

National Census of Electricity Operators

Republic of Liberia



August 29, 2019

PRELIMINARY SECTION

Table of Contents

PRELIMINARY SECTION	iii
List of Tables	v
List of Figures	vi
List of Plates	vii
Abbreviation	v
Executive Summary	vi
1 INTRODUCTION	9
1.1 Background	9
1.2 Goal of the Census	9
1.3 Objectives of the Census	9
1.4 Scope of the Census	9
1.4.1 Geographical Scope	9
1.4.2 Technical Scope	10
1.5 Definition of Key Terms	10
2 METHODOLOGY	12
2.1 Study Design	12
2.2 Study Population and Unit of Analysis	12
2.3 Data Collection Procedure	12
2.3.1 Data Collection Tool	13
2.4 Quality Assurance	13
2.5 Field Staff Selection and Training	14
3 SUMMARY OF FINDINGS	17
3.1 Overview	17
3.2 Findings for Small Operators	17
3.2.1 Classification of Electricity Operators	18
3.2.2 Technical Characteristics of Small Operators	18
3.2.3 Sales and Load	19
3.2.4 Labor and Staffing	19
3.2.5 Revenue, Expenses and Income	20
3.2.6 Electricity Pricing and Usage	20
3.2.7 Assets (in-service)	21
3.3 Liberia Electricity Corporation	22
3.3.1 Background	22
3.3.2 Technical Characteristics	22

3.3.3	Sales, Load and Labour	22
3.3.4	Electricity Pricing and Usage	22
3.3.5	Assets (in-service)	23
3.4	Jungle Energy Power (JEP)	23
3.4.1	Background	23
3.4.2	Technical Characteristics	23
3.4.3	Sales, Load and Labour	23
3.4.4	Electricity Pricing and Usage	24
3.4.5	Assets (in – service)	24
3.5	Comparison and Validation of Findings	24
4	RECOMMENDATIONS AND FIELD OBSERVATIONS	26
4.1	Threshold for Licensing	26
4.2	Comparison and Validation of Recommendations	27
4.3	Field Observation	28
	BIBLIOGRAPHY	29

List of Tables

Table 3.1 Descriptive Statistics on Annual Net Generation in MWh	Error! Bookmark not defined.
Table 3.2: Derived Indicators of Gross Revenue, Expenses and Income	20
Table 4.1: Voltage Levels modelled by Country (WAPP)	Error! Bookmark not defined.

List of Figures

Figure 3.1: Map of Operators that met the Minimum Threshold	17
Figure 3.2: Business Description	Error! Bookmark not defined.
Figure 3.3: Classification of Operators per activities in Section 5.1, sub-section 1 of the Electricity Law	Error! Bookmark not defined.
Figure 3.4: Category of Staff on Site	20

List of Plates

Plate 2.1: A field staff collecting data during the Pilot Census exercise	12
Plate 2.2: Field Supervisor and Chairman, Elect. Eng. Dept., UL inspecting an operator's facility	13
Plate 2.3: Data Collectors undergoing training at the University of Liberia, Electrical Eng. Dept	14
Plate 3.1: Team Delta (data collectors) about to be deployed	21

Abbreviation

CIE	Cote d'Ivoire Energie (CIE)
CLSG	Cote D'Ivoire, Liberia, Sierra Leone, and Guinea
CSEntry	CSPro Data Entry App
CSPro	Census Processing System
ECOWAS	Economic Community of West African States
ECREEE	Centre for Renewable Energy and Energy Efficiency
ELWA	Everlasting Love Winning Africa
GIS	Geographic Information System
GPS	Global Positioning System
GWh	Gigawatts hour
KW	Kilowatts
KWh	Kilowatts hour
LCPDP	Least Cost Power Development Plan
LEC	Liberia Electricity Corporation
LISGIS	Liberia Institute of Statistics and Geo-Information Services
LERC	Liberia Electricity Regulatory Commission
LUPSP	Liberia Utility Private Sector Partnership Options
MCA-Liberia	Millennium Challenge Account Liberia
MCC	Millennium Challenge Cooperation
MW	Megawatts
MWh	Megawatts hour
NCEO	National Census of Electricity Operators (Electricity Operator Census)
NEC	National Establishment Census
NPSRA	Nigeria Power Sector Reform Act
PIU	Project Implementation Unit
RESMP	Rural Energy Strategy and Master Plan
RIA	Roberts International Airport
WAPP	West African Power Pool

EXECUTIVE SUMMARY

Since the end of the Liberian civil conflict in 2005, significant effort has been made towards the rehabilitation and reconstruction of damaged electricity infrastructure. Currently, the operations of the Liberia Electricity Corporation (LEC) have been substantially restored and the national utility supplies electricity to customers in parts of Monrovia and suburbs. Supplementary, a number of small-scale, unlicensed operators produce and distribute electricity to off - grid - communities around Monrovia and in rural areas.

In October 2015, the Government of Liberia ratified the Electricity Law of Liberia ‘the Electricity Law’, thus, establishing the Liberia Electricity Regulatory Commission (LERC) with responsibilities to regulate the generation, transmission, distribution and sale of electricity within the territory of the Republic of Liberia and the import and export of the same.

On October 8, 2018, and with funding from Millennium Challenge Corporation (MCC); Millennium Challenge Account – Liberia (MCA-L) hired the services of a Consultant Demographer, Richard F. Ngafuan, to conduct a National Census of Electricity Operators (NCEO) for and on behalf of the LERC. The goals of the Census is to create a database of electricity operators in order to facilitate the registration and licensing of electricity operators in excess of a threshold to be recommended under this assignment and in addition, recommend definitions for transmission and distribution in terms of voltage level.

In an effort to achieve the aforementioned goals, the Consultant conducted a Pilot Census of electricity operators along the ELWA Junction – RIA Corridor, including the Liberia Electricity Corporation, from January 18 – January 25, 2019. This exercise was succeeded by the Main Census from March 1 to June 28, 2019. By using a logically structured and pre-coded questionnaire (see Annex 1), data collectors conducted interviews and gathered data relating to the location (geo-position), electricity sales and output, number and qualification of employees, operating revenue, expenses and income, electricity pricing and usage, value of assets (in-service) and system technical characteristics of electricity operators’ generation, transmission and/or distribution facilities.

The Consultant preliminarily identified electricity operators of interest from the database of the National Establishment Census (NEC) conducted by Liberia Institute of Statistics and Geo-Information Services (LISGIS) in 2017. Furthermore, reconnaissance surveys of major towns and commercial centres were used to identify additional operators not in the NEC database. The National Census of Electricity Operators received responses from a population of four hundred and thirty – seven (437) operators within the Republic of Liberia. Three hundred and forty - seven (347) operators constituting 79.4% of the population had installed generating capacity or distribution network line capacity that equalled and exceeded the predefined threshold of 50kW. One hundred and thirty - six operators equalled or exceeded the predefined threshold of 219 MWh energy production per annum. A total of three hundred and forty - five (345) small operators (excluding LEC and JEP) were enumerated and these results are presented in Annex 1. As indicated, three – hundred and one (301) operators constituting 87.3% of the total population of small operators were exclusively categorized as self – suppliers, twenty – seven (27) operators constituting 7.8% of the total population of small operators were exclusively categorized as commercial operators, whereas seventeen (17) operators constituting 4.9% of the total population of small operators were categorized as both self – suppliers and commercial operators. All three hundred and forty - five (345) small operators were engaged in generation and distribution. Forty - four (44) operators constituting 12.8% of the total population of small operators were engaged in the sale of electricity. No small operator was engaged in the transmission or import and export of electricity as observed from Annex 1.

