance (ODA) is divided into bilateral and multilateral components. Bilateral ODA is assistance provided by another country, either as a grant that does not need to be repaid, or as a loan with concessional terms. Multilateral ODA is assistance from an international financial institution (IFI) (such as the World Bank or International Monetary Fund), usually in the form of a loan with concessional terms, but also sometimes in the form of a grant.

Operation and Maintenance (O&M) Costs of New Physical Assets

The physical assets purchased with investment flows will have operation and maintenance (O&M) costs associated with them (i.e., ongoing fixed and variable costs such as salaries and raw materials). Operation and maintenance costs of new assets need to be included in I&FF assessments because these costs can vary considerably among investment flow types, and can have a significant effect on the total cost of an investment over its lifetime. For example, O&M costs are a much greater share of total costs (capital costs plus O&M costs) for gas-fired electricity generation than photovoltaic electricity generation. O&M costs include the following categories of costs:

- Salaries or wages of personnel;
- Fuel costs such as power and/or fuel for operations, fuel for production;
- Public utilities such as telephone service, Internet connectivity, etc.;
- Raw materials;
- Maintenance and/or leasing of equipment;
- Office supplies and consumables;
- Advertising;

- License or equivalent fees (such as corporation yearly registration fees) imposed by a government;
- Real estate expenses, including:
  - ✓ rent or lease payments
  - ✓ office space
  - ✓ furniture and equipment
  - ✓ property taxes and equivalent assessments
- Operations fees, such as fees assessed on transportation carriers for use of highways, and production or operation fees, such as subsidence fees imposed on oil wells;
- Insurance;
- Damage due to uninsured losses, accident, sabotage, negligence, or terrorism.

Scenario

A scenario is an internally consistent and plausible characterization of future conditions over some specified time period. Each sectoral I&FF assessment for mitigation (or adaptation) requires that both a baseline scenario and a mitigation (or adaptation) scenario be developed for that sector. In the I&FF assessment methodology, each scenario will have a stream of annual IF, FF, and O&M costs.

Baseline Scenario

The baseline scenario in both cases is a reflection of business-as-usual or non-policy case conditions, i.e., it is a description of what is likely to occur in the absence of new policies to address climate change. The baseline scenario should describe expected socioeconomic trends (e.g., population growth and migration, economic growth), technological change (if relevant), private sector and government plans for the sector, and expected business-as-usual investments in the sector (i.e., specific new assets and programs) given those trends and plans. If policies to address climate change are already being implemented, they should be reflected in the baseline scenario. The description of the plans or forecasts for investments should include information about the nature, scale, and timing of those investments; i.e., information that is needed to derive estimates of annual I&FF, and associated O&M costs.

Mitigation Scenario

The mitigation scenario incorporates measures to mitigate GHG emissions, i.e., the mitigation scenario should describe expected socioeconomic trends, technological change (if relevant), new measures to mitigate GHG emissions, and the expected investments in the sector given implementation of the mitigation measures. Similarly, the adaptation scenario incorporates new measures to respond to the potential impacts of climate change**.** The adaptation scenario should describe expected socioeconomic trends, technological change, new measures to respond to the potential impacts of climate change, and the expected investments in the sector given implementation of the measures to respond to potential impacts. Both the mitigation and adaptation scenarios should include information about the nature, scale, and timing of the investments.

Assessment Period and Base Year

The **assessment period** is the time horizon for the assessment; i.e., the number of years spanned by the baseline and climate change scenarios and the associated stream of annual IF, FF, and O&M costs. The assessment period for I&FF assessment should be at least 20 years and not more than 30 years. The **base year** is the first year of the assessment period, i.e., it is the first year of the baseline, mitigation, and adaptation scenarios. The base year should be set at a recent year for which I&FF and O&M information is available so that the IF, FF, and O&M costs for the first year of all the scenarios are historical data. This grounds the start of the streams of cost data for each scenario in reality.

2. Scope, Data Inputs, and Scenarios

2.1. Sectoral Scope

Before the civil crisis, the total installed electricity capacity of the national electricity grid operated by the LEC was approximately 195 megawatts (MW), while that of concessionaires was 212 MW. The total installed electricity generation capacity, including the private sector, was about 412 MW.

The LEC increased its energy generation from 2,045,644 kW in 2006 to 19,554,334 kWh in 2009 with a total cumulative energy generation of 42, 672,158 kWh for the period. Petroleum products consumption for 2008 was equivalent to about 8,450 TJ of energy (LPRC, 2008).

The GOL has signed a 25-year power purchase agreement (PPA) with Buchanan Renewable Energies (BRE), which is expected to construct a 35-megawatt biomass-fired power plant valued at about US$149 million to supply electricity to Monrovia and its surrounding communities. The plant will be fuelled with wood chips from old non-producing rubber trees, and will be located near Kakata, Margibi County approximately 50 kilometers from Monrovia.

Liberia's 2010 total installed power capacity is about 40 MW of which as has been previously mentioned LEC accounts for 22.64MW, while the potential energy demand estimates range from 110 MW in 2013 to 300 MW by 2020 (NORAD, 2008). In 2011, the LEC has an installed capacity of 22.64 MW consisting of only high speed diesel generators with 80 km of transmission and distribution network, and has at least 1,000 street lights and nearly 3,000 customers in Monrovia. Though this quick win intervention in the power sector is laudable, total reliance on fossil fuel increases GHG emissions. There is a need to switch to hydro for long-term power production to reduce petroleum import bills and mitigate climate change.

There is no generation capacity outside of Monrovia beyond privately-owned generators and scattered donor-funded pilot projects. A number of Government agencies, community organizations and private sector establishments in rural locations in several counties have been able to receive diesel generators and solar power systems through USAID, the United Nations Development Program, and some NGOs.

There are three Government energy parastatals established by law – the Liberia Electricity Corporation (LEC), created in 1973, the Liberia Petroleum Refining Corporation (LPRC), created in 1978, and the National Oil Company of Liberia (NOCAL), created in 2002. All these are corporate entities, wholly owned by the Government and managed by boards appointed by the President.

NOCAL and LPRC are the two institutions the Government of Liberia has legally established to administer and regulate the petroleum sector of Liberia under the policy guidance and supervision of the Ministry of Lands, Mines and Energy (MLME). NOCAL is responsible for the upstream petroleum sector, while the downstream petroleum sector is under the jurisdiction of the LPRC. In the upstream sector, the Government of Liberia (GOL), though

has not yet discovered any crude oil, it has awarded licenses to about seven foreign companies for offshore petroleum exploration in the country. As for the downstream sector, given its scrapped refinery, licensed private companies import petroleum products while LPRC owns and manages storage facilities. Yearly volumetric imports of approximately 175,000 metric tons consist predominantly of gasoline, diesel fuel, and to a lesser extent, jet fuel and kerosene. In 2008, the LPRC reported approximately 65,279,917 US gallons of refined petroleum product imports, comprising mainly gasoline, diesel fuel, and to a lesser extent, jet fuel and kerosene. Most of the petroleum usage in the country is for the transportation sector, which also has critical effects as a cost input to other goods and services. With the rising cost of petroleum products there is an increased awareness of the need to ensure that petroleum products are of first-rate quality and are used as efficiently as possible.

The current energy sector in Liberia is characterized by a dominance of traditional biomass consumption and low access to poor quality and relatively expensive modern energy services. This is a result of the country's underdeveloped economy whose infrastructure was extensively destroyed during the 14 years of civil crisis, from 1989 to 2003. The charcoal industry which now dominates the household energy sector is entirely run by private operators and community-based organizations. In 2004, it was estimated that over 95% of the population relied on firewood, charcoal, and palm oil for their energy needs. The production of fuel wood and charcoal is also an important source of employment and sale of these goods is a source of supplemental income for many low income and poor families. In some cases it supplements as much as 40 per cent of their total income (SOE, 2006). Annual consumption of woody biomass was estimated at about 10.8 million m^3 (CSET, 2004) for fire wood, and 36,500 tons (NACUL, 2005) for charcoal.

Modern energy services derived from electricity and petroleum products are predominantly used for economic production and transportation. In the household sector, the use of modern energy services consists mainly of kerosene, electricity, and liquefied petroleum gas for lighting, cooking, and entertainment in higher income urban households.

There is currently no reliable and sufficiently disaggregated data on the overall energy mix of Liberia from the production and consumption perspectives, including economic indicators such as its share of employment, contribution to GDP, fiscal revenues, trade and food security.

Nevertheless, the energy sector is a major driving force for nearly all socio-economic activities in Liberia because it underpins the delivery of basic social services and industrial production. Some of the key services that are inherently linked to the energy sector include transportation, electricity, communications, agriculture and fishery, health, education, and tourism. Besides its share of about 0.8% (CBL, 2008) of the overall gross domestic product (GDP) of Liberia as a sector, energy also contributes to employment, trade, fiscal revenues, food security, and regional and sub-regional development. For instance, Liberia is a member of the West African Power Pool (WAPP) which is aimed at creating an integrated energy market in ECOWAS states.

Some key constraints facing the energy sector include:

- Limited baseline data and other relevant information;
- Uncoordinated collection of baseline information on energy sources, services, consumption patterns and monitoring.

Nevertheless, this energy sector I&FF assessment report covers the following supply and demand side areas in both the baseline and mitigation scenarios for all three investment entities - households, corporations and government:

- Lighting;
- Cooking, Heating, Cooling & Motive Power;
- Charcoal Production;
- Renewable Energy.

The above named areas consider domestic, commercial and industrial energy production and consumption. All these include equipment and appliances both electric and non-electric.