Due to the strategic importance of LEC, as the major operator in Liberia, findings from LEC are presented in Annex 2. As indicated in Annex 2, LEC is engaged in the following regulated activities: generation, transmission, distribution, import of electricity, trading of electricity and transmission system operator. LEC has aggregate installed generating capacity of 144MW. These include an 88MW hydroelectric plant, three (3) HFO thermal plants with combined capacity of 38MW and a cross border distribution network with a

capacity of 8MW (even though current capacity utilization is approximately 50%). The cross border networks in Grand Gedeh County and Maryland County are managed directly by LEC and imports electricity from Cote d'Ivoire Energie (CIE). which is the national utility in neighboring Cote d'Ivoire.

Jungle Energy Power (JEP) is a private company contracted by LEC to operate and maintain the cross-border network in Nimba County. JEP is engaged in the following regulated activities: distribution, trading of electricity and import of electricity. JEP imports electricity from Cote d'Ivoire Energie (CIE). JEP operates approximately 140 km of 33kV distribution network. The network comprises thirty – eight (38) distribution transformers. Due to the strategic importance of JEP operations, findings from JEP are presented separately in Annex 3.

Findings from the National Census of Electricity Operators were compared to similar results presented in the “Liberia Utility Private Sector Partnership (LUPSP) Options Final Report” of October 2015 for the purpose of validating the NCEO dataset. A comparative analysis show that aggregate on – grid and aggregate off grid installed capacities nationwide is estimated in the LUPSP report as 22MW and 354MW respectively; aggregate on – grid capacity and aggregate off –grid capacity from the National Census of Electricity Operators is estimated at 136MW and 139MW respectively. The variance between off – grid estimates in the LUPSP Report and the NCEO Report is attributed to the fact that the NCEO did not enumerate operators below the 50KW predefined threshold hence, a substantial capacity below the 50KW threshold is unaccounted for. In addition, some major operators (listed in Annex 7) were non – responsive to the NCEO exercise. Also, the notable increase in off – grid capacity as indicated in the NCEO results may have triggered a corresponding decrease in off grid – capacity as more consumers become connected to the grid. The variance between on – grid estimates in the LUPSP Report and the NCEO results is attributed to the expansion of LEC installed capacity Essentially on - grid capacity has increased six – fold since the LUPSP Report of 2015.

Analysis of the small operators’ dataset in Annex 1 indicates that aggregate installed capacity (excluding LEC and JEP) is 131.2MW. 22% of electricity operators have installed capacity at site above 50kW but below or equivalent to 100kW which contributes 3.9% to the aggregate installed capacity (excluding LEC and JEP). 57.7% of electricity operators have installed capacity at site above 100kW but below or equivalent to 500kW which contributes 33.1% to the aggregate installed capacity (excluding LEC and JEP). And, 18.6% of electricity operators have installed capacity at site above or equivalent to 500kW which contributes 62.1% to the aggregate installed capacity (excluding LEC and JEP). Based upon the foregoing, electricity operators with an undertaking for generating electricity having aggregate installed capacity at site equivalent to or exceeding 100kW is recommended to obtain a license. It is further advised that licensing requirements be made less stringent for undertakings with installed capacities below 500kW to promote small scale renewable energy investments. In the case of renewable energy undertakings, where plant capacity factor is typically less than 50%, licensing threshold is defined in terms of annual energy produced. Hence, it is recommended that renewable energy undertakings with annual energy production equivalent to or exceeding 263 MWh be required to obtain a license. The preceding recommendation is based on the assumption that a 100 kW renewable energy undertaking operates at a capacity factor of 30% and is applicable to solar photovoltaic and small hydro plants. Operators of an undertaking for generating electricity with aggregate installed capacity below 100kW is not recommended to obtain a license, except in cases where said undertaking distributes electrical energy to other consumers other than self. In the case of this exception, it is recommended that licensing requirements be defined in terms of the number of customers. Hence, given that the median number of customers per commercial operators in Annex 1 is 36 a similar number of customers may be used as a benchmark for licensing these categories of operators. It is also important to emphasize that Section 5.2, sub –section 1 of the 2015 Electricity Law requires that; any person engaged in a regulated activity must register with the regulator. This legal requirement is critical to accurately establishing and updating the aggregate installed capacity nationwide. In order to establish conformity of the aforementioned licensing recommendation with best practices and standards in the Sub Saharan region, a comparative review of extant legislations from some Sub – Saharan countries was carried out (see Annex 6). An examination of licensing thresholds on a country – by – country basis showed that a licensing threshold of 100 kW is typical of similar countries in the SSA region.

A definition of Transmission and Distribution in terms of voltage levels necessitated an investigation of the technical and operational characteristics of LEC's transmission and distribution network (see Annex 2) - noting that as per Section 9.3 of the 2015 Electricity Law, LEC is the Transmission System Operator and National Grid Company. As indicated in Annex 2, LEC's transmission and distribution network is operated at the voltage levels of 66kV, 33kV, 22kV and .415/.230kV. LEC's distribution substations at major load centers are interconnected at the 66kV level and this existing network architecture necessitates the definition of Transmission Voltage as "any voltage exceeding thirty - three kilovolts (33kV) and such voltages at which an electrical facility is operated when used to deliver electricity in bulk" and shall include 66kV. Based upon the preceding, distribution Voltage is defined as "any voltage less than the minimum transmission voltage and such voltages at which an electrical facility or installation is operated in the final stages of the delivery of electricity to individual consumers" and shall include 33kV, 22kV and .415/.230kV. It is important to note that CLSG 225kV transmission network will become operational by 2020 under the framework of the West Africa Power Pool (WAPP). In order to benchmark the definition of transmission and distribution voltages against other countries within the ECOWAS region, a review of the 2018 ECOWAS Revised Master Plan for the Development of Power Generation and Transmission Infrastructure was carried out. As observed in the Master Plan, LEC's 66kV network is not modelled hence, by implication LEC's 66kV network is not meshed and cannot be **directly impacted** by the interconnection of WAPP even though islanded networks at 66kV levels will be connected to the 225kV backbone. Even though, 66kV is currently the highest voltage level on LEC's network, LERC may need to redefine the transmission and distribution voltage classes as the size and complexity of Liberia's national grid increase in the future.

During the NCEO exercise the overall response rate amongst operators was 78%. The non – responsiveness of operators to the Census exercise was mainly due to lack of awareness of the Liberia Electricity Regulatory Commission and its responsibilities. Non – responsiveness of operators to specific fields within the questionnaire was mainly related to questions on labour (number and qualification of employees) and sales and revenue, particularly amongst commercial operators. This apprehension, bordering on mistrust, could be attributed to cynicism that said information could be used to levy taxes. Adequate awareness of the roles and responsibilities of LERC couple with the LERC exercise of its legal authority as per the 2015 Electricity Law shall be required to mitigate these constraints.

1 INTRODUCTION

1.1 Background

In October 2015, the Government of Liberia amended Chapter 85 of the 1973 Public Authorities Law creating the Liberia Electricity Corporation (LEC). This amendment led to the passage and ratification of the 2015 Electricity Law of Liberia “the Electricity Law”. The Electricity Law established the legal and regulatory framework for the generation, transmission, distribution and sale of electricity within the territory of the Republic of Liberia and the import and export of same and created the Liberia Electricity Regulatory Commission (LERC), as an independent regulator for the electricity sector. In order to provide a legal basis for the regulation of the aforementioned activities in the electricity sector, Section 5.1, Subsections 1 and 2 of the Electricity Law reads:

1. *No persons may, without a license or registration issued by the Regulator in accordance with this Law,*
 - i. *operate any generation, transmission or distribution facility in excess of a threshold defined by the Regulator*
 - ii. *import and export electricity;*
 - iii. *be involved in trading of electricity; or*
 - iv. *be a transmission system operator*
2. *Notwithstanding Sub – section 1 of this Section, a person involved in regulated activities below the thresholds set by the regulations need not apply for or hold a licence issued by the Regulator.*

1.2 Goal of the Census

The goal of this Electricity Operators Census is to create a database of operators as per the regulated activities described in Section 5.1, sub – section 1 of the Electricity Law in order to facilitate the the registration and licensing of electricity operators in excess of a threshold to be recommended under this assignment.

1.3 Objectives of the Census

The objectives of the Electricity Operators Census are four-fold:

1. To **define** transmission and distribution in terms of voltage levels and **establish** thresholds for activities requiring licensing and registration. The arbitrarily predefined thresholds shall be generating capacity exceeding 50 kW or 219 megawatt hours per year for renewable energy plants, whichever is applicable.
2. To **identify and enumerate** operators engaged in the generation, transmission, distribution, sale and the import and export of electricity and **compile** an initial list of entities to be regulated by the LERC within the territory of the Republic of Liberia.
3. To **characterize** each electricity operator, as detailed in Annexes 1, 2, 3 and 4.
4. To classify each electricity operator in terms of regulated activities, as detailed in Annexes 1, 2, 3 and 4.

1.4 Scope of the Census

1.4.1 Geographical Scope

The geographical scope of the Census includes all fifteen (15) counties and all sixty (60) administrative districts - limited solely by the political boundary of the territory of the Republic of Liberia.



Figure 1.1: Political Map of Liberia showing the fifteen (15) counties

1.4.2 Technical Scope

The technical scope of the Census includes all operators with installed capacity which equals or exceeds 50 kW in aggregate at a site or renewable energy operators with a minimum annual energy output of 219 MWh.

1.5 Definition of Key Terms

Key terms used in this Report are derived from, and defined in accordance with Section 2.2 of the Electricity Law:

- Consumer or Customer:** current users of regulated electricity services, and includes those under a contractual agreement with the supplier, or who are entitled to have a reasonable expectation of services or who are affected by the services or how they are delivered.
- Distribution:** the conveyance or delivery of electricity to customer or end-users at the voltage level specified by the regulator
- Generation:** the process of generating electric power from any primary source of energy.
- Grid:** the interconnected network for delivering electricity from supplier to consumers.

- e. Large Consumer: end-users who consume more than a threshold number of kilowatt-hours as defined by a prescribed threshold,
- f. Liberia Electricity Corporation: the state-owned electricity operator that was created by Chapter 85 of the Public Authorities Law of the Republic of Liberia and all subsequent amendments of said law, which may include any successor companies that may be created in the future.
- g. Liberia Electricity Regulatory Commission: is the commission authorized regulate the electricity sector by giving licenses to electricity operators who are engaged in the generation, transmission, distribution and sale of electricity within the context of a defined threshold in the territorial confines of the country.
- h. Micro utility: entities and/or individuals who generate, distribute and/or supply electricity to a certain number of customers or less and/or below a certain threshold of total power generated annually.
- i. Regulator: The Liberia Electricity Regulatory Commission (LERC)
- j. Self-supplier: supply electricity for one's own need directly from self-generation
- k. Supply: the trading and the generation, transmission and distribution of electricity.
- l. Tariff: Electricity pricing, including related charges such as, but not limited to, connection charges.
- m. Transmission: the conveyance or delivery of electricity above the voltage level specified by the regulator.
- n. Transmission System Operator: the entity licensed to undertake some or all of the following activities:
 - a. coordinate the power supply to obtain instantaneous balance between generation and use of electricity,
 - b. dispatch all generation connected to the transmission infrastructure,
 - c. monitor the import and export of electricity,
 - d. and (d) prepare forecast of generation requirements, perform such other functions as may be prescribed in its license or in the regulations issued by the regulator.

2 METHODOLOGY

2.1 Study Design

The Electricity Operators Census uses a quantitative design in the collection and analysis of field data. A quantitative design is required because the key variables of the study are mainly structured for the collection of quantitative information as reflected in the data collection tools in Annexes 1, 2, 3 and 4.

2.2 Study Population and Unit of Analysis

The National Census of Electricity Operators cover electricity operators within the territory of the Republic of Liberia as per the regulated activities described in Section 5.1, sub – section 1 of the Electricity Law. Therefore, the primary unit of analysis is not the household or individual, as is the case of a typical population census rather electricity operators and service providers.

2.3 Data Collection Procedure

A comprehensive procedure was used during the census exercise to collect and compile data relating to location (geo-position), electricity sales and output, number and qualification of employees, operating revenue, expenses and income, electricity pricing and usage, value of assets (in – service) and system technical characteristics. Operators were preliminarily identified from the database of the National Establishment Census (NEC) conducted by Liberia Institute of Statistics and Geo-Information Services (LISGIS) in 2017. Furthermore, reconnaissance surveys of major towns and commercial centres were used to identify additional operators not in the NEC database.



Plate 2.1: Field staff collecting data with a mobile computing device during the Pilot Census exercise



Plate 2.2: Field Supervisor (Chairman, Elect. Eng. Dept., University of Liberia) inspecting an operator's substation facility

2.3.1 Data Collection Tool

The National Census of Electricity Operators Census employed a logically structured and pre-coded questionnaire (see Annex 7). The questionnaire was divided into nine (9) sections. Section A covered information about the name, location and classification of operator in terms of activity and operating model. Sections B and C captured information about electricity sales and load of each operator. Section D collected information regarding each operator's revenue and income, Section E collected information about electricity pricing and usage, Section F recorded information related to the value of each operator's assets (in-service), Section G recorded the operating expenses incurred by each operator and Sections H to J captured the technical characteristics of an operator's generation, transmission and/or distribution facilities.

To facilitate efficient and reliable data gathering, the pre – coded questionnaire in Annex 6 was developed into an algorithm and programmed using CSEntry software. The CSEntry software, which is a version of CSPro software, was used to capture data from the field in electronic format, rather than manually. Coding of the questionnaire enabled the development of an application in CSEntry to facilitate electronic data collection using mobile tablets. Electronic data capture improved the reliability of data gathering, allowed real time and remote monitoring of data collectors and geo - referencing of plant location along the corridor.

2.4 Quality Assurance

For the purpose of quality assurance, all census data were captured electronically. Electronic data capture improved the quality of data by reducing the various lines of errors associated with data entry and mitigating any loss of information associated with the misplacement of paper questionnaire. Additionally, prompting questions and skip patterns on the paper questionnaire were automatically addressed by the CSEntry software. Finally, the CSEntry software automatically captured GIS related information with respect to the location of the operators.

Field supervisors were selected to crosscheck and verify that the GPS points collected from the field georeferenced the actual location of operators. This allowed real - time and continuous monitoring of the data collectors.

Random spot checks and field visits were also made by the Consultant and MCA-L staff. In addition, random calls were made to operators to verify whether field visits were carried out or the interviews were conducted.

2.5 Field Staff Selection and Training

Based on the staffing requirements and the tasks undertaken during the Pilot Census, thirteen (13) field staff were hired to conduct data collection during the main census. These data collectors were further trained for forty (40) hours over a period of ten days - noting that all thirteen (13) selected field staff had undergone initial training prior to the Pilot Census.

Training covered but was not limited to the following:

1. use of the CSEntry Software;
2. procedure for automatically capturing GPS coordinates, saving data and securing the collected data;
3. protocol for engaging with the plant and system operators;
4. methods of obtaining primary data and secondary data based on the plant and system technical and operating characteristics as indicated or observed; and
5. ethical standards in data collection

As was the case during the Pilot Census, all thirteen (13) selected field staff exceeded the minimum required qualification of four (4) years training in electrical engineering leading to a Bachelor's degree (senior student of a recognized university) as all thirteen (13) data collectors were graduates of electrical engineering. In addition to academic qualifications, each data collector was required to demonstrate an adequate understanding of the use of the census instrument and an appreciation of the census methodology.