2.2. Data Inputs and Scenarios

2.2.1. Assessment Period and Cost Accounting Parameters

The recommended base year of 2005 was used. The year 2030 was used as the last year of the assessment period since this year aligns with typical sector development plans, and results in a reasonable assessment period. The recommended assessment period of 2005 through 2030 was used.

Cost Accounting Issues

It is recommended that countries follow a common approach for compiling data on the costs of IF, FF, and O&M so that results are transparent and comparable. Costs should be compiled in real (i.e., inflation adjusted) terms. Constant 2005 US$ are recommended for this purpose. It is as well recommended investment costs for assets (IF) be reported in the year in which they are expected to be incurred, rather than spreading the costs over the lifetime of the asset. It is also recommended financial flows and O&M costs be reported as annual costs in the year in which they occur.

Appropriate discounting of future costs (IF, FF, and O&M costs for the baseline and climate change scenarios) is recommended to account properly for varying opportunity costs and time preferences of investment entities. The discount rates chosen should reflect country-specific economic conditions. It is recommended that countries use two discount rates for their assessment: one public discount rate and one private discount rate or use the public discount rate for all sectors. The I&FF method does not consider explicitly the contribution of government subsidies in financing private sector (household and corporation) investments (IF and FF) and O&M costs because computing or discriminating subsidies for private investments is not always possible.

Since the US$ is considered a legal tender in Liberia, all monetary figures were deflated to 2005 US$. Here, the values in current US$ were deflated by the US$ Consumer Price Index (2005=100). In other words, an investment flow in a particular year in current US$ was divided by the CPI of the same year, and multiplied by 100 (for 2005 as base) to obtain the constant 2005 value of the current value for that particular year.

It is recalled that the discount rate reflects return on present consumption foregone or sacrificed to secure future consumption. The after-tax real interest rate or return on capital investment is used as the discount rate, remembering that a dollar NOW is worth more than a dollar TOMORROW! The World Bank's commonly-used 8-12% discount rate for economic analysis of projects in developing countries was employed as a reference. Specifically, the discount rate of 9% was used for this assessment because this is the same discount rate Buchanan Renewable Energy (BRE), the single largest private investor in the energy sector in Liberia, used for its 25-year 35-MW biomass-fired power plant.

Benefits and Non-Investment Costs of Mitigation Measures

The purpose of an I&FF assessment is to determine the incremental, direct monetary costs of climate change measures, and the likely sources of those investment funds. Since the methodology is not a cost-benefit type of analysis, quantitative estimates of the direct benefits of investments are not included. Direct benefits of climate change measures include net GHG reductions and climate impacts avoided. During the data evaluation, an attempt was made to assess the relative magnitude of revenues from those investments that will generate revenues over the lifetime of an asset (relative to lifetime O&M costs), and the likely sources of the revenues.

2.2.2. Analytical Approach

Countries were advised to use any of several analytical approaches to develop baseline, mitigation, and adaptation scenarios, and associated streams of annual IF, FF, and O&M costs. The approaches include a suitable sectoral model, a sectoral plan, a projection of sectoral trends, the current situation in the sector (assuming no change), or a combination of those approaches. It was suggested the selection be influenced by previous analytical work on mitigation and adaptation, such as Liberia's **Draft Initial National Communication**, as well as by the specific national circumstances (e.g., available in-country capacity and resources), sectoral scope, assessment period, and the preliminary climate change measures identified. Ideally, the approach chosen would involve econometric analysis or demand forecasting techniques.

Even though some members have had training in the use of LEAP, financial limitation precluded its use for this assessment. A projection of trends, or the current situation (assuming no change) was used as the basis for the analysis. The projection describes anticipated changes in the energy sector over the selected assessment period in ways that allow the identified preliminary mitigation measures to be re-evaluated and the scale and timing of their implementation identified (Step #5). The projection is based on sectoral demand forecasts, ideally using quantitative methods (e.g., extrapolation of historical sales data). The Excel sheets were used instead of any of the recommended sophisticated models.

2.2.3. Historical IF, FF, and O&M Data, and Subsidies

This section provides analysis of data collected and projected over a historical period (1995-2005). This section contains data on investment and financial flows as well as operation and maintenance costs within the energy sector in the historical period. The calculated historical figures are found in Table 3, comprising three parts for convenience.

The tables below provide historical data on IF, FF, and O&M for three investment entities over the 10 year period (1995-2005). Data for 1995 were obtained to project for the subsequent years considering an annual growth rate of 2.4%. Four investment types were considered. For lighting, data on incandescent lamps, kerosene lamps and palm oil lamps were calculated. For cooking and heating, the assessment considered charcoal stoves, LPG stoves and kerosene stoves. Data on charcoal kiln was used for investment in charcoal production while data obtained on investment in renewables considered solar and hydro. The historical data reveals a total investment of US$536.25 million over the 10 year period of 1995 to 2005.

Investment in cooking/heating/cooling/motive power during the historical period accounts for about 58% (US$308.66million) of the total, followed by investment in lighting at 18% (US 97.59 million). Investments in renewables and charcoal production account for only 17% (US$89.22 million) and 8% (US$ 41.09 million) respectively. These figures confirm that investments in cooking/hearting and lighting account for the largest portion of the annual historical data. The largest investments are expected to occur in 1995 at US$55.10 million with cooking/heating accounting for the largest portion of the investment at US$32.89 million.

More detailed analyses on the assumptions and other calculations are available in the attached excel spreadsheet. Using data from the Central Bank of Liberia (CBL), all figures were deflated at constant 2005 US dollars and the discount rate used, following BRE's lead, is 9%.

Table 3: Historical IF, FF and O&M Data

Year	Lighting									Cooking/ Heating/Cooling/Motive Power									Annual Total
	Households			Corporations			Government			Households			Corporations			Government			
	IF	FF	OM	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	
1995	1.01	0.10	0.25	5.05	0.51	1.26	1.64	0.16	0.41	3.11	0.31	0.78	11.97	1.20	2.99	9.28	0.93	2.32	43.29
1996	0.98	0.10	0.24	4.89	0.49	1.22	1.58	0.16	0.40	3.01	0.30	0.75	11.59	1.16	2.90	8.98	0.90	2.24	41.89
1997	0.95	0.09	0.24	4.73	0.47	1.18	1.53	0.15	0.38	2.91	0.29	0.73	11.21	1.12	2.80	8.69	0.87	2.17	40.54
1998	0.92	0.09	0.23	4.58	0.46	1.15	1.48	0.15	0.37	2.82	0.28	0.71	10.85	1.08	2.71	8.41	0.84	2.10	39.23
1999	0.89	0.09	0.22	4.43	0.44	1.11	1.44	0.14	0.36	2.73	0.27	0.68	10.50	1.05	2.62	8.14	0.81	2.03	37.96
2000	0.86	0.09	0.21	4.29	0.43	1.07	1.39	0.14	0.35	2.64	0.26	0.66	10.16	1.02	2.54	7.87	0.79	1.97	36.73
2001	0.83	0.08	0.21	4.15	0.42	1.04	1.34	0.13	0.34	2.56	0.26	0.64	9.83	0.98	2.46	7.62	0.76	1.90	35.55
2002	0.80	0.08	0.20	4.02	0.40	1.00	1.30	0.13	0.33	2.47	0.25	0.62	9.51	0.95	2.38	7.37	0.74	1.84	34.40
2003	0.78	0.08	0.19	3.89	0.39	0.97	1.26	0.13	0.31	2.39	0.24	0.60	9.21	0.92	2.30	7.13	0.71	1.78	33.29
2004	0.75	0.08	0.19	3.76	0.38	0.94	1.22	0.12	0.30	2.32	0.23	0.58	8.91	0.89	2.23	6.90	0.69	1.73	32.21
2005	0.73	0.07	0.18	3.64	0.36	0.91	1.18	0.12	0.29	2.24	0.22	0.56	8.62	0.86	2.16	6.68	0.67	1.67	31.17
Total	**9.49**	**0.95**	**2.37**	**47.44**	**4.74**	**11.86**	**15.37**	**1.54**	**3.84**	**29.21**	**2.92**	**7.30**	**112.35**	**11.24**	**28.09**	**87.07**	**8.71**	**21.77**	**406.26**

Year	Charcoal Production									Renewables									Annual Total
	Households			Corporations			Government			Households			Corporations			Government			
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	
1995	0.00	0.00	0.00	1.70	0.17	0.43	0.00	0.00	0.00	0.00	0.00	0.00	7.04	0.70	1.76	0.00	0.00	0.00	11.80
1996	0.00	0.00	0.00	1.86	0.19	0.47	0.00	0.00	0.00	0.00	0.00	0.00	6.82	0.68	1.70	0.00	0.00	0.00	11.71
1997	0.00	0.00	0.00	2.03	0.20	0.51	0.00	0.00	0.00	0.00	0.00	0.00	6.59	0.66	1.65	0.00	0.00	0.00	11.65
1998	0.00	0.00	0.00	2.22	0.22	0.56	0.00	0.00	0.00	0.00	0.00	0.00	6.38	0.64	1.60	0.00	0.00	0.00	11.62
1999	0.00	0.00	0.00	2.43	0.24	0.61	0.00	0.00	0.00	0.00	0.00	0.00	6.18	0.62	1.54	0.00	0.00	0.00	11.62
2000	0.00	0.00	0.00	2.66	0.27	0.66	0.00	0.00	0.00	0.00	0.00	0.00	5.98	0.60	1.49	0.00	0.00	0.00	11.66
2001	0.00	0.00	0.00	2.91	0.29	0.73	0.00	0.00	0.00	0.00	0.00	0.00	5.78	0.58	1.45	0.00	0.00	0.00	11.73
2002	0.00	0.00	0.00	3.18	0.32	0.79	0.00	0.00	0.00	0.00	0.00	0.00	5.60	0.56	1.40	0.00	0.00	0.00	11.85
2003	0.00	0.00	0.00	3.48	0.35	0.87	0.00	0.00	0.00	0.00	0.00	0.00	5.41	0.54	1.35	0.00	0.00	0.00	12.00
2004	0.00	0.00	0.00	3.80	0.38	0.95	0.00	0.00	0.00	0.00	0.00	0.00	5.24	0.52	1.31	0.00	0.00	0.00	12.21
2005	0.00	0.00	0.00	4.16	0.42	1.04	0.00	0.00	0.00	0.00	0.00	0.00	5.07	0.51	1.27	0.00	0.00	0.00	12.46
Total	**0.00**	**0.00**	**0.00**	**30.44**	**3.04**	**7.61**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**66.09**	**6.61**	**16.52**	**0.00**	**0.00**	**0.00**	**130.31**

Year	Lighting			Cooking/ Heating/Cooling/Mechanical work			Charcoal Production			Renewables			Total for all activities			Annual Total
	IF	FF	OM	IF	FF	OM	IF	FF	OM	IF	FF	OM	IF	FF	OM	
1995	7.70	0.77	1.93	24.36	2.44	6.09	1.70	0.17	0.43	7.04	0.70	1.76	40.81	4.08	10.20	55.10
1996	7.45	0.75	1.86	23.58	2.36	5.89	1.86	0.19	0.47	6.82	0.68	1.70	39.71	3.97	9.93	53.60
1997	7.21	0.72	1.80	22.81	2.28	5.70	2.03	0.20	0.51	6.59	0.66	1.65	38.66	3.87	9.66	52.19
1998	6.98	0.70	1.75	22.08	2.21	5.52	2.22	0.22	0.56	6.38	0.64	1.60	37.66	3.77	9.42	50.85
1999	6.76	0.68	1.69	21.36	2.14	5.34	2.43	0.24	0.61	6.18	0.62	1.54	36.73	3.67	9.18	49.58
2000	6.54	0.65	1.63	20.67	2.07	5.17	2.66	0.27	0.66	5.98	0.60	1.49	35.85	3.58	8.96	48.39
2001	6.33	0.63	1.58	20.01	2.00	5.00	2.91	0.29	0.73	5.78	0.58	1.45	35.02	3.50	8.76	47.28
2002	6.12	0.61	1.53	19.36	1.94	4.84	3.18	0.32	0.79	5.60	0.56	1.40	34.26	3.43	8.56	46.24
2003	5.92	0.59	1.48	18.73	1.87	4.68	3.48	0.35	0.87	5.41	0.54	1.35	33.55	3.35	8.39	45.29
2004	5.73	0.57	1.43	18.13	1.81	4.53	3.80	0.38	0.95	5.24	0.52	1.31	32.90	3.29	8.23	44.42
2005	5.55	0.55	1.39	17.54	1.75	4.39	4.16	0.42	1.04	5.07	0.51	1.27	32.32	3.23	8.08	43.63
Total	**72.29**	**7.23**	**18.07**	**228.64**	**22.86**	**57.16**	**30.44**	**3.04**	**7.61**	**66.09**	**6.61**	**16.52**	**397.45**	**39.75**	**99.36**	**536.56**

2.2.4. Baseline Scenario

This section provides analysis for data obtained in the baseline scenario over the assessment period. The baseline scenario involves investment and financial flows as well as operation and maintenance costs in the ongoing or existing investment in the energy sector.

Since the inauguration of a new democratically-elected Government led by President Ellen Johnson-Sirleaf, small but significant steps have been taken to re-establish public power supply and re-commercialize the Liberia Electricity Corporation (LEC). Launched in 2006 soon after the inauguration of the President, the Emergency Power Program (EPP) was designed to re-establish public power supply as part of the Government's political stabilization and economic reconstruction program. Several international partners, including the United States Agency for International Development (USAID), Ghana, Norway, the European Union, and the World Bank provided over US$40 million grant funding and technical assistance. LEC now has a system with 9.6-MW installed diesel generation capacity, 26.8 km of 66-kV transmission lines, 27 km of 22-kV distribution as well as 35-km of 400/230-V networks, and has about 1,000 street lights and over 2,300 customers in Monrovia. Although only set at levels to cover operational and maintenance costs, the current tariff is relatively high at US $0.43/kWh. This is however lower than the cost of self-generation which is estimated at not less than US $0.75/kWh. The LEC increased its energy generation from 2,045,644 kW in 2006 to 19,554,334 kWh in 2009 with a total cumulative energy generation of 42, 672,158 kWh. The GOL subsidizes the balance of LEC's costs and is expected to continue doing so during the transition to cheaper medium-term generation options now under active discussion and planning.

There is no generation capacity outside of Monrovia beyond privately-owned generators and scattered donor-funded pilot projects. A number of Government agencies, community and private sector establishments in rural locations in several counties have been able to receive diesel generators and solar power systems through USAID, the United Nations Development Programme (UNDP), and some non-governmental organizations (NGOs).

The estimated current level of "unserved" electricity demand is 11–25 MW. While Liberia's **First State of the Environment Report** forecasts that the demand for electricity will rise an average of 10.3% annually by 2010, and then decrease slightly to a 3.4% growth annually until 2020, a recent demand forecast by the IFC projects total demand for Monrovia and its environs of 19 MW by 2010, 34 MW by 2015, and 41 MW by 2020. For a variety of reasons, it appears that these forecasts are very conservative. The actual demand for Liberia, including the various concessions, is likely to be in excess of 350 MW by 2020, for the following reasons:

- Liberia's population, estimated at around 3.5 million from the results of the 2008 census, has been growing at an average annual rate of 2.1%. Over 53 percent of the population is under 18 years of age. With a large pent-up demand for consumer goods and services as evidenced by previous levels of demand and rising incomes, demand for energy used in the production of these goods will increase as the population rises.
- Since pre-conflict electricity capacity exceeded 400 MW, it seems likely that at some point the economy will begin to take off and very quickly reach previous levels of capacity.

Cement processing, rubber processing, brewery and other factories and industrial operations have a huge demand for power.

- Prior to the civil conflict, the iron ore industry had a total installed generation capacity of about 210 MW of electricity. Although none of these former mines is currently in operation, the Government has prioritized their re-opening in the short to medium term beginning with a recent concession agreement with Arcelor Mittal for one of the former mines. The next two concessions for the Western Cluster iron ore deposits and the Old Bong Mines will be awarded soon. Furthermore, aggressive mineral exploration and resource appraisal programs for additional iron ore deposits are underway. The prospects for new hard rock mines for minerals such as gold, diamonds, uranium, and bauxite are very promising. The demand for energy for these operations in the medium and long term will be very significant, and without a strong Government energy policy, the requisite power to fuel these mining operations will not be developed.
- The agriculture sector, although mostly artisanal at present, has a high demand for energy services. Agro-based concessions, such as rubber and other mechanized activities, produce electricity for their own consumption. Demand for energy in agriculture in the short, medium and long terms will be significant.

Table 4: Some Selected Indicators

Total Population (2008 Census)	3.476 Million
Urban Population (2008 Census)	47%
Rural Population (2008 Census)	53%
Population Growth Rate (2008 Census)	2.1%
GDP Per Capita (UN HD Report 2009)	362 PPP US$
HDI Ranking (UN HD Report 2009)	169/182 of countries
HDI (UN HD Report 2009)	0.442
Population with Access to Grid Electricity (Monrovia only)	<5%
Current Installed Capacity (National Grid)	22.64 MW
Current Mode of Electricity Generation	High Speed Diesel/Heavy Fuel Oil (Planned)
Current Electricity Tariff	US$ 0.43 per kWh plus 7% goods and services tax (or 0.46 US$)
Rural Areas Electrified By National Grid	0 %
Average Monthly Household Spending on Kerosene for Lighting only	US$10.00

Base Year Data

Indicator	Value
Charcoal Consumption in 2005	~36,500 tons
Fire Wood Consumption in 2005	~10.8 million m^3
Percentage of Rural Households with Access to	0.0%

Electricity	
Regional or Cross-border Interconnectivity (Miles of Cross-border Transmission Lines)	0 miles

The baseline assessment considered data over a 25 year period (2005-2030). Using 2005 as the base year, projections were made for the succeeding assessment years considering 2.4% annual population growth rate up to 2007 and then 2.1% for 2008-2030. As in the historical data assessment, similar investment types and entities were used in the baseline scenario. Importantly, ongoing investments in renewables were accounted for in the baseline period. Tables 6 and 7 below contain the results of baseline calculations. Total baseline investment is valued at US$499.57million. Note that all figures are deflated at constant 2005 US dollars using data provided by the CBL.

The tables generated from the calculations are given below. Table 5 provides data on the base year (2005) for the I&FF, totaling US$35.55 million for all investment types considered in this assessment. It is important to note that this figure excludes the 2005 O&M cost.

From Table 6, it can be noted that the total baseline scenario cumulative discounted IF&FF including O&M is $268.758 million of which investments in cooking/heating and charcoal production account for 40% ($108.78 million) and 29% (US$77.73 million), respectively. This suggests that more investments are required in the above two subsectors followed by investments in lighting at 15% (US$41.38 million) and renewable energy at 15% (US$40.86 million). Table 6 provides a detailed illustration of the cumulative discounted estimates for the baseline scenario. The major source of funding for the investments in lighting (US$21.60 million) and cooking/heating (US$59.40 million) is government, while those for renewables are corporations (US$22.96 million), and government (US$17.90 million). For charcoal production, the only contributing source of funding is corporations at US$77.73 million over the baseline assessment period.