Plate 2.3: Data Collectors undergoing training at the University of Liberia, Electrical Eng. Dept.



Figure 2.1: Power House at Yandobun Hydro Power facility, Lofa County



Figure 2.2: Power House at Totota Hybrid Solar/Diesel Power Station, Bong County

3 SUMMARY OF FINDINGS

3.1 Overview

The Electricity Operators Census received responses from a population of four hundred and thirty – seven (437) operators within the Republic of Liberia. Three hundred and forty - seven (347) operators constituting 79.4% of the population had installed generating capacity or distribution network line capacity that equaled and exceeded the pre - defined threshold of 50kW. One hundred and thirty - six operators equaled or exceeded the predefined threshold of 219 MWh energy production per annum. However, for the purpose of this report, Section 3.2 shall present the findings of small operators including community operators, renewable energy installations and self – suppliers. The findings of Liberia Electricity Corporation (LEC) and Jungle Energy Power (JEP) are presented in Section 3.3 and Section 3.4 respectively.

3.2 Findings for Small Operators

A total of three hundred and forty - five (345) small operators (excluding LEC and JEP) were enumerated as indicated in Annex 1. More operators were expectedly located in areas of higher economic activity within Liberia as indicated in Figure 3.1. Since most corporate establishments and public institutions in Liberia are found in Montserrado County, especially the Monrovia area, 49.9% of the total of three hundred and forty - five (345) small operators who met the threshold were found in Montserrado County.

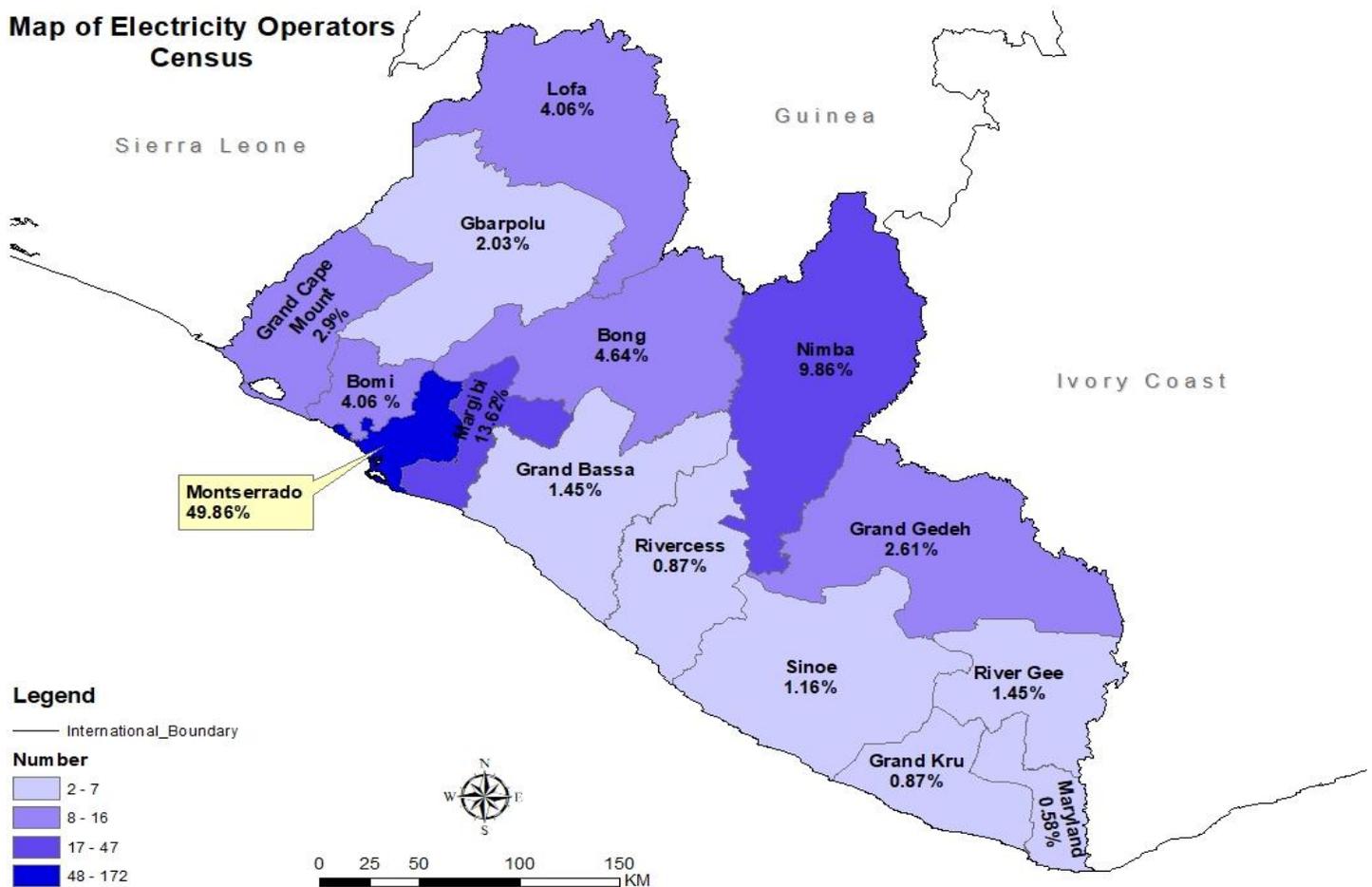


Figure 3.1: Distribution of Small Operators by County Level

3.2.1 Classification of Electricity Operators

Two (2) criteria were used to classify electricity operators; these include Operating Model and Regulated Activities. Whereas in terms of operating model, operators were classified as either self-supplier or commercial or both; in terms of regulated activities, operators were classified according to their engagement in the following activities - generation, transmission, distribution, trading (sales), import and export of electricity.

3.2.1.1 Classification by Operating Model

All three hundred and forty - five (345) small operators provided information on their operating model. As indicated in Annex 1, three – hundred and one (301) operators constituting 87.3% of the total population of small operators were exclusively categorized as self – suppliers, twenty – seven (27) operators constituting 7.8% of the total population of small operators were exclusively categorized as commercial operators, whereas seventeen (17) operators constituting 4.9% of the total population of small operators were categorized as both self – suppliers and commercial operators.

3.2.1.2 Classification by Regulated Activities

Section 5.1, sub-section 1 of the 2015 Electricity Law of Liberia outlines activities of electricity operators that would require licensing (regulated activities). These include;

- a. generation of electricity
- b. transmission of electricity
- c. distribution of electricity
- d. import and export of electricity
- e. trading of electricity
- f. transmission system operator

As indicated in Annex 1, all three hundred and forty - five (345) small operators were engaged in generation and distribution. Forty - four (44) operators constituting 12.8% of the total population of small operators were engaged in the sale of electricity. No small operator was engaged in the transmission or import and export of electricity as observed in Annex 1.

3.2.2 Technical Characteristics of Small Operators

With the exception of a single commercial operator with an 11kV distribution network, all twenty – six (26) commercial operators and all seventeen (17) self – suppliers/commercial operators supplied power from source to consumers at low voltages of 220V- 240V single phase or 380 - 415V three-phase. The implication of this is that power supply from small commercial operators to consumers may be characterized by poor quality due to significant voltage drops along the distribution lines. Only six (6) of the three hundred and forty - five (345) small operators had record on the total length of distribution lines.

Technical data on plant nameplate rating and the number of units per plant were recorded for all three hundred and forty - five (345) small operators. Statistical analysis of the data in Annex 1 indicates the aggregate installed capacity of small operators nationwide is 131.2MW.

3.2.3 Sales and Load

3.2.3.1 Net Generation

As indicated in Annex 1, data relating to the annual net generation was gathered for each operator. As observed from the field exercise, this data could not be obtained as primary data. However, indicators were used to compute annual net generation based on the formulations and assumptions in Annex 5.

The annual net generation of one hundred and thirty-six (136) small operators constituting 39.4% of the population equaled or exceeded the predefined energy threshold of 219MWh per annum and only two of these were renewable energy operators. Aggregate gross annual energy production for small operators was estimated as 165 GWh. Low energy production amongst operators was mainly due to low plant capacity factor arising from the limited operational hours of most of these plants.

3.2.3.2 Annual Power Purchased

None of the three hundred and forty - five (345) small operators kept records of power purchased from off – system sources even though some of these operators were consuming power from LEC’s grid. All twenty – seven (27) operators classified exclusively as commercial operators operated as isolated systems outside the geographical scope of the existing LEC grid.

3.2.3.4 Net Sales

Data were also gathered on the annual net sales of each commercial operator, this is shown in Annex 1. As observed, operators were non – responsive to providing information on annual net sales. The non-disclosure of information on annual sales by operators is due to cynicism that this information could be used for taxation purpose. Notwithstanding, indicators were used to compute annual net sales based on the formulations and assumptions in Annex 5. In this case, the net sales were equated to gross revenue. This was based on the assumption that there were no sale allowances and sale discounts to customers purchasing electricity after the price is set by the operator.

3.2.4 Labor and Staffing

Of the twenty – seven (27) operators classified exclusively as commercial operators, only twenty – one (21) operators provided data on number of staff. Staff was disaggregated as engineers, technicians and others (non – technical staff). Five (5) of the twenty – one (21) responsive operators had at least an engineer within their employ, nine (9) of the twenty – one (21) responsive operators had at least one technician within their employ, while all 17 exclusively commercial operators had staff who were categorized as non-technical staff suggesting that maintenance of the network was outsourced to contractors. An average of three (3) staff per operator was recorded for the twenty – one (21) responsive commercial operators

All twenty – seven (27) commercial operators were either generally non – responsive to providing data on the status of employment or had confusion drawing distinction between full-time and part-time employees as the difference between the two was sometimes blurred.

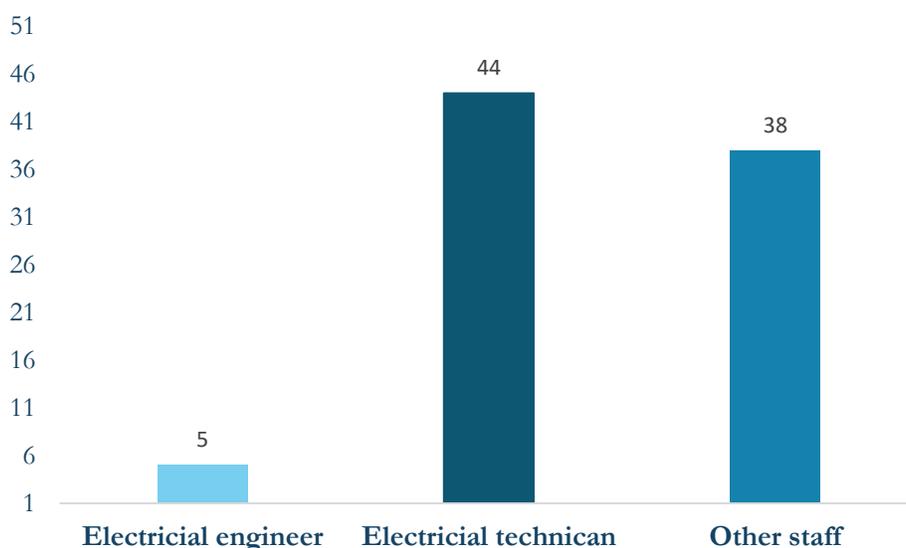


Figure 3.2: Classification of Staff for exclusively Commercial Operators

3.2.5 Revenue, Expenses and Income

Data on annual operating expenses, annual net revenue and annual net income was not disclosed by most operators. Of the twenty – seven (27) operators classified exclusively as commercial operators, only all directly disclosed information related to financial data. This data was not required of operators categorized as self – suppliers and self – supplier/commercial. The non – responsiveness of operators in providing information on revenue and income could be attributed to general cynicism associated with the disclosure of financial data.

In order to mitigate the foregoing, indirect and indicative questions were included in the questionnaire (see Annex 6 Section). These provided the relevant inputs to the assumptions and formulation sheet in Annex 5 and was used to estimate annual revenue, expense and income for some operators.

Table 3.1: Gross Revenue, Expenses and Income

	Valid N	Mean	Median	Mode	Sum
Gross revenue	27	178994.6	75589.44	6316.47	4,832,854.7
Expenses	27	13720.93	6203.99	1810.58	370464.99
Income	27	165273.7	69128.79	4364.79	4462389.8

As shown in Table 3.1, the aggregate estimated annual gross revenue for the twenty-seven (27) exclusively commercial operators was \$4.8M whereas, annual gross income was estimated at around \$4.5M. As observed from the assumption and formulations in Annex 5, annual expenses are largely based on the generating costs associated with each operator and to a lesser extent on other capital and overhead costs. Therefore, operating expense may be underestimated and annual gross income may be overstated.

3.2.6 Electricity Pricing and Usage

Annex 1 shows the price of electricity per operator and the average monthly energy usage per consumer category for each operator. Of the twenty – seven (27) operators classified exclusively as commercial operators eighteen (18) operators supplied information on the pricing of electricity in cents per kilowatts-hour. Of the 44 operators classified as self – supplier/commercial, thirty-one (31) operators provided information on price of electricity.

The price of electricity for individual operators ranged from 46c/kWh to 128c/kWh. This is significantly higher than the current price per unit of electricity supplied by LEC, which is 35c/kWh. There existed no variation in the price of electricity offered to industrial, commercial and residential consumers by small operators. The basis of electricity pricing for small commercial operators was computed as monthly consumption estimated on the basis of consumer's breaker ratings. This monthly flat rate was provided as \$/breaker amperage and converted to c/kWh by employing the assumptions and formulations in Annex 5. Due to the non – use of energy meters, operators could not provide accurate data on average monthly usage of electricity per consumer.

3.2.7 Assets (in-service)

As indicated in Annex 1, data were solicited from each operator regarding the book value of assets (in – service). Of the three hundred and forty - five (345) small operators, three hundred and twenty (320) operators provided records of the value of the plant (in service). The total value of generating plants in service recorded for three hundred and twenty (320) small operators (excluding LEC and JEP) was \$40.7M.



Plate 3.1: Team Delta (data collectors) about to be deployed

3.3 Liberia Electricity Corporation

3.3.1 Background

Liberia Electricity Corporation is the government - owned national utility of the Republic of Liberia and as per Section 9.3 of the 2015 Electricity Law of Liberia, LEC is the National Grid Company and Transmission System Operator. Due to the strategic importance of LEC, as the major operator in Liberia, findings from LEC is discussed in this Section. As indicated in Annex 2, LEC is engaged in the following regulated activities: generation, transmission, distribution, import of electricity, trading of electricity and transmission system operator.