For the baseline scenario annual IF, FF and O&M (as seen in table 7 below), the total for all investment types is US$499.56 million over the entire assessment period. Investment in charcoal production without any mitigation measure accounts for about 48% (US$131.80 million) of the total, followed by investment in cooking/heating at 29% (US 79.67 million). Investments in lighting and renewable energy account for only 12% (US$32.27 million) and 11% (US$ 30.45 million), respectively. These figures further confirm that investments in charcoal production and cooking/heating collectively account for the largest portion of the baseline scenario annual investments in this report. The largest investments are expected to occur in 2007 at US$57.84 million with cooking/heating/cooling/motive power and renewables accounting for the largest portions of 46% (US$26.85 million) and 26% (US$14.93 million), respectively.

The attached excel spreadsheet gives more detailed analyses on the assumptions and subsequent calculations.

Table 5: Base Year (2005) IF & FF Data, By Investment Type, Investment Entity, and Funding Source (Constant 2005 US$)

Category of Investment Entity	Source of I&FF Funds		Lighting		Cooking		Charcoal		Renewables	
			IF	FF	IF	FF	IF	FF	IF	FF
Households	Domestic	Equity and debt								
	Total Household Funds (all domestic)		0.73	0.07	2.24	0.22	0.00	0.00	0.00	0.00
Corporations	Domestic	Domestic equity (including internal cash flow)								
		Domestic borrowing (bonds and loans)								
		Total Domestic Sources								
	Foreign	Foreign direct investment (FDI)								
		Foreign borrowing (loans)								
		Foreign aid (ODA)								
		Total Foreign Sources								
	Total Corporation Funds		3.64	0.36	8.62	0.86	4.16	0.42	5.07	0.51
Government	Domestic	Domestic funds(budgetary)								
	Foreign	Foreign borrowing (loans)								
		Bilateral foreign aid (bilateral ODA)								
		Multilateral foreign aid (multilateral ODA)								
		Total Foreign Sources								
	Total Government Funds		1.18	0.12	6.68	0.67	0.00	0.00	0.00	0.00
Total Funds			**5.55**	**0.55**	**17.54**	**1.75**	**4.16**	**0.42**	**5.07**	**0.51**

Chart 3: Base Year IF & FF Data

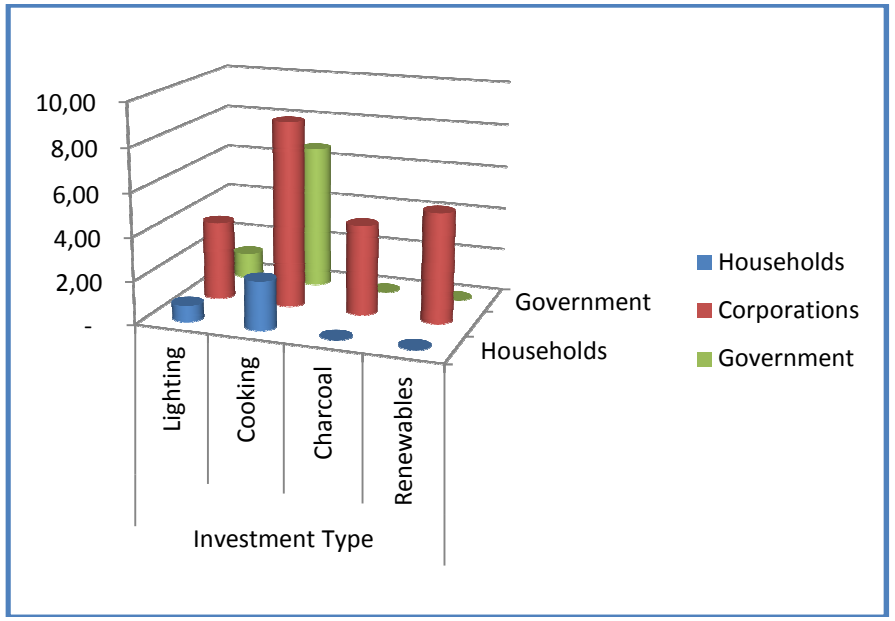


Table 6: Baseline Scenario: Cumulative Discounted IF, FF, and O&M Estimates, By Investment Type, Investment Entity, and Funding Source

Category of Investment Entity	Source of I&FF Funds		Lighting			Cooking			Charcoal			Renewables		
			IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
Households	Domestic	Equity and debt												
	Total Household Funds (all domestic)		2.44	0.24	0.61	7.52	0.75	1.88	0.00	0.00	0.00	0.00	0.00	0.00
Corporations	Domestic	Domestic equity (including internal cash flow)												
		Domestic borrowing (bonds and loans)												
		Total Domestic Sources												
	Foreign	Foreign direct investment (FDI)												
		Foreign borrowing (loans)												
		Foreign aid (ODA)												
		Total Foreign Sources												
	Total Corporation Funds		12.21	1.22	3.05	28.92	2.89	7.23	57.58	5.76	14.39	17.01	1.70	4.25
Government	Domestic	Domestic funds(budgetary)												
	Foreign	Foreign borrowing (loans)												
		Bilateral foreign aid (bilateral ODA)												
		Multilateral foreign aid (multilateral ODA)												
		Total Foreign Sources												
	Total Government Funds		16.00	1.60	4.00	44.14	4.41	11.03	0.00	0.00	0.00	13.26	1.33	3.31
Total Funds			**30.65**	**3.07**	**7.66**	**80.58**	**8.06**	**20.14**	**57.58**	**5.76**	**14.39**	**30.27**	**3.03**	**7.57**

Chart 4: Baseline Scenario: Cumulative Discounted IF, FF, and O&M Estimates

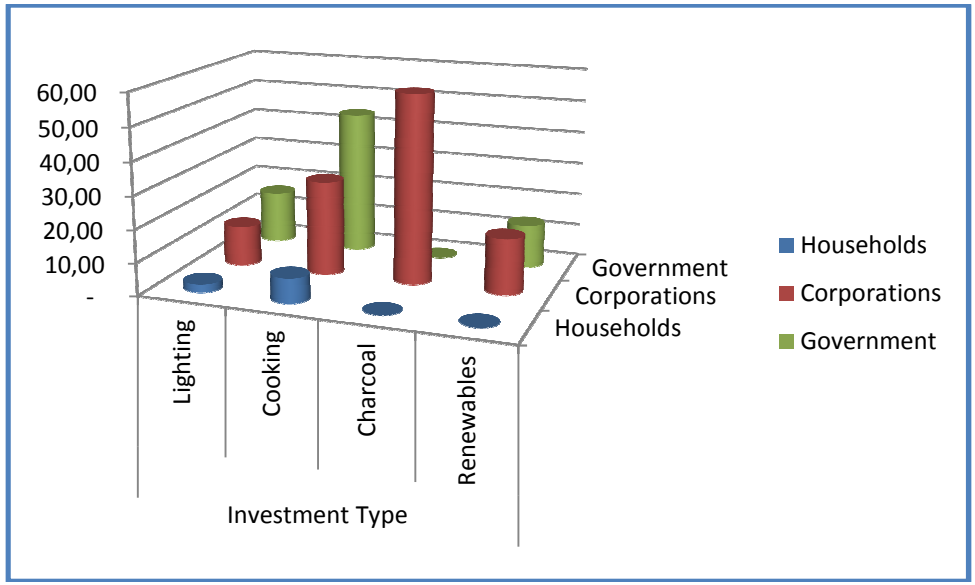
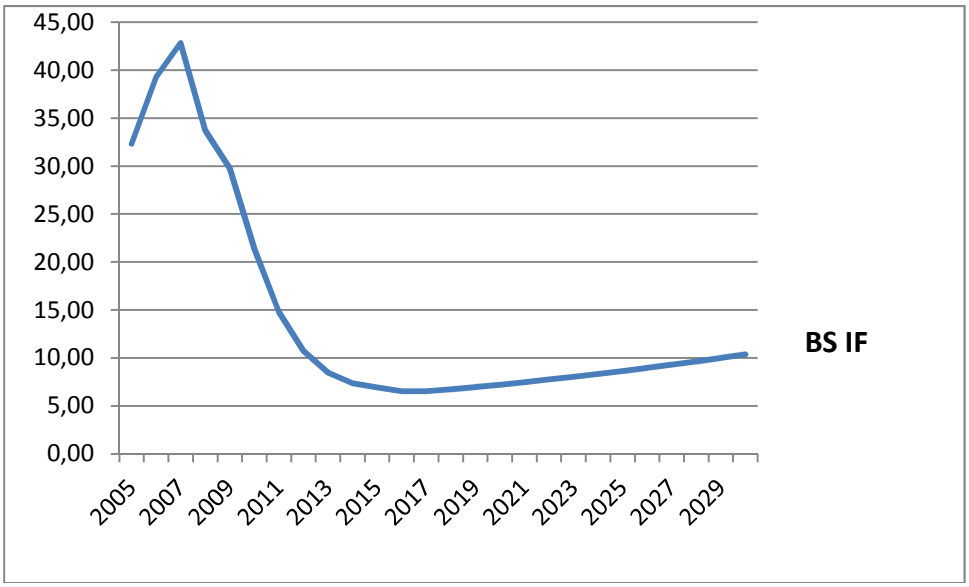


Table 7: Baseline Scenario: Annual IF, FF, and O&M Estimates by Investment Type (million 2005 US$)

Year	Lighting			Cooking			Charcoal			Renewables			Annual
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	Total
2005	5.55	0.55	1.39	17.54	1.75	4.39	4.16	0.42	1.04	5.07	0.51	1.27	43.63
2006	6.87	0.69	1.72	22.90	2.29	5.72	4.55	0.45	1.14	4.98	0.50	1.25	53.04
2007	7.17	0.72	1.79	19.89	1.99	4.97	4.72	0.47	1.18	11.06	1.11	2.76	57.84
2008	6.17	0.62	1.54	14.72	1.47	3.68	4.65	0.47	1.16	8.20	0.82	2.05	45.54
2009	4.59	0.46	1.15	14.91	1.49	3.73	4.82	0.48	1.21	5.43	0.54	1.36	40.17
2010	4.23	0.42	1.06	8.88	0.89	2.22	5.00	0.50	1.25	3.24	0.32	0.81	28.82
2011	3.14	0.31	0.78	4.76	0.48	1.19	5.19	0.52	1.30	1.73	0.17	0.43	20.00
2012	2.22	0.22	0.55	2.29	0.23	0.57	5.38	0.54	1.35	0.83	0.08	0.21	14.48
2013	1.53	0.15	0.38	0.99	0.10	0.25	5.58	0.56	1.40	0.36	0.04	0.09	11.42
2014	1.05	0.11	0.26	0.39	0.04	0.10	5.79	0.58	1.45	0.14	0.01	0.04	9.95
2015	0.74	0.07	0.18	0.13	0.01	0.03	6.00	0.60	1.50	0.05	0.00	0.01	9.35
2016	0.23	0.02	0.06	0.04	0.00	0.01	6.23	0.62	1.56	0.02	0.00	0.00	8.80
2017	0.07	0.01	0.02	0.01	0.00	0.00	6.46	0.65	1.61	0.00	0.00	0.00	8.83
2018	0.02	0.00	0.00	0.00	0.00	0.00	6.70	0.67	1.67	0.00	0.00	0.00	9.07
2019	0.00	0.00	0.00	0.00	0.00	0.00	6.95	0.69	1.74	0.00	0.00	0.00	9.39
2020	0.00	0.00	0.00	0.00	0.00	0.00	7.21	0.72	1.80	0.00	0.00	0.00	9.73
2021	0.00	0.00	0.00	0.00	0.00	0.00	7.47	0.75	1.87	0.00	0.00	0.00	10.09
2022	0.00	0.00	0.00	0.00	0.00	0.00	7.75	0.78	1.94	0.00	0.00	0.00	10.46
2023	0.00	0.00	0.00	0.00	0.00	0.00	8.04	0.80	2.01	0.00	0.00	0.00	10.85
2024	0.00	0.00	0.00	0.00	0.00	0.00	8.34	0.83	2.08	0.00	0.00	0.00	11.26
2025	0.00	0.00	0.00	0.00	0.00	0.00	8.65	0.86	2.16	0.00	0.00	0.00	11.67
2026	0.00	0.00	0.00	0.00	0.00	0.00	8.97	0.90	2.24	0.00	0.00	0.00	12.11
2027	0.00	0.00	0.00	0.00	0.00	0.00	9.30	0.93	2.33	0.00	0.00	0.00	12.56
2028	0.00	0.00	0.00	0.00	0.00	0.00	9.65	0.96	2.41	0.00	0.00	0.00	13.02
2029	0.00	0.00	0.00	0.00	0.00	0.00	10.01	1.00	2.50	0.00	0.00	0.00	13.51
2030	0.00	0.00	0.00	0.00	0.00	0.00	10.38	1.04	2.59	0.00	0.00	0.00	14.01
Total	**43.56**	**4.36**	**10.89**	**107.45**	**10.75**	**26.86**	**177.93**	**17.79**	**44.48**	**41.11**	**4.11**	**10.28**	**499.59**

Chart 5: Baseline Scenario



2.2.5. Mitigation Scenario: This scenario takes into account the programs and projects intended to be implemented in the country in this sector.

This section provides analysis for data obtained in the mitigation scenario over the assessment period. The mitigation scenario involves investment and financial flows as well as operation and maintenance costs in the recommended measures to address climate change.

Based upon the recommendations contained in the various documents listed in Section 1.2.1, **Previous Analyses Used**, the Energy Team decided to select the following preliminary mitigation measures for the energy sector:

1) Improved Efficiency of Energy Production and Use

Efficient charcoal kilns

Households and government are not expected to invest in this investment type.

Corporations
Corporations' projected base year investment in efficient charcoal production is roughly 17 million 2005 US$. The period total is about 189 million 2005 US$.

Improved charcoal stoves and LPG stoves

Households
Households' calculated base year investment in efficient charcoal stoves and liquefied petroleum gas (LPG) stoves is roughly 30 and 4 million US$, respectively. The period total is about 375 million 2005 US$.

Corporations
Corporations' projected base year investment in liquefied petroleum gas (LPG) stoves is roughly 4 million 2005 US$. The period total is about 18 million 2005 US$.

Government
Government's planned base year investment in liquefied petroleum gas (LPG) stoves is roughly 0.100 million 2005 US$. The period total is about 1.05 million 2005 US$.

Efficient lighting in commercial facilities, public facilities and homes

Households
Households are expected to invest in compact fluorescent lamps (CFLs) and solar lamps, The respective base year investments are 31 and 31 million 2005 US$. Households' IF for the period is about 683 million 2005 US$.

Corporations
Corporations are also anticipated to invest in compact fluorescent lamps (CFLs) and solar lamps, starting with a base year investment of about 5 million 2005 US$. Corporations' total IF Is projected to be 53 million 2005 US$.

Government
The government's projected base year investment in compact fluorescent lamps (CFLs) is 0.750 million 2005 US$ and for the entire period is 8 million 2005 US$.

2) Renewable Energy

Solar PV systems, Biomass-fired power plant, Large, small, mini and micro hydro power plants

Households
Households are expected to invest about 37 million 2005 US$ in 200-Wp solar panels in the base year. The period total investment flow is about 486 million 2005 US$.

Corporations
Corporations are expected to invest about 12 million 2005 US$ during the mitigation period, beginning in 2011with one million 2005 US$.

Government
Upon the analysis of various documents and based on information we received following discussions with government authorities, knowledgeable people in the donor community and several energy experts, the government will construct a number of micro hydro, mini hydro, small hydro and large hydro power plants to mitigate climate change in the energy sector. We then deduced from the various discussions that the government would construct hydro power plant in the following categories: micro, 10000kW at 4800.00US$/kW; mini, 15000kW at 4200.00US$; 50000kW at 3600.00US$; and large hydro, 617000 at 1200.00US$. Reckoning that each plant would be operated for 7008 annually, we calculated a total annual energy generation of 4850GWh – micro (70080MWh), mini (105,120MWh), small

(350,400MWh), and large hydro (4,336,936). The calculation of demand is based on the assumption that household demand is 500kWh/month and there are 700,000 households. We derived a total national energy demand of 4,200GWh per annum. Using an annual capital recovery factor (ACRF) of 0.1175, we computed the annual investment in hydro as follows: micro, 5,6 million US$; mini, 7.4 million US$; small, 21.2 millions, and large hydro, 87.0 million US$. We also assumed that each investment would require a foreign component of 80%.

The research also revealed that there were 361 public health facilities and 1,546 public schools that needed 1,000-Wp solar panels each. We assumed each solar panel would cost US$5,000.00.

The projections of those figures gave us the following result: the government will need to invest approximately 557 million US$ in renewables to mitigate climate change in the energy sector.

The main investment entities identified for this assessment are households (families and communities); corporations (NGOs and private businesses) and government (administrative agencies and parastatals).

The tables (8 and 9) below indicate projected investments to mitigate climate change in Liberia. The four investment types used in the previous scenario were also considered in this mitigation assessment for the same investment entities-households, corporations and government. Data were projected from 2005 to 2030 as was done in the baseline scenario, and annual growth rates of 2.4% and 2.1% were used from 2005 to 2007, and from 2008 to 2030 respectively. Significant investments in renewable energy and energy efficiency programs were highly considered as mitigation options or measures for the assessment. Total investment to mitigate climate change projected over the assessment period stands at US$3,215.84 million. All figures were converted to 2005 constant US dollars using data from the Central Bank of Liberia.

As the figures in Table 8 show, total cumulative discounted IF&FF including O&M is US$1,570 million of which investments in renewable energy and efficient lighting account for 39% ($608.03 million) and 34% (US$534.45 million) respectively for the assessment period (2005-2030). This suggests that more investments are required in the above two subsectors followed by investments in improved cooking/heating methods at 19% (US$292.03 million) and efficient charcoal production at 9% (US$135.46 million). Table 8 provides a detailed illustration of the cumulative discounted estimates for the mitigation scenario. The sources of funding for the investments in efficient lighting (US$395.89 million), cooking/heating (US$216.32 million) and renewables (US$450.39 million) are households (domestic), and corporations (US$100.34) for charcoal production. Corporations and Government are expected to contribute significant sums, US$249.86 million and US196.30 million, respectively for investment in renewable energy over the assessment period.

For the mitigation scenario annual IF, FF and O&M (as seen in table 9 below), the total for all investment types is US$3,215.84 million over the entire assessment period. Renewable energy investment accounts for about 44% (US$1.425 billion) of the total, followed by

investment in efficient lighting at 31% (US 1.005 billion). Investments in improved cooking/heating and efficient charcoal production methods account for only 17% (US$531 million) and 8% (US$ 255 million) respectively. These figures further confirm that investments in renewable energy and lighting are more required and collectively account for the largest portion of the mitigation scenario annual investments in this report. The largest investments are expected to occur in 2011 at US$224.35 million with renewable energy accounting for the largest portion of the investment at US$126.94 million.