3.3.2 Technical Characteristics

LEC has aggregate installed generating capacity of 144MW. These include an 88MW hydroelectric plant, three (3) HFO thermal plants with combined capacity of 38MW. The national utility also owns a cross border distribution network with a capacity of 8MW, even though current capacity utilization is approximately 50%. Electricity supply to the cross border network is imported from Cote d'Ivoire Energy (CIE), the national utility of Cote d'Ivoire. The cross border network span three counties, namely, Nimba, Maryland and Grand Gedeh counties. Whereas, the cross border network in Nimba County is managed by a third party, Jungle Energy Power (JEP); the networks in Maryland and Grand Gedeh counties are managed directly by LEC.

LEC operates 259.2 km of 22kV and 33kV distribution network and 80.4km of 66kV transmission network. Electricity is supplied to consumers as 220V single phase supply or 415V three phase supply.

3.3.3 Sales, Load and Labour

As indicated in Annex 2, LEC provided data for sales, load and labor covering the year 2018. Annual peak demand was reported as 33MW. Annual net energy generated was recorded as 201,052 MWh. As indicated in Annex 3, in addition, LEC imported 10,643 MWh of energy from CIE in the year 2018 via the cross border networks in Maryland and Grand Gedeh counties. Data on annual power imported via the cross border network in Nimba County was obtained from Jungle Energy Power, which is a third party contracted by LEC to operate the network in this location. This is covered under Section 3.4 of this report.

Data was also reported by LEC for net sales, revenue, income and expenses as indicated in Annex 2 (this is redacted in some version of this report).

The total number of staff at LEC was reported as nine hundred and eight (908) consisting of six hundred and one (601) full – time staff and three hundred and seven (307) part – time staff. These employees were disaggregated as engineers, technicians and others. Of the total of nine hundred and eight (908) employees, nineteen (19) were engineers, one hundred and fifty-seven (157) were technicians and five hundred and seventy-seven (577) were neither technicians nor engineers and categorized as non – technical staff. LEC technical staff constituted 30.5% of total staff.

3.3.4 Electricity Pricing and Usage

As indicated in Annex 2, LEC electricity tariff is 35c/kWh for all residential customer and 38c/kWh for commercial operators. This is lower than the average price of electricity amongst small commercial operators in Liberia with an exception being cross - border electricity which is priced at 25c/kWh as shown in Figure 3.3.

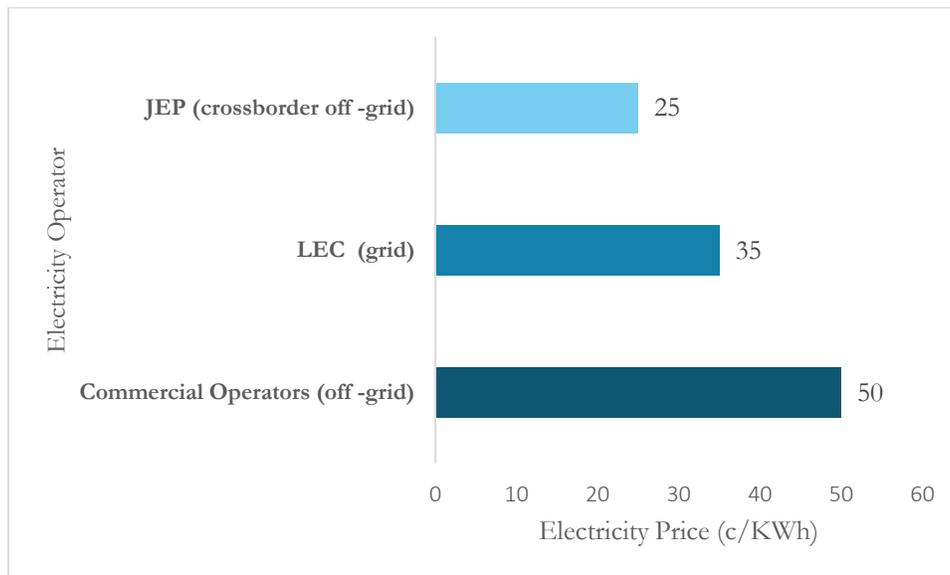


Figure 3.3: Electricity Price for various categories of Operators

LEC reported a customer base of 55,135 customers comprising of 54,243 residential customers. Residential customers thus constitute 98.4% of LEC’s customer base. The annual average energy consumption per residential customer was reported as 12, 973MWh.

3.3.5 Assets (in-service)

As indicated in Annex 2, LEC reported the book value of assets (in – service). Assets were disaggregated as generating assets, transmission assets, distribution assets and other assets. (this is redacted in some versions of this report).

3.4 Jungle Energy Power (JEP)

3.4.1 Background

Jungle Energy Power (JEP) is a private company contracted by LEC to operate and maintain the cross-border network in Nimba County. The cross-border networks in Grand Gedeh county and Maryland County are managed directly by LEC. JEP is engaged in the following regulated activities: distribution, trading of electricity and import of electricity. JEP imports electricity from Cote d’Ivoire (CE) energy which is the national utility in neighboring Cote d’Ivoire.

3.4.2 Technical Characteristics

As indicated in Annex 3, JEP operates approximately 140 km of 33kV distribution network. The network comprises thirty – eight (38) distribution transformers. Information regarding the sum of distribution transformer capacities of JEP’s network was not reported. Electricity is supplied to consumers as 220V single phase supply or 415V three phase supply.

3.4.3 Sales, Load and Labour

JEP provided data for sales, load and labor covering the year 2018. Annual net energy imported was reported as 706.3 MWh. JEP did not report data for net sales and revenue, income and expenses covering 2018 as observed in Annex 3.

The total number of staff at JEP was reported as one – hundred and seven (107). These employees were disaggregated as engineers, technicians and others. Of the total of one – hundred and seven (107) staff, only one (1) was an engineer.

In addition, of the total staff number of one – hundred and seven (107). forty – two (42) were full time staff and sixty – five (65) were part – time staff.

3.4.4 Electricity Pricing and Usage

As indicated in Annex 3, JEP’s electricity tariff is 27.5c/kWh which is 21.4% less than LEC’s tariff. JEP’s tariff of 27.5c/kWh consists of a 25c/kWh charge and a GST of 10% and this is applicable to both commercial and residential consumers. JEP reported a customer base of 4,600 customers. Residential customers constitute nearly 100% of JEP’s customer base. Plans are in place to connect commercial and industrial customers.

3.4.5 Assets (in – service)

JEP reported no data on the value of its assets. Whereas the cross border network is owned by LEC, JEP has made additional investments in equipment to operate the network; however, this data was not reported.

3.5 Comparison and Validation of Findings

Findings from the Electricity Operators Census was compared to similar results presented in the “Liberia Utility Private Sector Partnership (LUPSP) Options Final Report” of October 2015. As illustrated in Figure 3.4, the aggregate on – grid installed capacity nationwide estimated in the LUPSP report was 22MW and aggregate off grid installed capacity was estimated at 354MW including industrial, residential and commercial, micro – grids and cross border. The aggregate on – grid capacity reported during the National Census of Electricity Operators is 136MW as shown in Figure 3.4 and aggregate off grid installed capacity including industrial, residential and commercial, micro – grids and cross border was estimated at 139MW.

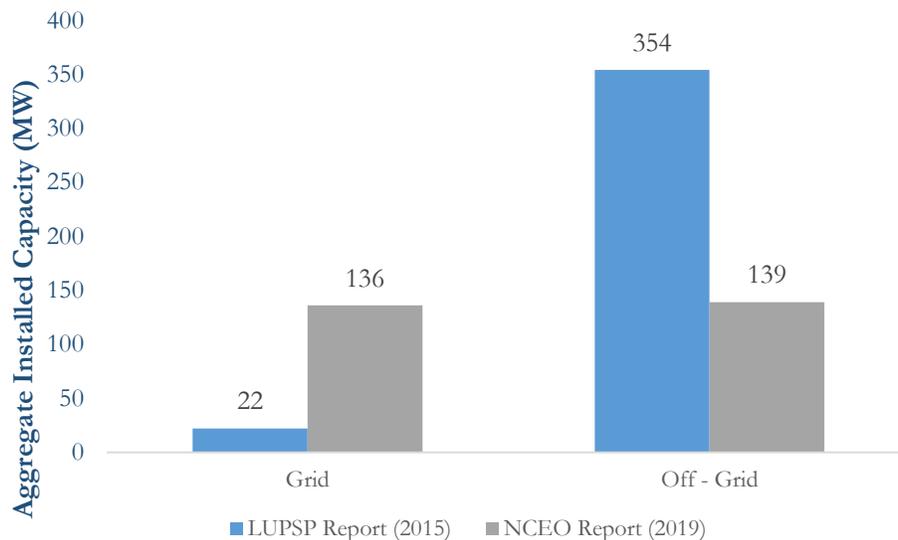


Figure 3.4: Comparative Aggregate Installed Capacity

The variance between off – grid estimates in the LUPSP Report and the EOC Report is attributed to the following:

- The National Census of Electricity Operators enumerated operators above a pre – defined threshold of 50 KW installed capacity whereas the LUPSP took into account all operators regardless of a pre – defined threshold. Essentially, a substantial capacity below the 50KW threshold is not accounted for in this report.
- Some major operators whose installed capacity equalled or exceeded the threshold of 50KW were non – responsive to the Census exercise. A list of non – responsive operators is included in Annex 7 for LERC’s

attention. An update of the Census database to include these operators will increase the aggregate off grid installed capacity.

- c. The notable increase in off – grid capacity as indicated in the National Census of Electricity Operators (NCEO) Report may have led to a corresponding decrease in off grid – capacity as more consumers become connected to the grid.

The variance between on – grid estimates in the LUPSP Report and the EOC Report is attributed to the expansion of LEC installed capacity with the commissioning of 2.5MW x 4 WB HFO Plant in 2015, 9MW x 2 GOL HFO plant in 2016, 5MW x 2 JICA HFO plant in 2016 and the 4 x 22MW Mt. Coffee Hydro Power Plant in 2016. Units of the 1MW x 22 HSD Plants have been substantially degraded and decommissioned leaving only 1 x 5MW HSD which constitutes a reserve. Essentially on - grid capacity has increased six – fold since the LUPSP Report of 2015.

As illustrated in Figure 2, while annual on – grid energy production was estimated at 47GWh in the LUPSP Report, annual on – grid energy production in the NCEO Report is estimated at 201GWh confirming that a substantial portion of installed capacity which existed off - grid in 2015 is now being met by the increased capacity of LEC. Annual off grid energy production in the LUPSP Report is estimated at 1,344 GWh while the EOC report estimates the annual off - grid energy production as 175.4 GWh. The constraints and limitations associated with the National Census of Electricity Operators outlined supra provides an indication that the census estimates may be conservative.

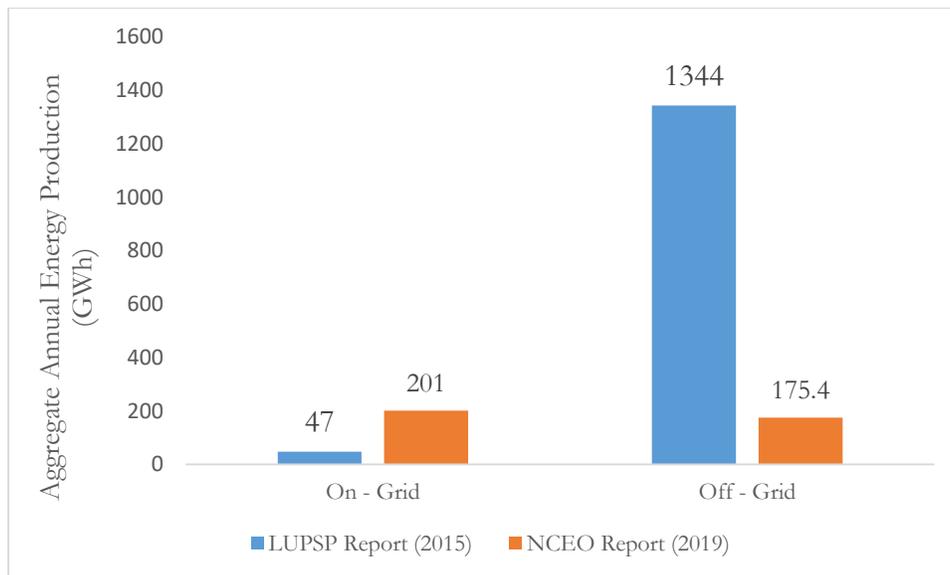


Figure 3.5: Comparative Aggregate Annual Energy Production

4 RECOMMENDATIONS AND FIELD OBSERVATIONS

4.1 Threshold for Licensing

Analysis of the small operators' data in Annex 2 indicates that aggregate installed capacity (excluding LEC and JEP) is 131MW. Seventy – six (77) operators constituting 22% of small operators have installed capacity on site above 50kW but below or equivalent to 100kW which contribute 4% to the aggregate installed capacity (excluding LEC and JEP). One hundred and ninety – nine (199) operators constituting 57.7% of small operators have capacity on site above 100kW but below or equivalent to 500kW which contributes 33.2% to the aggregate installed capacity (excluding LEC and JEP). And, sixty – four (64) operators constituting 18.6% of small operators have capacity on site above or equivalent to 500kW which contribute 62.1% of the aggregate installed capacity (excluding LEC and JEP). Based on the foregoing, a threshold of 100kW will accommodate 76.3% of electricity operators and offers a benchmark for determining a threshold for licensing.

Accordingly, the following recommendations are advanced;

1. A person who operates an undertaking for generating electricity with aggregate installed capacity at site equivalent to or exceeding 100 kW be required to obtain a license. The procedure and classification of said license is within the purview of LERC, however, it is recommended that the licensing requirements be less stringent for undertakings with installed capacities below 500 kW to promote small scale renewable energy investments. In the case of renewable energy undertakings, plant capacity factor is typically less than 50% (USEIA, 2015), hence, it is more practical to define threshold in terms of annual energy produced. With reference to the threshold defined supra, it is recommended that renewable energy undertakings with annual energy production equivalent to or exceeding 263 MWh be required to obtain a license. The preceding recommendation is based on the assumption that said renewable energy undertaking operates at a capacity factor of 30%. This is applicable to solar photovoltaic and small hydro plants.
2. A person who constructs, owns or operates an undertaking for generating electricity with aggregate installed capacity below 100 kW may not be required to obtain a license, except in cases where said undertaking distributes electrical energy to other consumers other than self. The procedure and classification of said license is within the purview of LERC, however, it is recommended that licensing requirements be defined in terms of the number of customers. Given that the mean number of customers per commercial operators (as per Annex 1) is 47 and the median number of customers per commercial operators is 36 (as per Annex 1), the median number of customers may be used as a benchmark for licensing these categories of operators.

Notwithstanding the foregoing, Section 5.2, sub –section 1 of the 2015 Electricity Law requires that; *“any person engaged in a regulated activity under this Law must register with the regulator.* One objective of this requirement is to more accurately establish the aggregate installed capacity nationwide.

Definition of Transmission and Distribution

A definition of Transmission and Distribution in terms of voltage levels necessitates an investigation of the technical and operational characteristics of LEC's transmission and distribution network - noting that as per Section 9.3 of the 2015 Electricity Law, LEC is the Transmission System Operator and National Grid Company.