More detailed analysis on the assumptions and calculations leading to the below tables can be found in the attached Excel spreadsheet.

Table 8: Mitigation Scenario: Cumulative Discounted IF, FF, and O&M Estimates, By Investment Type, Investment Entity, and Funding Source (million 2005 US$)

Category of Investment Entity	Source of I&FF Funds		Lighting			Cooking			Charcoal			Renewables		
			IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
Households	Domestic	Equity and debt												
	Total Household Funds (all domestic)		363.33	36.33	90.83	199.12	19.91	49.78	0.00	0.00	0.00	249.86	24.99	62.46
Corporations	Domestic	Domestic equity (including internal cash flow)												
		Domestic borrowing (bonds and loans)												
		Total Domestic Sources												
	Foreign	Foreign direct investment (FDI)												
		Foreign borrowing (loans)												
		Foreign aid (ODA)												
		Total Foreign Sources												
	Total Corporation Funds		28.20	2.82	7.05	13.75	1.38	3.44	100.34	10.03	25.09	4.24	0.42	1.06
Government	Domestic	Domestic funds(budgetary)												
	Foreign	Foreign borrowing (loans)												
		Bilateral foreign aid (bilateral ODA)												
		Multilateral foreign aid (multilateral ODA)												
		Total Foreign Sources												
	Total Government Funds		4.36	0.44	1.09	3.44	0.34	0.86	0.00	0.00	0.00	196.30	19.63	49.07
Total			**395.89**	**39.59**	**98.97**	**216.32**	**21.63**	**54.08**	**100.34**	**10.03**	**25.09**	**450.39**	**45.04**	**112.60**

Chart 6: Mitigation Scenario: Cumulative Discounted IF, FF, and O&M Estimates

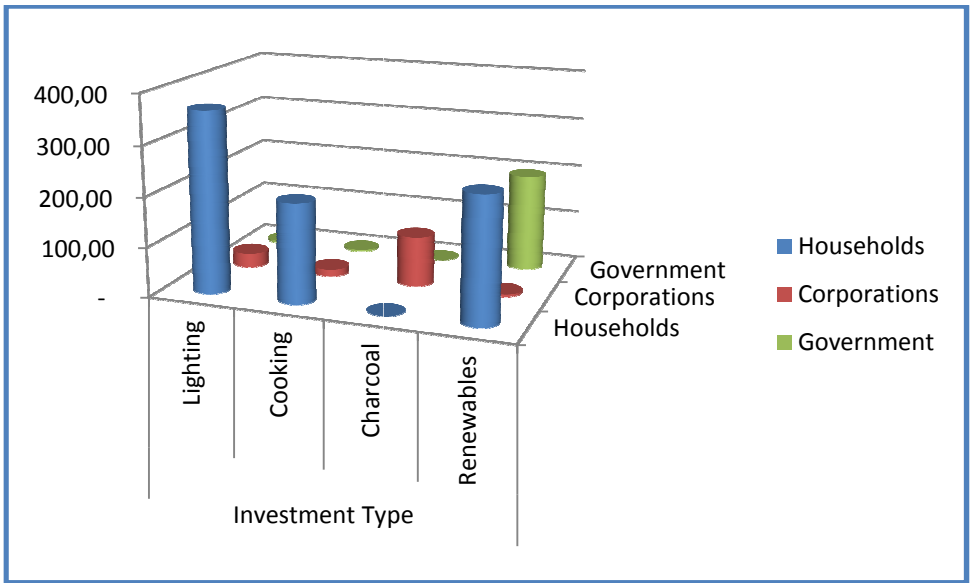
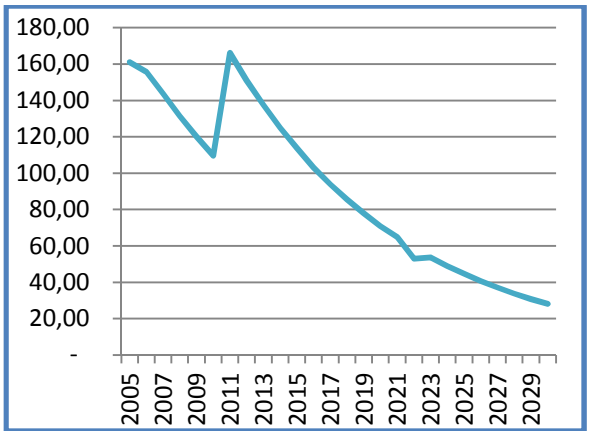


Table 9: Mitigation Scenario: Annual IF, FF, and O&M Estimates by Investment Type (million 2005 US$)

Year	Lighting			Cooking			Charcoal			Renewables			Annual Total
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	
2005	67.98	6.80	16.99	38.38	3.84	9.60	17.23	1.72	4.31	37.38	3.74	9.34	217.30
2006	65.78	6.58	16.45	37.14	3.71	9.29	16.67	1.67	4.17	36.17	3.62	9.04	210.28
2007	60.47	6.05	15.12	33.94	3.39	8.49	15.32	1.53	3.83	34.00	3.40	8.50	194.05
2008	52.69	5.27	13.17	29.12	2.91	7.28	13.36	1.34	3.34	36.30	3.63	9.07	177.48
2009	48.36	4.84	12.09	26.08	2.61	6.52	12.26	1.23	3.06	33.32	3.33	8.33	162.03
2010	44.39	4.44	11.10	23.39	2.34	5.85	11.25	1.13	2.81	30.58	3.06	7.64	147.98
2011	40.74	4.07	10.19	21.09	2.11	5.27	10.33	1.03	2.58	94.03	9.40	23.51	224.35
2012	37.39	3.74	9.35	19.12	1.91	4.78	9.48	0.95	2.37	85.06	8.51	21.26	203.92
2013	34.32	3.43	8.58	17.43	1.74	4.36	8.70	0.87	2.18	76.95	7.69	19.24	185.49
2014	31.50	3.15	7.88	15.93	1.59	3.98	7.99	0.80	2.00	69.62	6.96	17.41	168.81
2015	28.91	2.89	7.23	14.60	1.46	3.65	7.33	0.73	1.83	63.00	6.30	15.75	153.68
2016	26.54	2.65	6.63	13.39	1.34	3.35	6.73	0.67	1.68	56.42	5.64	14.10	139.15
2017	24.36	2.44	6.09	12.29	1.23	3.07	6.17	0.62	1.54	51.06	5.11	12.77	126.74
2018	22.36	2.24	5.59	11.28	1.13	2.82	5.67	0.57	1.42	46.22	4.62	11.56	115.45
2019	20.52	2.05	5.13	10.35	1.04	2.59	5.20	0.52	1.30	41.84	4.18	10.46	105.18
2020	18.83	1.88	4.71	9.50	0.95	2.38	4.77	0.48	1.19	37.88	3.79	9.47	95.83
2021	17.29	1.73	4.32	8.72	0.87	2.18	4.38	0.44	1.10	34.30	3.43	8.57	87.33
2022	14.26	1.43	3.57	7.19	0.72	1.80	3.62	0.36	0.90	27.92	2.79	6.98	71.54
2023	14.56	1.46	3.64	7.35	0.73	1.84	3.69	0.37	0.92	28.13	2.81	7.03	72.53
2024	13.37	1.34	3.34	6.74	0.67	1.69	3.39	0.34	0.85	25.47	2.55	6.37	66.11
2025	12.27	1.23	3.07	6.19	0.62	1.55	3.11	0.31	0.78	23.07	2.31	5.77	60.26
2026	11.26	1.13	2.81	5.68	0.57	1.42	2.85	0.29	0.71	20.90	2.09	5.23	54.94
2027	10.33	1.03	2.58	5.21	0.52	1.30	2.62	0.26	0.65	18.94	1.89	4.73	50.09
2028	9.49	0.95	2.37	4.78	0.48	1.20	2.40	0.24	0.60	17.16	1.72	4.29	45.67
2029	8.71	0.87	2.18	4.39	0.44	1.10	2.21	0.22	0.55	15.55	1.55	3.89	41.65
2030	7.99	0.80	2.00	4.03	0.40	1.01	2.03	0.20	0.51	14.09	1.41	3.52	37.98
Total	**744.68**	**74.47**	**186.17**	**393.33**	**39.33**	**98.33**	**188.75**	**18.88**	**47.19**	**1,055.34**	**105.53**	**263.83**	**3,215.84**

Chart 7: Mitigation Scenario Annual



3. Results

3.1 Incremental Changes in IF, FF, O&M Costs, and Subsidy Costs

This section provides incremental changes in investment and financial flows as well as operation and maintenance costs. Incremental changes refer to the changes in IF, FF, and O&M costs that are needed to implement the mitigation measures in each subsector. The baseline scenario costs were subtracted from the mitigation scenario costs to obtain the changes or additionality. This was done for cumulative and annual IF, FF, and O&M costs. The tables generated from the calculations are Table 10 and Table 11. Total cumulative changes in IF&FF including O&M (Table 10) is US$1.297 billion of which investments in renewable energy and efficient lighting account for 44% (US$567.16 million) and 38% (US$493.07 million) respectively for the assessment period (2005-2030). This suggests that more investments are required in the above two subsectors, followed by investments in improved cooking/heating/cooling/motive power methods 14 %(US$179.36 million), and efficient charcoal production 4% (US$ 57.73 million). Table 10 provides a detailed illustration of the incremental cumulative discounted estimates.