A review of data reported by LEC and contained in Annex 2, indicates that LEC's transmission and distribution network is operated at the following voltage levels: 66kV, 33kV, 22kV and .415/.230kV. It is important to also note that CLSG 225kV transmission network will become operational by year 2020 under the framework of the West Africa Power Pool (WAPP) and LEC's islanded network at the 66kV level will in the future be connected to the 225kV backbone. LEC's distribution substations at major load centers are interconnected at the 66kV level hence based on the existing network architecture, the following definition of transmission and distribution voltages are recommended;

1. Transmission Voltage - any voltage exceeding thirty - three kilovolts (33kV) and those voltages at which an electrical facility is operated when used to deliver electricity in bulk and shall include 66kV.
2. Distribution Voltage - any voltage less than the minimum transmission voltage and those voltages at which an electrical facility or installation is operated in the final stages of the delivery of electricity to individual consumers and shall include 33kV, 22kV and .415/.230kV.

4.2 Comparison and Validation of Recommendations

In order to establish conformity with best practices and standards in the Sub Saharan region, a comparative review of extant legislations from Uganda, Namibia, Tanzania, Zambia, Zimbabwe, Lesotho, Swaziland, Nigeria, Kenya and Botswana was carried out. A matrix indicating licensing thresholds on a country – by – country basis is contained in Annex 8. As illustrated in Figure 4.1, a threshold of 100W is typical of similar countries in the SSA region.

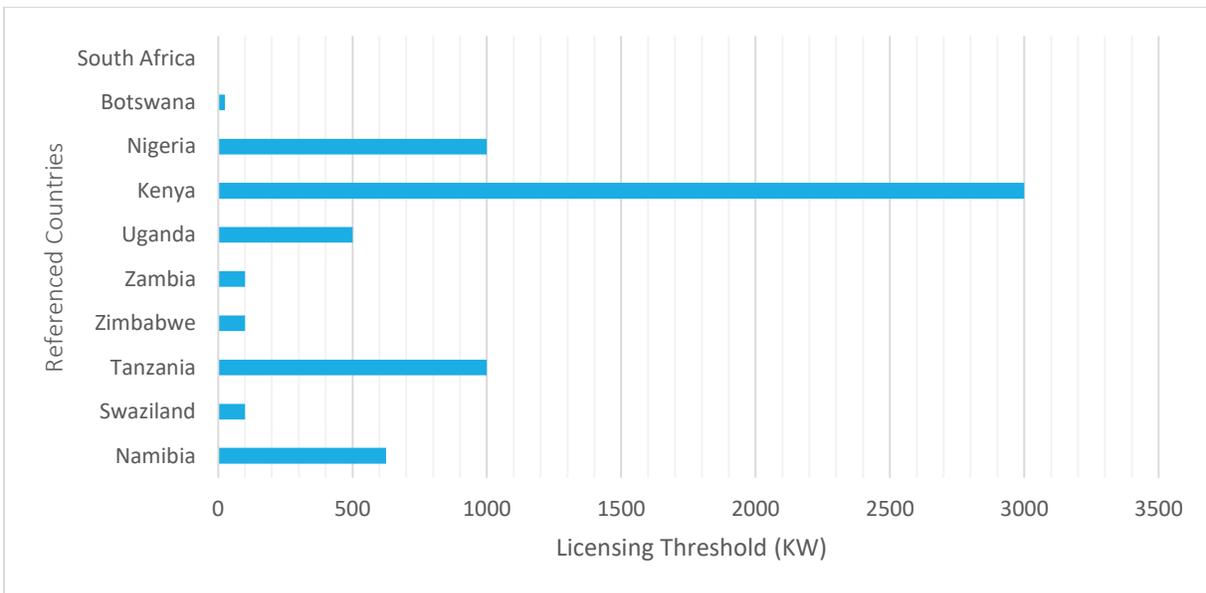


Figure 4.1: Licensing Threshold of similar countries in the SSA region

In order to benchmark these recommendations against transmission and distribution voltages of other countries within the ECOWAS region, a review of the 2018 ECOWAS Revised Master Plan for the Development of Power Generation and Transmission Infrastructure was carried out. The aforementioned Master Plan models existing and planned transmission lines for each member country within the West Africa Power Pool (WAPP). Table 1 summarizes the voltage levels modelled for each country. As shown below, LEC’s 66kV network is not modelled therefore, by implication LEC’s 66kV network is not meshed and cannot be **directly impacted** by the interconnection of WAPP. Even though, 66kV is currently the highest voltage level on LEC’s network, LERC may need to redefine the transmission and distribution voltage classes as the size and complexity of Liberia’s national grid increase in the future.

Table 4.1: Voltage Levels modelled by Country (WAPP)

No.	Country	Voltage Levels modelled
1	Senegal	225 & 90 KV
2	The Gambia	225 & 132 kV
3	Guinea Bissau	225 kV
4	Guinea	225 & 110 kV
5	Mali	225 & 150 kV

6	Liberia	225 kV
7	Sierra Leone	225 & 161 kV
8	Côte d'Ivoire	225 & 90 kV
9	Ghana	330 & 161 kV
10	Togo	330 & 161 kV
11	Benin	330 & 161 kV
12	Burkina Faso	225 & 90 kV
13	Niger	330 & 132 kV
14	Nigeria	330 & 132 kV

4.3 Field Observation

The following observations were recorded during the field exercise:

1. Overall response rate amongst operators was 87.6%. Out of four ninety-eight (499) operators identified, four hundred and thirty-seven (437) were responsive whereas sixty-two (62) were non-responsive. Three hundred and forty-seven (347) operators constituting 79.4% of the responsive operators had installed generating capacity or distribution network line capacity that equaled and exceeded the pre-defined threshold of 50kW. Non-responsiveness from operators was mainly due to lack of awareness of the Liberia Electricity Regulatory Commission and its responsibilities. Some operators displayed a lack of discernment between the roles of LEC and LERC. A list of non-responsive operators is contained in Annex 7 for LERC engagement in the future. A greater public awareness of the roles and responsibilities of LERC is needed.
2. Some operators were non-responsive to specific fields within the questionnaire. Non-responsiveness was mainly related to questions on labour (number and qualification of employees) and sales and revenue, particularly amongst commercial operators. This apprehension, bordering on mistrust, could largely be due to fear that the information gathered could be used by the Revenue Authority to levy taxes. A greater public awareness of the roles and responsibilities of LERC is needed.
3. Whereas data were collected on the number of staff per operator, a requirement to disaggregate this data by gender is of critical importance as this would provide an indication of the extent of gender inclusiveness in the electricity sector.
4. Due to the technical nature of the data gathered, data collectors were required to be at a minimum senior students or graduates in the field of electrical engineering with requisite knowledge and skillset. Competent persons in the aforementioned category are in limited supply hence, significant hours were allotted to recruitment and training by the Consultant. Same may be the necessary for future LERC staff.
5. The Census was scheduled during the rainy season, hence, major constraints were faced with the transportation of data collectors to rural communities, especially in the South-Eastern parts of Liberia. To mitigate the constraint of transportation, it is important to plan future operators' census for the dry season between the months of October and March.

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Annex 1: Small Operators Dataset (attached in MS Excel)

Annex 2: Liberia Electricity Corporation Dataset (attached in MS Excel)

Annex 3: Jungle Energy Power – Nimba Crossborder Electricity Dataset (attached in MS Excel)

Annex 4: Liberia Electricity Corporation - Grand Gedeh and Maryland Crossborder Electricity Dataset (attached in MS Excel)

Annex 5: Assumptions and Formulations (attached in MS Word)

Annex 6: National Census of Electricity Operators Questionnaire (attached in MS Word)

Annex 7: List of Non – Responsive Operators (attached in MS Excel)

Annex 8: Licensing Thresholds on a Country – by – Country Basis (attached in MS Word)