For incremental annual IF, FF and O&M (as seen in table 11 below), the total for all investment types is US$2.716 billion over the entire assessment period. Similarly, renewable energy investment accounts for about 50% (US$1.369 billion) of the total, followed by investment in efficient lighting at 35% (US 946.51 million). Investments in improved cooking/heating and efficient charcoal production methods account for only 14% (US$385.94 million) and 1% (US$ 14.6 million) respectively. These figures further confirm that investments in renewable energy and lighting are more required and collectively account for the largest portion of incremental annual investments in this report. The largest investments are expected to occur in 2011 at US$204.35 million and 2012 at US$189.44 million.

Table 10: Incremental Cumulative Discounted IF & FF Estimates, By Investment Type, Investment Entity, and Funding Source (million 2005 US$)

Category of Investment Entity	Source of I&FF Funds		Lighting			Cooking			Charcoal Production			Renewables			All Investment Types		
			ΔIF	ΔFF	ΔO&M	ΔIF	ΔFF	ΔO&M	ΔIF	ΔFF	ΔO&M	ΔIF	ΔFF	ΔO&M	ΔIF	ΔFF	ΔO&M
Households	Domestic	Equity and debt															
	Total Household Funds (all domestic)		360.89	36.09	90.22	191.60	19.16	47.90	0.00	0.00	0.00	249.86	24.99	62.46	802.35	80.24	200.59
Corporations	Domestic	Domestic equity (including internal cash flow)															
		Domestic borrowing (bonds and loans)															
		Total Domestic Sources	1.60	0.16	0.40	-13.65	-1.37	-3.41	8.55	0.86	2.14	-2.56	-0.26	-0.64	-6.06	-0.61	-1.51
	Foreign	Foreign direct investment (FDI)															
		Foreign borrowing (loans)															
		Foreign aid (ODA)															
		Total Foreign Sources	14.39	1.44	3.60	-1.52	-0.15	-0.38	34.21	3.42	8.55	-10.22	-1.02	-2.56	36.86	3.69	9.21
	Total Corporation Funds		15.98	1.60	4.00	-15.17	-1.52	-0.38	42.76	4.28	10.69	-12.78	-1.28	-3.19	30.80	3.08	7.70
Government	Domestic	Domestic funds(budgetary)	-2.33	-0.23	-0.58	-39.22	-3.92	-9.81	0.00	0.00	0.00	36.61	3.66	9.15	-4.94	-0.49	-1.24
	Foreign	Foreign borrowing (loans)															
		Bilateral foreign aid (bilateral ODA)															
		Multilateral foreign aid (multilateral ODA)															
		Total Foreign Sources	-9.31	-0.93	-2.33	-4.36	-0.44	-1.09	0.00	0.00	0.00	146.43	14.64	36.61	132.76	13.28	33.19
	Total Government Funds		-11.64	-1.16	-2.91	-43.58	-4.36	-10.89	0.00	0.00	0.00	183.04	18.30	45.76	127.82	12.78	31.96
Total			**365.24**	**36.52**	**91.31**	**132.86**	**13.29**	**36.63**	**42.76**	**4.28**	**10.69**	**420.12**	**42.01**	**105.03**	**960.98**	**96.10**	**240.25**

Note: Negative values mean net savings.

Table 11: Incremental Annual IF, FF & O&M Estimates by Investment Type (million 2005 US$)

Year	Lighting			Cooking			Charcoal			Renewables			All Investment Types			Annual Total
	ΔIF	ΔFF	ΔO&M	ΔIF	ΔFF	ΔO&M	ΔIF	ΔFF	ΔO&M	ΔIF	ΔFF	ΔO&M	ΔIF	ΔFF	ΔO&M	
2005	62.43	6.24	15.61	20.84	2.08	5.21	13.07	1.31	3.27	32.31	3.23	8.08	128.65	12.86	32.16	173.68
2006	58.92	5.89	14.73	14.24	1.42	3.56	12.12	1.21	3.03	31.19	3.12	7.80	116.47	11.65	29.12	157.24
2007	53.30	5.33	13.32	14.05	1.41	3.51	10.60	1.06	2.65	22.94	2.29	5.74	100.90	10.09	25.22	136.21
2008	46.53	4.65	11.63	14.40	1.44	3.60	8.71	0.87	2.18	28.10	2.81	7.03	97.73	9.77	24.43	131.94
2009	43.77	4.38	10.94	11.17	1.12	2.79	7.44	0.74	1.86	27.89	2.79	6.97	90.27	9.03	22.57	121.86
2010	40.16	4.02	10.04	14.51	1.45	3.63	6.25	0.62	1.56	27.34	2.73	6.84	88.27	8.83	22.07	119.17
2011	37.60	3.76	9.40	16.33	1.63	4.08	5.14	0.51	1.28	92.30	9.23	23.07	151.37	15.14	37.84	204.35
2012	35.18	3.52	8.79	16.83	1.68	4.21	4.10	0.41	1.02	84.22	8.42	21.06	140.33	14.03	35.08	189.44
2013	32.80	3.28	8.20	16.43	1.64	4.11	3.12	0.31	0.78	76.59	7.66	19.15	128.94	12.89	32.23	174.07
2014	30.45	3.05	7.61	15.55	1.55	3.89	2.20	0.22	0.55	69.48	6.95	17.37	117.68	11.77	29.42	158.86
2015	28.18	2.82	7.04	14.47	1.45	3.62	1.33	0.13	0.33	62.95	6.29	15.74	106.91	10.69	26.73	144.33
2016	26.31	2.63	6.58	13.35	1.33	3.34	0.50	0.05	0.12	56.40	5.64	14.10	96.56	9.66	24.14	130.36
2017	24.29	2.43	6.07	12.28	1.23	3.07	-0.28	-0.03	-0.07	51.06	5.11	12.76	87.34	8.73	21.84	117.91
2018	22.34	2.23	5.58	11.27	1.13	2.82	-1.03	-0.10	-0.26	46.22	4.62	11.55	78.80	7.88	19.70	106.38
2019	20.52	2.05	5.13	10.35	1.04	2.59	-1.75	-0.17	-0.44	41.84	4.18	10.46	70.96	7.10	17.74	95.80
2020	18.83	1.88	4.71	9.50	0.95	2.38	-2.43	-0.24	-0.61	37.88	3.79	9.47	63.78	6.38	15.95	86.11
2021	17.29	1.73	4.32	8.72	0.87	2.18	-3.09	-0.31	-0.77	34.30	3.43	8.57	57.21	5.72	14.30	77.24
2022	14.26	1.43	3.57	7.19	0.72	1.80	-4.14	-0.41	-1.03	27.92	2.79	6.98	45.24	4.52	11.31	61.07
2023	14.56	1.46	3.64	7.35	0.73	1.84	-4.35	-0.43	-1.09	28.13	2.81	7.03	45.69	4.57	11.42	61.68
2024	13.37	1.34	3.34	6.74	0.67	1.69	-4.95	-0.49	-1.24	25.47	2.55	6.37	40.63	4.06	10.16	54.85
2025	12.27	1.23	3.07	6.19	0.62	1.55	-5.54	-0.55	-1.38	23.07	2.31	5.77	35.99	3.60	9.00	48.59
2026	11.26	1.13	2.81	5.68	0.57	1.42	-6.11	-0.61	-1.53	20.90	2.09	5.23	31.73	3.17	7.93	42.83
2027	10.33	1.03	2.58	5.21	0.52	1.30	-6.68	-0.67	-1.67	18.94	1.89	4.73	27.80	2.78	6.95	37.53
2028	9.49	0.95	2.37	4.78	0.48	1.20	-7.24	-0.72	-1.81	17.16	1.72	4.29	24.18	2.42	6.05	32.65
2029	8.71	0.87	2.18	4.39	0.44	1.10	-7.80	-0.78	-1.95	15.55	1.55	3.89	20.84	2.08	5.21	28.14
2030	7.99	0.80	2.00	4.03	0.40	1.01	-8.35	-0.84	-2.09	14.09	1.41	3.52	17.76	1.78	4.44	23.97
Total	**701.12**	**70.11**	**175.28**	**285.88**	**28.59**	**71.47**	**10.82**	**1.08**	**2.70**	**1,014.22**	**101.42**	**253.56**	**2,012.04**	**201.20**	**503.01**	**2,716.25**

Note: Negative values mean net savings.

Chart 8: Incremental Annual IF & FF Estimates by Investment Type

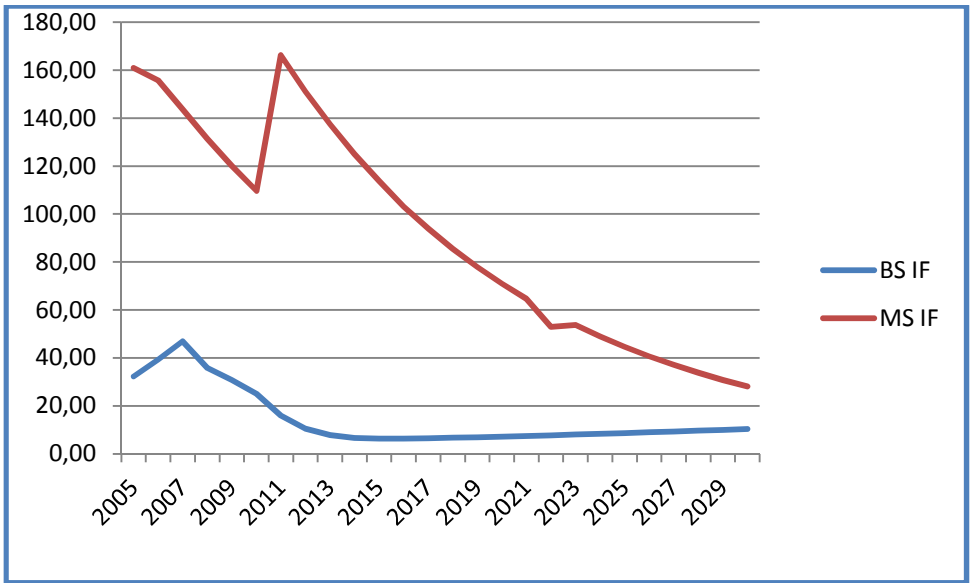
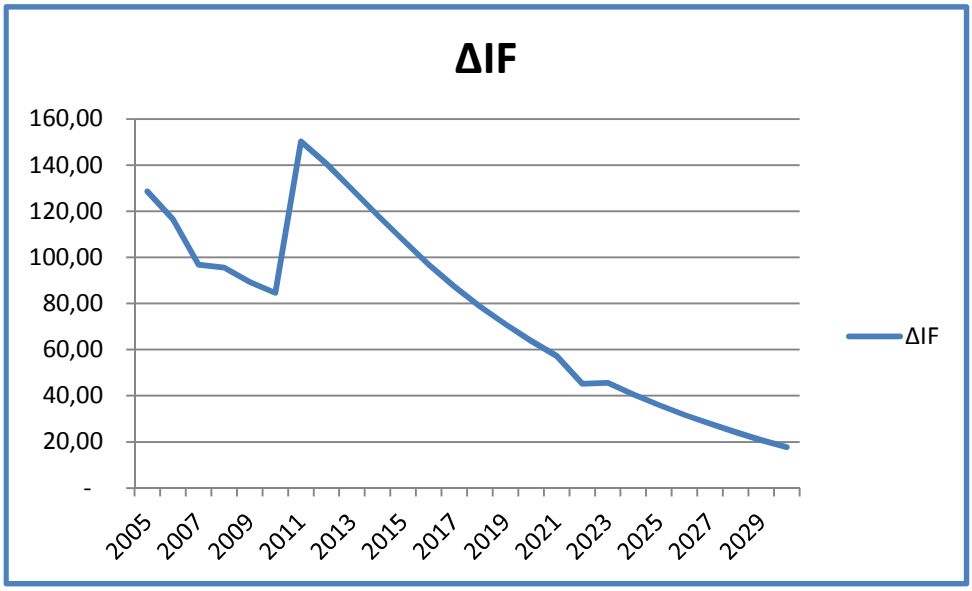


Chart 9: Incremental Investment Flow



3.1.1 Energy Efficiency

Energy efficiency is one of two major mitigation options recommended in this assessment. Lighting, cooking/heating/cooling/motive power, and charcoal production were prioritized as efficiency measures for this assessment. Perusal of Table 11 indicates that Investment in these efficiency measures amounts to US$1.347 billion, of which efficient lighting is largest, accounting for 70% (US$946.51 million). This is followed by efficient cooking/heating/ cooling/motive power at 29% (US$385.93 million), and just 1% for improved charcoal production at US$14.61 million.

3.1.2 Renewable Energy

This subsector, as earlier stated accounts for the highest level of investments required to mitigate climate change in the energy sector. Investments in renewable energy, mainly hydro, followed by biomass plants and solar energy technologies, account for 50% (US$1.369 billion) of all investments, the largest of which will occur in 2011 and 2012 at US$ 124.61 million and US$113.70 million. See Table 11.

3.2. Policy Implications

3.2.1 Policy Objectives

The policy objectives are to:

- Promote energy efficiency measures; and,
- Increase the renewable energy portfolio in the national energy menu or mix.

The analysis of the policy implications is guided and informed by the table in the I&FF Methodology document entitled: Potential Policy Options to Encourage GHG Mitigation in the Energy Sector. Having assessed the I&FF in Liberia's energy sector in order to address climate change in the country, it is important to highlight some key policy implications which should induce the necessary changes consistent with the recommended mitigation measures.

Firstly, the legislation of the Cabinet-approved National Energy Policy of Liberia (NEP) is required to achieve the necessary changes. Besides the issue of energy access, quality, standard and cost mentioned in the NEP, the establishment of the legal and regulatory framework as outlined in the policy is crucial. The policy mentions the restructuring of the Ministry of Land, Mines and Energy (MLME) by upgrading the energy section to a Deputy Ministerial leve. The NEP also recommends the establishment of an Energy Regulatory Board (ERB), the Rural and Renewable Energy Agency (RREA), the Rural Energy Fund (REFUND), the unbundling of the LEC and the reform of LPRC and NOCAL.

3.2.2 Energy Efficiency

Given the level of poverty in the country vis a vis the envisioned nation-wide use of energy efficient equipment and appliances, policy to introduce the provision of low interest loans, loan guarantees and grants as targeted subsidies to end-users, manufacturers, and importers, would be necessary for consideration.

Investment in energy efficient products and services, will require massive nation-wide awareness and sensitization targeting different categories of end-users (households, commercial and institutional facilities), financial advisory services to banking and other financial institutions for loans to energy enterprises investing in the provision of efficient energy products and services. This should also be buttressed or complemented by enforcing the use of energy efficient equipment and providing tax incentives to importers of such products. Key energy efficient products include compact fluorescent lamps (CFLs) for lighting; liquefied petroleum gas (LPG), improved charcoal cook stoves, solar cookers, and efficient charcoal kilns for charcoal production. Other energy efficient domestic, commercial

and industrial equipment for the aforementioned energy services as well as for motive power will enhance the achievement of the necessary changes or additionality envisaged in the assessment.

In order to realize the potential of end-use energy efficiency improvements, appropriate targets for every five years should be set up to 2030. Setting such targets will be consistent with the NEP and the Poverty Reduction Strategy PRS), which strive, among other things, to reduce poverty by providing access to modern energy services in rural and peri-urban areas. End-use energy efficiency norms, legislative and regulatory considerations should be integrated national energy policy and planning. Building capacity is critical to the formulation of energy efficiency policy and regulation, the establishment of standards and norms, the promotion and implementation of plans and programs at national and local levels. Equally significant is endorsing information and knowledge exchange mechanisms to deploy appropriate energy-efficient technology options.

On the basis of national circumstances and needs, agreed standards and labeling criteria should be established. Investment entities will need to use innovative business and financing mechanisms to promote standards and labels.

3.2.3 Renewable Energy

Policy to induce the energy production using renewable energy technologies as Liberia is endowed with potential renewable energy resources such as solar, biomass and hydro, will significantly contribute to mitigating climate change as the current alternatives being used are either inefficient, costly, unreliable and contribute to the emission of carbon and other noxious gases which are the major causes of global warming/climate change. Similar awareness and sensitization targeting households, businesses including financial institutions with the aim of stimulating and increasing access, use, and investment in renewable energy will catalyze the realization of the climate change mitigation objective over the period under review.

In addition to the establishment of the legal and regulatory framework, other key policies expected to be considered to facilitate the achievement of the necessary mitigation measures include attracting private investment to the energy sector through fiscal and tax incentives, technology transfer and local capacity building through training in clean and efficient energy technology applications, and developing and expanding the country's remote energy market through public and private partnership.

The contribution of renewable energy in the national primary energy mix should be progressively increased during the remaining years of assessment period (2011-2030.) Through rational incentive policy, regulatory, institutional and financial arrangements, a level playing field can be created to facilitate the adoption of relevant renewable energy systems. Capacity for technology transfer and adaptation of renewable energy applications should be developed.

Sound policy will be required to provide improved access to safe drinking water, basic health care and education for poor people through the utilization of renewable energy.

In view of the foregoing, it is pertinent therefore to state that the policy implications mentioned would require a comprehensive mechanism to be put in place that will lead to the contribution, participation and collaboration of all stakeholders ranging from the public to the private sector, NGOs, international development organizations, community-based groups, cooperatives, local government authorities, households, energy enterprises, end-users as well as banks and other financial institutions.

General Policy Implications

Some general issues must be prioritized that are crucial to climate change mitigation in the energy sector. Firstly, there should be annual national budgetary allocation to climate change activities for both adaptation and mitigation. The Government of Liberia (GOL), through the EPA, should put in place monitoring mechanism for climate change activities. In addition, effective enforcement mechanisms for environmental laws should be developed at national, county and local levels in a coordinated manner (e.g. County inspectors). Furthermore, training and research on climate change issues should be prioritized.

Importantly, there should also be an improved and effective inter-ministerial, agency and local government coordination regarding climate change mitigation issues and challenges.

Public awareness about GHG emissions in simple English and local languages should be implemented in the print, broadcast and folk media channels. These could be in the forms of radio/TV messages, jingles, drama as well as other information education communication/behavioral change communication (IEC/BCC) materials and messages for posters, flyers, billboards, wall writing, etc.

The Government should raise community awareness (conduct regional workshops), ensure development and implementation of regulations on charcoal production and keep promoting sustainable alternatives.

3.3. Key Uncertainties and Methodological Limitations

Liberia's energy sector development could still be regarded as remote. Furthermore, the sector's current reform process is still in its embryonic stage. There is yet no mechanism (database system) put in place at the level of the Ministry of Lands, Mines and Energy, to record, monitor and measure progress or development in Liberia's energy sector. Therefore, data paucity which was and still is a major constraint, led to projections made over the assessment period after obtaining data for only a couple of years. Annual projections made were based on the population growth rates reported during the assessment period.

In addition, due to similar problem of lack of adequate data, the assessment did not include the calculations and estimates of projections on annual quantities of carbon emissions, energy produced and consumed over the assessment period for the various scenarios.

It is however hoped that upon the setting up of a standard energy sector development database system, these uncertainties and limitations could be overcome leading to a more improved assessment of the investment and financial flows in Liberia's energy sector.

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Annexes (See Excel sheets/calculations)

Annex 1: Population Statistics
Annex 2: Summary of Historical Table
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